AMC Consultants Pty Ltd

ABN 58 008 129 164

4 Greenhill Road
WAYVILLE SA 5034

T +61 8 8201 1800
F +61 8 8201 1899
E amcadelaide@amcconsultants.com.au

2013 OYU TOLGOI TECHNICAL REPORT
TURQUOISE HILL RESOURCES LTD.

812023

March 2013

Title Page

Project Name: OYU TOLGOI PROJECT

Title: 2013 Oyu Tolgoi Technical Report

Location: Omnogovi Aimag, Mongolia

Effective Dates:

Effective Date of Technical Report:	25 March 2013
Effective Date of Mineral Reserve Estimates:	25 March 2013

Effective Dates of Mineral Resource Estimates:

Southern Oyu	19 March 2012
Hugo North and Hugo North Extension	20 February 2007
Hugo South	1 November 2003
Heruga	30 March 2010

Qualified Persons:

Bernard Peters, BEng (Mining), FAusIMM (201743), employed by AMC Consultants Pty Ltd as Mining Manager, was responsible for the overall preparation of the 2013 Technical Report and, the Mineral Reserve estimates of the 2013 Technical Report.

Sharron Sylvester, BSc (Geol), RPGeo AIG (10125), employed by AMC Consultants Pty Ltd as General Manager/Principal Geologist, was responsible for the preparation of the Mineral Resources.

Malcolm Bridges, BSc (Hons), FAusIMM (102216), employed by AMC Consultants Pty Ltd as Principal Geomechanics Consultant, was responsible for the preparation of the Geotechnical Sections.

Alan Riles, BMetallurgy (Hons Class I), AIG (4820), employed by AMC Consultants Pty Ltd as Associate Principal Metallurgical Consultant, was responsible for the preparation of the Processing Sections.

Signature Page

Effective Dates:

Effective Date of 2013 Technical Report:	25 March 2013
Effective Date of Mineral Reserve Estimates:	25 March 2013

Effective Dates of Mineral Resource Estimates:

Southern Oyu	19 March 2012
Hugo North and Hugo North Extension	20 February 2007
Hugo South	1 November 2003
Heruga	30 March 2010

Overall Preparation of the 2013 Technical Report and Mineral Reserve Estimates
/s/ Bernard Peters, BEng (Mining), F. AusIMM (201743), AMC Consultants Pty Ltd

Mineral Resources
/s/ Sharron Sylvester, BSc (Geol), RPGeo AIG (10125), AMC Consultants Pty Ltd

Geotechnical
/s/ Malcolm Bridges, BSc (Hons), FAusIMM (102216), AMC Consultants Pty Ltd

Processing
/s/ Alan Riles, BMetallurgy (Hons Class I), AIG (4820), AMC Consultants Pty Ltd

CONTENTS

TABLES

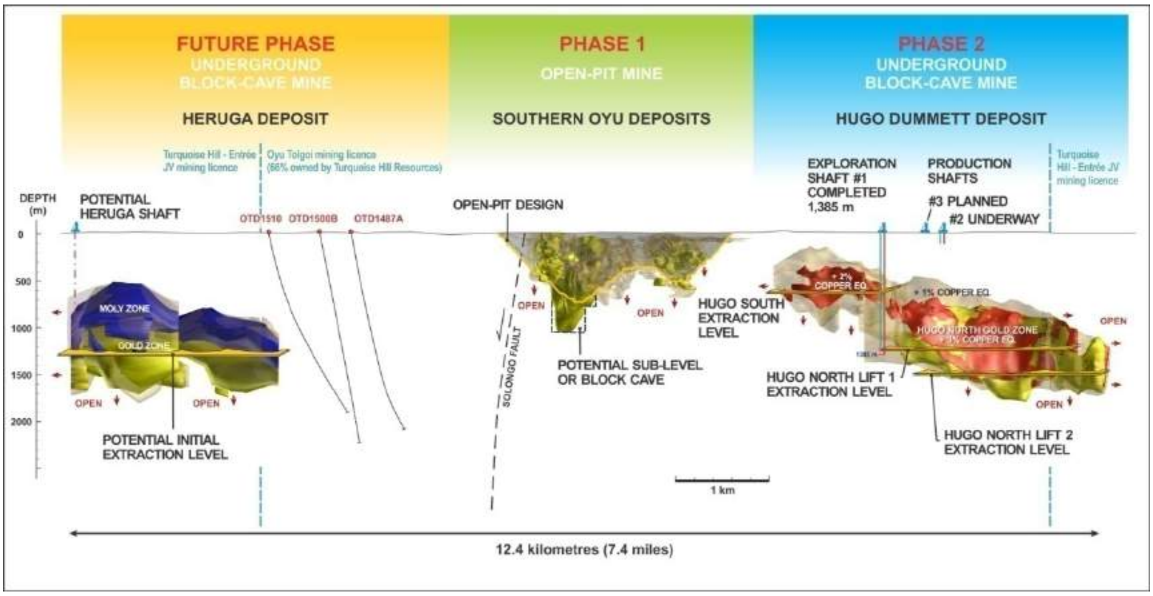
FIGURES

1 SUMMARY

1.1 Summary of Project Development

The Oyu Tolgoi copper and gold project (the Project) is located in the Southern Gobi region of Mongolia and is being developed by Oyu Tolgoi LLC (OT LLC). The Project consists of a series of deposits containing copper, gold, silver and molybdenum. The deposits lie in a structural corridor where mineralization has been discovered that is over 26 km long. The deposits stretch over 12 km, from the Hugo North deposit in the north through the adjacent Hugo South, down to the Southern Oyu deposit and extending to the Heruga deposit in the south as shown in Figure 1.1.

Figure 1.1 Oyu Tolgoi Long Section



The series of deposits contain a currently identified resource of 45.8 billion pounds of contained copper and 24.9 million ounces of contained gold in the Measured and Indicated Mineral Resource categories and 54.6 billion pounds of contained copper and 36.8 million ounces of contained gold in the Inferred category. The Oyu Tolgoi trend is still open to the north and south and the deposits have not been closed off at depth.

OT LLC is 66% owned by Turquoise Hill Resources Ltd (TRQ) and 34% owned by Erdenes-OT LLC. Rio Tinto plc (Rio Tinto) owns 51% of TRQ and Erdenes-OT LLC is owned by the Government of Mongolia. Rio Tinto is also the appointed manager of the Oyu Tolgoi project.

Rio Tinto as the manager of the project uses all its resources to continuously evaluate options for development plans and presents recommendations for investment and operational programs to the OT LLC board of directors as required. Approval of near term investment plans and decisions on the long-term development plans for Oyu Tolgoi are a joint decision by all stakeholders.

Over time, there is expected to be multiple investment decisions made for Oyu Tolgoi and the company is committed to fully evaluating each development option as and when it is required and ensuring that the commitments it makes represent the optimum use of capital to develop Oyu Tolgoi for Mongolia.

The initial investment decision was made in 2010 to construct the Southern Oyu Open Pit mine, a 100 ktpd concentrator and supporting infrastructure. These facilities are currently 99% percent complete and the operation is ramping towards full commercial production in the second half of 2013.

Part of the initial investment decision included an ongoing investment into the development of the Hugo North underground mine. Lift 1 of Hugo North is the most significant value driver for the project and plans for its further development are now at a feasibility stage. The current investment decision for OT LLC is the continued development of the underground mine in parallel with initial open pit operations as outlined in the underground feasibility study.

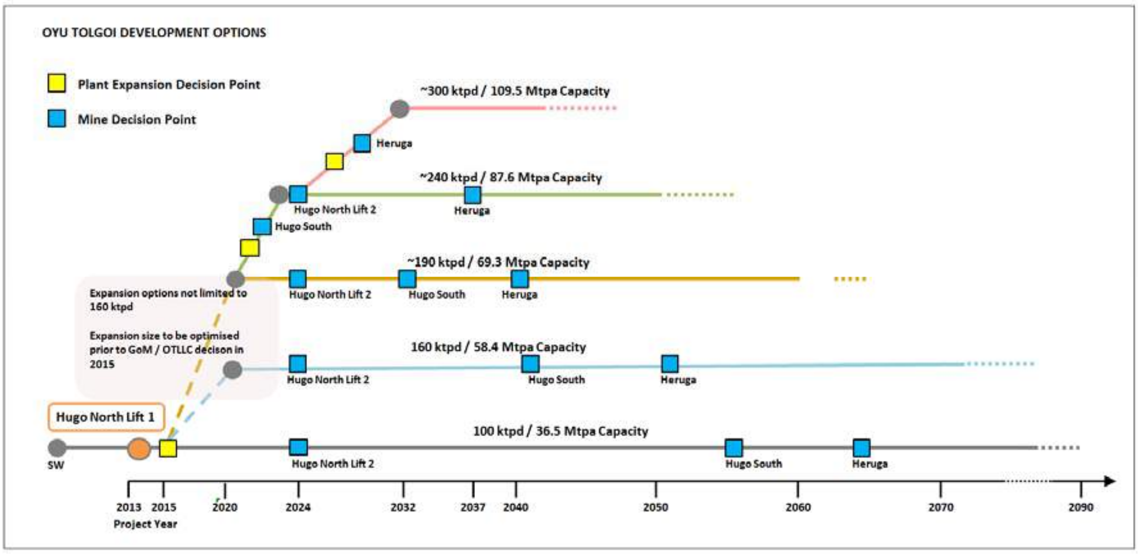
To support the continued underground development program, OT LLC in conjunction with Rio Tinto and TRQ, has been advancing a project financing package with a group of international banks. The project financing base case is the 100 ktpd capacity of the initial concentrator fed by the Southern Oyu Open Pit mine initially which is gradually displaced by the more valuable Hugo North underground ore. OT LLC has preserved the right to expand to 160 ktpd with the GOM and the Mineral Council and so it is not limited to the 2013 OTTR production scenario of 100 ktpd.

At a time when all capital commitments are subject to increasing scrutiny, the company has recognised that committing to focus on operations at 100 ktpd and develop Hugo North Lift 1 provides the best return to stakeholders with installed assets, is the most prudent use of scarce capital resources and preserves all options for future expansion and development of the entire Oyu Tolgoi resource. The project financing package that has been proposed for OT LLC includes the flexibility to expand the operation in the future.

Following the decision to continue to invest in the underground, a further investment decision is expected to be required no earlier than 2015, where a decision will be made to either remain with the 100 ktpd base case or expand the concentrator further to accommodate full production from both the underground and open pit mine. OT LLC intends to use this period through to 2015 to continue studies aimed at evaluating all options available for resource development to ensure that the development plans are optimal for all stakeholders.

Development of the entire resource is the objective of all stakeholders and over the life of Oyu Tolgoi the company will continue to progress their understanding of these resources and ultimately make decisions on development of the entire resource. Figure 1.2 shows an example of the potential decision tree for the potential development options at Oyu Tolgoi.

Figure 1.2 Oyu Tolgoi Development Options



The underground feasibility study has now advanced to a value engineering phase under the guidance of Rio Tinto and will extend to incorporating its strategic production planning and advanced valuation techniques. This next stage is intended to look at all possible development scenarios for the mine and not simply a single expansion scenario as has been the focus of past work. OT LLC will have the benefit of incorporating actual performance of the operating mine into the study before the next investment decision is made. As a result of this pending work and the incorporation of real life performance data the capital and operating costs estimates will likely change.

This report, the 2013 Oyu Tolgoi Technical Report (2013 OTTR), was prepared by Independent Qualified Persons (QPs), acting on behalf of TRQ. The 2013 OTTR is based on a review of the latest technical, production and cost information prepared by OT LLC for project financing and is based on feasibility level study work complying with Canadian National Instrument 43-101 Standards of Disclosure for Mineral Projects (NI 43-101). The 2013 OTTR meets the standards of US SEC Industry Guide 7 requirements for reporting Mineral Reserves. It is expected that the costs estimates will be refined and thus subject to some change in the Feasibility study which OT LLC expect to be complete in 2014.

Mongolia has its own system for reporting reserves and resources. OT LLC has registered a reserve with the GOM. A key difference between the two standards is the classification of material contained in Hugo North Lift 2, Hugo South and Heruga under Mongolian standards as reserves. This contrasts to the Canadian 43-101 definitions which include only Southern Oyu and Hugo North Lift 1 in the Mineral Reserve category.

The project scope for the 2013 OTTR and evaluation of Mineral Reserves matches that of the project financing, a 100 ktpd concentrator fed by the Hugo Dummett underground mine and the Southern Oyu open pit. A summary of the production and financial results for the 2013 Reserve Case are shown in Table 1.1.

Table 1.1 2013 Reserve Case Summary Production and Financial Results

Description	Units	2013 Reserve Case
Inventory		Mineral Reserve
Total Processed	bt	1.5
NSR	$/t	47.17
Cu Grade	%	0.89
Au Grade	g/t	0.34
Ag Grade	g/t	2.03
Copper Recoverable	Billion lb	26.5
Gold Recoverable	Moz	12.9
Silver Recoverable	Moz	83.0
2013 Reserve Case	years	43
10 Year Cash Cost After Credits	$/lb	0.89
20 Year Cash Cost After Credits	$/lb	0.86
Phase 1 Capital (99% complete)	US$B	6.2
Phase 2 Capital	US$B	5.1
NPV (8%) After Tax	US$B	9.9
IRR After Tax	%	42.6
Payback Period	years	7.4

Notes:

1. Metal prices used for calculating the Southern Oyu open pit Net Smelter Return (NSR) and the Hugo North underground Net Smelter Return (NSR) are as follows: copper at $2.81/lb; gold at $970/oz; and silver at $15.50/oz, all based on long-term metal price forecasts at the beginning of the mineral reserve work. The analysis indicates that the Mineral Reserve is still valid at these metal prices.
2. The NSR has been calculated with assumptions for smelter refining and treatment charges, deductions and payment terms, concentrate transport, metallurgical recoveries and royalties.
3. For the open pit processing and general administration, the following operating costs have been used to determine cut-off grades: Southwest at $8.37/t, Central Chalcocite, Central Covellite, and Central Chalcopyrite at $7.25/t.
4. For the underground block cave, all mineral resources within the shell have been converted to mineral reserves. This includes low grade Indicated mineral resources and Inferred mineral resources, which has been assigned a zero grade and treated as dilution.
5. Only Measured mineral resources were used to report Proven mineral reserves and only Indicated mineral resources were used to report Probable mineral reserves.
6. EJV is the Entrée Joint Venture. The Shivee Tolgoi Licence and the Javkhlant Licence are held by Entrée. The Shivee Tolgoi Licence and the Javkhlant Licence are planned to be operated by OT LLC. OT LLC will receive 80% of cash flows after capital and operating costs for material originating below 560m, and 70% above this depth.
7. The base case financial analysis has been prepared using the following current long-term metal price estimates: copper at $2.87/lb; gold at $1,350/oz; and silver at $23.50/oz. Metal prices are assumed to fall from current prices to the long term average over five years.
8. The mineral reserves reported above are not additive to the mineral resources.
9. Capital includes only direct project costs and does not include non-cash shareholder interest, management fees, tax pre-payments, forex adjustments, T Bill purchases or exploration phase expenditure.

1.2 Project Overview

In April 2010, OT LLC approved and commenced a Phase 1 construction program entailing an open pit mine, 100 ktpd concentrator, infrastructure, operational readiness programme, and early stage underground development work for an underground block cave mine. The Phase 1 construction program is almost complete and the operation is in the later stages of commissioning and commencing commercial production. Although initial production from Oyu Tolgoi comes primarily from the Southern Oyu open pit, the high grade Hugo North underground block cave provides a significant increase in value to all stakeholders and is currently progressing towards first production in 2016 and, ultimately, a full production level of 95,000 tonnes per day.

The analysis in the 2013 OTTR has been called the 2013 Reserve Case in order to distinguish it from the cases in previous studies of Oyu Tolgoi. The 2013 Reserve Case is an update of the previous project study Integrated Development Operations Plan (IDOP). IDOP was published in March 2012 and was an update to two previous studies: the Integrated Development Plan 2010 (IDP10) and Integrated Development Plan 2005 (IDP05). IDP05, IDP10, and IDOP were published in Technical Reports.

On 31 March 2010, the comprehensive the Oyu Tolgoi Investment Agreement (IA) took full legal effect after the Government Of Mongolia (GOM) confirmed that the conditions precedent had been satisfied. Under the terms of the IA, the GOM agreed to become a partner in the development of the Project. The GOM has acquired a 34% interest in the TRQ subsidiary, Oyu Tolgoi LLC, which holds the Oyu Tolgoi mining licences. Mongolia's interest will be held through the state-owned, sovereign-wealth resources company Erdenes MGL LLC. TRQ own a 66% indirect interest in OT LLC.

Given the extent of the mineral discoveries associated with the Project and the potential for additional discoveries, TRQ and the GOM agreed that the approved IA should conform with the provision of Minerals Law of Mongolia specifying that certain deposits of strategic importance qualify for 30 years of stabilized tax rates and regulatory provisions, with an option of extending the term of the IA for an additional 20 years. Major taxes and rates stabilized for the life of the agreement include: corporate income tax, customs duty, value-added tax; excise tax; royalties; exploration and mining licences; and immovable property and/or real estate tax. It is important to note that the IA was negotiated on the same principles as projected in the Life-of-Mine (Sensitivity) Case of IDP10. The 2013 Reserve Case is therefore only a part update to the initial phase of the plan.

As part of the GOM's approval process, open pit reserves were registered in 2007 and updated with open pit and underground reserves in 2009 to convert the Shivee Tolgoi and Javkhlant exploration licences to mining licences (Mongolia has its own code for registering reserves that is a part of the GOM approval process).

The series of deposits contain a currently identified resource of 45.8 billion pounds of contained copper and 24.9 million ounces of contained gold in the Measured and Indicated Mineral Resource categories and 54.6 billion pounds of contained copper and 36.8 million ounces of contained gold in the Inferred category.

The reasonable prospects analysis has identified a reduction in cut-off grade which is the predominant factor for the change in resource relative to reporting in previous years. The Oyu Tolgoi trend is still open to the north and south and the deposits have not been closed off at depth.

The 2013 OTTR uses updated 2012 Mineral Resources for the Southern Oyu Tolgoi deposit and the Hugo North Mineral Resources as first reported in 2007. The 2013 OTTR includes Mineral Resources from the Oyu Tolgoi deposit (wholly owned by OT LLC) and Entrée Joint Venture (EJV) licence areas. Although the overall strategy for the development of Oyu Tolgoi remains the same in the 2013 OTTR as it did in IDOP, IDP10 and IDP05, there have been changes to several key areas which are addressed in this project update.

Major updates to the project status since the IDOP TR was completed and plans for Q1'13 include:

- Construction of the Oyu Tolgoi mine's first phase of development reached 99% completion at the end of 2012. Total capital invested in the construction of the first phase of the Oyu Tolgoi mine to the end of 2012 was approximately $6 billion. The final cost for the phase-one capital project is expected to be approximately $6.2 billion, within 3% of the initial budget, excluding foreign-exchange exposures.
- The mining and stockpiling of the first open-pit ore began in May 2012 and approximately 9 Mt of ore was stockpiled at the end of 2012. The primary crusher, overland conveyor and coarse-ore stockpile circuits were commissioned in Q3'12 and 435,000 tonnes of ore had been sent through to the coarse ore storage facility at the end of 2012.
- Following the signing of the binding Power Purchase Agreement with the Inner Mongolian Power Corporation in early November 2012, electrical transmission lines for power to the Oyu Tolgoi mine were energized and operational.
- Construction of the concentrator was completed in Q4'12 and a commissioning ceremony was held on 27 December 2012. First ore was fed into the semi-autogenous grinding (SAG) mill on 2 January 2013.
- First concentrate was produced on 31 January 2013. Commencement of commercial production is expected by the end of Q2'13 subject to the resolution of the issues being discussed with the Government of Mongolia.
- Underground lateral development at the Hugo North Deposit was suspended in February 2012 as planned to enable the upgrading of hoisting equipment at Shaft 1 and was restarted during Q3'12 following the completion of the upgrade. 1,500 metres of lateral development were achieved from mid-September 2012 to the end of December 2012 after the completion of the shaft changeover.
- Construction of Shaft 2 at the Hugo North Deposit is progressing well with the headframe reaching its final height of 96 m in Q2'12. The headframe and ancillary buildings were 99% complete at the end of Q4'12. Shaft-sinking activities began in December 2011, and the depth of the shaft is now approximately 980 m below surface, 74% of its final 1,319 m depth.

- The construction of Shaft 5 began in October 2012. Pre-sinking works have been completed and sinking activity is planned to commence in April 2013. Shaft 5 will provide primary ventilation for underground operations and is expected to have a final depth of 1,195 metres.
- Construction of off-site facilities and infrastructure were behind schedule at the end of Q4'12 due to slower progress in the building of the Oyu Tolgoi-Gashuun Sukhait road to the Mongolia-China border, the diversion of the Undai River and development of the Khanbumbat permanent airport. Road development was impacted by local permitting issues related to modifications associated with Oyu Tongio's environmental commitments. Road work has been suspended for the winter although there should be no impact upon the transporting concentrate to the border. Work on the river diversion commenced in December 2012; however progress was also impacted by local permitting issues. The permanent airport work was completed in January 2013 and began operating in February 2013.
- Long-term sales contracts have been signed for 75% of the Oyu Tolgoi mine's concentrate production in the first three years, while 50% of concentrate production is contracted for ten years (subject to renewals). In addition to the signed contracts, in principle commitments have been made at international terms for up to 25% of the concentrate available for export. These commitments range from three to ten years and are subject to the conclusion of detailed sales contracts.
- Completion of plant commissioning and commencement of commercial production.
- The Environmental and Social Impact Assessment (ESIA) undertaken as part of the project finance process was publically disclosed in August 2012.
- TRQ and Rio Tinto has been actively engaged with lenders to refine the overall financing plan and term sheet with the aim of raising $3 billion to $4 billion . Bids have been received from a number of banks that would allow the Company to achieve its project financing target and discussions are ongoing with the lenders to finalize the terms of those offers. The project financing is subject to the unanimous approval of the Oyu Tolgoi LLC Board of Directors which includes representatives from the Government of Mongolia. TRQ anticipates the closing of final binding documentation and project financing funding to occur in the first half of 2013.

Having taken into account the project status, the key changes in 2013 OTTR compared to the IDOP TR are:

- Reserve based on the already constructed 100 ktpd concentrator with a part expansion of the concentrator to allow for the higher grade feed from Hugo North.
- Signing of a binding Power Purchase Agreement with the Inner Mongolia Power Corporation to supply power to the Oyu Tolgoi mine.
- Construction of a power station no longer included in project scope with costs adjusted to reflect a third party power provider throughout the life of the mine.
- Updated open pit designs on Southern Oyu Tolgoi and commencement of open pit mining including delivery of first ore to the plant.
- Updated underground designs on Hugo North and continued underground development.

- Upgrading of the Shaft 1 hoisting equipment and revision of the production schedule to account for changed timing of the underground production.
- Revisions to capital estimates and updates for costs expended to date.

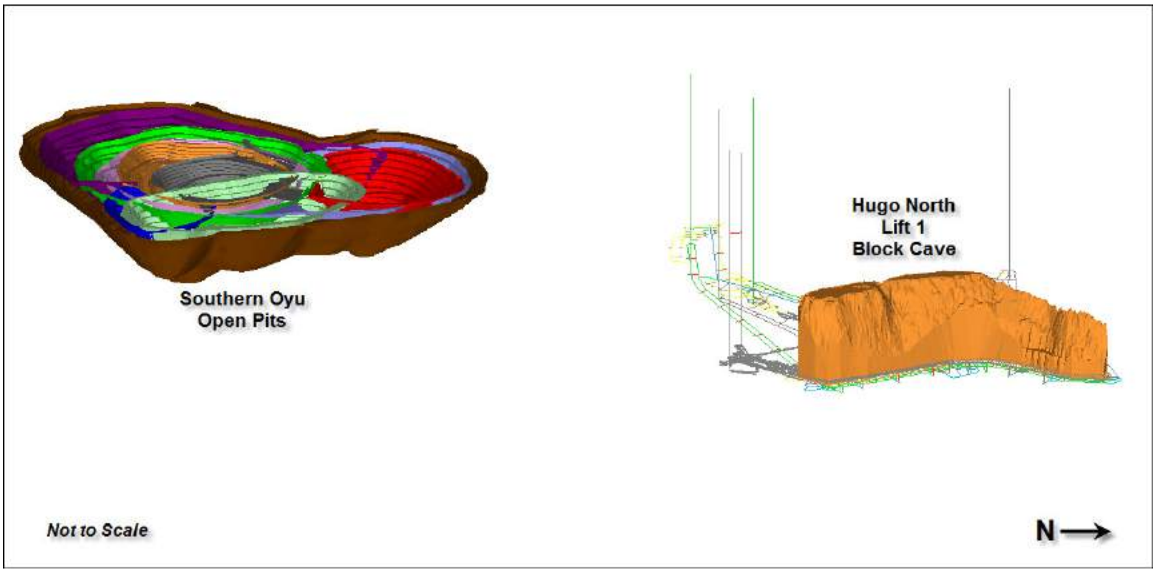
Oyu Tolgoi has a large mineral resource providing management with flexibility in studying alternative paths for mine development to match future economic conditions. Ongoing planning work using Inferred resources has identified the potential for further expansions.

Five deposits have been identified in the mineral resource at Oyu Tolgoi; they are Southwest, Central, Hugo South, Hugo North, and Heruga. Southwest and Central comprise the Southern Oyu Tolgoi deposit, and Hugo South and Hugo North comprise the Hugo Dummett deposit. Heruga is a separate deposit south of the Southern Oyu deposit. The mine planning work to date suggests the following relative ranking for overall return from each deposit, from highest value to lowest:

- Hugo North
- Southwest
- Central
- Hugo South
- Heruga

The 2013 Reserve Case assumes processing of 1.5 bt of ore, mined from the Southern Oyu open pit and the first lift in the Hugo North underground block cave. The mining areas included in the 2013 Reserve Case are shown schematically in Figure 1.3.

Figure 1.3 Mining Areas



The predominant source of ore at start up is the Southern Oyu Open Pit. In parallel to this surface works, underground infrastructure, and mine development is ongoing for the Hugo North underground block cave deposit. Stockpiling allows the higher grade ore from Hugo North to gradually displace the open pit ore as the underground production ramps up to reach 95 ktpd.

The ore is planned to be processed through conventional crushing, grinding, and flotation circuits. The concentrate produced will be trucked to smelters in China.

Oyu Tolgoi is a remote greenfields project and extensive infrastructure has been constructed in addition to the concentrating facilities. The major initial infrastructure elements include:

- Water Borefields
- Water Treatment
- Housing
- Airstrip
- Supporting Facilities
- Power

In order to provide an analysis of the 2013 OTTR, costs to December 2012 were treated as sunk was applied to the operating and capital costs to prepare a schedule of expected cash flow. Metal prices used for the analysis were assumed to trend from current prices down to the long-term price forecasts over five years. A summary of the production and financial results for the 2013 Reserve Case are shown in Table 1.2 Throughout this Report, measurements are in metric units and currency in United States dollars unless otherwise stated.

Table 1.2 2013 Reserve Case Summary Production and Financial Results

Description	Units	2013 Reserve Case
Inventory		**Mineral Reserve**
Total Processed	bt	1.5
Net Smelter Return	$/t	47.17
Cu Grade	%	0.89
Au Grade	g/t	0.34
Ag Grade	g/t	2.03
Copper Recoverable	Billion lb	26.5
Gold Recoverable	Moz	12.9
Silver Recoverable	Moz	83.0
2013 Reserve Case	years	43
10 Year Cash Cost After Credits	$/lb	0.89
20 Year Cash Cost After Credits	$/lb	0.86
Phase 1 Capital (99% complete)	US$B	6.2
Phase 2 Capital	US$B	5.1
NPV (8%) After Tax	US$B	9.9
IRR After Tax	%	42.6
Payback Period	years	7.40

Notes:

1. Metal prices used for calculating the Southern Oyu open pit Net Smelter Return (NSR) and the Hugo North underground NSR are as follows: copper at $2.81/lb; gold at $970/oz; and silver at $15.50/oz, all based on long-term metal price forecasts at the beginning of the mineral reserve work. The analysis indicates that the Mineral Reserve is still valid at these metal prices.
2. The NSR has been calculated with assumptions for smelter refining and treatment charges, deductions and payment terms, concentrate transport, metallurgical recoveries and royalties.
3. For the open pit processing and general administration, the following operating costs have been used to determine cut-off grades: Southwest at $8.37/t, Central Chalcocite, Central Covellite, and Central Chalcopyrite at $7.25/t.
4. For the underground block cave, all mineral resources within the shell have been converted to mineral reserves. This includes low grade Indicated mineral resources and Inferred mineral resources, which has been assigned a zero grade and treated as dilution.
5. Only Measured mineral resources were used to report Proven mineral reserves and only Indicated mineral resources were used to report Probable mineral reserves.
6. EJV is the Entrée Joint Venture. The Shivee Tolgoi Licence and the Javkhlant Licence are held by Entrée. The Shivee Tolgoi Licence and the Javkhlant Licence are planned to be operated by OT LLC. OT LLC will receive 80% of cash flows after capital and operating costs for material originating below 560m, and 70% above this depth.
7. The base case financial analysis has been prepared using the following current long term metal price estimates: copper at $2.87/lb; gold at $1,350/oz; and silver at $23.50/oz. Metal prices are assumed to fall from current prices to the long term average over five years.
8. The mineral reserves reported above are not additive to the mineral resources.
9. Capital includes only direct project costs and does not include non-cash shareholder interest, management fees, tax pre-payments, forex adjustments, T Bill purchases or exploration phase expenditure.

Figure 1.4 shows the annual and cumulative cash flow for project. Concentrate and copper and gold metal production is shown in Figure 1.5. The annual production tonnages processed at the major pit stages and the block cave lifts (split between mining method) are shown in Figure 1.6.

Figure 1.4 Cumulative After Tax Cash Flow – 2013 Reserve Case

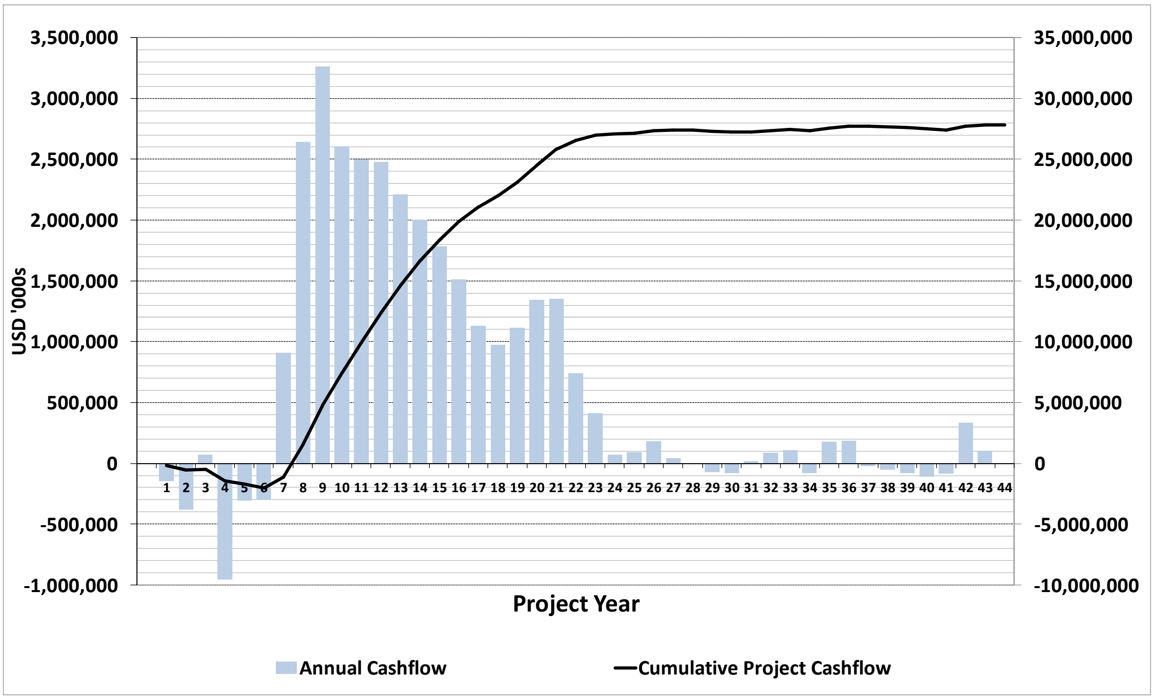


Figure 1.5 Concentrate and Metal Production – 2013 Reserve Case

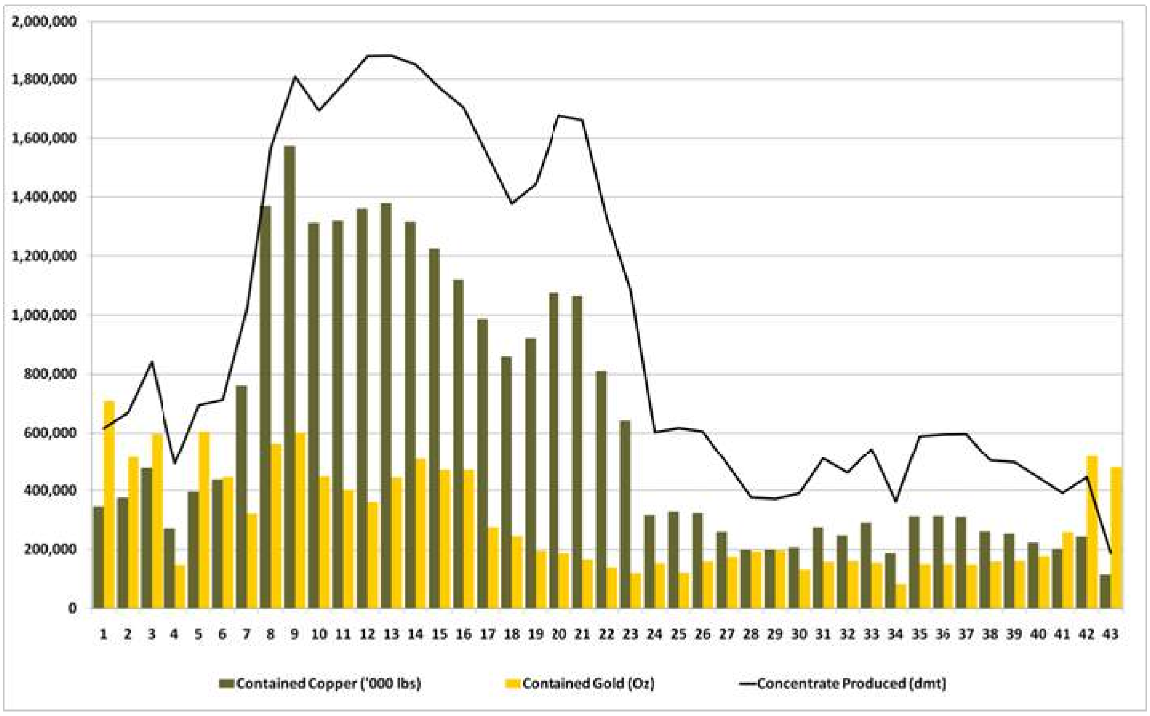
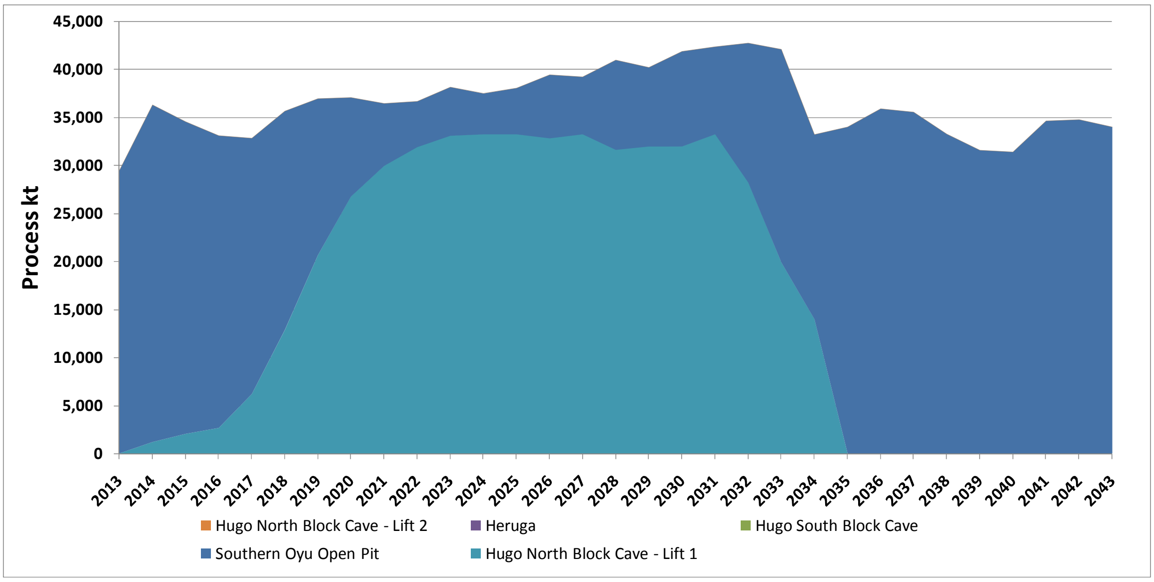


Figure 1.6 Processing by Source – 2013 Reserve Case



1.3 Qualified Persons

The following Qualified Persons (QPs) were responsible for the preparation of the 2013 Technical Report:

- Bernard Peters, BEng (Mining), FAusIMM (201743), employed by AMC Consultants Pty Ltd (AMC) as Mining Manager/Principal Mining Engineer, was responsible for the overall preparation of the report and the Mineral Reserve estimates.
- Sharron Sylvester, BSc (Geol), RPGeo AIG (10125), employed by AMC as General Manager, Principal Geologist, was responsible for the preparation of the Mineral Resources.
- Malcolm Bridges, BSc (Hons), FAusIMM (102216), employed by AMC as Principal Geomechanics Consultant, was responsible for the preparation of the Geotechnical Sections.
- Alan Riles, B.Metallurgy (Hons Class I), AIG (4820), employed by AMC as Associate Principal Metallurgical Consultant, was responsible for the preparation of the Processing Sections.

1.4 Project Location and Ownership

The majority of the identified mineralization on the Project occurs within the Oyu Tolgoi Property at the Hugo Dummett and Southern Oyu porphyry deposits. TRQ operates the Project through OT LLC. OT LLC, in turn, holds its rights to the Project through mining licence 6709A (the “OT Licence”), comprising approximately 8,496 ha of property. The GOM granted the OT Licence to IMMI (now OT LLC) in 2003 along with mining licences for three properties identified as mining licences 6708A, 6710A and 6711A. Subsequently, licence 6711A has been relinquished.

The OT Licence includes the right to explore, develop mining infrastructure and facilities and conduct mining operations on the Project. In 2006, the Mongolian parliament passed new mining legislation and changed the term of mining licences to a 30-year term with two 20-year extensions. Figure 1.7 shows the location of Oyu Tolgoi regionally and along the Mongolian Chinese border.

Figure 1.8 shows the deposits and licence boundaries.

Figure 1.7 Project Location

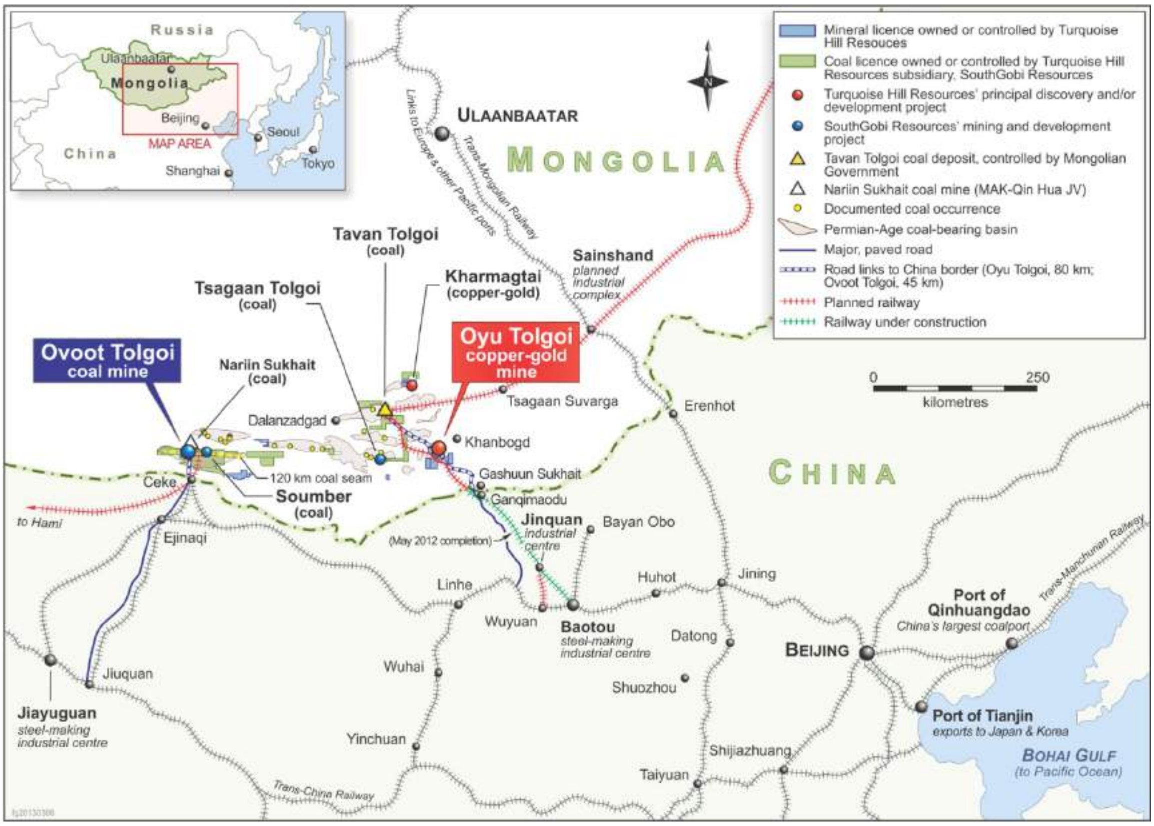
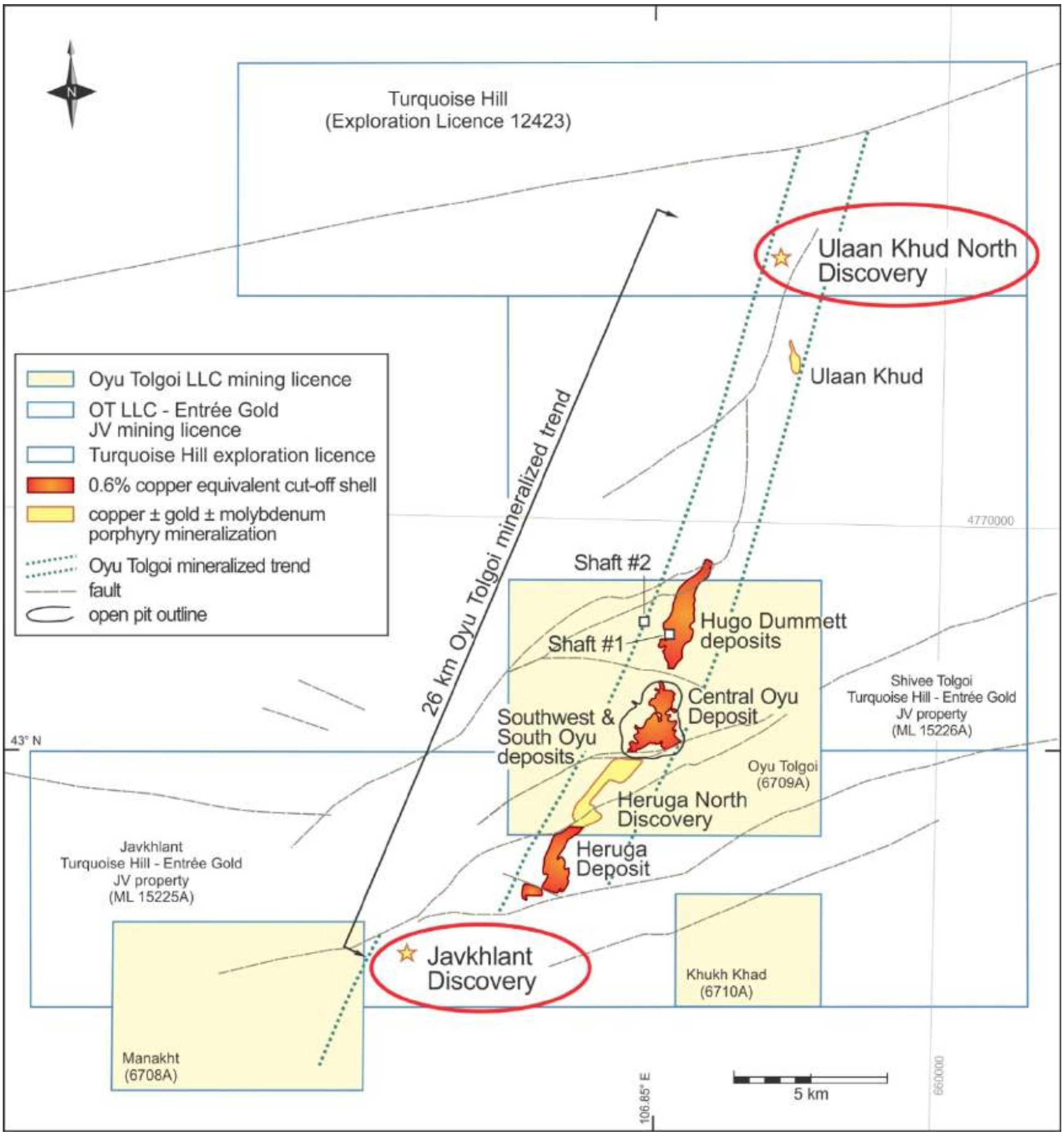


Figure 1.8 Oyu Tolgoi and Surrounding Licences



The OT Licence property was surveyed by an independent consultant in 2002 and by a qualified Mongolian Land Surveyor in 2004 to establish the legal boundaries of the OT Licence concession.

On 8 June 2011, the Government of Mongolia passed Resolution 175, the purpose of which is to authorize the designation of certain land areas for "state special needs" within certain defined areas in proximity to the Oyu Tolgoi Project. These state special needs areas are to be used for infrastructure facilities necessary in order to implement the development and construction of major mineral projects, including the Oyu Tolgoi Project.

Most of the land areas designated for special needs are already subject to existing mineral exploration and mining licences issued by the Government of Mongolia to third parties and, in certain cases, a mineral resource has been declared and registered with the applicable governmental authorities in respect of such licenses. OT LLC has entered into certain consensual arrangements with some of the affected third parties; however, such arrangements have not been completed with all affected third parties. If OT LLC cannot enter into consensual arrangements with an affected third party and such third party's rights to use and access the subject land area are adversely affected by application of Resolution 175, the Government of Mongolia will be responsible for compensating such third parties in accordance with the mandate of Resolution 175. It is not clear at this time, whether the Government of Mongolia will expect some of the compensation necessary to be paid to such third parties to be borne by OT LLC or if it will assume that obligation alone. It is also expected, but not yet formally confirmed by the Government of Mongolia, that any consensual arrangements effected with affected third parties by OT LLC will make the application of Resolution 175 unnecessary. To the extent that consensual arrangements are not entered into with affected third parties and the Government of Mongolia seeks contribution or reimbursement from OT LLC for compensation it provides such third parties, the amount of such contribution or reimbursement is not presently quantifiable and may be significant. The description of Resolution 175 has been provided by TRQ and has been relied on under Item 3 of NI 43-101 Reliance on Other Experts.

1.5 Mineral Resource

The total Mineral Resources for the Project are shown in Table 1.3. Table 1.3 also includes mineralization on the Shivee Tolgoi and Javkhlant Joint Venture Properties, which are shown separately. A profile of the Oyu Tolgoi deposits is shown in Figure 1.9.

Mongolia has its own system for reporting reserves and resources. OT LLC has registered a reserve with the GOM. A key difference between the two standards is the classification of material contained in Hugo North Lift 2, Hugo South and Heruga under Mongolian standards as reserves. This contrasts to the Canadian 43-101 definitions which include only Southern Oyu and Hugo North Lift 1 in the Mineral Reserve category.

The base case copper equivalent (CuEq) cut-off grade assumptions for each deposit were determined using cut-off grades applicable to mining operations exploiting similar deposits. The CuEq cut-off applied for the underground was 0.37% CuEq and the CuEq cut-off applied to the open pit was 0.22% CuEq.

Hugo Deposits and Southern Oyu

Based on a Cu price of $0.80/lb and Au price of $350/oz, the 2003 CuEq formula is:

$$\textbf{CUEQ\% = Cu\% + (Au g/t) * (11.25 / 17.64)}$$

Where:

17.64 = (Cu $/lb) / (lb/t) = 0.80 / 2,204.62

11.25 = (Au $/oz) / (g / oz) = 350 / 31.10348

Not adjusted for metallurgical recovery

2010 CuEq Formula – Heruga

The decision was taken to use a copper price of $1.35 / lb and a gold price of $650 / oz, and to incorporate molybdenum into the CuEq calculation at a price of $10 / lb.

The resultant 2010 formula was:

CUEQ% = Cu% + ((Au g/t * 18.98) + (Mo g/t * 0.01586)) / 29.76

Where:

18.98 = (Au $ / g) * Au Recovery Factor% = 20.90 * 90.822% (rounded to 91%)

0.01586 = (Mo $ / g) * Mo Recovery Factor% = 0.0220462 * 71.94% (rounded to 72%)

29.76 = Cu $ / %

Molybdenum is used only in the CuEq formula at the Heruga deposit. Silver is not used in the CuEq formula for any of the deposits. The contained gold and copper estimates in Table 1.3 have not been adjusted for metallurgical recoveries.

Figure 1.9 Idealized Profile of Southern Oyu, Hugo Dummett, and Heruga Deposits (Section Looking West)

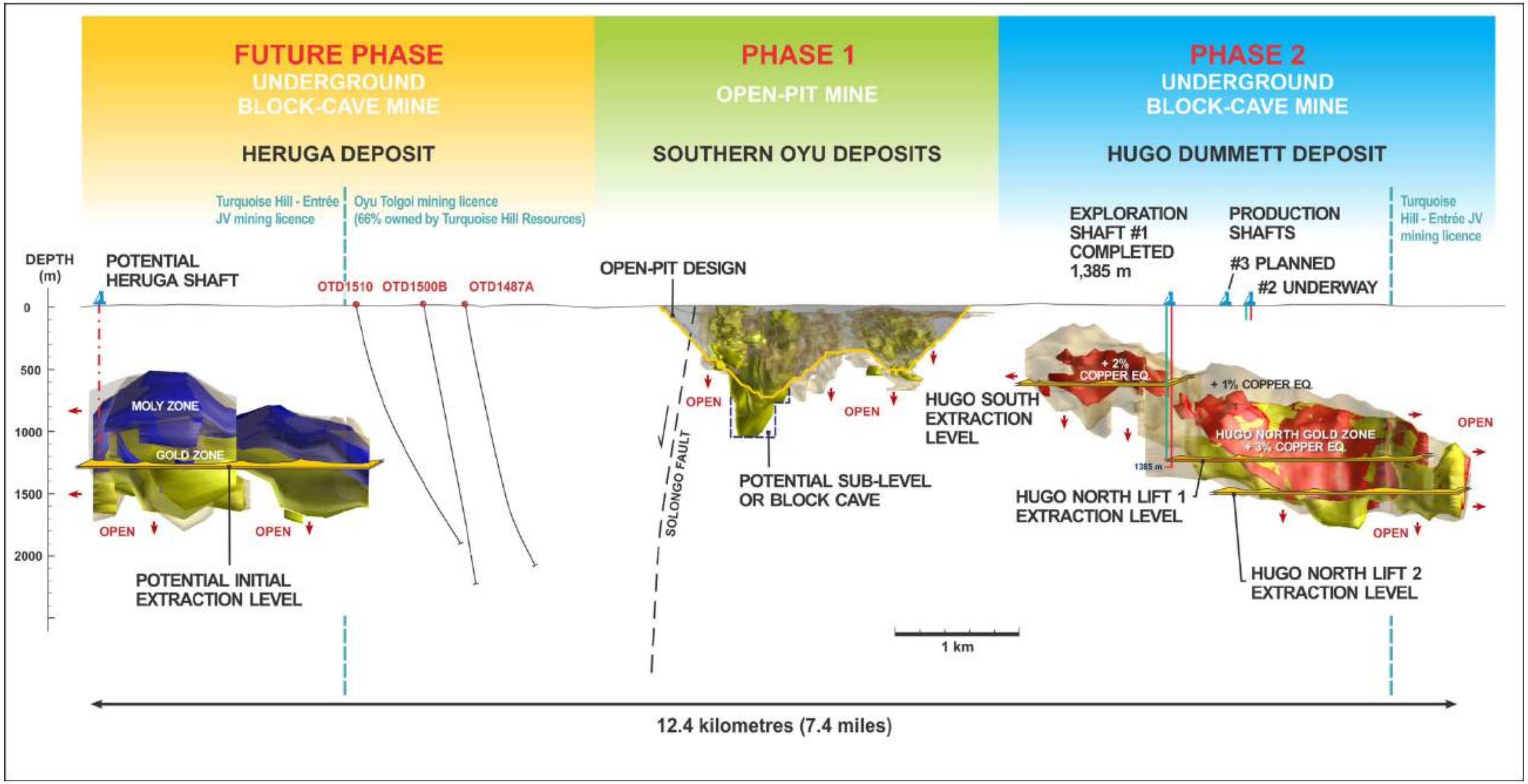


Table 1.3 Oyu Tolgoi Mineral Resource Summary, 19 March 2013

Classification	Deposit	Tonnage (Mt)	Cu (%)	Au (g/t)	Ag (g/t)	Mo (ppm)	CuEq (%)	Contained Metal				
								Cu (Mlb)	Au (Moz)	Ag (Moz)	Mo (Mlb)	CuEq (Mlb)
Southern Oyu Deposits – Open Pit (0.22% CuEq Cut-Off)												
Measured		445	0.52	0.41	0.96	50.8	0.79	5,137	5.84	13.77	49.8	7,693
Indicated		652	0.39	0.23	0.90	54.2	0.54	5,647	4.80	18.85	77.8	7,747
Measured + Indicated		1,096	0.45	0.30	0.93	52.8	0.64	10,783	10.65	32.62	127.6	15,440
Inferred		218	0.27	0.15	0.77	46.7	0.37	1,293	1.08	5.38	22.5	1,765
Southern Oyu Deposits – Underground (0.37% CuEq Cut-Off)												
Measured		21.8	0.41	0.64	0.98	47.3	0.82	198	0.45	0.69	2.27	395
Indicated		150	0.36	0.50	0.92	40.2	0.68	1,194	2.40	4.45	13.3	2,244
Measured + Indicated		172	0.37	0.52	0.93	41.1	0.70	1,393	2.85	5.14	15.6	2,639
Inferred		237	0.38	0.29	0.87	38.5	0.57	1.988	2.24	6.62	20.1	2,968
Hugo Dummett Deposits (0.37% CuEq Cut-Off)												
Indicated	OT LLC	775	1.69	0.36	3.71	42.5	1.92	28,890	8.98	92.4	72.6	32,820
	EJV	132	1.65	0.55	4.09	35.7	2.00	4,800	2.32	17.4	10.4	5,810
	All Hugo North	907	1.69	0.39	3.77	41.5	1.93	33,690	11.3	110	83.0	38,630
Inferred	OT LLC	1,015	0.81	0.25	2.34	41.9	0.97	18,080	8.28	76.4	93.8	21,700
	EJV	135	0.93	0.25	2.44	23.6	1.09	2,760	1.08	10.5	7.0	3,230
	All Hugo North	1,150	0.82	0.25	2.35	39.8	0.98	20,840	9.36	87.0	101	24,930
Inferred	Hugo South	820	0.78	0.04	1.79	66.8	0.82	14,100	1.82	47.1	121	14,890
Inferred	North & South	1,969	0.80	0.18	2.12	51.0	0.92	34,930	11.2	134	221	39,820
Heruga Deposit (0.37% CuEq Cut-Off)												
Inferred Heruga Javkhlant EJV		1,824	0.38	0.36	1.35	110	0.67	15,190	21.3	79.4	444	26,850
Inferred Heruga TRQ		120	0.40	0.29	1.54	108	0.64	1,060	1.12	6.0	29	1,700
Inferred (All Heruga)		1,944	0.38	0.36	1.37	110	0.67	16,250	22.4	85.3	473	28,550

Classification	Deposit	Tonnage (Mt)	Cu (%)	Au (g/t)	Ag (g/t)	Mo (ppm)	CuEq (%)	Contained Metal				
								Cu (Mlb)	Au (Moz)	Ag (Moz)	Mo (Mlb)	CuEq (Mlb)
Oyu Tolgoi Project Grand Total												
Measured		467	0.51	0.42	0.96	50.64	0.79	5,300	6.3	14.4	52	8,140
Indicated		1,709	1.07	0.34	2.42	46.24	1.29	40,470	18.5	133	174	48,640
Measured + Indicated		2,176	0.95	0.36	2.11	47.18	1.18	45,772	24.85	147.52	226.3	56,780
Inferred		4,369	0.57	0.25	1.65	76.31	0.76	54,616	35.79	231.28	735.0	73,165

Notes:

- The contained gold and copper estimates in the tables have not been adjusted for metallurgical recoveries.
- The 0.37% CuEq cut-off is equivalent to the underground Mineral Reserve cut-off determined by OT LLC
- The Mineral Resources include Mineral Reserves.
- CuEq has been calculated using assumed metal prices ($1.35/lb for copper and $650/oz for gold and $10/lb for molybdenum);
- CuEq% = Cu% + ((Au g/t*18.98)+(Mo g/t*.01586))/29.76.
- Mo grades outside of Heruga are assumed to be zero for CuEq calculations.
- The CuEq formula also includes different levels of metallurgical recovery for the metals. Gold was assumed to have 91% of copper recovery, molybdenum 72% of copper recovery.
- Mineral Resources that are not Mineral Reserves do not have demonstrated economic viability.
- EJV is the Entrée Gold Joint Venture. The Shivee Tolgoi and Javkhlant licences are held by Entrée Gold. The Shivee Tolgoi and EJV Javkhlant Licences are planned to be operated by OT LLC. OT LLC will receive 80% of cash flows after capital and operating costs for material originating below 560 m, and 70% above this depth.

1.6 Mineral Reserves

The Mineral Reserves for the Project have been estimated using the Southern Oyu and Hugo North Mineral Resources. The Hugo North Mineral Reserve contains ore that is on the OT LLC Oyu Tolgoi licence and on the EJV Shivee Tolgoi licence. The EJV Shivee Tolgoi licence is subject to a joint venture agreement between OT LLC and Entrée Gold.

Total Mineral Reserves for the Project and the OT LLC and EJV Mineral Reserves for the open pit and underground components of the Project are shown in Table 1.4. The Mineral Reserves for 2013 OTTR are based on mine planning work prepared by OT LLC. This work was reviewed extensively by AMC and has been used as the basis for reporting the 2013 OTTR Mineral Reserves.

The mine design work on the Southern Oyu open pits was prepared by OT LLC and was used as the basis for the March 2013 Southern Oyu Open Pit Mineral Reserve. The mine design work on Hugo North Lift 1 was prepared by OT LLC and was used as the basis for the 2013 Hugo North Underground Mineral Reserve. This work was reviewed by OT LLC and accepted as the basis for the underground mine planning in 2013 OTTR. AMC has agreed with this conclusion and has used the results.

Mineral Reserves were last reported in the IDOP Technical Report March 2012. A comparison of the IDOP and 2013 OTTR Mineral Reserves is shown in Table 1.5. Although the total tonnes of the Mineral Reserve sets are very similar, there is a 10.3% increase in ore tonnes, a 4.4% increase in recovered copper, a 4.3% increase in recovered gold and a 0.4% increase in recovered silver compared to the IDOP Mineral Reserves from 2012. Almost all of the difference is in the Southern Oyu open pit designs which have been expanded relative to the IDOP pit designs. This reflects the increase in the detail of the work being undertaken by OT LLC.

Mongolia has its own system for reporting reserves and resources. OT LLC has registered a reserve with the GOM. A key difference between the two standards is the classification of material contained in Hugo North Lift 2, Hugo South and Heruga under Mongolian standards as reserves. This contrasts to the Canadian 43-101 definitions which include only Southern Oyu and Hugo North Lift 1 in the Mineral Reserve category.

1.6.1 Southern Oyu Open Pit Mineral Reserve

In order to estimate the Mineral Reserves, AMC relied on the study work prepared by OT LLC. Pit designs were prepared using industry standard mining software, assumed metal prices as described above, and smelter terms as set forth in the 2013 OTTR. The estimate was prepared on a simplified project analysis on a pre-tax basis. Key variables noted by AMC include: marketing matters, water supply and management, underground ventilation development and power supply. The report only considers Mineral Resources in the Measured and Indicated categories, and engineering that has been carried out to a feasibility level or better to estimate the open pit Mineral Reserve.

1.6.2 Hugo North Underground Mineral Reserve

Mine planning work by OT LLC has continued since the previous Mineral Reserve estimate in 2012. The underground Mineral Reserve has increased by 53 Mt.

The Hugo Dummett underground deposit will be mined by block caving; a safe, highly productive, cost-effective method. The deposit is comparable in dimension and tonnage to other deposits currently operating by block cave mining elsewhere in the world. The mine planning work has been prepared using industry standard mining software, assumed metal prices as described above and smelter terms as set forth in the 2013 OTTR. The Hugo North Mineral Reserve only considers Mineral Resources in the Indicated category because there are no Measured Resources in Hugo North. The engineering has been carried out to a pre-feasibility level or better to estimate the underground Mineral Reserve. To ensure that Inferred Resources do not become included in the reserve estimate, copper and gold grades on Inferred Resources within the block cave shell were set to zero and such material was assumed to be dilution. The block cave shell was defined by a $15/t NSR. Further mine planning will examine lower shut-offs. The Hugo North Mineral Reserve is on both the OT LLC Oyu Tolgoi licence and the EJV Shivee Tolgoi licence.

Table 1.4 Oyu Tolgoi Project Mineral Reserve, 25 March 2013

Estimate	Ore (Mt)	NSR ($/t)	Cu (%)	Au (g/t)	Ag (g/t)	Recovered Metal		
						Copper (Mlb)	Gold (koz)	Silver (koz)
Southern Oyu Deposits								
Proven	433	31.09	0.53	0.42	1.37	4,175	4,388	14,860
Probable	616	21.46	0.40	0.24	1.13	4,462	3,378	17,264
Mineral Reserve (Proven + Probable)	1,048	25.44	0.46	0.31	1.23	8,637	7,766	32,124
Hugo Dummett Deposits								
Probable (Hugo North – OT LLC)	460	93.45	1.80	0.37	3.74	16,759	4,602	47,647
Probable (Hugo North – EJV Shivee Tolgoi)	31	95.21	1.73	0.62	3.74	1,090	521	3,229
Mineral Reserve (Probable) (All Hugo North)	491	93.57	1.80	0.39	3.74	17,849	5,123	50,877
Oyu Tolgoi Project Mineral Reserve								
Proven	433	31.09	0.53	0.42	1.37	4,175	4,388	14,860
Probable	1,107	53.46	1.02	0.30	2.29	22,311	8,501	68,141
Mineral Reserve (Proven + Probable)	1,539	47.17	0.89	0.34	2.03	26,486	12,889	83,001

Notes:

1. Metal prices used for calculating the Southern Oyu open pit NSR and the Hugo North underground Net Smelter Return (NSR) are as follows: copper at $2.81/lb; gold at $970/oz; and silver at $15.50/oz, all based on long-term metal price forecasts at the beginning of the mineral reserve work. The analysis indicates that the mineral reserve is still valid at these metal prices.
2. The NSR has been calculated with assumptions for smelter refining and treatment charges, deductions and payment terms, concentrate transport, metallurgical recoveries and royalties.
3. For the open pit processing and general administration, the following operating costs have been used to determine cut-off grades: Southwest at $8.37/t, Central Chalcocite, Central Covellite, and Central Chalcopyrite at $7.25/t.
4. For the underground block cave, all mineral resources within the shell have been converted to mineral reserves. This includes low grade Indicated mineral resources and Inferred mineral resources, which has been assigned a zero grade and treated as dilution.
5. Only Measured mineral resources were used to report Proven mineral reserves and only Indicated mineral resources were used to report Probable mineral reserves.
6. EJV is the Entrée Joint Venture. The Shivee Tolgoi Licence and the Javkhlant Licence are held by Entrée. The Shivee Tolgoi Licence and the Javkhlant Licence are planned to be operated by OT LLC. OT LLC will receive 80% of cash flows after capital and operating costs for material originating below 560m, and 70% above this depth.
7. The base case financial analysis has been prepared using the following current long term metal price estimates: copper at $2.87/lb; gold at $1,350/oz; and silver at $23.50/oz. Metal prices are assumed to fall from current prices to the long term average over five years.
8. The mineral reserves reported above are not additive to the mineral resources.

Table 1.5 Mineral Reserve Reconciliation 2013 OTTR and IDOP TR

Estimate	Mineral Reserve	Ore (Mt)	NSR ($/t)	Cu (%)	Au (g/t)	Ag (g/t)	Recovered Metal		
							Copper (M lb)	Gold (koz)	Silver (koz)
2013 OTTR	Proven	433	31.09	0.53	0.42	1.37	4,175	4,388	14,860
	Probable	1,107	53.46	1.02	0.30	2.29	22,311	8,501	68,141
	Mineral Reserve	1,539	47.17	0.89	0.34	2.03	26,486	12,889	83,001
IDOP	Proven	125	36.42	0.58	0.91	1.49	1,374	2,892	10,018
	Probable	1,270	37.46	0.98	0.30	2.16	23,995	9,465	72,635
	Mineral Reserve	1,395	37.37	0.94	0.35	2.10	25,369	12,357	82,654
Difference	Proven	308	–5.32	–0.05	–0.49	–0.12	2,801	1,496	4,842
	Probable	–164	15.99	0.04	0.01	0.13	–1,685	–964	–4,494
	Mineral Reserve	144	9.80	–0.06	–0.01	–0.07	1,117	532	348
% Difference	Proven	246.9%	–14.6%	–8.3%	–54.2%	–8.2%	204.0%	51.7%	48.3%
	Probable	–12.9%	42.7%	4.5%	2.9%	6.0%	–7.0%	–10.2%	–6.2%
	Mineral Reserve	10.3%	26.2%	–6.1%	–4.2%	–3.2%	4.4%	4.3%	0.4%

Notes:

1. IDOP Mineral Reserves have the effective date 29 March 2012.
2. 2013 Oyu Tolgoi Technical Report Mineral Reserves have the effective date 25 March 2013..
3. Metal prices used for calculating the Southern Oyu open pit NSR and the Hugo North underground Net Smelter Return (NSR) are as follows: copper at $2.81/lb; gold at $970/oz; and silver at $15.50/oz, all based on long-term metal price forecasts at the beginning of the mineral reserve work. The analysis indicates that the mineral reserve is still valid at these metal prices.
4. The NSR has been calculated with assumptions for smelter refining and treatment charges, deductions and payment terms, concentrate transport, metallurgical recoveries and royalties.
5. For the open pit processing and general administration, the following operating costs have been used to determine cut-off grades: Southwest at $8.37/t, Central Chalcocite, Central Covellite, and Central Chalcopyrite at $7.25/t.
6. For the underground block cave, all mineral resources within the shell have been converted to mineral reserves. This includes low grade Indicated mineral resources and Inferred mineral resources, which has been assigned a zero grade and treated as dilution.
7. Only Measured mineral resources were used to report Proven mineral reserves and only Indicated mineral resources were used to report Probable mineral reserves.
8. EJV is the Entrée Joint Venture. The Shivee Tolgoi Licence and the Javkhlant Licence are held by Entrée. The Shivee Tolgoi Licence and the Javkhlant Licence are planned to be operated by OT LLC. OT LLC will receive 80% of cash flows after capital and operating costs for material originating below 560m, and 70% above this depth.
9. The base case financial analysis has been prepared using the following current long term metal price estimates: copper at $2.87/lb; gold at $1,350/oz; and silver at $23.50/oz. Metal prices are assumed to fall from current prices to the long term average over five years.
10. The mineral reserves reported above are not additive to the mineral resources.

1.6.3 Project Finance

During 2012 and early 2013, both TRQ and Rio Tinto have been actively engaged with lenders to refine the overall project financing plan and term sheet with the aim of raising $3 billion to $4 billion.

In August 2012, the Environmental and Social Impact Assessment undertaken as part of the project finance process was publically disclosed.

The overall terms and conditions for project financing have been generally agreed with lenders. In addition to the core lending group, the companies invited a wider selection of international banks to participate in the project finance consortium. In Q1’13, interested banks conducted a site visit to the Oyu Tolgoi mine. In late February 2013, the boards of the European Bank of Reconstruction and Development and the International Finance Corporation approved their respective participation in project financing. Bids have been received from a number of banks that would allow the Company to achieve its project financing target and discussions are ongoing with the lenders to finalize the terms of those offers. The project financing is subject to the unanimous approval of the Oyu Tolgoi LLC Board of Directors which includes representatives from the Government of Mongolia. TRQ anticipates the closing of final binding documentation and project financing funding to occur in the first half of 2013.

1.6.4 Power

TRQ announced on 5 November 2012, that Oyu Tolgoi LLC had signed a binding Power Purchase Agreement with the Inner Mongolia Power Corporation to supply power to the Oyu Tolgoi mine. The term of this agreement covers the commissioning of the business plus the initial four years of commercial operations.

The Oyu Tolgoi Investment Agreement recognized that the reliable supply of electrical power is critical to the mine. The agreement also confirmed that TRQ has the right to obtain electrical power from inside or outside Mongolia, including China, to meet its initial electrical power requirements for up to four years after Oyu Tolgoi commences commercial production. The agreement established that a) Turquoise Hill has the right to build or sub-contract construction of a coal-fired power plant at an appropriate site in Mongolia’s South Gobi Region to supply Oyu Tolgoi and b) all of the mine’s power requirements would be sourced from within Mongolia no later than four years after the start of commercial production. TRQ continues to evaluate several options to meet its commitment to sourcing power from within Mongolia including the development of a dedicated power plant and ownership and funding options to meet this requirement.

1.6.5 Environment

1.6.5.1 Environmental and Social Impact Assessment

OT LLC has completed a comprehensive Environmental and Social Impact Assessment (ESIA) for the Oyu Tolgoi Project. The ESIA undertaken as part of the project finance process was publically disclosed in August 2012. The culmination of nearly 10 years of independent work and research carried out by both international and Mongolian experts, the ESIA identifies and assesses the potential environmental and social impacts of the project, including cumulative impacts, focusing on key areas such as biodiversity, water resources, cultural heritage, and resettlement.

The ESIA also sets out measures through all project phases to avoid, minimize, mitigate, and manage potential adverse impacts to acceptable levels established by Mongolian regulatory requirements and good international industry practice, as defined by the requirements of the Equator Principles, and the standards and policies of the International Finance Corporation (IFC), European Bank for Reconstruction and Development (EBRD), and other financing institutions.

Corporate commitment to sound environmental and social planning for the project is based on two important policies: TRQ's Statement of Values and Responsibilities, which declares its support for human rights, social justice, and sound environmental management, including the United Nations Universal Declaration of Human Rights (1948); and The Way We Work 2009, Rio Tinto’s Global Code of Business Conduct that defines the way Rio Tinto manages the economic, social, and environmental challenges of its global operations.

OT LLC has implemented and audited an environmental management system (EMS) that conforms to the requirements of ISO 14001:2004. Implementation of the EMS during the construction phases to focus on the environmental policy; significant environmental aspects and impacts and their risk prioritization; legal and other requirements; environmental performance objectives and targets; environmental management programs; and environmental incident reporting. The EMS for operations consists of detailed plans to control the environmental and social management aspects of all project activities following the commencement of commercial production in 2013.The Oyu Tolgoi ESIA builds upon an extensive body of studies and reports, and Detailed Environmental Impact Assessments (DEIA’s) that have been prepared for project design and development purposes, and for Mongolian approvals under the following laws:

- The Environmental Protection Law (1995)
- The Law on Environmental Impact Assessment (1998, amended in 2001)
- The Minerals Law (2006)

These initial studies, reports and DEIA’s were prepared over a six-year period between 2002 and 2008, primarily by the Mongolian company Eco-Trade LLC, with input from Aquaterra on water issues.

The original DEIA's provided baseline information for both social and environmental issues. These DEIA's covered impact assessments for different project areas, and were prepared as separate components to facilitate technical review as requested by the GOM.

The original DEIA's were in accordance with Mongolian standards and while they incorporated World Bank and IFC guidelines, they were not intended to comprehensively address overarching IFC policies such as the IFC Policy on Social and Environmental Sustainability, or the EBRD Environmental and Social Policy.

Following submission and approval of the initial DEIA's, the Mongolian Government requested that OT LLC prepare an updated, comprehensive ESIA whereby the discussion of impacts and mitigation measures was project-wide and based on the latest project design. The ESIA was also to address social issues, meet Mongolian government (legal) requirements, and comply with current IFC good practice.

For the ESIA the baseline information from the original DEIA's was updated with recent monitoring and survey data. In addition, a social analysis was completed through the commissioning of a Socio-Economic Baseline Study and the preparation of a Social Impact Assessment (SIA) for the project.

The requested ESIA, completed in 2012, combines the DEIA's, the project SIA, and other studies and activities that have been prepared and undertaken by and for OT LLC.

1.6.6 Water Management

Due to low average annual precipitation in the project area, water management and conservation are given the highest priority in all aspects of project design.

The development of a borefield to access groundwater reserves within the Gunii Hooloi aquifer basin has been established as the most cost-effective option to meet the raw water demand for the project. Water from the borefield is used for process water supply, dust suppression in the mining areas, and potable use. Another major component of the water management plan is the diversion of the Undai River to accommodate project facilities. Undai River water is not used by the mine, diversion is to totally preserve this water in the environment.

Oyu Tolgoi will benchmark its water conservation efforts against other mines by assessing factors such as quantified water consumption per tonne of concentrate produced. The current water budget is based on the use of 550 L/t, which compares favourably with other large operations in similar arid conditions. OT LLC is committed to water conservation.

It is also assumed that no water will become available through mine dewatering. Although the need for mine dewatering at a rate of up to 90 L/s is predicted, this will be at a key stage of the mine development, and the actual flow could be lower. The total site design water demand ranges from a low of 465 L/s in spring to a high of 1,205 L/s in winter.

1.6.7 Open Pit

Pre-stripping of overburden to gain access to ore in the Phase 1 open pit mine began on schedule in August 2011 using the OT LLC earthworks fleet. OT LLC now has the fleet of electric and diesel shovels and 290 t trucks in operation at the open pit. The mining and stockpiling of the first open pit ore began in May 2012 and approximately 9 million tonnes of ore was stockpiled at the end of 2012. The primary crusher, overland conveyor, and coarse-ore stockpile circuits were commissioned in Q3'12 and 435,000 tonnes of ore had been sent through to the coarse ore storage facility at the end of 2012.

OT LLC carried out the pit optimization, mine planning, and scheduling work for the Oyu Tolgoi open pits. This work included the integration of the underground plans. During 2012 the pit designs were refined and redesigned. The current pit designs have been used for Mineral Reserve reporting.

1.6.8 Underground Development

In January and February 2012, 1,560 m of underground drilling was completed before the Shaft 1 shut down. Underground drilling recommenced in Q4'12. Characterization holes were also drilled for Shaft 4, Shaft 5 and Vent Raise 3.

At Hugo North Lift 1, 18,829 metres of infill drilling were completed. The drilling is designed to bring the first seven years of production into measured confidence category. The infill drilling program was 60% complete at year end and drilling will continue in 2013.

1.6.9 Current Exploration Activities

During 2012, exploration drilling continued on the Oyu Tolgoi Project and 28,431 m of surface exploration diamond drilling and 1,752 m of condemnation drilling were completed. The surface exploration drilling included 13,228 m of drilling on the Oyu Tolgoi mining licence, 9,058 m of drilling on Entrée Gold's Javkhlant mining licence, 5,776 m on Entrée Gold's Shivee mining licence and 367 m of drilling on Oyu Tolgoi LLC's Manakht mining licence. The condemnation drilling was on Oyu Tolgoi LLC's Manakht licence.

At the start of Q1'12, there were five exploration drill rigs in operation which had been reduced to one drill rig by the end of the Q4'12. In April 2012, management of the exploration programme transferred from TRQ to Oyu Tolgoi LLC. Following this change, the strategy of the exploration programme was restated by Oyu Tolgoi LLC and TRQ to be: the development of a pipeline of projects within the contract area, to seek a transformational discovery (long-life, low cost, high grade copper resources), especially in those areas where it may impact on the current development of the Oyu Tolgoi ore bodies. This included further delineation of resource potential at Heruga North.

To implement the strategy there will be a shift in emphasis in 2013 from drilling to data compilation, 3D modelling and interpretation to generate the next series of prioritized exploration targets. The Heruga geology model will be updated and a new resource estimate completed to incorporate the Heruga North resource potential. Drilling and expenditure will be significantly reduced compared to recent years.

1.6.10 Government and Community Relations

A number of substantive issues have recently been raised by the Government of Mongolia relating to implementation of the Investment Agreement, the companion Shareholders' Agreement and project finance.

TRQ and Rio Tinto continue to have productive discussions with the Government of Mongolia on a range of issues related to the implementation of the Investment Agreement, including project development and costs, operating budget, project financing, management fees and governance. While progress on these issues has been made, all parties have agreed to continue discussions during March 2013 with a goal of resolving the issues in the near term.

The Oyu Tolgoi LLC Board has approved continued funding to progress the project as discussions with the Government proceed. Oyu Tolgoi is expected to reach commercial production by the end of June 2013 subject to the resolution of the issues being discussed with the Government.

In October 2012, the Company, Rio Tinto and Oyu Tolgoi LLC, rejected a request from the Government of Mongolia to renegotiate the Oyu Tolgoi Investment Agreement. The rejection followed the receipt of a letter from the Minister of Mining requesting the parties renegotiate the landmark agreement that was signed in October 2009 and became fully effective in March 2010.

In its proposed 2013 budget, the Government of Mongolia has included revenue from the application of a progressive royalty scheme to Oyu Tolgoi. However, the Investment Agreement provides a stabilized royalty rate of 5% over the life of the agreement and specifies that new laws made after its signing will not apply to Oyu Tolgoi. Any change to Oyu Tolgoi's royalty rate would require the agreement of all parties to the Investment Agreement.

As recently as October 2011, the Mongolian Government reaffirmed that the Investment Agreement was signed in full compliance with all laws and regulations of Mongolia.

1.6.11 Human Resources and Training Strategy

The Oyu Tolgoi mine's staffing strategy continues to focus on the utilization of Mongolian men and women whose skills are being developed, and who are receiving training throughout the construction phase. As of the end of December 2012, the Oyu Tolgoi mine had a workforce of approximately 13,000, which included over 11,000 Mongolians.

Oyu Tolgoi has committed more than $126 million in funding over five years for education and training programs in Mongolia. The majority of the projects and initiatives under this funding are targeting the building of a Mongolian talent pipeline for the future. Under this investment, Oyu Tolgoi is building three new vocational education centres and upgrading four existing vocational education centres in seven towns and cities of Mongolia. Oyu Tolgoi is training 3,300 workers in 21 aimags and providing scholarships for hundreds of students to study in national and international universities.

1.6.12 Occupational Health, Hygiene and Safety

OT LLC's HSE management system has been implemented and been audited as compliant against AS/NZS ISO 14001:2004 Environmental Management System and OHSAS 18001:2007 Occupational Health and Safety management system. The(HSE MS) was developed to provide management with clear direction on HSE management, means to ensure compliance, and a basis for driving improvements. The Oyu Tolgoi HSE MS applies to all persons working for or on behalf of Oyu Tolgoi, including contractors, suppliers, the general public, special interest groups, and government representatives, and covers the health, safety, and environmental management of all Oyu Tolgoi's activities, assets, products, and services.

The HSE policy has been developed and is regularly reviewed in consultation with key stakeholders. The policy is intended to reflect a best practice approach to health, safety, and environment with the underlying principle that all people are accountable for health and safety.

The HSE policy is seen as an enabler for the entire HSE MS. It provides high-level principles that are intended to be implemented through the application of all parts of the HSE MS. The policy is endorsed by the Chief Executive Officer to ensure the appropriate priority is placed on implementation and compliance.

1.7 Financial Summary

1.7.1 Key Assumptions

The 2013 OTTR is an update of the Reserve Case previously presented in IDOP. The results of the 2013 Reserve Case show an after tax NPV8 of $9.9 billion. The case exhibits an after tax IRR of around 43% and a payback period of around 7.4 years.

Key economic assumptions in the analyses are shown in Table 1.6. Metal prices are assumed to fall from current prices to the long-term average over five years.

Table 1.6 Economic Assumptions

Parameter	Financial Analysis Assumptions (2013 real $)	
Copper Price	$2.90 avg ($2.87 long-term)	per lb
Gold Price	$1,398/oz Au avg ($1,350 long-term)	per oz
Silver Price	$23.96/oz Ag avg ($23.50 long-term)	per oz
Treatment Charges	$70.00 long-term	per dmt concentrate
Copper Refining Charge	$0.07 long-term	per lb
Gold Refining Charge	$5.00	per oz

1.7.2 Investment Agreement and Taxation Assumptions

Both the process of negotiation and the final agreement of the IA presented an opportunity to confirm how the laws of Mongolia should be interpreted in their application to the Project and provided for some specific terms to apply to the Oyu Tolgoi Project. For OT LLC, the agreement has provided the confidence in the stability of the terms the Project will operate under and reliably assess its intended investment in the Project. The agreement itself is effective for an initial term of 30 years an extension of a further 20 years.

In accordance with the requirements outlined in the 2006 Minerals Law of Mongolia, upon execution of the IA and the fulfilment of all conditions precedent, the GOM has become a 34% shareholder in OT LLC through the immediate issue of OT LLC's common shares to a shareholding company owned by the GOM. Upon a successful renewal of the IA after the initial 30-year term, the GOM also has the option to increase its shareholding to 50%, under terms to be agreed with TRQ at the time.

A number of conditions precedent were set down in October 2009 and were required to be met before the IA terms came into effect. These were met and confirmed by the GOM in March 2010, triggering the issue of the GOM's equity share in the Project and bringing the IA into full effect.

Despite its role as an equity owner, the GOM will not be required to contribute to the initial capital cost of the Project. TRQ, as the parent company, retains the right to fund the Project by way of a combination of debt, and equity provided the debt to equity ratios fall within the 3:1 ratio required by Mongolian law.

In the case of shareholder debt, loans (including existing shareholder loans at the time of the agreement) initially attracted an interest rate of 9.9% (real) per annum with corresponding adjustments to be made to the outstanding balance to reflect increases in US CPI during each period. The coupon rate applicable to redeemable preference shares was to be 9.9% (real) and carry the same escalation terms. All principal and interest outstanding on shareholder debt, outstanding coupon payments on redeemable preference shares and the face value of those redeemable preference shares must be paid in full prior to any dividends on common shares being paid.

In 2011, an Amended Shareholders Agreement was concluded which reduced the applicable rate from 9.9% to LIBOR plus 6.5%. In addition, an in principle agreement was reached to convert the balance of preference shares into ordinary shares. Both adjustments were to take place based on 31 January 2011 balances, although the preference share conversion had not occurred by 31 December 2011.

Under the authority of the Shareholders Agreement, TRQ has the right to act as or appoint a management team to oversee the construction and operation of Oyu Tolgoi. The management team is compensated with a Management Services Payment equal to 3% of total operating and capital costs prior to commencement of operations and 6% of operating and capital costs during operations. This payment is included in the economic analysis as a project expense and is confirmed as tax deductible in the IA.

OT LLC is required to achieve commencement of production within seven years of the effective date of the IA.

Under the terms of the IA, a range of key taxes has been identified as stabilized for the term of the agreement at the rates and base currently applied. The following taxes comprise the majority of taxes and fees payable to the GOM under Mongolian law and are shown with their stabilized rates:

- Corporate income tax 25%
- Mineral Royalties 5% (gross sales value)
- Value added tax 10%
- Customs duties 5%
- Withholding tax 20%

In accordance with the Excess Profits Tax invalidating law, as from 1 January 2011, the taxpayer will not be subject to the excess profits tax or any similar windfall tax.

OT LLC is also only subject to those taxes currently listed in the General Taxation Law and not taxes introduced at any future date. These taxes are collectively noted as non-discriminatory taxes and as such cannot be imposed on OT LLC in any manner other than that applied to all taxpayers.

OT LLC may also apply to take advantage of any future law or treaty that comes into force and which would apply any rates lower than those specified in the IA.

The GOM recently enacted amendments to the legislation governing the carry forward of income tax losses. The loss carry forward period has been extended to 8 years and if sufficient, can be applied to offset 100% of taxable income. This contrasts with the previous law in which losses carried forward for 2 years and were subject to a 50% limit.

The agreement also provides OT LLC with the benefit of a 10% tax credit for all capital investment made during the construction period. The amount of this credit can be carried forward and credited in the three subsequent profitable tax years. It is noted in the agreement that if Mongolian Value Added Tax (VAT) payments, which are currently non-refundable, become refundable in the future, the availability of the investment tax credit will cease from that point. In that event, past earned investment tax credits will still be applied.

1.7.3 Operating Assumptions

Although it has a requirement to make its self discovered water resources available to be used for household purposes, it is confirmed in the agreement that OT LLC holds the sole rights to use these water resources for the Project. The contract for the utilization of water with the GOM water authority is in effect for 30 years with subsequent 20-year periods of renewal.

The supply of power has been recognized as being critical to the execution of the Oyu Tolgoi Project in the IA. OT LLC has been given the right to import power initially but must secure power from sources within Mongolia from the fourth year of operation.

OT LLC also has the right to construct roads for the transport of its product and airport facilities to suit the Project’s needs. The GOM has committed to providing OT LLC with non-discriminatory access to any railway constructed between Mongolia and China if such a railway is constructed.

1.7.4 Project Results

A summary of the 2013 Reserve Case project financial results is shown in Table 1.7.

The estimates of cash flows of the Project have been prepared on a real basis based at 1 January 2013 and discounted back to a current day Net Present Value (NPV) at a rate of 8%. Long-term metal prices used for the analysis are copper $2.87/lb, gold $1,350/oz, and silver $23.50/oz.

Table 1.7 2013 Reserve Case Financial Results

		Before Taxation	After Taxation
Net Present Value (US$M)	**Undiscounted**	33,153	27,825
	5.0%	16,525	14,294
	6.0%	14,509	12,611
	7.0%	12,770	11,150
	8.0%	11,263	9,877
	9.0%	9,953	8,763
	10.0%	8,812	7,787
Internal Rate of Return	–	43.27%	42.64%
Project Payback Period (Years)	–	7.41	7.41

Mine site cash costs are shown in Table 1.8. Those costs relating to the direct operating costs of the mine site, namely:

- Mining
- Concentration
- Tailings
- General and administrative (G&A) costs
- Operational Support Costs
- Infrastructure
- Management fees

In addition, realization costs are shown which indicate the actual realizable value of Payable Copper produced after accounting for the transport treatment and GOM royalties payable on these sales.

Table 1.8 2013 Reserve Case Unit Operating Costs by Copper Production

	$/lb Payable Copper			
	2013 Reserve Case	**5 Yr Avg**	**10 Yr Avg**	**20 Yr Avg**
Mine Site Cash Cost	1.37	3.09	1.47	1.08
Treatment Charges, Refining charges (“TC/RC”s), Royalties and Transport Cash Cost	0.51	0.65	0.50	0.49
Total Cash Costs Before Gold Credits	**1.88**	**3.74**	**1.97**	**1.57**
Gold Credits	0.59	2.22	1.00	0.64
Silver Credits	0.07	0.10	0.07	0.07
Total Cash Costs After Credits	**1.22**	**1.42**	**0.89**	**0.86**

Notes: Payments made directly to TRQ from the Project, principally 50% of the management fee as specified in the terms of the IA and a 2%NSR based payment (2% Ex BHP Payment)are not included in the Mine Site Cash Cost per pound of payable copper. These payments due to TRQ add to around 0.11 $/lb over the 2013 Reserve Case.

The revenues and operating costs have been presented in Table 1.9, along with the net sales revenue value attributable to each key period of operation.

Table 1.9 2013 Reserve Case Operating Costs and Revenues

	US$M	**$/t Ore Milled**		
	Total 2013 Reserve Case	**5 Yr Avg**	**10 Yr Avg**	**LOM Avg**
Revenue				
Gross Sales Revenue	93,016	59.27	82.12	60.43
Less: Realization Costs				
Concentrate Transport	3,578	1.69	2.55	2.32
Treatment and Refining	4,733	2.21	3.55	3.07
Government Royalty	4,650	2.96	4.11	3.02
2% Ex BHP Payment	1,680	1.11	7.43	1.09
Total Realization Costs	**14,641**	**7.97**	**17.64**	**9.51**
Net Sales Revenue	**78,375**	**51.30**	**64.49**	**50.92**
Less: Site Operating Costs				
Mining (all sources)	8,917	7.74	7.66	5.79
Processing	13,721	8.78	8.93	8.91
Tailings	1,270	1.02	1.20	0.82
G&A	1,934	4.97	3.23	1.26
Operations Support	1,713	3.01	2.18	1.11
Infrastructure	2,010	2.18	2.03	1.31
Entrée JV Fees	525	–	0.01	0.34
Government Fees & Charges	3,664	3.46	3.20	2.38
Management Fees	2,486	3.23	2.61	1.61
Total Site Operating Costs	**36,240**	**34.39**	**31.01**	**23.54**
Operating Margin	**42,136**	**16.91**	**33.44**	**27.38**

Notes:

1. Turquoise Hill 2% Ex-BHP Payment is shown as a realization cost but modeled to be non-tax deductible.
2. Other operating costs include payments forecast to be made to the EJV as calculated in the Financial Model.

The scope of the Phase 1 programme included all required capital to ready the mine to operate at 100 ktpd including the concentrator, open pit mining, infrastructure, and operational readiness. It also included Shaft 2 development and lateral development until mid-2012 in order to continue progressing the Hugo North Underground mine. The scope of the Phase 2 program will include all required capital to fully develop the underground mine and also includes co-commitments in concentrator modifications and infrastructure required to sustain operations at 100 ktpd as the underground mine expands.

Total project direct capital costs are shown in Table 1.10 divided between expenditures until 2013 and expenditures after 2013. The changes in financial results for a range of copper and gold prices are shown in Table 1.11.

Table 1.10 Total Project Capital Cost – 2013 Reserve Case

US$M	Total Pre-2013	Phase 1 & 2 From 2013	Sustaining	Total
Direct Costs				
Open Pit	423	–	535	958
Underground	495	2,348	1,094	3,937
Concentrator	944	131	275	1,350
Infrastructure	1,204	67	154	1,426
Power Station	–	–	–	–
Tailings Storage Facility (TSF)	60	–	57	117
Subtotal	**3,125**	**2,546**	**2,038**	**7,787**
Indirect Costs & Allowances				
Indirect Costs	221	193	–	414
Freight	215	107	–	322
Construction O&M, Commissioning, Spares	492	297	–	789
Subtotal	**929**	**597**	**–**	**1,525**
Contractor Execution				
Contractor Margins	162	84	–	246
E/EPCM/PMC	598	394	–	992
Subtotal	**760**	**477**	**–**	**1,238**
Owner Execution				
O&M, Commissioning, Owners Teams, Spares	792	281	15	1,088
Subtotal	**792**	**281**	**15**	**1,088**
GOM Fees & Charges				
Mongolian Customs Duties	113	84	53	250
Mongolian VAT	346	347	165	858
Other Mongolian Fees, Taxes & Charges	2	29	–	31
Subtotal	**461**	**460**	**218**	**1,140**
Contingencies				
Contingencies	121	740	–	861
Subtotal	**121**	**740**	**–**	**861**
Total Development Program	**6,198**	**5,101**	**2,349**	**13,648**

Notes: Capital includes only direct project costs and does not include non-cash shareholder interest, management fees, foreign exchange gains or losses, forex movements, tax pre-payments, T Bill purchases or exploration phase expenditure.

Table 1.11 After Tax Metal Price Sensitivity – 2013 Reserve Case

After Tax Values	Gold ($/oz)				
Copper ($/lb)	**1,000**	**1,150**	**1,350**	**1,500**	**1,750**
Project Net Present Value at 8% ($M) After Tax					
2.50	6,945	7,358	7,834	8,186	9,339
2.75	8,410	8,759	9,217	9,563	10,709
2.87	9,074	9,418	9,877	10,217	11,362
3.00	9,790	10,131	10,585	10,926	12,067
3.50	12,510	12,851	13,308	13,650	14,766
Project Internal Rate of Return (IRR%) After Tax					
2.50	34.1%	35.5%	37.3%	38.7%	43.3%
2.75	37.9%	39.2%	41.0%	42.3%	46.7%
2.87	39.6%	40.9%	42.6%	43.9%	48.3%
3.00	41.4%	42.7%	44.4%	45.7%	49.9%
3.50	47.7%	48.9%	50.5%	51.8%	55.7%
Project Payback (Years)After Tax					
2.50	7.98	7.87	7.72	7.62	7.32
2.75	7.72	7.62	7.50	7.42	7.17
2.87	7.61	7.52	7.41	7.34	7.11
3.00	7.51	7.43	7.33	7.26	7.04
3.50	7.21	7.15	7.07	7.02	6.65
Total Cash Costs (after Credits) – First Ten years					
2.50	1.00	0.95	0.87	0.87	0.62
2.75	1.01	0.96	0.88	0.88	0.63
2.87	1.02	0.97	0.89	0.89	0.64
3.00	1.03	0.97	0.89	0.89	0.64
3.50	1.03	0.98	0.90	0.90	0.65

1.8 Future Work

1.8.1 OT LLC Value Engineering

OT LLC plans to undertake engineering studies of expansion options in the continuing Feasibility Study for Oyu Tolgoi. This will include examining all production scenarios and associated expansion options. OT LLC plans a focused and structured review of the study work to be used in the capital approvals process as the operation developments. AMC believes that further design work could identify opportunities to improve project economics via cost reductions and mine plan optimization.

The Phase 2 Project Expansion Plan should continue to be studied to identify the capacity and definition of the project expansion requirements, infrastructure, power supply, water permitting, concentrate marketing, the underground feasibility study, and further work on mine closure and reclamation plan. A detailed execution plan is being developed for Phase 2 that includes lessons learned and incorporates tools and advancements from the Phase 1 project execution.

1.8.2 Alternative Production Cases

The mine designs and production schedules available for the alternative production cases are:

- Southern Oyu Open Pits (2013 Mineral Reserve)
- Hugo North Lift 1 Block Cave (2013 Mineral Reserve)
- Hugo North Lift 2 Block Cave (Inferred)
- Hugo South Block Cave or Open Pit (Inferred)
- Heruga Block Cave (Inferred)

Under the NI 43-101 guidelines, Inferred Mineral Resources are considered too speculative geologically to have the economic considerations applied to them that would allow them to be categorized as Mineral Reserves. There is no certainty that the alternative production cases will be realized.

Currently the designs for Hugo North Lift 2, Hugo South Block Cave, and Heruga are the same as those in IDP10. The Hugo South open pit designs were updated in 2012. From the designs two sets for long-term production scheduling can be prepared, one with Hugo South as underground and one as open pit. The two sets are shown in Figure 1.10 and Figure 1.11. The work on the alternative production cases is not complete, in particular the definition of the expansion sizes and costing of the cases.

Figure 1.10 Alternative Production Design Set 1

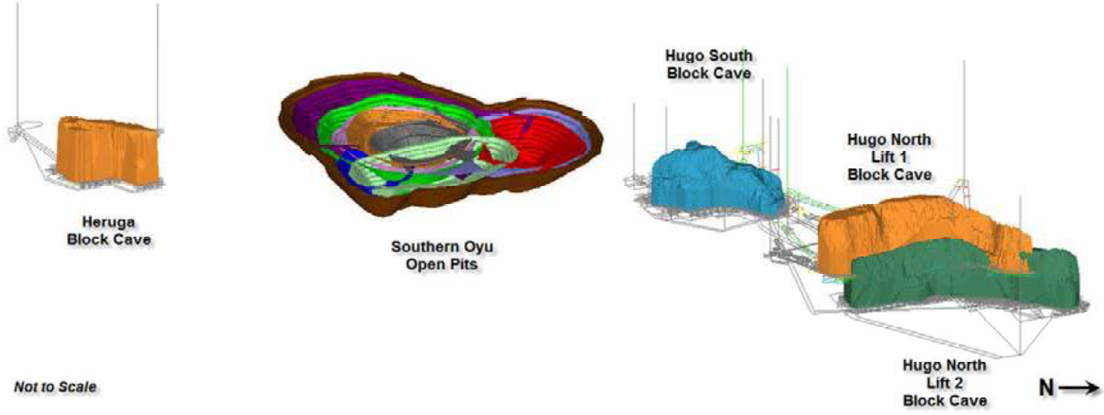
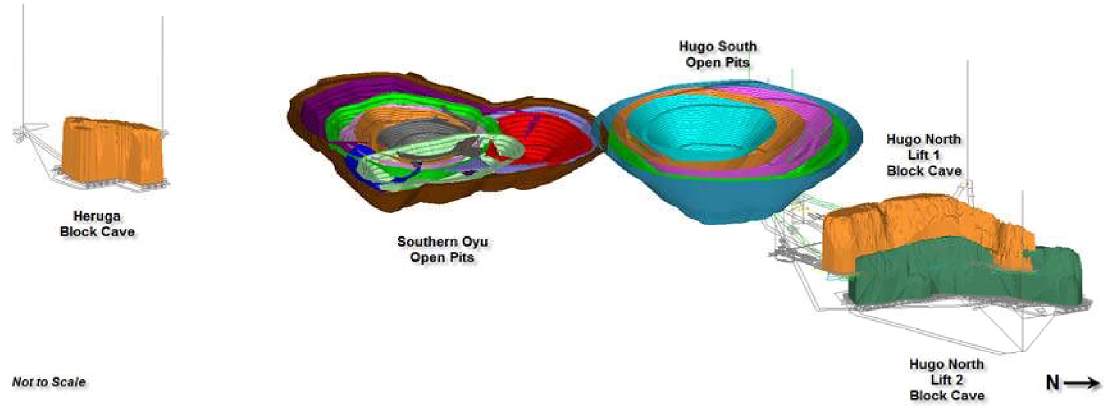
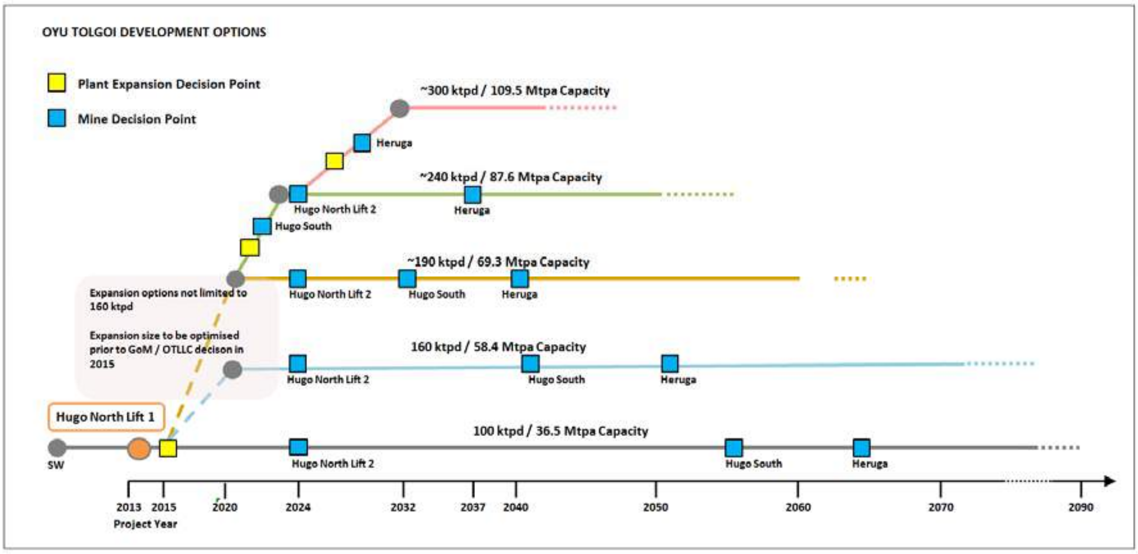


Figure 1.11 Alternative Production Design Set 2



These cases will be part of the strategic planning that is being undertaken by OT LLC. This work will examine the plant capacity for expansions. Figure 1.12 shows the expansion matrix that has been identified as part of the study planning.

Figure 1.12 Oyu Tolgoi Development Options



1.8.3 Power Supply Determination

The supply of power has been recognized as being critical to the execution of the Oyu Tolgoi Project in the IA. OT LLC has been given the right to import power initially but must secure power from sources within Mongolia from the fourth year of operation.

The PPA is now in place to allow power to be imported from Inner Mongolia. The next phase of the IA is for OT LLC to source power from Mongolia by the fourth year of operation in accordance with the terms of the IA.

There is no provision for a plant in the current capital cost estimates and the financing that would be required is not contemplated as part of the Company's current financing plan.

OT LLC is currently considering a range of options to ensure a reliable and efficient power supply after Year 4. OT LLC retains the right to develop a power station on the site.

1.8.4 Water Permit

OT LLC's strategy is to obtain approval for increases to the currently approved water reserve ahead of any mine expansion plans. The objective of the study will be to assess the impact if any on the concentrator expansion on water demand and to determine the need for obtaining GOM approval for any substantial increase in the approved water demand from the Gunii Hooloi aquifer.

The current estimate of average water demand for the concentrator expansion to 160 ktpd is 918 L/s, which is marginally above the rate of 870 L/s that has already been approved by the GOM.

1.8.5 Concentrate Marketing

Long-term sales contracts have been signed for 75% of the Oyu Tolgoi mine's concentrate production in the first three years, while 50% of concentrate production is contracted for ten years (subject to renewals). In addition to the signed contracts, in early November 2012, Oyu Tolgoi committed in principle, subject to the conclusion of detailed sales contracts, up to 25% of concentrate available for export would be made available at international terms to smelters in Inner Mongolia for the first ten years.

OT LLC has developed a marketing plan and currently includes consideration of the following factors:

- Location value to customer compared to imported material landed at Chinese ports.
- Precious metals recovery and payment.
- Length of contract.
- Percentage of off-take to smelters versus traders.
- Percentage of tonnage on contract versus spot.
- Percentage of feed for any one smelter.
- Number of smelters for a given scale of operation.
- Management of concentrate quality and volume during commissioning and ramp-up.
- Alternate off-shore logistics and costs.
- Delivery point and terms.
- Packaging.

A detailed timeline has been developed for marketing, logistics, and contract-to-cash functions. OT LLC's Sales and Marketing will be supported by Rio Tinto Copper Marketing, led by its Chief Marketing Officer. The marketing team will oversee and execute all sales and marketing activities on behalf of OT LLC.

1.8.6 Underground Feasibility Study

Design and planning of the Hugo North underground mine has reached an advanced feasibility level (UG FS) and approval for the continued development of the Hugo North underground mine, the Phase 2 capital program, is now the focus of the company. Optimisation and implementation of this planning should continue.

1.8.7 Socio-economic Aspects of Mine Closure Plan

The preliminary mine closure and reclamation plan includes provisions to ensure that adverse socio-economic impacts of mine closure are minimized and positive impacts are maximized. To this end, OT LLC has planned that allowances will be incorporated into the annual mine operations budget starting 10 years before mine closure to address the costs of:

- Lost employment by the mine workforce.
- Adverse effects on supply chain businesses and downstream businesses, affected communities, public services, and infrastructure.
- Promoting ongoing sustainability among affected stakeholders and communities.

The details of additional socio-economic aspects of a conceptual mine closure plan have not yet been fully developed and are the subject of work to be done in the near future.

1.8.8 Infrastructure

There may be additions to scope beyond those contained in this report and OT LLC has advised that it will be considering revisions to the project scope which may include:

- Operations camp expansion.
- Border facilities upgrade.
- Concentrate bagging plant upgrade.
- Power substation expansions.
- Central maintenance complex.
- Central control room.
- Borefield expansion.
- Operations warehouse expansion.
- Core storage warehouse.

There may be additions to scope beyond these items and all items and updated cost estimates will be included in the Feasibility Study.

2 INTRODUCTION

2.1 Issuer for Whom Report Prepared

This report is titled the 2013 Technical Report and has been prepared for TRQ.

2.1.1 Ownership/Joint Venture

The project area comprises five contiguous properties, as listed in Table 2.1. In 2011, all mining licences in Mongolia were subject to a review in accordance with a change in the geodesic projection maintained by the Government of Mongolia (GOM). As a result, the licences held by OT LLC were re-surveyed, and a slight reduction in total area is reported. This has been ratified by the GOM, and new licence certificates have been issued to reflect the changes. Table 2.1shows both the original and updated names and areas of the five properties. In general the information in this section refers to the original licence numbers.

Table 2.1 Properties of the Project Area

Original Mining Licence Number	Original Area (ha)	Licence Number (Nov-10)	Updated Area ha	Legal Owner
6708A	4,533	MV-06708	4,533	OT LLC
6709A	8,490	MV-06709	8,490	OT LLC
6710A	1,763	MV006710	1,763	OT LLC
15226A (Shivee Tolgoi)	54,760 of which 39,864 are under agreement	MV015226	54,653 of which 39,864 are under agreement	Entrée LLC (a subsidiary of Entrée Gold Inc)
15225A (Javkhlant)	20,346, all under agreement	MV015225	20,327, all under agreement	Entrée LLC (a subsidiary of Entrée Gold Inc)

OT LLC has an economic interest in ML 15225A and 15226A pursuant to an Equity Participation and Earn-in Agreement with Entrée (as amended). This agreement contemplates the establishment of a joint venture between the parties that provides for OT LLC to hold legal title in ML 15225A and 15226A and, subject to its terms and to OT LLC meeting prescribed earn-in expenditures. Whilst a JV has not been formed, the earn in requirements have been met and OT LLC's participating interest in the joint venture (including the licences) will be:

- In respect of the proceeds from mining from the surface to 560 m below the surface, 70%.
- In respect of the proceeds from mining from depths beneath 560 m, 80%.

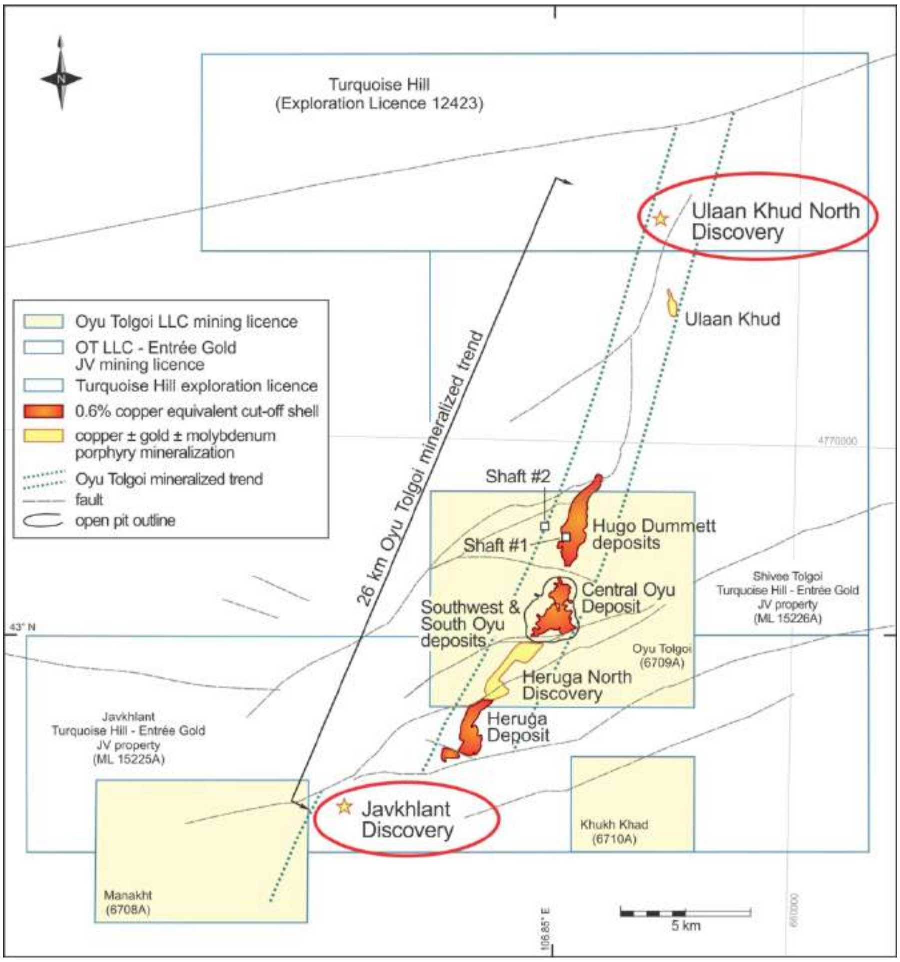
The vast majority of the identified mineralization for the project occurs at the Hugo Dummett and Southern Oyu porphyry deposits within the Oyu Tolgoi Property. The northernmost extension of the Hugo Dummett deposit (Hugo North) crosses onto the Shivee Tolgoi Property. The Heruga deposit lies almost entirely within the Javkhlant Property, with only the northern extreme passing into ML 6709A. There are numerous exploration targets across ML 6708A, 6709A, 15225A, and 15226A.

In October 2009, Ivanhoe Mines Ltd. (now TRQ), OT LLC, and Rio Tinto International Holdings Limited signed an Investment Agreement (IA) with the GOM. The IA defines the fiscal and regulatory environment under which the project will operate and stipulates that the GOM own 34% equity of OT LLC, with the option to increase its equity holding by a further 16% after the IA is extended beyond its initial 30-year term, providing the shareholders of OT LLC can reach agreement on the arrangement at that time. At the time of signing the IA, there remained a number of conditions precedent to it becoming effective. On 31 March 2010, it was announced that these conditions had been met or waived, and this was confirmed by the GOM. The main conditions that were met or waived were as follows:

- The Mongolian feasibility study of the Oyu Tolgoi Project has been considered and submitted in accordance with the laws and regulations of Mongolia.
- The balance of existing income tax losses, capitalized expenses, and outstanding tax liabilities or credits has been confirmed by the tax office. This condition was waived prior to the Effective Date of the IA.
- The balance of existing shareholder loans has been agreed upon.
- Company restructuring required to execute the agreement has been completed.
- A standing working committee has been established with members of the GOM and OT LLC to provide a means to expedite permits, customs clearance, or general GoM administration.
- TRQ's interests in mining licences 15225A and 15226A (referred to in the IA as exploration licences 3148X and 3150X) held by Entrée Gold LLC have been transferred to OT LLC. Although the licences have yet to be transferred to OT LLC, the condition precedent is fully satisfied as it only required the transfer of economic interests in the licence.
- Rio Tinto has paid the second tranche equity investment in TRQ.

TRQ acquired 100% interest in the mineral exploration rights to the area now covered by ML 6709A pursuant to an earn-in agreement dated 5 May 2000 (and subsequently amended 13 March 2002) with BHP on an exploration licence (MEL) covering 1,120 km^2 (112,000 ha) (BHP Earn-in Agreement). The MEL, named “210,” was originally issued to BHP on 17 February 1997 and was later re-named MEL 66X. In September 2000, the licence was reduced in size and converted to four non-contiguous MELs, one of which represented ML 6709A. The boundaries of ML 6709A, along with the surface projection of the main deposits and proposed open pit outlines, are shown in Figure 2.1.

Figure 2.1 Oyu Tolgoi Project Land Tenure



The terms of this original agreement called for TRQ to spend a total of $6 million on exploration over seven years and to pay BHP $5 million (TRQ press release, 8 May 2000). Upon transfer of the MEL, TRQ agreed to a 2% net smelter return (NSR) based payment payable to BHP. The terms of the BHP agreement were met by TRQ in April 2002, giving it 100% interest in the Oyu Tolgoi Property. The 2% NSR was subsequently acquired by TRQ in February 2004 (two payments totalling US$37 m), thereby removing any future obligations to BHP Billiton. (On 29 June 2001, BHP merged with Billiton resulting in a company name change to BHP Billiton).

On 23 December 2003, TRQ was granted 100% interest in a Mining Licence for the Oyu Tolgoi Property (Mining Licence 6709A, covering 8,496 ha;), in accordance with the Minerals Law of Mongolia. When originally granted, the OT Mining Licence had a term of 60 years, with an option to extend the licence for an additional term of up to 40 years. In 2006, the Mongolian parliament passed new mining legislation that changed the term of mining licences to 30 years with two 20-year extensions.

Mineral production from the Property is subject to a 5% royalty on the sales value of all products, except coal and common minerals, extracted from the mining licence that are sold, shipped for sale, or used. Royalties are payable to the GOM and are governed by Article 38 of the Minerals Law of Mongolia.

The boundary coordinates of the Mining Licence are defined on Table 2.2 by latitude/longitude and also by UTM coordinates (WGS-84, Zone 48N).

Table 2.2 Oyu Tolgoi Property (Mining Licence 6709A) Boundary Coordinates

Point	Latitude/Longitude, MSK42		UTM, WGS-84, Zone48N	
	Latitude	Longitude	Northing	Easting
1	42 58' 30" N	106 47' 30" E	4759595.99	646096.71
2	43 03' 00" N	106 47' 30" E	4767924.92	645918.99
3	43 03' 00" N	106 55' 00" E	4768149.90	656099.64
4	42 58' 30" N	106 55' 00" E	4759820.93	656289.77

Note: : Point 1 corresponds with the NW corner of the Licence, as shown on Figure 2.1, and then moving clockwise.

Payments to maintain mining and exploration licences in Mongolia are payable in advance on an annual basis according to the schedule shown on Table 2.3. An exploration licence is valid for a three-year period with two three-year extensions for a total of nine years. Prior to expiry of the exploration licence, application can be made for conversion to a mining licence. The current licences can be maintained for another three-year extension, referred to as the pre-mining period, by making application and by paying annual fees of $1.50/ha during this extension period as defined in Article 32.2.

Table 2.3 Exploration and Mining Licence Annual Maintenance Costs

Years of Licence	Exploration Licence Cost Per Hectare (US$)	Mining Licence Cost Per Hectare (US$)
1	0.10	15.00
2	0.20	15.00
3	0.30	15.00
4	1.00	15.00
5	1.00	15.00
6	1.00	15.00
7	1.50	15.00
8	1.50	15.00
9	1.50	15.00*

*Beyond Year 9, the mining licence fee remains at US$15.00/ha.

The approximate exploration and mining licence fees paid to date by TRQ for the Oyu Tolgoi Property are shown on Table 2.4. OT LLC advises that all payments have been made to keep the licence in good standing at the effective date of the Technical Report.

Table 2.4 Exploration and Mining Licence Fees (2000 to 2008)

Mining/Exploration Licence	Year	Licence Fees (US$/ha)	Total Payments (US$)
Exploration Licence	2000	1.00	8,496
	2001	1.00	8,496
	2002	1.50	12,744
	2003	1.50	12,744
Mining Licence 6709A (Oyu Tolgoi)	2004	5.00	42,480
	2005	5.00	42,480
	2006	5.00	42,480
	2007	15.00	127,440
	2008	15.00	127,440
Total Fees Paid			**424,800**

The annual payment will be approximately US$127,440 for the Oyu Tolgoi Mining Licence (8,496 ha), and $597,960 for the Shivee Tolgoi JV Mining Licence (39,864 ha).

OT LLC is also contractually obliged to meet payments on the Javkhlant JV Mining licence (54,653 ha; $819,789) as well as ML6708 (4,533 ha; $68,000) and ML6710 (1,763; $26,441) for a total $1.35 million for 2013.

The Oyu Tolgoi Property was legally surveyed in August 2002 by Surtech International Ltd. using the internationally recognized survey datum WGS-84 Zone 48N. In September 2004, Geomaster Co. Ltd. (Geomaster), a licensed Mongolian land survey company, re surveyed the mining concession’s corner points based on the official Mongolian survey datum “MSK42” and marked the corners with concrete and steel pylons. In November 2004, Geomaster also surveyed the northern boundary between the Oyu Tolgoi Property and the adjacent Shivee Tolgoi JV Property and marked it with wooden posts on 250 m to 500 m intervals. The differences between these two surveys are considered insignificant.

In early 2011, the GOM changed its official survey datum to WGS-84 Zone 48N. In accordance with the requirements of the change, Geomaster resurveyed the licences, and new licence certificates reflecting the slight change were issued to OT LLC.

On 17 May 2006, an expert group established by the GoM recommended registration of the project’s open pit reserves under Mongolian guidelines; as part of its conclusions, the expert group confirmed that IMMI (precursor to OT LLC) had title to the Oyu Tolgoi licence 6709A.

On 1 July 2009, a new experts group, the current Minerals Council, recommended to the Ministry of Mineral Resources and Energy and the Mineral Resources Authority of Mongolia that the Oyu Tolgoi Commercial Minerals be registered. “Commercial Minerals” include Mongolian Mineral Resources and Mongolian Mineral Reserves and can only be reported in Mongolia by registration by the Ministry of Mineral Resources and Energy.

Included in the recommendations was an acknowledgment of the IMMI licences and a recommendation that the Shivee Tolgoi 3148X and Javkhlant 3150X exploration licences be converted to mining licences, which has now been done: Shivee Tolgoi 15226A and Javkhlant 15225A. The IA describes the exploration and mining licences relating to the Oyu Tolgoi Project and confirms OT LLC's interest in these licences.

2.1.2 Rio Tinto Agreement

On 18 October 2006, TRQ entered into a private placement agreement with Rio Tinto International Holdings Limited (Rio Tinto), a wholly owned member of the Rio Tinto Group. Under the terms of the agreement, Rio Tinto agreed to acquire 19.7% of the issued and outstanding common shares of TRQ in two tranches. Through a series of other agreements with TRQ, and others; through its exercise of warrants; and through purchases, Rio Tinto has since increased its shareholding in TRQ to approximately 51%. Under the terms of the private placement agreement, Rio Tinto and TRQ established a joint "Technical Committee" to oversee and approve all aspects of the engineering, construction, development, and operation of the Oyu Tolgoi Project. Rio Tinto also acquired a right of first refusal in the event of TRQ proposing to dispose of any interest, direct or indirect, in the Oyu Tolgoi Project to a third party, other than the GOM.

On 8 December 2010, TRQ entered into a heads of agreement with Rio Tinto. The terms of this agreement include but are not limited to:

- Rio Tinto agreed to make available to TRQ a non-revolving interim funding facility of up to US$1.8 billion to be used to fund expenditures in respect of the Oyu Tolgoi Project, while the parties agreed to work together to complete the project financing.
- Pursuant to the terms of a governance agreement, Rio Tinto and TRQ established a joint "Operating Committee" through which decisions concerning the exercise of TRQ's indirect voting rights in OT LLC are made at both the board of directors' level and the shareholder level.
- Pursuant to the terms of a management agreement, a Rio Tinto affiliate could be appointed to manage, supervise, and conduct all matters and activities related to the Oyu Tolgoi Project.

On 17 April 2012, Rio Tinto and Ivanhoe entered into a memorandum of agreement under which Rio Tinto agreed to support and provide certain elements of a comprehensive funding package for Ivanhoe to underpin the development of the Oyu Tolgoi Project. The parties also agreed to make changes to Ivanhoe's board and management. More specifically, under the memorandum of agreement, among other terms:

- Rio Tinto agreed to provide a standby commitment for the full amount of a US$1.8 billion rights offering by Ivanhoe. Rio Tinto also agreed to provide US$1.5 billion of bridge financing to Ivanhoe. The proceeds from the rights offering and the bridge financing funding are to be used by Ivanhoe only to fund expenditure in respect of the Oyu Tolgoi Project.

- Rio Tinto restated its commitment to work with Ivanhoe to secure the project financing and agreed to provide completion support by way of a guarantee of certain obligations of Ivanhoe under the project financing. Once project financing is in place, both the US$1.8 billion interim funding facility made available under the 2010 heads of agreement and any amounts drawn down under the US$1.5 billion bridge financing are required to be repaid to Rio Tinto in full.
- It was agreed that a new 13-member Ivanhoe board would be formed, the majority of whom were to be independent directors, comprising:
  - Eleven Rio Tinto-nominated directors, six of whom would be independent until at least 18 January 2014.
  - Two directors nominated by Robert Friedland, one of whom was to be independent, for so long as Mr Friedland retains an interest in Ivanhoe of at least 10%.
- It was agreed that Rio Tinto would be entitled to nominate, and the Ivanhoe board would approve, the CEO and CFO of Ivanhoe.
- Ivanhoe issued to Rio Tinto a new anti-dilution subscription right to enable it to maintain its proportional interest in Ivanhoe and approximately 74.2 million additional fixed price Series D share warrants.

Following the Ivanhoe rights offering, which expired on 19 July 2012 (in which approximately 99.2% of the shares were taken up in the initial subscriptions of the offering rights), Rio Tinto together with 7999674 Canada Inc., also a wholly owned member of the Rio Tinto Group, increased its shareholding in Ivanhoe from approximately 50.9% to approximately 51%.

Copies of the private placement agreement, the heads of agreement and the memorandum of agreement have been filed on SEDAR and can be accessed at www.sedar.com.

2.2 Terms of Reference and Purpose of Report

The Oyu Tolgoi copper and gold project (the "Project") is located in the southern Gobi region of Mongolia and is being developed by Oyu Tolgoi LLC (OT LLC). Oyu Tolgoi consists of a series of deposits containing copper, gold, silver and molybdenum. The deposits stretch over 12 km, from the Hugo North deposit in the North through the adjacent Hugo South, down to the Southern Oyu deposit and extending to the Heruga deposit in the South.

This report, the 2013 OTTR, was prepared for TRQ. The 2013 OTTR is based on the most current technical, production and cost information prepared by OT LLC to support project financing.

Independent Qualified Persons (QP), acting on behalf of TRQ, reviewed the available studies as part of the preparation for the 2013 OTTR and in conjunction with TRQ prepared the 2013 OTTR with costs to the end of 2012 as reported to TRQ by OT LLC.

The 2013 OTTR used only Measured and Indicated Mineral Resources and is a complete study of all aspects of the Project. The 2013 OTTR analyses a reserve case only (2013 Reserve Case) and is based on a feasibility quality level study complying with NI 43-101, although some parts of the Oyu Tolgoi Project are further advanced and are in the execution phase. The work of the 2013 OTTR meets the standards of US SEC Industry Guide 7 requirements for reporting Reserves.

2.3 Units of Measure and Currency

Throughout this Report, measurements are in metric units and currency in United States dollars unless otherwise stated.

2.4 Sources of Information and Study Participants

This report was compiled by the Qualified Persons listed on the Title Page. Original authors and companies are listed throughout the text.

2.5 Personal Site Inspections

The following site visits were carried out by the Qualified Persons:

- Bernard Peters visited the property in March 2003, July 2003, April 2006, April 2009, July 2010, October 2011, November 2012, and 28 January 2013 to 31 January 2013. Meetings were also attended in Ulaanbataar with OT LLC (formerly IMMI) and Mongolian authorities to discuss the Project from 2003 to 2011. Some of these meetings did not include site visits. Other visits were made to Mongolia and China as part of work on the Project.
- Sharron Sylvester visited the property from 28 January 2013 to 31 January 2013.
- Malcolm Bridges visited the property from 28 January 2013 to 31 January 2013.
- Alan Riles visited the property from 28 January 2013 to 31 January 2013.

3 RELIANCE ON OTHER EXPERTS

The authors of this report state that they are Qualified Persons for those areas as identified in the appropriate “Certificate of Qualified Person” attached to this report. The authors have relied upon, and believe there is a reasonable basis for this reliance, the following experts and reports have contributed information regarding legal, land tenure, corporate structure, permitting, environmental, and other issues in portions of this Technical Report in the Sections as noted below.

Reports used in Section 4, Property Description and Location:

The following reports and documents affirm the ownership of the explorations and mining licences related to Oyu Tolgoi.

- Ministry of Mineral Resources and Energy, Mineral Resources Authority of Mongolia, Conclusion Of The Minerals Council, 1 July 2009. The Minerals Council is a group of Experts appointed by the GOM to review and recommend on the Mongolian Commercial Minerals registration.
- Investment Agreement. The IA describes the licence areas and confirms the ownership by OT LLC.
- TRQ Annual Information Form (AIF) For the year ended 31 December 2012. Dated 25 March, 2013. The AIF describes the circumstances and potential impact of the GOM Resolution 175.
- Integrated Development and Operations Plan, (IDOP) OT LLC April 2011.
- The information on approval status of the Detailed Environmental Impact Assessment Report was provided by OT LLC (email 23 March 2012, OT LLC National Compliance).
- Oyu Tolgoi Project - ESIA, July 2012, http://ot.mn/en/node/2679.
- OT DIDOP ver 1 Draft Section 03-Ownership and Legal Rev1 Dec 2012 provided by OT LLC was used for the description of the ownership, permitting and legal framework of the project and Mongolia.

Reports used in Section 5, Accessibility, Climate, Local Resources, Infrastructure, and Physiography:

- Ivanhoe Mines Mongolia Inc. Oyu Tolgoi Project, Project No. A2MW Process Design Criteria Section:0.05 Site Conditions. Fluor Canada.
- The information in Section 20 Environment was prepared by OT LLC.

Reports used in Section 20, Environmental Studies, Permitting, And Social Or Community Impact:

- Oyu Tolgoi Project - ESIA, July 2012, http://ot.mn/en/node/2679.
- Integrated Development and Operations Plan, (IDOP)OT LLC April 2011.
- EGI Report 8550/589, May 2003. Acid Rock Damage (ARD) Assessment of the Turquoise Hill (Oyu Tolgoi) Gold and Copper Project.

- EGI Report 8550/633, June 2004. Manual for Turquoise Hill Waste Rock Leach Columns Operated by Ivanhoe Mines Mongolia.
- EGI Report 8550/638, June 2004. Preliminary Cover Design Investigations for Control of ARD at Turquoise Hill.
- EGI Report 8550/641, October 2004. Assessment of Geochemical Data for the Turquoise Hill Project.
- EGI Report 8550/677, June 2005. Geochemical Assessment of Pilot Plant and Bench Test Tailings for the Oyu Tolgoi (Turquoise Hill) Project.
- EGI E-mail, 16 June 2005. Oyu Tolgoi Waste Rock Column Update.
- EGI Appendix A – Assessment of Acid Forming Characteristics.
- Aquaterra Report, 15 June 2005. Oyu Tolgoi Integrated Development Plan, Water Supply and Dewatering Sections.
- Aquaterra Report, September 2004. Oyu Tolgoi Camp and Construction Water Supply.
- Aquaterra Report, October 2004. Feasibility Study, Oyu Tolgoi Dewatering Investigation – Open Pit and Block Cave Mining.
- Aquaterra Report, November 2004. Groundwater Conditions at the Hugo Shaft.
- Aquaterra Memo, 12 July 2004. Open Pit and Underground Mine Dewatering Predictions.
- Sustainability Report, 10 January 2005. Training System Development Report.
- Eco-Trade Ltd., October 2002. Environmental Baseline Study.
- Eco-Trade Co., April 2003. Preliminary Community Consultation Report for the Project.
- The Mongolian Academy of Sciences Institute of Archaeology, 2002. The Report for the Archaeological Excavation Conducted on the Licensed Field of the "Ivanhoe Mines Mongolia INCII".
- The Mongolian Academy of Sciences Institute of Archaeology, 2003. A Summary Report of the Archaeological Excavation Works Conducted through Roads from Oyu Tolgoi, an Exploitation Site of "Ivanhoe Mines Mongolia Inc". Company, To Gashuun Sukhait Frontier Crossing Point in the Territory of Khanborg Soum, South Gobi Aimak.
- Eco-Trade Ltd. Environmental Consultants, Mongolia, 2004. Oyu Tolgoi Project Environmental Impact Assessment.
- Volume 1, Report of Oyu Tolgoi to Gashuun Sukhait Road and Infrastructure Corridor, Environmental Protection Plan and Environmental Monitoring Plan.
- Sustainability 2005, Coordinate environmental, archaeological, and socioeconomic assessments and 2007 updates.

Reports used in Section 22 Economic Analysis:

- OT DIDOP VER 1 DRAFT, Section 03-Ownership and Legal Rev1 Dec 2012 provided by OT LLC was used for the assumptions regarding taxes and GOM charges.

- The application of taxes in the costing and economic analysis was reviewed and confirmed by OT LLC. Email A Cookson Subject Re: Tax Questions, 21 March 2013.

Reports used in Section 24.2 Risk Assessment:

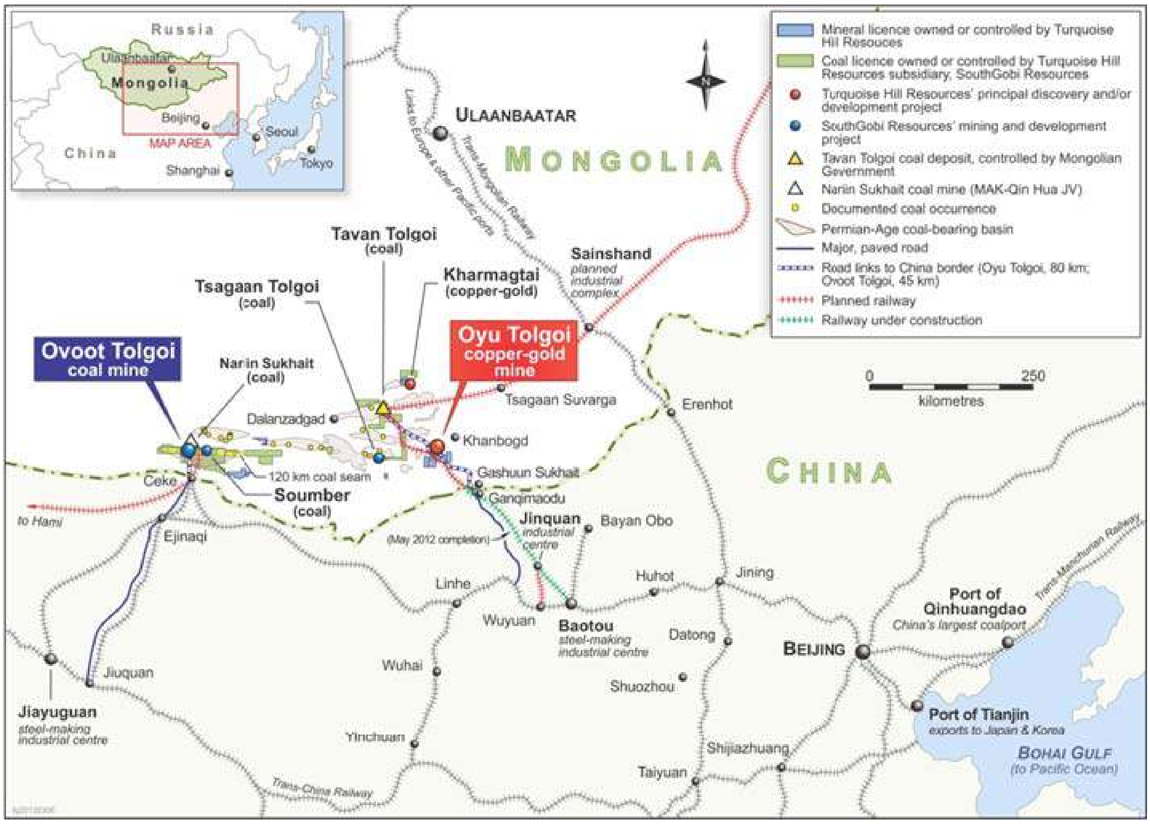
- OT DIDOP VER 1 DRAFT. Section 03-Ownership and Legal Rev1 Dec 2012 provided by OT LLC for political, tax and environmental risks.

4 PROPERTY DESCRIPTION AND LOCATION

4.1 Property Location

The Project is in the Aimag of Omnogovi, located in the South Gobi region of Mongolia. The property is approximately 550 km south of the capital city, Ulaanbaatar, and 80 km north of the border with China (Figure 4.1).

Figure 4.1 Project Location Map



The Project comprises 5 contiguous properties; three held by 100% by Oyu Tolgoi (6708A, 6709A, and 6710A) and two held by Entrée Gold LLC in bare trust for the JV between OT and Entrée (Shivee Tolgoi and Javkhlant).The vast majority of the identified mineralization on the Project occurs within the Oyu Tolgoi Property at the Hugo Dummett and Southern Oyu Porphyry Deposits. Only the northernmost extension of the Hugo Dummett Deposit (Hugo North) crosses onto the Shivee Tolgoi Joint Venture Property and the majority of Heruga mineralization occurs on the Javkhlant property. (Entrée Gold Inc. refers to the Hugo North Deposit within its property limits, as the Copper Flats Deposit.) AMC has relied on OT LLC for the description of the Mineral Tenure in this section.

4.2 Permits and Agreements

4.2.1 Legal – Mongolia

The Mongolian Minerals Law (2006) and Mongolian Land Law (2002) govern OT LLC's exploration, mining, and land use rights for the Project. Water rights are governed by the Mongolian Water Law and the Mongolian Minerals Law. These laws allow licence holders to use the land and water in connection with exploration and mining operations, subject to the discretionary authority of Mongolian national, provincial, and regional governmental authorities as granted under Mongolian law.

OT LLC has and continues to study the permitting and approval requirements for the development of the Oyu Tolgoi Project and maintains a permit and licencing register. OT LLC personnel work with the Mongolian authorities and have developed descriptions of the permitting processes and procedures for the Oyu Tolgoi Project permitting in Mongolia. Key permits have already been obtained and with a small number of permits still in process. OT LLC has advised that it expects that all permits will be obtained in a suitable time frame for the project development. Under the terms of the IA, a working group consisting of OT LLC and government representatives has been formed to assist in the permitting process.

With the adoption of the new Minerals Law in 2006, the GOM set the royalty rate at 5.0% of the sales value of all minerals, except coal and common minerals, extracted from a mining licence area which have been sold, shipped for sale or used. TRQ holds a 2% net smelter returns based payment over the property which was purchased from BHP Exploration in 2004.

For areas covered by exploration licences, an environmental plan accompanied the annual work plans submitted to the relevant soum, or district (Khanbogd Soum). The original environmental performance bond was posted in 1998 by BHP and is still retained by the soum for the ongoing work. Further requirements for environmental impact assessment are discussed below.

4.2.2 Investment Agreement and Taxation Assumptions

Both the process of negotiation and the final agreement presented an opportunity to confirm how the laws of Mongolia should be interpreted in their application to the Oyu Tolgoi Project and provided for some specific terms to apply to the Project. For OT LLC, the agreement has provided the confidence in the stability of the terms the Project will operate under and reliably assess its intended investment in the Project. The agreement itself is effective for an initial term of 30 years with an available extension of a further 20 years.

In accordance with the requirements outlined in the 2006 Minerals Law of Mongolia, upon execution of the IA and the fulfilment of all conditions precedent, the GOM became a 34% shareholder in OT LLC through the immediate issue of OT LLC's common shares to a shareholding company owned by the GOM.

Upon a successful renewal of the IA after the initial 30-year term, the GOM also has the option to increase its shareholding to 50%, under terms to be agreed with TRQ at the time.

The IA has been signed by all parties and became effective at the 31 March 2010 as a number of conditions precedent before terms come into effect were completed to the satisfaction of all parties. The main conditions precedent to the agreement were as follows:

- The submitted Mongolian feasibility study of the Project has been considered in accordance with the laws and regulations of Mongolia.
- Balance of existing income tax losses, capitalized expenses, outstanding tax liabilities or credits, had been confirmed by the tax office.
- The balance of shareholder loans had been agreed and audited.
- Company restructuring required to execute the agreement has been completed.
- A standing working committee being established with members of the GOM and OT LLC to provide a means to expedite permits, customs clearance or general GOM administration.
- Transfer of the Ivanhoe interests in licenses 15225A and 15226A held by Entrée LLC to OT LLC.
- Payment of the second tranche equity investment in Ivanhoe Mines Ltd by Rio Tinto.

Despite its role as an equity owner, the GOM will not be required to contribute to the initial capital cost of the Project, TRQ as the parent company, retains the right to fund the Project by way of a combination of debt, redeemable preference shares and common shares provided the debt to equity ratio falls within the 3:1 ratio required by Mongolian Law.

In the case of shareholder debt, loans (including existing shareholder loans at the time of the agreement) will attract an interest rate of 9.9% (real) with corresponding adjustments to be made to the outstanding balance to reflect increases in US CPI during each period. The coupon rate applicable to redeemable preference shares will be 9.9% (real) and carry the same escalation terms. All principal and interest outstanding on shareholder debt, outstanding coupon payments on redeemable preference shares and the face value of those redeemable preference shares must be paid in full prior to any dividends on common shares being paid.

In 2011, an Amended Shareholders Agreement was concluded which reduced the applicable rate from 9.9% to LIBOR plus 6.5%. In addition, an in principle agreement was reached to convert the balance of preference shares into ordinary shares. Both adjustments were to take place based on the 31 January 2011 balances, although the preference share conversion had not occurred by 31 December 2011.

Under the authority of the Shareholders Agreement, TRQ has the right to act as or appoint a management team to oversee the construction and operation of Oyu Tolgoi. The management team is compensated with a Management Services Payment equal to 3% of total operating and capital costs prior to commencement of operations and 6% of operating and capital costs during operations. This payment is included in the economic analysis as a project expense and is confirmed as tax deductible in the IA.

OT LLC is required to achieve commencement of production within 7 years of the effective date of the agreement.

Under the terms of the IA, a range of key taxes have been identified as stabilized for the term of the agreement at the rates and base currently applied. The following taxes comprise the majority of taxes and fees payable to the GOM under Mongolian Law and are shown with their stabilized rates:

- Corporate income tax 25%
- Royalties 5% (gross sales value)
- Value added tax 10%
- Customs duties 5%

In accordance with the EPT invalidating law, as from 1 January 2011, the taxpayer will not be subject to the excess profits tax or any similar windfall tax.

OT LLC is also only subject to those taxes currently listed in the General Taxation Law and not taxes introduced at any future date. These taxes are collectively noted as non-discriminatory taxes and as such cannot be imposed on OT LLC in any manner other than that applied to all taxpayers. OT LLC may also apply to take advantage of any future law or treaty that comes into force and which would apply any rates lower than those specified in the IA.

The GOM recently enacted amendments to the legislation governing the carry forward of income tax losses. The loss carry forward period has been extended to 8 years and, if sufficient, can be applied to offset 100% of taxable income. This contrasts with the previous law in which losses carried forward for 2 years and were subject to a 50% limit.

The agreement also provides OT LLC with the benefit of a 10% tax credit for all capital investment made during the construction period. The amount of this credit can be carried forward and credited in the three subsequent profitable tax years. It is noted in the agreement that if VAT payments, which are currently non-refundable, become refundable in the future, the availability of the investment tax credit will cease from that point. In that event, past earned investment tax credits will still be applied.

Although it has a requirement to make its self-discovered water resources available to be used for household purposes, it is confirmed in the agreement that OT LLC holds the sole rights to use these water resources for the Project. The contract for the utilization of water with the GOM water authority is in effect for 30 years with subsequent 20-year periods of renewal.

The supply of power has been recognized as being critical to the execution of the Oyu Tolgoi Project in the agreement. OT LLC has been given the right to import power initially but must secure power from sources within Mongolia for the fourth year of operation.

OT LLC also has the right to construct roads for the transport of its product and airport facilities to suit the Project's needs. The GOM has committed to providing OT LLC with non-discriminatory access to any railway constructed between Mongolia and China if such a railway is constructed.

4.2.3 Shivee Tolgoi Property

On 9 November 2004 (the Shivee Tolgoi Effective Date), an Earn-In and Equity Participation Agreement (the Earn-In Agreement) was finalized between Ivanhoe Mines and Entrée Gold Inc. (Entrée) giving Ivanhoe Mines the right to earn an interest in a portion (39,864 ha) of the overall area of Entrée's Shivee Tolgoi property and was initially referred to as the Shivee Tolgoi Earn-in Property (the Earn-in Property; (Figure 2.1). On 11 March 2008, Ivanhoe Mines notified Entrée that it had incurred sufficient expenditures (>$27.5 m) to earn a 60% interest as was outlined in the initial agreement. At the end of June 2008, Ivanhoe Mines notified Entrée that it had incurred sufficient expenditures (>$35 m) to earn an 80% participating interest and thereby forming a joint venture. The property is now referred to as the Shivee Tolgoi Joint Venture ("Shivee Tolgoi JV").

The JV property is adjacent to the north, east, and south of the Oyu Tolgoi Property and includes Entrée's Javkhlant Mining Licence (15225A) and the eastern portion of the Shivee Tolgoi Mining Licence (15226A). The details of the two licences are provided in Table 4.1. The boundaries of the two mining licences are defined by latitude and longitude coordinates and by UTM coordinates with datum set to WGS-84, Zone 48N and these are listed in Table 4.2.

Table 4.1 Details of Shivee Tolgoi Joint Venture Property

Mining Licence	Mining Licence Name	Area (ha)	Area of Agreement (ha)	Licence Date	Date of Licence Extension
15226A	Shivee Tolgoi	54,760	19,518	27 October 2009	27 October 2039
15225A	Javkhlant	20,346	20,346	27 October 2009	27 October 2039
Total			**39,864**		

The two exploration licences (3148X and 3150X) considered in the JV property were granted in April 2001 to a private Mongolian company, Mongol Gazar Co. Ltd. (Mongol Gazar) and were originally acquired by Entrée (through its wholly owned Mongolian subsidiary Entrée LLC) in July 2002 via a 5-year option agreement. In September 2003, the option agreement was replaced by a purchase agreement and Entrée completed the 100% purchase of the licences in November 2003.

In October 2009, Entrée received notice that its application for conversion of the Shivee Tolgoi and Javkhlant exploration concessions to mining licences had been approved by the Mineral Resources Authority of Mongolia and the licences have been received, as shown in Table 4.2.

On 27 February 2013, notice (the “Notice”) was delivered to Entrée by MRAM that by Order No. 43 dated February 22, 2013, the Ministry of Mining had cancelled the 10 July 2009 Order of the Ministry of Mineral Resources and Energy (the “2009 Order”) registering the Hugo North Extension and Heruga reserves. The registration of reserves is a pre-condition to applying for the conversion of an exploration licence into a mining licence. The Notice stated that the 2009 Order breached Clause 48.4 of the Minerals Law of Mongolia and Clause 9 of the Charter of the Minerals Resource Counsel. The Notice further advised that any transfer, sale or lease of the Shivee Tolgoi and Javhlant mining licences is temporarily suspended. Entrée is currently working to determine the full impact of the Notice and to resolve these issues.

Successful conversion of these exploration licences to mining licences was a condition precedent to the IA and the rights of the Earn-In Agreement held by Ivanhoe Mines were transferred to OT LLC.

These mining licences are contained within the Contract Area covered by the IA. Under the terms of the Entrée-OT LLC joint venture, Entrée retains either a 20% or 30% carried interest on these licences, dependent on the depth of mineralization. The duration and financial obligations to the GOM for the mining licences are described in the introduction to Section 4.2.2.

Table 4.2 Shivee Tolgoi Joint Venture Property Boundary Coordinates

Mining Licence	Point	Latitude/Longitude, MSK		UTM, WGS-84, Zone 48N	
		Latitude	Longitude	Easting	Northing
15226A (Shivee Tolgoi eastern portion only)	1	43,08,00 N	106,47,30 E	645752.90	4777222.00
	2	43,08,00 N	107,00,00 E	662698.13	4777605.65
	3	43,00,00 N	107,00,00 E	663051.38	4762798.00
	4	43,00,00 N	106,55,00 E	656258.54	4762639.53
	5	43,03,00 N	106,55,00 E	656131.70	4768192.34
	6	43,03,00 N	106,47,30 E	645950.77	4767967.25
15225A (Javkhlant)	1	43,00,00 N	106,36,00 E	630445.98	4762098.85
	2	43,00,00 N	106,47,30 E	646069.34	4762414.47
	3	42,58,30 N	106,47,30 E	646128.58	4759638.09
	4	42,58,30 N	106,55,00 E	656321.92	4759863.13
	5	43,00,00 N	106,55,00 E	656258.54	4762639.53
	6	43,00,00 N	107,00,00 E	663051.38	4762798.00
	7	42,55,30 N	107,00,00 E	663249.69	4754468.83
	8	42,55,30 N	106,55,00 E	656448.59	4754310.38
	9	42,57,30 N	106,55,00 E	656364.16	4758012.21
	10	42,57,30 N	106,51,30 E	651605.97	4757905.31
	11	42,55,30 N	106,51,30 E	651687.83	4754203.49
	12	42,55,30 N	106,44,00 E	641486.25	4753985.55
	13	42,57,00 N	106,44,00 E	641428.99	4756761.90
	14	42,57,00 N	106,38,00 E	633271.07	4756598.47
	15	42,55,30 N	106,38,00 E	633325.02	4753822.13
	16	42,55,30 N	106,36,00 E	630604.62	4753769.81

Note: Point 1 for each Licence corresponds with the NW corner of the Licence and then moving clockwise (see Figure 4.1)

4.3 Environmental Considerations and Liabilities

Holders of a mining licence in Mongolia must comply with environmental protection obligations established in the Environmental Protection Law of Mongolia, Law of Environmental Impact Assessment and the Minerals Law. These obligations include preparation of an environmental impact assessment (EIA) for mining proposals, submitting an annual environmental protection plan, posting an annual bond against completion of the protection plan and submitting an annual environmental report.

OT LLC has posted environmental bonds to the Mongolian Ministry for Nature and Environment (MNE) in accordance with the Minerals Law of Mongolia for restoration and environmental management work required for exploration and the limited development work undertaken at the site. OT LLC pays to the Khanbogd Soum annual fees for water and road usage, while sand and gravel use fees are paid to the Aimag government in Dalanzadgad.

OT LLC has completed a comprehensive Environmental and Social Impact Assessment (ESIA) for the Oyu Tolgoi Project. The culmination of nearly 10 years of independent work and research carried out by both international and Mongolian experts, the ESIA identifies and assesses the potential environmental and social impacts of the project, including cumulative impacts, focusing on key areas such as biodiversity, water resources, cultural heritage, and resettlement.

The ESIA also sets out measures through all project phases to avoid, minimize, mitigate, and manage potential adverse impacts to acceptable levels established by Mongolian regulatory requirements and good international industry practice, as defined by the requirements of the Equator Principles, and the standards and policies of the International Finance Corporation (IFC), European Bank for Reconstruction and Development (EBRD), and other financing institutions.

Corporate commitment to sound environmental and social planning for the project is based on two important policies: TRQ's Statement of Values and Responsibilities, which declares its support for human rights, social justice, and sound environmental management, including the United Nations Universal Declaration of Human Rights (1948); and The Way We Work 2009, Rio Tinto's Global Code of Business Conduct that defines the way Rio Tinto manages the economic, social, and environmental challenges of its global operations.

OT LLC has implemented and audited an environmental management system (EMS) that conforms to the requirements of ISO 14001:2004. Implementation of the EMS during the construction phases will focus on the environmental policy; significant environmental aspects and impacts and their risk prioritization; legal and other requirements; environmental performance objectives and targets; environmental management programs; and environmental incident reporting. The EMS for operations consists of detailed plans to control the environmental and social management aspects of all project activities following the commencement of commercial production in 2013.

The Oyu Tolgoi ESIA builds upon an extensive body of studies and reports, and DEIA's that have been prepared for project design and development purposes, and for Mongolian approvals under the following laws:

- The Environmental Protection Law (1995)
- The Law on Environmental Impact Assessment (1998, amended in 2001)
- The Minerals Law (2006)

These initial studies, reports and DEIAs were prepared over a six-year period between 2002 and 2008, primarily by the Mongolian firm Eco-Trade LLC, with input from Aquaterra on water issues.

The original DEIA's provided baseline information for both social and environmental issues. These DEIA's covered impact assessments for different project areas, and were prepared as separate components to facilitate technical review as requested by the GOM.

The original DEIA's were in accordance with Mongolian standards and while they incorporated World Bank and IFC guidelines, they were not intended to comprehensively address overarching IFC policies such as the IFC Policy on Social and Environmental Sustainability, or the EBRD Environmental and Social Policy.

Following submission and approval of the initial DEIA's, the Mongolian Government requested that OT LLC prepare an updated, comprehensive ESIA whereby the discussion of impacts and mitigation measures was project-wide and based on the latest project design. The ESIA was also to address social issues, meet Mongolian government (legal) requirements, and comply with current IFC good practice.

For the ESIA the baseline information from the original DEIA's was updated with recent monitoring and survey data. In addition, a social analysis was completed through the commissioning of a Socio-Economic Baseline Study and the preparation of a Social Impact Assessment (SIA) for the project.

The requested ESIA, completed in 2012, combines the DEIA's, the project SIA, and other studies and activities that have been prepared and undertaken by and for OT LLC.

A summary of the previous DEIA's prepared for the Oyu Tolgoi Project is shown in Table 4.3.

Table 4.3 Previous DEIA Studies for the Oyu Tolgoi Project

EIA Study Title	Description	Date	Status
Oyu Tolgoi Project Environmental Baseline Study	This study covers geography, geological, hydrology, hydrogeology, soil, climate, air quality, flora and fauna, the socio-economic status and infrastructure of the Oyu Tolgoi Project site and its surrounding areas.	2002	Submitted November 2002 as DEIA. Screening approval not required for baseline study.
Oyu Tolgoi Project EIA Volume I: Transport and Infrastructure Corridor from Oyu Tolgoi to Gashuun Sukhait	EIA of the original road and power line proposal from Gashuun Sukhait (GS) to Oyu Tolgoi via the western route. See Chapter A5 Figure 5.6. Provides approval for access through the South Gobi Strictly Protected Area (SGSPA).	2004	Approved May 2004.
Supplementary EIA Volume I: For Route Changes to the Oyu Tolgoi to Gashuun Sukhait Transport Corridor	Assessment of the revised Eastern route to GS and includes an assessment of existing environmental damage caused to the western route from coal traffic. See Chapter A5 Figure 5.6.	2006	Approved March 2007.
Oyu Tolgoi Project EIA Volume II: Water Supply from the Gunii Hooloi (GH) and Galbyn Gobi (GG) Groundwater Aquifer Areas	Provides an evaluation of the proposed aquifers for the provision of a sustainable water supply to the Oyu Tolgoi Project.	2005	Approved September 2005.
Supplementary EIA Volume II: Supplementary EIA of GH and GG Groundwater Aquifer Areas	Provides an update of the approved EIA Volume II from 2005. Updated assessment of potential impacts and risks, and upgrade of groundwater monitoring in GH area reflecting higher water demand.	2010	Initial Screening by MNET in December 2009. Final review and approval by the Water Authority and MNET in March 2011.

EIA Study Title	Description	Date	Status
Supplementary EIA Volume II: Supplementary EIA for GH bore field pipelines and associated infrastructure.	The report was updated further based on an engineering report of Dec 2008. The report covers pipelines, wells, pumps, ponds, lagoon, power supply and access roads from the GH Borefield to the Oyu Tolgoi site.	2009	Initial draft 2008. Updated December 2009. Approved March 2010.
Oyu Tolgoi Project Volume III: Oyu Tolgoi Mining and Processing Facilities	EIA of the open pits, underground, and concentrator, tailings, and all facilities and support infrastructure located within the Oyu Tolgoi Mine Licence Area. The assessment was largely based on the 2005 Integrated Development Plan (IDP), but reflected the general permitting layout of May 2006. The maximum production rate was assumed to be 85,000 tpd.	2006	Approved December 2007.
Oyu Tolgoi Project Volume IV: Coal Fired Steam Power Plant	EIA documentation drafted for a 3 x 100 MW coal fired power plant in 2006.	2006	Draft Technical Summary & DEIA completed but not submitted.
Oyu Tolgoi Project Volume V: Domestic Airport Re-location.	The project includes the construction of a temporary gravel Airstrip 10 km north of the Oyu Tolgoi Mine Licence with 2,000 m runway, taxiway, safety end-strip, apron, control tower, passenger terminal, car parking, 15 x 15 m waiting hall, illumination of runway, electric power that is supplied by 40 kVA power generator, surface water drainage system and fence. This EIA covers the new airport construction and operation. This facility is a temporary facility and will be replaced by the Permanent Airport.	2007	Approved September 2007.
Environmental Impact Assessment for the Permanent Airport	EIA for the construction and operation of the Permanent Airport.	2011	Approved 2011.
Undai River Diversion Detailed Environmental Impact Assessment	EIA for the diversion of the Undai River	2011	Awaiting approval by MNET (as of April 2012).

Additional environmental studies that relate to specific components of the project and that have not required a full-scale DEIA have been undertaken to achieve regulatory approvals. These are summarized in Table 4.4.

Table 4.4 Additional Environmental Approvals, Studies, and Environmental Impact Assessments for Oyu Tolgoi Project

Project EIA Component	Description	Date	Status
Petrovis Temporary Fuel Station Facility at Oyu Tolgoi Site	Completed for the fuel facility built in 2004 within the Licence Area	2005	Approved 2005
Oyu Tolgoi Fuel Depot and Fuel Station	The fuel station expanded in 2008 and a new fuel depot was constructed. The fuel station is 2.0 ha, and has 4 half-concealed tanks of 25 m^3 capacity for A-92, A-80 fuel type, 10 tanks of 50 m^3 capacity for diesel, and 2 dispensers.	2010	Submitted to MNET on 18 February 2010 and approved 13 September 2010
Shaft 1	EIA of the shaft, headframe facilities, waste rock, and water disposal	2005	Approved June 2005
Shaft 2	EIA of the shaft, headframe facilities, waste rock, and water disposal	2006	Approved December 2007
Waste Water Treatment Plant	Supplementary documentation for the construction camp waste water treatment plant with a 4,000 person equivalent capacity	2007	Approved May 2007
Quarry Batch Plant and Quarry	Assessment of the existing hard rock quarry, concrete batching plant, and crusher located at the northern boundary of the Licence Area	2007	Approved April 2007
20 MW Diesel Power Plant	The assessment included the initial development of 6 x 2 MW diesel power station (DPS) followed by a stage two addition of 4 x 2 MW diesel generators to the DPS.	2007	Approved September 2007
Chemicals	Covers the importation and use of chemicals for construction and development	2008	Approved April 2008

4.3.1 Scope of the Environmental and Social Impact Statement

The IFC and the EBRD have similar, but different, definitions for the scope of an impact assessment. Both institutions frame assessments in terms of a project's "area of influence." The guidance provided by both IFC and the EBRD and IFC was utilized in defining the scope of the ESIA. Key elements of the scope of the ESIA are set out below.

4.3.1.1 Project Elements Directly Addressed in the ESIA

For the purposes of the ESIA, the "project" constitutes the direct activities that are to be financed and/or over which the project can exert control and influence through its project design, impact management, and mitigation measures. This includes:

- All Oyu Tolgoi Project facilities within the Mine Licence Area and surrounding 10 km buffer zone, including the following key features:
  - Open pit mining facilities.
  - Underground mining facilities.
  - Accommodation camps.
  - Construction-related activities and facilities, including concrete batch plant, quarry, and laydown areas.

  - Power generation facilities.
  - Heating plant and boilers.
  - Crusher.
  - Concentrator.
  - Tailings storage facility.
  - Water management facilities (including diversion of the Undai River).
  - Waste water management facilities for camps and mining operations.
  - Waste management facilities (municipal and industrial).
  - Waste rock storage facilities.
  - Access roads within the Mine License Area.
  - Vehicle and equipment maintenance and repair facilities.
  - Fuel storage facilities.
  - Electrical power distribution.
  - Administration buildings and catering facilities.
- Airport facilities, including a temporary and permanent airport and associated local access roads to the Oyu Tolgoi site.
- Contractor accommodation camps adjacent to Khanbogd.
- Potential dedicated off-site worker accommodation planned for Khanbogd.
- Gunii Hooloi water abstraction borefield and the water pipeline supplying the mine, as well as maintenance roads, pumping stations, construction camps, storage lagoons, and other support infrastructure.
- Infrastructure improvements (and associated resource use) by Oyu Tolgoi between the mine site and the Chinese border, including the 220 kV power transmission line, the access road that will be used for concentrate export, construction camps, local water boreholes, and borrow pits.
- Dedicated border crossing at Gashuun Sukhait for the exclusive use of the Oyu Tolgoi Project.
  - The concentrate will be sold by Oyu Tolgoi at the Mongolia/China border crossing at Gashuun Sukhait. The point of sale marks a key boundary to the project area.
  - Infrastructure Components that may be Transferred to Third-Party Ownership in the Future.

A number of infrastructure components of the project considered within the ESIA will be constructed by OT LLC but may be transferred at some stage to public or third party operation and/or ownership. Transfer of these infrastructure components to public operation and ownership will limit the degree of control that OT LLC can exert over their management and operation.

These infrastructure components may be owned and operated by the Government and will or may be used by members of the public and/or other commercial operations, and include:

- The permanent airport, which is planned to be handed over to the Government after the completion of the project construction phase.
- The road from Oyu Tolgoi to the Chinese border at Gashuun Sukhait, which follows the alignment for the designated national road and is planned to be handed over to the Government upon completion of the project construction phase.
- The dedicated border crossing facility at Gashuun Sukhait, which will be operated by the Mongolian authorities.
- The 220 kV electricity transmission line from the Chinese border to Oyu Tolgoi, which may become owned by the Government of Mongolia.
- Future Project Elements not Directly Addressed in the ESIA.
- In addition to the project elements identified above, certain other activities and facilities are expected to be developed over time, either as part of or in support of the project, that do not constitute part of the project for the purposes of the ESIA. These include:
  - Project expansion to support an increase in ore throughput from 100,000 t/d up to 160,000 t/d.
  - Long-term project power supply. Under the terms of the IA, OT LLC will source electricity from within Mongolia within four years of the commencement of project operations. OT LLC may develop a coal-fired power plant within the Oyu Tolgoi Mine Licence Area to provide the required power from Mongolian sources. This development is considered to be an Associated Facility (as defined in IFC PS1) of the Oyu Tolgoi Project and is the subject of an ESIA that will be supplemental to the ESIA for the Oyu Tolgoi Project.

While the impacts of these future project elements (and their mitigation and management) are not directly addressed in the ESIA they are considered in the cumulative impact assessment of the ESIA.

5 ACCESSIBILITY, CLIMATE, LOCAL RESOURCES, INFRASTRUCTURE AND PHYSIOGRAPHY

5.1 Topography, Elevation, and Vegetation

5.1.1 Topography and Elevation

The topography of the project area largely consists of gravel-covered plains, with low hills along the northern and western lease borders. Small, scattered rock outcrops and colluvial talus are widespread within the northern, western, and southern parts of the property.

The Project is centered at approximately latitude 43°00'45"N, longitude 106°51'15"E or UTM coordinates 4764000 N and 651000 E with datum set to WGS-84, Zone 48N. The Southern Oyu and Hugo Dummett Deposits are the principal zones of mineralization defined on the Project and these occur within a north-north-east trending, 8 km long and 1 km wide mineralized “corridor” in the central portion of the Project at elevations ranging from approximately 1,140 masl to 1,215 masl.

5.2 Property Access

5.2.1 Property Access – General

Access to the property from the Mongolian capital, Ulaanbaatar, is possible either by an unpaved road, via Mandalgovi, a 12 hour drive under good conditions, or by air. Oyu Tolgoi LLC has constructed a 2,000 m long gravel airstrip at the site and routinely receives flights from Ulaanbaatar. The Trans Mongolian Railway crosses the Mongolia-China border approximately 420 km east of the property, traversing the country from south-east to north-west through Ulaanbaatar to the border with Russia. At the Mongolian-Chinese border the rail gauge changes from the Russian standard to the Chinese standard. A desert trail connects the rail line at Sajn Sand to the site.

The Chinese government has upgraded 226 km of road from Ganqimaodao to Wuyuan, providing a direct road link between the Mongolian border crossing at Gushaan Suhait, 80 km south of Oyu Tolgoi, and the Trans-China Railway system. A rough track/trail crosses the desert from the Mongolian border to the site.

Ulaanbaatar has an international airport, and Mandalgovi and Dalanzadgad have regional airports. There is currently charter air service between the site and Ulaanbaatar. The closest regional airport in China is at Hohhot. There are no airport facilities at Wuyuan or Bayan Obo.

5.2.2 Property Access – Protected Areas

The Small Gobi Strictly Protected Area (SGSPA) is approximately 80 km south of the mine licence area, on the Mongolia-China border. The access road corridor traverses through 13 km of the protected area. With the acceptance of the EIA for the corridor in June 2004, OT LLC has received approval to cross through this area.

5.3 Regional Population Centres and Infrastructure

There are a number of communities in the South Gobi region. The most prominent is Dalanzadgad, population 15,000, which is the center of the Omnogovi Aimag and is 220 km north-west of the Oyu Tolgoi property. Facilities at Dalanzadgad include a regional hospital, tertiary technical colleges, a domestic airport, and a 6 MW capacity coal-fired power station. OT LLC envisions that Dalanzadgad may be suitable as a regional center for recruiting and training. The closest community to the property is Khanbogd, the center of the Khanbogd soum. Khanbogd has a population of approximately 2,500 and is 35 km to the east. Other communities relatively near to the Project include Mandalgovi (population 13,500), the capital of the Dundgovi Aimag, 310 km north of the Project on the road to Ulaanbaatar, Bayan Ovoo (population 1,600), 55 km to the west, and Manlai (population 2,400), 150 km to the north.

5.4 Climate and Length of Operating Season

5.4.1 Climate and Operating Season

The South Gobi region has a continental, semi-desert climate. The spring and autumn seasons are cool, summers are hot, and winters are cold. Typical of desert climates, the site has low average humidity and significant variations in daily temperatures.

Knight Piésold conducted an extensive evaluation of the available climatic information for the Project area using regional data from bibliographical sources and local data from nearby climate stations.

The climatic conditions are such that the operating season for the Project will cover the entire year on a continuous shift basis. Minor disruptions are expected and have been allowed for in the Project operating hours estimates.

5.4.2 Data Sources

Data were derived primarily from climatic records for Byan Ovoo, approximately 75 km west of Oyu Tolgoi, and from 2 years of available Oyu Tolgoi site data. Although these data have some limitations, they are considered adequate for use in design. Data were also obtained from Khanbogd, approximately 45 km north-east of the site, Dalanzadgad, 220 km north-west, and Hailutu, 200 km south-west, but the information from Byan Ovoo was deemed the most representative of conditions at Oyu Tolgoi.

5.4.3 Air Temperature

Temperatures range from an extreme maximum of about 50°C to an extreme minimum of about -34°C. The typical air temperature in winter fluctuates between 6°C and -21°C. In the coldest month, January, the average temperature is -12°C. Data from Byan Ovoo are shown in Table 5.1.

Table 5.1 Monthly Temperatures (°C) Based on Byan Ovoo Data

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum	-34	-33	-25	-22	-13	0.4	4	2	-4	-20	-26	-33
Average	-12	-8	-0.4	9	17	23	25	22	16	7	-2	-10
Maximum	9	16	24	31	38	49	40	39	39	30	25	14

5.4.4 Relative Humidity

The average relative humidity ranges from 18.7% in May to 53.3% in January. Daily relative humidity is dependent on current temperature and varies considerably. Table 5.2 shows monthly relative humidity statistics using the calculated hourly averages from the site weather station. The design relative humidity for summer is based on an analysis of the July 2002 and 2003 hourly temperatures and corresponding relative humidity values. The design relative humidity for a 1 July temperature of 34.5°C is 15.1%.

Table 5.2 Monthly Relative Humidity

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum	19	12	3	2	1	1	4	8	1	2	5	10
Average	53	38	23	24	18	31	37	36	34	30	40	43
Maximum	81	67	88	89	100	96	100	100	100	81	85	80

5.4.5 Ground Temperature

From the data available to date, the minimum recorded ground temperature is -39°C and the maximum is 70°C. Table 5.3 shows the design freezing depths at the site based on the Mongolian Climate Data and Geophysical Parameters for Use in Construction Design Code Document No. CNR 2.01-01-93.

Table 5.3 Design Soil Freezing Depths

Soil Type	Freezing Depth(m)
Clayey soil	1.5
Sandy soil	1.9
Gravely soil	2.2

5.4.6 Solar Radiation

Solar radiation data have been collected at the Oyu Tolgoi site station since 2002. Solar radiation is measured in W/m^2 and fluctuates during the day, ranging from 0 W/m^2 at night and peaking soon after mid-day. The average daily maximum for the 2 years of data available is 655 W/m^2, the highest daily maximum is 1,030 W/m^2, and the lowest daily maximum is 76 W/m^2.

Maximum levels of solar radiation are lower during the winter. The average daily maximum is 429 W/m^2 for January and 859 W/m^2 for July.

5.4.7 Precipitation

Average annual precipitation is 57 mmpa, 90% of which falls as rain and the rest as snow. Snowfall accumulations rarely exceed 50 mm. Maximum rainfall events of up to 43 mmph for a 1-in-10-year, 10-minute storm event have been recorded. In an average year, rainfalls occur on only 19 days, and snow falls on 10–15 days. The ground snow load is 0.1 kPa. Monthly rainfall data are shown in Table 5.4 and Table 5.5. Both tables are derived from Byan Ovoo data for 1975 to 2002.

Table 5.4 Rainfall Summary (mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Maximum daily	2.1	3.8	4.4	10.4	19.0	16.2	29.5	102.0	19.2	4.0	4.3	1.5	–
Average monthly	0.4	0.4	0.8	1.4	3.1	8.1	18.1	17.8	5.0	0.9	0.6	0.2	56.8
Average rain days per month	0.6	0.6	1.0	0.8	1.5	3.0	4.5	3.9	1.4	0.6	0.7	0.4	19.0

Table 5.5 Rainfall Intensities (mmph)

Return Interval Duration	1 in 2 Years	1 in 10 Years	1 in 20 Years	1 in 50 Years	1 in 100 Years	1 in 500 Years
10 minutes	15.4	44.2	63.5	99.8	138.3	284.2
30 minutes	10.0	28.7	41.3	64.8	89.9	187.7
60 minutes	6.8	19.5	28.0	44.0	60.9	125.2
2 hours	4.3	12.3	17.7	27.8	38.6	79.3
3 hours	3.2	9.2	13.3	20.9	28.9	59.4
6 hours	1.9	5.5	7.9	12.4	17.2	35.4
12 hours	1.1	3.2	4.6	7.3	10.1	20.7
24 hours	0.7	1.9	2.7	4.2	5.9	12.0
48 hours	0.4	1.1	1.5	2.3	3.2	6.3
72 hours	0.3	0.8	1.0	1.6	2.2	4.2

5.4.8 Thunderstorms and Lightning

Local records indicate that thunderstorms are likely to occur from 2 to 8 days each year at Oyu Tolgoi. Electrical activity generally totals about 29 hours each year. An average storm will have up to 83 lightning flashes a minute.

5.4.9 Evaporation

Given the importance of this variable for determining project water requirements, a number of different methods were used to generate and analyse evaporation data to determine design levels. The results are summarized in Table 5.6. It should be noted that site measurements are ongoing to confirm these results.

Table 5.6 Design Evaporation Data

Month	Sublimation (Water bodies Frozen in Winter) (mm)	Evaporation	
		Winter	Summer
		(Open Water bodies) (mm)	
January	22	82	–
February	41	101	–
March	–	–	142
April	–	–	256
May	–	–	439
June	–	–	378
July	–	–	382
August	–	–	285
September	–	–	192
October	–	–	132
November	53	11	–
December	27	88	–
Total Water Loss: Sublimation + Evaporation = 2,349 mm			

5.4.10 Wind Loading and Dust Generation

Wind is usually present at the site, predominantly from the north. Very high winds are accompanied by sandstorms that often severely reduce visibility for several hours at a time. At present, site-specific wind monitoring data are available for only a short period of time, less than a year. Based on regional information, windstorms can have gusts up to 50 m/s. Snowstorms and blizzards with winds up to 40 m/s occur in the Gobi region for 5 to 8 days each Winter. Spring dust storms are far more frequent and can continue through June and July. The average storm duration is 6 to 7 hours. An average of 120 hours of dust storm activity and 220 hours of drifting dust are recorded each year.

Based on the Mongolian Code, the Basic Wind Speed is 34 m/s. Maximum 1 hour speeds recorded at Byan Ovoo are shown in Table 5.7. The number of dust storms per month is shown in Table 5.8.

Table 5.7 Maximum One-Hour Wind Speeds (m/s) at Byan Ovoo

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Maximum wind speed	13.4	14.0	15.4	18.1	16.6	16.2	16.3	14.8	16.0	18.6	19.3	14.5

Table 5.8 Frequency of Dust Storms in the Gobi Desert

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
No. of days	0.7	1.0	2.4	4.7	4.1	1.5	1.0	0.4	0.6	0.7	1.9	0.7

5.5 Site Infrastructure and Local Resource Considerations

5.5.1 Power

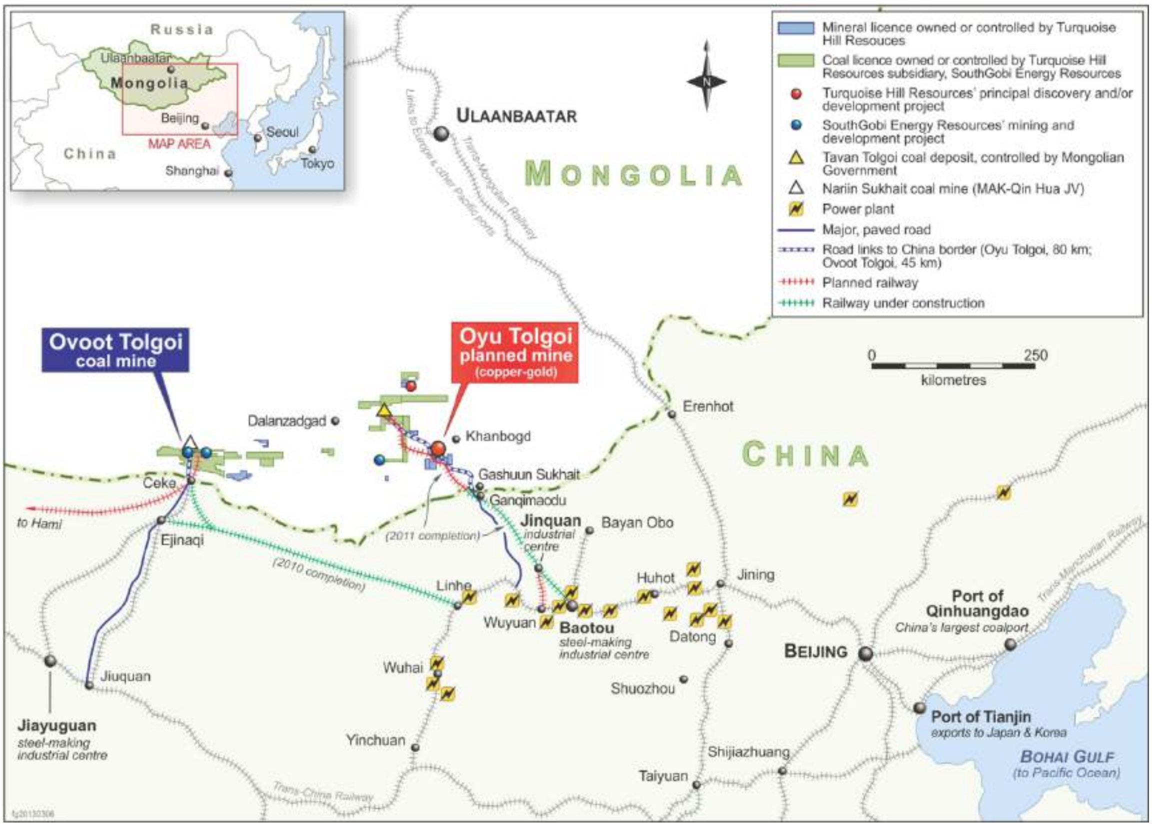
The supply of power has been recognized as being critical to the execution of the Oyu Tolgoi Project in the IA. OT LLC has been given the right to import power initially but must secure power from sources within Mongolia from the fourth year of operation.

TRQ announced on 5 November 2012, that Oyu Tolgoi had signed a binding Power Purchase Agreement with the Inner Mongolia Power Corporation to supply power to the Oyu Tolgoi mine. The term of this agreement covers the commissioning of the business plus the initial four years of commercial operations. The locations of power providers in northern China is shown in Figure 5.1.

TRQ continues to evaluate several options to meet its commitment to sourcing power from within Mongolia including the development of a dedicated power plant and ownership and funding options to meet this requirement.

The Oyu Tolgoi IA recognized that the reliable supply of electrical power is critical to the mine. The agreement also confirmed that TRQ has the right to obtain electrical power from inside or outside Mongolia, including China, to meet its initial electrical power requirements for up to four years after Oyu Tolgoi commences commercial production.

Figure 5.1 Power Northern China Grid



5.5.2 Water

The Project area is located within the closed Central Asian drainage basin and has no outflow to the ocean. Most riverbeds in this drainage basin are ephemeral creeks that remain dry most times of the year. The Undai River is the most significant hydrological feature of the Project area. A tributary of the river passes through the site.

Flows after heavy summer rainstorms often result in very turbulent, high-velocity mud flows, locally termed “Gobian wild floods.” These floods have been known to destroy road crossings and to carry away vehicles caught in the riverbeds. No surface flow data are available for these isolated and episodic flood events. During exploration, only two such events were experienced from 2002 to 2009. Further discussions with locals indicate these events can occur yearly (excluding current drought conditions).

Shallow springs are used by wildlife and livestock as drinking water sources. Migratory wildlife movements during summer months in the Gobi are likely to be dictated by the presence of surface water in natural springs.

Water quality baseline data for surface waters throughout the Project area, access road corridor, and aquifer areas are being collected through current monitoring programs. This information will be established prior to project development as a basis for assessing potential project-related impacts on surface water quality during routine monitoring.

Potential impacts on surface water systems in the Project area will include local changes to natural flow paths and depletion of springs, ephemeral wetlands, and salt-marshes from project development and operation activities. The mitigation and design work with regard to surface water focused on the potential impacts to surface water quality include increased sedimentation and risk of pollution of springs, ephemeral wetlands, and salt-marshes from increased erosion, contaminated dust fallout, contaminant spills, and accidents associated with project construction and operational activities.

Fugitive dust control management plans and spill management systems are being developed to avoid and mitigate potential impacts to air and surface water quality. These studies will be used to mitigate impacts that may result in loss of wildlife habitat, decrease in wildlife health, and decrease in wildlife population because of higher mortality rates.

On and off-site infrastructure associated with the upgrading of road facilities at the site and along the corridor include the formation of dedicated stream crossings, which may reduce the number of undefined and informal crossings that now exist along tracks within the corridor.

5.5.2.1 Hydrogeology and Groundwater Quality

Detailed groundwater investigations to date have been concentrated in the Gunii Hooloi, Galbyn Gobi, and Nariin Zag aquifer areas to assess the potential to meet the Oyu Tolgoi Project’s estimated water demand. Groundwater investigations conducted in

the mine licence area focused on assessment of required dewatering rates for mine works and the potential to meet the Project's camp and construction water demands.

Process water supply has been registered and will be piped from the Gunii Hooloi basin to the north-west of the Project area. Current studies are ongoing at site to confirm groundwater model predictions with respect to dewatering of the pit and underground and groundwater environmental impacts.

5.5.3 Site Infrastructure

Oyu Tolgoi is a remote greenfields project and extensive infrastructure has been constructed in addition to the concentrating facilities. The major initial infrastructure elements include:

- Water Borefields

  Water is supplied from the Gunii Hooloi basin which extends 35 to 75 km north of the Oyu Tolgoi site. Bores will be developed in the south-west and the north-east areas of the Gunii Hooloi borefield with storage lagoons along the pipeline designed to provide for emergency use without impacting site water needs.

- Water Treatment

  A permanent water treatment facility and bottling plant has been constructed to treat raw water from the Gunii Hooloi borefield to drinking (potable) and domestic water standards.

- Housing

  Accommodation facilities will be constructed to support the operations phase of the Project. Temporary facilities will also be constructed throughout the Project to support additional manpower requirements for construction and expansion demands.

- Airstrip

  The airport will be located approximately 7 km north of the Oyu Tolgoi mine site and facilitates the transport of people and goods to the site from Ulaanbaatar and other points of departure.

- Supporting Facilities

  Administration, training, mine equipment maintenance, gatehouse, medical center, fire station, heating plant, fuel storage, and warehouse facilities, among others were constructed to support operational requirements over the life-of-mine.

- Railroads

  During the initial 3 years of operation, the transport of bulk supplies and the delivery of copper concentrate to China will be by access road to the railhead. However, direct rail transport is considered a long-term transportation solution after this initial development period.

5.5.4 Other

5.5.4.1 Land Use

The land surrounding the mine licence area is predominantly used for nomadic herding of goats, camels, and sheep by small family units. Use is based on informal traditional Mongolian principles of shared grazing rights with limited land tenure for semi-permanent winter shelters and other improvements. Initiation of the herder support program has reduced the incidence of land use conflict between current mineral exploration and grazing practices. The Project intends to maintain co-existence of traditional grazing practices and mineral development except where there is a risk to public safety or livestock.

5.5.4.2 Risk Assessment

The Law of Mongolia on Environmental Impact Assessment (2001) and the guidelines issued for the IMMI EIA (2001) require the inclusion of a risk assessment in project documentation. “Risk assessment” means identification and prediction of the possible emergencies and accidents that could occur during the production process or natural disasters, and elimination and mitigation of their consequences.

5.5.4.3 Ongoing Work

A complete list of outstanding work to be completed at various stages of development, and current status, is included in the report. Key work includes baseline studies and assessment of project-related impacts along the access road corridor from Mongolia-China border to Wuyuan, China; wildlife population dynamics, habitat use, ecology and migratory habits of key species within the region; transboundary issues, cumulative effects, human health risks, and noise effects; and continued evaluation of acid mine drainage and metal leachate potential, hydrology, water quality of surface water occurrences, groundwater resources, air quality, soil chemistry; and projected impacts. Completion of this work will aid in customizing and improving existing environmental management and monitoring plans as part of an Adaptive Environmental Management System.

5.5.4.4 Closure and Reclamation

As part of overall project planning, OT LLC has prepared a preliminary reclamation and closure plan. Certain features of the mine, such as the open pit, waste dumps, and tailings impoundment, will create permanent changes to the current landscape that cannot be completely remedied through reclamation. The closure plan will; however, ensure that these disturbed areas are seismically and chemically stable as to limit the ecological impacts to the surrounding water, air, and land.

The closure plan for the Project will address the socio-economic impacts of mine closure considering that the existence and economic survival of some communities may have become dependent on the Project. Issues include ongoing environmental management during and after reclamation, loss of jobs, and socio-economic impact to the region.

The primary reclamation objective is to develop the mine in a manner that prevents leaving an unsustainable environmental legacy and that considers community input and values. Other key objectives are as follows:

- Protect public health and safety during all stages of project development.
- Prevent or mitigate environmental degradation caused by mining-related activities.
- Return the maximum amount of disturbed land to pre-mining conditions suitable for nomadic herdsmen and their grazing animals.
- Secure the open pit areas, subsidence zones, waste dumps, and tailings storage facilities to ensure public and environmental safety.
- Plan and implement reclamation techniques that eliminate the need for long-term maintenance presence on site and permit OT LLC to "walk away" from the reclaimed mine with no environmental or social encumbrances.

OT LLC will develop environmental monitoring plans, including proposed activities and schedules, to ensure that environmental parameters meet the criteria, standards, and limits laid out in the EIA and Environmental Protection Plan. In accordance with Mongolian law, OT LLC will undertake monitoring at its own expense using approved methods and accredited facilities. The monitoring will permit procedures and activities to be adjusted and/or modified as necessary to ensure optimal environmental protection.

Parameters to be monitored during the closure and post-closure phases of the mine include the following:

- Surface water and groundwater quality.
- Physical stability of tailings deposits.
- Physical stability of the river water diversion dike, waste rock dumps, drainage ditches, and concrete shaft/raise caps.
- Isolation of open pit voids and unfilled subsidence zones, including status of open water and erosion controls.
- Success of indigenous revegetation, including remediation as required until proven to be self-sustaining.
- Condition of groundwater monitoring wells, piezometers, survey monuments, and other instrumentation.
- Effectiveness of dust-control measures on waste rock, tailings storage facility, and other waste areas with specific attention to potential wind-blown contaminant sources.

5.5.4.5 Seismic Zone and Risk

OT LLC reported in IDOP that a seismic hazard assessment of the Oyu Tolgoi site was completed. The seismicity of the Oyu Tolgoi site was determined to be low, and the seismicity of eastern Mongolia is generally low. However, to the west of Oyu Tolgoi lies the Mongolian Altai – a tectonically active mountain range stretching 1,700 km from south-west Siberia to the Gobi Desert. The easternmost extension of the Mongolian Altai is known as the Gobi Altai, which dies out approximately 50 km to 100 km west of Oyu Tolgoi.

The Research Center for Astronomy and Geophysics of Academy of Science (Seismology Center) is responsible for assessing seismology in Mongolia. OT LLC appointed the Seismology Center to perform a seismic assessment for the project that was incorporated into the assessment.

6 HISTORY

6.1 Project Exploration History

6.1.1 Oyu Tolgoi Licence

The existence of copper in the Oyu Tolgoi area has been recognized since the Bronze Age, but contemporary exploration for Mineral Resources did not begin until the 1980s, when a joint Mongolian and Russian geochemical survey team identified a molybdenum anomaly over the Central deposit. Evidence of alteration and copper mineralization at the South deposit was first noted by Garamjav in 1983, during a regional reconnaissance of the area. In September 1996, Garamjav guided geologists from Magma Copper Company (Magma) to the area. These geologists identified a porphyry-copper leached cap over Central Oyu and quickly moved to secure exploration tenements. Magma was subsequently acquired by BHP (BHP), later BHP-Billiton. The target at Oyu Tolgoi was a large supergene-enriched porphyry.

Geophysical surveying at Oyu Tolgoi was first initiated by BHP in 1997. An airborne magnetometer survey was flown at a height of approximately 100 m on 300 m-spaced, east-west oriented lines over approximately 1,120 km^2 of BHP's mineral concession. The survey provided good resolution of the magnetic features to facilitate geological and structural interpretation across the concession areas. BHP also undertook an induced polarization (IP) survey utilising a single gradient array with a 2,000 m AB and a ground magnetometer survey. The first survey was conducted on north-south-oriented lines and produced data that were difficult to reconcile to the then-known geology. A later survey completed in 2001 was conducted on east-west-oriented lines, and therefore perpendicular to the structural grain. This immediately showed the close correlation between mineralization and chargeable response, which has proven to be highly successful in further exploration. Both IP datasets were surveyed by a local Mongolian surveying team at 250 m line spacing. The surveys covered the Southern, Southwest, Central, and North Oyu exploration targets but did not extend into the Far North region that ultimately became the Hugo Dummett deposit.

BHP carried out geological, geochemical (stream sediment and soil), and geophysical surveys and diamond drilling programs (23 drillholes total) in the Central and South deposits in 1997 and 1998. Copper and gold values were encountered at depths from 20 m to 70 m below surface, and a supergene-enriched, chalcocite blanket was encountered in one drillhole (OT-3). Based on the results of this drilling, BHP performed a mineral resource estimate in 1998, but the resulting tonnage and grade estimate was considered too small to meet BHP corporate objectives, and BHP elected to offer the property for joint venture.

Ivanhoe visited Oyu Tolgoi in May 1999 and agreed to acquire 100% interest in the property, subject to a 2% net smelter return royalty. In 2000, Ivanhoe completed 8,000 m of reverse circulation (RC) drilling, mainly at the Central deposit, to explore the chalcocite blanket discovered earlier by BHP. Based on this drilling, Ivanhoe updated the mineral resource estimates.

In 2001, Ivanhoe continued RC drilling, mostly in the South deposit area, to test for additional supergene copper mineralization, and then drilled three core holes to test the deep hypogene copper–gold potential. One of these holes, OTRCD150, drilled over Southwest Oyu, intersected 508 m of chalcopyrite mineralization from a depth of 70 m, grading 0.81% Cu and 1.17 g/t Au. This marked the discovery of the Southern Oyu deposit.

These results encouraged Ivanhoe to mount a major follow-up drill program. In late 2002, drilling in the far northern section of the property intersected 638 m of bornite–chalcopyrite-rich mineralization in drillhole OTD270, starting at a depth of 222 m. This hole marked the discovery of the Hugo Dummett deposit. A first-time mineral resource estimate for the deposit was prepared in 2004, and the mineral resources were updated in 2005 and again in 2007.

In 2004, a scoping study was prepared to evaluate the economics of mining the Southern Oyu deposit by open-pit methods. In 2005, the first integrated development plan (IDP05) for the project was prepared, which envisaged the Southern Oyu deposit being open-pit mined, and the Hugo North deposit being extracted using underground block-cave methods.

Ivanhoe initiated a 6.7 m diameter exploration shaft (Shaft 1) into the Hugo North Deposit. The Shaft 1 head-frame, hoisting plant and associated infrastructure were completed in January 2006. The shaft was completed to a depth of 1,385 m in January 2008. Shaft 1 is designed to provide access to the Hugo North and Hugo South deposits. Development from the shaft will enable additional delineation drilling and rock characterization for proposed mining operations. Lateral development work is currently in progress.

In 2010, the integrated development plan (IDP) was updated as a development and operating plan (IDOP) within the framework of a signed and effective IA with the Government of Mongolia. The 2010 integrated development plan (IDP10) assumed that the mining operation would still comprise open pit mining of the Southern Oyu deposit and block caving of an initial portion of the Hugo North deposit. Development of the Hugo South, Heruga, and a second stage of Hugo North were considered in the DIDOP Addendum as part of a sensitivity case, as development of these deposits was likely to require future separate development decisions.

During 2011–2012, a detailed integrated development and operating plan was prepared (DIDOP); the report is an update of IDOP and IDP10.

6.1.2 Joint Venture Licences

Exploration work on the Shivee Tolgoi and Jahvklant licences was initiated in November 2004, following the signing of the Earn-in Agreement with Entrée Gold.

Prior to that time, Entrée had undertaken soil geochemical surveys, ground magnetics, Bouguer gravity and pole-dipole geophysical surveying, and geological mapping, but had failed to locate any mineralization of significance.

Starting at the northern boundary of the Oyu Tolgoi mining licence, an IP survey was run on 100 m spaced lines oriented east-west to trace the northern projection of the Hugo North deposit. This initial IP survey used gradient array with 11,000 m AB electrode spacing, and covered an area extending 5.6 km north of the boundary and 10 km in width. Subsequent IP surveys covering smaller areas within the larger area were carried out with gradient arrays. The IP surveys resulted in the delineation of a significant chargeability feature being traced for approximately 4 km north along strike of the Hugo North deposit. Additional IP chargeability targets were also revealed 2.5 km to 3 km west of the Hugo North trend and are referred to as the Eagle anomalies.

Ivanhoe commenced drilling northward from the northern boundary of the Oyu Tolgoi mining licence in 2005. A first-time resource estimate for the Hugo North Extension deposit was completed in 2006.

In 2005 and 2006, IP surveying was carried out on 100 m spaced, east-west lines across Entrée Gold’s Javkhlant licence to the south of the Southern Oyu Mineral Resource area. This resulted in the discovery of three significant chargeability IP anomalies subsequently named the Sparrow South, Castle Rock, and SW Magnetic anomalies. Core drilling was initiated to test these IP anomalies in early 2007. A series of successful drillholes in the area supported a first-time mineral resource estimate over what is now known as the Heruga deposit (formerly the Sparrow South anomaly) in 2008.

7 GEOLOGICAL SETTING AND MINERALIZATION

7.1 Geological Setting

Information in this section is collated from geological and technical reports completed on the project during the period 2003–2011, the PhD thesis completed by Alan Wainwright on the Oyu Tolgoi deposit setting in 2008, and other sources as noted.

7.1.1 Deposit Model

The Oyu Tolgoi deposits display copper–gold porphyry and related high-sulphidation copper–gold deposit styles.

The following discussion of the typical nature of porphyry-copper deposits is sourced from Sillitoe (2010), Singer et al. (2008), and Sinclair (2006).

7.1.1.1 Geological Setting

Porphyry-copper systems commonly define linear belts, some many hundreds of kilometres long, and some occurring less commonly in apparent isolation. The systems are closely related to underlying composite plutons, at paleo-depths of 5 km to 15 km, which represent the supply chambers for the magmas and fluids that formed the vertically elongate (>3 km) stocks or dyke swarms and associated mineralization.

Commonly, several discrete stocks are emplaced in and above the pluton roof zones, resulting in either clusters or structurally controlled alignments of porphyry-copper systems. The rheology and composition of the host rocks may strongly influence the size, grade, and type of mineralization generated in porphyry-copper systems. Individual systems have life spans of circa 100,000 years to several million years, whereas deposit clusters or alignments, as well as entire belts, may remain active for 10 million years or longer.

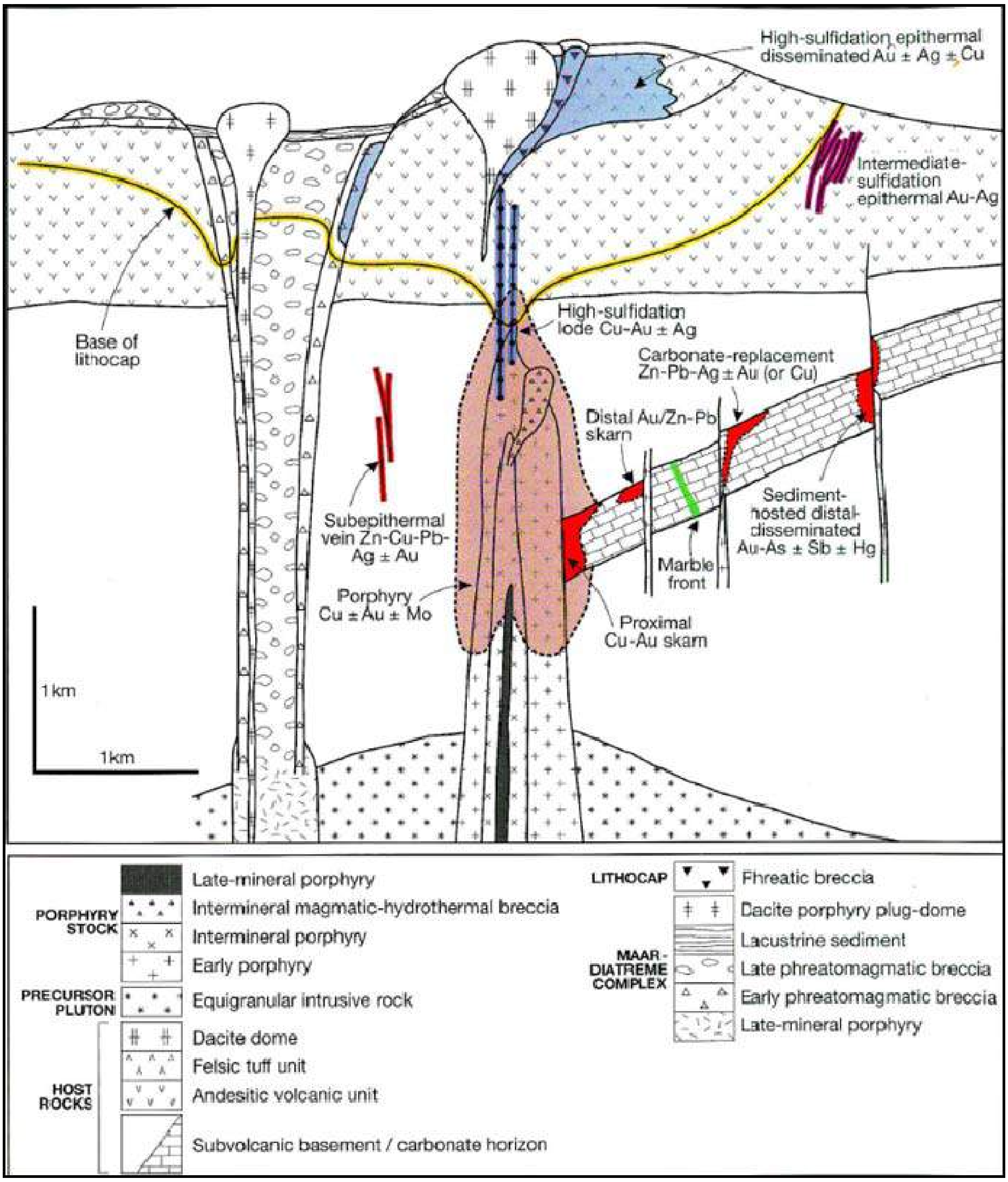
Deposits are typically semicircular to elliptical in plan view. In cross-section, ore-grade material in a deposit typically has the shape of an inverted cone with the altered, but low grade, interior of the cone referred to as the “barren” core. In some systems, the barren core may be a late-stage intrusion.

The alteration and mineralization in porphyry-copper systems are zoned outward from the stocks or dyke swarms, which typically comprise several generations of intermediate to felsic porphyry intrusions. Porphyry copper–gold–molybdenum deposits are centred on the intrusions, whereas carbonate wall rocks commonly host proximal copper–gold skarns and less commonly, distal base metal and gold skarn deposits. Beyond the skarn front, carbonate-replacement copper and/or base metal–gold deposits, and/or sediment-hosted (distal-disseminated) gold deposits can form. Peripheral mineralization is less conspicuous in non-carbonate wall rocks, but may include base metal- or gold-bearing veins and mantos. Data compiled by Singer et al. (2008) indicate that the median size of the longest axis of alteration surrounding a porphyry copper deposit is 4 to 5 km, while the median size area of alteration is 7 to 8 km^2.

High-sulphidation epithermal deposits may occur in lithocaps above porphyry-copper deposits, where massive sulphide lodes tend to develop in their deeper feeder structures, and precious metal-rich, disseminated deposits form within the uppermost 500 m.

Figure 7.1 shows a schematic section of a porphyry-copper deposit, illustrating the relationships of the lithocap to the porphyry body and associated mineralization styles.

Figure 7.1 Schematic Section, Porphyry-Copper Deposit



Note: Figure from Sillitoe (2010)

7.1.1.2 Mineralization

Porphyry-copper mineralization occurs in a distinctive sequence of quartz-bearing veinlets as well as in disseminated forms in the altered rock between them. Magmatic-hydrothermal breccias may form during porphyry intrusion, with some breccias containing high-grade mineralization because of their intrinsic permeability. In contrast, most phreatomagmatic breccias, constituting maar–diatreme systems, are poorly mineralized at both the porphyry copper and lithocap levels, mainly because many such phreatomagmatic breccias formed late in the evolution of systems, and the explosive nature of their emplacement fails to trap mineralizing solutions.

Copper-ore mineral assemblages are a function of the chemical composition of the fluid phase and the pressure and temperature conditions affecting the fluid. In primary, unoxidized or non supergene-enriched ores, the most common ore–sulphide assemblage is chalcopyrite ± bornite, with pyrite and minor amounts of molybdenite. In supergene-enriched ores, a typical assemblage can comprise chalcocite + covellite ± bornite, whereas, in oxide ores, a typical assemblage could include malachite + azurite + cuprite + chrysocolla, with minor amounts of minerals such as carbonates, sulphates, phosphates, and silicates. Typically, the principal copper sulphides consist of millimetre scale grains, but may be as large as 1 to 2 cm in diameter and, rarely, pegmatitic (larger than 2 cm).

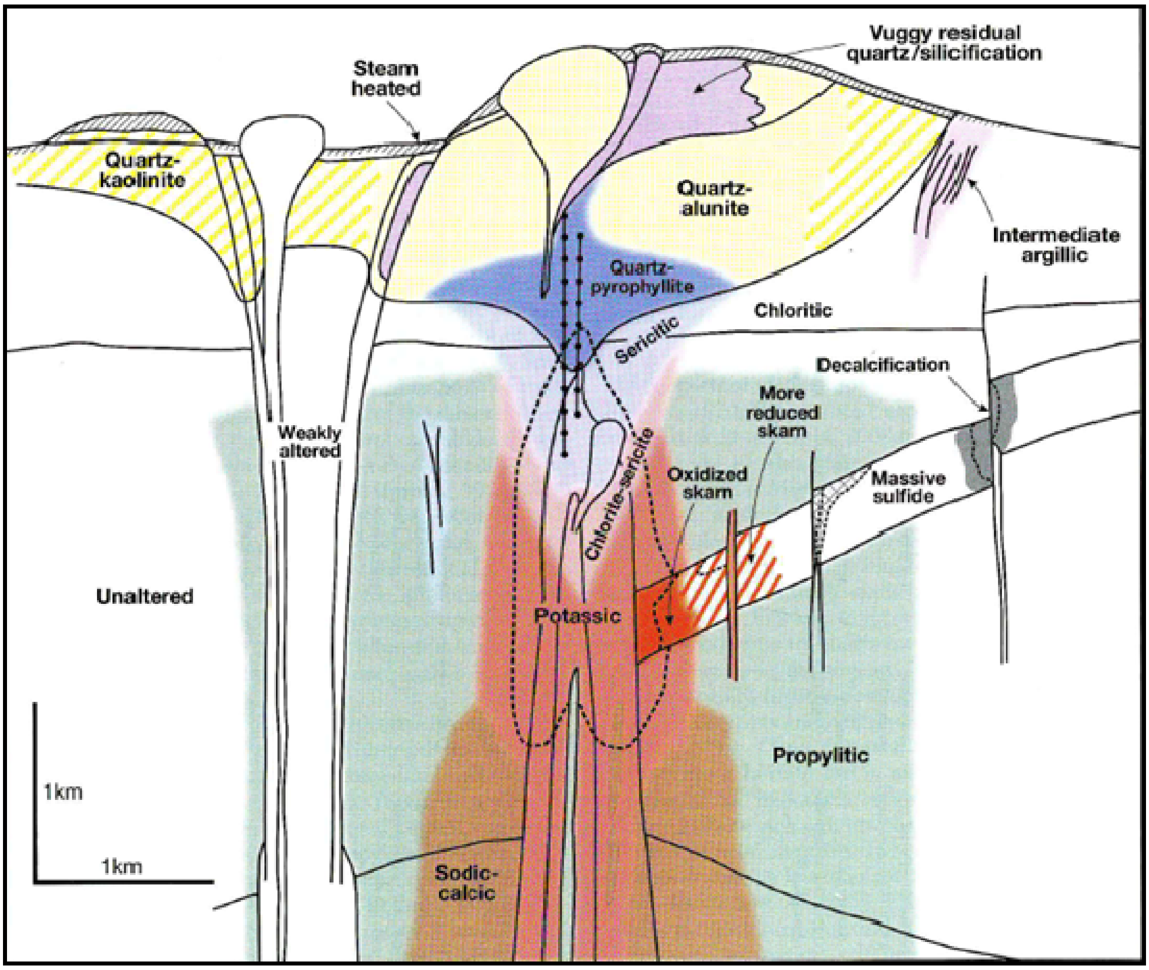
7.1.1.3 Alteration

Alteration zones in porphyry-copper deposits are typically classified on the basis of mineral assemblages. In silicate-rich rocks, the most common alteration minerals are K-feldspar, biotite, muscovite (sericite), albite, anhydrite, chlorite, calcite, epidote, and kaolinite. In silicate-rich rocks that have been altered to advanced argillic assemblages, the most common minerals are quartz, alunite, pyrophyllite, dickite, diaspore, and zunyite. In carbonate rocks, the most common minerals are garnet, pyroxene, epidote, quartz, actinolite, chlorite, biotite, calcite, dolomite, K-feldspar, and wollastonite. Other alteration minerals commonly found in porphyry-copper deposits are tourmaline, andalusite, and actinolite. Figure 7.2 shows the typical alteration assemblage of a porphyry copper system.

Porphyry-copper systems are initiated by injection of oxidized magma saturated with sulfur- and metal-rich, aqueous fluids from cupolas on the tops of the subjacent parental plutons. The sequence of alteration–mineralization events is principally a consequence of progressive rock and fluid cooling, from >700° to <250°C, caused by solidification of the underlying parental plutons and downward propagation of the lithostatic–hydrostatic transition. Once the plutonic magmas stagnate, the high temperature, generally two phase hyper-saline liquid and vapour responsible for the potassic alteration and contained mineralization at depth and early overlying advanced argillic alteration, respectively, gives way, at <350°C, to a single-phase, low-to-moderate-salinity liquid that causes the sericite–chlorite and sericitic alteration and associated mineralization. This same liquid also is a source for mineralization of the peripheral parts of systems, including the overlying lithocaps.

The progressive thermal decline of the systems combined with syn-mineral paleo-surface degradation results in the characteristic overprinting (telescoping) and partial to total reconstitution of older by younger alteration–mineralization types. Meteoric water is not required for formation of this alteration–mineralization sequence although its late ingress is commonplace.

Figure 7.2 Schematic Section Showing Typical Alteration Assemblages



Note: Figure from Sillitoe (2010)

7.1.1.4 Applicability of the Model to Oyu Tolgoi

Features that classify the Oyu Tolgoi deposits as porphyry-copper-type deposits include:

- Mineralization is in or adjoining porphyritic intrusions of quartz monzodiorite composition.
- Multiple emplacements of successive intrusive phases and a variety of breccias are present.
- Mineralization is spatially, temporally, and genetically associated with hydrothermal alteration of the intrusive bodies and host rocks.

- Large zones of veining and stockwork mineralization, together with minor disseminated and replacement mineralization, occur throughout large areas of hydrothermally altered rock, commonly coincident wholly or in part with hydrothermal or intrusion breccias.
- Hydrothermal alteration is extensive and zoned, which is common to porphyry copper deposits. Major alteration minerals in the biotite–chlorite, intermediate argillic, sericite, and K-spar alteration zones include quartz, chlorite, sericite, epidote, albite, biotite, haematite–magnetite, pyrophyllite, illite, and carbonate. Advanced argillic alteration zones can contain minerals such as kaolinite, zunyite, pyrophyllite, muscovite, illite, topaz, diaspore, andalusite, alunite, montmorillonite, dickite, tourmaline, and fluorite. In the leached cap, smectite and kaosmectite can also occur. The alteration assemblages are consistent with the physico-chemical conditions of a porphyry environment.
- Pyrite is the dominant sulphide, reflecting the typical high-sulfur content of porphyry-copper deposits. The major ore minerals include chalcopyrite, bornite, chalcocite, covellite, and enargite. In some zones, minerals such as tennantite, tenorite, cubanite, and molybdenite have been identified. Gold typically occurs as inclusions in the sulphide minerals.
- Copper grades are typical of the range of porphyry-copper grades (0.2% to >1% Cu).

The Oyu Tolgoi porphyry-copper deposits display a range of mineralization styles, alteration characteristics, and deposit morphologies that are likely to reflect differences in structural controls, host rock lithology, and depth of formation. Structural influences account for the most part for the differences in shape and distribution of mineralization within the deposits. The more typical copper–gold porphyry style alteration and mineralization tend to occur at deeper levels, predominantly within basalt and quartz monzodiorite.

High-sulphidation mineralization and associated advanced argillic alteration are most common within the wall rocks (basaltic tuffs and fragmental rocks) to the quartz monzodiorite, where it intrudes to levels high in the stratigraphic succession and in narrow structurally controlled zones. High-sulphidation mineralization often forms in steam condensate zones and then collapses back into the hypogene zone, causing overprinting and textural destruction.

The Hugo Dummett deposits have several features that are unusual when compared with typical porphyry-copper systems, including:

- Anomalously high copper and gold grades, particularly in the northern part.
- An unusually weakly altered pre-mineral volcano-sedimentary cover sequence that lies just above the porphyry system.
- Quartz + sulphide vein contents commonly exceeding 15%, and locally in excess of 90%, in the high grade portion of the deposit.
- A highly-elongate gently-plunging tabular shape to the high-grade stockwork system.

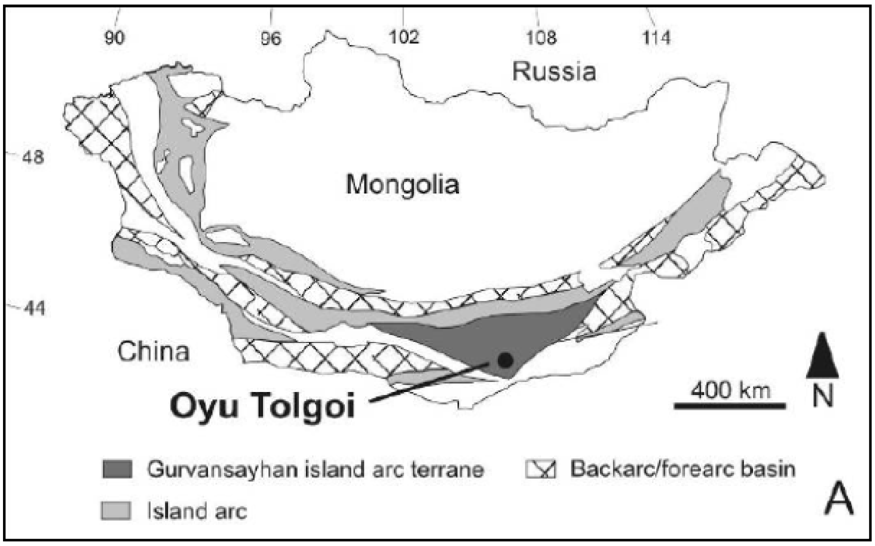
The formation of the known, 800 m extent, high-grade portion of the Hugo Dummett deposits as a tabular, intensely veined, subvertical body contrasts markedly with most porphyry-copper deposits, which tend to have steep, roughly cylindrical, or elongate forms. The unusual form of the Hugo Dummett deposits could be the result of emplacement within a structurally restricted zone. The lack of alteration in the overlying sequence is likely a reflection of the chemical inertness of the siltstone sequences.

The Heruga deposit is also slightly unusual in that, unlike the other Oyu Tolgoi deposits, it has distinctly higher grades of molybdenum, which form a molybdenum-rich carapace at higher elevations overlying gold–copper-rich mineralization at depth.

7.1.2 Regional Geology

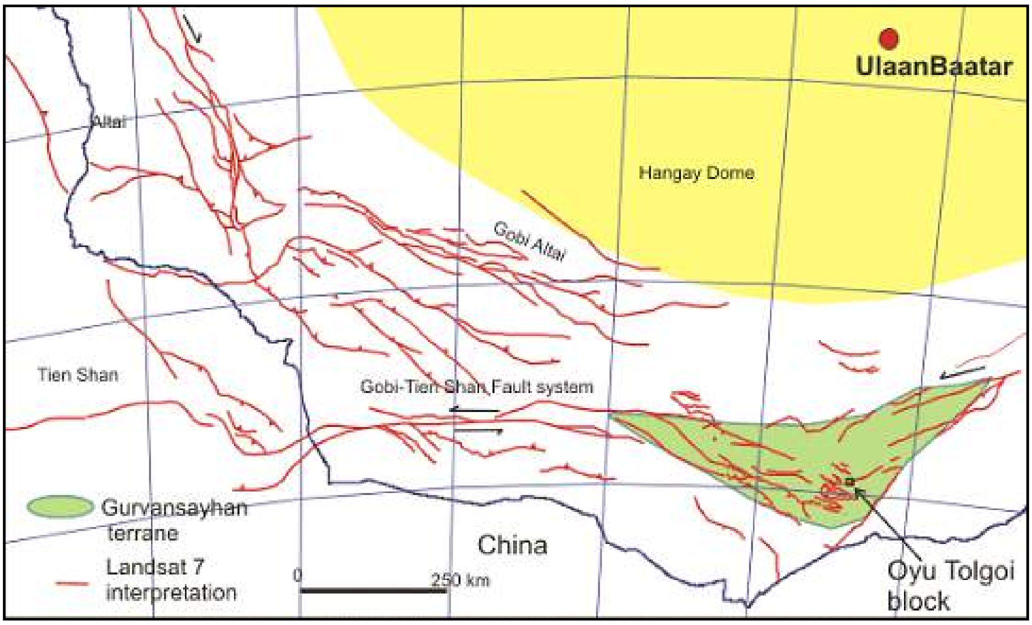
The Oyu Tolgoi porphyry deposits are hosted within the Gurvansayhan Terrane, part of the Central Asian Orogenic Belt, rocks of which now comprise the South Gobi region of Mongolia (Figure 7.3 and Figure 7.4).

Figure 7.3 Regional Setting, Gurvansayhan Terrane



Note: Figure from Wainwright (2008)

Figure 7.4 Regional Structural Setting, Gurvansayhan Terrane



Note: North is to top of plan.

Development of the Central Asian Orogenic Belt consisted of Palaeozoic-age accretionary episodes that assembled a number of island and continental margin magmatic arcs, rifted basins, accretionary wedges, and continental margins. Arc development ceased by about the Permian. During the Late Jurassic to Cretaceous, north–south extension occurred, accompanied by the intrusion of granitoid bodies, unroofing of metamorphic core complexes, and formation of extensional and transpressional sedimentary basins. North-east–south-west shortening is superimposed on the earlier units, and is associated with major strike-slip faulting and folding within the Mesozoic sedimentary basins.

The Gurvansayhan Terrane is interpreted to be a juvenile island arc assemblage that consists of highly deformed accretionary complexes and volcanic arc assemblages dominated by imbricate thrust sheets, dismembered blocks, mélanges, and high-strain zones. Lithologies identified to date in the Gurvansayhan Terrane include Silurian to Carboniferous terrigenous sediments, volcanic-rich sediments, carbonates, and intermediate to felsic volcanic rocks. Sedimentary and volcanic units have been intruded by Devonian granitoids and Permo–Carboniferous diorite, monzodiorite, granite, granodiorite, and syenite bodies, which can range size from dykes to batholiths.

Major structures to the west of the Gurvansayhan Terrane include the Gobi-Tien Shan sinistral strike-slip fault system that splits eastward into a number of splays in the Oyu Tolgoi area, and the Gobi Altai Fault system, which forms a complex zone of sedimentary basins over-thrust by basement blocks to the north and north-west of Oyu Tolgoi (refer to Figure 7.4). To the east of the Gurvansayhan Terrane, regional structures are dominated by the north-east-striking East Mongolian Fault Zone, which forms the southeast boundary of the terrane. This regional fault may have formed as a major suture during Late Palaeozoic terrane assembly, with Mesozoic reactivation leading to the formation of northeast-elongate sedimentary basins along the fault trace.

7.1.3 District Geology

7.1.3.1 Overview

The Oyu Tolgoi copper–gold porphyry deposits are situated in a poorly exposed inlier of Devonian mafic to intermediate volcanic, volcaniclastic, and sedimentary rocks that have been intruded by Devonian to Permian felsic plutons. These rocks are unconformably overlain by poorly consolidated Cretaceous sedimentary rocks and younger unconsolidated sedimentary deposits. A district-wide stratigraphic column that shows the relative thicknesses of the various lithologies is presented in Figure 7.5.

Two major stratigraphic sequences are recognized in the project area:

- Tuffs, basaltic rocks, and sedimentary strata of probable island-arc affinity, assigned to the Upper Devonian Alagbayan Formation.
- An overlying succession containing conglomerates, fossiliferous marine siltstones, sandstones, water-lain tuffs, and basaltic to andesitic flows and volcaniclastic rocks, assigned to the Carboniferous Sainshandhudag Formation. The two sequences are separated by a regional unconformity that, in the Oyu Tolgoi area, is associated with a time gap of about 10 to 15 Ma.

The volcanic and sedimentary rocks are cut by several phases of intrusive rocks ranging from batholithic intrusions to narrow discontinuous dykes and sills. Compositional and textural characteristics vary.

A thin covering of gently dipping to horizontal Cretaceous stratified clay and clay-rich gravel overlies the Palaeozoic sequence, infilling palaeo-channels and small fault-controlled basins.

The Oyu Tolgoi Project area is underlain by complex networks of poorly exposed faults, folds, and shear zones. These structures influence the distribution of mineralization by both controlling the original position and form of mineralized bodies, and modifying them during post-mineral deformation events. The district geology is shown in Figure 7.6.

Figure 7.5 Project Stratigraphic Column

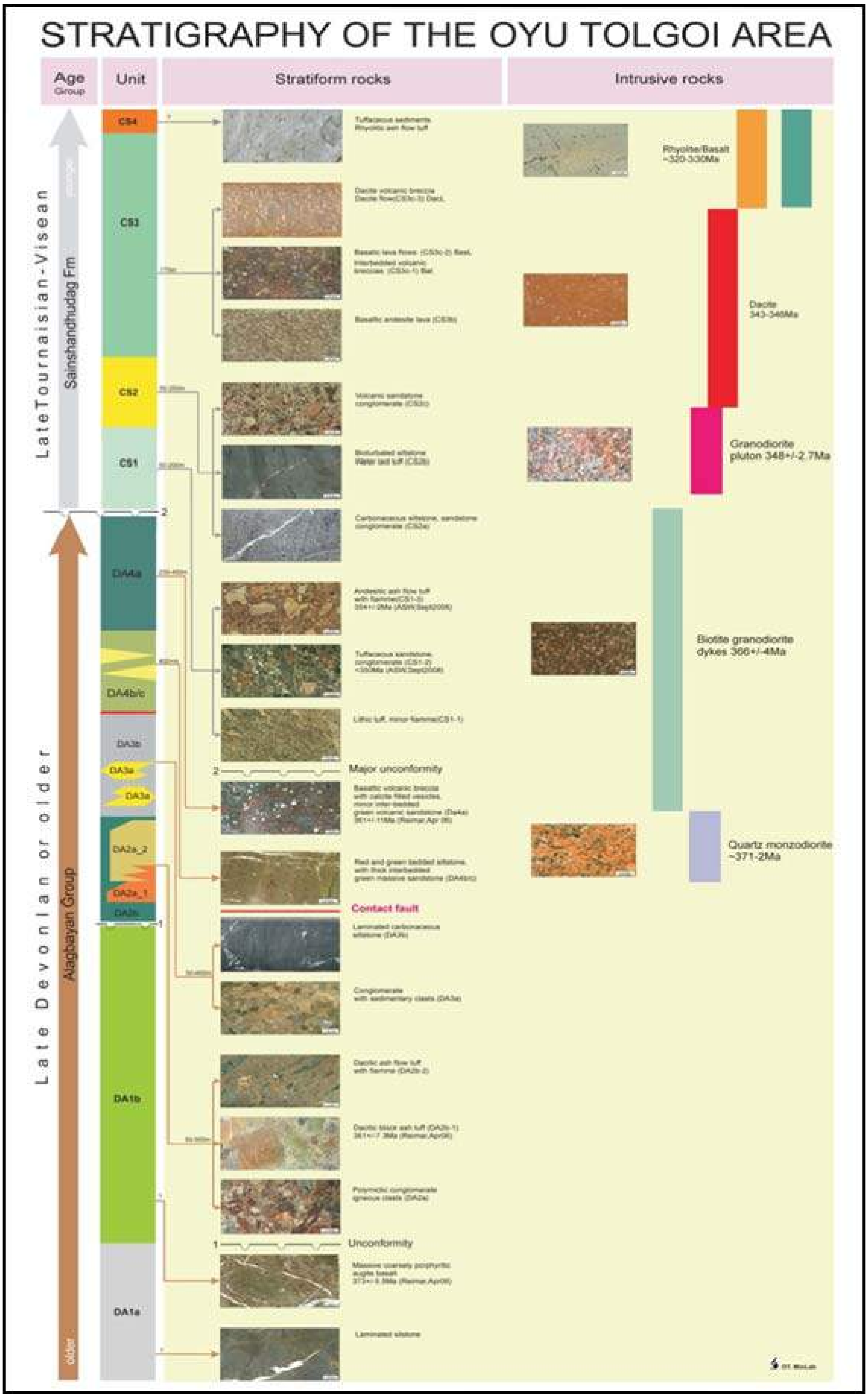
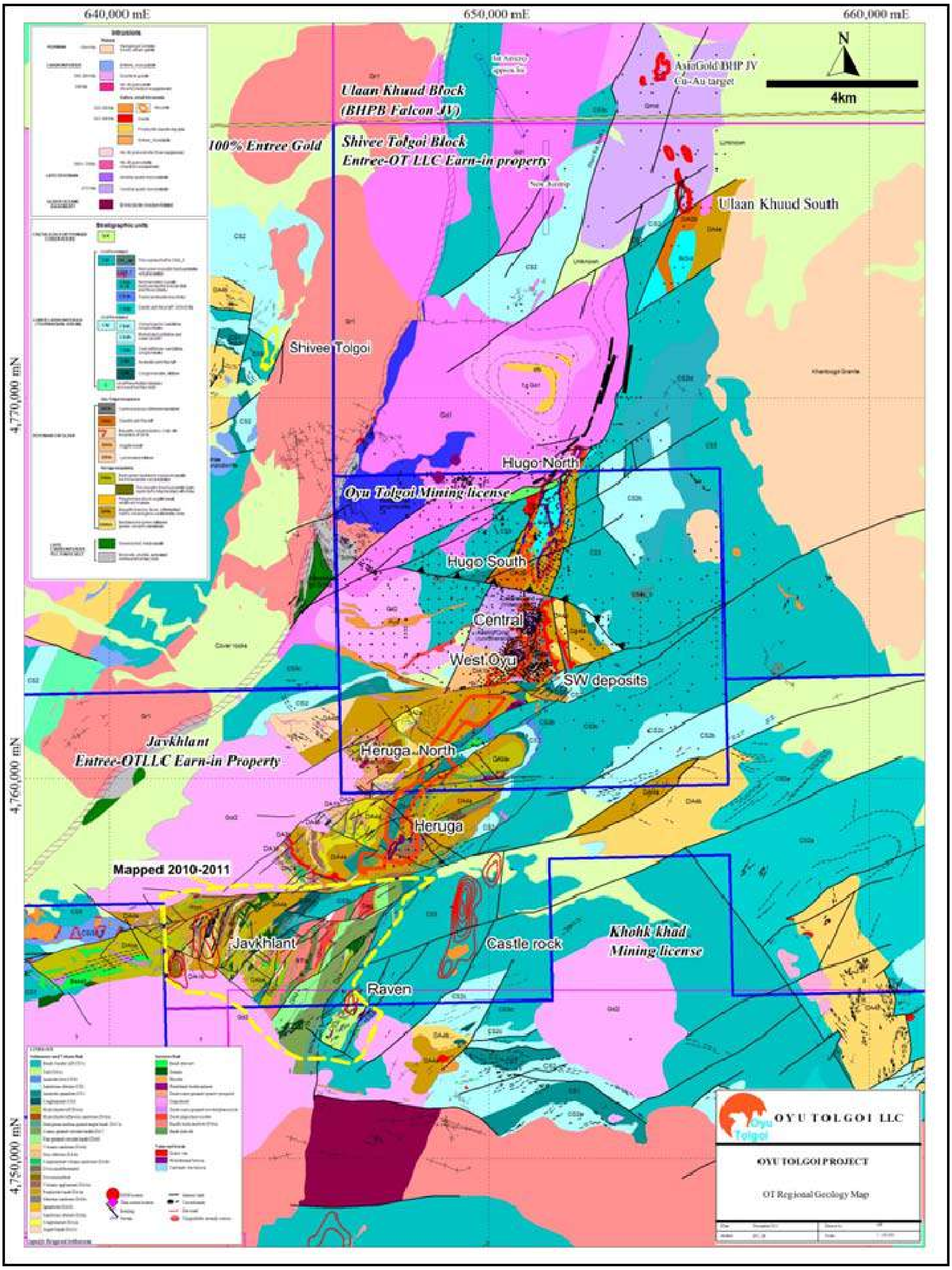


Figure 7.6 Project Geology Plan



Note: BHPB is no longer in joint venture on the Ulaan Khuud Block

The Oyu Tolgoi copper–gold deposits currently comprise, from north to south:

- Hugo Dummett (includes the Hugo North Extension zone, which is the extension of the Hugo North deposit onto the joint venture ground).
- Hugo South.
- Southern Oyu (includes the Southwest Oyu, South Oyu, Wedge, Central Oyu, Bridge, Western, and Far South zones).
- Heruga.

The surface traces and surface projection of the distinct porphyry centres define a north-north-east-trending mineralized corridor underlain by east-dipping panels of Upper Devonian or older layered sequences intruded by quartz monzodiorite and granodiorite stocks and dykes (refer to Figure 7.5).

7.1.3.2 Sedimentary Lithologies

Four major lithological divisions are present within the Alagbayan Formation, and each of these divisions consists of two or more mappable subunits (Table 7.1).

The two lower units are commonly strongly altered and form important mineralization hosts, while the two upper units lack significant alteration and mineralization. Unit DA4 is separated from the underlying Alagbayan Group units by a contact-parallel fault, known as the Contact Fault.

The Sainshandhudag Formation is divided into three major units at Oyu Tolgoi: a lowermost tuffaceous sequence, an intermediate clastic package, and an uppermost volcanic/volcaniclastic sequence (Table 7.2). The unit post-dates porphyry mineralization and is separated from the underlying Devonian rocks by a regional unconformity.

7.1.3.3 Intrusive Rocks

Intrusive rocks are widely distributed through the Oyu Tolgoi area and range from large batholithic intrusions to narrow discontinuous dykes and sills. At least seven classes of intrusive rocks can be defined on the basis of compositional and textural characteristics (Table 7.3).

Copper-gold porphyry mineralization is related to the oldest recognized intrusive suite, comprising large Devonian quartz monzodiorite intrusions that occur in all of the deposit areas.

Table 7.1 Major Units of the Alagbayan Formation

Unit	Lithologies	Description
DA1	Basaltic flows and volcaniclastic rocks; several hundred metres in thickness.	Two subunits: Lower: grey to green, finely-laminated, volcanogenic siltstone and interbedded fine sandstone (DA1a). Upper: dark green, massive porphyritic (augite) basalt. Overlies and partially intercalated with basal unit (DA1b).
DA2	Dacite tuff/volcaniclastic rocks; at least 200 m thick	Three subunits: Lower: monolithic to slightly polylithic basaltic lapilli tuff to volcaniclastic conglomerate/breccia. Underlies and partially intercalated with middle unit (DA2a) Middle: buff to dark green, dacite lapilli tuff. Overprinted by intense sericite and advanced argillic alteration (DA2b_1) Upper: weakly altered to unaltered polymictic block tuff to breccia, with lesser intercalated lapilli tuff (DA2b_2).
DA3	Clastic sedimentary sequence; approximately 100 m thick	Two subunits: Polylithic conglomerate, sandstone, and siltstone. Abundant in the South Oyu deposits and parts of the Hugo South deposit (DA3a). Rhythmically interbedded carbonaceous siltstone and fine brown sandstone. Ubiquitous in drill holes in Hugo North and is also discontinuously distributed in the more southerly deposits (DA3b).
DA4	Basaltic flows/fragmental rocks, siltstone; approximately 600 m thick	Three subunits: Dark green basaltic volcanic breccia with vesicular, fine-grained to coarsely porphyritic basaltic clasts is the dominant lithotype; interlain with volcanogenic sandstones and conglomerates (DA4a). Thinly interbedded red and green siltstone, which contain subordinate basalt layers in their lower levels (DA4b). Massive green to grey sandstone with rare siltstone interbeds (DA4c).

Table 7.2 Major Units of the Sainshandhudag Formation

Unit	Lithologies	Description
CS1	Andesitic lapilli tuff and volcaniclastic rocks; approximately 200 m thick	Andesitic lapilli tuff with abundant fiamme, and subordinate block tuff to breccia.
CS2	Conglomerate, sandstone, tuff, and coal; approximately 200 m thick	Typically shows a progression from a lower conglomerate–sandstone–siltstone-dominant unit (CS2a) to an overlying siltstone–waterlain tuff unit (CS2b). Carbonaceous siltstone and coal beds occur in the lower part of the sequence.
CS3	Basaltic and andesite lava and volcaniclastic rocks; approximately 800 m thick	Four subunits: Basal: thin volcanic sandstone (CS3a). Lower middle: discontinuous porphyritic basaltic andesitic lava sequence (CS3b). Upper middle: thick basaltic breccia-to-block tuff unit (CS3c_1). Upper: intercalated to overlying porphyritic basalt flow sequence (CS3c_2).

Table 7.3 Major Intrusive Rock Units

Unit	Lithologies	Age	Description
Intrusions	Quartz monzodiorite to monzodiorite	371 ± 2 Ma	Texturally and compositionally varied. Typically phenocryst-crowded, with >40% plagioclase phenocrysts up to 5 mm long, and 10–15% biotite and hornblende. Abbreviated to QMD.
Intrusion, dykes and sills	Biotite granodiorite	366 ± 4 Ma	Contain large plagioclase phenocrysts with lesser small biotite phenocrysts, within a fine-grained to aphanitic brown groundmass. Intrusions are compositionally and texturally varied and probably include several intrusive phases. Forms a large stock at Hugo North (BiGd)
Intrusions	Syenite, granite, quartz monzonite, quartz diorite, and quartz syenite	348 ± 3 Ma	Large, polyphase granitic complex bounding the Oyu Tolgoi Project to the northwest.
Dykes	Hornblende–biotite andesite and dacite	343 ± 3 Ma	Typically strongly porphyritic with feldspar, hornblende, and biotite. Quartz phenocrysts are common.
Dykes and sills	Rhyolite; range from metres to a few tens of metres wide	320 ± 10 Ma	Aphanitic and aphyric. Intrusive breccias are common along dyke contacts, commonly incorporating both rhyolitic and wall rock fragments within a flow-banded groundmass.
Dykes	Basalt/dolerite; in deposit area range from metres to a few tens of metres wide; in southwest part of the project can occur as large, sill-like intrusive masses	Carboniferous	Intrude all stratified units. Typically aphanitic to fine-grained, locally vesicular, and contain variable amounts of plagioclase phenocrysts.
Intrusions	Alkaline granite	Permian	Large, circular intrusion exposed just east of the Oyu Tolgoi Project that is defined by abundant pegmatite dykes.

7.1.3.4 Structure

The Oyu Tolgoi Project area is underlain by complex networks of faults, folds, and shear zones. Most of these structures are poorly exposed on surface and have been defined through integration of detailed exploration data (primarily drillhole data), property-scale geological mapping, and geophysical data. There is evidence for several phases of deformation and reactivation of the early faults during later deformational events. Major fault structural elements are summarized in Table 7.4.

Table 7.4 Major Structures

Structure	Setting	Description
Central Fault	West-north-west-striking, moderately north-dipping structure that lies between the Hugo South deposit and Central Oyu zone of the Southern Oyu deposit	Fault consists of several splays and may have experienced multiple periods of displacement. Early fault displacement resulted in north-side-down apparent offset, followed by a later apparent reverse displacement of lesser magnitude. Visible as linear magnetic feature cutting the overlying Sainshandhudag Formation.
Contact Fault	Low-angle thrust fault generally parallel to bedding; occurs from Heruga deposit in the south to the Hugo Dummett deposits in the north	Places overturned upper Devonian sedimentary and volcanic rocks belonging to the DA4 unit over upright Devonian sediments of unit DA3b. Does not truncate mineralization.
Axial Fault	Hypothetical, based on alignment of the Southwest Oyu and Central Oyu zones and the Hugo Dummett deposits, and the elongate form of the Hugo Dummett deposit	Alignments suggest an underlying north northeast-striking fault or fault zone controlled emplacement of porphyry intrusions and related hydrothermal activity
West Bat, East Bat Faults	North–north-east-trending, bounding Hugo Dummett deposit.	Control the structural high which hosts Hugo Dummett. Offsets of post-mineral stratigraphic contacts measure at least 1 km (east-side-up) for the West Bat Fault, and 200–300 m (west-side-up) for the East Bat Fault.
East Bounding and West Bounding Faults	North-east- to north-north-east-trending; bounding the Southwest Oyu zone	Form a primary control on the distribution of copper and gold mineralization. Presence of mineralized clasts within the fault zones implies faults were active post-mineralization. East bounding fault is a gently listric, steeply west-dipping fault zone in the order of >50 m wide. The fault has been modeled as a series of segments displaced across newly interpreted north-west–south-east-trending faults.
Bor Tolgoi and Bor Tolgoi West Faults	North-east- to north–north-east-trending; bounding the Heruga deposit	Display 300–500 m of west side down apparent offset of stratigraphic contacts.
Boundary Fault system	East–north-east-striking fault zone; juxtaposes the Devonian sequence hosting and overlying the Oyu Tolgoi deposits against the Carboniferous granitic complex to the north.	Faults within this system include the North Boundary Fault, an unnamed splay of the North Boundary Fault, and the Boundary Fault. Faults dip steeply to the north or northwest, and occur as strongly-developed, foliated gouge and breccia zones ranging from tens of centimetres to several tens of metres wide.
Northwest Shear Zone	Ductile shear zone that cuts across the far northwest corner of the Oyu Tolgoi Project area	Wide shear zone with mylonitic to ultramylonitic rocks in the center, grading outward over about 200 m to rocks lacking visible ductile strain. Marks the break between the Alagbayan and Sainshandhudag Formations and the Carboniferous granitic complex.

Structure	Setting	Description
Solongo Fault	East- to east–north-east-striking, subvertical structure; cuts across the Oyu Tolgoi property just south of the Southwest Oyu and South Oyu zones	Typically occurs as a strongly tectonized, foliated zone up to several tens of metres wide. Forms a major structural break; a minimum of approximately 1,600 m of south-side-down stratigraphic offset where it juxtaposes mineralized basalt (unit DA1) in the South Oyu zone against sediments correlated with the upper Alagbayan Formation (unit DA4) to the south.
North-west-trending faults	Southern Oyu	Subvertical to steeply northeast-dipping faults associated with rhyolite dykes
East-north-east-striking faults	Regional bounding faults at Heruga deposit	Form prominent features on both magnetic and satellite images. Geological mapping shows a 500 m apparent dextral displacement of dykes and stratigraphic contacts across the faults.

Variations in bedding attitude recorded in both oriented drill core and surface outcrops define two orientations of folds on the Oyu Tolgoi property: a dominant set of north-east-trending folds, and a less developed set of north-west-trending folds. These folds are well defined in bedded strata of both the Sainshandhudag and Alagbayan formations. They may be present in stratified rocks throughout the property, but outcrop and drillhole data are insufficient to define them in many areas. There is no evidence of a penetrative fabric (e.g., cleavage) associated with folding.

Together, the two orientations of folds form a dome-and-basin interference pattern, but it is not possible to determine their relative ages. Both of the dominant fold orientations occur in Lower Carboniferous strata, indicating that both folding events post-date mineralization.

Sedimentary facing direction indicators, including grading, scour and fill structures, load casts, and cross-bedding, are sporadically observed in drill core by Oyu Tolgoi geologists along the east flank of the Hugo Dummett deposit suggest that parts of the Alagbayan Formation are overturned. However, no large isoclinal folds have been mapped from drill core. These folds are cut by dykes of the 366 Ma biotite granodiorite suite and therefore were formed within the Late Devonian. Such folds and geopetal features are difficult to ascribe to regional tectonic events, and may simply be localized features of rapid facies changes in a proximal submarine volcanic environment.

OT LLC has a current structural mapping program underway, which may revise some elements of the interpretations when completed.

8 DEPOSIT TYPES

8.1 Mineral Deposits

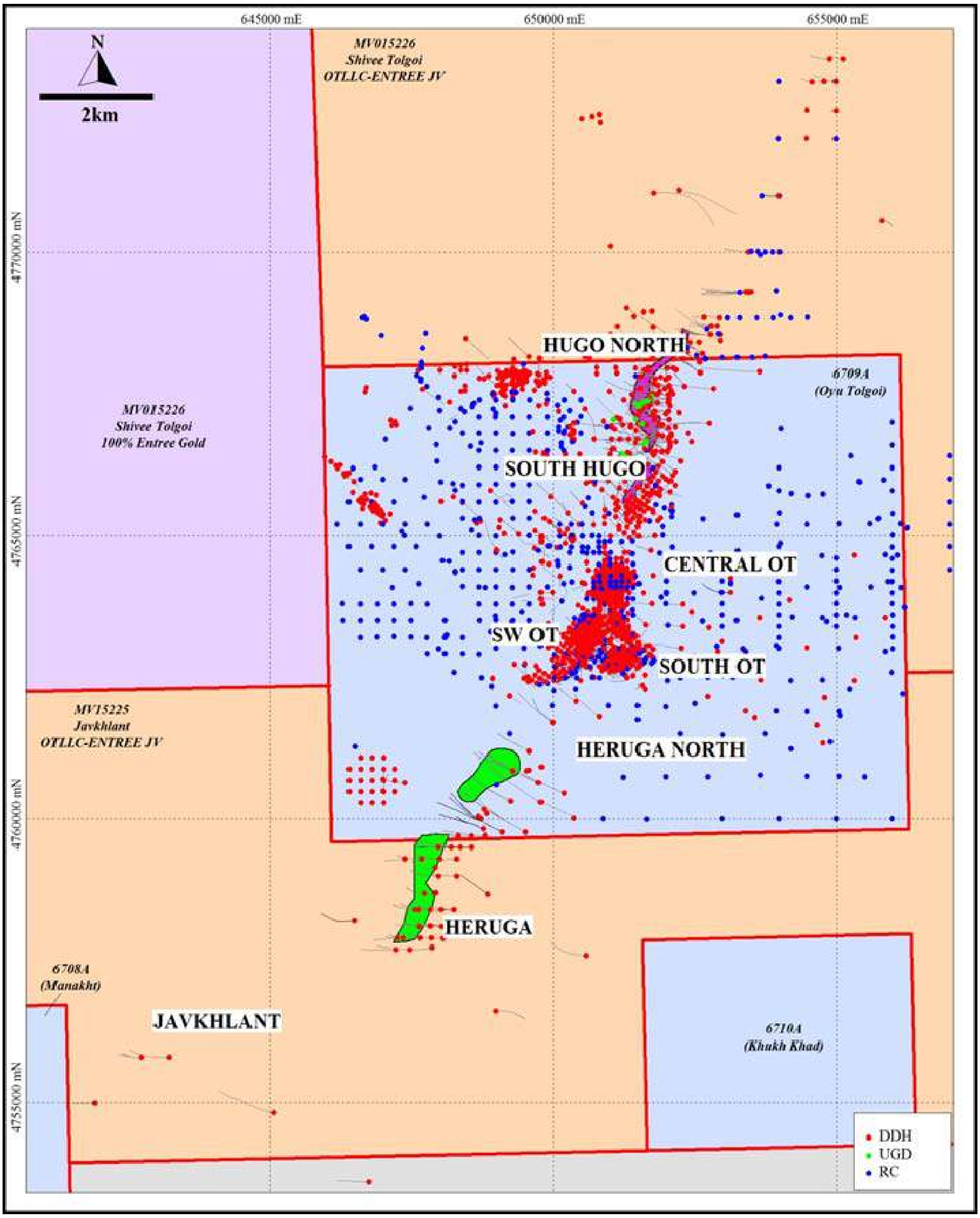
The deposits that are incorporated in the current mine plan are the Southern Oyu and Hugo Dummett North (Lift 1). The Hugo Dummett North (Lift 2), Hugo Dummett South, and Heruga deposits are currently outside the mine plan.

Figure 8.1 shows the locations of the major deposit areas in relation to the Oyu Tolgoi and Joint Venture licence boundaries. The figure also indicates the drill collars and clearly outlines the major deposit and prospect areas.

Figure 8.2 shows a schematic project layout plan indicating the relative locations of the planned Hugo Dummett lifts and projected time-frames.

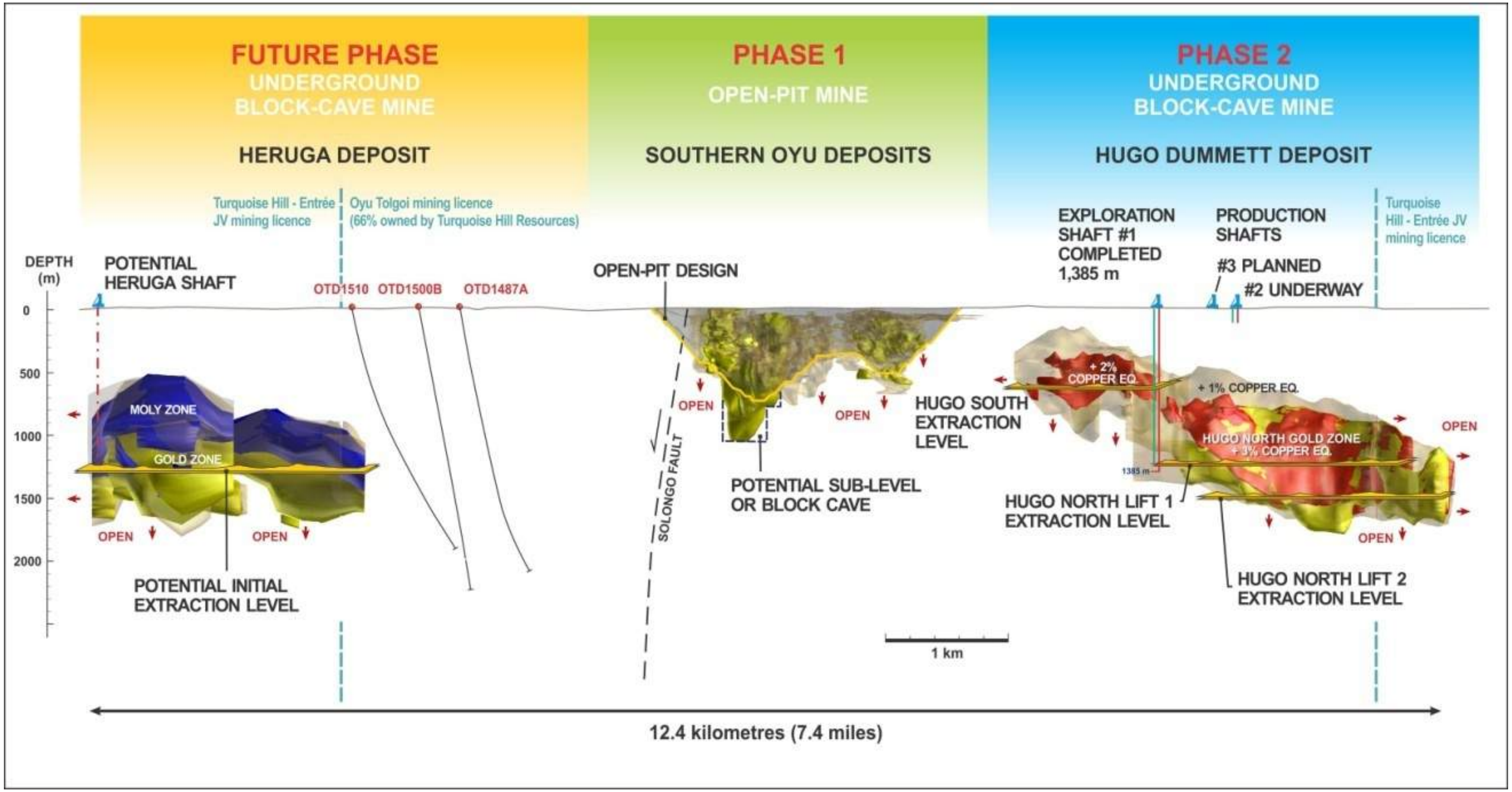
Southern Oyu has, historically, been treated as a number of separate deposits; however, for mining purposes, the one pit will extract all deposits, and therefore the descriptors in this section have taken the approach that the orebody comprises a number of mineralized zones within an overall single deposit framework.

Figure 8.1 Deposit Layout Plan



Note: BHPB is no longer in joint venture on the Ulaan Khuud Block

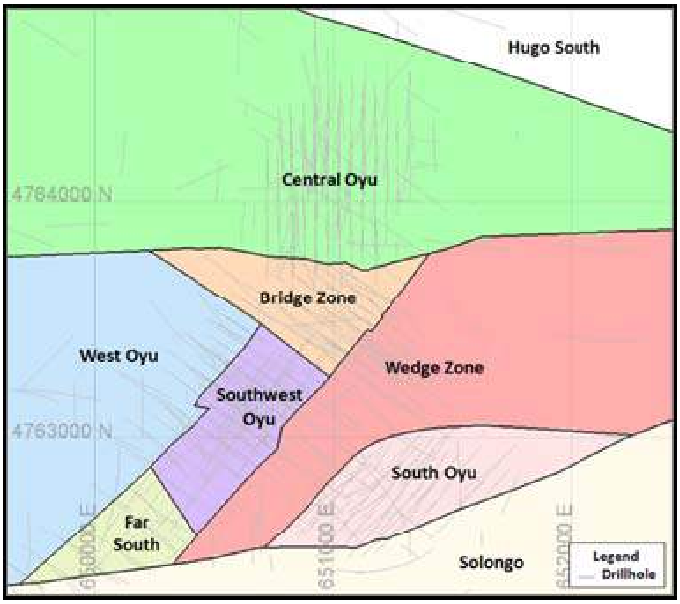
Figure 8.2 Idealized Long Section (looking west, showing estimated time to start of production)



8.1.1 Southern Oyu Deposit

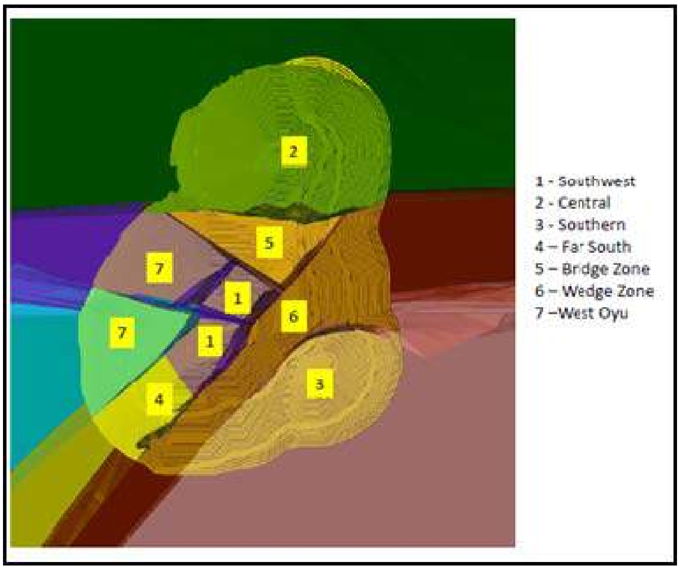
The Southern Oyu deposit includes the main Southwest Oyu (Southwest), South Oyu (South), Wedge, and Central Oyu (Central) zones (Figure 8.3) and a number of smaller, fault-bounded zones, described in the following subsections. The planned open pit will incorporate the majority of these zones (Figure 8.4).

Figure 8.3 Schematic Plan of Southern Oyu Deposit Showing Major Zones



Note: North is to top of figure. Grid squares are 1 km x 1 km.

Figure 8.4 Schematic Plan of Proposed Southern Oyu Pit Showing Zone Locations



Note: Pit extents are approximately 2 km x 3 km. North is to top of figure.

The zones form contiguous sectors of mineralization representing multiple mineralizing centres, each with distinct styles of mineralization, alteration, and host rock lithology. The boundaries between the individual deposits and zones coincide with major faults. Faulting has resulted in different erosional histories for the zones, depending on the depth to which a zone has been down-faulted or uplifted relative to neighbouring zones. A level plan showing the simplified geology of the Southern Oyu area is included as Figure 8.5.

8.1.1.1 Southwest Oyu

Zone Dimensions

The Southwest Oyu (Southwest) zone is a gold-rich porphyry system characterized by a south-west-plunging, pipe-like geometry that has a vertical extent of as much as 700 m. The high-grade core of the zone is about 250 m diameter; the low-grade shell (0.3% Cu) surrounding the core may extend for distances as much as 600 m x 2 km.

Lithologies

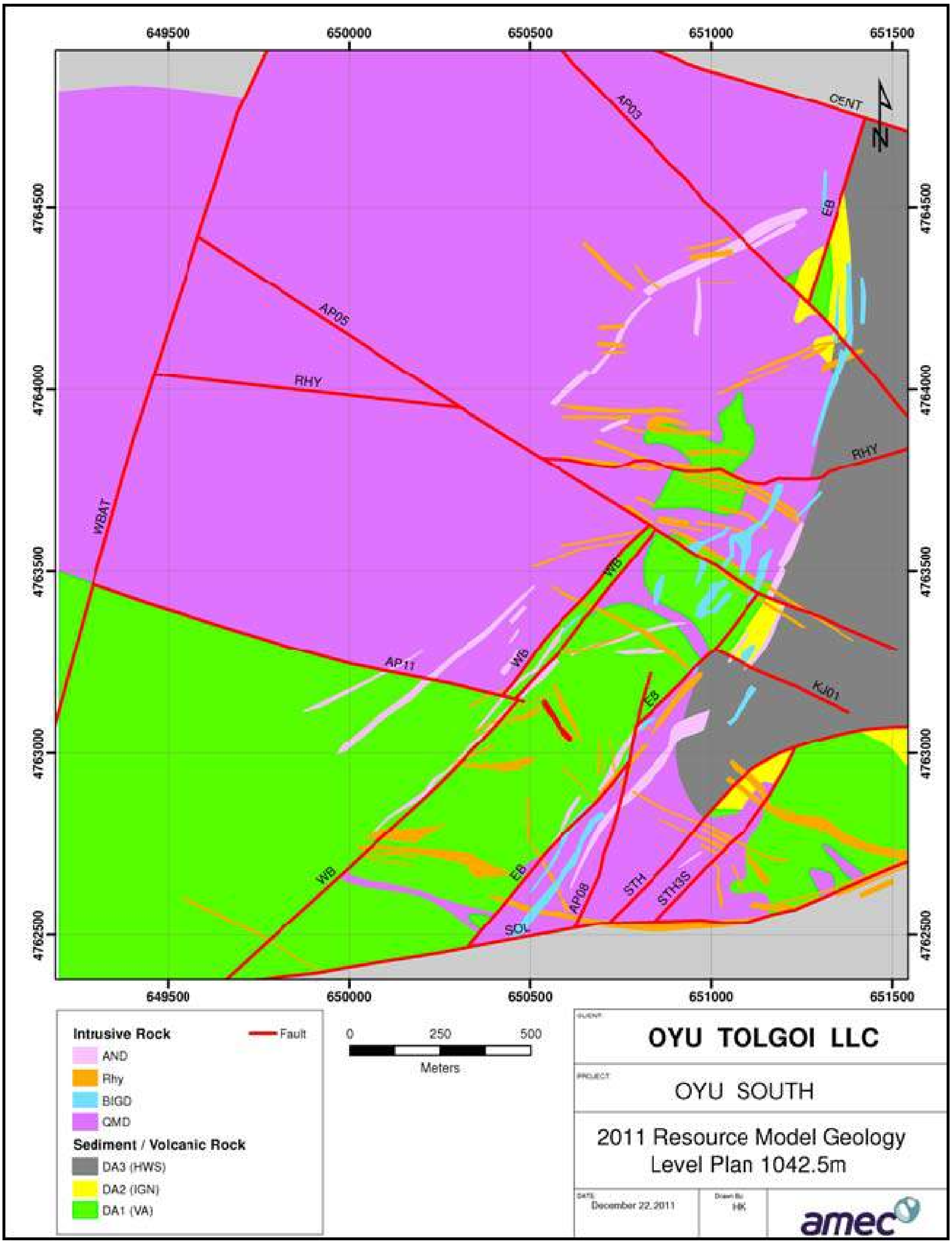
Over 80% of the deposit is hosted by massive to fragmental porphyritic augite basalt of the Upper Devonian Alagbayan Formation, with the remainder hosted by intra-mineral, Late Devonian quartz monzodiorite intrusions.

The quartz monzodiorite intrusions form irregular plugs and dykes related to several distinct phases. These include:

- Early strongly altered quartz veined dykes mainly limited to the high-grade central deposit core (informally referred to as OT–QMD).
- Superimposed younger fragmental dykes entraining early quartz vein clasts but lacking strong sulphide mineralization (informally referred to as xQMD).
- Voluminous massive quartz monzodiorite (informally referred to as QMD) containing weaker mineralization, flanking and underlying the high-grade deposit core.

Several phases of post-mineral dykes cut the Southwest zone. Most of the dykes belong to the rhyolite, hornblende–biotite andesite, or biotite granodiorite intrusive phases. Dykes commonly have steep dips, and many are localized along faults. The rhyolite dykes tend to have west to west-north-west strike directions in the deposit core and north-east strike directions when emplaced along major faults. Hornblende–biotite andesite dykes strike east-north-east except where they intrude along the major north-east-trending faults.

Figure 8.5 Geology Plan, Southern Oyu Area



Note: WB – West Boundary; EB – East Boundary; WBAT – West Bat SOL – Solongo; STH – South; STH3S – South 3 Splay; RHY – Rhyolite; CENT – Central. Faults with an AP prefix are from a 2010 structural interpretation by Alasdaire Pope. Faults with a KJ prefix are from a 2011 structural interpretation by Keenan Jennings.

Structures

Most of the Southwest zone, including the entire high-grade, gold-rich core of the zone, lies between two north-east-striking faults, termed the West Bounding Fault and the East Bounding Fault. Both faults are clearly defined on ground-magnetic geophysical images, and their positions and orientations are well constrained by numerous drillhole intersections.

The bounding faults consist of foliated cataclasite, gouge/breccia, and mylonitic bands that occur in zones ranging from a few metres to a few tens of metres wide. The cataclasite within the fault zones contains abundant quartz, quartz sulphide, and sulphide (pyrite, chalcopyrite, sphalerite, and galena) clasts in a comminuted matrix that is locally overprinted by fine-grained pyrite and chalcopyrite. These relationships imply that at least some of the fault movement was contemporaneous with mineralization. Kinematic indicators within the fault zones imply dominantly subhorizontal, sinistral movement on the bounding faults. Both faults have local sub-parallel splays. Correlation of drillhole intersections constrains an average fault dip of 80° towards 310° for both faults.

The East Bounding Fault juxtaposes younger rocks to the south-east against the Alagbayan Formation rocks (augite basalt) hosting the deposit, while the West Bounding Fault is mainly intra-formational within the augite basalt. The West Bounding Fault is commonly intruded by hornblende–biotite andesite dykes, whereas rhyolite dykes are more common along the East Bounding Fault.

Structural Setting

Fault geometry and kinematics, vein orientations, and deposit geometry at Southwest support a structural model invoking formation of a dilational fault transfer zone. This zone is delineated by the West Bounding Fault on the north-west and the East Bounding Fault on the south-east. The preferred vein orientation within the core of the deposit reflects the local stress geometry within this zone of dilation. The Southwest zone probably formed as a subvertical cylindrical body and attained its present west-south-west plunge during post-mineral regional deformation. This post-mineral rotation is consistent with the easterly stratigraphic dips of both pre- and post-mineral rocks in the deposit area.

Mineralization

Quartz-dominant veins with variable amounts of sulphide (pyrite, chalcopyrite, bornite), K-feldspar, chlorite, and carbonate are ubiquitous in the Southwest zone, and there is a general correlation between vein density and copper and gold grades. Most veins have widths of several millimetres to several centimetres, although within the core of the deposit veins up to a metre or more thick may occur. Vein contacts can be either planar or variably deformed, and folded and/or faulted veins are common. Veins within the high grade deposit core display sub-parallel to sheeted forms with a preferred south-west-dipping orientation. These pass into more irregularly oriented stockwork veins in peripheral mineralized zones, where subvertical north to north-west-striking orientations are most common.

Alteration

Alteration within the basaltic rocks at Southwest Oyu consists of moderate chlorite, biotite, hematite–magnetite, weak sericite, and pink albite fracture and vein selvages. Hematite overprints magnetite. Quartz monzodiorite is typically pervasively altered with quartz, sericite, and pyrite, as well as albite within vein selvages, small radiating clusters of tourmaline, and fluorite in quartz veins. Advanced argillic alteration, consisting of quartz, sericite, and kaolinite with late dickite veins, is associated with the high-sulphidation mineralization in the quartz monzodiorite breccia.

8.1.1.2 Far South

The Far South is considered to be an extension of the Southwest zone, and is separated from it by a major north-west–south-east-trending fault. The zone has approximate dimensions of about 100 x 250 m.

8.1.1.3 South Oyu

Zone Dimensions

The South Oyu (South) zone is developed mainly in basaltic volcanics and related to small, strongly-sericite altered quartz monzodiorite dykes. Zone dimensions are about 400 m x 300 m in area, and mineralization extends to depths of over 500 m.

Lithologies

The South Oyu zone occurs within an east- to north-east-dipping sequence of Alagbayan Formation strata (basalt and basaltic tuff units), intruded on the south-west by an irregular quartz monzodiorite body. Much of the basalt sequence contains fragmental textures with juvenile pyroclasts and is texturally similar to the overlying basalt tuff sequence. The overlying basaltic tuff sequence was previously interpreted to be dacitic in composition. However, whole-rock geochemistry has shown the basaltic tuff sequence to be similar in composition to the underlying basalt and that the unit has been affected by advanced argillic alteration to give it the appearance of a dacitic tuff.

To the north-east, the altered and mineralized rocks are overlain by mudstones and conglomerates of the upper Alagbayan Formation, which pass up-section into the overlying basalt and sediment sequence and ultimately into rocks of the Sainshandhudag Formation.

The zone is cut by numerous barren dykes, most of which belong to the post-mineral rhyolite and basalt intrusive suites. These dykes typically have widths of only a few metres, with the exception of a major, east-west rhyolite dyke that cuts through the middle of the South zone and attains widths of up to a few tens of metres. This wide dyke commonly balloons into larger intrusive masses where it intersects the South and Solongo faults. Although irregular in form, the rhyolite dykes have approximate west to west-north-west strikes and steep dips. In contrast, the basalt dykes have moderate north-east dips, which are sub-parallel to contacts within the stratified host rocks.

Structures

The South zone lies within a faulted block that is bounded on the north-west by the north-east-striking South Fault, and on the south by the east-north-east-striking Solongo Fault. The South Fault forms a zone with several strands over a width of up to 90 m, which juxtapose progressively younger strata on the north-west against older strata to the south-east. Drillhole intersections of these faults typically consist of gouge and breccia zones up to several metres wide. To the west, the faults strike into a large quartz monzodiorite intrusion. The faults are difficult to trace through the intrusion and off-set of the intrusive contact is minimal, implying that most movement pre-dated emplacement of the quartz monzodiorite.

The Solongo Fault truncates the southern edge of the South zone. It forms a wide, strongly tectonized zone. Stratigraphic offset on the Solongo Fault is at least 1,600 m (south-block down). Consequently, no significant mineralization has been identified on the south side of the fault at shallow (<1,000 m) levels.

Mineralization

Copper mineralization in the South zone is associated with stockworks of thin (usually <10 cm) quartz–sulphide veins. In surface exploration pits and trenches, veins occur as steep, north-west-striking, strongly sheeted sets. However, veins intersected in drillholes have a stockwork style and lack the strong preferred orientation visible in surface exposures.

Mineralization in the South Oyu zone is hosted dominantly in quartz monzodiorite in the south-western portion of the deposit, in basalt throughout the central portion of the deposit, and in a minor zone of basaltic tuff and breccia on the northern margin. Contorted quartz veins are present, but there is no clearly defined zone of high quartz vein density such as at the Southwest zone. As a result, fracture-controlled sulphide veins are minor, and sulphides occur dominantly as disseminated chalcopyrite, bornite, and molybdenite. Chalcopyrite is the principal copper sulphide, but in higher-grade areas bornite locally exceeds chalcopyrite in abundance. Magnetite occurs as disseminations and as veins; small zones with elevated gold values occur locally.

A small zone of high-sulphidation mineralization occurs within a quartz monzodiorite breccia in the western part of the deposit, adjacent to the South Fault. Mineralization here consists of pyrite, chalcopyrite, bornite, covellite, and primary chalcocite in quartz–sericite–kaolinite alteration, with late dickite veins.

An oxide zone approximately 60 m thick overlies the South deposit, and consists of malachite, azurite, cuprite, chrysocolla, neotocite and tenorite, hosted within basalt and quartz monzodiorite.

8.1.1.4 Wedge

Zone Dimensions

The Wedge zone has an irregular, crescent-like shape. The zone is about 500 to 600 m at the widest point in the north, tapering to a width of about 200 m in the south, and approximately 1,400 m long. Mineralization extends to depths of over 500 m.

Lithologies

The Wedge zone occurs within a north-east-dipping sequence of Upper Devonian Alagbayan Formation strata similar to that hosting the adjacent South deposit. However, in the Wedge zone the basaltic tuff unit is significantly thicker (up to 180 m) than in the South zone and forms the dominant host to copper mineralization. On the north-east, structurally overlying non-mineralised rocks of the Alagbayan Formation (unit DA4) and the lower Sainshandhudag Formation (of Carboniferous age) form the immediate hanging wall to mineralization.

Mineralized rocks in the Wedge zone are cut by abundant barren dykes, including biotite granodiorite, hornblende–biotite andesite, and rhyolite compositions. Biotite granodiorite and hornblende–biotite andesite are more common along the north-west margin of the deposit and typically have north-east strikes, parallel to the East Bounding Fault. These intrusions were interpreted as sills, frequently intruding along the stratigraphic contact between the basaltic tuff and the overlying sedimentary strata. In 2011, most contacts were re-interpreted as steep-dipping, north-east-trending features. Rhyolite dykes are common throughout the deposit and typically have steeply dipping contacts but varied strike orientations.

Structures

The Wedge zone occupies a rectangular fault block bounded on the west by the north-east-striking East Bounding Fault and on the south by the east-north-east-striking South Fault. Within this block, stratigraphic contacts are continuous and relatively planar, showing little evidence of structural disruption.

Movement on the East Bounding and South Faults has juxtaposed younger strata within the fault block hosting the Wedge deposit against older strata on the adjacent blocks containing the Southwest and South zones. Stratigraphic contacts are relatively continuous between the Wedge deposit and the Central zone, implying that displacement on the East Bounding Fault is largely transferred to the Rhyolite Fault (between the Southwest and Central zone), leaving the Wedge and Central zones as a structurally intact block that has been displaced downward relative to the Southwest and South zones.

Fault disruption is common along the contact between the Alagbayan Formation basaltic tuff and the overlying sedimentary strata. However, there is no evidence of significant stratigraphic omission or repetition associated with this faulting, and the movement may be relatively minor.

Mineralization

The Wedge zone contains a core of high-sulphidation mineralization hosted principally in basaltic tuff and breccia, grading downward and southward into chalcopyrite mineralization in basalt and quartz monzodiorite host rocks.

High-sulphidation mineralization consists of pyrite, chalcopyrite, bornite, enargite, covellite, and primary chalcocite in advanced argillic-altered host rocks. Higher grades of copper (>0.8% Cu) occur in a shallowly east-dipping zone in the upper hundred metres of basaltic tuff/breccia unit. Gold is absent except locally in drillholes adjacent to the South Fault. Mineralization is open to the north.

High-sulphidation mineralization grades downward into chalcopyrite, with lesser bornite within massive augite basalt host rocks, and pyrite and chalcopyrite mineralization in quartz monzodiorite.

Alteration

Basaltic tuff and breccia within the Wedge zone are characterized by advanced argillic alteration consisting of kaolinite, zunyite, pyrophyllite, muscovite, illite, topaz, diaspore, alunite, montmorillonite, late dickite, and fluorite. A barren, specular, hematite-rich sector occurs marginal to the advanced argillic alteration, and is progressively overprinted by advanced argillic alteration assemblages with increasing copper grades towards the centre of the deposit. The advanced argillic alteration grades downward into biotite and chlorite alteration with hematite overprinting magnetite, mainly within massive augite basalt host rocks underlying the basaltic tuff/breccia.

In the southern part of the Wedge zone, sericite and pyrite alteration occurs within the quartz monzodiorite.

8.1.1.5 Central Oyu

Deposit Dimensions

The Central zone is about 2,300 m wide and tapers from about 200 m long in the east to more than 600 m in length to the west. Mineralization extends to depths of over 500 m.

Lithologies

The Central zone is hosted within a swarm of feldspar-phyric quartz monzodiorite intrusions, emplaced into porphyritic augite basalt and overlying basaltic tuff of the Alagbayan Formation. The basaltic tuff is in turn overlain by unmineralized sedimentary and mafic volcanic rocks of the Alagbayan Formation unit DA4, which currently dip moderately to the east.

Several phases of intra-mineral and late-mineral quartz monzodiorite intrusions have been distinguished in the Central zone based on textural variations and intensity of mineralization and alteration. Most have dyke forms, emanating from a larger intrusive mass to the north and west of the deposit area. The quartz monzodiorite dykes terminate within the base of the sedimentary units of the upper Alagbayan Formation.

Basalt flows and basaltic tuffs of the Alagbayan Formation are preserved as a series of isolated, irregular, moderately north- to north-east-dipping bodies within the quartz monzodiorite dyke swarm. These volcanic windows are up to 200 m thick and extend several hundred metres down dip to the limit of drilling. The contact between the basaltic tuff and the overlying sedimentary sequence is commonly faulted and forms the upper limit to mineralization, as elsewhere in the Oyu Tolgoi district.

Post-mineral dykes are common in the Central zone and comprise rhyolite, biotite granodiorite, hornblende–biotite andesite, and dacite dykes. The rhyolite dykes are most abundant, with the majority occurring as west- and west-north-west-striking bodies in the southern half and on the periphery of the deposit. Biotite–granodiorite dykes occur along the eastern margin of the deposit and tend to strike north to north-north-east. East-north-east-striking hornblende–biotite andesite dykes occur mainly along the north-eastern margin of the deposit.

Structures

The structural setting within the Central zone is still not well understood.

Drillholes show little evidence of significant post-mineral faulting, and the mineralogical zoning, grade distribution, and continuity of contacts are consistent with the overall area, being contained in a structurally intact block. However, there is also evidence to suggest that a series of north-west-trending faults both bound and displace some of the host augite basalt blocks. Given that the majority of the high-grade mineralization at Central lies within the augite basalt units, some discontinuity of grade match is noted within and between these fault-bounded blocks. Additional work is required to better constrain the structural model for the Central zone.

Post-mineral faults form minor zones of breccia and cataclasite in some drillholes, but it is not possible to correlate these intersections between drillholes to define continuous fault surfaces. Pre- or syn-mineral faults, if present, are largely obscured by intrusive and hydrothermal overprinting.

The Central zone is overlain to the east by non-mineralized conglomerate, mudstone, and siltstone of the hanging wall to mineralization, the Alagbayan Formation (DA4). Wide zones of breccia and foliated breccia occur along the basal contact of, and within, the lower portion of these sedimentary strata. The displacement history of these faults is uncertain, and they may be related to minor post-mineralization movement between the two rheologically contrasting rock packages.

Along its southern margin, the Central zone is juxtaposed against the Southwest zone area by an east-west-striking fault that is now occupied by a rhyolite dyke swarm (the Rhyolite Fault). The basaltic tuff and overlying sedimentary units have been uplifted and eroded from the block south of this fault.

Mineralized veins within the Central zone show a range in orientations, the most common of which have south-west-, west-, and north-west-dipping attitudes. Vein orientations are similar to those documented in the Southwest zone, although the degree of preferred orientation in the core of the zone is weaker at Central by comparison. Similar preferred vein orientations at Central and Southwest suggest that

the two zones were formed in a similar structural regime. However, the Central zone lacks the strong bounding fault control that is fundamental to the form and geometry of the Southwest zone. This lack of bounding fault control may account for the more irregular form of the mineralized body at Central.

Post-mineral tilting of the Central zone is implied by bedding dips in the enclosing and overlying stratigraphic sequence. Rotating the structural data for the Central zone sufficiently to restore bedding to horizontal indicates a strong preference for subvertical veins within the deposit at the time of formation.

Mineralization

Mineralization in the Central zone is characterized by an upward-flaring, high-sulphidation zone that overprints and overlies porphyry-style chalcopyrite–gold mineralization. A secondary-enriched supergene chalcocite blanket tens of metres in thickness overlies the high-sulphidation covellite–pyrite zone.

Chalcopyrite–gold mineralization is dominant on the southern and western margins of Central within either basalt or quartz monzodiorite adjacent to intrusive contacts with basalt. Higher grades are associated with zones of intensely contorted quartz stockwork veins, where the gold (ppm) to copper (%) ratios reach 2:1. Peripheral, lower-grade mineralization has gold to copper ratios of less than 1:1. Hematite, pyrite, chalcopyrite, bornite, magnetite, and gold occur disseminated in the zone and as fracture fillings. Hematite is pervasive and overprints magnetite.

The high-sulphidation part of the Central zone lacks significant gold and contains a mineral assemblage of pyrite, covellite, chalcocite/digenite, enargite, tennantite, cubanite, chalcopyrite, and molybdenite. Dominant host rocks are dacite tuff and quartz monzodiorite. Higher-grade mineralization is associated with disseminated and coarse-grained fracture-filling sulphides in zones of intense contorted quartz stockwork veins and anastomosing zones of hydrothermal breccias. Hydrothermal breccia consists of quartz vein and quartz monzodiorite fragments within an intensely sericitized matrix. The sulphide-filled fractures cut both the quartz veins and enclosing wall rock. High-grade mineralization grades outward to a broad, weakly veined, low-grade halo of dominantly disseminated sulphides. Pyrite, chalcopyrite, bornite, and enargite occur here as relic grains replaced by chalcocite, and covellite, and pyrite also hosts small inclusions of covellite. Covellite, chalcocite, and enargite occur as intimate intergrowths or as free disseminations. Cubanite and tennantite occur intergrown with, or replacing, enargite, and molybdenite occurs locally with quartz.

A supergene enrichment zone overlies the high- sulphidation assemblage and underlies a 20 to 60 m thick, hematitic limonite, goethite-rich leached cap. The supergene zone consists of pyrite, hematite, and chalcocite/digenite, with lesser amounts of colusite, enargite, tenorite, covellite, bornite, chalcopyrite, cuprite, and molybdenite. Pyrite is the dominant sulphide and occurs as disseminated crystals. Sooty chalcocite occurs as rims or microveinlets in pyrite and covellite, and as independent disseminations. Colusite occurs as single grains or intergrown with chalcocite/digenite and/or pyrite. Tenorite occurs interstitial to silicate-iron oxide grain boundaries. Micrograins of chalcopyrite replaced by bornite and covellite occur as small inclusions within pyrite.

Minor exotic copper oxide mineralization occupies a bedrock depression on the north-eastern flank of the Central zone. Chrysocolla, malachite, and neotocite mineralization occurs over a 400 m x 300 m area as a thin, 2 to 4 m thick layer at the base of the gravels. The leached cap is generally devoid of mineralization except on the edges of the eastern and southern flanks of the deposit, where patchy malachite and neotocite occur.

Alteration

Alteration in the Central zone shows a close spatial relationship to mineralization and original host lithology. Biotite–chlorite and intermediate argillic alteration coincide with chalcopyrite–gold mineralization within basalt. Advanced argillic and sericite alteration coincides with the high-sulphidation mineralization within quartz monzodiorite and basaltic tuff/breccia.

The biotite–chlorite zone consists of an assemblage of biotite, chlorite, epidote, sericite, albite, carbonate, and anhydrite. Hematite and minor magnetite occur in veins and as disseminations. Biotite has been overprinted by chlorite and sericite, and magnetite has been altered to hematite. Anhydrite and carbonates occur as late veins. K-feldspar alteration increases at depth beneath Central, occurring as vein selvages within biotite-altered basalt.

Intermediate argillic alteration forms a narrow zone separating the advanced argillic and sericite alteration from the biotite chlorite alteration. Intermediate argillic alteration is characterized by a creamy yellow to pale green coloured assemblage of kaolinite, chlorite, pyrophyllite, and illite.

Advanced argillic and sericite alteration are associated with high-sulphidation mineralization, hosted primarily within dacite and quartz monzodiorite. The advanced argillic assemblage consists of topaz, quartz, zunyite, diaspore, alunite, illite, andalusite, late kaolinite, and dickite. There is a zonation from an advanced argillic assemblage of zunyite, andalusite, and alunite associated with higher-grade hydrothermal breccia-hosted mineralization, to a muscovite, sericite-dominant peripheral zone associated with lower-grade disseminated mineralization.

Alteration within the supergene zone is characterized by illite, muscovite, kaolinite, alunite, and pyrophyllite. Montmorillonite, smectite, kaosmectite, illite, and kaolinite are the dominant clay minerals in the leached cap.

8.1.1.6 Bridge Zone

Deposit Dimensions

The Bridge zone has a triangular shape, tapering from about 500 m wide in the north to about 30 m wide in the south, and is approximately 250 m long. Mineralization extends to depths of over 500 m.

Lithologies

The Bridge zone consists of copper-mineralized basalt and quartz monzodiorite between the Southwest and Central deposits.

Mineralization and Alteration

Low-grade copper mineralization is characterized by lower vein densities than in surrounding deposits and is hosted in chlorite- and epidote-altered basalt and lesser sericite- and albite-altered quartz monzodiorite. Magnetite veinlets post-date the quartz veins but predate the main sulphide event.

Chalcopyrite, bornite, and pyrite are mainly disseminated, with fracture- or vein-controlled sulphides being less prominent. There is no clear geological boundary distinguishing the disseminated mineralization from the adjacent peripheral zone mineralization.

8.1.1.7 West Oyu

The West Oyu structural zone is defined based on a soil anomaly and fault interpretations. Drillholes testing the Southwest Oyu and Far South mineralization were collared in the West Oyu domain and drilled to the south-east to intercept the mineralization in these zones. To date, results are not encouraging.

8.1.2 Hugo Dummett Deposits

The Hugo Dummett deposits, Hugo North and Hugo South, contain porphyry-style mineralization associated with quartz monzodiorite intrusions, concealed beneath a sequence of Upper Devonian and Lower Carboniferous sedimentary and volcanic rocks. The deposits are highly elongated to the north-north-east and extend over 3 km. The dividing line between the two deposits is 4766300 N, a location marked by the thinning and locally discontinuous nature of the high-grade copper mineralization (defined by greater than 2% copper). The line, which is broadly coincident with the east-striking 110° Fault (refer to Figure 7.6 for the projections of the major faults in the area of the Hugo Dummett deposits), separates the gold- and copper-rich zone hosted in augite basalt and quartz monzodiorite of the Hugo North deposit from the more southerly, gold-poor, ignimbrite- and augite basalt-hosted mineralization at Hugo South.

Early technical reports on the project refer to the Far North zone; this is was the initial name for the Hugo Dummett area, and the usage has been discontinued. A portion of the Hugo North deposit extends onto the Shivee Tolgoi mining licence. This portion is known as the Hugo North Extension and in technical reports filed by Entrée Gold is referred to as the Copper Flats deposit.

8.1.2.1 Hugo South

Deposit Dimensions

The Hugo South deposit is separated from the Southern Oyu deposit group by the Central Fault and from the Hugo North deposit by the 110° fault. The deposit is tapered, being approximately 650 m wide and about 850 to 1,300 m long.

Lithologies

The Hugo South deposit is hosted by an easterly dipping sequence of volcanic strata correlated with the lower part of the Devonian Alagbayan Formation, and by quartz monzodiorite intrusive rocks. Stratigraphically lowest rocks in the sequence consist of porphyritic (augite) basalt flows and minor volcaniclastic strata. These are overlain by basaltic tuffs and breccias forming a sequence varying from 100 m to 200 m thick. The basaltic fragmental sequence was previously thought to be dacitic in composition. Whole-rock geochemistry has shown it to be similar in composition to the underlying basalt, and it has been affected by advanced argillic alteration to give it the appearance of a dacitic tuff. As such, the true boundary between the augite basalt and the fragmental rocks is difficult to determine, being texturally destroyed and diffuse in character.

Weakly-altered to unaltered sedimentary and volcanic rocks of the upper Alagbayan Formation and Sainshandhudag Formation structurally overlie the mineralized sequence along the eastern flank of the Hugo South deposit. The thickness of the non-mineralized Alagbayan Formation sequence commonly exceeds 600 m, although structural thickening may occur within the sequence. The Sainshandhudag Formation strata unconformably overlie, and are locally faulted against, the Alagbayan Formation.

Several phases of intrusive rocks occur in the Hugo South deposit. The oldest recognized intrusions are quartz monzodiorite bodies, which underlie the entire deposit area and contain low copper grades. Quartz monzodiorite contacts are irregular, but overall show a preferred easterly dip, sub-parallel to contacts in the enclosing stratified rocks. The quartz monzodiorite is broadly contemporaneous with alteration and mineralization, and two varieties are distinguished on the basis of alteration characteristics and position within the deposit:

- An intensely quartz-veined phase that occurs along the upper margin of the main intrusive body or as a separate east-dipping tabular body in the overlying strata.
- A lower-grade, more weakly veined variety, which makes up the large intrusive body forming the lower part of and underlying the entire deposit.

Late- to post-mineral biotite granodiorite intrusions form a north-north-east-striking dyke complex cutting across the western edge of the deposit. Correlations between drillhole intersections and measurements of individual contacts indicate that dyke contacts have a moderate to steeply west-dipping preferred orientation.

Younger intrusions include rhyolite, hornblende–biotite andesite, dacite, and basalt/dolerite compositional varieties. These intrusions usually occur as dykes with subvertical orientations, or less commonly as easterly-dipping sills emplaced along stratigraphic contacts. They are non-mineralized and appear to be volumetrically insignificant except locally in the deposit.

The Hugo South deposit occurs within a north–north-easterly elongate block bounded on the north and south by moderately north-dipping faults and on the east and west by steep, north-north-east-striking faults. Strata within the block form a homoclinal sequence dipping moderately to the east-south-east.

Structures

Deformation of the Hugo South deposit is dominated by brittle faulting. Major faults cutting the deposit can be grouped on the basis of orientation into four sets:

- East-west-striking, moderately north-dipping faults (e.g., 110, Central Faults). The 110 Fault defines the division between the Hugo North and Hugo South deposits, although mineralization is continuous across the fault. The Central Fault is a shallowly to moderately north-dipping structure that lies beneath the southern portion of the Hugo Dummett deposit.
- Steep north-north-east-striking faults (e.g., East and West Bat, East Hugo, and Axial Faults). The linear mineralized trend defined by the Central, Southwest, and Hugo Dummett deposits likely reflects the presence of a deep, north-north-east-striking crustal fault or fault zone controlling magma emplacement and mineralization, termed the Axial Fault. The West Bat Fault is a north-north-east-striking, subvertical structure that extends along the west side of the Hugo Dummett deposit. It cuts the north-western edge of the Hugo North deposit, but is well to the west of the main part of the Hugo South deposit. The East Bat Fault is a north-north-east-striking, subvertical structure occurring along the east side of the Hugo Dummett deposit. The East Hugo Fault occurs as a north- to north-north-west-striking, steeply east-dipping zone of strong to intense brecciation and clay gouge along the east limb of the Hugo South and Hugo North deposits.
- North-north-east-striking faults that dip moderately east, sub-parallel to lithological contacts (e.g., Contact, Lower Faults). The Contact Fault has been interpreted as a bedding-parallel detachment zone that normally occurs at the contact between tectonized mudstones stratigraphically overlying the deposit (Unit DA3) and overlying basalt flows and volcaniclastic rocks (unit DA4). This interpretation remains to be confirmed. The Lower Fault occurs as an intensely brecciated, clay gouge-rich zone within the middle or lower portion of the mineralized body, typically 200 to 400 m below the Contact Fault.
- East-west-striking, subvertical faults (e.g., East-West Fault). The East-West Fault cuts across and displaces the northern end of the Hugo South deposit.

Two orientations of folds were identified in the Hugo South deposit area: a dominant set of north-north-east-trending folds, and a subordinate set of north-west-trending folds. Both of the dominant fold orientations also occur in Carboniferous post-mineral strata, indicating that both events post-date mineralization and may have modified the form of the deposit.

Mineralization

Copper mineralization at the Hugo South deposit is centred on a high-grade (typically >2% Cu) zone of intense quartz stockwork veining, which in much of the deposit is localized within narrow quartz monzodiorite intrusions and extends into the enclosing basalt and basaltic fragmental units. The intense stockwork zone has an elongate tabular form, with a long axis plunging gently to the north-north-west and an intermediate axis plunging moderately to the east. Copper grades gradually decrease upwards from the stockwork zone through the upper part of the massive augite basalt and the basaltic tuff, and a broader zone of lower grades occurs below and to the west in basalt and quartz monzodiorite.

Dominant sulphide minerals at Hugo South are chalcopyrite, bornite, chalcocite, and pyrite, with minor molybdenite, enargite, tennantite, and covellite. More rarely, sphalerite and galena can occur. Sulphides are zoned, with bornite ± chalcopyrite, chalcocite, and tennantite comprising the highest grades (>2.5% Cu), grading outwards to chalcopyrite (1% to 2% Cu). Pyrite–chalcopyrite ± enargite, tennantite, bornite, chalcocite, and (rarely) covellite occur in a lower-grade zone (<1% Cu), mainly in advanced argillic-altered basaltic tuff.

Alteration

Alteration in the Hugo South deposit is typical of copper porphyry systems, including K silicate (minor), advanced argillic, muscovite/sericite, and intermediate argillic styles. The mineral groupings used to define individual zones are not necessarily true assemblages that formed contemporaneously, but are associations that may represent several paragenetic stages. The distribution of the alteration is strongly lithologically controlled: basaltic tuff typically shows strong advanced argillic alteration, whereas basalt tends to be chlorite–muscovite–hematite-altered with pyrophyllitic advanced argillic alteration in its uppermost parts. Pockets of advanced argillic alteration occur locally in the high-grade zone in the quartz monzodiorites.

8.1.2.2 Hugo North

Deposit Dimensions

The Hugo North deposit is virtually contiguous with the Hugo South deposit and occurs within a similar geological setting. The two deposits are separated by a 110°-striking, 45° to 55° north-dipping fault that displaces Hugo North vertically down a modest distance from Hugo South. Hugo North extends from +500 msl (mean sea level) to depths well below 400 msl and has a strike length in excess of 1,800 m and a width of 500 m.

Lithologies

Host rocks at Hugo North are an easterly dipping sequence of volcanic and volcaniclastic strata correlated with the lower part of the Devonian Alagbayan Formation, and quartz monzodiorite intrusive rocks that intrude the volcanic sequence.

Stratigraphically lowest rocks in the host sequence are basalt flows and minor volcaniclastic strata, overlain by a basaltic tuff and breccia sequence. The basaltic tuff sequence has been affected by advanced argillic alteration to give it the appearance of a dacitic tuff. The host sequence basaltic volcanics are overlain by dacitic block and ash tuff and dacitic ash flow tuff. Weakly altered to unaltered sedimentary and volcanic rocks of the upper Alagbayan Formation and Sainshandhudag Formation structurally overlie the mineralized sequence along the eastern flank of the deposit.

Intrusive rocks at Hugo North are dominated by quartz monzodiorite bodies that underlie the entire deposit area and host a significant portion of the copper and gold mineralization. Intrusive contacts are typically irregular but overall show a preferred easterly dip, subparallel to stratification in the overlying rocks. The quartz monzodiorites are contemporaneous with alteration and mineralization. The quartz monzodiorite is considered to be the progenitor porphyry, and two zones are distinguished on the basis of alteration characteristics and position within the deposit.

A late- to post-mineralization biotite granodiorite intrusion forms a northerly striking dyke complex cutting across the western edge and deeper levels of the deposit. At higher levels, the biotite granodiorite flares out considerably to form a voluminous body. Although this intrusion locally contains elevated copper grades adjacent to intrusive contacts or within xenolith-rich zones, it is essentially barren.

The positions and orientations of dyke contacts are reasonably well established in the Hugo North deposit area on the basis of correlations between drillhole intersections and measurements of individual contacts using oriented drill core. Dominant dyke orientation varies with depth. At levels above approximately 250 m RL, where the biotite granodiorite cuts through the non-mineralized hanging wall strata, it occurs as a single intrusive mass with contacts dipping moderately to steeply to the west. Below this level, the biotite granodiorite is more complex, occurring as multiple and subparallel to anastomosing dykes that cut through the quartz monzodiorite intrusion and mineralized Alagbayan Formation strata.

Structures

The Hugo North deposit occurs within easterly dipping homoclinal strata contained in a north-north-easterly elongate fault-bounded block. The northern end of this block is cut by several northeast-striking faults near the northern boundary of the Oyu Tolgoi property, but the deposit remains open along trend north of these faults. The structural geometry and deformation history of the Hugo North deposit are, in general, similar to those of the Hugo South deposit.

The following paragraphs detail the information available on the structural setting of the Hugo North deposit as interpreted at the time of construction of the 2007 geological model. An updated geological and structural interpretation is underway, and is discussed in Sections 9.4.3 and 9.4.4.

Deformation of the Hugo North deposit is dominated by brittle faulting. Major faults cutting the deposit can be grouped on the basis of orientation into the following sets:

- East-west-striking, moderately north-dipping faults (e.g., 110 Fault). The 110 Fault defines the division between the Hugo North and Hugo South deposits.
- Steep, north-north-east-striking faults (e.g., East and West Bat Fault, 160 Fault, and Axial Faults). The subvertical, north-north-east-striking West Bat Fault occurs along the west side of the Hugo North deposit and cuts the western edge of the northern part of the deposit. The linear mineralized trend defined by the Central, Southwest, and Hugo Dummett deposits likely reflect the presence of a deep, north-north-east-striking crustal fault or fault zone controlling magma emplacement and mineralization, termed the Axial Fault. The subvertical, north-north-east-striking West Bat Fault occurs along the west side of the Hugo North deposit and cuts the western edge of the northern part of the deposit. The north-north-east-striking East Bat Fault follows the east flank of the Hugo Dummett deposit, well east of the known deposit extents. The 160 Fault can be traced through the southern part of the Hugo North deposit, where it cuts across stratigraphic contacts at moderate angles and forms a sharp break in alteration intensity and copper grade.
- North-north-east-striking, moderately east-dipping faults subparallel to lithological contacts (e.g., Contact, Lower Faults). The Contact Fault is a bedding-parallel detachment zone that normally occurs at the contact between tectonized mudstones that stratigraphically overlie the deposit (unit DA3) and overlying basalt flows and volcaniclastic rocks (unit DA4). The Lower Fault at Hugo North occurs as an intensely brecciated, locally foliated, clay-rich gouge zone within the middle or lower portion of the high-grade mineralized body, typically at a level 200 m to 400 m below the Contact Fault.
- East-north-east-striking faults (e.g., Boundary Fault System, Rhyolite Fault). The Boundary Fault follows the intrusive contact of the granitic complex in the north-west part of the Oyu Tolgoi Project area and juxtaposes strongly mineralized rocks against post-mineral Carboniferous strata near the northern property boundary. The North Boundary Fault juxtaposes Carboniferous granitic rocks against Carboniferous strata to the south. The subvertical, east-north-east-striking Rhyolite Fault cuts across the southern part of the Hugo North deposit and coincides with a wide zone of rhyolite dykes.

Fold styles and orientations in the Hugo North deposit are similar to those at Hugo South, with most folding restricted to the upper part of the Alagbayan Formation and overlying Sainshandhudag Formation.

Mineralization

The highest-grade copper mineralization in the Hugo North deposit is related to a zone of intensely stockworked-to-sheeted quartz veins known as the QV90 zone, so named because >90% of the rock has >15% quartz veining. The high-grade zone is centred on thin, east-dipping, quartz monzodiorite intrusions or within the apex of the large quartz monzodiorite body, and extends into the adjacent basalt. In addition, moderate to high grade copper and gold values occur within quartz monzodiorite below and to the west of the intense vein zone, in the Hugo North gold zone. This zone is distinct and has a high Au (ppm) to Cu (%) ratio of 0.5:1.

Bornite is dominant in the highest-grade parts of the deposit (3% to 5% Cu) and is zoned outward to chalcopyrite (2% Cu). At grades of <1% Cu, pyrite–chalcopyrite dominates. Within the upper levels where advanced argillically altered basaltic tuff is reported, the assemblage comprises pyrite–chalcopyrite ± enargite, tennantite, bornite, chalcocite, and more rarely covellite.

The high-grade bornite zone consists of relatively coarse bornite permeating quartz and disseminations in wall rocks, usually intergrown with subordinate chalcopyrite. Pyrite is rare to absent except locally where the host rocks are advanced argillically altered. Although chalcocite is commonly found with bornite at Hugo South, it is less common at Hugo North. High-grade bornite is associated with minor amounts of tennantite, sphalerite, hessite, clausthalite, and gold that occur as inclusions or at grain boundaries.

Elevated gold grades in the Hugo North deposit occur within the up-dip (western) portion of the intensely veined, high-grade core and within a steeply dipping lower zone cutting through the western part of the quartz monzodiorite. Quartz monzodiorite in the lower zone exhibits a characteristic pink to buff colour, with a moderate intensity of quartz veining (5% to 25% by volume) and is characterized by finely disseminated bornite and chalcopyrite. Sulphides are disseminated throughout the rock in the matrix as well as in quartz veins. The fine-grained bornite has a black “sooty” appearance. Red coloration of the rock type is attributed to fine hematite dusting, primarily associated with albite.

Alteration

The Hugo North deposit is characterized by copper–gold porphyry and related styles of alteration similar to those at Hugo South. These include biotite–K-feldspar (K-silicate), magnetite, chlorite–muscovite–illite, albite, chlorite–illite–hematite–kaolinite (intermediate argillic), quartz–alunite–pyrophyllite–kaolinite–diaspore–zunyite–topaz–dickite (advanced argillic), and sericite–muscovite zones. The distribution of alteration zones is similar to that in the Hugo South deposit except that the advanced and intermediate argillic zones are more restricted and occur mainly along the outer and upper margins of the intrusive system.

Chlorite–illite marks the outer boundary of the advanced argillic zone. It occurs mainly in the coarse, upper part of the basaltic tuff/breccia.

Quartz–pyrophyllite–kaolinite–dickite (advanced argillic) is hosted mainly in the lower part of the basaltic tuff, although on some sections at Hugo North it extends into strongly veined quartz monzodiorite.

The advanced argillic zone is typically buff or grey, and late dickite on fractures is ubiquitous. Within the advanced argillic zone, a massive quartz–alunite zone forms a pink–brown bedding-parallel lens. As with elsewhere within the property, the advanced argillic alteration is texturally destructive and often obliterates the contact between the augite basalt and overlying basaltic tuff. As a result, it is typically a diffuse lithological and mineralization contact that characterizes this zone.

Topaz is widespread as late alteration controlled by structures cutting both the advanced and intermediate argillic zone. In certain areas topaz appears to replace parts of the quartz–alunite zone. In addition, topaz may also occur disseminated with quartz–pyrophyllite–kaolinite.

Hematite–siderite–illite–pyrophyllite–kaolinite–dickite (intermediate argillic) is an inward zonation from the advanced argillic zone, and is commonly hosted by augite basalt but may also occur in basaltic ash-flow tuff. Hematite usually comprises fine specularite and may be derived from early magnetite or Fe rich minerals such as biotite or chlorite.

Hematite–chlorite–illite–(biotite–magnetite) (chlorite) is transitional to the intermediate argillic zone and is commonly hosted by augite basalt. It is characterized by a green colour and relict hydrothermal magnetite, either disseminated or in veins.

Muscovite–illite (sericite) generally occurs in the quartz monzodiorite intrusions and is a feature of the strongly mineralized zone. Alteration decreases with depth in the quartz monzodiorite.

8.1.2.3 Hugo North Extension

The Hugo North Extension is a term used to delimit that portion of the Hugo North deposit that extends into the Joint Venture ground. The zone extends from the licence boundary north for approximately 700 m and appears to be closed off to the north; drilling on a section approximately 150 m north of the northernmost extent of the Hugo North Extension grade shell has indicated that mineralization is truncated by an east-west-trending fault. North of the fault, the prospective stratigraphy has been down-dropped to depths greater than 2,000 m below the surface.

8.1.3 Heruga

The Heruga deposit is the most southerly of the currently known deposits at Oyu Tolgoi. The deposit is a copper–gold–molybdenum porphyry deposit and is zoned with a molybdenum-rich carapace at higher elevations overlying gold-rich mineralization at depth. The top of the mineralization starts 500 to 600 m below the present ground surface.

The deposit has been drilled over a 2.3 km length, is elongated in a north-north-east direction, and plunges to the north. Exploration of the down-plunge extension is active as at 31 March 2012. The northern boundary of the mineralization is assumed to be the Solongo Fault, which marks the southern boundary of the planned South Oyu open pit.

Quartz monzodiorite intrusions intrude the Devonian augite basalts as elsewhere in the district, and again are considered to be the progenitors of mineralization and alteration. Within Heruga itself quartz monzodiorite intrusions are small compared to the stocks present in the Hugo Dummett and Southern Oyu areas, perhaps explaining the lower grade of the Heruga deposit. Non-mineralized dykes, which make up about 15% of the volume of the deposit, cut all other rock types. However, the quartz monzonite body appears to flare to the east and forms a large stock within the Heruga area of interest.

The deposit is transected by a series of north-north-east-trending vertical fault structures that step down 200 m to 300 m at a time to the west and have divided the deposit into at least two structural blocks.

Mineralized veins have a much lower density at Heruga than in the more northerly Southern Oyu and Hugo Dummett deposits. High-grade copper and gold intersections show a strong spatial association with contacts of the mineralized quartz monzodiorite porphyry intrusion in the southern part of the deposit, occurring both within the outer portion of the intrusion and in adjacent enclosing basaltic country rock.

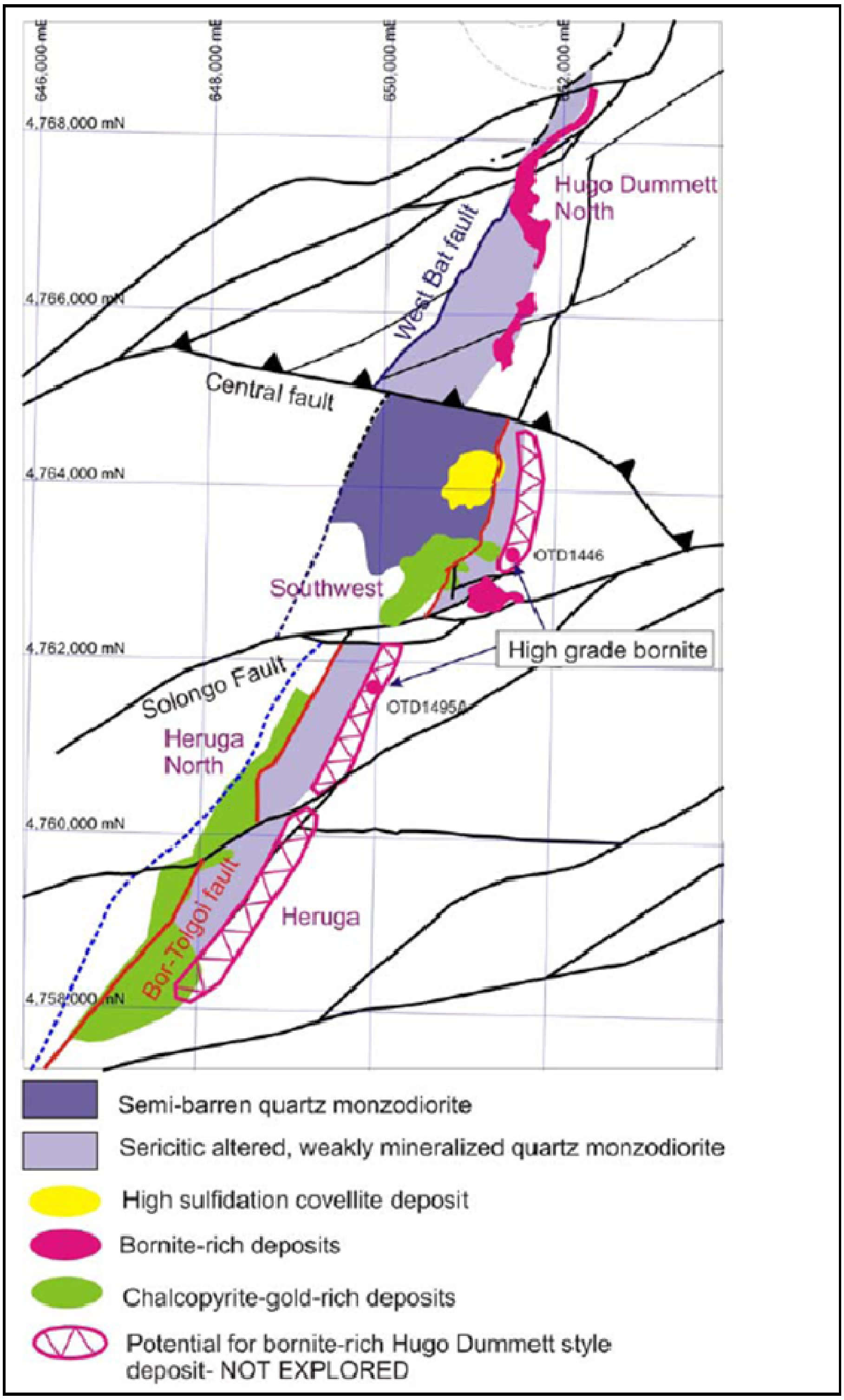
At deeper levels, mineralization consists of chalcopyrite and pyrite in veins and disseminated within biotite–chlorite–albite–actinolite-altered basalt or sericite–albite-altered quartz monzodiorite. The higher levels of the orebody are overprinted by strong quartz–sericite–tourmaline–pyrite alteration where mineralization consists of disseminated and vein-controlled pyrite, chalcopyrite, and molybdenite.

There is no oxide zone at Heruga. No high-sulphidation style mineralization has been identified to date.

8.1.4 Exploration Potential

Figure 8.6 shows the locations of the major target areas that are currently considered to have exploration potential. The project retains exploration prospectivity in addition to these areas.

Figure 8.6 Prospective Mineralized Horizons, Project Area



8.1.4.1 Hugo North Extensions

While recent drilling in the area immediately north of Hugo Dummett North has suggested that the mineralization is significantly downthrown in a series of complex structural slices, further work is warranted. A number of as yet unexplained geophysical anomalies are apparent, and a weak soil geochemistry anomaly is noted that projects directly above the zone of interest (i.e., above the area mapped as Carboniferous granite immediately to the north-west of the northern projection of the Hugo North grade shell).

More recent interpretations show significant strike-slip displacement of mineralization along east-west structures. Further, there appears to be some indication that the large Carboniferous granitoid body to the north-west may be an allochthonous block overlying a target. Further interpretation and drill testing of such as target is planned.

8.1.4.2 Ulaan Khuud South

In the north of the project area, elevated copper and gold grades are present in basalts 10 km north of the northern end of Hugo Dummett. A total of 29 core holes have been drilled with a best intersection of 94 m at 0.58% Cu, 0.19 g/t Au, and 270 ppm Mo from 608 m to 702 m in EGD127.

Immediately north of the property boundary, Asia Gold has reported the discovery of Oyu Tolgoi-style copper–molybdenum–gold mineralization at Ulaan Khud North. Ivanhoe has described the deposit as:

> "A total of 25 drill holes totalling 6,561 metres, ranging in depth from 182 metres to 377 metres, defined the new zone of shallow porphyry copper mineralization over an area of 600 metres by 300 metres. Most of the holes are vertical and were drilled on a 100-metre-square grid. The mineralized zone starts beneath 60 to 80 metres of Cretaceous clay and gravels. The mineralization at Ulaan Khud North starts as shallow as 60 metres below surface, much higher than the mineralized zone at Hugo Dummett to the south. The fact that Ulaan Khud North occurs in similar Devonian host rocks to Hugo Dummett suggests that the main Oyu Tolgoi porphyry system trend is relatively shallow in this area and that potential for surface-mineable targets still exist within the Oyu Tolgoi trend and Ulaan Khud North in particular."

OT LLC understands that Asia Gold has a pre-mining agreement with the Government of Mongolia, based on a Mineral Resource estimate (classifications unknown) of 23 Mt grading 0.5% Cu. Under this agreement, Asia Gold has three years (to approximately early 2014) to convert the licence to a mining licence. Additional drilling was completed in 2011, although this work appears to have limited the size potential of the deposit.

The Ulaan Khud North discovery indicates that further work is warranted targeting shallow mineralization in basalt blocks under cover in the Ulaan Khud South area.

8.1.4.3 Heruga North

The Heruga North zone, which in earlier reports was referred to as the New Discovery zone, is the down-plunge extension of the Heruga mineralization located up-plunge to the south. The top of Heruga North is approximately 1,100 m below surface and slopes gradually downward as it extends to the north. The Solongo Fault forms the projected northern limit of mineralization associated with Heruga (Figure 8.6).

An interpretation that the gold-rich zone on the western side of Heruga North might be off-set to the west and continue on the western side of the Heruga deposit has been drill tested. No extension is considered likely because drilling encountered Carboniferous granodiorite rather than the prospective Devonian stratigraphy.

Ongoing evaluation of the drill results from Heruga and Heruga North indicated that the eastern margins of the quartz monzodiorite at Heruga had not been effectively tested. When compared with Heruga North, where mineralization is commonly present on the eastern margins of the monzodiorite, there may be potential for development of bornite-rich mineralization on the eastern side of the Heruga deposit. The conceptual exploration target prospectivity zones for quartz monzodiorite-hosted mineralization in the project area, including Heruga, are also shown in Figure 8.6.

Drilling completed to date indicates the eastern margin of the quartz monzodiorite is further east than initially predicted.

8.1.4.4 Javkhlant

The Javkhlant target area consists of a number of geophysical anomalies that include:

- Javkhlant I: weaker IP anomaly associated with Devonian rocks
- Javkhlant II: strong IP anomaly associated with Devonian rocks
- Javkhlant III: corresponding to a rhyolite dyke array in a fault-bounded area northwest of Jahvkhlant II, IP anomaly identified during the Zeus survey
- Raven: south-east of Javkhlant II and a weak IP anomaly.

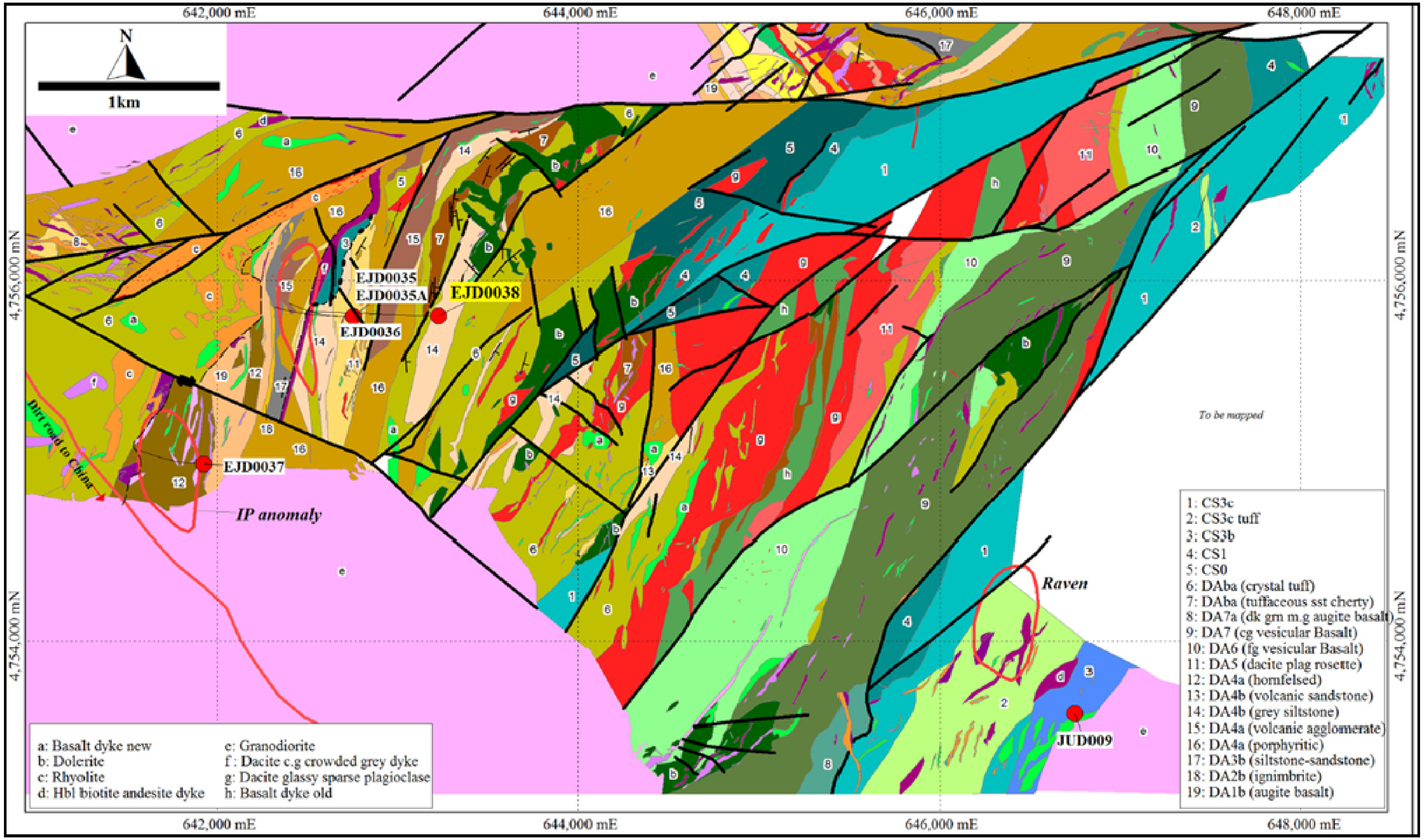
The Javkhlant I and Javkhlant II anomalies, discovered during regional IP surveying in 2005, are approximately 5 km to the south-west of Heruga. Subsequent to the initial discovery, detailed geological mapping, ground magnetic surveys, and Zeus IP surveying have better defined the IP anomalies and their geological context. On current interpretations, Javkhlant I and Javkhlant II are likely to represent a continuous zone of mineralization that has been cut and displaced by a north-west-trending fault (Figure 8.7). The anomalies could also represent the faulted offset of the Heruga mineralization, displaced 5 km to the west on an east-north-east-trending fault.

Javkhlant I was initially tested by drilling in 2010. Drillhole EJD0035A encountered a wide intercept of low-grade copper mineralization (30 m at 0.92% Cu from 1,422 m depth) hosted in a dacitic ignimbrite (basaltic tuff?) and associated with advanced argillic alteration. Subsequent drilling in 2011; however, encountered abundant fine disseminated pyrite with minor zones of semi-massive pyrite ± chalcopyrite hosted in two Devonian basalt lithologies immediately east and down-dip of this initial intersection.

The presence of mineralization in the DA4 and DA1 units, hornfelsing, and a lack of porphyry-style quartz veining are currently interpreted to suggest the mineralization and alteration at Javkhlant I may be related to a Carboniferous granodiorite. The interpretation is supported by the identification of the phosphate mineral lazulite; the only other known occurrence of lazulite is at the Lookout Hill prospect, which is a Carboniferous-age mineralizing system related to nearby granites.

The drillhole sited at Javkhlant II intersected strong hornfelsing, related to the Carboniferous granodiorite, and disseminated and vein pyrite/pyrrhotite with pyrite up to 8% and trace chalcopyrite hosted in a hornfelsed Devonian basalt. Four narrow zones of very low grade copper and trace molybdenum and gold were returned. The IP anomaly is considered to be related to the pyritization of the basalt. At present, this is the southernmost known mineralization on the Oyu Tolgoi trend.

Figure 8.7 Javkhlant IP Anomaly Locations



The Javkhlant III anomaly was identified in 20 km AB Zeus data within a fault-bounded area north of the Javkhlant I anomaly. A major fault forms the southern boundary of the fault-bounded area and is characterized by abundant 'buck' quartz veins and rhyolite dykes that are commonly brecciated and quartz vein replete. Volcano-sedimentary rocks crop out sparsely between mapped dyke swarms but probably comprise a large part of the subcrop. These rocks, previously mapped as Carboniferous in character, are currently interpreted to be part of the hanging wall Devonian sequence. This interpretation increases the potential for discovery of further extensions of the Oyu Tolgoi trend.

The Javkhlant III anomaly corresponds with the rhyolitic dyke array on the south-west side of the fault slice, but as the IP response does not appear in shallower AB chargeability data, it is likely to be a deep-seated feature and may represent the signature of deeply buried Devonian host rocks. The geophysical target can only be evaluated with drilling.

9 EXPLORATION

9.1 Grids and Surveys

Coordinates used for exploration on the project are mostly UTM coordinates with the datum set to WGS-84, Zone 48N. The boundary coordinates of the Mining and Exploration Licences are defined by latitude and longitude coordinates. The official Mongolian survey datum is “MSK42,” using the Baltic mean sea level as the elevation datum. It was noted the coordinates obtained using the MSK42 data were almost identical to those using WGS-84, Zone 48N.

Various topographic surveys have been completed on the project area, the most recent of which was completed in 2010 by Geomaster, covering a 10 km x 10 km area using an electronic total station instrument with an accuracy of 5 cm. The survey had a contour interval of 1 m.

In 2011, the governing authority in Mongolia changed the official survey datum to WGS84, Zone 48N. As a consequence, there has been a small shift in the bounding coordinates of the licences. Geomaster is completing a new survey of the boundaries using the total station instrument on behalf of OT LLC.

OT LLC intends to acquire a GeoEye satellite image and use it to derive a new topographic map (refer to Section 9.2).

9.2 Imaging

In 2001, Pacific Geomatics were commissioned to produce 1:100,000 scale LandSat satellite images and a structural and alteration interpretation over a 1,500 km^2 area centred on the project. These data are integrated into a GIS database and have been used to aid in the structural interpretation of the project and for alteration mapping.

In 2003, Pacific Geomatics provide Quickbird imaging over the entire Oyu Tolgoi mining licence. OT LLC has engaged Fugro Spatial to acquire GeoEye imagery over the entire area of the mining licences and extend this coverage along key infrastructure corridors such as the Gunii Holoii water bore field and the road to the China/Mongolia border. Resolution is anticipated to be approximately 0.5 m in the vertical and horizontal components.

9.3 Geological Mapping

9.3.1 Surface Mapping

Geological mapping programs have been restricted by the paucity of outcrop in the project area.

Outcropping mineralized zones (Southwest, South, and Central Oyu) were mapped at 1:1,000 scale in 2001. The central part of the Oyu Tolgoi licence area was mapped at 1:5,000 scale in 2001, and the entire Oyu Tolgoi licence area was mapped at 1:10,000 scale in 2002.

Additional geological and structural mapping was completed by Alan Wainwright during 2005–2008 as part of his PhD thesis research.

Mapping on the Shivee Tolgoi licence has consisted of 1:20,000 and 1:10,000 scale regional mapping, with detailed prospect-scale mapping completed at 1:2,000 scale, undertaken in the period 2004–2008.

A detailed 1:2,500 surface geological mapping program was initiated in 2011 across a portion of the Javkhlant area west of Heruga, and is focused on determining stratigraphic relations that may indicate vectors to prospective stratigraphy. The long-term aim is to complete a detailed geological map of the area extending eastwards to the Khukh Haad license, a distance of about 8 km, of which approximately 2 km extending east from Javkhlant have been mapped to date.

9.3.2 Underground Mapping

Detailed geological mapping on the 1300 Level from the Hugo North underground workings is currently being undertaken and will be used to guide planned updates to the geology model interpretations. Underground mapping is incomplete, and additional work is planned, particularly in the area of the West Bat Fault.

The following have been noted from the work completed to date.

- Very few faults are mapped in the underground drilling, and they do not appear to match the locations of interpreted faults. This may be due to incorrect interpretation; however, it is considered to be more likely to be an artefact of different logging protocols between the surface and underground mapping programs, a lack of logging detail in structural logging columns (i.e., no information has been entered into the data table during logging), and a difference in interpretation between a "geotechnical" fault, recognition of which is typically based on a broken zone, and a "geological" fault, which is typically based on juxtaposed rocks of different character that may be healed, and which may have good geotechnical characteristics, such as rock quality designation (RQD).
- There are inconsistencies in logging of the Carboniferous sequence to the west of the West Bat Fault, making it difficult to correlate units that can then be used to determine displacements on faults that may cut the West Bat Fault.

9.4 Structural Studies

9.4.1 Southern Oyu

During 2010–2011, the structural and geological model for Southern Oyu was updated using all currently available information and based on level plan interpretations. Major faults identified from this program are incorporated in the updated 2012 Southern Oyu resource cell models.

A provisional fault hierarchy for the area was established:

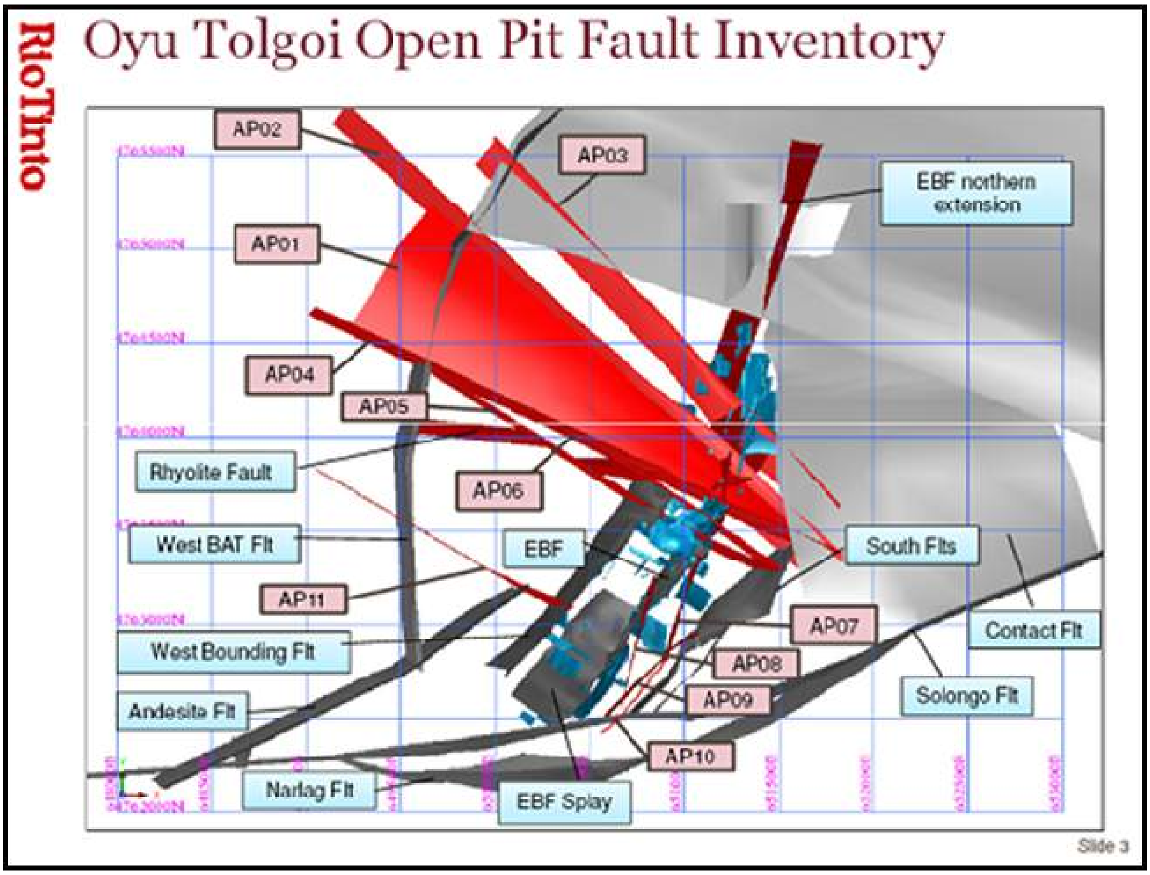
- Early stage: north-north-east-trending faults (East Boundary Fault, West Boundary Fault, Andesite Fault).
- Middle stage: north-north-west-trending faults (AP01, AP02, AP03, AP04, AP05, AP06, AP011, and Rhyolite Fault).
- Late stage: east-north-east-trending faults (Solongo Fault system and associated splays).

Figure 9.1 shows the current fault interpretation for Southern Oyu.

Key elements from the work completed to date are as follows:

- Eleven new faults were modelled from level plan interpretations.
- Faults in the southern part of the Hugo fault model were extruded to the margins of the model for convenience. The result is that the northern part of the South Oyu open pit and South Hugo fault models overlap, but do not actually link together structurally or geologically. Rectification of this issue is planned and is critical to obtaining a district-wide coherent structural architecture.

Figure 9.1 Fault Locations and Orientations (2011 Interpretation)



- The East Boundary Fault was extended to the north, re-modelled as a steeply west dipping, gently listric fault, and interpreted as a >50 m wide fault zone characterized by fault gouge, lithological repetitions, and a swarm of BiGd dykes. The fault has been modelled as a series of segments displaced across newly interpreted north-west–south-east-trending faults.
- The geologically unusually shallow-dipping BiGd intrusions in the Central Pit were re-modelled as steeply dipping dykes, compatible with the BiGd intrusions associated with the well-constrained East Boundary Fault in the Southwest zone. The dykes are interpreted to be intimately associated with extensional faulting along the East Boundary Fault. The orientation of these dykes presents a potential geotechnical risk, and further work will be required to confirm the subvertical reinterpretation.
- The previously modelled east-west-trending Rhyolite Fault between the Southwest and Central zones, which was the northernmost fault in the 2005 model, was retained but re-modelled into segments separated by the newly interpreted north-west-south-east-trending faults.
- The north-north-west-trending faults appear to be subvertical to steeply north-easterly dipping. Faults AP04, AP05, and AP06 are coincident with a swarm of presumably synchronously intruded rhyolite dykes (which have the same strike, but shallower, 60° to 70° dips) between the Central and Southwest zones.

It was concluded that:

- The East Boundary Fault is likely to form a significant geotechnical and hydro geological feature during mining operations.
- Changes in interpretations of the dip of the BiGd intrusions, when confirmed, could have significant benefits for slope design. In the previous model, BiGd dykes are not only parallel to the slope, but immediately below the ramps on the east side of the pit, posing a major slope stability hazard. It was recommended that the BiGd units in the Central zone be re-modelled, with geotechnical holes sited to determine whether the BiGd units are favourably steeply dipping (as in the 2011 work), or unfavourably dipping west, parallel to the Central Pit slope (as previously modelled).

9.4.2 Hugo Area

Rio Tinto staff, on behalf of OT LLC, performed an initial structural review of the faulting and fault models during 2009–2010 for the Hugo Dummett deposit area in support of the planned block cave mining operation. The resulting fault model is principally based on apparent displacements of geological boundaries, coupled with interpretation and analysis of structural data collected from drill core.

Work to date on cross-sectional and level-plan interpretation at 1:2,500 scale shows the apparent presence of numerous north-west- and north-east-trending faults oblique to the east-west-trending sections. In addition, cross-referencing this with the completed underground drilling demonstrates that the regional West Bat Fault structure is more planar than originally modelled. It is possible that this may translate in to a modest increase in resource potential (not within current cave footprints). It is also possible that some of the irregularities in modelling the position of the West Bat Fault may be the result of cumulative survey errors towards the end of very deep holes that commonly penetrate the fault at oblique angles. This new interpretation is considered more kinematically probable and highlights the fact that apparent rapid directional changes along the trace of the West Bat Fault are more likely to reflect off-sets on cross-cutting faults, especially within the Entrée lease area. Such an interpretation had been previously proposed, but has not, as yet, been unambiguously demonstrated.

The proposed faults in the Hugo North Extension area (Entrée zone) appear to be discontinuous in level plan interpretations. From this, it is inferred that the faults anastomose along strike and with depth, such that in the east-north-east-striking and north-north-west-dipping Entrée zone there may be fault segments that dip to the south-south-east as well as to the north-north-west. In the Hugo North Extension, for mine planning purposes, the faulting is expected to have locally offset zones of high-grade mineralization that are connected in the current resource model.

Results of the work are currently being incorporated into a planned update of the Hugo Dummett resource models.

9.4.3 2011 Preliminary Interpretation

During 2010–2011, a significant amount of work was undertaken to review the geological and structural setting of the Oyu Tolgoi mineralization, particularly in the Hugo North area. OT LLC advised the conclusions reached from the current level of information presented in the following paragraphs are provisional the work remains in progress.

Initial project structural interpretations assumed ductile tectonic activity with the Contact Fault acting as a thrust fault ramp and consequent overturning of the hanging wall rocks. However, the current investigation has not, to date, identified any penetrative deformations (e.g., cleavage development) within any of the rock units. This would tend to indicate that the Contact Fault is not part of a typical thrust-and-fold belt assemblage.

In addition, close inspection of the footwall and hanging wall rocks has shown that there is no direct correlation between lithologies. The current conclusion is that although the footwall and hanging wall rocks are likely to be of approximately similar ages, there is insufficient information to determine which is older, younger, or if the ages are actually contemporaneous, or if the hanging wall and footwall lithologies are facies equivalents.

This uncertainty means that the nature of the Contact Fault remains to be established. It may either be an extensional fault or, as originally suggested, a thrust fault.

Ongoing structural modelling is focusing on the Oyu Tolgoi district being subject to brittle tectonics, comprising strike-slip faulting resulting from approximate east-west-oriented compression. Data that support this interpretation include:

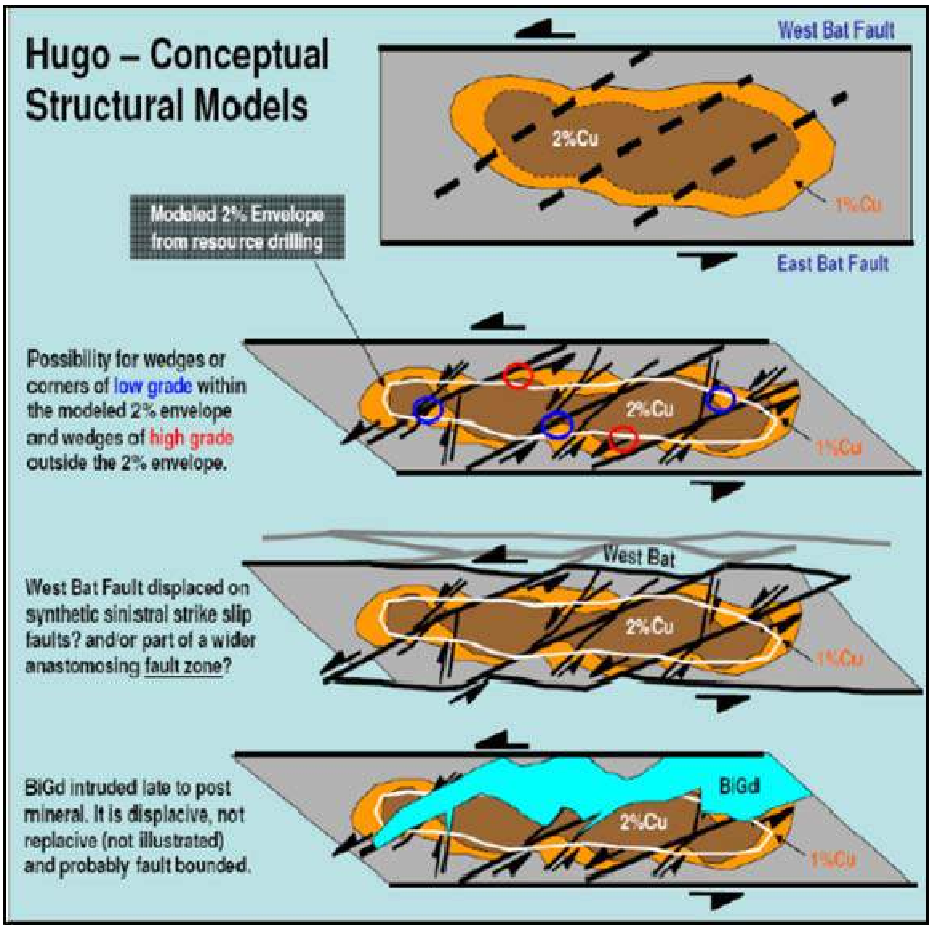
- High cut-off angles between bedding planes and faults.
- Many subvertical fault orientations indicated by drilling, geological and structural mapping, and IP responses.
- Large volumes of fault gouge.
- Multiple subvertical quartz tension-gash vein systems and dykes.
- Clear displacement of grade shells in the Hugo and Heruga deposits.

The effect of this interpretation is that for the block cave design, there will locally be juxtapositions of higher-grade mineralization (>2% Cu) against unmineralized or barren lithologies within the footprint of the planned caving operation. For Hugo North, the interpretational impact is likely to be most significant in the northern part of the Hugo North block, in the zone where the strike changes from predominantly north–south to a north-east trend. The strike change is interpreted to be the result of a set of faults cross cutting the planned cave that are as yet poorly represented in drill core.

A schematic showing a conceptual local impact on the model interpretation of the cross-cutting faults is included as Figure 9.2.

Additional work is planned to map the positions of potential mineralization off-sets and the locations of unmineralized blocks adjacent to high-grade material. A drill program has commenced, which will focus on documenting such grade contrasts in the planned cave footprint.

Figure 9.2 Conceptual Structural Model Example of Potential Impact of Cross-Faulting at Hugo North



9.5 Geotechnical Surveys

Although a great deal of prospecting and lithogeochemical sampling has been completed by Ivanhoe and previous companies in the Oyu Tolgoi licence area, the data have been superseded by drilling information in the South Oyu and Hugo Dummett areas. This work is summarized in Table 9.1 for the soil samples collected between 1997 and 2008.

Work completed on the Joint Venture area has consisted of trenching, soil and mobile metal ion (MMI) soil sampling, rock chip and grab sampling, and stream sediment and pan concentrate sampling. This work is summarized in Table 9.2 for the total geochemical dataset.

Table 9.1 Soil Sampling

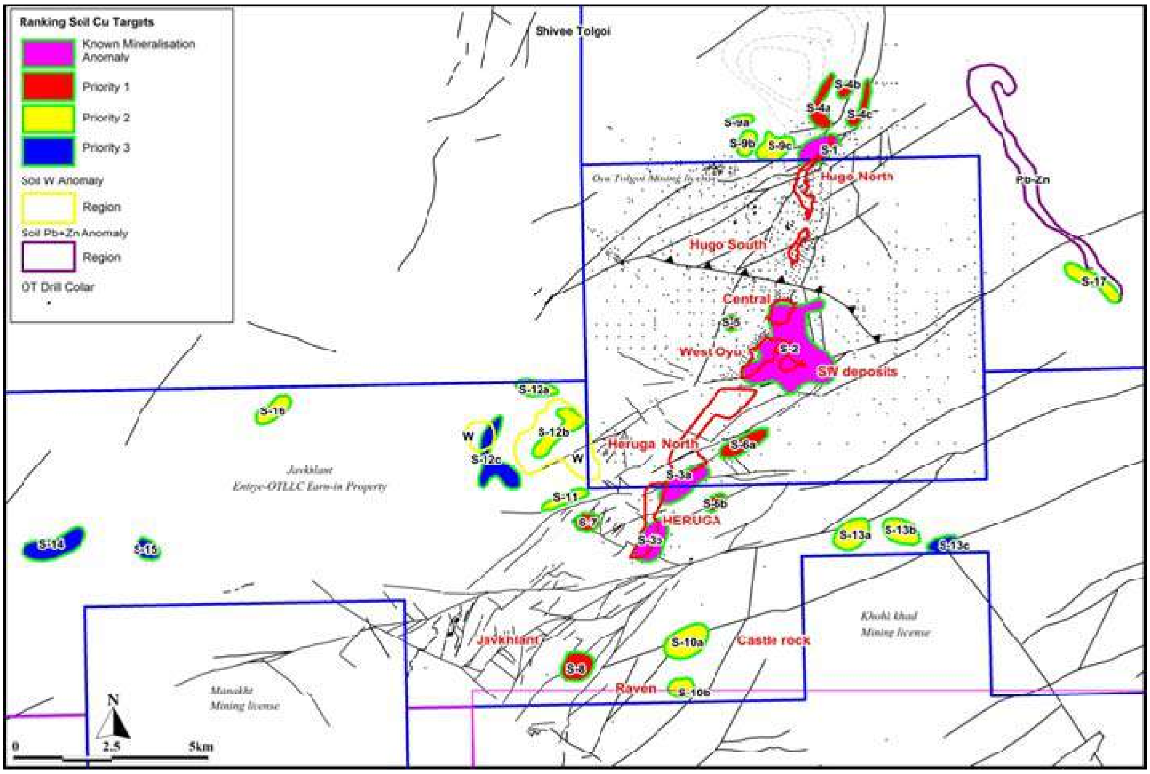
Area/Prospect	Year	Company
Southwest	1997–99	BHP
Copper Flats	2002–03	Entrée Gold
Eastern Entrée	2003–04	Entrée Gold
Oortsog	2003–04	Entrée Gold
Southwest	2004	Entrée Gold
West RAB	2004	Ivanhoe
Western Entrée	2004–05	Entrée Gold
Exotic Cu	2005	Ivanhoe
OT South	2005	Ivanhoe
Hugo South	2005–06	Ivanhoe
West Oyu	2006	Ivanhoe
Gandulga	2006	Ivanhoe
Ulaan Khuud	2006	Ivanhoe
BHP3	2006	Ivanhoe
Heruga	2008	Entrée Gold

Table 9.2 Geochemical Sampling Totals, Joint Venture Area

Licence	Year	Rock Chip Samples	Soil Samples	Stream Sediment Samples	Trench Samples
Shivee Tolgoi	2003–2003	75	2,140	–	450
	2004	–	–	–	1,363
Javkhlant	2002–2003	45	–	25	–
	2006–2007	43	314	–	–

During 2011, all previous geochemical surveys completed in the Oyu Tolgoi Project area were reviewed (Sketchley, 2011). Survey data were levelled and compiled into a single dataset, and the anomalies were ranked according to location and type (Bell et al., 2012). Anomalous zones were compared to the rock chip and drill databases. Known anomalies are shown in Figure 9.3.

Figure 9.3 Summary Plan, Surface Copper Geochemical Anomalies



Results of the review were:

- Anomalous areas are considered to be related to known and explored mineralization or are lithologically associated.
- Areas not previously covered by soil geochemistry are underlain by large intrusions, non-prospective rock exposures, or thick alluvial cover.
- Highly prospective areas have been extensively drilled, and thick cover sequences render buried mineralization undetectable by surface geochemical methods.

Asia Gold concluded that no new or additional infill surface sampling was warranted in the licence areas.

9.6 Geophysics

9.6.1 Oyu Tolgoi Licence

The initial geophysical surveys conducted by BHP in 1997 and 1998 consisted of airborne magnetics, ground magnetics, and gradient-array IP. The airborne magnetic survey was flown on 300 m spaced east–west lines with approximately 100 m mean terrain clearance. The ground magnetic survey and IP survey were completed on 250 m line spacings; the latter showed chargeability anomalies over Central, South, and Southwest Oyu.

In 2001, Delta Geoscience of B.C., Canada were contracted, to conduct gradient-array IP on 100 m spaced north–south lines over the 3 km x 4 km core block of Oyu Tolgoi. Using multiple current electrode (AB) spacings ranging from 1,000 m to 3,600 m, the sulphide assemblages in Southwest, South, and Central Oyu were clearly defined on all of the AB plans, indicating significant vertical depths for the mineralization in all zones. Delta Geoscience re-oriented the IP survey lines to east-west and resurveyed the core block of Oyu Tolgoi on 100 m spaced lines using multiple AB current electrode spacings. This survey resulted in an entirely different chargeability signature that reflected a continuous zone of sulphide mineralization extending north-north-easterly from the south-western end of Southwest Oyu through to the northernmost extent of the property, for a total strike length of approximately 5 km. Detailed total field, ground magnetic surveys, reading 25 m x 5 m and 50 m x 10 m centres, were completed over the full Oyu Tolgoi mining lease. The data were merged to produce a high-quality magnetic image of the block.

In 2002, the geophysical program was further expanded to include a gravity survey over the Oyu Tolgoi concession block. The survey was controlled by GPS with readings taken on 50 m centres over the core of the concession and 100 m centres over the extremities. The Bouger map was reduced to residual gravity for contouring.

In 2005, telluric electromagnetic (TEM) surveying was also conducted over the eastern half of the concession in conjunction with extensive TEM surveying used to define the Cretaceous-aged, semi-consolidated sedimentary basins along the Galbyn Gobi and Gunii Hooloi valleys, south-east and north-east, respectively, from Oyu Tolgoi. These basins developed along the East Mongolian Fault system and a splay off of the fault, and form reservoirs for extensive water resources.

On the Oyu Tolgoi concession, the TEM work was designed to delineate smaller drainage basins that could have channelled copper-rich surficial waters from the exposed copper deposits during the Cretaceous period. These “pregnant waters” could potentially have precipitated copper into river gravels downstream to form secondary “exotic” copper deposits, although to date no such deposits have been discovered. Moreover, given the relative lack of supergene alteration of the known deposits and a paucity of evidence of unroofing of the porphryies, the potential for a large-scale exotic copper deposit is considered unlikely.

A Zeus-based geophysical survey operation started at Oyu Tolgoi on 19 June 2009 and terminated on 11 November 2009. Survey work continued during 2010 outside the Ivanhoe ground in the Shivee Tolgoi licence. The Zeus IP survey used east-west lines, which resulted in the generation of north-south-trending anomalies.

The “Zeus System” is a high-powered, low signal-to-noise induced polarization/resistivity instrumentation platform that its owners claim to allow exploration personnel with unprecedented high-resolution images of the geology and mineralization to depths of more than 3 km below the surface. The Zeus system is reportedly based on the use of multiple signal measuring systems with broadly spaced electrode configurations.

The owners claim that post-acquisition processing then allows images of conductive and resistive blocks to depths below 3 km. However, no inversion is carried out on the data, and independent reviews have identified this as a potential issue. To address this, the owners have recently pursued inversion processing of the data. However, progress has been slow because of the complexity of inverting gradient array-type 3D IP data.

During 2011, Fugro was contracted to complete a district-wide magnetotellurics (MT) survey. Experience with MT has shown that the data can detect and delineate isolated conductors at substantial depths, and reliable 3D models of conductivity can be derived that are readily integrated with geology. The Fugro field crew collected 1,006 individual stations covering the main mineralized zones from Ulaan Khuud in the north extending down to Javkhlant. Approximately 30 planned stations around the Southern Oyu area and to the west of the Hugo deposits were omitted because of mine construction activities. Approximately 10% of the stations were repeated due to high noise levels that were attributed to cultural activity. Results are currently being interpreted in the context of new target generation activities within the district.

9.6.2 Joint Venture Licences

An initial IP survey (and detailed magnetics), using gradient-array with 11,000 m electrode spacing, commenced north of Oyu Tolgoi but was eventually extended through 2005 to cover all of the ground within the Shivee Tolgoi licence and to include the Javkhlant licence area. Three north-south-trending chargeability anomalies were defined.

In late 2008, a 26.6 km^2 detailed magnetometer survey was undertaken in the Hugo North Extension area. Lines were oriented east-west at 25 m spacing with continuous readings. Two large magnetic features occur in the survey area.

At the same time, a 26.6 km^2 detailed magnetometer survey was undertaken in the Heruga area to obtain a more detailed view of the geology and structure. Lines were oriented east-west at 25 m spacing, with continuous readings.

During mid-2011, a ground-magnetic survey was undertaken to the east and west of Javkhlant and Heruga, extending eastward to the edge of the Khukh Khaad mining licence to the east and westward into the Manakht licence:

- Manakht licence – 1,138 line km over 161 lines with 25 m line spacing oriented east-west, with continuous readings.
- Khukh Khaad licence – 1,007 line km over 221 lines with 25 m line spacing oriented east-west, with continuous readings.

A GEM GSM 19W (v7) Proton Precession equipment unit was used for this work.

9.7 Trenching

During 2002, two trenches were completed over surface exposures of the Southwest Oyu zone. Both trenches were approximately 60 m in length and provided early-stage geological and assay information regarding the deposit.

During 2003 and 2004, an extensive 8,000 m trenching program was carried out over the South and Southwest zones, plus an additional 20 km of trenches were completed in various other locations throughout the licence. Trenches at the South zone ranged in length from 280 m to 1,177 m and averaged around 600 m. Trenches were generally excavated 25 m apart, sampled over 2 m intervals, and assayed for Cu, Au, Mo, As, and Ag.

A number of trenches were excavated in 2009–2011 to support construction activities. These were reviewed by site geologists to confirm mapping across the licence areas. However, the vast majority of the excavations are within Cretaceous clays, and therefore no sampling was carried out.

9.8 Geotechnical Studies

9.8.1 Southern Oyu

During 2010–2011, a substantial program was undertaken to upgrade the geotechnical model for the Southern Oyu open pit, review pit dewatering strategies, and revise the structural framework.

Geotechnical Modelling

The initial pit geotechnical work was done between 2003 and 2005 by SRK for IMMI. SRK used an unconventional empirical approach whereby in situ rock mass ratings (IRMR) were converted to mining rock mass ratings (MRMR), the rock mass ratings system developed by Dennis Laubscher and more commonly used for the development of underground openings. These ratings were then correlated to an empirical design chart to produce slope angles. An independent review of the work undertaken in 2005 indicated that the method does not account for structures other than in the rock mass ratings and is therefore of limited value in open pit slope design.

A kinematic analysis was performed in 2009 with the intent of supplementing the SRK work and potentially removing some of the conservatism highlighted by independent review. The work was affected by Golder being unable to produce structural sets from the core data despite significant effort. As a result, mapped data from four distal sources, Camel Well, Shaft 1, Shaft 2, and the Box Cut at Hugo North, were used, but the data are not considered representative of actual conditions likely to be encountered during open pit mining.

A drill program of 13 drillholes was completed to provide increased confidence in the geotechnical and hydrogeological conditions within the mine footprint. Drillholes were targeted to supply information on the area that would constitute the first seven years of mining activity to a level suitable for operational design. The geotechnical field program used both manual logging and Acoustic Televiewer logging, in addition to sampling of core for laboratory assessment of rock material characteristics, to supplement historical testwork. A 3D geotechnical model was then developed, which included a pit-wall hazard map.

Key findings from the program were:

- Detailed major structure and rock mass fabric assessment was carried out coupled with a fault and lithological model upgrade.
- Rock mass quality is good to very good for principal rock units represented in the open pit.
- Flac 3D predictive modelling suggests that no complex failure mechanisms are likely for the first three phases of pit development.
- Overall slope stability will be most influenced by structural geology elements and kinematics.

Pit-hazard maps highlight weak clay alteration and structural complexities on the east wall of the pit; consideration of this zone must be made in determining ramp positions.

Hydrogeology

The diamond drillholes and additional supplementary reverse circulation holes were subject to downhole packer testing to quantify the hydrogeological characteristics of targeted fault/dyke structures and also the rock mass fabric. Holes were then left with either a standpipe or installed with vibrating wire pressure transducers for ongoing monitoring. A 3D district hydrogeological model was developed to provide predictive capacity in assessing groundwater conditions. Key outcomes from this work include:

- The district hydraulic gradient is from north-west to south-east, although the gradient is very shallow and close to hydrostatic in part.
- The hydraulic conductivity is low to very low; there is only a two-orders-of-magnitude change between the upper 100 m (corresponding to oxidized and weathered zone) and depths below 100 m.
- Most structures form low-conductivity barriers or are hydraulically indistinct from the rock mass.
- A shallow water table will be encountered from almost the onset of stripping.

- Water inflows are predicted to be low to moderate during mining of the upper benches and in the order of 15 to 25 L/s. This contrasts with mining at Bingham Canyon, where water inflows were 500 L/s.
- The water inflows are not anticipated to increase during the planned mine life.
- Due to very low hydraulic conductivity, pit-slope pore pressures will climb significantly; however, the rate of mining will far exceed the ability to equilibrate.
- Horizontal drains may be required to assist in pore pressure reduction.
- Leakage from the tailings storage facility (TSF) is unlikely to be a significant factor due to low conductivities. Loading is not predicted to substantially increase pore pressures.
- The dewatering strategy is likely to include typical in-pit sumps and pumping.

9.9 Petrology, Mineralogy, and Other Research Studies

A number of research, petrological, and mineralogical studies have been performed. These include age dating of key lithological units; detailed stratigraphic reviews; petrographic and spectral analysis of alteration products and minerals; and detailed structural reviews and evaluations, particularly in the areas proposed for the block caving operation at Hugo Dummett.

OT LLC maintains, an in-house petrology laboratory in the Oyu Tolgoi Geosciences Department. Equipment for making polished mineral specimen blanks and polished thin sections is currently in use.

Alteration minerals are determined by short-wave infrared spectrometry – short-wave infra-red (SWIR) or portable infrared mineral analyzer (PIMA) analysis – on typical specimens from a number of alteration zones in each drillhole.

A program of preparing mineralization samples and making metallurgical index estimates from all of the Oyu Tolgoi deposits was undertaken between 2002 and 2006.

9.9.1 Research Studies

A number of research theses have been completed on the project area and are listed below in alphabetical order by author surname:

- Amaramgalan, S., 2008: U-Pb geochronology and multi-isotope systematics of granitoids from Mongolia, Central Asian Orogenic Belt: Implications for granitoid origin and crustal growth during the Phanerozoic: PhD thesis, Okayama University, Japan, 162 p.
- Ayush, O., 2006: Stratigraphy, geochemical characteristics and tectonic interpretation of Middle to Late Paleozoic arc sequences from the Oyu Tolgoi porphyry Cu-Au deposit: MSc thesis (in Mongolian), Mongolian Univ. Science and Technology, Ulan Bator, Mongolia, 80 p.
- Jargaljav, G., 2009: Mineralization and metasomatic alteration of Central Oyu copper-gold deposit: PhD thesis (in Russian), Irkutsk Technical University, Irkutsk, 129 p.

- Khashgerel, B., 2010: Geology, whole-rock geochemistry, mineralogy and stable isotopes (O, H and S) of sericitic and AA alteration zones, Oyu Tolgoi porphyry Cu-Au deposits, Mongolia: PhD thesis, Univ. of Tsukuba, Japan, 114 p.
- Myagmarsuren, S., 2007: Sulfide mineral paragenesis at the Hugo Dummett porphyry Cu-Au deposit, Oyu Tolgoi, Mongolia: MSc thesis, Tohoku University, Japan, 93 p.
- Oyunchimeg, R., 2008: Sulfide mineralogy and gold mineralization at Hugo Dummett porphyry Cu-Au deposit, Oyu Tolgoi mineral district, Mongolia: PhD thesis (in Mongolian), Mongolian Univ. Science and Technology, Ulan Bator, Mongolia, 116 p.
- Savage, N., 2010: Origin of clasts, mineralization and alteration within the DA2a conglomerate, Heruga porphyry Cu-Au-Mo deposit, Oyu Tolgoi, Mongolia; evidence for an older porphyry system or part of the early Oyu Tolgoi paragenesis?: m.Sc Mining Geology Dissertation, Cambourne School of Mines UK. 119 p.
- Wainwright, A. J., 2008: Volcanostratigraphic framework and magmatic evolution of the Oyu Tolgoi porphyry Cu-Au district, South Mongolia: PhD: Univ. British Columbia, Vancouver, 263 p.

9.10 Future Exploration Strategy

Drill Targets

Key targets identified from the exploration programs to date that are likely to warrant drill testing are as follows:

- The IP signature of the Heruga deposit extends to depth, well below the deepest mineralized drill intercepts. Earlier IP surveys in this area indicated the Heruga mineralized trend may be offset to the west and continue as a chargeability high for a further 4 km to the south on the Javkhlant licence.
- Within the Heruga North zone, the combined geological mapping, gravity, magnetic, and IP data suggest continuation of the host Devonian volcanic sequences at depth between Southwest Oyu and Heruga. An IP chargeability anomaly clearly extends along this interval but weakens to the north of Heruga, perhaps reflecting increasing depth to mineralization.
- Additional potential was identified at Hugo North at depth and along strike to the north from the Hugo North Extension area. The Hugo North and Hugo North Extension deposits occur along the eastern flank of the identified Zeus IP anomaly. A drillhole located approximately 1,300 m north of the Oyu Tolgoi/Shivee Tolgoi mining licence boundary (drillhole EGD081B) intersected what was interpreted as Hugo North-style mineralization at a vertical depth of approximately 1,200 m, suggesting that the mineralization potentially continues to the north, well past the extent of detailed drilling. However, drilling to date has demonstrated a complex structural setting, and further work is required to refine future targeting in the area.

Regional Exploration

Regional exploration on the Oyu Tolgoi licence was essentially halted in 2008. Exploration continued within the Joint Venture ground, but has been primarily focused on the Heruga deposit area.

OT LLC has indicated that future exploration activities are likely to include:

- Infill drilling on about a 2–3 km strike extent of IP/drill anomalies identified to the north of the Hugo North Extension area.
- Additional drilling in the Heruga North zone.
- Assessment of targets elsewhere in the district where similar structural and alteration styles are apparent.

Based on analogous deposits in the south-west USA and Chile, porphyry systems tend to form in clusters, and as such the immediate environs of Oyu Tolgoi are considered highly prospective for additional mineralization. To this end, future exploration strategies will seek to leverage the existing IA to create further value for shareholders of OT LLC by discovering and developing additional mineralization.

9.11 Exploration Targets

Mineralization that falls outside the Pit 47 boundary was examined for potential for reporting as an Exploration Target. Two areas were reviewed:

- Classified blocks between Pit 47 and the $5 Cu pit
- Classified blocks outside the $5 Cu pit.
- Exploration Targets must be declared as a range of tonnages and grades.

For the Exploration Target lying between Pit 47 and the $5 Cu Pit, the endpoints of the range are the 0.22% CuEq and 0.37% CuEq cut-off grades within constraining stope-block shapes.

For the Exploration Target outside the $5 Cu pit, the endpoints of the range have been chosen using 0.37% CuEq and 0.45% CuEq cut-off grades applied to constraining stope-block shapes.

The resulting exploration targets are:

- Classified blocks between Pit 47 and the $5 Cu pit: A tonnage range of 180 to 330 Mt grading 0.3% to 0.4% Cu and 0.3 to 0.4 g/t Au (0.5% to 0.7% CuEq).
- Classified blocks outside the $5 Cu pit: A tonnage range of 210 to 290 Mt grading 0.35% to 0.4% Cu and 0.4 to 0.5 g/t Au (0.6% to 0.7% CuEq).

10 DRILLING

10.1 Drill Programs

Core drillholes are the principal source of geological and grade data for the Oyu Tolgoi Project. A small percentage of the drilling total comes from reverse circulation (RC) or combined RC/core drilling. Most of the RC holes were drilled in the early days of exploration at the Southern Oyu deposits. Combined RC/core holes, which have RC at the top of the hole and core drilling at the base, also make up a small percentage of the total number of holes on the project.

The first drilling on the project was completed by BHP in 1997 and 1998, during which time 23 core holes (3,902 m) were drilled at the Southern Oyu deposits. Ivanhoe carried out approximately 109 holes (8,828 m) of reverse circulation (RC) drilling in 2000, mainly at Central Oyu, to explore the chalcocite blanket discovered earlier by BHP.

In 2001, Ivanhoe continued RC drilling (16 holes totalling approximately 2,091 m), mostly in the South Oyu area; however, a combined RC collar/core tail drilling method was tested for hole number OTRCD149. Two additional holes were drilled using this method (OTRCD50 and 52), along with an additional seven RC holes totalling 801.5 m (up to hole OTRC158), before Ivanhoe switched to core drilling methods for all of its exploration.

As of 12 May 2011, a total of approximately 1,065,075 m of drilling in 2,190 holes has been completed on the Project. Of this, 992,673 m was core drilling in 1,541 holes and 60,004 m was completed in 696 RC holes. The drilling has been spread mostly over the Hugo Dummett and Southern Oyu deposits. Included in these totals are approximately 525 holes (75,427 m) drilled as part of a condemnation program to assist in the determination of suitable sites for items such as the proposed plant, infrastructure, and dumps, and for water and geotechnical purposes.

A drillhole summary table is included as Table 10.1. The drillhole collars were shown in Figure 9.3.

Table 10.1 Drillhole Summary Table

Deposit	Core Holes	Length of DDH (m)	RC Holes	Length of RC (m)	Comb. RC/ Core Holes	Length of Comb RC/Core (m)	All Holes	Total Length (m)
Hugo Dummett Deposits								
Hugo South	128	91,638	45	3,263	12	8,886	185	103,787
Hugo North	362	329,485	4	319	4	3,636	370	333,439
Total Hugo Dummett	490	421,123	49	3,582	16	12,522	555	437,226
Southern Oyu Deposits								
Southwest	222	128,330	28	4,576	3	2,092	253	134,998
Central	239	88,547	71	6,694	–	–	310	95,241
South	90	33,582	26	3,275	2	891	118	37,748
Wedge	46	25,364	12	1,338	–	–	58	27,702
West	46	17,602	115	4,929	–	–	161	22,531
Total Southern Oyu	643	293,425	252	20,812	5	2,983	900	318,220
"Other" Drilling								
Shaft Farm (exploration and geotechnical)	25	19,499	28	847	0	0	53	20,346
X-Grid	6	571	0	0	0	0	6	571
East Side Licence	18	3,901	144	15,547	8	2,400	162	19,448
"Other"[3]	162	24,356	57	5,336	1	196	219	29,692
Total "Other" Drilling	211	48327	229	21,730	9	2,596	440	70,057
Entree JV Drilling								
Heruga North	47	63,922	10	2,072	0	0	57	65,994
Shivee Tolgoi	106	101,980	73	4,868	2	736	181	107,584
Heruga	44	63,896	83	6,940	2	0	57	65,994
Total Entree JV Drilling	197	229,798	166	13,880	4	736	295	239,572
Grand Total (All Drilling)	**1,541**	**993,673**	**696**	**60,004**	**34**	**18,837**	**2,190**	**1,065,075**

Note: Includes all holes drilled to 12 May 2011. Not all of this drilling is relevant to the Mineral Resource estimate.
A portion of these holes were collared in the Shivee Tolgoi lease and drilled back into the Oyu Tolgoi lease.
Includes holes drilled for geotechnical, water, and condemnation purposes.
Approximately 79% of the combined RC/core drilling is by core methods.

10.2 Drill Orientations

The drillholes are drilled at a wide range of azimuths and dips depending upon the orientation of the mineralization, but an east to west orientation is dominant throughout the project area. Drilling is normally oriented perpendicular to the strike of the mineralization. Depending on the dip of the drillhole, and the dip of the mineralization, drill intercept widths are typically greater than true widths.

Average drillhole lengths at the Hugo Dummett and Southern Oyu deposits range from 316 m (Oyu South) to 894 m (Hugo North) and average around 525 m overall.

The drill spacing is at a nominal 70 m on and between drill sections in the Southern Oyu deposits. Drill spacing at Hugo North is on approximate 125 m x 75 m centres. Drill spacing typically widens toward the margins of the deposits.

10.3 Drill Contractors

Exploration diamond drilling on the project has been almost continuous since 2001, using a variety of different contractors. Most of the more recent drilling was contracted to Major Pontil Pty Ltd. (Major), based out of Australia, which has used a variety of rigs, some with depth capabilities in excess of 2,500 m. Rigs that have recently been or are currently on site include UDR 1000, 1500 and 5000, LM90, and Schramm units.

Other drilling campaigns have been completed by Gobi Drilling, Can Asia, Mongolia Drilling Services, Australian Independent Diamond Drillers, and Soil Trade.

10.4 Core Diameters

The vast majority of core diameters at the Southern Oyu and Hugo Dummett deposits have been either PQ-size (85 mm nominal core diameter), HQ-size (63.5 mm nominal core diameter), or NQ-size (47.6 mm nominal core diameter), with a small percentage drilled with BQ-size core (35.5 mm nominal core diameter). Most holes at Hugo North were collared with PQ core and were reduced to HQ at depths of around 500 m prior to entering the mineralized zone. A few holes have continued to depths of about 1,300 m using PQ diameter. Size reduction in any given hole occurs at varying depths depending on drilling conditions.

Many of the deeper holes, especially at Hugo North (including Copper Flats), include multiple “daughter” holes (wedges) drilled from a PQ diameter “parent” drillhole. A bend is placed in the parent hole at the location where the planned daughter holes are to branch off. The bend is achieved by means of a Navi-Drill® (navi) bit, which is lowered down the hole to the desired depth and aligned along the azimuth of the desired bend. As the navi bit advances, a bend is achieved at the rate of 1° every 3 m. No core is recovered from the navi-drilled interval, and the core diameter is reduced, generally to HQ size.

Most core has been drilled using Ball Mark™ or Ace™ oriented core marking systems to assist with geological and structural interpretations and for geotechnical purposes.

10.5 Core Transport

At the drill rig, the drillers remove core from the core barrel and place it directly in wooden or plastic core boxes. Individual drill runs are identified with small wooden or plastic blocks, where the depth (m) and hole number are recorded. Unsampled core is never left unattended at the rig; boxes are transported to the OT LLC core logging facility at the main camp twice a day under a geologist's or technician's supervision. Core is transported in open boxes in the back of a truck.

Those holes drilled specifically for geotechnical purposes are transferred at the rig to a steel V-rail and logged on site before transport back to the core shed.

10.6 Geological Logging

The RC logging comprised capture of geological, alteration, and mineralization data on paper logging forms.

Core logging facilities are indoors. Core logging takes place on sturdy steel racks, each of which is capable of holding upwards of 25 or more core boxes. Upon arrival at the core shed, the core is subject to the following procedures:

- Quick review.
- Box labelling check: The core boxes are checked to ensure they are appropriately identified with the drill hole number, metres "from–to," and box number written with a permanent marker on the front.
- Core "re-building": Core is rotated to fit the ends of the adjoining broken pieces.
- Core photography.
- Geotechnical logging, using pre-established codes and logging forms, includes: length of core run, recovered/drilled ratio, rock quality designation (RQD), and maximum length, structural data, and oriented core data. Orientated core measurements were logged as interval data using standardized codes for structural and vein data only; the orientated core measurements usually did not commence until the hole was within the mineralised zone).
- Geological logging: Until August 2010 this was completed on paper logging forms. After that, OT LLC implemented a digital logging data capture system, using commercially-available acQuire® software, which uses standardized templates and validated logging codes that must be filled out prior to log completion. The logging is entered directly into laptops at the core shed and is wirelessly synchronized with the geological database. The template includes header information, lithology description and lithology code, graphic log, coded mineralization, and alteration.
- The geologist marks a single, "unbiased" cutting line along the entire length of the core for further processing.

10.7 Recoveries and Rock Quality Designation

Recovery data were not collected for the RC drill programs.

OT LLC's geological staff measure the following core recovery and rock quality designation (RQD) parameters at the core logging area:

- Block interval
- Drill run (m)
- Measured length (m)
- Calculated recovery (%)
- RQD measured length (m)
- Calculated RQD (%).

The methodology used for measuring recovery is standard industry practice.

In general, OT LLC reports that core recoveries obtained by the various drilling contractors have been very good, averaging between 97% and 99% for all of the deposits. In localized areas of faulting and/or fracturing the recoveries decrease; however, this occurs in a very small percentage of the overall mineralized zones. In addition, OT LLC notes decreased recoveries near surface in overlying non-mineralized Cretaceous clays and to a lesser extent in a portion of the oxidized rocks (generally above 100 m depth), owing to the lower competencies of these units.

Table 10.2 shows the recovery averages per year from 1998 to 2011.

Table 10.2 Summary of Average Drilling Recoveries

	All Drilling			Recoveries Below 100 m	
Year	Recovery (%)	Number of Measurements		Recovery (%)	Number of Measurements
1998	75.6	19		n/a	n/a
2001	97.4	5,784		98.4	3,876
2002	97.8	33,964		98.6	26,359
2003	97.4	61,182		98.8	48,722
2004	97.7	66,116		98.6	54,605
2005	98.6	25,224		99.1	21,927
2006	98.5	21,570		99.1	17,909
2007	98.3	17,986		98.4	15,867
2008	99.5	8,905		99.6	8,151
2009	99.8	1,956		99.8	1,845
2010	99.3	12,312		99.9	11,741
2011	99.5	22,117		99.8	21,524

10.8 Collar Surveys

Collar survey methods were similar for core and RC drillholes.

Upon completion of a drillhole, the collar and anchor rods are removed, and a PVC pipe is inserted into the hole. The drillhole collar is marked by a cement block inscribed with the hole number (e.g., OTD663). Proposed drillhole collars and completed collars are surveyed by a hand-held GPS unit for preliminary interpretations. After the hole is completed it is re-surveyed using a Nikon theodolite instrument. The two collar readings are compared, and if any significant differences are noted the total station reading is re-surveyed; otherwise it is adopted as the final collar reading.

10.9 Downhole Surveys

RC drillholes were typically not downhole surveyed. Drillholes are assumed to be without deviation from the collar survey. In general, most RC holes are less than 100 m in depth and therefore unlikely to experience excessive deviations in the drill trace.

OT LLC uses downhole survey instruments to collect the azimuth and inclination at specific depths of the core drillholes for the majority of the diamond drilling programs. The principal types of survey method used over the duration of the drilling programs include Eastman Kodak, Pontil, Flexit, Ranger, gyro, and north-seeking gyro.

No downhole survey data were collected during the first 149 holes drilled on the Project, including the initial core drill program by BHP in 1998 and the 125 RC holes completed by Ivanhoe in 2001 and 2002.

The first surveys initiated by Ivanhoe were for holes OTRCD149, 150, and 152, which were surveyed by the Eastman Kodak method. Ivanhoe used this method interchangeably with gyro and Ranger as the principal means of measuring deviations until approximately hole OTD397, after which gyro, north-seeking gyro, Flexit, and Ranger methods were used. A small percentage of the holes in the database remain unsurveyed. It should be noted that the Eastman Kodak, Pontil, Flexit, and Ranger methods derive azimuth measurements using a magnet and are therefore subject to potential problems that can be caused by magnetic minerals, common at some of the deposits on the Oyu Tolgoi Project.

Since January 2006, the procedure has been to measure deviations initially using a Flexit instrument along approximately 60 m intervals in order to monitor the drillhole progress. At completion, all holes are re-surveyed with a north-seeking gyro or “SRG”-gyro instrument at approximately 5 m to 20 m intervals. The gyro instruments are not dependent on magnetic readings and are therefore considered to be more appropriate methods for this style of deposit and the depth of the holes.

OT LLC has a detailed validation program built into the database to reveal any moderate kinks or deviations in the downhole data. All of these are checked and adjusted, if required, before finalizing the database.

10.10 Core Storage

All core is stored in a secure location at the main camp. Core is stacked on pallets in a stable, 3 x 3 box configuration to a height of about 1 m (15 boxes per pallet). Each pallet is covered with a canvas tarpaulin, which is labelled with hole identification and the interval that is stacked in the pallet.

11 SAMPLE PREPARATION, ANALYSES AND SECURITY

11.1 Sampling Methods

11.1.1 Geochemical Sampling

Sampling programs on the Oyu Tolgoi lease included stream sediment, soil, trench, and rock chip samples. All of the sampling was carried out by Ivanhoe personnel or contractors.

Sampling on the Shivee Tolgoi JV leases also included stream sediment, soil, trench, and rock chip samples.

All of these early-stage sampling methods have been superseded by drill data, which form the basis of the mineral resource estimates, and therefore the early-stage sampling methods are not discussed further.

11.1.2 Core Drilling

Core cutting protocols for core drilling completed on both the Oyu Tolgoi and Shivee Tolgoi JV areas are as follows:

- Core is photographed.
- The uncovered core boxes are transferred from the logging area to the cutting shed (approximately 50 m) by forklift on wooden pallets.
- Long pieces of core are broken into smaller segments with a hammer.
- Core is cut with a diamond saw, following the line marked by the geologist. The rock saw is regularly flushed with fresh water.
- Both halves of the core are returned to the box in their original orientation.
- The uncovered core boxes are transferred from the cutting shed to the sampling area (approximately 50 m) by a fork lift carrying several boxes on a wooden pallet; constant 2 m sample intervals are measured and marked on both the core and the core box with a permanent marker; a sample tag is stapled to the box at the end of each 2 m sample interval; sample numbers are pre-determined and account for the insertion of quality assurance and quality control (QA/QC) samples (core twins, standards, blanks).
- Samples are bagged. These are always half-core samples collected from the same side of the core. Each sample is properly identified with inner tags and outside marked numbers. Samples are regularly transferred to a sample preparation facility operated by SGS Mongolia LLC (SGS Mongolia) approximately 50 m from the sample bagging area.

The unsampled half of the core remains in the box, in its original orientation, as a permanent record. Where additional sampling is needed (e.g., for metallurgical testwork), a skeleton core is left. In some cases however, the additional testwork has consumed the entire core, and only photographic records remain. Core boxes are subsequently transferred to the on-site core storage area.

Non-mineralized dykes that extend more than 10 m along the core length are generally not sampled.

11.1.3 Bulk Density/Specific Gravity Determinations

OT LLC has collected an extensive database of specific gravity determinations for the South Oyu and Hugo Dummett deposits from core samples between 2002 and 2008, after which data collection ceased but recommenced during 2012. Currently, there are over 52,000 specific gravity determinations in the database.

Samples for specific gravity determination were taken at approximately 10 m intervals per drillhole and tabulated by rock type. The specific gravity for non-porous samples, the most common type, is calculated using the weights of representative samples in water (W2) and in air (W1). The specific gravity is calculated by the formula:

$$\frac{W1}{W1-W2}$$

Less commonly, porous samples were dried and then coated with paraffin before weighing. Allowance was made for the weight and volume of the paraffin when calculating the specific gravity.

Similar methods were used to determine the specific gravity values for the Heruga deposit.

Table 11.1 summarizes the specific gravity values for the key lithologies.

Table 11.1 Specific Gravity Values by Lithology

Lithology	Lithology Code	Average SG Value	Lithology	Lithology Code	Average SG Value
Andesitic ignimbrite (CS1)	Andi	2.70	Basaltic volcaniclastic	Vat	2.85
Andesitic lava (CS3b)	AndL	2.69	Fine laminated tuff (DA1a)	Vatl	2.81
Gold-rich QMD	Auqm	2.75	Dacitic block-ash tuff (DA2b)	Vbx	2.71
Basalt	Ba	2.72	Andesitic-dacitic volcanic breccia (DA2b)	Vbx2	2.73
Brown augite basalt lava (CS3c_2)	BasL	2.68	Porphyritic basalt	Vp	2.77
Basaltic lapillic tuff (CS3c_1)	Bat	2.67	Tuffaceous sandstone	VSst	2.75
Bi granodiorite	BiGd	2.70	Xenolithic biotite granodiorite	xBiG	2.72
Conglomerate	Cong	2.73	Xenolithic porphyritic andesite	xPan	2.75
Cretaceous clay	Cret	2.04	Xenolithic quartz monzodiorite	xQmd	2.74
Carbonaceous shale	CSh	2.50	Blank (used for control)	(blank)	2.29
Porphyritic dacite	Dac	2.64	Khanbogd Granite	Kgte	2.66
Dacitic flow	DacL	2.63	Coarse volcaniclastic with sedimentary clasts	Vcx	2.67
Dolerite dykes	Dol	2.79	Rhyolitic Ignimbrite	Rhyl	2.67
Early QMD	Eqmd	2.81	Hornfels	Hfs	2.67
Fault zone	Fz	2.71	Fine-grained granodiorite	Gd	2.65
Globular ignimbrite (DA2a)	Glob	2.79	Intrusive breccia	Qmdx	2.71
Hornblende Biotite Granodiorite	HbBi	2.68	Dacite–basalt breccia	DacB	2.68
Hydrothermal breccia	Hbx	2.76	Diorite	Dio	2.75
Dacitic to andesitic ash flow tuff / lapilli tuff	Ign	2.83	Trachyandesite lava	Tand	2.66
Basaltic- tuffs and flows	L	2.79	OT quartz monzodiorite	OT-Q	2.74
Late QMD	Lqmd	2.78	Quartz monzonite	Qm	2.74
Quartz monzodiorite	Qmd	2.75	Andesitic tuff	AndT	2.72
Quartz vein percentage >90% with a vein percentage >15%	Qv90	2.78	Quaternary cover	Qco	2.18
Rhyolite	Rhy	2.62	Porphyritic augite basalt (DA1b)	Va	2.84
Fine grained sandstone-siltstone; tuffaceous, carbonaceous	Sst-	2.73	–	–	–
Average All Lithologies	–	–	–	–	2.75

11.2 Sample Preparation and Analytical Laboratories

11.2.1 Laboratories

Until September 2011, all routine sample preparation and analyses of the Oyu Tolgoi samples were carried out by SGS Mongolia, which operates an independent sample preparation facility at the Oyu Tolgoi site and an analytical laboratory in Ulaanbaatar. SGS Mongolia, part of the global SGS Group, and predecessors have maintained a full service laboratory in Ulaanbaatar since the late 1990s. This laboratory was recognized as having ISO 9001:2000 accreditation and conforms to the requirements of ISO/IEC 17025 for specific registered tests. The laboratory performs all fire assay analyses.

Currently, once on-site sample preparation has been completed, resource and exploration samples are shipped to the ALS Chemex facility in Vancouver, Canada, for inductively-coupled plasma analyses. Since 2005, ALS Chemex has held ISO/IEC 17025 accreditation.

During 2002 and 2003, the on-site sample preparation facility and analytical laboratory were operated under the name Analabs Co. Ltd. Analabs is an Australian-based company controlled by Scientific Services Limited, which was bought by the SGS Group in 2001. SGS is an internationally recognized organization that operates over 320 laboratories worldwide, many of which have ISO 9002 certification. The operating name of the Mongolian subsidiary was changed to SGS Mongolia LLC (SGS Mongolia) in 2004.

Until May 2005 (OTD900), SGS Welshpool in Perth, Australia, was designated as the secondary (check) laboratory. This laboratory currently has ISO:17025 accreditation, but whether it did at the time of the analyses is unknown.

After May 2005, the secondary laboratory was changed to Genalysis Laboratory Services Pty Ltd. (Genalysis), also in Perth. The National Association of Testing Authorities Australia has accredited Genalysis to operate in accordance with ISO/IEC 17025 (1999), which includes the management requirements of ISO 9002:1994.

Check assays are also performed by Actlabs Asia LLC, part of the global Actlabs Group, which has maintained a full service laboratory in Ulaanbaatar since 2006. The laboratory has sample preparation, weighing, fire assaying, wet laboratory, and instrumentation sections. It maintains an ISO 17025 accreditation and participates in CANMET and Geostats Proficiency Testing Programs.

Check assays in the early phases of project drilling were performed by Bondar Clegg and Chemex laboratories. It is not known what certification these laboratories held at the time of the check assay programs.

11.3 Sample Preparation

All rock and drill samples since 2002 have been submitted to the same sample preparation and analytical laboratory that was operated by either Analabs or SGS.

The preparation facility was installed in 2002 as a dedicated facility for the Oyu Tolgoi Project during exploration and resource definition stages. The laboratory was operating continuously up to the end of 2008, when it was put on care and maintenance during a slowdown in drilling operations. It re-opened sporadically during 2009, and resumed continuous operations in mid-2010, when drilling operations increased. Although the facility has mostly dealt with samples from the project, it also has, on occasion, prepared some samples from other TRQ projects in Mongolia.

Split-core samples from the Oyu Tolgoi and Joint Venture areas were prepared for analysis at the on-site sample preparation facility operated by SGS Mongolia. The prepared pulps were then shipped by air to Ulaanbaatar under the custody of either OT LLC personnel, where they were assayed at the laboratory facility operated by SGS Mongolia.

All sample preparation procedures and QA/QC protocols were established by Ivanhoe Mines in consultation with SGS Mongolia and have been continued by OT LLC. The maximum sample preparation capacity has been demonstrated to be around 600 samples per day when the sample preparation facility is fully staffed.

The sample preparation facility has one large drying oven, two Terminator jaw crushers, and three LM2 pulverisers. The crushers and pulverisers have forced air extraction and compressed air for cleaning.

The sample preparation protocol for Oyu Tolgoi samples is as follows:

- Coding – An internal laboratory code is assigned to each sample at reception.
- Drying – The samples are dried at 75°C for up to 24 hours.
- Crushing – The entire sample is crushed to obtain nominal 90% at 3.35 mm.
- Splitting – The sample passes twice through a nominal 1 inch (approximately 2.5 cm) Jones™ splitter, reducing the sample to approximately 1 kg. The coarse reject is stored.
- Pulverization – The sample is pulverized for approximately 5 minutes to achieve nominal 90% at 75 µm (200 mesh). A 150 g sample is collected from the pulverizer and sealed in a Kraft™ envelope. The pulp rejects are stored on site.
- The pulps are put back into the custody of OT LLC personnel, and SRM control samples are inserted as required.
- Shipping – The pulps are stored in a core box and locked and sealed with "tamper-proof" tags. Sample shipment details are provided to the assaying facility both electronically and as paper hard copy accompanying each shipment. The box is shipped by air to Ulaanbaatar where it is picked up by SGS Mongolia personnel and taken to the analytical laboratory. SGS Mongolia staff confirm by electronic transmission that the seal on the box is original and has not been tampered with.

- Storing and submitting – The pulp rejects are stored on site at the laboratory for several months and then returned to the project office in Ulaanbaatar for storage.

Between sample processing, all equipment is flushed with barren material and blasted with compressed air. Screen tests are done on crushed and pulverized material from one sample taken from the processed samples that make up part of each final batch of 20 samples to ensure that sample preparation specifications are being met.

Reject samples are stored in plastic bags inside the original cloth sample bags and are placed in bins on pallets and stored at site. Duplicate pulp samples are stored at site in the same manner as reject samples.

11.4 Analytical Methods

All samples submitted were routinely assayed by SGS Mongolia for gold, copper, iron, molybdenum, arsenic, and silver on 2 m composite intervals.

During the early exploration programs, copper, and molybdenum were determined by acid digestion of a subsample, followed by an AAS finish. Samples were digested with nitric, hydrochloric, hydrofluoric, and perchloric acids to dryness before being leached with hydrochloric acid to dissolve soluble salts and made to volume with distilled water. Routine assays up to 2% Cu used a subsample size of 0.5 g, whereas a subsample size of 0.25 g was used for samples expected to be over-range, or >2% Cu. The detection limits of the copper and molybdenum methods were 0.001% and 10 ppm, respectively.

Gold was determined using a 30 g fire assay fusion cupelled to obtain a bead and digested with aqua regia, followed by an atomic absorption spectroscopy (AAS) finish, with a detection limit of 0.01 g/t. The same acid digestion process used for copper and molybdenum was also used for analyses of silver and arsenic with detection limits of 1 ppm and 100 ppm, respectively.

SGS Mongolia used the same methodologies for the OT LLC samples.

A trace elements composites (TEC) program was undertaken in addition to routine analyses. Ten-metre composites of equal weight were made up from routine sample pulp reject material. The composites were subject to multi-element analyses comprising a suite of 47 elements determined by inductively-coupled plasma (ICP) optical emission spectroscopy / mass spectrometry (ICP-OES/MS) after four-acid digestion. Additional element analyses included mercury by cold vapour AAS, fluorine by KOH fusion/specific ion electrode, and carbon/sulfur by LECO furnace. Results from the TEC program were used for deleterious element modelling.

During 2011, an audit of assay techniques was instigated on the restricted suite of Cu, Au, Fe, Mo, Ag, and As. The audit suggested that high detection limits for As, Ag, and Mo restricted the usefulness of the information gained from these elements to only well mineralized areas. The most serious example of high-detection thresholds was for As, where 99% of the As assays were found to be below the threshold for repeatable data, the threshold being equal to five times the lower detection limit.

The result is that all elements analyzed, apart from Cu and Fe, are considered to have been compromised for exploration purposes by the detection limit. Since Au is assayed by a separate method, that of fire assay, the assays are deemed not to have been compromised.

Similarly, gold concentrations were historically analyzed using a 30 g fusion with an atomic absorption (AA) determination. This gives an accurate range from 0.01 ppm to 10 ppm Au; however, by using inductively-coupled plasma/atomic emission spectroscopy (ICP-AES) to analyze the gold in solution concentration, a ten times decrease in detection limit is possible with a similar upper detection limit. The current drill database shows 50% of the Au analyses are below five times the current detection limit.

As a consequence, a shift to high-resolution ICP-mass spectrometry (MS) for routine samples was implemented in September 2011. Given the relative complexity of ICP-MS equipment and the tendency for laboratories to centralize them globally to assist with operation and maintenance, this has necessitated a shift to an offshore laboratory for analysis of all resource and exploration samples.

As a result, the following actions were taken:

- SGS will continue to manage the on-site sample preparation facility.
- SGS in Ulaanbaatar was appointed the primary laboratory for Au and F to ensure rapid turnaround of gold values.
- ALS (Vancouver) was appointed the primary laboratory for the high-resolution multi element ICP-MS based suite (42 elements) and LECO S and C analyses.
- ALS and SGS will act as the secondary laboratories for each other, reinstating the secondary laboratory checks systematically in resource and exploration drilling. The check sample rate will be at a nominal at a check rate ratio of one sample in 20.

The intended outcome for this is to:

- Identify grade and mineralization type (Cu, Au).
- Identify new mineralization from pathfinder elements (As, Bi, Pb, Zn, etc.).
- Determine the distribution of potential credit elements (Ag, Mo).
- Determine deleterious elements and allow mitigation procedures to be prepared (S, As, F, Cl, Se, Ti).
- Support the mapping of deleterious alteration or rock types to allow mitigation procedures to be prepared (Si, K, Na, Ca).
- Support the mapping of rock types for appropriate logging of litho-types.

Run-of-mine samples will continue to be subject to a separate analytical flowchart on completion of the mine laboratory on site.

11.5 Quality Assurance and Quality Control Methods

Intial geological aspects of the QA/QC program were set up during 2001. Simple analytical quality control procedures were followed until March 2002 when a formal program was set up. This work included development of procedural guidelines, laboratory audits, and preparation of reference materials, with initial on-site monitoring conducted by designated staff. As noted in 11.3, QA/QC reviews were intermittent in the period 2007 to end-2010.

11.5.1 QA/QC Program Outline

Samples were initially assembled into groups of 15 or 16 samples, and then four or five quality control samples were interspersed to make up a batch of 20. The quality control samples consisted of one duplicate split core sample, one uncrushed field blank, a reject or pulp preparation duplicate, and one or two standard reference material (SRM) samples (one <2% Cu and one >2% Cu if higher-grade mineralization is present based on visual estimates). The two copper SRMs were necessary because SGS Mongolia used a different analytical protocol to assay all samples >2% Cu. The SRMs were matrix-matched to ensure consistency with routine analytical samples. OT LLC has continued this procedure.

The split core, reject, and pulp duplicates are used to monitor precision at the various stages of sample preparation. The field blank can indicate sample contamination or sample mix-ups, and the SRM is used to monitor accuracy of the assay results.

The SRMs are prepared from material of varying matrices and grades to formulate bulk homogenous material. Ten samples of this material are then sent to each of at least seven international testing laboratories. The resulting assay data are analyzed statistically to determine a representative mean value and standard deviation necessary for setting acceptance/rejection tolerance limits. Blank samples are also subjected to a round-robin program to ensure the material is barren of any of the grade elements before the blank samples are used for monitoring contamination.

From January 2006 (OTD930/EGD53) to mid-2007, the check assay program was in abeyance based on recommendations from Smee (2006), who concluded:

> "The check analysis confirms the conclusions drawn from the ongoing quality control program, but at a considerable cost in time, effort, and money. I recommend that the check assay program be discontinued."

Check sampling was re-instated in mid-2007 and continued through to mid-2009, when it was again discontinued due to a slowdown in drilling activities.

In September 2011, when the change in laboratory protocols was initiated, check assays once again became routine in the program. Insufficient data are currently available from the re-introduced program to draw firm conclusions; however, no evidence of bias is apparent from the small dataset that is available.

11.5.2 Standard Reference Materials

Standard reference materials (SRMs) routinely used at Oyu Tolgoi are matrix-matched and developed from drill core crushed rejects. Materials are pulverized, screened to minus 75 µm, homogenized, and tested for homogeneity, and then sets of randomly selected samples are sent to international laboratories for round-robin testing.

Tolerance limits for SRMs were set at two and three standard deviations from final round robin mean value of the reference material. A single batch failed when SRM assays were beyond the three-standard deviation limit, and any two consecutively assayed batches failed when SRM assays were beyond the two-standard deviation limit on the same side of the mean.

The performance of the SRM samples was monitored as the assay results arrived at site in the period 2002–2007. The ability of the laboratories to return assay values in the prescribed SRM ranges has steadily improved to greater than 99% by end-2007. All samples were given a “fail” flag as a default entry in the project database. Each sample was re-assigned a date-based “pass” flag when the assays passed acceptance criteria.

In August 2007, a commercial molybdenum SRM was introduced to monitor molybdenum assays from Heruga. Because other deposits at Oyu Tolgoi have low molybdenum values, close to detection limit, a molybdenum standard had not previously been required. In August and September 2007, the failure rate of the SRMs increased to 9% and 5%, respectively. The higher failure rate was attributed to the commercial SRM not being “matrix-matched” to core samples and therefore producing a significantly low bias in the molybdenum assays. In October 2007, the commercial SRM was replaced with a matrix matched molybdenum SRM, and by January 2008 the failure rate had fallen to 1%.

The 2011 Sketchley review noted that for SRMs analysed between 1 January 2008 and 1 November 2010, the laboratory has a slight upward drift for copper, resulting in an operating range for some SRMs that partly overlaps the two standard deviation tolerance limit established for SRM data.

Due to the change in analytical method in 2011, the SRM materials are currently undergoing re-certification.

11.5.3 Blanks

Barren material was procured from a local site and tested to ensure a barren nature for use as field blanks. Tolerance limits for field blanks were set at 0.06 g/t Au, 0.06% Cu, and 10 ppm Mo. Batches are automatically failed and re-assayed if these tolerance limits are exceeded, unless values are extremely low, in which case a barren override is applied in the database, and the batch remains as is.

Evaluation of the blank samples submitted to the laboratory in the period 2002–2007 indicated a low incidence of contamination for the analytical programs for the South Oyu and Hugo Dummett deposits. A few cases of sample mix-ups were identified during the review of the blank performance, which were investigated at site and corrected.

No evidence of systematic contamination was noted for the review of data from 1 January 2008 to 1 November 2010 (Sketchley, 2011).

11.5.4 Duplicate Samples

Duplicates routinely used at Oyu Tolgoi include core, coarsely-crushed rejects, and pulps. Core duplicates are taken in the field from one-half of core that has been split along a continuous line marked along the middle of the core, parallel to the long axis. Coarsely crushed rejects and pulp duplicates are taken in the laboratory by using a riffle splitter. Assays of each type follow the parent sample in a batch.

Laboratory check pulp samples sent to an umpire laboratory were only used up to the end of 2005 for the Southern Oyu and Hugo Dummett deposits. Other duplicate sample types employed in the QA/QC program were core, coarse reject, and pulp.

In the period 2002–2007 copper generally performed very well with absolute relative difference results well within expected limits; gold absolute relative difference results are higher than copper but considered acceptable. Core duplicates for both copper and gold were above the ideal arbitrary absolute relative difference value of 30%, which was related to an uneven distribution of mineralization between core halves as typically caused by quartz vein and fracture controlled mineralization.

At Hugo North, percentage differences for gold for the coarse reject and pulp duplicate samples were about the same because of the finer reject crushing size. Although the reject precision was within the ideal threshold, the pulp duplicates tended to be higher, probably because most gold values lay near the detection limit where precision was poorer. This is further supported by an improvement in precision at higher grades, although there is also a possibility of gold liberation during pulverization. For copper, both coarse reject and pulp duplicates were also similar because of the finer reject crushing size, with both being well within the ideal limits.

The review of the 2008–2010 data noted a strong bias for several gold duplicate samples, which is most likely related to sample mix-ups, as that pattern is present for core, coarsely crushed, and pulp samples. The remaining data display normal distribution patterns, and the precision is deemed acceptable for the types of material and mineralization being examined (Sketchley, 2011).

11.5.5 Sample Security

Sample security relied upon the fact that the samples were always attended to or locked in a sample dispatch facility. Sample collection and transportation have always been undertaken by company or laboratory personnel using company vehicles. Chain-of-custody procedures consisted of filling out sample submittal forms that were sent to the laboratory with the sample shipments to ensure that the laboratory received all the samples.

11.6 Databases

Prior to August 2010, all geological and geotechnical drillhole data were entered into an MS Access relational database that had been developed in-house. Data were then exported from the main database to MapInfo® and Surpac™ databases for end-users.

In August 2010, OT LLC elected to migrate the Access® database to a full Oracle content database (OCDB) acQuire® database with links to the software programs MapInfo® and Vulcan™. The main database is read-only for these programs, preventing accidental overwriting and ensuring up-to-date live and centralized data, rather than distributed databases.

Before August 2010, all drillhole data were initially manually recorded in the field or in the core logging shed on paper logging sheets. The logging geologist then introduced logging information into the Access® database, which had a series of embedded checking programs to look for obvious errors. Formational names were subsequently assigned according to the accepted geological interpretation and position within the stratigraphic column.

With the move to acQuire®, direct digital data capture was instituted, with the design stubs for the logging sheets not permitting any invalid data. No drillhole can be completed and entered into the database until the logging is correctly entered.

SGS Mongolia reports the results digitally via email and submits signed paper certificates. General turn-around is approximately seven days. All hard copy assay certificates are stored in a well-organized manner in a secure location on site.

Before August 2010, the digital assay results were imported to the Access® files once the assay data had been received from the laboratory in Ulaanbaatar. This has been replaced by direct import to the acQuire® database. None of the assay data are manually entered. Project personnel visually check each assay on the signed paper certificate against the assay entry in the digital database.

Final surveyed collars (total station) are entered manually into the database and are visually checked against the preliminary, hand-held GPS readings. No double data entry is applied during the entry of the final collar coordinates.

Data were presented in up-to-date 50 m to 100 m-spaced MapInfo™ drill sections in two directions (north-west and north-east) and reconciled to 50 m spaced level plans to ensure that domains (solids) were properly constructed and interpretations were sound. Sections and levels were reviewed regularly to ensure that all holes crossed the target where planned and that data density was sufficient to make an appropriate interpretation. OT LLC notes that this approach will be continued for exploration data; however, for mineral resource and mine geology purposes, it is likely that section and level plan interpretations and any subsequent modifications will be completed using Vulcan™ modelling software.

The solids of all lithologies and mineralization types are present on the interpretations, and if significant deviations are noted in the holes, or they appear to miss their targets, additional holes are planned to infill untested areas in the model.

OT LLC intends to develop a comprehensive and coherent geological (geometric) model based on sound and accurate geological information as the basis for future resource estimates. Digital data are backed up regularly.

12 DATA VERIFICATION

12.1 External Reviews 2002–2010

A number of data reviews have been undertaken by independent third-party consultants as part of preparation of technical reports on the project, including:

- Roscoe Postle Associates (RPA), 2002. Review of exploration information from earlier work and visited the project site in Mongolia and the Analabs assay laboratory in Ulaanbaatar. A suite of independent core samples were collected and assayed. Duplicate analytical datasets were examined. No biases or errors were noted that would impact Mineral Resource estimates.
- Barry Smee, 2002–2008. Review of sample preparation, analytical, and QA/QC data. Inspections and reports were completed in 2002, 2003, 2004, 2005, 2006, and 2008. No significant biases or errors were noted that would affect Mineral Resource estimates.
- AMEC and GRD Minproc, 2002–2011. Review of QA/QC data and databases in support of Mineral Resource estimates undertaken in 2002, 2003, 2005, 2006 and 2007, and independent core check sampling. QA/QC reviews showed acceptable analytical precision, low contamination, and a small number of sample mix-up errors. The database iterations reviewed were considered sufficiently error-free to support Mineral Resource estimation. In 2003, AMEC noted that samples in the Southern Oyu area assayed before drillhole OTD231 were poorly supported by QA/QC data. To assess any potential for bias, a 20% re-assay program of the assays was undertaken. Analysis of results confirmed the presence of a bias in the higher-grade ranges for Au (>6 g/t) and Cu (>2%). Assays from that sampling period that exceeded the respective metal thresholds were adjusted downward by 14% for Au and 11% for Cu before resource estimation. On examining the database in 2011, AMEC determined that 34 gold assay results (0.3% of the assays for the period in question and 0.03% of the Southern Oyu assays overall) and 72 copper assay results (0.7% of the assays for the period in question and 0.6% of the Southern Oyu assays overall) would be affected by this correction. Because of the relatively few samples affected, high-value capping and outlier restriction are believed to be effective tools to manage these biases. Applying a bias correction to the affected data in the primary database and noting the correction is currently considered a more appropriate solution. A 2011 review of QA/QC progress reports prepared by OT LLC between April 2005 and December 2010 showed that Cu, Au, and Mo bias and failure rates for standards, field preparation, pulp duplicates, and field blanks were regularly examined. However, the reports viewed did not discuss QA/QC results for Ag. The recommended data supporting Ag analysis should be compiled in order to support the use of Ag grades in Mineral Resource estimation.
- Quantitative Geoscience, 2007–2008; 2010. Data verification of previous estimates, review of on-site sample preparation facility, independent sampling, and review of geology, mineralization, core sampling, sample preparation, QA/QC, and mineral resource modelling for the Heruga and Heruga North (New Discovery) areas and for geotechnical drilling underway at Hugo North. No biases or errors were noted that would impact Mineral Resource estimates.

Other than the issues noted above, all reviewers have concluded the Oyu Tolgoi drillhole dataset was sufficiently free of errors, reasonably accurate, precise, and free of contamination, and suitable for use in estimating Mineral Resources.

12.1.1 TRQ Review 2011

In 2011, TRQ carried out a review of the QA/QC system. The review covered laboratory audits, quality assurance procedures, quality control monitoring, and database improvements at Oyu Tolgoi for the period 2008 to 2010. Recommendations arising from the review included:

- QA/QC improvements at site:
- Updating SRM inventory and sample storage.
- Re-designing batch layouts.
- Re-instating bias charts, failures table, load statistics, failure rates.
- Upgrading analytical suites.
- Improving specific gravity measuring techniques.
- Rectifying SRM failures and duplicates mix-ups.
- Completing check assaying.
- Completing regular progress reports.
- Preparation laboratory improvements:
- Minimizing fine particle extraction biases.
- Using correct pulverizing amounts.
- Rectifying safety issues.
- Using correct sizing test amounts.
- Proper archiving.
- Database improvements:
- Improving functionality.
- Correcting integrity issues.
- Fixing operational issues.

Implementation of the recommendations by OT LLC is underway, with a number of the recommendations either already addressed, such as changes in analytical methods for multi-element exploration suite, or under advisement.

12.1.1.1 Evaluation of Drill Data

As part of the update to Mineral Resource estimates for the Southern Oyu (SO) deposits, the following database reviews were undertaken:

- Data collected prior to 15 April 2005 and incorporated in the 2011 database were compared with a locked MS Access® database from 2006.
- Data collected since 15 April 2005 data and incorporated in the 2011 database were compared to original supporting documents, where available.
- Core-logging and sampling procedures were reviewed.
- The discovery outcrop at Oyu Tolgoi was inspected.

No new drill core or drill sites were inspected, and no independent samples were taken.

The results of the database review are summarized in Table 12.1.

Table 12.1 2011 Southern Oyu Data Verification

Item	Pre-2005	Post-2005	Recommendation/Comment
Drill Collars	No independent inspection of collar locations performed; Greg Neubecker, of Surteck International completed an audit of drill collar surveys in 2004. Results compared well with the database. Database verification of hole collars indicated no differences between the 2005 and 2011 databases.	No independent inspection of collar locations performed. No database verification of drillhole collars performed.	The land surveyor should complete a surface collar location re-survey program of some of the drillholes completed since 2005 as a verification check.
Downhole Surveys	There are 7,268 survey records in the 2005 survey table; 6,804 of these have matching depth intervals in the 2011 survey table. The missing 468 intervals are attributed to end-of-hole surveys reported in 2005. These end-of-hole surveys are likely not actual surveys but repeats of the deepest survey copied to the end of the hole.	No database verification of downhole surveys performed.	Verify reason for omission of the 468 missing survey intervals. If these have been omitted due to copying of the deepest drill survey information, then the omission of these from the current database is considered appropriate.
Assay Tables	There are 47 assay intervals associated with four drill holes in the 2005 assay table not included in 2011 assay table. All but three of these intervals are in hole SBS001, collared in the South West Oyu deposit area. The assignment of 0.0005% Cu as a lower detection limit may represent an error in the conversion. There are 69 Cu values that do not match. Most of these 69 differences are less than 0.09 ppm Cu. The 69 differences identified represent 0.07% of the Cu assays for the 2005 assay table. Unassayed gold intervals reported as -9999 in 2005 are reported as null values in 2011; two samples which were considered as LDL in 2005 have assay values of 0.02 ppm Au in 2011. There are 50 intervals where Au values do not match. Most of these 50 differences are less than 0.09 ppm Au. There is a bias of lower grades reported in 2011 for paired differences greater than 0.1 ppm Cu. The 50 differences identified represent 0.05% of the gold assays for the 2005 assay table. Unassayed Mo intervals reported as -9999 in 2005 are reported as null values in 2011. The assignment of 2.5 ppm may represent an error in the conversion of LDL. There are 18 Mo values that do not match. These show a bias of lower grades reported in 2011. The 18 differences identified represent 0.02% of the Mo assays for the 2005 assay table. Unassayed silver intervals reported as -9999 in 2005 are reported as null values in 2011 with four exceptions. There are three intervals where Ag values do not match. The differences identified represent <0.01% of the Ag assays for the 2005 assay table. Unassayed arsenic intervals reported as -9999 in 2005 are reported as null values in 2011 with one exception. Two assay intervals previously recorded as below detection limit are now assigned values. There are eight intervals where As values do not match. The differences identified represent 0.01% of the As assays for the 2005 assay table.	There are 5,799 assays associated with the 90 new holes drilled since 2005. Assay certificates for these samples were loaded into the database, and Au, Cu, Mo, Ag, and As grades were compared to the 2011 assay table "Best assay" values. No errors were found for 4,976 sample intervals. Assay certificates from 2005 and 2006, containing results for the remaining 823 intervals were not initially requested and were not reviewed.	Review lower detection limit value assignments; review all noted differences to ensure final assay value is supported by original data. None of the differences noted for the pre-2005 data are expected to cause any material impact on the estimation of grades in the 2012 mineral resource estimate.

13 MINERAL PROCESSING AND METALLURGICAL TESTING

13.1 Summary

The Project under consideration consists of three main feed sources:

- Southwest
- Central
- Hugo North

The Mineral Reserve considers Southwest and Central ores will be extracted by open cut mining. IDP05 which was a Preliminary Assessment Report considered Hugo North mining by block caving.

The Southwest deposit is a gold-rich porphyry system characterized by pipe-like geometry approximately 250 m in diameter and extending over 700 m vertically. The copper mineralization is dominated by chalcopyrite, with minor bornite (less than 20%).

The South deposit outcrops as copper oxides underlain by secondary sulfides and then chalcopyrite. The copper grade is lower than in the other deposits, and there is little gold. Some of the South deposit will fall within the bounds of the Southwest pit. For this reason, both the South and Southwest ores are hereafter referred to as Southwest.

The Central deposit is “funnel” shaped, with a chalcocite enrichment blanket overlying a large covellite zone. A chalcopyrite/gold zone lies at the base of the covellite zone, although this is expected to contribute less than 5% of the material mined from the Central deposit.

Hugo North dips away and has very high copper grades at a depth of 1,000 m or more. Gold appears to increase with depth, with some coarse, visible particles observed in the drill core. Copper mineralization consists of chalcopyrite, bornite, and chalcocite.

In 2001, OT LLC initiated and supervised a program of work to investigate the metallurgical response of samples of drill core from the Southwest, Central, and Hugo Dummett deposits. Testwork carried out by SGS Lakefield Research Limited (SGS Lakefield), A.R. MacPherson Consultants Ltd. (ARM), and Terra Mineralogical Services established basic comminution parameters, the amenability of gold recovery by gravity concentration, and the amenability of copper and gold recovery by flotation. Limited testwork was also conducted on samples from the South deposit.

The results of this phase of the work, which provided the original definition of key metallurgical parameters, are summarised below by the three main ore sources:

- South West:
  - Moderate to hard Ball Mill Work Index (BWI) of 15-20.
  - 16-45% gravity recoverable gold, but gold very fine so plant recovery likely to be lower.

  - Cyanide leaching recoveries of gold very high, confirming the gold to be fine and well-liberated.
  - Chalcopyrite the dominant copper mineral; locked cycle tests obtained 83–93% copper recovery to 28% Cu concentrate with gold recoveries following copper but 15–20% less. Fluorine expected to trigger smelter penalties.
  - Acid base accounting (ABA) on flotation tails showed them to be non-acid generating.
- Central:
  - Low to moderate BWI of 10–13.
  - One gravity test gave only 9% gold recovery.
  - Cyanide gold leaching recoveries in 30–55% range.
  - Mineralogy consists of chalcopyrite plus secondary copper minerals and pyrite with copper/pyrite intergrowths and some enargite.
  - Locked cycle tests showed highly variable grade-recovery performance with significant arsenic and fluorine levels incurring smelter penalties, with arsenic close to rejection limits.
  - Significantly more complex than South West and possibly incompatible to blend with Southwest.
  - ABA on flotation tails indiacted potential fo acid generation, as expected from pyrite content.
- Hugo North:
  - Moderate BWI of 12–16.5.
  - Chalcopyrite and chalcocite dominant; locked cycle tests produced 29–40% Cu concentrates with recoveries around 90%. Fluorine and arsenic both would incur modest smelter penalties.
  - ABA on flotation tails showed them to be potentially acid generating.

In 2003, the then study managers, AMEC Ausenco Joint Venture (AAJV), together with OT LLC, determined that an additional phase of metallurgical testwork was necessary to support a feasibility study. The 2004 to 2005 program was designed to establish the flotation and comminution response of ores from Southwest, Central, Hugo South, and Hugo North. Laboratory batch-scale and pilot-plant flotation testwork programs were conducted at AMMTEC Ltd. (AMMTEC) in Perth. Additional testwork to define fundamental flotation and comminution parameters was executed by MinnovEX. Laboratory-scale comminution testwork programs were also conducted at AMMTEC. SGS Lakefield carried out a SAG pilot-plant test program to confirm the laboratory-scale testwork. Laboratory batch-scale and pilot-plant flotation testwork programs were conducted at AMMTEC Ltd. (AMMTEC) in Perth. Additional testwork to define fundamental flotation and comminution parameters was executed by MinnovEX. Laboratory-scale comminution testwork programs were also conducted at AMMTEC. SGS Lakefield carried out a SAG pilot-plant test program to confirm the laboratory-scale testwork.

An important part of this additional testwork was related to the Hugo North ore deposit and years 0–5 and 6–9 production composites as well as the northern extensions of this orebody; key results are summarised below:

- Optimum grind size was 140–155 µm in the main (southern) section of the orebody but finer, 110 µm, in the north.
- Locked cycle tests on the main orebody confirmed the Lakefield results with 93–94% copper recovery (and 80% gold recovery) a copper concentrate of 42% in years 0-5, falling to 32% in years 6–9 as chalcocite became less dominant. Penalty element levels were low, arsenic being well below penalty levels and fluorine just triggering a penalty.
- Similar results were obtained for sample 963 fan from the north, but sample fan 918 yielded lower copper recoveries (88%) and significantly higher arsenic levels, just below the penalty trigger.

Another important part of the AMMTEC testwork was variability tests on the main Hugo North orebody and also on the Hugo North Extension.

Significant variability in ore hardness was found, especially for the main Hugo North orebody, and also for flotation grade-recovery performance, re-inforcing in AMC's opinion, the importance of sound geometallurgical modelling as a basis for blending, especially with the more problematic Central ore.

In 2006 and 2007, SGS (MinnovEX) conducted confirmatory metallurgical cleaner testwork on the Southwest and Central deposits. During the same period, core became available from additional drilling of the Hugo North Sub-Level Cave (SLC) and Entrée deposits, and Process Research Associates (PRA) was contracted to conduct the metallurgical testwork of these new reserves.

13.2 Sample Representation

The main source of IDP05 feed samples for the metallurgical testwork program was diamond drill core from the resource drilling program.

Samples were taken from the Southwest, Central, Hugo South, and Hugo North deposits. The samples collected from Southwest and Central were based on 100 m x 100 m x 45 m vertical height "metallurgical blocks" generated from the 20 m x 20 m x 15 m high resource model blocks that fell within the NSR $2.81 pit shell during the first 10 years of production (based on the current mining schedule, at 9 June 2004). Samples were selected from metallurgical blocks lying more than 25% within the NSR shell. Each metallurgical block was defined by a simple three-coordinate system of Level [L], Row [R], and Column [C].

Quarter core was taken from drillhole intercepts that passed through the blocks. If more than one hole passed through a block, then the intercept with the grade closest to that of the average grade of the metallurgical block was chosen. If no hole passed through the block, then the hole in an adjacent block closest to the resource model block grade was chosen.

Samples from Hugo South and Hugo North were taken from the holes that passed through the block-cave envelopes identified in the mining schedule at 9 June 2004. The block level [L] designation is the same for all deposits at Oyu Tolgoi. Therefore, nominal mining blocks were superimposed at each level to delineate the block-cave mining areas. Quarter core was taken from each 2 m geological assay interval along the core from the point where it entered each metallurgical block to the point where it left. These samples were kept in a separate bag until compositing so that location and geological assay data could be referenced. If all of the 2 m sample intervals that constituted the upper, middle, or lower vertical 15 m of a metallurgical block were outside the NSR shell, then they were rejected as barren material. Otherwise, the 2 m samples were added to the hole composite that represented the metallurgical block.

Because the Hugo North orebody is very deep and a relatively small number of holes were available at the time of the sampling program, every available drillhole that could be sampled was sampled. With the non-selective nature of block-cave mining, even obviously barren dyke material, which would be part of the internal dilution, was sampled and included in composite preparation.

The Hugo North, Hugo South, and Central deposits have not been sampled to their limits but only to the limits of zones corresponding to the early years of production, e.g. the end of Year 7 in the case of Hugo South.

13.2.1 Comminution

(1) Origin of Core Samples for 2003 – 2005 Grindability Testwork – IDP05

The IDP05 comminution samples represented the complete set of samples used for the current 2009 comminution plant design. Samples tested post 2005 are used to populate the geostatistical cell model to determine the processing rates in the production schedule given a fixed plant design.

The core samples delivered for grindability testwork over the 2003 to 2005 period covered Southwest, Hugo North, Central and Hugo South.

Table 13.1 lists the number of samples taken for comminution testwork per deposit.

Table 13.1 Number of Samples taken per Deposit for 2003-2005 Testwork(Samples for Comminution Testwork from All Deposits)

	Years of Scheduled Production*	Production First Ten Years* (Mt)	No. of Met Blocks	No. of Holes in Met Blocks	No. of Holes Sampled	No. of Comminution Samples Collected	No. of Samples Tested
Southwest	0-15	231	424	363	106	198	169
Central	6-14	30	–	51	45	56	81
Hugo North	4-20+	71	–	–	28	97	36
Hugo South	9-20+	4	–	71	71	81	10

*Based on the IDP05 Production Schedule.

For Southwest, a comminution sample was taken for every metallurgical block representing the first three years of mine production. From then on, samples were selected to provide an adequate sample distribution for a given level. For all comminution samples, quarter core was taken from core diameters greater than 55 mm, and half core for core diameters less than 55 mm. Most samples taken were in the weight range 5.0 to 5.5 kg but, for approximately every tenth sample, a larger sample of two 6.0–6.5 kg samples was taken and combined to make up a nominally 12 kg sample on which a full Bond Work Index test could be performed.

The purpose of the MinnovEX testwork was for nominal throughput determination based on the tonnage calculated for each metallurgical block represented by a drill core sample. To achieve this objective, Ci (Crusher Index); SPI (SAG Power Index); BWi and Mod-Bond (Bond Work Index and Mod-Bond Work Index) tests were carried out. Table 13.2 provides a list the number of SPI, Ci, Mod-Bond and full BWi tests performed per deposit, between 2003 and 2005.

Table 13.2 Number of Comminution Tests Performed at MinnovEX per Deposit

Deposit/Sample	SPI Tests	Ci Tests	Mod-Bond Tests	BWi Tests	Production First Ten years (Mt)	SPI Representation (per Mt)
Southwest	169	124	167	31	231	0.68
Hugo South	10		10	3	4	2.50
Hugo North	36	36	36	2	71	0.51
Central	81	18	78	5	30	2.70
Entree	9	9	9	–	–	–
Composite	11	11	–	–	–	–
Unallocated	7	7	–	7	–	–
Total	**350**	**206**	**319**	**48**	**336**	**–**

In addition to the above comminution tests, 26 samples were tested at AMMTEC, for the CEET-JK model comparison study, and 4 samples of Heruga were tested for BWi at G&T Metallurgical.

(2) Origin of Bulk Sample for 2005 Pilot Campaign

An exploratory hole (OTD725) was drilled in the Southwest orebody to intercept a cross-section of typical plant feed types, guided by geological information gained from the previous exploration program. Downhole grades and SPI measurements were taken. An interval from 68–72 m downhole was selected based on SPI, lithology, and grade being near the orebody average.

A 3 m diameter shaft was sunk in the vicinity of this hole, at UTM coordinates 650,718 m E, 4,763,089 m N, centred on previously drilled diamond drillhole OTD189. A 250 t bulk sample was taken from the sides of the bottom 6 m of this shaft at a depth 68–74 m below surface. Care was taken to blast minimally to ensure that the material taken from the shaft was not over-fractured. The sample was shipped to SGS Lakefield for pilot testing.

A 250 t bulk sample was shipped to SGS Lakefield for the 2005 pilot plant campaign. A subsample of the pilot plant SAG feed material was submitted to MinnovEX for SPI and Mod-Bond measurement. A pilot plant campaign was conducted to confirm the suitability of Oyu Tolgoi Southwest material for semi-autogenous grinding and to validate the CEET Model.

(3) CEET Validation with JKSimmet

The 26 samples were selected in order to cover each of the significant feed types throughout the deposits. Sample mass and top size requirements dictated that PQ drill core was needed for these validation samples. Of the 26 samples, 22 of the samples were selected from three PQ holes through the Southwest deposit, and four samples were selected from one PQ hole in the Central deposit.

(4) Origin of Core Samples for 2006-2007 Grindability Testwork

A minimum of 80 samples from the Hugo North SLC region was required to undertake geostatistical calculations for this region; therefore additional core samples from this region were located, shipped and tested at SGS Lakefield in 2006. The 82 samples comprised 16 core samples already tested during the 2003–2005 program, and 66 new core samples shipped from the Oyu Tolgoi site in October 2006. Nine Entrée samples were tested in early 2007.

Sampling was based on 10 cm/m over a 15 m interval and the core sample was provided as a combination of half-NQ and half-PQ core. Most of the samples were from the bornite core and were split between the two main rock types; the remainder of the samples were from the HW argillic alteration zone and the FW disseminated Cpy mineralization in Qmd.

13.2.2 Flotation

Table 13.3 and Table 13.4 provide a summary of the flotation sample representation and testwork for the 2004, and the 2006–2007 periods, respectively. Drillhole locations are provided in the geology section.

Table 13.3 Flotation Test Representation(List of Samples for 2004 Test Program)

	Production First Ten Years* (Mt)	Composites	No. of Met Blocks	No. of Holes in Met Blocks	No. of Variability Samples
Southwest	231	Periodic Composites Months 0-6 Months 7-12 Year 2 Year 3 Year 4 Year 5 Years 6-10 2006 Minnovex	424	363	285 7
Central	30	Chalcocite Covellite Chalcocite/Covellite 2006 Minnovex	–	–	30 5
Hugo North SLC	71	Upper Phase 1 2007 SLC	–	–	30 55
Hugo South	4	Phase 1	–	–	20
Entrée	–	Rougher Cleaner	–	–	6 6
Heruga	–	–	–	–	9 comp.

*Tonnages refer to the IDP05 Schedule

Table 13.4 2007 Summary of Flotation Testwork 2006–2007 Summary of Laboratory Scale Flotation Tests

Test	SW	HN	SLC	Central	HS	Entrée	Heruga
Rougher							
Batch	149	8	–	25	10	–	4
pH/Reagent	20	–	11	–	–	–	–
% Sol.	–	–	3	–	–	–	–
P. Grind	133	45	9	41	21	6	–
FKT/MFT	7	4	6	1	1	–	–
Variability	266	47	55	41	–	–	–
Cleaner							
Batch	50	–	–	11	–	–	4
pH	3	–	9	–	–	–	–
Regrind	51	–	10	–	–	6	–
FKT	2	–	2	2	–	–	–
Column	8	–	2	–	–	–	–
Locked Cycle	21	8	3	22	3	–	–
Pilot Plant	2	1	–	–	–	–	–

(1) IDP05 2001–2003 – Early Lakefield

The early Lakefield work consists primarily of seven composites: two Southwest, one South, three Central and one Hugo North. The total drillhole representation is:

- Southwest – 3,076 m
- Hugo North – 852 m
- Central – 1,284 m

(2) IDP05 2003–2004

The 2004-2005 IDP05 work consisted primarily of period composites: seven Southwest, three Central, three Hugo North and one Hugo South. There were also two pilot plant trials: one Southwest and one Hugo North. The total drillhole representation was:

- Southwest – 17,280 m; pilot – 16,351 m
- Hugo North – 1,210 m; pilot – 1,650 m
- Central – 779 m
- Hugo South – 1,506 m

(3) 2006-2007 Southwest, Central, SLC

The confirmatory work conducted at SGS-Lakefield was on the same period composites for Southwest and Central. The Hugo North SLC work was on three composites consisting 122 m of core.

(4) Entrée and Heruga

Entrée scoping consisted of three composites with 630 m of core and Heruga scoping consisted of four composites of 80 m of core.

(5) Plant Feed Representation and Mine Planning

Note that where reference is made to blocks being treated at certain times in the production schedule (for example, Table 13.3) these references refer to the mine plans current at the time the test program was being planned. As mine plans have changed over time, so too has the relationship between the test samples and the time when the represented material is likely to be processed.

13.3 Test Programs

In late 2003, AAJV and IMMI (now OT LLC) determined that additional testwork was necessary to support the feasibility study. The objective of the new testwork was to confirm the amenability of the flow sheet adopted from the early testwork done for the Preliminary Assessment and to characterize the potential plant feed featured in the new mine plans in terms of flotation and comminution response. The testwork scope included:

- Additional bench-scale batch and locked-cycle flotation testing on Southwest and Central production composites to confirm the previous results and to test flow sheet alternatives.
- Bench-scale batch and locked-cycle flotation testing on Hugo South and North production composites to develop pre-feasibility level metallurgical parameters.
- Variability testing on Southwest samples to finalize the plant design parameters.
- Bulk flotation testwork on Southwest samples to confirm plant design parameters and to produce sufficient concentrate and tailing samples for vendor testwork and concentrate marketing.
- Bench-scale comminution testwork to develop design parameters.
- Pilot-scale comminution testwork to confirm the circuit design and throughput.

During the course of the testwork, potential risks and opportunities were to be identified and information was to be gathered to develop strategies to minimize smelter penalties.

The flotation testwork data forms the basis for all metallurgical modelling. A substantial results database exists for the Southwest ores and moderate databases exist for Central, Hugo North, and Hugo South ores.

The flotation tests summarized in Table 13.5 (approximately 1,137 tests) have been conducted since the beginning of the Oyu Tolgoi test program and the majority of them have been used in model development and in the review process. These tests are detailed in reports from Ammtec, SGS and PRA and are discussed at length in reports by Aminpro and in this review report.

Table 13.5 Oyu Tolgoi Project Flotation Testwork (Quantity of tests on each sample type)

Deposit	SW	C-Cv	C-Cc	C-Cpy	C-4,5,6	HS	HN	HN Entrée	Orebody Comps
Roughers	213	36	20	1	94	–	87	6	–
Cleaners and Roughers	390	13	12	–	110	42	74	6	4
Lock Cycle Tests	6	1	1	–	–	1	5	–	–
Column	8	–	–	–	–	–	2	–	–
Pilot	4	–	–	–	–	–	1	–	–

The comminution testwork for each deposit is summarized in Table 13.6. This work has been analyzed and used to prepare the throughput recommendations for each of the ores.

Table 13.6 Summary of Comminution Samples Dispatched to Testwork Facilities

Facility	Location	Scale of Testwork	Testwork Conducted	Quantity
MinnovEX Technologies	Toronto, Canada	Bench scale	SAG Power Index [SPI] (measured in minutes)	350
			Bond Ball Mill Work Index [BWi] (measured in kWh/t)	48
			Modified Bond Index [Mod-Bond] (measured in kWh/t)	319
			MinnovEX Crusher Index [Ci]	206
			specific gravity	7
AMMTEC	Perth, Australia	Bench scale	JKTech FAG/SAG Mill parameters	26
			JKTech Rod/Ball Mill Appearance function	26
			Unconfined Compressive Strength [UCS]	26
			Bond Impact Crushing Work Index	26
			Bond Abrasion Index	26
			Bond Rod Mill Work Index	26
			Specific gravity	26
SGS Lakefield	Lakefield, Canada	Pilot scale	Pilot-plant runs at a series of circuit options	12 tests on one bulk sample
		Bench scale	JKTech FAG/SAG Mill parameters	Tests on seven composite samples (2003)
			JKTech Rod/Ball Mill Appearance function	
			Unconfined Compressive Strength [UCS]	
			Bond Impact Crushing Work Index	
			Bond Abrasion Index	
			Bond Rod Mill Work Index	
			Specific gravity	

13.3.1 AMMTEC Bench-Scale Flotation Test Program

AMMTEC Perth, an experienced Australian metallurgical laboratory, was selected to perform the bench-scale flotation work. In early 2004, the testwork program parameters were finalized, and a campaign was initiated to collect samples from existing drill core at site. Concurrent with this sampling program, composite samples from the 2003 program were shipped to Perth for AMMTEC to conduct a series of validation and calibration tests. The 2004 samples began arriving in Perth in May 2004, and testwork commenced soon after. This program was completed in early 2005.

13.3.2 MinnovEX Comminution Testing

The MinnovEX Comminution Economic Evaluation Tool (CEET) was used as the primary methodology for estimating throughput rates. CEET uses grinding parameters measured from the geological drill core sample set. Samples were selected from the core at the same time as the flotation sample set and were sent to the MinnovEX laboratory in Toronto.

13.3.3 MinnovEX FLEET Testwork Program

To provide a secondary confirmation of flotation parameters, portions of the composite samples developed in Perth were sent to MinnovEX for MinnovEX Flotation Tests (MFT). These MFT parameters were used in conjunction with the MinnovEX Flotation Economic Evaluation Tool (FLEET) to provide alternative kinetic information intended to translate the laboratory tests into plant design criteria and to validate circulating loads.

13.3.4 AMMTEC Comminution Testing

A secondary, or validation, assessment of the milling rates was undertaken with the JKSimMet simulator method, which uses a suite of parameters obtained from testing of large-diameter (PQ or larger) core. Four PQ holes were drilled to intercept as many feed types as possible. Selected core from these holes was shipped to AMMTEC in late 2004 for measurement of JK grinding parameters. Splits from these samples were also sent to MinnovEX for SPI determinations.

13.3.5 SAG Pilot Plant

A bulk 250 t sample of mined rock, typical of Southwest ore, was shipped to SGS Lakefield in early 2005. A series of pilot-scale plant tests, intended to confirm the prediction of the bench scale comminution work, was conducted in April 2005.

13.3.6 Hugo Far North (Hugo North Extension)

While the 2004 test program was in progress, IMMI (now OT LLC) identified potentially large reserves of copper-rich material to the north of the previously sampled area of Hugo North. Additional samples were taken from that part of the orebody for bench-scale flotation work at AMMTEC and MinnovEX and bench-scale comminution work at MinnovEX. Flotation testwork focused on the kinetics of the roughers and cleaners by PRA was also carried out on samples from this area.

13.3.7 Bulk Flotation Test

Large composites of Southwest and Hugo North samples were made up from surplus sample at the AMMTEC laboratory. These samples were processed through pilot-scale equipment to generate large samples of concentrate and tailings for further testing. Concentrate was required for marketing analysis and to measure the thickening and filtration design parameters. Tailings material was required to confirm the design parameters for the thickeners, transportation pumping, and tailings deposition method. As well as physical plant design data, tailings were also evaluated to define environmental parameters.

13.3.8 Concentrate Upgrading Program, Lakefield

The bulk flotation test at AMMTEC on Southwest material did not produce concentrate to specification because the material had not been reground properly. Unfortunately, the physical characteristics of the test equipment were not adjusted until the Southwest material sample had been consumed. The off specification sample was shipped to SGS Lakefield, where it was reground to the correct size and upgraded in a pilot-scale flotation column brought in from MinnovEX. The Hugo North bulk flotation test was satisfactory and produced concentrate and tailings consistent with the design criteria.

13.3.9 Final Product Concentrate Assay Analysis

Final concentrates from the locked-cycle tests were assayed for a range of minor elements, as shown in Table 13.7. Fluorine and arsenic are the only significant deleterious elements identified.

Table 13.7 Concentrate Assay Analysis

Element	Unit	Southwest				Hugo North		Hugo South 0-5 Yrs	Central Covellite
		Range		Average	Median	0-5 Yrs	6-9 Yrs		
Ag	ppm	34	49	44	45	73	63	62	40
Al	ppm	5,125	9,150	6,845	7,160	8,415	10,950	11,750	6,175
As	ppm	20	1,290	431	140	400	800	2 320	3,180
Au	ppm	10	31	23	25	9	4	2	2
Ba	ppm	20	36	28	27	45	50	51	60
Be	ppm	<0.1	0	0	0	0	<0.1	<0.1	<2
Bi	ppm	<10	<10	<10	<10	<10	<10	<10	<10
Ca	ppm	1,715	3,260	2,197	1,973	880	777	812	1,370
Cd	ppm	8	65	24	15	7	8	25	100
Cl	ppm	<50	1,600	464	100	<50	<50	<50	<50
Co	ppm	85	178	127	128	19	64	80	163
Cr	ppm	18	40	26	22	130	100	44	182
Cu	%	20.4	25.7	23.4	24.5	41.6	31.8	32.8	20.5
F	ppm	250	410	320	310	330	420	510	130
Fe	%	26.8	31.3	29.5	30.2	17.3	21.1	22.9	26.9
Ge	ppm	1	25	6	1	<0.5	1	3	30
Hg	ppm	0	2	1	0	3	4	<0.1	1
K	ppm	1,587	2,600	2,121	2,200	3,005	2,500	1,423	1,110
Li	ppm	<5	5	4	<5	<5	<5	<5	<5
Mg	ppm	1,700	3,015	2,299	2,090	930	765	691	335
Mn	ppm	60	260	123	91	81	85	116	27
Mo	ppm	1,031	3,071	1,987	1,850	548	286	798	130
Na	ppm	980	1,404	1,147	1,090	399	300	161	206
Ni	ppm	56	138	103	105	125	78	53	235
P	ppm	<100	100	100	100	100	100	235	200

Element	Unit	Southwest				Hugo North		Hugo South 0-5 Yrs	Central Covellite
		Range		Average	Median	0-5 Yrs	6-9 Yrs		
Pb	ppm	248	1,182	546	441	247	184	165	45
Pd	ppm	0	0	0	0	<0.1	<0.10	<0.10	<0.10
Pt	ppm	<0.05	0	0	<0.05	<0.1	<0.10	<0.10	<0.10
Re	ppm	<0.05	3	1	0	0	0	1	0
S	%	34.4	38.0	36.0	36.1	27.4	28.7	32.8	45.3
Sb	ppm	10	65	31	30	142	380	10	10
Se	ppm	180	275	227	235	390	280	30	90
SiO2	%	3.8	7.5	4.7	4.2	8.4	8.7	8.3	4.7
Sn	ppm	1.0	4.7	2.3	1.8	1.2	4.1	10.1	19.3
Sr	ppm	18	58	32	27	69	109	122	114
Te	ppm	5	10	7	7	30	25	24	10
Ti	ppm	570	1,360	890	735	515	665	908	230
Tl	ppm	<0.5	1,160	129	<0.5	<0.5	<0.5	1	4
V	ppm	22	71	45	43	26	73	62	508
Y	ppm	4	7	5	4	<1	1	<1	2
Zn	ppm	488	2,931	1,808	2,069	444	425	853	1,455
Zr	ppm	255	437	350	346	485	451	353	479

13.4 2006–2007 Confirmatory Testwork

13.4.1 2006 SGS-Lakefield – Southwest and Central – Rougher/Cleaner Kinetics Verification

In 2006, confirmatory rougher and cleaner kinetics testwork was conducted at SGS Lakefield. The testwork was conducted on the 2004–2005 IDP05 period composite samples to verify the IDP05 kinetics. The cleaner tests included variations in pH and regrind. As the kinetics of the roughers was developed under an FKT test, the parameter extractions include a relationship between kinetics and primary P_{80}.

13.4.2 Hugo North

A complete suite of rougher and cleaner flotation work was carried conducted at Process Research Associates Ltd (PRA) Laboratory in Vancouver. Variability work was conducted to determine the effect of head grade on recovery, and rougher and cleaner tests were conducted to determine the effect of pH and grind. Samples were selected in the area of the deposit that is to be mined first.

13.5 2008 Heruga Scoping Study

Four composite samples of the Heruga deposit were sent to G&T laboratory for initial scoping testwork to assess, the mineralogical characteristics of feed and flotation products, the flotation response of each sample, the bond work index and to analyze the exit streams from the float work to identify opportunities for further improvement in metallurgical performance.

The Heruga metallurgical scoping study was conducted at G&T Metallurgical Services Ltd. and is reported in “Preliminary Metallurgical Assessment of Metallurgical Composites”, Ivanhoe Mines.– Oyu Tolgoi Project Mongolia, KM2133, 5 August 2008. Overall, the composites responded well to the applied Oyu Tolgoi flow sheet.

14 MINERAL RESOURCE ESTIMATES

14.1 Mineral Resource Estimation

The following subsections describe the methods used and results of the mineral resource estimates for the Southwest, South, Central, Wedge deposits (collectively the Southern Oyu deposits) and the Hugo, Hugo North, and Hugo North Extension deposits (collectively the Hugo North deposit).

The Heruga and Hugo South deposits are discussed in less detail as they are not included in the first mining phase of the Oyu Tolgoi Project.

14.1.1 History of Mineral Resource Estimates

Estimates were prepared in the period 2003 to 2012 as summarized Table 14.2.

Hugo South Mineral resources that were estimated in 2003 are current as at the Effective Date of the Technical Report. Southern Oyu Mineral resources estimated in 2005 were updated in 2012. The 2012 Southern Oyu Mineral Resources are current as at the Effective Date of the Technical Report.Hugo North Mineral resources were estimated in 2007 and are current as at the Effective Date of the Technical Report.

The current Heruga deposit Mineral Resource estimate was completed in 2010 and is current as at the Effective Date of the Technical Report.

Reviews of the drillhole data, interpretation wireframes (lithology, structure, and grade), and cell models for Southern Oyu, Hugo North, Hugo South, and Heruga were completed in 2013.

14.1.2 Databases

Database close-off dates for the mineral resource estimates are summarized in Table 14.1.

Table 14.1 Database Close-off Dates

Deposit	Data Close-out Date
Southwest	12 May 2011
Central	12 May 2011
Southern Oyu	12 May 2011
Wedge	12 May 2011
Hugo North	1 November 2006
Hugo North Extension	1 November 2006
Hugo South	1 November 2003
Heruga	21 June 2009

Table 14.2 Historic Mineral Resource Estimates

Year of Estimate	Company	Reference	Area	Drill Data	Comments
2003 (November)	AMEC	Juras, 2003; Parker and Juras, 2004	Hugo Dummett, Hugo South	136 drillholes (129,680 m).	Classified Inferred.
2005 (May)	AMEC	Juras, 2005 and Gingrich, 2005	Hugo North, Southwest, South, Central and Wedge	583 drillholes (273,000 m)at Southern Oyu; 156 drillholes (200,000 m) at Hugo North.	Classified Measured (Southwest only) where drilling within 55 m. For the Southwest deposit the two holes needed to be within 75 m, with at least one hole within 55 m to be classified Indicated. For South, Central, and Wedge, both holes needed to be within 65 m, with at least one hole within 45 m, to be classified as Indicated. For Hugo North, where the drill spacing is on approximately 125 m x 75m centres, Indicated classification can be used.
2006	AMEC	Peters et al., 2006	Northern Hugo North/Hugo North Extension	98 drillholes (93,000 m).	Classified Inferred.
2007	AMEC	Peters et al., 2007	Hugo North	366 drillholes (287,202 m) at Hugo Dummett. 722 drillholes (284,378 m) at Southern Oyu. 82 drillholes (59,963 m) at northern Hugo North and Hugo North Extension.	Classified Indicated and Inferred.
2009 (June)	Quantitative Geoscience	Peters et al., 2010	Hugo North Extension	45 drillholes (43,283 m).	Classified Indicated and Inferred.
2010	Quantitative Geoscience	Peters et al., 2010	Heruga	40 drillholes (53,931 m).	Classified Inferred.
2012	OT LLC		Southwest, South, Central, Wedge, and Bridge zones	708 drillholes (353,402 m).	Classified Measured, Indicated, and Inferred.

14.1.3 Geological and Grade Shell Models

OT LLC produced 3D geological models of the major structures and lithological units, based on the structural and geological information outlined in the geological discussion in this report. The geological shapes for the deposits are listed in Table 14.3.

For each deposit, appropriate copper and gold shells at various cut-off grades were also defined (Table 14.4). These shapes were then edited on plan and cross-section views to be generally consistent with the structural and lithological models and the drillhole assay data.

Checks on the structural, lithological, and grade shell models indicated that, in most cases, the shapes honoured the drillhole data and interpreted geology.

The lithological shapes and faults, together with copper and gold grade shells, constrain the grade analysis and interpolation within each deposit. Typically the faults form the first order of hard boundaries constraining the lithological interpretation.

The wireframed solids and surfaces were used to code the drillhole data with relevant domain flags. Plans and cross-sections that displayed colour-coded drillholes were plotted and inspected to ensure the proper assignment of domains to the drillholes.

Domains were established using the codes outlined in Table 14.5 to Table 14.6, where the domain variable used in grade estimation was a four-digit integer code composed from the following fields in the composite database: deposit (DPOSIT), grade shell (CUDOM, AUDOM and MODOM at Heruga, CDOMAIN and GDOMAIN at Hugo and Soutern Oyu), lithology (FLAG), and supergene (SUPERG). The third digit in the code was originally intended to accommodate a greater number of lithology codes, but remains generally unused.

Table 14.3 Surfaces used in Geological Models, Oyu Tolgoi Project

Area	Comment
Surfaces – General	
Topography	Project-wide.
Base of Quaternary cover	For each deposit
Base of Cretaceous clays and gravels	For each deposit
Base of oxidation	Project-wide, but relevant only for the Southern Oyu deposits .
Base of supergene alteration	Project-wide, but relevant only for the Southern Oyu deposits.
Solids/Surfaces – Lithology	
Top of quartz monzodiorite (Qmd) surface	Hugo South only.
Quartz monzodiorite (Qmd) solid	Hugo North, Hugo North Extension, Southern Oyu.
Augite basalt (Va) D1	Southern Oyu deposits.
Ignimbrite (Ign) DA2	Southern Oyu deposits.
Base of ash flow tuff (DA2a - ign)	Project-wide.

Area	Comment
Base of unmineralized volcanic and sedimentary units; DA2b or DA3 or DA4	Project-wide. used as a hanging wall limit to grade interpolation.
Hangingwall sequence (HWS), DA3, DA4, CS1–CS4	Southern Oyu zones.
Xenolithic biotite granodiorite (xBiGd) containing quartz-veined and mineralized fragments	Hugo North deposit only.
Biotite granodiorite (BiGd) dykes	Project-wide, most important in Hugo deposits unmineralized unit.
Rhyolite (Rhy) dykes	Project-wide, most important in Southern Oyu deposits unmineralized unit.
Hornblende–biotite andesites, dacites (And) dykes; HbBiAnd, Dac	Southern Oyu deposits.
Surfaces – Faults	
East Bat Fault	Hugo area: used to define Hugo North eastern limit
West Bat Fault	Hugo area: used to define Hugo North, Central, and West Oyu western limits
110 Fault North Boundary Fault	Hugo area: forms boundary between Hugo South and Hugo North deposits. Hugo North area: used to define north-western limit
Central Fault	Hugo South area: forms boundary between Hugo South and Central Oyu deposits
East Bounding Fault	Southern Oyu deposits area: forms eastern boundary to the Southwest deposit and western boundary to the Wedge deposit
West Bounding Fault	Southern Oyu deposits area: forms informal western boundary to the Southwest deposit (generally marks contact between unmineralized Qmd and mineralized Va)
Rhyolite Fault	Southern Oyu deposits area: marks boundary between Southwest and Central deposits
South Fault (includes South Splay 3)	Southern Oyu deposits area: marks boundary between Wedge and South deposits
Solongo Fault	Southern Oyu deposits area: defines the southern edge of the South deposit.
AP and KJ fault series	Southern Oyu deposits area: Internal faults in the area of estimated mineral resources.

Table 14.4 Grade Shell Construction Parameters

Deposit	Grade Shell (Au g/t)	Grade Shell (Cu %)	Grade Shell (Mo ppm)
Southwest	>0.7	>0.3	–
Central	>0.7	>0.3	–
South	>0.3	>0.3	–
Bridge	–	>0.3	–
Wedge	–	>0.3	–
Hugo South	–	0.6; 1.0; 2.0	–
Hugo North	0.3; 1.0	0.6; quartz veining 15% by volume	–
Hugo North Extension	0.3; 1.0	0.6; quartz veining 15% by volume	–
Heruga	0.3; 0.7	0.3	100

Table 14.5 Domain Codes – Hugo

DPOSIT (1st digit)			GS_CU or GS_AU (2nd digit)			FLAG (4th digit)	
Description	**Code**		**Description**	**Code**		**Description**	**Code**
All	1		**GS_CU - North**			Basalt	0
–	–		Outside grade shells	0		Ign	2
–	–		Inside 0.6 grade shell	1		Qmd	3
–	–		Inside15% quartz veining shell	2		Sed	4
–	–		**GS_CU - South**			Ign	6
–	–		Outside grade shells	0		Rhy	7
–	–		Inside 0.6 grade shell	1		HbBiAn	8
–	–		Inside 1.0 grade shell	2		BiGd	9
–	–		Inside 2.0 grade shell	3		–xBiGd	10
–	–		**GS_AU - All**			Basalt Dykes	11
			Outside grade shells	0			
			Inside grade shell	1			

Table 14.6 Domain Codes – Southern Oyu

DPOSIT (1st digit)			CDOMAIN or GDOMAIN (2nd digit)			FLAG (4th digit)	
Description	**Code**		**Description**	**Code**		**Description**	**Code**
Default/None	0		Outside grade shells	1		Va	1
Southwest (SW)	1		Inside 0.3 grade shell	2		Ign	2
Central (CO)	2		Inside 0.7 grade shell (Au only)	3		Qmd	3
South (SO)	3		–	–		HWS	4
Far South (FS)	4		–	–		BiGd	5
Bridge (BZ)	5		–	–		And	6
Wedge (WZ)	6		–	–		Rhy	7
West (WO)	7		–	–		Clay	8
South of the Solongo Fault	8		–	–		–	–
Supergene	9		–	–		–	–

Table 14.7 Domain Codes – Heruga

SDOM (1st digit)			CUDOM, AUDOM, MODOM (2nd digit)			FLAG (4th digit)	
Description	**Code**		**Description**	**Code**		**Description**	**Code**
West of Bor Tolgoi	1		Outside grade shells	0		Va	0
East Main Ore Block	2		Inside 0.3 grade shell (Au g/t & Cu%) or 100 ppm Mo grade shell	1		Qmd	3
Central Sliver	3		Inside 0.7 Au g/t grade shell (Au only)	2		And	8
West Main Ore Block	4		–	–		BiGd	9
South of South Bor Tolgoi	5		–	–			

14.1.4 Grade Capping and Evaluation of Outlier/Extreme Grades

Extreme (outlier) copper and gold grades were evaluated using histograms, probability, and cumulative distribution function plots.

14.1.4.1 Southern Oyu

The copper grades in the Southern Oyu deposits did not have grade capping applied.

For most domains, an outlier restriction method, rather than a global grade capping approach, was applied to gold, silver, molybdenum, and arsenic during grade estimation. A 50 m isotropic outlier sample search distance was used during estimation for the main lithological units: Va, Ign, Qmd, and HWS. A 20 m x 20 m x 15 m isotropic outlier sample search distance was used during estimation for dykes.

Global grade capping was applied to composites before applying the outlier search restriction to further limit the risk of outlier gold values in four domains, and consisted of 3 g/t Au in two domains and 8 g/t Au in the other two domains. The predicted metal removed for each element by capping, excluding blocks above the oxide surface, is as follows:

- Au = 3.5%
- Ag = 3.7%
- As = 0.4%
- Mo = 2.7%

Grade caps are summarized in Table 14.8.

14.1.4.2 Hugo North and Hugo North Extension

Outlier restriction, imposing grade capping to spatially outlying data, was applied during grade estimation for the Hugo North area. An outlier restriction of 50 m was used to control the effects of high-grade copper and gold values within the domains, particularly in the background domains where unrestricted high-grade composites tended to result in overstated estimates from extreme grade composites. In outlier-restricted kriging, outliers (i.e. values above the specified cut-off) are restricted to the specified cut-off threshold value if the distance from the sample to the interpolated block is greater than 50 m. If the distance to the interpolated block is less than 50 m, the outliers are used at their full value. The outlier thresholds applied were defined at the ninety-ninth percentile of their respective population. The thresholds for restrictions are shown in Table 14.9 (copper) and Table 14.10 (gold).

14.1.4.3 Hugo South

Grade caps on outlier grades were employed at Hugo South. These are summarized in Table 14.11.

14.1.4.4 Heruga

As well as global grade capping of extreme grades, some outlier restriction was also applied for the Heruga deposit, particularly in the background domains. Capping was generally applied at values close to or above the 99th percentile for gold and molybdenum. No capping was felt warranted for copper. Cap levels are shown in Table 14.12.

Table 14.8 Outlier Restrictions/Grade Caps, Southern Oyu

Domain	Outlier Search Restriction Threshold				Global Capping Threshold Au (g/t)
	As (g/t)	Mo (ppm)	Au (g/t)	Ag (g/t)	
1101	110	230	0.6	2.9	–
1103	115	85	0.6	2.5	–
1201	500	260	2.0	2.9	–
1203	500	260	1.0	2.9	–
1301	n/a	n/a	6.0	4.5	8.0
1303	n/a	n/a	8.0	4.5	–
2101	200	80	0.4	2.1	–
2102	900	260	0.7	2.1	–
2103	105	150	0.7	2.9	–
2104	100	12	0.15	1.0	–
2201	800	250	0.9	3.5	–
2202	1100	240	0.9	3.5	–
2203	1100	250	0.9	3.5	–
2204	–	–	n/a	n/a	–
2301	n/a	n/a	2.3	3.5	–
2302	n/a	n/a	0.7	3.5	–
2303	n/a	n/a	0.7	3.5	–
3101	400	70	0.55	3.6	3.0
3102	401	70	0.32	3.6	–
3103	500	85	0.55	4.6	3.0
3104	–	–	0.1	–	–
3201	1,050	85	3.0	8.5	–
3202	800	130	3.0	8.5	–
3203	1,050	85	3.0	8.5	–
3204	–	–	n/a	8.5	–
3301	n/a	n/a	3.0	8.5	–
3303	n/a	n/a	3.0	8.5	–
4101	110	230	0.6	2.9	–
4103	115	–	0.6	2.5	–
4201	500	350	2.0	2.9	–
4203	500	350	1.0	2.9	–

Domain	Outlier Search Restriction Threshold				Global Capping Threshold Au (g/t)
	As (g/t)	Mo (ppm)	Au (g/t)	Ag (g/t)	
4301	n/a	n/a	6.0	4.5	8.0
4303	n/a	n/a	8.0	4.5	–
5101	110	82	0.6	2.9	–
5102	110	82	–	–	–
5103	115	85	0.6	2.5	–
5104	–	–	–	–	–
5201	500	130	2.0	2.9	–
5202	–	–	n/a	n/a	–
5203	500	130	1.0	2.9	–
6101	900	130	0.28	1.6	–
6102	900	130	0.42	3.0	–
6103	900	130	0.42	3.0	–
6104	105	5.5	0.05	0.5	–
6201	500	160	1.5	4.0	–
6202	1,100	490	1.5	4.0	–
6203	1,100	160	1.5	4.0	–
6204	900	–	n/a	n/a	–
6301	n/a	n/a	1.5	4.0	–
6303	n/a	n/a	1.5	4.0	–
7101	300	150	0.45	2.9	–
7103	105	30	0.31	2.9	–
7201	105	160	1.3	4.0	–
7203	105	160	1.3	–	–
7301	n/a	n/a	1.3	4.0	–
7303	n/a	n/a	1.3	-	–
9100	–	150	0.4	3.8	–
9200	–	245	1.0	–	–
Bigd	–	–	0.35	–	–
And	–	–	0.35	–	–
Rhy	–	–	0.35	–	–

Table 14.9 Outlier Restrictions/Grade Caps Applied to Cu Grade Domains - Hugo North

Grade Domain	Va Outlier Threshold Cu (%)	Qmd Outlier Threshold Cu (%)	Ign Outlier Threshold Cu (%)	xBiGd Outlier Threshold Cu (%)
15% quartz vein	7.5	7.0	5.5	3.5
Cu 0.6%	2.5	2.5	2.5	2.0
Background	0.7	0.85	0.85	0.7

Table 14.10 Outlier Restrictions/Grade Caps Applied to Au Grade Domains - Hugo North

Grade Domain	Outlier Threshold Au (g/t)
1 g/t gold zone	5.0
West gold zone	2.0
Main gold zone	2.0
Background Qmd, XBiGd	0.4
Background Va	0.5
Background Ign	0.3

Table 14.11 Outlier Restrictions/Grade Caps - Hugo South

Grade Domain	Cu (%)	Au g/t	Mo ppm
2% Cu shell	11	2.0	600
1% Cu shell	5	2.0	1,100
0.6% Cu shell	3	2.0	1,100
Background	3	1.5	1,100
Number of assays capped	18	21.0	14

Table 14.12 Outlier Restrictions/Grade Caps - Heruga

Domain	Metal	Domain	Cap	Distance	Outlier Cap
Background	Au	1,000 to 4,000	3 g/t	50 m	1.0 g/t
Background	Au	5,000	3 g/t	50 m	0.3 g/t
Background	Mo	All	1,000 ppm	100 m	500 ppm
0.3 Au shell	Au	2,000	3 g/t	–	–
0.3 Au shell	Au	4,000	5 g/t	–	–
0.7 Au shell	Au	2,000	10 g/t	–	–
100 Mo shell	Mo	All	3,000 ppm	–	–

14.1.5 Composites

The drillhole assays were composited into fixed-length, downhole composites at a size that was considered appropriate when taking into account estimation block size, required lithological resolution, and probable mining method. However, the selection of a 5 m composite length results for Hugo and Heruga should be re-assessed because the raw sample length is predominantly 2 m, and a 5 m composite results in approximately a third of the raw sample intervals being split between two different composites.

This compositing honoured the domain zones by breaking the composites on the domain boundary. The domains used in compositing were a combination of the grade shells and lithological domains. Composite lengths of 8 m (approximately half the 15 m selective mining unit size of 15 m) were used for the Southern Oyu deposits, and 5 m lengths were used for all other deposits.

Intervals of less than either 8 m or 5 m lengths represented individual residual composites from end-of-hole or end-of-domain intervals. Composites that were less than 2.5 m long (Hugo North) or 2 m long (Heruga and Southern Oyu) were discarded from the dataset used in interpolation.

For the Southern Oyu deposits, the following default values were applied to any gaps in the intervals of the assay table during compositing:

- Cu 0.005%
- Au 0.005 g/t
- Ag 0.5 g/t
- As 25 ppm
- Mo 2.5 ppm

At Hugo North, the composites included any post-mineralization dyke intervals that were deemed too small to be part of a dyke geology model. Any unsampled material included in the composites for Hugo North was set to:

- Cu 0.001%
- Au 0.01 g/t

For the Heruga deposit, the composites included any post-mineralization dyke material intervals that were deemed too small to be part of a dyke geology model. Any unsampled material included in the composites was set to:

- Cu 0.001%
- Au 0.01 g/t
- Mo 10 ppm

14.1.6 Exploratory Data Analysis

The lithological, structural, and mineralization domains for Hugo North and the Southern Oyu deposits were reviewed to determine appropriate estimation or grade interpolation parameters. Several different procedures were applied to the data to discover whether statistically distinct domains could be defined using the available geological models.

The data analyses were conducted on composited assay data, typically using either 8 m or 5 m downhole composites. Descriptive statistics, histograms and cumulative probability plots, box and contact plots, and X–Y scatter plots were completed for copper and gold in each deposit area.

Results obtained were used to guide the construction of the cell model and the development of estimation plans.

14.1.6.1 Southern Oyu

Copper grades inside the grade shells display generally similar means and coefficients of variation (CV's) between deposits, and low CV's of between 0.6 and 0.75. The Va, Ign, and Qmd units were grouped inside the grade shells due to similar mean values seen in univariate statistics. Outside the copper grade shells, and in Va or in the combined Va+Qmd units in the Southern Oyu deposit, CV's are similar to those inside the grade shells. Other copper populations outside the shells typically display lower mean grades and higher CV's when compared to Va or Va+Qmd in the Southern Oyu deposit.

Gold grades inside the 0.3 g/t Au grade shells of the significant gold-bearing depositis (Southwest, Far South, Bridge Zone, and Central Oyu) display generally similar means and low CV's (<1). Samples inside the 0.7 g/t Aushell are dominantly in the Va unit of the Southwest deposit, are similar in mean and CV to the Qmd inside the 0.7 g/t Au shell of the Southwest domain, and show low CV's (~0.7). The few samples inside the 0.7 g/t Au shell of the Central deposit show lower mean grades and higher CV's than the Southwest deposit inside the 0.7 g/t Au shell.

Outside the gold grade shells in Va unit, CV's are similar to inside the grade shells, with the exception of the combined Va+Qmd unit in the South deposit, which has a very high CV due to some extreme outlier grades. Other gold domains outside the shells typically display lower mean grades and higher CV's, when compared to the Va units outside shells.

The correlation coefficients between Cu–As, Cu–Mo, and Au–Ag, although varying by domain, were generally weak, ranging from 0.2–0.4, 0.2–0.4, and 0.2–0.25, respectively. The differences in the mean grades inside and outside the grade shells supported for the application of copper grade shells to constrain arsenic and molybdenum estimation and the application of gold shells to constrain silver estimation.

14.1.6.2 Hugo North and Hugo North Extension

Copper grades in the mineralized units (Va, Ign, Qmd, and xBiGd) show single lognormal to near-normal distributions inside each domain (0.6% Cu and 15% quartz vein shells). Coefficients of variation values are low at 0.4 to 0.6. There are small variations in grade as a result of lithological differences within the copper domains: generally, Qmd and Va have the highest values, followed by Ign. The lowest grades of all lithologies is demonstrated by xBiGd. The cumulative distribution function patterns of copper data for all domains show evidence for three populations: a higher-grade population (above a copper threshold value of 2.0% Cu to 2.5% Cu), a lower-grade zone (threshold value of 0.4% Cu to 0.5% Cu), and a background lowest-grade domain. The pattern supports the construction of the 15% quartz vein shell (2% Cu is approximately coincident) and the 0.6% Cu shell.

Gold grade distributions at Hugo North show typical positively skewed trends. The distributions are slightly more skewed than those for copper, but the level of skewness can still be described as only mild to moderate within each domain. The Qmd shows higher average gold values than the Va unit, which in turn is higher than the Ign.

Coefficients of variation values for the host lithologies are moderate, varying from 0.6 to 0.9.

The cumulative distribution function pattern of gold data of all domains and the background domain shows evidence for three populations: a higher-grade population (above a gold threshold value of 1 g/t Au), a lower-grade zone (threshold value of 0.2 g/t Au to 0.3 g/t Au), and a background lowest-grade domain. The pattern supports the construction of the 1 g/t Au and 0.3 g/t Au grade shells.

At Hugo North the gold to copper relationships that were identified in 2005 are poorer. Generally two trends may be present. The more common is a low gold trend that outlines a gold to copper ratio of about 1:10 in the mineralized volcanic units. The Qmd unit also displays the 1:10 gold to copper ratio trend but also shows a more gold enriched gold to copper ratio of about 1:2.

14.1.6.3 Hugo South

Copper grade behaves as expected between interpreted grade shells. No significant 'within shell' variations due to lithology were observed. Gold grade distributions showed typical lognormal trends in all domains. Molybdenum grades were generally low, but Hugo South was observed to have higher molybdenum grades than Hugo North.

14.1.6.4 Heruga

Copper grades within the 0.3% Cu shell generally displayed single distributions with some evidence of a lower-grade population due to the presence of unmineralized post-mineralization dykes that have not been captured by wireframes. Coefficients of variation values were relatively low at 0.5 to 0.6. The cumulative distribution function plot for the entire population supported the construction of a grade shell in the 0.3% Cu to 0.4% Cu range.

Gold grades were observed to display moderate positive skewness and multiple populations with evidence of lower grade populations in the range of 0.2 g/t to 0.3 g/t.

Molybdenum grades within the 100 ppm Mo shell display low to moderate positive skewness and a single population distribution.

14.1.7 Estimation Domains

A variety of boundary strategies were implemented to account for domain boundary uncertainty (dilution) and to reproduce the input grade sample distribution in the cell model. Soft boundaries allowed full sharing of composites between domains during grade estimation; firm boundaries allowed sharing of composites from within a certain distance of the boundary; and hard boundaries allowed no composite sharing between domains. The descriptive statistics, such as mean grade, for each set of adjoining domains were compared to establish whether a boundary would be designated as soft, firm, or hard. Contact plots and visual inspection of grade distributions were also used in cases where results were unclear or were contrary to geological interpretations.

14.1.7.1 Southern Oyu

The following major faults were considered as hard boundaries in all cases: Central fault, Solongo fault, East Boundary fault, West Boundary fault, Rhyolite fault, and South fault (near the mineralized zones). The fault boundaries between most major deposit zones are largely defined by these faults and are therefore considered to be hard boundaries during estimation. The exceptions are the boundaries between the Southwest Oyu and Bridge zones, and the Southwest Oyu and Far South zones, which were determined as soft, firm, or hard on a case-by-case basis from statistical relationships.

Boundaries between lithologies, and mineralization domains were based on detailed soft-firm-hard (SFH) matrices. Typically, the following boundaries were broadly applied; however, actual boundaries as indicated in the SFH matrices are complex:

- Silver uses the same SFH relationships as gold.
- Arsenic and molybdenum use the same SFH relationships as copper.
- For copper, the contact between the Qmd and Va units is typically a soft boundary, but more rarely can be firm or hard. The Ign boundary is more-often-than-not a soft boundary with the Qmd and Va units, but can on rare occasions be hard to the Va and Qmd units.
- Gold SFH relationships across changing lithologies are more complex, and no general observations can be drawn: in all cases, the SFH domain matrix should be referenced.
- The Central, West Oyu, Wedge, and South zone boundaries are each hard to all other deposits. The boundaries between the Southwest, Bridge, and Far South zones are soft in most cases.
- Grade shell boundaries are typically firm; most commonly sharing samples within 40 m of the boundary, but occasionally a more restricted distance is used, where a boundary can share samples within 20 m of the boundary.

14.1.7.2 Hugo South

Grades for cells within the three copper grade shells were estimated by treating the grade shells as hard boundary; Thus only composites within the shell were used to estimate blocks within the shell.

14.1.7.3 Hugo North and Hugo North Extension

Different boundary designations of soft, firm, or hard can be used for the different lithologies, depending on the grade shell. The lithological contact boundaries are summarized in the matrix in Table 14.13 for copper and in Table 14.14 for gold. Contacts between grade shells were treated as hard contacts.

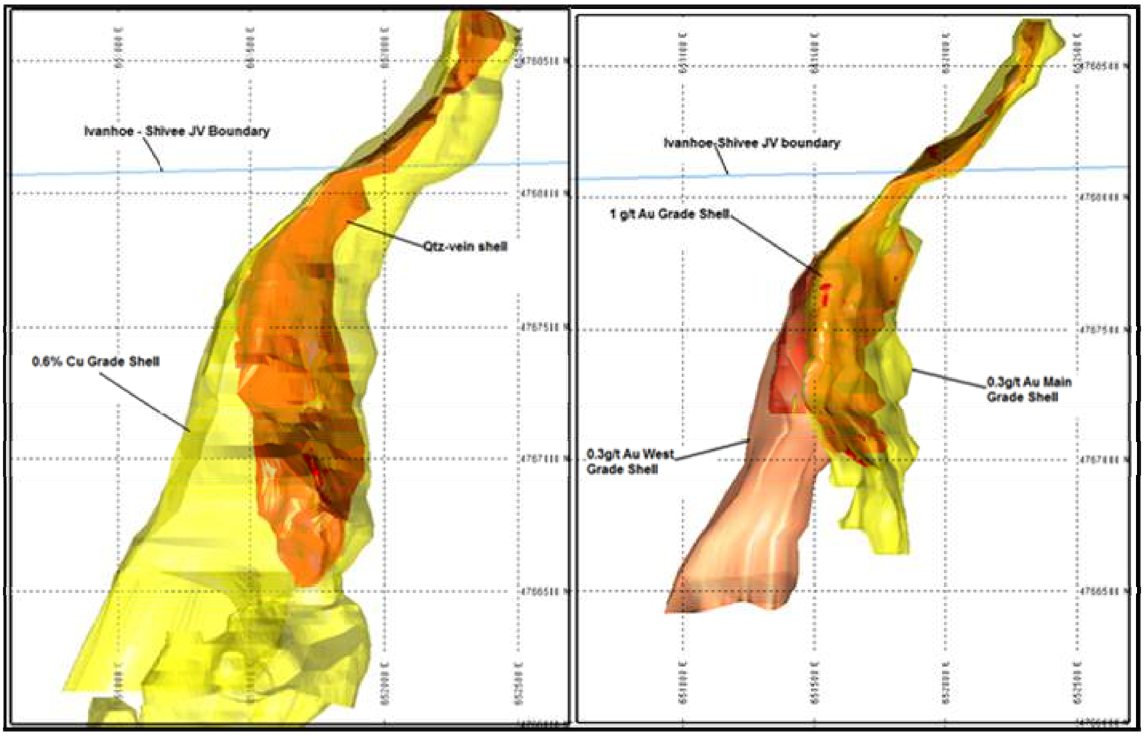
Table 14.13 Hugo North Domain Boundary Contact Matrix – Copper

Shell	Va	Qmd	Ign	xBiGd
Background Shell				
Va	Soft	Hard	Hard	Hard
Qmd	Hard	Soft	Hard	Hard
Ign	Hard	Hard	Soft	Hard
xBiGd	Hard	Hard	Hard	Soft
0.6% Shell				
Va	Soft	Hard	Soft	Hard
Qmd	Hard	Soft	Hard	Hard
Ign	Soft	Hard	Soft	Hard
xBiGd	Hard	Hard	Hard	Soft
Qtz Shell				
Va	Soft	Soft	Soft	Hard
Qmd	Soft	Soft	Hard	Hard
Ign	Soft	Hard	Soft	Hard
xBiGd	Hard	Hard	Hard	Soft

Table 14.14 Hugo North Domain Boundary Contact Matrix – Gold

Shell	Va	Qmd	Ign	xBiGd
Background Shell				
Va	Soft	Hard	Soft	Soft
Qmd	Hard	Soft	Hard	Hard
Ign	Soft	Hard	Soft	Hard
xBiGd	Soft	Hard	Hard	Soft
Main Shell				
Va	Soft	Soft	Soft	Hard
Qmd	Soft	Soft	Hard	Hard
Ign	Soft	Hard	Soft	Hard
xBiGd	Hard	Hard	Hard	Soft
West Shell				
Va	Soft	Hard	Hard	Hard
Qmd	Hard	Soft	Hard	Soft
Ign	Hard	Hard	Soft	Hard
xBiGd	Soft	Hard	Hard	Soft
1 g/t Au Shell				
Va	Soft	Soft	Soft	Hard
Qmd	Soft	Soft	Hard	Hard
Ign	Soft	Hard	Soft	Hard
xBiGd	Hard	Hard	Hard	Soft

Figure 14.1 Copper and Gold Grade Shells, Hugo North and Hugo North Extension



14.1.7.4 Heruga

Data analysis showed no discernable difference between the two main host lithologies, augite basalt and quartz monzodiorite. Therefore, for estimation purposes the two lithologies were grouped into a single lithological domain. The post-mineralization lithologies (LQmd, BiGd, HbBiAn), while represented in the cell model, were not estimated, but rather were assigned zero grade. Within each structural block, the model was therefore split according to whether or not it was mineralized or unmineralized, and by grade shell.

14.1.8 Variography

The correlograms were calculated and modelled in Sage2001® software.

14.1.8.1 Southern Oyu

The quality of fit for the variogram model for the copper correlograms was excellent for the Southwest domain inside copper grade shells and good for the Central domain inside the copper grade shells. The quality of fit for the copper model in other domains ranged from moderate to good. Model fits for gold correlograms were less robust than for the copper correlograms. Gold grade shells are typically smaller than the copper grade shells, and are divided into 0.3 g/t Au and 0.7 g/t Au datasets, resulting in less data available to support correlogram construction for each gold grade shell domain.

Model fits for silver, arsenic, and molybdenum were moderate to good for the larger domains inside grade shells.

For other domains, model fits were typically interpretable, and the results of the Sage2001® autofitting function were commonly relied upon, due to the lesser economic significance of these elements outside of the grade-bearing domains.

Table 14.15 summarizes the results of the copper correlograms by domain, and Table 14.16 shows the results for gold by domain.

Table 14.15 Copper Correlogram Model Parameters by Domain – Southern Oyu

Domain	Structure	Gamma	Plunge (RotY)	Dip (RotX)	Range X (m)	Range Y (m)	Range Z (m)	Plunge (RotY)
1101	Nugget	0.3	–	–	–	–	–	–
	Exp1	0.55	-13	5	-21	77.8	18.9	165
	Exp2	0.15	-13	5	-21	101.6	915	473
1103	Nugget	0.25	–	–	–	–	–	–
	Exp1	0.57	-29	12	7	154.5	102.3	321
	Exp2	0.18	-29	12	7	27.1	14.1	25
1201, 1203	Nugget	0.15	–	–	–	–	–	–
	Exp1	0.36	230	-70	0	31.1	23.2	70.3
	Exp2	0.49	230	-70	0	391.9	347.3	256
2101 – 2103	Nugget	0.1	–	–	–	–	–	–
	Exp1	0.5	-5	2	12	23.9	34.8	13.6
	Exp2	0.4	-5	2	12	79.7	141	259
2104	Nugget	0.15	–	–	–	–	–	–
	Exp1	0.752	90	-45	0	35.7	80	58.1
	Exp2	0.098	90	-45	0	588.6	400	400
2201 – 2204	Nugget	0.2	–	–	–	–	–	–
	Exp1	0.55	31	11	12	49.9	51.4	105
	Exp2	0.25	31	11	12	913	346.2	134
3101, 3103	Nugget	0.2	–	–	–	–	–	–
	Exp1	0.6	60	-75	0	31.7	16.4	46.5
	Exp2	0.2	60	-75	0	197.9	176.1	86.6
3102	Nugget	0.15	–	–	–	–	–	–
	Sph1	0.5	-46	13	-10	125	90	40
	Sph2	0.35	16	28	-32	160	120	200
3104	Nugget	0.15	–	–	–	–	–	–
	Exp1	0.752	90	-45	0	35.7	80	58.1
	Exp2	0.098	90	-45	0	588.6	400	400

Domain	Structure	Gamma	Plunge (RotY)	Dip (RotX)	Range X (m)	Range Y (m)	Range Z (m)	Plunge (RotY)
3201 – 3204	Nugget	0.1	–	–	–	–	–	–
	Exp1	0.652	320	0	-36	25.7	153.4	56.7
	Exp2	0.248	320	0	-36	1145.1	109	343
4101, 4103	Nugget	0.3	–	–	–	–	–	–
	Exp1	0.55	-8	4	4	118.2	16.2	42
	Exp2	0.15	-8	4	4	91.3	397.3	1,805
4201, 4203	Nugget	0.15	–	–	–	–	–	–
	Exp1	0.65	50	-5	58	50	60	20
	Exp2	0.2	50	-5	58	75	25	30
5101 – 5103	Nugget	0.05	–	–	–	–	–	–
	Exp1	0.6	0	0	0	30	30	30
	Exp2	0.35	0	0	0	180	180	180
5104	Nugget	0.15	–	–	–	–	–	–
	Exp1	0.752	90	-45	0	35.7	80	58.1
	Exp2	0.098	90	-45	0	588.6	400	400
5201 – 5203	Nugget	0.13	–	–	–	–	–	–
	Exp1	0.35	1	3	15	100	40	200
	Exp2	0.52	1	3	15	300	70	40
6101 – 6103	Nugget	0.35	–	–	–	–	–	–
	Exp1	0.5	38	-9	-19	220	116.2	53.8
	Exp2	0.15	38	-9	-19	700	279.3	1,000
6104	Nugget	0.15	–	–	–	–	–	–
	Exp1	0.752	90	-45	0	35.7	80	58.1
	Exp2	0.098	90	-45	0	588.6	400	400
6201–6204	Nugget	0.2	–	–	–	–	–	–
	Exp1	0.6	40	-11	-61	256.4	58	53.8
	Exp2	0.2	40	-11	-61	188.7	1089.3	126
7101	Nugget	0.34	–	–	–	–	–	–
	Exp1	0.54	0	0	0	190	190	190
	Exp2	0.12	0	0	0	1,000	1,000	1,000
7103	Nugget	0.329	–	–	–	–	–	–
	Exp1	0.3	33	-6	3	48.9	9.3	296
	Exp2	0.371	33	-6	3	121.3	96.3	226
7201, 7203	Nugget	0.3	–	–	–	–	–	–
	Exp1	0.58	0	0	0	23	23	23
	Exp2	0.12	0	0	0	22	22	22
9101 – 9203	Nugget	0.1	–	–	–	–	–	–
	Exp1	0.9	0	0	0	100	100	100

Table 14.16 Au Correlogram Model Parameters by Domain – Southern Oyu

Domain	Structure	Gamma	Bearing (RotZ)	Plunge (RotY)	Dip (RotX)	Range X (m)	Range Y (m)	Range Z (m)
1101	Nugget	0.4	–	–	–	–	–	–
	Exp1	0.46	24	-27	-96	86.6	32	105
	Exp2	0.14	-46	16	-9	107.6	258.1	1,896
1103	Nugget	0.3	–	–	–	–	–	–
	Exp1	0.34	12	-65	-93	146.7	9.5	123
	Exp2	0.36	-3	-8	8	69.8	139.2	691
1201, 1203	Nugget	0.2	–	–	–	–	–	–
	Exp1	0.6	43	-28	-66	28.7	27.1	10.1
	Exp2	0.2	43	-28	-66	230	285.8	93.7
1301	Nugget	0.21	–	–	–	–	–	–
	Exp1	0.49	140	0	-55	97.4	76.3	120
	Exp2	0.3	140	0	-55	533.3	414.3	182
1303	Nugget	0.33	–	–	–	–	–	–
	Exp1	0.42	37	88	-66	31	130.1	85
	Exp2	0.25	37	88	-66	62	407.9	61.2
2101	Nugget	0.2	–	–	–	–	–	–
	Exp1	0.6	8	-37	-132	552.5	180.9	272
	Exp2	0.2	-103	13	14	98	8.3	469
2102–2103	Nugget	0.1	–	–	–	–	–	–
	Exp1	0.55	-10	23	13	22.6	67.1	29.7
	Exp2	0.35	-10	23	13	129.8	285	186
2104, 3104, 5104,	Nugget	0.05	–	–	–	–	–	–
6104	Exp1	0.757	4	22	-19	28.6	29.9	28.3
	Exp2	0.193	4	22	-19	223.3	220.6	221
2201–2303	Nugget	0.15	–	–	–	–	–	–
	Exp1	0.45	56	13	53	97.3	20	32.4
	Exp2	0.4	56	13	53	122.4	299.4	122
3101	Nugget	0.1	–	–	–	–	–	–
	Exp1	0.625	-46	-1	0	16.1	26.1	18.6
	Exp2	0.275	-46	-1	0	316.2	312.5	319
3102	Nugget	0.1	–	–	–	–	–	–
	Exp1	0.585	-13	23	41	30.3	30.2	30.9
	Exp2	0.315	-13	23	41	294.8	289.3	291

Domain	Structure	Gamma	Bearing (RotZ)	Plunge (RotY)	Dip (RotX)	Range X (m)	Range Y (m)	Range Z (m)
3103	Nugget	0.1	–	–	–	–	–	–
	Exp1	0.722	-22	5	-8	22.2	22.7	23.1
	Exp2	0.178	-22	5	-8	138.2	137.7	138
3201–3303	Nugget	0.207	–	–	–	–	–	–
	Exp1	0.376	104	3	14	211.6	41.7	5.1
	Exp2	0.417	3	53	-69	34	248.1	14.2
4101, 4103	Nugget	0.1	–	–	–	–	–	–
	Exp1	0.65	0	0	0	21	21	21
	Exp2	0.25	0	0	0	435	435	435
4201–4303	Nugget	0.3	–	–	–	–	–	–
	Exp1	0.55	0	-15	0	130	35	62
	Exp2	0.15	-33	-10	15	359.1	487.1	2,126
5101	Nugget	0.35	–	–	–	–	–	–
	Exp1	0.45	-18	-34	-154	45.4	8.9	143
	Exp2	0.2	-31	34	-32	159.2	496.5	2,300
5102–5103	Nugget	0.1	–	–	–	–	–	–
	Exp1	0.6	10	40	3	60	100	30
	Exp2	0.3	10	40	3	100	700	130
5201–5203	Nugget	0.2	–	–	–	–	–	–
	Exp1	0.6	43	-28	-66	28.7	27.1	10.1
	Exp2	0.2	43	-28	-66	230	285.8	93.7
6101–6103	Nugget	0.15	–	–	–	–	–	–
	Exp1	0.6	44	-30	-23	108.7	8.2	47.6
	Exp2	0.25	48	4	-64	90.2	278.5	480
6201–6303	Nugget	0.1	–	–	–	–	–	–
	Exp1	0.4	0	0	0	135	135	135
	Exp2	0.5	0	0	0	135	135	135
7101	Nugget	0.15	–	–	–	–	–	–
	Exp1	0.35	49	-81	118	161.1	44.6	27.2
	Exp2	0.35	-4	2	2	64.9	410.5	19
7103	Nugget	0.3	–	–	–	–	–	–
	Exp1	0.54	55	-45	19	175.2	55.7	8.7
	Exp2	0.15	18	115	40	26.9	41.5	408
7201–7303	Nugget	0.4	–	–	–	–	–	–
	Exp1	0.45	0	0	0	15	15	15
	Exp2	0.15	0	0	0	140	140	140

Domain	Structure	Gamma	Bearing (RotZ)	Plunge (RotY)	Dip (RotX)	Range X (m)	Range Y (m)	Range Z (m)
9101–9203	Nugget	0.2	–	–	–	–	–	–
	Exp1	0.16	0	0	0	30	30	30
	Exp2	0.64	0	0	0	130	130	130

14.1.8.2 Hugo North and Hugo North Extension

The spatial variability characteristics of the Hugo North deposit are summarized in Table 14.17 and Table 14.18 (copper), and Table 14.19 and Table 14.20 (gold). The data are also based on the use of a correlogram.

Some grade shells were subdivided into north and south sectors to take into account the large change in direction (i.e. bend) of the deposit that occurs near 4,767,600 mN .

The mineralization controls were considered to be related to the intrusive history and structural geology (faults). The patterns of anisotropy demonstrated by the various correlograms tended to be consistent with geological interpretations, particularly to any bounding structural features (faults and lithological contacts) and quartz + sulphide vein orientation dataThe nugget effects tended to be low to moderate in all of the estimation domains. Copper variograms generally had nugget effects of between 15% and 30% of the total variation, whereas gold variograms had more variable nugget effects from 15% to 65% of the total variation.

Both copper and gold displayed short ranges for the first structure and moderate to long ranges for the second structure (if any).

Table 14.17 Copper Correlogram Parameters, Hugo North

		Zone				
		Background	**0.6% Shell North**	**0.6% Shell South**	**Quartz Shell North**	**Quartz Shell South**
Model		**Spherical**	**Spherical**	**Spherical**	**Spherical**	**Spherical**
Sills	Nugget	0.20	0.13	0.15	0.30	0.25
	C1	0.55	0.35	0.40	0.20	0.45
	C2	0.25	0.52	0.45	0.50	0.30
Rotation Angles	Z	0	45	25	45	-15
	X	0	0	-30	0	-30
	Y	0	0	20	0	20
Ranges	Y1	17	10	15	15	30
	X1	17	15	15	15	10
	Z1	17	20	15	15	15
	Y2	200	140	220	150	200
	X2	180	100	120	100	120
	Z2	220	175	200	150	200

Note: Models are spherical .Traditional ranges are used for the exponential variograms. Axis rotations are left-hand, right-hand, left-hand for the Z, X and Y axis, respectively.

Table 14.18 Copper Azimuth and Dip Angles, Rotated Correlogram Axes – Hugo North

	Axis Azimuth				Axis Dip		
Zone	**Y**	**X**	**Z**		**Y**	**X**	**Z**
Background	0	0	0		0	0	90
0.6% Shell North	45	135	0		0	0	90
0.6% Shell South	25	105	349		-30	17	54
Qtz Shell North	45	135	0		0	0	90
Qtz Shell South	345	65	309		-30	17	54

Note: Azimuths are in degrees. Dips are positive up and negative down.

Table 14.19 Gold Correlogram Parameters, Hugo North

		Zone				
		Background North	Background South	0.3 g/t Main Shell	0.3 g/t West Shell	1 g/t Shell
Model		**Exponential**	**Spherical**	**Exponential**	**Exponential**	**Exponential**
Sills	Nugget	0.151	0.200	0.653	0.500	0.549
	C1	0.557	0.373	0.347	0.500	0.451
	C2	0.292	0.427	–	–	–
Rotation Angles	Z	-29	50	-2	-6	-81
	X	13	-9	38	22	70
	Y	-14	-51	-72	-7	2
	Z	-9	8	–	–	–
	X	45	-31	–	–	–
	Y	24	31	–	–	–
Ranges	Y1	27	70	61	469	12
	X1	15	54	139	30	149
	Z1	93	30	25	49	22
	Y2	1333	977	–	–	–
	X2	210	400	–	–	–
	Z2	919	969	–	–	–

Note: Traditional ranges (short ranges) are used for the exponential variograms. Axis rotations are left-hand, right-hand, left-hand for the Z, X and Y axis, respectively.

Table 14.20 Gold Azimuth and Dip Angles, Rotated Correlogram Axes – Hugo North

	First Structure							Second Structure					
	Axis Azimuth			Axis Dip				Axis Azimuth			Axis Dip		
Zone	**Y**	**X**	**Z**	**Y**	**X**	**Z**		**Y**	**X**	**Z**	**Y**	**X**	**Z**
Background North	58	-13	331	13	105	71		351	45	99	17	204	40
Background South	151	-50	50	-9	133	39		8	-31	81	26	319	48
0.3 g/t Main Shell	26	-48	358	38	100	14		–	–	–	–	–	–
0.3 g/t West Shell	82	-6	354	22	157	67		–	–	–	–	–	–
1 g/t Shell	11	1	279	70	101	20		–	–	–	–	–	–

Note: Azimuths are in degrees. Dips are positive up and negative down.

14.1.8.3 Hugo South

Correlograms indicated a north-easterly trend at Hugo South. The mineralization displayed a consistent steep easterly dip with a flat plunge. Ranges were longest along strike of the respective trend for copper and a mixture of along-the-trend and down-the-dip of the trend for gold. Ranges for the first structure in all metals tended to be less than 75 m. The ranges in the second structure tended to be less than 200 m.

14.1.8.4 Heruga

Although data are limited, an attempt was made to model directional variograms for gold, copper, and molybdenum. Copper and gold showed relatively low nuggets of 25% to 35% of the total variance, whereas molybdenum was moderate to high at 40% of the sill. All three metals showed relatively short first structures and long second structures of 250 m to 300 m.

14.1.9 Model Setup

The cell size for the Southern Oyu cell model was selected based on mining selectivity considerations for open pit mining. It was assumed the smallest cell size that could be selectively mined as mill feed or waste, referred to the selective mining unit (SMU), was approximately 20 m x 20 m x 15 m. A subcelled model was used for resource estimation that has parent (maximum) cell dimensions equal to those of the ultimate resource cell model (20 m x 20 m x 15 m) and daughter (minimum subcell) cell dimensions to as small as 5 m x 5 m x 5 m. The actual subcell sizes vary as necessary in order to fit the specified boundaries of the wireframes used to tag the cell model. Grade variables were regularized to the tonnage-weighted (volume x density) mean of the subcell source grade values enclosed in the destination parent cells.

For Hugo North, mining selectivity was less of an issue because the mining method envisioned, block cave mining, does not require consideration of selectivity. The same cell size of 20 m x 20 m x 15 m was used for ease of integrating the cell models for mine planning considerations.

SG data were assigned to a unique assay database file. These data were composited into 8 m, 15 m, and 5 m fixed-length downhole values for the Southern Oyu, Hugo North, and Heruga models, respectively.

Various coding was completed on the cell models in preparation for grade interpolation. The cell models were coded according to zone, lithological domain, and grade shell. Percentage below topography was also calculated into the model cells. Post-mineralization dykes were considered as potentially selectively mineable.

Only the hypogene mineralization was estimated, with the supergene chalcocite blanket at Central Oyu being the only exception. The base of sulphide oxidation surface defined the top of the hypogene mineralization in the Southern Oyu deposits.

14.1.9.1 Southern Oyu

Modelling at Southern Oyu consisted of grade interpolation by ordinary kriging (OK). Nearest neighbour (NN) grades were also interpolated for validation purposes.

Search ellipsoid orientations were based upon the geometry of macro-scale grade trends, typically reflected in the grade shell boundaries. A three-pass kriging strategy was used to estimate the cell grades. The first estimation pass kriging neighbourhood approximately corresponds to cells expected to satisfy Measured and Indicated classification criteria. The kriging neighbourhood was expanded and relaxed with each successive pass while maintaining the same axial ratios for samples searches as in the first pass.

Estimations were run one domain at a time, with three passes per domain. The following exceptions represent groups of domains that were estimated together:

- All supergene outside grade shells (three passes).
- All supergene inside grade shells (three passes).
- All BiGd dykes (one pass).
- All andesite dykes (one pass).
- All rhyolite dykes (one pass).

The selection of sample search ellipsoids was largely based on macro-scale grade controls seen in the average grade shell orientation within a given domain. In some domains, such as Southwest Oyu, search ellipsoid selection was influenced by grade trends that were identifiable within a grade shell by using robust anisotropic variogram models or visual identification of grade trends seen in drillholes.

The ranges and the rotation angles for the various search ellipsoids are included as Table 14.20 (copper, arsenic, and molybdenum) and (gold and silver).

Search pass 2 was executed on cells that did not receive an interpolated grade in pass 1, and pass 3 was executed on cells that did not receive an interpolated grade in passes 1 or 2. A cell discretization regime of 4 x 4 x 2 was used when estimating cell grades. For all elements, a minimum of six composites and maximum of nine composites were required for the first and second estimation passes. In addition, a maximum of three composites per drillhole was permitted. For the third pass, a minimum of two composites and a maximum of eight composites were required, as well as a maximum of five composites per drillhole. A single estimation pass was used to estimate dyke cells, requiring a minimum of three composites, a maximum of eight composites, and a maximum of five composites per drillhole.

During estimation of the subcelled model, the estimated grade of the parent cells was assigned to each subcell. Grade composites flagged as less than zero grade were excluded from sample selection. Grade composites less than 2 m in length were also excluded. The composites were length-weighted during estimation.

Composites were weighted by ordinary kriging according to variogram parameters, with the exception of dyke grades, which were interpolated using inverse distance weighting to the power of two (ID2).

The SG estimation domains were based on three attributes: deposit, oxidation code (above or below the lowest modelled limit of oxidation), and lithology. ID2 was used to estimate the SG values in the subcelled model. The SG estimation domain boundaries were treated as hard boundaries; SG composites from one domain could not be used to inform cells of another domain. Only SG composites from certain domains were used to inform target cells of the same domain. The estimation search neighbourhood used an isotropic search of 100 m as well as conditions on sample counts: a minimum of two and a maximum of twelve composites within the search radius and a maximum of two samples from any individual drillhole to inform the cell estimate.

Twelve SG estimation domains lack samples in the composite database. Default SG values from nearby, lithologically similar domains were assigned to each of the domains lacking composites.

Table 14.21 Search Parameters for Copper, Arsenic, and Molybdenum Estimations – Southern Oyu

Deposits	Bearing (RotZ)	Plunge (RotY)	Dip (RotX)	Search Pass	X-Axis (m)	Y-Axis (m)	Z-Axis (m)	Long Axis Azimuth	Long Axis Dip	Intermed. Axis Azimuth	Intermed. Axis Dip
Southwest, South Oyu, Bridge Zone, Far South, Wedge Zone, and West Oyu	50	0	-70	1	75	60	40	050	0˚	140	-70˚
				2	105	90	60	050	0˚	140	-70˚
				3	400	300	200	050	0˚	140	-70˚
Central Oyu	0	0	0	1	60	60	75	0	-90˚	n/a	n/a
				2	90	90	115	0	-90˚	n/a	n/a
				3	300	300	375	0	-90˚	n/a	n/a
Supergene	0	0	0	1	60	60	30	90	0˚	0	0˚
				2	90	90	45	90	0˚	0	0˚
				3	240	240	120	90	0˚	0	0˚
Dykes	0	0	0	1	300	300	300	n/a	n/a	n/a	n/a

Table 14.22 Search Parameters for Gold and Silver Estimations – Southern Oyu

Deposits	Bearing (RotZ)	Plunge (RotY)	Dip (RotX)	Search Pass	X-Axis (m)	Y-Axis (m)	Z-Axis (m)	Long Axis Azimuth	Long Axis Dip	Intermed. Axis Azimuth	Intermed. Axis Dip
Southwest, BZ, Bridge Zone, Far South, Wedge Zone, and West Oyu	50	0	-70	1	75	60	40	050	0˚	140	-70˚
				2	125	90	60	050	0˚	140	-70˚
				3	375	300	200	050	0˚	140	-70˚
Central Oyu	50	0	-90	1	75	60	40	050	0˚	0	-90˚
				2	125	90	60	050	0˚	0	-90˚
				3	375	300	200	050	0˚	0	-90˚
South Oyu	130	0	0	1	60	40	60	130	0˚	0	-90˚
				2	90	60	90	130	0˚	0	-90˚
				3	240	160	240	130	0˚	0	-90˚
Supergene	0	0	0	1	60	60	30	90	0˚	0	0˚
				2	90	90	45	90	0˚	0	0˚
				3	240	240	120	90	0˚	0	0˚
Dykes	0	0	0	1	300	300	300	n/a	n/a	n/a	n/a

14.1.9.2 Hugo North and Hugo North Extension

Interpolation at Hugo North and Hugo North Extension was limited to the mineralized lithological units (Va, Ign, Qmd, and xBiGd). Only cells within those units were interpolated, and only like-flagged composites were used. Metal values within cells belonging to all other units (post-mineralization dykes and sediments) were set to zero.

Modelling consisted of grade interpolation by OK except for bulk density, which was interpolated using inverse distance weighting to the power of three (ID3). Both restricted and unrestricted grades were interpolated to allow calculation of the metal removed by the outlier restriction. Nearest neighbour grades were also interpolated for validation purposes. Cells and composites were matched on estimation domain.

The search ellipsoids were oriented preferentially to the general orientation of the grade shells. The ranges and the rotation angles for the various search ellipsoids are included as Table 14.23 (copper) and Table 14.24 (gold).

The search strategy employed concentric expanding search ellipsoids. The first pass used a relatively short search ellipse relative to the long axis of the correlogram ellipsoid. For the second pass, the search ellipse was increased by 50% (up to the full range of the correlogram) to allow interpolation of grade into those cells not estimated by the first pass. A final, third, pass was undertaken using a larger search ellipsoid.

To ensure that at least two boreholes were used in the estimate, the number of composites from a single drillhole that could be used was set to one less than the minimum number of composites.

Table 14.23 Copper Search Ellipsoids, Hugo North

Model	Axis	Zone					
		Background North	**Background South**	**0.6% Cu Shell North**	**0.6% Cu Shell South**	**Qaurtz Shell North**	**Quartz Shell South**
Rotation Angles	Z	45	0	45	25	45	-15
	X	0	0	0	-30	0	-30
	Y	0	0	0	20	0	20
Ranges – First Pass	Y	150	150	150	150	150	150
	X	100	100	50	50	35	35
	Z	150	150	150	150	150	150
Ranges – Second Pass	Y	225	225	225	225	225	225
	X	150	150	75	75	50	50
	Z	225	225	225	225	225	225
Ranges – Third Pass	Y	400	400	400	400	400	400
	X	200	200	125	150	100	100
	Z	400	400	400	400	400	400
Number of Comps	Min	4	4	4	4	4	4
	Max	15	15	15	15	15	15
	Max per DDH	3	3	3	3	3	3

Note: MIN = minimum number of composites; MAX = maximum number of composites; Max per DDH = maximum number of composites derived from a single borehole; bkgrnd = background. Axis rotations are left-hand, right-hand, left-hand for the Z, X and Y axis, respectively.

Table 14.24 Gold Search Ellipsoids, Hugo North

Model	Axis	Zone					
		Background	0.3 g/t Au Main Shell North	0.3 g/t Au Main Shell South	0.3 g/t Au West Shell	1 g/t Au Shell North	1 g/t Au Shell South
Rotation Angles	Z	0	30	0	0	30	0
	X	0	0	0	0	0	0
	Y	0	0	10	0	0	10
Ranges – First Pass	Y	200	150	150	375	150	150
	X	200	25	25	50	25	25
	Z	200	150	150	50	150	150
Ranges – Second Pass	Y	300	170	170	470	170	170
	X	300	45	45	75	45	45
	Z	300	170	170	75	170	170
Ranges – Third Pass	Y	500	250	250	600	175	175
	X	500	250	250	300	175	175
	Z	500	250	250	300	175	175
Number of Composites	Min	5	5	5	5	5	5
	Max	20	20	20	20	20	20
	Max per DDH	4	4	4	4	4	4

Note: MIN = minimum number of composites; MAX = maximum number of composites; Max per DDH = maximum number of composites derived from a single borehole; bkgrnd = background. Axis rotations are left-hand, right-hand, left-hand for the Z, X and Y axis, respectively.

These parameters were based on the geological interpretation, data analyses, and variogram analyses. The number of composites used to estimate grades into a model cell followed a strategy that matched composite values and model cells sharing the same domain. The minimum and maximum number of composites was adjusted to incorporate an appropriate amount of grade smoothing.

Model cells that fall along grade domain boundaries were assigned two or more values, one for each of the grade domains present within the cell. A final undiluted value was calculated by averaging the values for each domain within the cell, weighed by the percentage of each domain within the cell. This resulted in slightly smoothed metal grades along grade shell boundaries.

An outlier restriction was used to control the effects of high-grade copper and gold samples within the domains.

The planned mining method for Hugo North, underground block caving, allows for virtually no segregation of diluting material. Therefore at Hugo North, the final grade for model cells that containe more than 15% and less than 85% of mineralized material or plant feed by volume were re-calculated using volume-weighted averaging of the interpolated grade and dyke grade (taken as zero) to 100% ore. Cells containing more than 85% feed were allowed to retain the existing interpolated grades. For cells with less than 15% feed by volume, the cells were reset to 100% but at zero grade values.

14.1.9.3 Hugo South

The cell size was 20 mE x 20 mN x 15 mRL. Bulk density data were assigned to a unique MineSight® assay database file. These data were composited into 15 m fixed length downhole values to reflect the cell model bench height. Domain codes were assigned by a simple majority. In the case of assigning dyke codes to the cell model, a slightly higher percentage (60%) was necessary. For the ore percent model, the default value was set to 100% but modified to reflect where cells were intersected by dykes. Percentage below topography was also calculated into the model cells.

Modelling at Hugo South consisted of grade interpolation by OK. Nearest-neighbour grades were also estimated for validation purposes. The search ellipsoids were oriented preferentially to the orientation of the copper grade shells, with the long axis at 20° east of north, with no plunge, and dipping 55° to the south-east.

A two-pass approach was used for interpolation within the grade shells. The first pass allowed a single drillhole to place a grade estimate in a cell, while the second allowed a minimum of two holes from the same estimation domain. A single-pass, two-hole minimum rule was used in the background domains. All cells received grades from a minimum of three and maximum of four composites from a single drillhole (for the two-hole minimum pass). Maximum composite limits varied by metal: nine for copper, 15 for gold, and 12 for molybdenum. Most interpolation runs implemented an outlier restriction to limit grade smearing in areas of limited data.

14.1.9.4 Heruga

The selected cell size was 20 m x 20 m x 15 m for consistency with previous modelling at other Oyu Tolgoi deposits. This cell size was also considered to be suitable for mining studies based on the block cave approach, which is the assumed mining method for the Heruga deposit. Subcelling of the larger cells was used when flagging the model with dyke wireframes. The cell model was coded according to zone, lithological domain, and grade shell. Post-mineralization dykes and the late quartz monzodiorite were assumed to represent waste of zero grade cross-cutting the mineralized lithologies.

Only the mineralized lithologies, Qmd and Va, were estimated. All other units in the model were set to zero grade. Modelling consisted of grade interpolation by OK. As part of the model validation, grades were also interpolated using nearest-neighbour, ID3, and OK of uncapped composites. Density was interpolated using ID3.

The search ellipsoids were oriented preferentially to the general trend of the grade shells. A staged search strategy was applied, with the first pass at 200 m and a second at 400 m. A minimum two-hole rule was applied to both passes. Any cells not interpolated by the first two passes were filled with a third pass that removed the two-hole constraint. Outlier restriction was applied as a second cap whereby grades over a particular threshold were only used in cells within a specified distance from a drillhole (50 m to 100 m). Outside of this distance the lower capped value was used.

The final subcell model was regularized to a full-sized cell model after estimation was complete.

14.1.10 Model Validation

14.1.10.1 Southern Oyu

The variogram models and search ellipsoids were visually validated as a check for reasonableness against grade trends and grade shells. These checks were performed for copper and gold in the major domains at a minimum and also for less significant domains when deemed appropriate.

Checks were also performed on the ID3 density model. The composites and estimated cells were scrutinized to identify cells with unreasonable density values compared to the composite values. A means comparison chart and swath plots were also used to assist in validating the density estimation.

A NN interpolated model was created to approximate the declustered composite distribution. This NN model was used to check for global bias of the grade estimates above zero cut-off and to check for local bias using swath plots. The NN model was alo used as the first step in checking for cell model smoothing, using volume-variance corrections from the composite scale to the SMU scale.

Extensive visual checks were undertaken, comparing composites to cell estimates as well as the behaviour of grade estimates near firm boundaries. Histograms of cells with and without firm boundaries were compared to assess the impact on removal of ‘troughs’ that were not seen in the composites histograms.

A final set of checks were performed to compare the original 2005 model to the 2012 model and to compare elements of the 2005 model to the 2012 model:

- Examination of dilution inside the 2005 and 2012 models, first, by assuming 'whole block' dilution, i.e. selective mining cannot occur on a scale finer than 20 m x 20 m x 15 m and, second, by assuming selective mining of dykes as was applied in 2005, although 100% of the dykes interpreted in 2012 were assumed to be "selectively mineable" for the purposes of those dilution calculations. There was considered to be very good agreement between the 2005 and 2012 models.
- Review of the 2005 and 2012 model copper and gold grade maps on level plans. The most notable areas of grade change between the 2005 and 2012 models was noted to occur at the grade shell margins and often for only a single cell width.
- Comparison of the 2005 and 2012 model 'grade shell difference' maps for copper and gold on plans and sections. Significant differences were observed where the grade shell strategy has changed, e.g. the creation of copper grade shells in the Southwest Oyu and Far South deposits in 2012 where none were used in 2005, and of 0.3 g/t Au grade shells in the Southwest Oyu and Far South deposits where only 0.7 g/t Au shells had been used in 2005. Outside of these areas, the 2012 grade shells generally appear to be slightly more conservative than the 2005 grade shells.
- Evaluation of the 2005 vs. 2012 volumes of each primary lithology in 30 m 'swaths' for cells classified as Measured or Indicated in 2005. Results indicated an acceptable comparison
- Comparison of 2005 vs. 2012 dyke volumes was undertaken. The 2012 dyke volume falling within the designated pit was 3% to 4% higher than in 2005, with 63.8 Mm^3 in 2005 and 65.8 Mm^3 in 2012.
- Examination of histograms of 2005 cell grades, 2012 cell grades, and 2012 composites, for copper and gold in select domains. The histograms display the reduction in 2012 of 'valleys' seen in the 2005 cell distribution that were not observed in the composite distributions.
- Review of plans and sections of classification differences where the class assigned to a cell was 1 or 2 in the 2005 model but not assigned the same values in the 2012 model, or vice versa, or where both models shared the same values. Overall volumes were similar, though it was observed that the 2005 classification was more liberal near the grade shell boundaries, and that some of the documented classification criteria may not have been strictly followed in the 2005 classification.
- A comparison of the 2012 Mineral Resource estimates relative to the 2005 Mineral Resource estimates showed that there is a noteworthy drop in Ag metal (–26%) and to a lesser extent Mo metal (–10%) in the 2012 model estimates in the Measured and Indicated material. AMEC mentions in its report titled Southern Oyu Deposit Mineral Resource Estimation Updated (25 May 2012) that the drop in estimated Ag grade is a result of various factors including data density, sample location, grade estimation parameters, and other factors. No explanation is given for the drop in Mo grade.

Unlike the Ag assay data used in the 2005 Mineral Resource estimation, which were derived using ICP analysis, the assay data used to estimate Ag in the 2012 Mineral Resource estimate were derived using AAS analysis. In contrast to the difference observed in the estimates, the mean AAS Ag grade in the drillhole data used in 2012 to estimate the grades is 7% higher than the mean ICP Ag grade.

AMEC states that the use of AAS Ag in 2012 does not, in it's opinion, pose any risk to the project. However, as Ag is included in the NSR calculations, the drop in estimated Ag grade in the 2012 Mineral Resource warrants further investigation prior to future use of these estimates.

It is to be noted that while OT LLC's internal reporting of Mineral Resources is taken from the 2012 Ag, As and Mo estimates, the current mine planning work still uses the Ag, Mo and As grades from the 2005 Mineral Resource model, and the current Mineral Reserve reported in this 2013 OTTR is based on the 2005 Ag, (see Section 15.1.1).

14.1.10.2 Hugo North

Detailed visual validation of the Hugo North and Southern Oyu cell models was performed in plan and section, comparing resource cell grades to original drillhole data. The checks showed good agreement between drillhole composite values and model cell values. The hard boundaries between grade shells appeared to have constrained grades to their respective estimation domains. The addition of the outlier restriction values succeeded in minimizing grade smearing.

Cell model estimates were checked for global bias by comparing the average metal grades (with no cut-off) from the OK estimates with means from NN estimates. Results showed no issues with global bias in the estimates (Table 14.25).

Table 14.25 Global Model Mean Grade Values by Domain in Each Zone – All Deposits (NN vs. OK Estimates)

Domain/Zone	NN Estimate	OK Estimates	% Difference
Cu (%) – Southern Oyu Deposits			
Southwest – Far South Va	0.217	0.220	+1.4
Southwest – Va	0.386	0.395	+2.3
Southwest – Qmd	0.040	0.042	+5.0
Southwest – Bridge Cu Shell	0.414	0.426	+2.9
Central Cu shell	0.611	0.613	+0.3
Central Cu Shell	0.107	0.105	-1.9
Central Background	0.474	0.470	-0.8
South Cu Shell	0.172	0.172	–
South Background	0.501	0.485	-3.2
Wedge Cu Shell	0.113	0.116	+2.6
Au (g/t) – Southern Oyu Deposits			
Southwest Au Shell	1.350	1.358	+0.6
Southwest Background (Va)	0.323	0.321	-0.6
Southwest Background (Qmd)	0.044	0.046	+4.5
Central Au Shell	0.603	0.579	-4.0
Central Background	0.074	0.073	-1.4
South Au Shell	0.345	0.344	-0.3
South Background	0.077	0.077	–
Wedge	0.054	0.052	-3.8
Cu (%) Hugo North			
All Zones	1.677	1.674	-0.2
Quartz Vein Domain	3.212	3.192	-0.6
0.6% Cu Domain	1.061	1.070	0.8
Cu Background	0.222	0.229	3.2
Au (g/t) Hugo North			
All Zones	0.39	0.38	-2.6
1 g/t Au Zone	1.42	1.39	-2.1
Main 0.3 g/t Au Zone	0.54	0.52	-3.7
West 0.3 g/t Au Zone	0.50	0.50	0.0
Au Background	0.11	0.10	-9.1

Models were also checked for local trends in the grade estimates (grade slice or swath plots). This was undertaken by plotting the mean values from the nearest-neighbour estimate vs. the OK results for benches (in 30 m swaths) and for northings and eastings (in 40 m swaths).

The OK estimates are expected to be smoother than the NN estimates, thus the NN estimate should fluctuate around the OK estimate on the plots. No significant trends in the copper or gold estimates were observed in either the Southern Oyu and Hugo North models.

Example swath plots for elevation and northing, respectively, for the Hugo North deposit are presented in Figure 14.2 and Figure 14.3 for copper and Figure 14.4 and Figure 14.5 for gold.

Figure 14.2 Comparison of Hugo North OK and NN Copper Estimates with Increasing Depth (15% Quartz Vein Cu Domain)

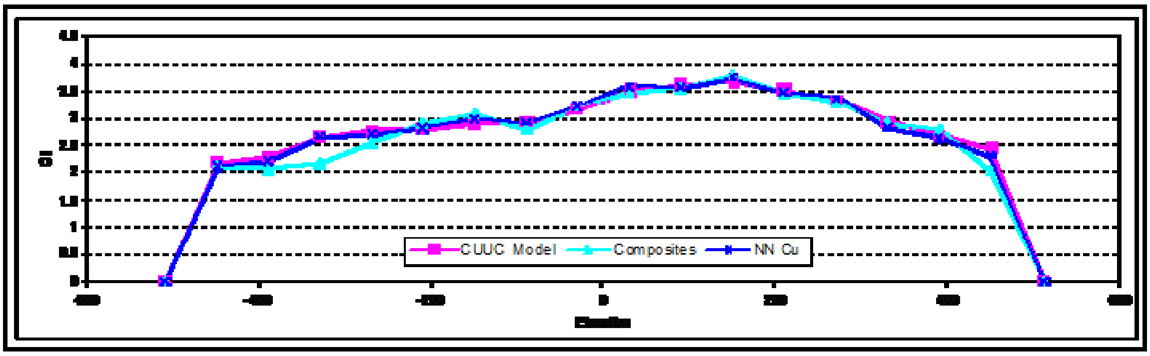


Figure 14.3 Comparison of Hugo North OK and NN Copper Estimates with Increasing Northing (15% Quartz Vein Cu Domain)

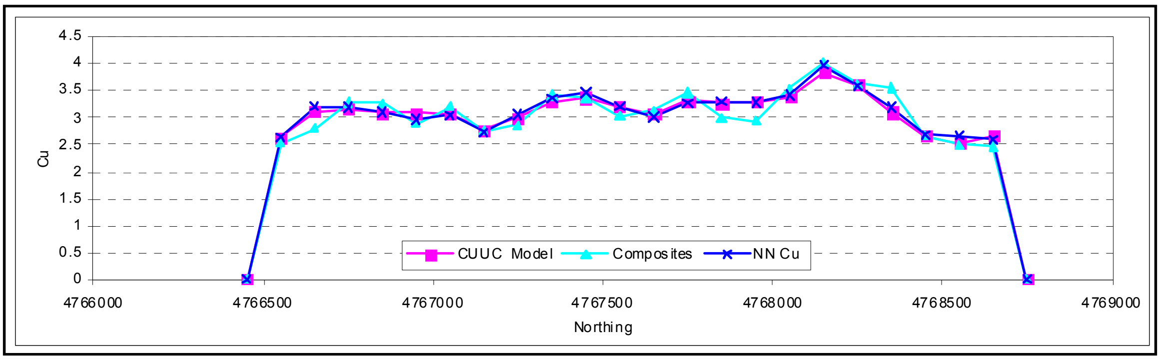


Figure 14.4 Comparison of Hugo North OK and NN Gold Estimates with Increasing Depth (Main +1 g/t Au domains)

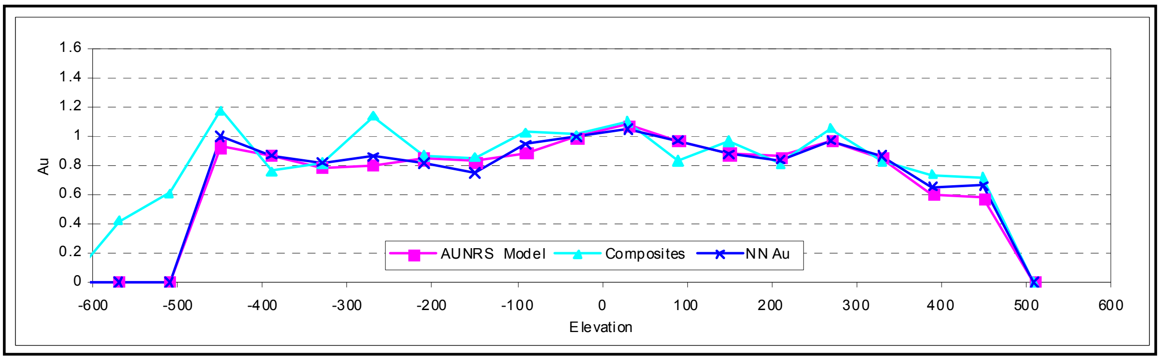
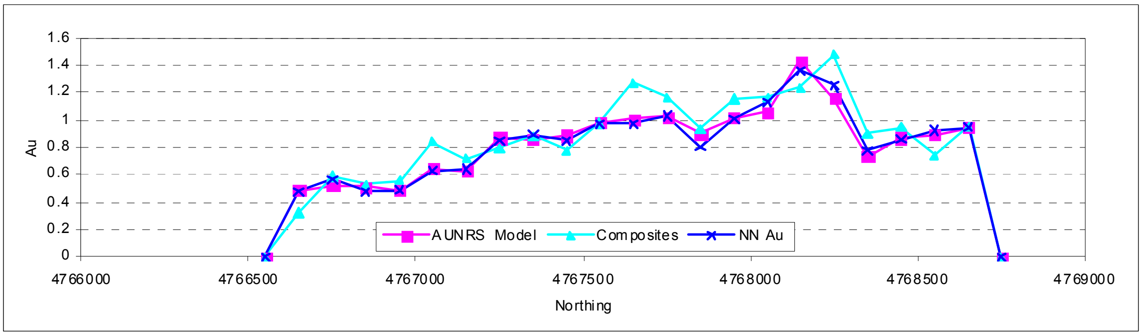


Figure 14.5 Comparison of Hugo North OK and NN Gold Estimates with Increasing Northing (Main +1 g/t Au Domains)



14.1.10.3 Hugo South

Visual inspection indicated no major issues with the model. Grade-tonnage predictions produced for the model show that grade and tonnage estimates were validated by the change-of-support calculations over the likely range of mining grade cut-off values (0.8% to 1.2% Cu).

The cell model estimates were checked for global bias by comparing the average metal grades (with no cut-off) from the model (OK estimates) with means from NN estimates. No biases were identified.

Local trends in the grade estimates were verified using swath plots. The trends behaved as predicted and showed no significant bias in the estimates.

14.1.10.4 Heruga

A detailed visual validation of the Heruga resource model found that flagging of the drill data file and the cell model was completed as intended. The cell model estimates were checked for global bias by comparing the average metal grades from the model with means from unrestricted nearest-neighbour estimates. No biases were identified.

The distribution of the grades in the model was compared to the distribution of the original drillhole data, the composites used to build the model, and the declustered NN model. In all cases, although smoothed due to the OK interpolation method, the model was found to reflect the underlying data used to build it. The degree of smoothing occurring within the model was considered reasonable for the type of deposit and the likely block cave mining method.

The resource model was also checked for trends and local bias using 50 m swath plots that compared the restricted OK estimates to NN estimates. The trends behaved as predicted and showed no significant bias in the estimates.

14.1.11 Mineral Resource Confidence Classification

Classification was based on a set of rules involving estimation (OK) passes, distances to nearest composites, and numbers of holes used to inform the cell estimates. A separate ID2 estimation was completed for copper grade composites at Southern Oyu, which was used to interpolate the initial classification model.

The initial classification was then assessed and modified with an algorithm designed to eliminate isolated cells of a particular classification by switching them to majority classification of the surrounding cells.

Confidence categories obtained from the 2004 edition of the Australasian Joint Ore Reserves Committee (JORC) Code and the 2010 Canadian Institute of Mining, Metallurgy and Petroleum (CIM) Definition Standards for Mineral Resources and Mineral Reserves were applied to the entire Southern Oyu cell model. The Hugo cell model was classified using the 2004 JORC Code confidence categories.

Mineral Resources were classified based on the criteria outlined in the following subsections.

14.2 Assessment of Reasonable Prospects for Economic Extraction

14.2.1 Derivation of Cut-off Grades

The open pit cut-off grade is 0.22 % CuEq, which is equivalent to the open pit Mineral Reserve cut-offs of Southwest at $8.37/t, Central Chalcocite, Central Covellite, and Central Chalcopyrite at $7.25/t.

The underground cut-off grade is 0.37 % CuEq, which is equivalent to the underground Mineral Reserve cut-offs of $15/t NSR.

The reasonable prospects analysis has identified a reduction in cut-off grade which is the predominant factor for the change in resource relative to reporting in previous years.

14.2.1.1 Copper Equivalent Formula Derivation

In order to assess the value of the total suite of minerals of economic interest in the mineral inventory, formulae have been developed to calculate copper equivalency (CuEq) based on given prices and recoveries. There are two CuEq formulae currently in use at Oyu Tolgoi.

2003 CuEq Formula – Hugo Deposits and Southern Oyu

Based on a Cu price of $0.80/lb and Au price of $350/oz, the 2003 CuEq formula is:

$$\mathbf{CUEQ\% = Cu\% + (Au\ g/t) \times (11.25 / 17.64)}$$

Where:

17.64= (Cu $/lb) / (lb/t) = 0.80 / 2,204.62

11.25 = (Au $/oz) / (g / oz) = 350 / 31.10348

Not adjusted for metallurgical recovery

2010 – Heruga

The decision was taken to use a copper price of $1.35 / lb and a gold price of $650 / oz, and to incorporate molybdenum into the CuEq calculation at a price of $10 / lb.

The resultant 2007 formula was:

CUEQ% = Cu% + ((Au g/t * 18.98) + (Mo g/t x 0.01586)) / 29.76

Where:

18.98 = (Au $ / g) * Au Recovery Factor% = 20.90 * 90.822% (rounded to 91%)

0.01586 = (Mo $ / g) * Mo Recovery Factor% = 0.0220462 * 71.94% (rounded to 72%)

29.76 = Cu $ / %

14.2.2 Conceptual Mining Considerations in Support of Mineral Resource Declaration

14.2.2.1 Southern Oyu

Constraining Mineral Resources Amenable to Open Pit Mining Methods

For the part of Southern Oyu that is amenable to open pit mining methods, the Mineral Resources have been constrained within the current feasibility pit design. The same pit design has been used to define Mineral Reserves. Mineral Resources are inclusive of Mineral Reserves.

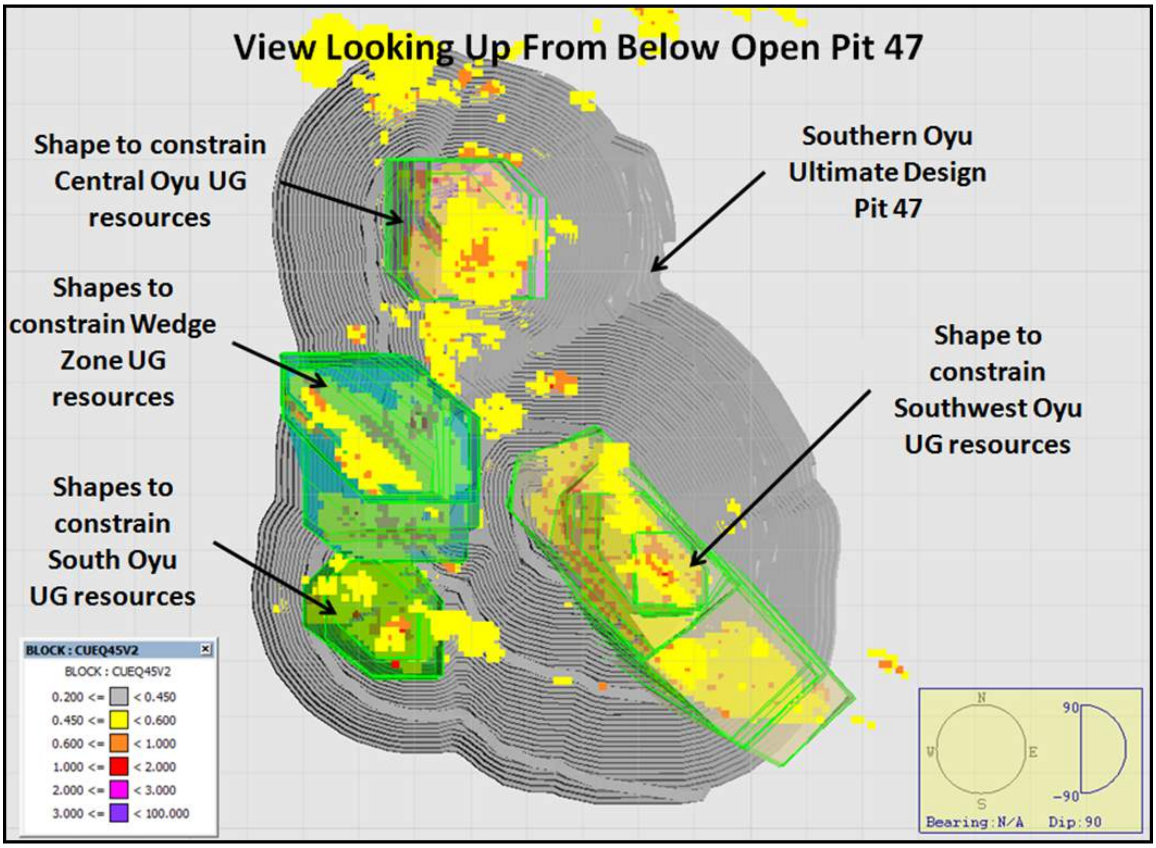
Constraining Mineral Resources Amenable to Underground Mining Methods

There are four targets for underground mining beneath Pit 47. Underground stope-block shapes (assuming mechanized block caving) were defined with at least a 100 m x 200 m footprint for these four areas (Figure 14.6).

Constraining stope-block shapes were outlined in 3D using estimations of economic criteria that would pay for primary and secondary development, mining, ventilation, tramming, hoisting, processing, and general and administrative costs, i.e., the underground stope shape cut-off.

The underground stope shapes used at Southern Oyu were defined on a 0.45% CuEq cut-off, which would return $20.42/t. This estimated return would cover a conceptual $12.05/t for mining and $8.37/t for processing and general and administrative costs.

Figure 14.6 Projected View from Below Pit 47 Looking Up at Southern Oyu Underground Deposits (Central Oyu, South Oyu, Southwest Oyu, and Wedge Zone)



14.3 Tabulating Mineral Resources

Once the open pit and underground constraining shapes were generated, resources were stated for those model cells within the constraining underground stope-block shapes that met a given CuEq cut-off grade.

14.3.1 Mineral Resource Confidence Classification

Classification was undertaken using a set of rules based on estimation (OK) passes, distances to nearest composites, and numbers of holes used to inform the cell estimates to establish an initial classification. A separate ID2 estimation was run for copper grade composites at Southern Oyu, which was used to interpolate the initial classification model.

The initial classification was then assessed and modified with an algorithm designed to eliminate isolated cells of a particular classification by switching them to majority classification of the surrounding cells.

Confidence categories, contained in the 2004 edition of the Australasian Joint Ore Reserves Committee (JORC[1]) Code and the 2010 Canadian Institute of Mining, Metallurgy and Petroleum (CIM) Definition Standards for Mineral Resources and Mineral Reserves, were applied to the entire Southern Oyu cell model. The Hugo cell model was classified using the 2004 JORC Code confidence categories.

Mineral Resources were classified based on the criteria outlined in the following sections.

14.3.1.1 Southern Oyu

Measured Mineral Resources

A three-hole rule was applied where cells contained an estimated grade from three or more composites from different holes, all within 50 m and at least one composite within 30 m of the cell centroid. These cells were classified as Measured.

Indicated Mineral Resources

The drillhole spacing over much of the Southern Oyu area is approximately 70 m. The drillhole spacing and geological and grade continuity over this area was considered to support an Indicated Mineral Resource classification in this area. A two-hole rule was used where cells containing an estimated grade were required to have been informed by two or more composites from different holes. Furthermore, for the Southwest Oyu deposit, the two holes needed to be within a distance of 75 m, with at least one hole within 55 m of the cell centroid. For the remaining deposits, the two holes needed to be within 65 m with at least one hole within 45 m of the bock centroid.

---

1 Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves, The JORC Code 2004 Edition, Effective December 2004, Prepared by the Joint Ore Reserves Committee of the Australasian Institute of Mining and Metallurgy, Australian Institute of Geoscientists, and Minerals Council of Australia (JORC).

Inferred Mineral Resources

Estimates in the Southern Oyu area with that did not meet the classification criteria for Measured or Indicated Mineral Resources were assigned to Inferred Mineral Resources if the cell centroid was within 150 m of a copper composite.

14.3.1.2 Hugo North

There are no Measured Mineral Resources at Hugo North.

Indicated Mineral Resources

The Indicated Mineral Resource category was supported at Hugo North where the drill spacing is on approximately 125 m x 75 m centres. The spacing was supported by a drill spacing study completed in July 2003. Geological and grade continuity was demonstrated by inspection of the model and drillhole data in plans and sections over the various zones.

Inferred Mineral Resources

Interpolated cells that did not meet the criteria for Indicated Mineral Resources were classified as Inferred Mineral Resources if they fell within 150 m of a drillhole composite.

14.3.1.3 Hugo South and Heruga

There are no Measured Mineral Resources at Hugo South or Heruga.

Inferred Mineral Resources

Interpolated cells were classified as Inferred Mineral Resources if they fell within 150 m of a drillhole composite. All mineralization at Hugo South and Heruga is currently classified as Inferred Mineral Resources.

14.4 Mineral Resource Statement

Mineral Resources are classified in accordance with the 2010 CIM Definition Standards for Mineral Resources and Mineral Reserves. Mineral Resources are inclusive of Mineral Reserves and do not include dilution.

Readers are cautioned that Mineral Resources that are not Mineral Reserves do not have demonstrated economic viability.

The contained gold and copper estimates in the Mineral Resource tables have not been adjusted for metallurgical recoveries; however, the differential recoveries were taken into account when calculating the 2010 copper equivalency formula. The various recovery relationships at Oyu Tolgoi are complex and relate both to grade and Cu:S ratios.

For the purposes of calculating equivalence, gold recovery is assumed to be 91% of copper recovery, and molybdenum is assumed to be 72% of copper recovery.

Mineral resources were also estimated for trace and impurity elements including arsenic, fluorine, sulfur, and silver, as well as the copper and gold estimates reported in these tables. A sulphide mineral abundance model was also created for Southern Oyu and Hugo North that will allow improved estimates of geometallurgical modelling and assist with characterization of tailings acid rock drainage (ARD) capacity.

The Project Mineral Resources are summarised in Table 14.26.

Table 14.27, Table 14.28, and Table 14.29 present the updated (2012) Southern Oyu open pit Mineral Resources by Measured, Indicated and Inferred classification (respectively) at incremental CuEq cut-off's. Table 14.30, Table 14.31, and Table 14.32 present the Southern Oyu underground Mineral Resources by Measured, Indicated and Inferred classification (respectively) at incremental CuEq cut-off's.

Table 14.33 and Table 14.34 present the Hugo North Mineral Resources (2007) by Indicated and Inferred classification (respectively) at incremental CuEq cut-off's.

Table 14.35 presents the Mineral Resource estimate for Hugo South (2003) and Table 14.36 presents the Mineral Resource estimate for Heruga (2010).

The base case cut-off CuEq grade is highlighted for each table.

Table 14.26 Oyu Tolgoi Mineral Resource Summary, 19 March 2013

Classification	Deposit	Tonnage (Mt)	Cu (%)	Au (g/t)	Ag (g/t)	Mo (ppm)	CuEq (%)	Contained Metal				
								Cu (Mlb)	Au (Moz)	Ag (Moz)	Mo (Mlb)	CuEq (Mlb)
Southern Oyu Deposits – Open Pit (0.22% CuEq Cut-Off)												
Measured		445	0.52	0.41	0.96	50.8	0.78	5,140	5.84	13.77	49.8	7,693
Indicated		652	0.39	0.23	0.90	54.2	0.54	5,650	4.80	18.85	77.8	7,747
Measured + Indicated		1,096	0.45	0.30	0.93	52.8	0.64	10,780	10.65	32.62	127.6	15,440
Inferred		218	0.27	0.15	0.77	46.7	0.37	1,290	1.08	5.38	22.5	1,765
Southern Oyu Deposits – Underground (0.37% CuEq Cut-Off)												
Measured		21.8	0.41	0.64	0.98	47.3	0.82	198	0.45	0.69	2.27	395
Indicated		150	0.36	0.50	0.92	40.2	0.68	1,190	2.40	4.45	13.3	2,244
Measured + Indicated		172	0.37	0.52	0.93	41.1	0.70	1,390	2.85	5.14	15.6	2,639
Inferred		237	0.38	0.29	0.87	38.5	0.57	1.990	2.24	6.62	20.1	2,968
Hugo Dummett Deposits (0.37% CuEq Cut-Off)												
Indicated	OT LLC	775	1.69	0.36	3.71	42.5	1.92	28,890	8.98	92.4	72.6	32,820
	EJV	132	1.65	0.55	4.09	35.7	2.00	4,800	2.32	17.4	10.4	5,810
	All Hugo North	907	1.69	0.39	3.77	41.5	1.93	33,690	11.3	110	83.0	38,630
Inferred	OT LLC	1,015	0.81	0.25	2.34	41.9	0.97	18,080	8.28	76.4	93.8	21,700
	EJV	134	0.93	0.25	2.44	23.6	1.09	2,760	1.08	10.5	7.0	3,230
	All Hugo North	1,150	0.82	0.25	2.35	39.8	0.98	20,840	9.36	87.0	101	24,930
Inferred	Hugo South	820	0.78	0.07	1.79	66.8	0.82	14,100	1.82	47.1	121	14,890
Inferred	North & South	1,969	0.80	0.18	2.12	51.0	0.92	34,930	11.2	134	221	39,820
Heruga Deposit (0.37% CuEq Cut-Off)												
Inferred Heruga Javkhlant EJV		1,824	0.38	0.36	1.35	110	0.67	15,190	21.2	79.4	444	26,850
Inferred Heruga TRQ		120	0.40	0.29	1.54	108	0.64	1,060	1.12	5.97	28.8	1,700
Inferred (All Heruga)		1,944	0.38	0.36	1.37	110	0.67	16,250	22.4	85.3	473	28,550

Classification	Deposit	Tonnage (Mt)	Cu (%)	Au (g/t)	Ag (g/t)	Mo (ppm)	CuEq (%)	Contained Metal				
								Cu (Mlb)	Au (Moz)	Ag (Moz)	Mo (Mlb)	CuEq (Mlb)
Oyu Tolgoi Project Grand Total												
Measured		467	0.51	0.42	0.96	50.6	0.78	5,340	6.29	14.5	52	8,0910
Indicated		1,709	1.07	0.34	2.42	46.2	1.29	40,530	18.5	133	174	48,620
Measured + Indicated		2,176	0.95	0.36	2.11	47.2	1.18	45,870	24.8	148	226	56,710
Inferred		4,368	0.57	0.26	1.65	76.3	0.76	52,490	36.8	231.4	737	73,100

Notes:

- The contained gold and copper estimates in the tables have not been adjusted for metallurgical recoveries.
- The 0.37% CuEq cut-off is equivalent to the underground Mineral Reserve cut-off determined by OT LLC.
- The Mineral Resources include Mineral Reserves.
- CuEq has been calculated using assumed metal prices ($1.35/lb for copper and $650/oz for gold and $10/lb for molybdenum).
- CuEq% = Cu% + ((Au g/t*18.98)+(Mo g/t*.01586)) / 29.76. Mo grades outside of Heruga are assumed to be zero for CuEq calculations.
- The CuEq formula also includes different levels of metallurgical recovery for the metals. Gold was assumed to have 91% of copper recovery, molybdenum 72% of copper recovery.
- Mineral Resources that are not Mineral Reserves do not have demonstrated economic viability.
- EJV is the Entrée Gold Joint Venture. The Shivee Tolgoi and Javkhlant licences are held by Entrée Gold. The Shivee Tolgoi and EJV Javkhlant Licences are planned to be operated by OT LLC. OT LLC will receive 80% of cash flows after capital and operating costs for material originating below 560 m, and 70% above this depth.

Table 14.27 Measured Open Pit Mineral Resources, Southern Oyu, Effective Date 19 March 2013 (base-case is highlighted)

Area & Class	Deposit	CuEq Cut-off (%)	Tonnage (Mt)	Cu (%)	Au (g/t)	Ag (g/t)	Mo (ppm)	CuEq (%)	Contained Metal				
									Cu (Mlb)	Au (Moz)	Ag (Moz)	Mo (Mlb)	CuEq (Mlb)
Southern Oyu Open Pit – MEASURED	SOUTHWEST, SOUTH, FAR SOUTH, BRIDGE, WEDGE, and WEST OYU DEPOSITS	3.50	1.31	1.51	4.32	2.43	85.6	4.26	43.4	0.18	0.10	0.25	123
		3.00	2.72	1.33	3.74	2.10	80.1	3.72	79.9	0.33	0.18	0.48	223
		2.50	6.88	1.14	3.07	1.68	77.4	3.10	174	0.68	0.37	1.17	471
		2.00	17.7	0.99	2.46	1.41	74.8	2.56	388	1.40	0.80	2.92	1,001
		1.50	39.2	0.90	1.89	1.23	73.8	2.10	778	2.38	1.55	6.38	1,817
		1.00	78.0	0.80	1.35	1.14	66.7	1.66	1,379	3.39	2.85	11.5	2,861
		0.90	90.8	0.78	1.23	1.12	65.6	1.56	1,553	3.60	3.26	13.1	3,128
		0.80	107	0.74	1.12	1.10	63.8	1.45	1,751	3.84	3.79	15.1	3,432
		0.70	130	0.70	0.99	1.08	61.8	1.33	2,010	4.12	4.51	17.7	3,811
		0.60	158	0.66	0.86	1.06	59.5	1.21	2,295	4.39	5.38	20.8	4,214
		0.50	195	0.61	0.74	1.04	57.0	1.08	2,627	4.65	6.52	24.5	4,661
		0.45	215	0.59	0.69	1.03	55.8	1.03	2,780	4.77	7.08	26.4	4,865
		0.40	234	0.57	0.65	1.01	54.7	0.98	2,914	4.86	7.61	28.1	5,041
		0.37	245	0.55	0.62	1.01	53.8	0.95	2,990	4.91	7.94	29.1	5,139
		0.35	253	0.54	0.61	1.00	53.4	0.93	3,040	4.95	8.16	29.8	5,203
		0.30	273	0.52	0.57	0.99	51.9	0.89	3,148	5.02	8.71	31.2	5,342
		0.25	290	0.50	0.54	0.99	50.3	0.85	3,233	5.07	9.21	32.2	5,451
		0.22	301	0.49	0.53	0.98	49.3	0.83	3,274	5.10	9.48	32.7	5,504
		0.20	307	0.49	0.52	0.98	48.8	0.82	3,296	5.12	9.65	33.0	5,533

Area & Class	Deposit	CuEq Cut-off (%)	Tonnage (Mt)	Cu (%)	Au (g/t)	Ag (g/t)	Mo (ppm)	CuEq (%)	Contained Metal				
									Cu (Mlb)	Au (Moz)	Ag (Moz)	Mo (Mlb)	CuEq (Mlb)
Southern Oyu Open Pit – MEASURED	CENTRAL DEPOSIT	3.50	-	-	-	-	-	-	-	-	-	-	-
		3.00	-	-	-	-	-	-	-	-	-	-	-
		2.50	0.018	2.36	0.33	2.28	32.7	2.57	0.94	0.0002	0.0013	0.0013	1.02
		2.00	0.26	1.41	1.17	1.34	50.8	2.16	8.07	0.0098	0.011	0.029	12.3
		1.50	3.28	1.31	0.64	1.36	51.3	1.71	94.5	0.067	0.14	0.37	124
		1.00	20.8	1.03	0.38	1.21	49.0	1.27	472	0.26	0.81	2.25	583
		0.90	29.9	0.96	0.34	1.15	50.2	1.17	632	0.32	1.11	3.31	774
		0.80	42.0	0.89	0.30	1.10	52.3	1.08	825	0.40	1.48	4.84	999
		0.70	58.3	0.82	0.26	1.05	55.3	0.99	1,058	0.48	1.96	7.10	1,267
		0.60	77.9	0.76	0.22	1.02	56.6	0.90	1,305	0.55	2.56	9.73	1,548
		0.50	102	0.69	0.19	1.00	57.5	0.82	1,565	0.64	3.30	13.0	1,843
		0.45	112	0.67	0.18	0.99	57.0	0.79	1,657	0.66	3.57	14.1	1,948
		0.40	121	0.65	0.18	0.97	56.3	0.76	1,730	0.69	3.79	15.0	2,031
		0.37	126	0.64	0.17	0.97	56.0	0.75	1,763	0.70	3.90	15.5	2,069
		0.35	129	0.63	0.17	0.96	55.8	0.74	1,783	0.71	3.96	15.8	2,093
		0.30	135	0.61	0.17	0.95	55.0	0.72	1,819	0.72	4.10	16.3	2,136
		0.25	140	0.60	0.16	0.94	54.3	0.70	1,847	0.74	4.22	16.8	2,170
		0.22	144	0.59	0.16	0.93	53.9	0.69	1,863	0.74	4.29	17.1	2,189
		0.20	146	0.58	0.16	0.92	53.6	0.68	1,872	0.75	4.33	17.2	2,199

Area & Class	Deposit	CuEq Cut-off (%)	Tonnage (Mt)	Cu (%)	Au (g/t)	Ag (g/t)	Mo (ppm)	CuEq (%)	Contained Metal				
									Cu (Mlb)	Au (Moz)	Ag (Moz)	Mo (Mlb)	CuEq (Mlb)
Southern Oyu Open Pit – MEASURED	ALL SOUTHERN OYU DEPOSITS	3.50	1.31	1.51	4.32	2.43	85.6	4.26	43.4	0.18	0.10	0.25	123
		3.00	2.72	1.33	3.74	2.10	80.1	3.72	79.9	0.33	0.18	0.48	223
		2.50	6.90	1.15	3.07	1.69	77.3	3.10	174	0.68	0.37	1.18	472
		2.00	18.0	1.00	2.44	1.41	74.5	2.55	396	1.41	0.82	2.95	1,013
		1.50	42.5	0.93	1.79	1.24	72.1	2.07	872	2.44	1.70	6.75	1,941
		1.00	98.9	0.85	1.15	1.15	63.0	1.58	1,851	3.64	3.66	13.7	3,445
		0.90	121	0.82	1.01	1.13	61.8	1.47	2,185	3.93	4.37	16.4	3,902
		0.80	149	0.78	0.89	1.10	60.6	1.35	2,576	4.24	5.27	19.9	4,431
		0.70	188	0.74	0.76	1.07	59.8	1.22	3,067	4.60	6.48	24.8	5,078
		0.60	236	0.69	0.65	1.05	58.6	1.11	3,600	4.94	7.95	30.5	5,761
		0.50	298	0.64	0.55	1.03	57.2	0.99	4,192	5.29	9.82	37.5	6,505
		0.45	327	0.62	0.52	1.01	56.2	0.95	4,437	5.43	10.6	40.5	6,813
		0.40	355	0.59	0.49	1.00	55.2	0.90	4,644	5.55	11.4	43.2	7,072
		0.37	371	0.58	0.47	0.99	54.5	0.88	4,753	5.61	11.8	44.6	7,208
		0.35	382	0.57	0.46	0.99	54.2	0.87	4,823	5.65	12.1	45.6	7,296
		0.30	407	0.55	0.44	0.98	52.9	0.83	4,968	5.74	12.8	47.5	7,478
		0.25	431	0.54	0.42	0.97	51.6	0.80	5,080	5.81	13.4	49.0	7,621
		0.22	445	0.52	0.41	0.96	50.8	0.78	5,137	5.84	13.8	49.8	7,693
		0.20	453	0.52	0.40	0.96	50.3	0.77	5,167	5.86	14.0	50.2	7,732

Note: 1) Mineral Resources are reported using a 0.22% copper equivalency cut-off grade.
2) Mineral Resources are contained within a conceptual open pit shell (Pit 10) that uses a copper price of $2.81/lb Cu and a gold price of $970/oz Au, and recoveries sourced from "Base Data Template No. 29" dated November 2011.
3) The copper equivalency is calculated using the formula CuEq = %Cu + (g/t Au) x (11.25 / 17.64). This formula assumes 100% Cu and Au recoveries. Mo and Ag are not used to estimate the copper equivalency grade. As is a deleterious element and not a value contributor.
4) Mineral Resources are inclusive of Mineral Reserves.
5) Mineral Resources that are not Mineral Reserves do not have demonstrated economic viability.
6) Rounding as required by reporting guidelines may result in apparent summation differences.

Table 14.28 Indicated Open Pit Mineral Resources, Southern Oyu, Effective Date 19 March 2013 (base-case is highlighted)

Area & Class	Deposit	CuEq Cut-off (%)	Tonnage (Mt)	Cu (%)	Au (g/t)	Ag (g/t)	Mo (ppm)	CuEq (%)	Contained Metal				
									Cu (Mlb)	Au (Moz)	Ag (Moz)	Mo (Mlb)	CuEq (Mlb)
Southern Oyu Open Pit – INDICATED	SOUTHWEST, SOUTH, FAR SOUTH, BRIDGE, WEDGE, and WEST OYU DEPOSITS	3.50	0.17	1.42	4.19	3.26	68.8	4.09	5.30	0.023	0.018	0.026	15.3
		3.00	0.34	1.28	3.67	2.48	83.4	3.62	9.55	0.040	0.027	0.062	27.1
		2.50	1.10	1.07	2.98	2.01	69.1	2.97	26.0	0.11	0.071	0.17	72.1
		2.00	3.77	0.92	2.35	1.67	64.5	2.42	76.8	0.28	0.20	0.54	201
		1.50	10.2	0.84	1.78	1.33	70.7	1.97	189	0.59	0.44	1.60	446
		1.00	30.7	0.74	1.11	1.31	66.2	1.45	503	1.10	1.29	4.48	982
		0.90	42.7	0.71	0.93	1.31	66.5	1.31	671	1.28	1.80	6.26	1,231
		0.80	62.4	0.67	0.77	1.25	67.8	1.16	924	1.54	2.51	9.32	1,598
		0.70	95.8	0.62	0.62	1.17	70.1	1.02	1,308	1.92	3.59	14.8	2,147
		0.60	151	0.56	0.50	1.09	70.1	0.88	1,878	2.43	5.31	23.4	2,941
		0.50	226	0.51	0.41	1.04	67.5	0.77	2,541	2.99	7.53	33.7	3,847
		0.45	271	0.48	0.37	1.01	65.8	0.72	2,891	3.26	8.81	39.3	4,315
		0.40	323	0.46	0.34	0.99	64.0	0.67	3,256	3.53	10.3	45.5	4,799
		0.37	357	0.44	0.32	0.98	63.0	0.65	3,474	3.69	11.2	49.5	5,087
		0.35	381	0.43	0.31	0.97	62.2	0.63	3,624	3.79	11.9	52.3	5,283
		0.30	441	0.41	0.28	0.95	59.6	0.59	3,955	4.02	13.5	58.0	5,711
		0.25	499	0.38	0.26	0.94	56.5	0.55	4,231	4.19	15.0	62.2	6,064
		0.22	534	0.37	0.25	0.93	54.6	0.53	4,373	4.27	15.9	64.3	6,242
		0.20	554	0.36	0.24	0.92	53.5	0.52	4,449	4.32	16.4	65.4	6,338

Area & Class	Deposit	CuEq Cut-off (%)	Tonnage (Mt)	Cu (%)	Au (g/t)	Ag (g/t)	Mo (ppm)	CuEq (%)	Contained Metal				
									Cu (Mlb)	Au (Moz)	Ag (Moz)	Mo (Mlb)	CuEq (Mlb)
Southern Oyu Open Pit – INDICATED	CENTRAL DEPOSIT	3.50	-	-	-	-	-	-	-	-	-	-	-
		3.00	-	-	-	-	-	-	-	-	-	-	-
		2.50	-	-	-	-	-	-	-	-	-	-	-
		2.00	0.10	1.54	0.97	1.55	36.1	2.16	3.54	0.0033	0.0052	0.0083	4.97
		1.50	1.47	1.20	0.80	1.30	42.1	1.71	38.6	0.038	0.061	0.14	55.2
		1.00	8.35	1.01	0.40	1.11	55.9	1.26	185	0.11	0.30	1.03	233
		0.90	12.5	0.94	0.34	1.05	58.0	1.16	259	0.14	0.42	1.59	319
		0.80	19.0	0.86	0.29	1.00	57.8	1.05	362	0.18	0.61	2.42	441
		0.70	30.7	0.78	0.24	0.93	60.8	0.94	530	0.24	0.92	4.12	634
		0.60	46.6	0.71	0.20	0.89	62.7	0.84	726	0.31	1.33	6.44	860
		0.50	65.2	0.64	0.18	0.85	60.6	0.76	920	0.38	1.78	8.71	1,086
		0.45	75.1	0.61	0.17	0.83	59.3	0.72	1,009	0.41	2.00	9.82	1,189
		0.40	84.0	0.58	0.16	0.82	58.1	0.69	1,081	0.44	2.20	10.8	1,273
		0.37	89.3	0.57	0.16	0.81	57.2	0.67	1,119	0.46	2.32	11.3	1,318
		0.35	93.0	0.56	0.16	0.80	56.6	0.66	1,143	0.47	2.40	11.6	1,347
		0.30	103	0.53	0.15	0.79	54.9	0.63	1,201	0.49	2.62	12.4	1,417
		0.25	112	0.50	0.14	0.78	53.2	0.60	1,249	0.52	2.82	13.2	1,475
		0.22	118	0.49	0.14	0.78	52.1	0.58	1,273	0.53	2.94	13.6	1,505
		0.20	122	0.48	0.14	0.77	51.5	0.57	1,288	0.54	3.02	13.9	1,523

Area & Class	Deposit	CuEq Cut-off (%)	Tonnage (Mt)	Cu (%)	Au (g/t)	Ag (g/t)	Mo (ppm)	CuEq (%)	Contained Metal				
									Cu (Mlb)	Au (Moz)	Ag (Moz)	Mo (Mlb)	CuEq (Mlb)
Southern Oyu Open Pit – INDICATED	ALL SOUTHERN OYU DEPOSITS	3.50	0.17	1.42	4.19	3.26	68.8	4.09	5.30	0.023	0.018	0.026	15.3
		3.00	0.34	1.28	3.67	2.48	83.4	3.62	9.55	0.040	0.027	0.062	27.1
		2.50	1.10	1.07	2.98	2.01	69.1	2.97	26.0	0.11	0.071	0.17	72.1
		2.00	3.87	0.94	2.31	1.67	63.8	2.42	80.3	0.29	0.21	0.54	206
		1.50	11.7	0.88	1.66	1.33	67.1	1.94	228	0.63	0.50	1.73	501
		1.00	39.1	0.80	0.96	1.27	64.0	1.41	688	1.20	1.59	5.51	1,215
		0.90	55.1	0.76	0.80	1.25	64.6	1.27	930	1.42	2.22	7.85	1,549
		0.80	81.4	0.72	0.66	1.19	65.4	1.14	1,287	1.72	3.12	11.7	2,039
		0.70	126	0.66	0.53	1.11	67.8	1.00	1,837	2.16	4.51	18.9	2,781
		0.60	198	0.60	0.43	1.04	68.3	0.87	2,604	2.74	6.64	29.8	3,801
		0.50	292	0.54	0.36	0.99	66.0	0.77	3,461	3.36	9.31	42.4	4,933
		0.45	346	0.51	0.33	0.97	64.4	0.72	3,900	3.67	10.8	49.1	5,505
		0.40	407	0.48	0.30	0.95	62.8	0.68	4,337	3.97	12.5	56.3	6,072
		0.37	446	0.47	0.29	0.94	61.8	0.65	4,593	4.14	13.5	60.8	6,404
		0.35	474	0.46	0.28	0.94	61.1	0.63	4,767	4.26	14.3	63.9	6,630
		0.30	544	0.43	0.26	0.92	58.7	0.59	5,156	4.51	16.1	70.4	7,129
		0.25	612	0.41	0.24	0.91	55.9	0.56	5,480	4.71	17.8	75.4	7,539
		0.22	652	0.39	0.23	0.90	54.2	0.54	5,647	4.80	18.9	77.8	7,747
		0.20	676	0.38	0.22	0.89	53.1	0.53	5,737	4.86	19.5	79.2	7,861

Note:
1) Mineral Resources are reported using a 0.22% copper equivalency cut-off grade.
2) Mineral Resources are contained within a conceptual open pit shell (Pit 10) that uses a copper price of $2.81/lb Cu and a gold price of $970/oz Au, and recoveries sourced from "Base Data Template No. 29" dated November 2011.
3) The copper equivalency is calculated using the formula CuEq = %Cu + (g/t Au) x (11.25 / 17.64). This formula assumes 100% Cu and Au recoveries. Mo and Ag are not used to estimate the copper equivalency grade. As is a deleterious element and not a value contributor.
4) Mineral Resources are inclusive of Mineral Reserves.
5) Mineral Resources that are not Mineral Reserves do not have demonstrated economic viability.
6) Rounding as required by reporting guidelines may result in apparent summation differences.

Table 14.29 Inferred Open Pit Mineral Resources, Southern Oyu, Effective Date 19 March 2013 (base-case is highlighted)

Area & Class	Deposit	CuEq Cut-off (%)	Tonnage (Mt)	Cu (%)	Au (g/t)	Ag (g/t)	Mo (ppm)	CuEq (%)	Contained Metal				
									Cu (Mlb)	Au (Moz)	Ag (Moz)	Mo (Mlb)	CuEq (Mlb)
Southern Oyu Open Pit – INFERRED	SOUTHWEST, SOUTH, FAR SOUTH, BRIDGE, WEDGE, and WEST OYU DEPOSITS	3.50	-	-	-	-	-	-	-	-	-	-	-
		3.00	-	-	-	-	-	-	-	-	-	-	-
		2.50	0.0684	2.38	0.511	1.18	22.5	2.71	3.59	0.0011	0.0026	0.0034	4.09
		2.00	0.119	2.10	0.681	1.37	28.8	2.53	5.52	0.0026	0.0053	0.0076	6.66
		1.50	0.242	1.72	0.614	1.41	39.0	2.11	9.17	0.0048	0.0110	0.0208	11.3
		1.00	0.902	1.12	0.426	1.41	55.5	1.40	22.3	0.0123	0.0410	0.110	27.7
		0.90	1.58	0.918	0.447	1.39	78.0	1.20	31.9	0.0227	0.0702	0.271	41.8
		0.80	2.68	0.785	0.424	1.30	82.0	1.06	46.4	0.0366	0.112	0.485	62.4
		0.70	5.94	0.641	0.381	1.16	91.3	0.884	84.1	0.0727	0.221	1.20	116
		0.60	12.3	0.551	0.328	1.07	88.5	0.761	150	0.130	0.424	2.41	207
		0.50	24.6	0.473	0.283	1.00	79.9	0.653	256	0.223	0.793	4.33	354
		0.45	36.8	0.428	0.260	0.947	73.9	0.593	347	0.307	1.12	5.99	481
		0.40	55.9	0.386	0.234	0.901	68.4	0.535	476	0.420	1.62	8.42	659
		0.37	71.2	0.362	0.220	0.880	65.1	0.503	569	0.503	2.01	10.2	789
		0.35	82.2	0.349	0.212	0.866	63.0	0.484	632	0.559	2.29	11.4	876
		0.30	118	0.312	0.193	0.827	58.2	0.435	813	0.735	3.15	15.2	1,134
		0.25	163	0.280	0.174	0.796	52.9	0.391	1,006	0.915	4.18	19.0	1,406
		0.22	193	0.263	0.163	0.781	49.5	0.367	1,118	1.01	4.84	21.0	1,559
		0.20	212	0.253	0.156	0.775	47.4	0.353	1,183	1.06	5.28	22.1	1,647

Area & Class	Deposit	CuEq Cut-off (%)	Tonnage (Mt)	Cu (%)	Au (g/t)	Ag (g/t)	Mo (ppm)	CuEq (%)	Contained Metal				
									Cu (Mlb)	Au (Moz)	Ag (Moz)	Mo (Mlb)	CuEq (Mlb)
Southern Oyu Open Pit – INFERRED	CENTRAL DEPOSIT	3.50	-	-	-	-	-	-	-	-	-	-	-
		3.00	-	-	-	-	-	-	-	-	-	-	-
		2.50	-	-	-	-	-	-	-	-	-	-	-
		2.00	-	-	-	-	-	-	--	-	-	-	-
		1.50	0.0177	1.46	0.333	0.811	23.7	1.67	0.569	0.0002	0.0005	0.0009	0.652
		1.00	0.263	1.03	0.241	0.820	36.8	1.18	5.97	0.0020	0.0069	0.0213	6.86
		0.90	0.365	0.973	0.234	0.801	31.3	1.12	7.82	0.0027	0.0094	0.0252	9.02
		0.80	0.586	0.892	0.207	0.756	51.7	1.02	11.5	0.0039	0.0142	0.0668	13.2
		0.70	0.889	0.820	0.170	0.749	52.1	0.929	16.1	0.0049	0.0214	0.102	18.2
		0.60	1.49	0.717	0.147	0.734	56.7	0.811	23.6	0.0070	0.0352	0.187	26.6
		0.50	3.29	0.577	0.131	0.733	47.2	0.661	41.9	0.0139	0.0775	0.342	47.9
		0.45	4.99	0.516	0.128	0.725	42.9	0.598	56.8	0.0205	0.116	0.472	65.7
		0.40	6.98	0.472	0.118	0.727	40.6	0.547	72.7	0.0264	0.163	0.624	84.3
		0.37	9.04	0.442	0.108	0.715	40.0	0.510	88.1	0.0313	0.208	0.798	102
		0.35	10.9	0.421	0.100	0.706	37.2	0.485	101	0.0351	0.247	0.894	116
		0.30	15.1	0.381	0.0919	0.690	31.3	0.440	127	0.0448	0.336	1.04	147
		0.25	21.6	0.335	0.0861	0.668	27.2	0.390	159	0.0597	0.463	1.29	186
		0.22	25.5	0.313	0.0838	0.658	25.4	0.366	176	0.0687	0.539	1.43	206
		0.20	29.2	0.294	0.0819	0.651	23.9	0.346	189	0.0768	0.611	1.54	223

Area & Class	Deposit	CuEq Cut-off (%)	Tonnage (Mt)	Cu (%)	Au (g/t)	Ag (g/t)	Mo (ppm)	CuEq (%)	Contained Metal				
									Cu (Mlb)	Au (Moz)	Ag (Moz)	Mo (Mlb)	CuEq (Mlb)
Southern Oyu Open Pit – INFERRED	ALL SOUTHERN OYU DEPOSITS	3.50	-	-	-	-	-	-	-	-	-	-	-
		3.00	-	-	-	-	-	-	-	-	-	-	-
		2.50	0.0684	2.38	0.51	1.18	22.5	2.71	3.59	0.0011	0.0026	0.0034	4.09
		2.00	0.119	2.10	0.68	1.37	28.8	2.53	5.52	0.0026	0.0053	0.0076	6.66
		1.50	0.260	1.70	0.59	1.37	37.9	2.08	9.74	0.0050	0.0114	0.0217	11.9
		1.00	1.16	1.10	0.38	1.28	51.3	1.35	28.3	0.0144	0.0480	0.132	34.6
		0.90	1.94	0.93	0.41	1.28	69.2	1.19	39.7	0.0254	0.0796	0.296	50.8
		0.80	3.27	0.80	0.39	1.20	76.6	1.05	57.9	0.0405	0.126	0.551	75.6
		0.70	6.83	0.67	0.35	1.11	86.2	0.89	100	0.0776	0.243	1.30	134
		0.60	13.8	0.57	0.31	1.03	85.1	0.77	173	0.137	0.459	2.59	233
		0.50	27.9	0.49	0.27	0.97	76.0	0.65	298	0.237	0.871	4.67	402
		0.45	41.8	0.44	0.24	0.92	70.2	0.59	403	0.327	1.24	6.46	547
		0.40	62.9	0.40	0.22	0.88	65.3	0.54	548	0.446	1.78	9.05	743
		0.37	80.3	0.37	0.21	0.86	62.3	0.50	657	0.535	2.22	11.0	891
		0.35	93.1	0.36	0.20	0.85	60.0	0.48	733	0.594	2.53	12.3	993
		0.30	133	0.32	0.18	0.81	55.1	0.44	940	0.779	3.48	16.2	1,281
		0.25	185	0.29	0.16	0.78	49.9	0.39	1,165	0.974	4.64	20.3	1,591
		0.22	218	0.27	0.15	0.77	46.7	0.37	1,293	1.08	5.38	22.5	1,765
		0.20	241	0.26	0.15	0.76	44.6	0.35	1,372	1.14	5.89	23.7	1,870

Note: 1) Mineral Resources are reported using a 0.22% copper equivalency cut-off grade.
2) Mineral Resources are contained within a conceptual open pit shell (Pit 10) that uses a copper price of $2.81/lb Cu and a gold price of $970/oz Au, and recoveries sourced from “Base Data Template No. 29” dated November 2011.
3) The copper equivalency is calculated using the formula CuEq = %Cu + (g/t Au) x (11.25 / 17.64). This formula assumes 100% Cu and Au recoveries. Mo and Ag are not used to estimate the copper equivalency grade. As is a deleterious element and not a value contributor.
4) Mineral Resources are inclusive of Mineral Reserves.
5) Mineral Resources that are not Mineral Reserves do not have demonstrated economic viability.
6) Rounding as required by reporting guidelines may result in apparent summation differences.

Table 14.30 Measured Underground Mineral Resources, Southern Oyu, Effective Date 19 March 2013 (base-case is highlighted)

Area & Class	Deposit	CuEq Cut-off (%)	Tonnage (Mt)	Cu (%)	Au (g/t)	Ag (g/t)	Mo (ppm)	CuEq (%)	Contained Metal				
									Cu (Mlb)	Au (Moz)	Ag (Moz)	Mo (Mlb)	CuEq (Mlb)
Southern Oyu Underground – MEASURED	SOUTHWEST, SOUTH, FAR SOUTH, BRIDGE, WEDGE, and WEST OYU DEPOSITS	3.50	-	-	-	-	-	-	-	-	-	-	-
		3.00	0.016	1.06	3.23	2.26	51.5	3.12	0.38	0.0017	0.0012	0.0019	1.13
		2.50	0.12	0.89	2.95	2.26	43.8	2.77	2.28	0.011	0.0085	0.011	7.12
		2.00	0.37	0.78	2.54	2.00	40.3	2.40	6.36	0.030	0.024	0.033	19.5
		1.50	1.24	0.62	2.03	1.66	38.8	1.92	17.1	0.081	0.066	0.11	52.5
		1.00	4.40	0.47	1.49	1.31	34.9	1.42	45.2	0.21	0.18	0.34	137
		0.90	5.54	0.44	1.38	1.22	34.3	1.32	53.5	0.25	0.22	0.42	161
		0.80	6.93	0.41	1.27	1.17	34.4	1.22	63.3	0.28	0.26	0.53	187
		0.70	8.58	0.39	1.16	1.11	35.4	1.13	74.7	0.32	0.31	0.67	214
		0.60	10.3	0.39	1.04	1.09	36.5	1.05	88.1	0.34	0.36	0.83	239
		0.50	12.5	0.38	0.91	1.06	38.6	0.96	105	0.37	0.43	1.06	266
		0.45	14.2	0.38	0.83	1.05	39.7	0.90	118	0.38	0.48	1.24	284
		0.40	15.8	0.37	0.76	1.04	39.7	0.86	129	0.39	0.53	1.38	298
		0.37	16.6	0.37	0.73	1.04	39.4	0.83	134	0.39	0.56	1.45	306
		0.35	17.2	0.36	0.72	1.04	39.4	0.82	137	0.40	0.57	1.49	310
		0.30	18.3	0.35	0.69	1.03	38.8	0.79	142	0.40	0.60	1.56	318
		0.25	19.3	0.34	0.66	1.01	38.1	0.76	145	0.41	0.63	1.62	324
		0.22	20.1	0.33	0.64	1.00	37.5	0.74	148	0.41	0.65	1.66	328
		0.20	20.6	0.33	0.63	0.99	37.1	0.73	149	0.41	0.66	1.68	330

Area & Class	Deposit	CuEq Cut-off (%)	Tonnage (Mt)	Cu (%)	Au (g/t)	Ag (g/t)	Mo (ppm)	CuEq (%)	Contained Metal				
									Cu (Mlb)	Au (Moz)	Ag (Moz)	Mo (Mlb)	CuEq (Mlb)
Southern Oyu Underground – MEASURED	CENTRAL DEPOSIT	3.50	-	-	-	-	-	-	-	-	-	-	-
		3.00	-	-	-	-	-	-	-	-	-	-	-
		2.50	-	-	-	-	-	-	-	-	-	-	-
		2.00	0.086	1.27	1.47	0.89	36.0	2.21	2.39	0.0040	0.0025	0.0068	4.16
		1.50	0.43	1.11	1.09	0.72	47.9	1.81	10.5	0.015	0.0099	0.045	17.1
		1.00	1.01	0.91	0.82	0.77	51.3	1.43	20.2	0.027	0.025	0.11	31.8
		0.90	1.41	0.83	0.72	0.80	53.9	1.29	25.8	0.033	0.036	0.17	40.1
		0.80	2.03	0.78	0.60	0.81	57.3	1.16	34.7	0.039	0.053	0.26	51.8
		0.70	2.55	0.74	0.53	0.82	60.0	1.08	41.4	0.043	0.067	0.34	60.3
		0.60	3.09	0.70	0.47	0.80	62.7	1.00	47.8	0.046	0.080	0.43	68.1
		0.50	3.77	0.65	0.42	0.79	65.4	0.92	54.0	0.051	0.096	0.54	76.4
		0.45	4.19	0.62	0.40	0.80	71.6	0.87	57.5	0.053	0.11	0.66	80.8
		0.40	4.66	0.59	0.37	0.79	72.2	0.83	61.0	0.055	0.12	0.74	85.2
		0.37	5.14	0.57	0.35	0.80	72.9	0.79	64.2	0.057	0.13	0.83	89.2
		0.35	5.39	0.55	0.34	0.79	72.3	0.77	65.8	0.058	0.14	0.86	91.2
		0.30	6.17	0.52	0.31	0.78	70.9	0.71	70.3	0.061	0.16	0.96	96.9
		0.25	6.99	0.48	0.28	0.77	68.7	0.66	74.2	0.063	0.17	1.06	102
		0.22	7.52	0.46	0.27	0.76	67.0	0.63	76.3	0.065	0.18	1.11	105
		0.20	7.92	0.44	0.26	0.76	65.4	0.61	77.7	0.066	0.19	1.14	106

Area & Class	Deposit	CuEq Cut-off (%)	Tonnage (Mt)	Cu (%)	Au (g/t)	Ag (g/t)	Mo (ppm)	CuEq (%)	Contained Metal				
									Cu (Mlb)	Au (Moz)	Ag (Moz)	Mo (Mlb)	CuEq (Mlb)
Southern Oyu Underground – MEASURED	ALL SOUTHERN OYU DEPOSITS	3.50	-	-	-	-	-	-	-	-	-	-	-
		3.00	0.016	1.06	3.23	2.26	51.5	3.12	0.38	0.0017	0.0012	0.0019	1.13
		2.50	0.12	0.89	2.95	2.26	43.8	2.77	2.28	0.011	0.0085	0.011	7.12
		2.00	0.45	0.88	2.33	1.79	39.5	2.36	8.75	0.034	0.026	0.039	23.6
		1.50	1.67	0.75	1.79	1.42	41.1	1.89	27.6	0.096	0.076	0.15	69.6
		1.00	5.41	0.55	1.36	1.21	37.9	1.42	65.4	0.24	0.21	0.45	169
		0.90	6.94	0.52	1.25	1.14	38.3	1.31	79.3	0.28	0.25	0.59	201
		0.80	8.96	0.50	1.12	1.09	39.6	1.21	98.1	0.32	0.31	0.78	239
		0.70	11.1	0.47	1.01	1.04	41.0	1.12	116	0.36	0.37	1.01	275
		0.60	13.4	0.46	0.91	1.03	42.6	1.04	136	0.39	0.44	1.26	307
		0.50	16.3	0.44	0.80	1.00	44.8	0.95	159	0.42	0.52	1.61	342
		0.45	18.4	0.43	0.73	0.99	46.9	0.90	176	0.43	0.59	1.90	364
		0.40	20.4	0.42	0.67	0.98	47.1	0.85	190	0.44	0.65	2.12	384
		0.37	21.8	0.41	0.64	0.98	47.3	0.82	198	0.45	0.69	2.27	395
		0.35	22.6	0.41	0.62	0.98	47.2	0.81	203	0.45	0.71	2.35	401
		0.30	24.4	0.39	0.59	0.96	46.9	0.77	212	0.46	0.76	2.52	414
		0.25	26.3	0.38	0.56	0.95	46.2	0.73	220	0.47	0.80	2.68	426
		0.22	27.6	0.37	0.54	0.94	45.5	0.71	224	0.48	0.83	2.77	433
		0.20	28.5	0.36	0.52	0.93	45.0	0.70	227	0.48	0.85	2.82	437

Note: 1) Mineral Resources are reported using a 0.37% copper equivalency cut-off grade.

2) Mineral Resources are contained within a conceptual mining block (UG4) that uses a copper price of \$2.81/lb Cu and a gold price of \$970/oz Au, and recoveries sourced from “Base Data Template No. 29” dated November 2011.

3) The copper equivalency is calculated using the formula CuEq = %Cu + (g/t Au) x (11.25 / 17.64). This formula assumes 100% Cu and Au recoveries. Mo and Ag are not used to estimate the copper equivalency grade. As is a deleterious element and not a value contributor.

4) Mineral Resources are inclusive of Mineral Reserves.

5) Mineral Resources that are not Mineral Reserves do not have demonstrated economic viability.

6) Rounding as required by reporting guidelines may result in apparent summation differences.

Table 14.31 Indicated Underground Mineral Resources, Southern Oyu, Effective Date 19 March 2013 (base-case is highlighted)

Area & Class	Deposit	CuEq Cut-off (%)	Tonnage (Mt)	Cu (%)	Au (g/t)	Ag (g/t)	Mo (ppm)	CuEq (%)	Contained Metal				
									Cu (Mlb)	Au (Moz)	Ag (Moz)	Mo (Mlb)	CuEq (Mlb)
Southern Oyu Underground – INDICATED	SOUTHWEST, SOUTH, FAR SOUTH, BRIDGE, WEDGE, and WEST OYU DEPOSITS	3.50	-	-	-	-	-	-	-	-	-	-	-
		3.00	0.050	0.93	3.45	2.62	48.9	3.13	1.03	0.0056	0.0042	0.0054	3.46
		2.50	0.12	0.90	3.10	2.24	52.2	2.88	2.32	0.012	0.0085	0.014	7.43
		2.00	0.72	0.73	2.46	2.16	48.2	2.30	11.7	0.057	0.050	0.077	36.5
		1.50	3.59	0.60	1.90	1.60	47.0	1.81	47.2	0.22	0.18	0.37	143
		1.00	16.1	0.46	1.34	1.27	38.4	1.32	165	0.69	0.66	1.36	469
		0.90	23.1	0.44	1.21	1.17	36.3	1.21	223	0.89	0.87	1.85	614
		0.80	32.6	0.42	1.07	1.11	35.2	1.10	304	1.12	1.17	2.53	793
		0.70	44.0	0.41	0.94	1.07	35.0	1.01	397	1.34	1.51	3.40	981
		0.60	61.9	0.39	0.81	1.02	36.0	0.91	534	1.60	2.02	4.91	1,235
		0.50	87.6	0.37	0.68	0.98	37.4	0.80	708	1.92	2.76	7.22	1,546
		0.45	103	0.36	0.62	0.97	37.9	0.75	806	2.06	3.20	8.61	1,707
		0.40	120	0.34	0.57	0.96	37.8	0.71	906	2.19	3.70	9.97	1,862
		0.37	129	0.34	0.54	0.96	37.6	0.68	955	2.25	3.97	10.7	1,939
		0.35	135	0.33	0.53	0.96	37.5	0.67	990	2.29	4.18	11.2	1,993
		0.30	150	0.32	0.49	0.95	37.0	0.63	1,062	2.37	4.60	12.3	2,100
		0.25	164	0.31	0.46	0.94	36.3	0.60	1,117	2.44	4.98	13.1	2,183
		0.22	171	0.30	0.45	0.94	35.8	0.59	1,142	2.46	5.19	13.5	2,220
		0.20	176	0.30	0.44	0.94	35.4	0.58	1,157	2.48	5.32	13.7	2,242

Area & Class	Deposit	CuEq Cut-off (%)	Tonnage (Mt)	Cu (%)	Au (g/t)	Ag (g/t)	Mo (ppm)	CuEq (%)	Contained Metal				
									Cu (Mlb)	Au (Moz)	Ag (Moz)	Mo (Mlb)	CuEq (Mlb)
Southern Oyu Underground – INDICATED	CENTRAL DEPOSIT	3.50	-	-	-	-	-	-	-	-	-	-	-
		3.00	-	-	-	-	-	-	-	-	-	-	-
		2.50	0.017	1.23	2.16	1.70	59.1	2.60	0.45	0.0012	0.0009	0.0022	0.95
		2.00	0.050	1.05	1.91	1.44	61.5	2.27	1.15	0.0031	0.0023	0.0067	2.49
		1.50	0.47	0.94	1.30	0.92	77.7	1.77	9.65	0.019	0.014	0.080	18.1
		1.00	1.65	0.85	0.77	0.78	79.0	1.34	31.0	0.041	0.042	0.29	48.8
		0.90	2.43	0.81	0.64	0.74	74.3	1.21	43.1	0.050	0.057	0.40	64.8
		0.80	3.92	0.75	0.50	0.72	72.5	1.07	64.9	0.063	0.091	0.63	92.6
		0.70	6.31	0.70	0.40	0.70	71.5	0.95	97.0	0.080	0.14	0.99	132
		0.60	9.28	0.64	0.33	0.71	67.5	0.85	132	0.099	0.21	1.38	175
		0.50	13.9	0.58	0.27	0.71	64.3	0.75	177	0.12	0.32	1.97	231
		0.45	16.6	0.55	0.25	0.70	60.8	0.71	201	0.13	0.38	2.23	259
		0.40	19.7	0.52	0.23	0.69	57.1	0.66	225	0.14	0.44	2.47	288
		0.37	21.8	0.50	0.22	0.69	55.3	0.64	240	0.15	0.49	2.66	306
		0.35	23.2	0.49	0.21	0.69	53.9	0.62	249	0.16	0.52	2.76	317
		0.30	27.1	0.45	0.19	0.69	51.2	0.58	272	0.17	0.60	3.06	345
		0.25	31.7	0.42	0.18	0.69	48.9	0.53	295	0.18	0.70	3.42	373
		0.22	34.6	0.40	0.17	0.68	47.4	0.51	306	0.19	0.76	3.62	388
		0.20	36.9	0.39	0.16	0.68	46.4	0.49	314	0.19	0.81	3.77	398

Area & Class	Deposit	CuEq Cut-off (%)	Tonnage (Mt)	Cu (%)	Au (g/t)	Ag (g/t)	Mo (ppm)	CuEq (%)	Contained Metal				
									Cu (Mlb)	Au (Moz)	Ag (Moz)	Mo (Mlb)	CuEq (Mlb)
Southern Oyu Underground – INDICATED	ALL SOUTHERN OYU DEPOSITS	3.50	-	-	-	-	-	-	-	-	-	-	-
		3.00	0.050	0.93	3.45	2.62	48.9	3.13	1.03	0.0056	0.0042	0.0054	3.46
		2.50	0.13	0.94	2.99	2.18	53.1	2.84	2.77	0.013	0.0094	0.016	8.39
		2.00	0.77	0.75	2.42	2.11	49.1	2.30	12.8	0.060	0.052	0.083	39.0
		1.50	4.06	0.64	1.83	1.52	50.5	1.80	56.8	0.24	0.20	0.45	161
		1.00	17.7	0.50	1.29	1.22	42.2	1.32	196	0.74	0.70	1.65	517
		0.90	25.5	0.47	1.15	1.13	39.9	1.21	266	0.94	0.93	2.24	679
		0.80	36.5	0.46	1.01	1.07	39.2	1.10	368	1.18	1.26	3.16	886
		0.70	50.3	0.44	0.88	1.02	39.6	1.00	494	1.42	1.65	4.40	1,113
		0.60	71.1	0.42	0.74	0.98	40.1	0.90	665	1.70	2.23	6.29	1,410
		0.50	102	0.40	0.62	0.94	41.1	0.79	885	2.04	3.07	9.20	1,777
		0.45	120	0.38	0.57	0.93	41.1	0.75	1,007	2.19	3.58	10.8	1,966
		0.40	139	0.37	0.52	0.92	40.6	0.70	1,130	2.33	4.14	12.4	2,150
		0.37	150	0.36	0.50	0.92	40.2	0.68	1,194	2.40	4.45	13.3	2,244
		0.35	159	0.35	0.48	0.92	39.9	0.66	1,239	2.45	4.69	13.9	2,310
		0.30	178	0.34	0.45	0.91	39.2	0.62	1,334	2.54	5.20	15.3	2,445
		0.25	196	0.33	0.42	0.90	38.3	0.59	1,412	2.62	5.68	16.5	2,556
		0.22	206	0.32	0.40	0.90	37.7	0.58	1,448	2.65	5.95	17.1	2,607
		0.20	213	0.31	0.39	0.90	37.3	0.56	1,472	2.67	6.12	17.5	2,640

Note: 1) Mineral Resources are reported using a 0.37% copper equivalency cut-off grade.

2) Mineral Resources are contained within a conceptual mining block (UG4) that uses a copper price of \$2.81/lb Cu and a gold price of \$970/oz Au, and recoveries sourced from "Base Data Template No. 29" dated November 2011.

3) The copper equivalency is calculated using the formula CuEq = %Cu + (g/t Au) x (11.25 / 17.64). This formula assumes 100% Cu and Au recoveries. Mo and Ag are not used to estimate the copper equivalency grade. As is a deleterious element and not a value contributor.

4) Mineral Resources are inclusive of Mineral Reserves.

5) Mineral Resources that are not Mineral Reserves do not have demonstrated economic viability.

6) Rounding as required by reporting guidelines may result in apparent summation differences.

Table 14.32 Inferred Underground Mineral Resources, Southern Oyu, Effective Date 19 March 2013 (base-case is highlighted)

Area & Class	Deposit	CuEq Cut-off (%)	Tonnage (Mt)	Cu (%)	Au (g/t)	Ag (g/t)	Mo (ppm)	CuEq (%)	Contained Metal Cu (Mlb)	Contained Metal Au (Moz)	Contained Metal Ag (Moz)	Contained Metal Mo (Mlb)	Contained Metal CuEq (Mlb)
Southern Oyu Underground – INFERRED	SOUTHWEST, SOUTH, FAR SOUTH, BRIDGE, WEDGE, and WEST OYU DEPOSITS	3.50	-	-	-	-	-	-	-	-	-	-	-
		3.00	-	-	-	-	-	-	-	-	-	-	-
		2.50	-	-	-	-	-	-	-	-	-	-	-
		2.00	0.12	0.99	1.90	3.47	31.5	2.20	2.59	0.0072	0.013	0.0082	5.75
		1.50	0.90	0.71	1.64	2.25	31.0	1.76	14.1	0.047	0.065	0.062	34.9
		1.00	8.45	0.73	0.76	1.45	29.1	1.21	135	0.21	0.39	0.54	226
		0.90	14.6	0.70	0.63	1.27	28.8	1.10	224	0.30	0.60	0.93	354
		0.80	25.3	0.65	0.54	1.14	28.9	0.99	362	0.44	0.93	1.61	554
		0.70	40.3	0.57	0.51	1.04	30.1	0.90	510	0.66	1.35	2.67	800
		0.60	65.6	0.51	0.45	0.97	31.9	0.80	741	0.96	2.04	4.62	1,160
		0.50	119	0.44	0.38	0.92	35.9	0.69	1,168	1.45	3.54	9.45	1,804
		0.45	156	0.42	0.35	0.90	38.1	0.64	1,426	1.74	4.51	13.1	2,185
		0.40	195	0.39	0.32	0.89	38.8	0.59	1,672	2.01	5.54	16.6	2,549
		0.37	222	0.38	0.30	0.88	38.6	0.57	1,836	2.16	6.27	18.9	2,782
		0.35	244	0.36	0.29	0.87	38.5	0.55	1,962	2.27	6.83	20.7	2,955
		0.30	310	0.34	0.26	0.86	37.7	0.50	2,312	2.55	8.57	25.8	3,429
		0.25	370	0.32	0.23	0.84	36.3	0.46	2,580	2.78	10.1	29.6	3,795
		0.22	400	0.30	0.22	0.84	35.4	0.45	2,691	2.88	10.8	31.2	3,951
		0.20	420	0.30	0.22	0.83	34.8	0.44	2,754	2.94	11.3	32.2	4,040

Area & Class	Deposit	CuEq Cut-off (%)	Tonnage (Mt)	Cu (%)	Au (g/t)	Ag (g/t)	Mo (ppm)	CuEq (%)	Contained Metal Cu (Mlb)	Contained Metal Au (Moz)	Contained Metal Ag (Moz)	Contained Metal Mo (Mlb)	Contained Metal CuEq (Mlb)
Southern Oyu Underground – INFERRED	CENTRAL DEPOSIT	3.50	-	-	-	-	-	-	-	-	-	-	-
		3.00	-	-	-	-	-	-	-	-	-	-	-
		2.50	-	-	-	-	-	-	-	-	-	-	-
		2.00	-	-	-	-	-	-	-	-	-	-	-
		1.50	0.017	1.10	1.02	0.92	67.1	1.76	0.40	0.0005	0.0005	0.0024	0.64
		1.00	0.33	0.87	0.36	0.66	39.9	1.11	6.44	0.0039	0.0071	0.029	8.15
		0.90	0.74	0.80	0.35	0.70	38.6	1.02	13.0	0.0082	0.017	0.063	16.6
		0.80	1.74	0.73	0.30	0.77	38.6	0.92	28.0	0.017	0.043	0.15	35.4
		0.70	3.12	0.67	0.27	0.77	41.6	0.84	46.2	0.027	0.078	0.29	57.9
		0.60	4.92	0.62	0.23	0.78	44.9	0.77	67.8	0.036	0.12	0.49	83.6
		0.50	7.57	0.56	0.20	0.76	41.3	0.69	93.8	0.049	0.18	0.69	115
		0.45	9.90	0.52	0.19	0.74	40.0	0.64	114	0.059	0.24	0.87	140
		0.40	13.0	0.48	0.17	0.72	38.1	0.59	137	0.071	0.30	1.09	168
		0.37	15.1	0.46	0.16	0.71	36.8	0.56	152	0.078	0.34	1.22	186
		0.35	16.5	0.44	0.16	0.70	35.8	0.54	161	0.084	0.37	1.30	198
		0.30	20.7	0.41	0.15	0.68	33.6	0.50	186	0.097	0.46	1.54	228
		0.25	24.8	0.37	0.14	0.68	32.4	0.46	205	0.11	0.54	1.77	253
		0.22	27.8	0.35	0.13	0.68	31.4	0.44	217	0.12	0.61	1.92	268
		0.20	30.4	0.34	0.13	0.67	30.8	0.42	226	0.12	0.66	2.06	280

Area & Class	Deposit	CuEq Cut-off (%)	Tonnage (Mt)	Cu (%)	Au (g/t)	Ag (g/t)	Mo (ppm)	CuEq (%)	Contained Metal				
									Cu (Mlb)	Au (Moz)	Ag (Moz)	Mo (Mlb)	CuEq (Mlb)
Southern Oyu Underground – INFERRED	ALL SOUTHERN OYU DEPOSITS	3.50	-	-	-	-	-	-	-	-	-	-	-
		3.00	-	-	-	-	-	-	-	-	-	-	-
		2.50	-	-	-	-	-	-	-	-	-	-	-
		2.00	0.12	0.99	1.90	3.47	31.5	2.20	2.59	0.0072	0.013	0.0082	5.75
		1.50	0.92	0.72	1.63	2.23	31.6	1.76	14.5	0.048	0.066	0.064	35.5
		1.00	8.78	0.73	0.75	1.42	29.5	1.21	142	0.21	0.40	0.57	234
		0.90	15.4	0.70	0.62	1.24	29.2	1.10	237	0.31	0.61	0.99	371
		0.80	27.0	0.65	0.52	1.12	29.5	0.99	390	0.46	0.97	1.76	589
		0.70	43.4	0.58	0.49	1.02	30.9	0.90	556	0.69	1.42	2.96	858
		0.60	70.5	0.52	0.44	0.95	32.8	0.80	809	0.99	2.16	5.10	1,243
		0.50	127	0.45	0.37	0.91	36.3	0.69	1,262	1.50	3.72	10.1	1,919
		0.45	166	0.42	0.34	0.89	38.2	0.64	1,540	1.79	4.75	14.0	2,325
		0.40	207	0.40	0.31	0.88	38.8	0.59	1,810	2.08	5.84	17.7	2,718
		0.37	237	0.38	0.29	0.87	38.5	0.57	1,988	2.24	6.62	20.1	2,968
		0.35	260	0.37	0.28	0.86	38.3	0.55	2,123	2.36	7.21	22.0	3,153
		0.30	331	0.34	0.25	0.85	37.4	0.50	2,497	2.65	9.03	27.3	3,657
		0.25	395	0.32	0.23	0.83	36.0	0.46	2,785	2.89	10.6	31.4	4,048
		0.22	428	0.31	0.22	0.83	35.1	0.45	2,908	3.00	11.4	33.2	4,219
		0.20	450	0.30	0.21	0.82	34.5	0.44	2,981	3.06	11.9	34.3	4,320

Note: 1) Mineral Resources are reported using a 0.37% copper equivalency cut-off grade.

2) Mineral Resources are contained within a conceptual mining block (UG4) that uses a copper price of \$2.81/lb Cu and a gold price of \$970/oz Au, and recoveries sourced from "Base Data Template No. 29" dated November 2011.

3) The copper equivalency is calculated using the formula CuEq = %Cu + (g/t Au) x (11.25 / 17.64). This formula assumes 100% Cu and Au recoveries. Mo and Ag are not used to estimate the copper equivalency grade. As is a deleterious element and not a value contributor.

4) Mineral Resources are inclusive of Mineral Reserves.

5) Mineral Resources that are not Mineral Reserves do not have demonstrated economic viability.

6) Rounding as required by reporting guidelines may result in apparent summation differences.

Table 14.33 Indicated Mineral Resources – Hugo North, Effective Date 19 March 2013 (base-case is highlighted)

Area & Class	Owner	CuEq Cut-off (%)	Tonnage (Mt)	Cu (%)	Au (g/t)	Ag (g/t)	Mo (ppm)	CuEq (%)	Contained Metal				
									Cu (Mlb)	Au (Moz)	Ag (Moz)	Mo (Mlb)	CuEq (Mlb)
Hugo North – INDICATED	OT LLC	3.50	125	3.75	0.93	7.13	34.0	4.34	10,335	3.76	28.7	9.38	11,979
		3.00	175	3.49	0.84	6.82	34.2	4.03	13,508	4.71	38.4	13.20	15,569
		2.50	228	3.25	0.76	6.49	33.9	3.73	16,343	5.56	47.6	17.05	18,772
		2.00	277	3.03	0.69	6.14	33.7	3.47	18,490	6.18	54.7	20.60	21,193
		1.50	356	2.69	0.61	5.55	35.2	3.08	21,111	7.00	63.5	27.65	24,172
		1.00	541	2.15	0.47	4.53	39.5	2.44	25,631	8.10	78.8	47.2	29,172
		0.90	585	2.05	0.44	4.35	40.4	2.33	26,455	8.30	81.8	52.1	30,085
		0.80	626	1.97	0.42	4.20	41.1	2.24	27,142	8.48	84.5	56.7	30,850
		0.70	667	1.89	0.40	4.06	41.8	2.15	27,747	8.64	86.9	61.4	31,525
		0.60	703	1.82	0.39	3.94	42.3	2.07	28,214	8.77	89.0	65.6	32,050
		0.50	736	1.76	0.38	3.84	42.5	2.00	28,563	8.88	90.7	68.9	32,445
		0.45	750	1.74	0.37	3.79	42.5	1.97	28,696	8.92	91.4	70.3	32,596
		0.40	765	1.71	0.36	3.74	42.5	1.94	28,820	8.95	92.0	71.7	32,736
		0.37	775	1.69	0.36	3.71	42.5	1.92	28,893	8.98	92.4	72.6	32,818
		0.35	781	1.68	0.36	3.69	42.5	1.91	28,936	8.99	92.7	73.1	32,866
		0.30	798	1.65	0.35	3.64	42.5	1.88	29,048	9.02	93.3	74.7	32,990
		0.25	818	1.62	0.34	3.57	42.4	1.84	29,159	9.04	94.0	76.5	33,113
		0.22	831	1.59	0.34	3.53	42.4	1.81	29,218	9.06	94.4	77.6	33,179
		0.20	840	1.58	0.34	3.51	42.3	1.79	29,257	9.07	94.7	78.4	33,221

Area & Class	Owner	CuEq Cut-off (%)	Tonnage (Mt)	Cu (%)	Au (g/t)	Ag (g/t)	Mo (ppm)	CuEq (%)	Contained Metal				
									Cu (Mlb)	Au (Moz)	Ag (Moz)	Mo (Mlb)	CuEq (Mlb)
Hugo North – INDICATED	ENTRÉE	3.50	22.3	3.68	1.43	7.92	46.9	4.59	1,809	1.03	5.68	2.31	2,258
		3.00	32.0	3.36	1.29	7.45	43.8	4.18	2,370	1.33	7.67	3.09	2,952
		2.50	42.4	3.08	1.17	7.03	40.6	3.83	2,881	1.60	9.57	3.79	3,581
		2.00	52.3	2.84	1.09	6.62	38.0	3.53	3,270	1.83	11.1	4.38	4,072
		1.50	65.4	2.56	0.96	6.10	35.4	3.17	3,687	2.02	12.8	5.11	4,571
		1.00	84.7	2.22	0.80	5.42	33.5	2.73	4,142	2.19	14.8	6.26	5,099
		0.90	89.7	2.14	0.77	5.25	33.4	2.63	4,235	2.21	15.1	6.61	5,202
		0.80	96.7	2.04	0.72	5.01	33.6	2.50	4,353	2.24	15.6	7.17	5,333
		0.70	107	1.91	0.66	4.68	34.4	2.33	4,517	2.27	16.2	8.13	5,508
		0.60	117	1.80	0.61	4.43	35.2	2.19	4,645	2.29	16.7	9.08	5,645
		0.50	124	1.73	0.58	4.27	35.7	2.10	4,724	2.30	17.0	9.76	5,731
		0.45	127	1.70	0.56	4.20	35.7	2.06	4,757	2.31	17.2	10.0	5,766
		0.40	130	1.67	0.55	4.13	35.7	2.02	4,782	2.31	17.3	10.3	5,794
		0.37	132	1.65	0.55	4.09	35.7	2.00	4,796	2.32	17.4	10.4	5,809
		0.35	134	1.63	0.54	4.06	35.7	1.98	4,807	2.32	17.4	10.5	5,821
		0.30	138	1.59	0.52	3.97	35.6	1.93	4,836	2.32	17.6	10.8	5,852
		0.25	143	1.54	0.51	3.85	35.2	1.86	4,867	2.33	17.7	11.1	5,885
		0.22	146	1.51	0.50	3.79	34.9	1.83	4,882	2.33	17.8	11.3	5,901
		0.20	149	1.49	0.49	3.74	34.7	1.80	4,893	2.33	17.9	11.4	5,913

Area & Class	Owner	CuEq Cut-off (%)	Tonnage (Mt)	Cu (%)	Au (g/t)	Ag (g/t)	Mo (ppm)	CuEq (%)	Contained Metal				
									Cu (Mlb)	Au (Moz)	Ag (Moz)	Mo (Mlb)	CuEq (Mlb)
Hugo North – INDICATED	TOTAL OT LLC and ENTRÉE	3.50	147	3.74	1.01	7.25	35.9	4.38	12,144	4.79	34.4	11.7	14,237
		3.00	207	3.47	0.91	6.92	35.6	4.05	15,879	6.04	46.1	16.3	18,522
		2.50	270	3.22	0.82	6.57	34.9	3.75	19,224	7.16	57.2	20.8	22,353
		2.00	329	3.00	0.76	6.22	34.4	3.48	21,760	8.02	65.8	25.0	25,265
		1.50	421	2.67	0.67	5.64	35.3	3.10	24,798	9.02	76.3	32.8	28,743
		1.00	626	2.16	0.51	4.65	38.7	2.48	29,773	10.3	93.5	53.4	34,270
		0.90	675	2.06	0.48	4.47	39.5	2.37	30,689	10.5	96.9	58.7	35,287
		0.80	722	1.98	0.46	4.31	40.1	2.27	31,496	10.7	100	63.9	36,183
		0.70	774	1.89	0.44	4.14	40.8	2.17	32,264	10.9	103	69.6	37,034
		0.60	820	1.82	0.42	4.01	41.3	2.09	32,859	11.1	106	74.6	37,695
		0.50	859	1.76	0.40	3.90	41.5	2.01	33,288	11.2	108	78.7	38,176
		0.45	877	1.73	0.40	3.85	41.5	1.98	33,453	11.2	109	80.3	38,362
		0.40	895	1.70	0.39	3.80	41.5	1.95	33,603	11.3	109	82.0	38,531
		0.37	907	1.69	0.39	3.77	41.5	1.93	33,689	11.3	110	83.0	38,627
		0.35	914	1.67	0.38	3.75	41.5	1.92	33,743	11.3	110	83.6	38,687
		0.30	936	1.64	0.38	3.68	41.4	1.88	33,884	11.3	111	85.5	38,843
		0.25	962	1.61	0.37	3.61	41.3	1.84	34,026	11.4	112	87.6	38,998
		0.22	977	1.58	0.36	3.57	41.2	1.81	34,101	11.4	112	88.9	39,080
		0.20	989	1.57	0.36	3.54	41.2	1.79	34,150	11.4	113	89.8	39,135

Note: 1) Mineral Resources are reported using a base case 0.37% copper equivalency cut-off grade. Other cases shown in this table are sensitivity cases.
2) The copper equivalency is calculated using the formula CuEq = Cu% + (Au g/t) x (11.25 / 17.64). This formula assumes 100% Cu and Au recoveries.
3) Mineral Resources are inclusive of Mineral Reserves.
4) Mineral Resources that are not also reported as Mineral Reserves have not been demonstrated to have economic viability.
5) Rounding as required by reporting guidelines may result in apparent summation differences.

Table 14.34 Inferred Mineral Resources – Hugo North, Effective Date 19 March 2013 (base-case is highlighted)

Area & Class	Owner	CuEq Cut-off (%)	Tonnage (Mt)	Cu (%)	Au (g/t)	Ag (g/t)	Mo (ppm)	CuEq (%)	Contained Metal				
									Cu (Mlb)	Au (Moz)	Ag (Moz)	Mo (Mlb)	CuEq (Mlb)
Hugo North – INFERRED	OT LLC	3.50	3.64	3.06	1.41	5.98	37.0	3.96	245	0.16	0.70	0.30	318
		3.00	12.9	2.80	0.98	6.07	42.3	3.43	795	0.41	2.51	1.20	972
		2.50	29.0	2.43	0.96	5.78	40.0	3.04	1,554	0.89	5.39	2.56	1,945
		2.00	54.6	2.08	0.91	5.27	35.9	2.66	2,505	1.60	9.25	4.33	3,204
		1.50	128	1.69	0.65	4.32	32.7	2.10	4,754	2.67	17.7	9.20	5,923
		1.00	385	1.25	0.41	3.33	36.0	1.51	10,604	5.06	41.3	30.5	12,815
		0.90	451	1.18	0.38	3.20	37.8	1.43	11,787	5.53	46.4	37.6	14,204
		0.80	530	1.12	0.35	3.03	39.9	1.34	13,042	6.02	51.7	46.7	15,675
		0.70	612	1.05	0.33	2.88	41.5	1.26	14,191	6.48	56.6	56.0	17,026
		0.60	722	0.98	0.30	2.70	42.6	1.17	15,523	7.03	62.6	67.8	18,598
		0.50	841	0.90	0.28	2.54	42.6	1.08	16,707	7.61	68.7	79.1	20,033
		0.45	910	0.86	0.27	2.47	42.4	1.03	17,293	7.91	72.1	85.0	20,752
		0.40	974	0.83	0.26	2.39	42.0	0.99	17,784	8.15	74.9	90.2	21,350
		0.37	1,015	0.81	0.25	2.34	41.9	0.97	18,081	8.28	76.4	93.8	21,701
		0.35	1,042	0.80	0.25	2.31	41.9	0.95	18,260	8.35	77.4	96.3	21,913
		0.30	1,108	0.76	0.24	2.24	41.9	0.92	18,668	8.50	79.6	102	22,385
		0.25	1,171	0.74	0.23	2.17	41.4	0.88	19,000	8.62	81.6	107	22,769
		0.22	1,207	0.72	0.22	2.13	41.1	0.86	19,160	8.67	82.6	109	22,953
		0.20	1,231	0.71	0.22	2.10	40.8	0.85	19,257	8.71	83.2	111	23,065

Area & Class	Owner	CuEq Cut-off (%)	Tonnage (Mt)	Cu (%)	Au (g/t)	Ag (g/t)	Mo (ppm)	CuEq (%)	Contained Metal				
									Cu (Mlb)	Au (Moz)	Ag (Moz)	Mo (Mlb)	CuEq (Mlb)
Hugo North – INFERRED	ENTRÉE	3.50	1.41	3.32	1.03	5.31	32.1	3.98	103	0.05	0.24	0.10	124
		3.00	3.62	2.97	0.88	5.79	34.3	3.53	237	0.10	0.67	0.27	282
		2.50	5.85	2.68	0.87	5.63	33.1	3.23	346	0.16	1.06	0.43	417
		2.00	11.0	2.21	0.86	5.12	27.2	2.76	533	0.30	1.80	0.66	666
		1.50	29.1	1.73	0.58	4.42	21.7	2.10	1,108	0.54	4.13	1.39	1,345
		1.00	62.2	1.39	0.39	3.77	22.6	1.64	1,909	0.78	7.54	3.10	2,250
		0.90	70.0	1.33	0.37	3.62	23.6	1.56	2,054	0.82	8.14	3.65	2,414
		0.80	78.2	1.27	0.34	3.47	24.5	1.49	2,190	0.87	8.72	4.23	2,568
		0.70	86.9	1.21	0.32	3.29	25.6	1.42	2,318	0.90	9.21	4.90	2,713
		0.60	95.5	1.15	0.31	3.14	26.4	1.35	2,425	0.94	9.62	5.56	2,835
		0.50	105	1.09	0.29	2.96	26.6	1.27	2,526	0.98	10.0	6.16	2,952
		0.45	113	1.04	0.28	2.79	25.7	1.22	2,596	1.01	10.2	6.44	3,038
		0.40	127	0.96	0.26	2.54	24.2	1.13	2,708	1.05	10.4	6.79	3,169
		0.37	134	0.93	0.25	2.44	23.6	1.09	2,756	1.08	10.5	6.99	3,228
		0.35	140	0.91	0.24	2.37	23.2	1.06	2,789	1.10	10.6	7.14	3,270
		0.30	152	0.85	0.23	2.20	22.0	1.00	2,857	1.15	10.8	7.38	3,360
		0.25	162	0.81	0.23	2.10	21.3	0.96	2,903	1.18	10.9	7.61	3,418
		0.22	165	0.80	0.22	2.07	21.3	0.94	2,919	1.18	11.0	7.76	3,437
		0.20	168	0.79	0.22	2.05	21.2	0.93	2,929	1.19	11.1	7.84	3,448

Area & Class	Owner	CuEq Cut-off (%)	Tonnage (Mt)	Cu (%)	Au (g/t)	Ag (g/t)	Mo (ppm)	CuEq (%)	Contained Metal				
									Cu (Mlb)	Au (Moz)	Ag (Moz)	Mo (Mlb)	CuEq (Mlb)
Hugo North – INFERRED	TOTAL OT LLC and ENTRÉE	3.50	5.05	3.13	1.30	5.80	35.7	3.96	349	0.21	0.94	0.40	441
		3.00	16.5	2.84	0.96	6.01	40.6	3.45	1,032	0.51	3.19	1.47	1,254
		2.50	34.9	2.47	0.94	5.75	38.8	3.07	1,900	1.06	6.45	2.98	2,362
		2.00	65.6	2.10	0.90	5.24	34.5	2.68	3,038	1.90	11.1	4.99	3,870
		1.50	157	1.70	0.64	4.34	30.7	2.10	5,862	3.21	21.9	10.6	7,267
		1.00	447	1.27	0.41	3.40	34.1	1.53	12,513	5.84	48.8	33.6	15,065
		0.90	521	1.20	0.38	3.25	35.9	1.45	13,841	6.35	54.5	41.3	16,619
		0.80	608	1.14	0.35	3.09	38.0	1.36	15,232	6.89	60.4	50.9	18,243
		0.70	699	1.07	0.33	2.93	39.5	1.28	16,509	7.38	65.8	60.9	19,739
		0.60	818	1.00	0.30	2.75	40.7	1.19	17,948	7.97	72.2	73.4	21,433
		0.50	947	0.92	0.28	2.59	40.8	1.10	19,232	8.58	78.7	85.2	22,986
		0.45	1,023	0.88	0.27	2.50	40.5	1.05	19,890	8.92	82.3	91.4	23,790
		0.40	1,101	0.84	0.26	2.41	40.0	1.01	20,493	9.21	85.3	97.0	24,519
		0.37	1,150	0.82	0.25	2.35	39.8	0.98	20,837	9.36	87.0	101	24,930
		0.35	1,181	0.81	0.25	2.32	39.7	0.97	21,049	9.45	88.0	103	25,182
		0.30	1,260	0.77	0.24	2.23	39.5	0.93	21,525	9.65	90.4	110	25,744
		0.25	1,333	0.75	0.23	2.16	39.0	0.89	21,903	9.80	92.5	115	26,187
		0.22	1,372	0.73	0.22	2.12	38.7	0.87	22,079	9.86	93.6	117	26,390
		0.20	1,399	0.72	0.22	2.10	38.5	0.86	22,186	9.89	94.3	119	26,513

Note: 1) Mineral Resources are reported using a base case 0.37% copper equivalency cut-off grade. Other cases shown in this table are sensitivity cases.
2) The copper equivalency is calculated using the formula CuEq = Cu% + (Au g/t) x (11.25 / 17.64). This formula assumes 100% Cu and Au recoveries.
3) Mineral Resources are inclusive of Mineral Reserves.
4) Mineral Resources that are not also reported as Mineral Reserves have not been demonstrated to have economic viability.
5) Rounding as required by reporting guidelines may result in apparent summation differences.

Table 14.35 Inferred Mineral Resources – Hugo South, Effective Date 19 March 2013 (base-case is highlighted)

Area & Class	Owner	CuEq Cut-off (%)	Tonnage (Mt)	Cu (%)	Au (g/t)	Ag (g/t)	Mo (ppm)	CuEq (%)	Contained Metal				
									Cu (Mlb)	Au (Moz)	Ag (Moz)	Mo (Mlb)	CuEq (Mlb)
Hugo South – INFERRED	OT LLC	3.50	4.96	3.70	0.25	6.20	41.5	3.86	405	0.040	0.99	0.45	422
		3.00	11.2	3.37	0.21	5.59	41.1	3.50	835	0.076	2.02	1.02	868
		2.50	21.7	3.01	0.18	5.12	43.7	3.13	1,439	0.12	3.57	2.09	1,492
		2.00	37.9	2.65	0.15	4.62	44.6	2.75	2,217	0.18	5.63	3.73	2,297
		1.50	67.4	2.20	0.12	3.86	46.3	2.28	3,275	0.27	8.36	6.89	3,392
		1.00	191	1.55	0.087	2.79	53.2	1.60	6,502	0.54	17.1	22.4	6,737
		0.90	224	1.45	0.087	2.67	55.4	1.50	7,162	0.63	19.2	27.4	7,438
		0.80	289	1.30	0.087	2.49	60.2	1.36	8,285	0.81	23.2	38.4	8,641
		0.70	378	1.16	0.085	2.33	64.9	1.21	9,665	1.03	28.3	54.1	10,115
		0.60	455	1.07	0.082	2.21	66.7	1.12	10,689	1.20	32.3	66.9	11,213
		0.50	553	0.97	0.078	2.07	67.6	1.02	11,782	1.39	36.8	82.4	12,391
		0.45	628	0.90	0.075	1.97	67.8	0.95	12,517	1.52	39.8	93.9	13,181
		0.40	736	0.83	0.072	1.86	67.5	0.87	13,442	1.69	44.0	109	14,182
		0.37	820	0.78	0.069	1.79	66.8	0.82	14,095	1.82	47.1	121	14,892
		0.35	883	0.75	0.067	1.74	66.1	0.79	14,559	1.92	49.5	129	15,397
		0.30	1,056	0.67	0.064	1.65	63.9	0.71	15,677	2.17	55.9	149	16,626
		0.25	1,242	0.61	0.060	1.56	61.1	0.65	16,702	2.41	62.2	167	17,756
		0.22	1,346	0.58	0.058	1.51	59.5	0.62	17,189	2.53	65.6	177	18,294
		0.20	1,412	0.56	0.057	1.49	58.5	0.60	17,463	2.60	67.6	182	18,599

Note: 1) Mineral Resources are reported using a base case 0.37% copper equivalency cut-off grade. Other cases shown in this table are sensitivity cases.
2) The copper equivalency is calculated using the formula CuEq = Cu% + (Au g/t) x (11.25 / 17.64). This formula assumes 100% Cu and Au recoveries.
3) Mineral Resources are inclusive of Mineral Reserves.
4) Mineral Resources that are not also reported as Mineral Reserves have not been demonstrated to have economic viability.
5) Rounding as required by reporting guidelines may result in apparent summation differences.

Table 14.36 Inferred Mineral Resources – Heruga, Effective Date 19 March 2013 (base case is highlighted)

Area & Class	Owner	CuEq Cut-off (%)	Tonnage (Mt)	Cu (%)	Au (g/t)	Ag (g/t)	Mo (ppm)	CuEq (%)	Contained Metal				
									Cu (Mlb)	Au (Moz)	Ag (Moz)	Mo (Mlb)	CuEq (Mlb)
Heruga – INFERRED	OT LLC	3.50	-	-	-	-	-	-	-	-	-	-	-
		3.00	-	-	-	-	-	-	-	-	-	-	-
		2.50	-	-	-	-	-	-	-	-	-	-	-
		2.00	-	-	-	-	-	-	-	-	-	-	-
		1.50	0.12	0.58	1.45	1.27	52.2	1.54	1.56	0.0056	0.0049	0.014	4.10
		1.00	5.67	0.55	0.85	1.58	107	1.15	68.5	0.16	0.29	1.34	144
		0.90	11.2	0.54	0.68	1.57	130	1.05	133	0.25	0.57	3.21	258
		0.80	22.0	0.53	0.55	1.60	136	0.95	255	0.39	1.13	6.61	461
		0.70	41.9	0.50	0.44	1.63	133	0.85	467	0.59	2.20	12.3	789
		0.60	63.2	0.48	0.37	1.65	128	0.79	671	0.75	3.35	17.8	1,095
		0.50	85.5	0.45	0.33	1.62	122	0.72	847	0.90	4.45	22.9	1,363
		0.45	101	0.42	0.31	1.58	115	0.68	947	1.01	5.14	25.7	1,527
		0.40	113	0.41	0.30	1.56	111	0.66	1,021	1.08	5.70	27.7	1,643
		0.37	120	0.40	0.29	1.54	108	0.64	1,060	1.12	5.97	28.8	1,702
		0.35	123	0.39	0.29	1.53	107	0.63	1,075	1.13	6.09	29.2	1,726
		0.30	131	0.38	0.28	1.51	104	0.62	1,107	1.17	6.35	30.1	1,778
		0.25	137	0.38	0.27	1.49	102	0.60	1,131	1.19	6.54	30.7	1,815
		0.22	140	0.37	0.27	1.47	100	0.59	1,142	1.20	6.62	30.9	1,831
		0.20	142	0.37	0.26	1.46	99.6	0.59	1,147	1.20	6.66	31.1	1,840

Area & Class	Owner	CuEq Cut-off (%)	Tonnage (Mt)	Cu (%)	Au (g/t)	Ag (g/t)	Mo (ppm)	CuEq (%)	Contained Metal				
									Cu (Mlb)	Au (Moz)	Ag (Moz)	Mo (Mlb)	CuEq (Mlb)
Heruga – INFERRED	ENTRÉE	3.50	-	-	-	-	-	-	-	-	-	-	-
		3.00	-	-	-	-	-	-	-	-	-	-	-
		2.50	1.35	0.83	3.40	4.00	87.3	3.04	24.6	0.15	0.17	0.26	90.6
		2.00	5.76	0.66	2.60	3.66	121	2.39	84.4	0.48	0.68	1.54	303
		1.50	28.7	0.57	1.86	2.59	124	1.83	362	1.72	2.39	7.86	1,155
		1.00	189	0.57	0.96	1.99	155	1.26	2,365	5.83	12.1	64.5	5,258
		0.90	294	0.56	0.80	1.92	160	1.15	3,601	7.52	18.1	104	7,442
		0.80	447	0.54	0.66	1.85	160	1.05	5,308	9.53	26.5	157	10,314
		0.70	657	0.51	0.56	1.75	151	0.95	7,386	11.9	36.9	219	13,775
		0.60	910	0.48	0.49	1.63	141	0.87	9,570	14.4	47.8	283	17,387
		0.50	1,214	0.44	0.43	1.51	130	0.79	11,775	17.0	59.0	349	21,056
		0.45	1,411	0.42	0.41	1.45	123	0.74	13,003	18.5	65.9	383	23,114
		0.40	1,670	0.39	0.38	1.39	115	0.69	14,425	20.3	74.6	422	25,538
		0.37	1,824	0.38	0.36	1.35	110	0.67	15,190	21.2	79.4	444	26,846
		0.35	1,931	0.37	0.35	1.33	107	0.65	15,693	21.9	82.6	457	27,694
		0.30	2,177	0.35	0.33	1.28	102	0.61	16,734	23.2	89.6	488	29,468
		0.25	2,361	0.33	0.32	1.24	97.4	0.59	17,383	24.0	94.2	507	30,588
		0.22	2,454	0.33	0.31	1.22	95.2	0.57	17,665	24.4	96.3	515	31,070
		0.20	2,509	0.32	0.30	1.21	93.8	0.57	17,813	24.6	97.4	519	31,324

Area & Class	Owner	CuEq Cut-off (%)	Tonnage (Mt)	Cu (%)	Au (g/t)	Ag (g/t)	Mo (ppm)	CuEq (%)	Contained Metal				
									Cu (Mlb)	Au (Moz)	Ag (Moz)	Mo (Mlb)	CuEq (Mlb)
Heruga – INFERRED	TOTAL OT LLC and ENTRÉE	3.50	-	-	-	-	-	-	-	-	-	-	-
		3.00	-	-	-	-	-	-	-	-	-	-	-
		2.50	1.35	0.83	3.40	4.00	87.3	3.04	24.6	0.15	0.17	0.26	90.6
		2.00	5.76	0.66	2.60	3.66	121	2.39	84.4	0.48	0.68	1.54	303
		1.50	28.8	0.57	1.86	2.59	124	1.83	364	1.72	2.39	7.88	1,159
		1.00	195	0.57	0.96	1.98	153	1.26	2,433	5.98	12.4	65.9	5,402
		0.90	305	0.56	0.79	1.91	159	1.15	3,735	7.76	18.7	107	7,700
		0.80	470	0.54	0.66	1.83	158	1.04	5,564	9.92	27.7	164	10,775
		0.70	699	0.51	0.56	1.74	150	0.94	7,853	12.5	39.1	232	14,564
		0.60	973	0.48	0.48	1.63	140	0.86	10,241	15.2	51.1	301	18,481
		0.50	1,299	0.44	0.43	1.52	130	0.78	12,622	17.9	63.5	372	22,419
		0.45	1,512	0.42	0.40	1.46	122	0.74	13,950	19.5	71.0	408	24,641
		0.40	1,783	0.39	0.37	1.40	114	0.69	15,447	21.4	80.3	450	27,181
		0.37	1,944	0.38	0.36	1.37	110	0.67	16,249	22.4	85.3	473	28,548
		0.35	2,054	0.37	0.35	1.34	107	0.65	16,767	23.0	88.7	487	29,420
		0.30	2,308	0.35	0.33	1.29	102	0.61	17,841	24.3	95.9	518	31,246
		0.25	2,498	0.34	0.31	1.25	97.7	0.59	18,514	25.2	101	538	32,403
		0.22	2,594	0.33	0.31	1.23	95.5	0.58	18,806	25.6	103	546	32,900
		0.20	2,651	0.32	0.30	1.22	94.1	0.57	18,960	25.8	104	550	33,163

Note: 1) Mineral Resources are reported using a base case 0.37% copper equivalency cut-off grade. Other cases shown in this table are sensitivity cases.

2) The copper equivalency is calculated using the formula CuEq = Cu% + ((Au g/t x 18.98) + (Mo g/t x 0.01586)) / 29.76. This formula assumes 91% Au recovery and 72% Mo recovery.

3) Mineral Resources are inclusive of Mineral Reserves.

4) Mineral Resources that are not also reported as Mineral Reserves have not been demonstrated to have economic viability.

5) Rounding as required by reporting guidelines may result in apparent summation differences.

14.5 Factors That Could Affect the Mineral Resource Estimates

Areas of uncertainty that could materially affect the Mineral Resource estimates include the following:

- Commodity pricing.
- Interpretations of fault geometries.
- Effect of alteration as a control on mineralization.
- Lithological interpretations on a local scale, including dyke modelling and discrimination of different Qmd phases.
- Pit slope angles.
- Geotechnical assumptions related to the proposed block cave design.
- Metal recovery assumptions.
- Dilution considerations.
- Contaminants such as arsenic and fluorine.
- Estimates of operating costs used to support reasonable prospects assessment.
- Changes to drill spacings and number of drillhole composites used to support classification categories.

15 MINERAL RESERVE ESTIMATES

15.1 Mineral Reserve

The Mineral Reserves for the project have been estimated using the Southern Oyu and Hugo North Mineral Resources. Total Mineral Reserves for the project and the OT LLC and EJV Mineral Reserves for the open pit and underground components of the project are shown in Table 15.1. The Mineral Reserves for the 2013 OTTR are based on mine planning work prepared by OT LLC. Mine designs were prepared using industry-standard mining software, assumed metal prices as described in the notes to the Mineral Reserves, and smelter terms as set forth in Section 22. The report only considers Mineral Resources in the Measured and Indicated categories, and engineering that has been carried out to a feasibility level or better to estimate the open pit and underground Mineral Reserve.

Table 15.1 Total Oyu Tolgoi Project 2013 Mineral Reserve, 25 March 2013

Deposit	Ore (Mt)	NSR ($/t)	Cu (%)	Au (g/t)	Ag (g/t)	Recovered Metal		
						Copper (Mlb)	Gold (koz)	Silver (koz)
Southern Oyu Deposits								
Proven	433	31.09	0.53	0.42	1.37	4,175	4,388	14,860
Probable	616	21.46	0.40	0.24	1.13	4,462	3,378	17,264
Mineral Reserve (Proven + Probable)	1,048	25.44	0.46	0.31	1.23	8,637	7,766	32,124
Hugo Dummett Deposits								
Probable (Hugo North – OT LLC)	460	93.45	1.80	0.37	3.74	16,759	4,602	47,647
Probable (Hugo North – EJV Shivee Tolgoi)	31	95.21	1.73	0.62	3.74	1,090	521	3,229
Mineral Reserve (Probable) (All Hugo North)	491	93.57	1.80	0.39	3.74	17,849	5,123	50,877
Oyu Tolgoi Project Mineral Reserve								
Proven	433	31.09	0.53	0.42	1.37	4,175	4,388	14,860
Probable	1,107	53.46	1.02	0.30	2.29	22,311	8,501	68,141
Mineral Reserve (Proven + Probable)	1,539	47.17	0.89	0.34	2.03	26,486	12,889	83,001

Notes:

1. Metal prices used for calculating the Southern Oyu open pit NSR and the Hugo North underground Net Smelter Return (NSR) are as follows: copper at $2.81/lb; gold at $970/oz; and silver at $15.50/oz, all based on long-term metal price forecasts at the beginning of the mineral reserve work. The analysis indicates that the mineral reserve is still valid at these metal prices.
2. The NSR has been calculated with assumptions for smelter refining and treatment charges, deductions and payment terms, concentrate transport, metallurgical recoveries and royalties.
3. For the open pit processing and general administration, the following operating costs have been used to determine cut-off grades: Southwest at $8.37/t, Central Chalcocite, Central Covellite, and Central Chalcopyrite at $7.25/t.
4. For the underground block cave, all mineral resources within the shell have been converted to mineral reserves. This includes low grade Indicated mineral resources and Inferred mineral resources, which has been assigned a zero grade and treated as dilution.
5. Only Measured mineral resources were used to report Proven mineral reserves and only Indicated mineral resources were used to report Probable mineral reserves.
6. EJV is the Entrée Joint Venture. The Shivee Tolgoi Licence and the Javkhlant Licence are held by Entrée. The Shivee Tolgoi Licence and the Javkhlant Licence are planned to be operated by OT LLC. OT LLC will receive 80% of cash flows after capital and operating costs for material originating below 560m, and 70% above this depth.
7. The base case financial analysis has been prepared using the following current long term metal price estimates: copper at $2.87/lb; gold at $1,350/oz; and silver at $23.50/oz. Metal prices are assumed to fall from current prices to the long term average over five years.
8. The mineral reserves reported above are not additive to the mineral resources.

The Hugo North Mineral Reserve contains ore that is on the OT LLC Oyu Tolgoi licence and on the EJV Shivee Tolgoi licence. The EJV Shivee Tolgoi licence is subject to a joint venture agreement (EJV) between OT LLC and Entrée Gold. The part of the Mineral Reserve that is on the Oyu Tolgoi licence and is 100% owned by OT LLC is shown in Table 15.2. The part of the Mineral Reserve that is on the EJV Shivee Tolgoi licence and is subject to the OT LLC Entrée Gold joint venture agreement is shown in Table 15.3.

Table 15.2 OT LLC Oyu Tolgoi Project Mineral Reserve, 25 March 2013

Classification	Ore (Mt)	NSR ($/t)	Cu (%)	Au (g/t)	Ag (g/t)	Recovered Metal		
						Copper (Mlb)	Gold (koz)	Silver (koz)
Proven	433	31.09	0.53	0.42	1.37	4,175	4,388	14,860
Probable	1,075	52.25	1.00	0.29	2.25	21,221	7,980	64,912
Total OT LLC	1,508	46.18	0.87	0.33	2.00	25,396	12,368	79,772

Notes:

1. Metal prices used for calculating the Southern Oyu open pit NSR and the Hugo North underground Net Smelter Return (NSR) are as follows: copper at $2.81/lb; gold at $970/oz; and silver at $15.50/oz, all based on long-term metal price forecasts at the beginning of the mineral reserve work. The analysis indicates that the mineral reserve is still valid at these metal prices.
2. The NSR has been calculated with assumptions for smelter refining and treatment charges, deductions and payment terms, concentrate transport, metallurgical recoveries and royalties.
3. For the open pit processing and general administration, the following operating costs have been used to determine cut-off grades: Southwest at $8.37/t, Central Chalcocite, Central Covellite, and Central Chalcopyrite at $7.25/t.
4. For the underground block cave, all mineral resources within the shell have been converted to mineral reserves. This includes low grade Indicated mineral resources and Inferred mineral resources, which has been assigned a zero grade and treated as dilution.
5. Only Measured mineral resources were used to report Proven mineral reserves and only Indicated mineral resources were used to report Probable mineral reserves.
6. EJV is the Entrée Joint Venture. The Shivee Tolgoi Licence and the Javkhlant Licence are held by Entrée. The Shivee Tolgoi Licence and the Javkhlant Licence are planned to be operated by OT LLC. OT LLC will receive 80% of cash flows after capital and operating costs for material originating below 560m, and 70% above this depth.
7. The base case financial analysis has been prepared using the following current long term metal price estimates: copper at $2.87/lb; gold at $1,350/oz; and silver at $23.50/oz. Metal prices are assumed to fall from current prices to the long term average over five years.
8. The mineral reserves reported above are not additive to the mineral resources.

Table 15.3 EJV Mineral Reserve, 25 March 2013

Classification	Ore (Mt)	NSR ($/t)	Cu (%)	Au (g/t)	Ag (g/t)	Recovered Metal		
						Copper (Mlb)	Gold (koz)	Silver (koz)
Proven	–	–	–	–	–	–	–	–
Probable	31	95.21	1.73	0.62	3.74	1,090	521	3,229
Total EJV	31	95.21	1.73	0.62	3.74	1,090	521	3,229

Notes:

1. Table shows only part of the Mineral Reserve.
2. Metal prices used for calculating the Southern Oyu open pit NSR and the Hugo North underground Net Smelter Return (NSR) are as follows: copper at $2.81/lb; gold at $970/oz; and silver at $15.50/oz, all based on long-term metal price forecasts at the beginning of the mineral reserve work. The analysis indicates that the mineral reserve is still valid at these metal prices.
3. The NSR has been calculated with assumptions for smelter refining and treatment charges, deductions and payment terms, concentrate transport, metallurgical recoveries and royalties.
4. For the open pit processing and general administration, the following operating costs have been used to determine cut-off grades: Southwest at $8.37/t, Central Chalcocite, Central Covellite, and Central Chalcopyrite at $7.25/t.
5. For the underground block cave, all mineral resources within the shell have been converted to mineral reserves. This includes low grade Indicated mineral resources and Inferred mineral resources, which has been assigned a zero grade and treated as dilution.
6. Only Measured mineral resources were used to report Proven mineral reserves and only Indicated mineral resources were used to report Probable mineral reserves.
7. EJV is the Entrée Joint Venture. The Shivee Tolgoi Licence and the Javkhlant Licence are held by Entrée. The Shivee Tolgoi Licence and the Javkhlant Licence are planned to be operated by OT LLC. OT LLC will receive 80% of cash flows after capital and operating costs for material originating below 560m, and 70% above this depth.
8. The base case financial analysis has been prepared using the following current long term metal price estimates: copper at $2.87/lb; gold at $1,350/oz; and silver at $23.50/oz. Metal prices are assumed to fall from current prices to the long term average over five years.
9. The mineral reserves reported above are not additive to the mineral resources.

15.1.1 Southern Oyu Open Pit Mineral Reserve

The Mineral Reserves in the Southern Oyu open pits are shown in Table 15.4. Pit designs were prepared using industry-standard mining software, assumed consensus metal prices as described above, and smelter terms as set forth in Section 22. The estimate was prepared on a simplified project analysis on a pre-tax basis. The report only considers Mineral Resources in the Measured and Indicated categories, and engineering that has been carried out to a feasibility level or better to estimate the open pit Mineral Reserve.

The silver grades used and reported by OT LLC in the Southern Oyu open pit mine planning work for the 2013 Mineral Reserve are the silver grades reported in the 2005 Mineral Resource model for Southern Oyu. This is the result of a timing issue in that the silver grades were not completed when the mine planning work was undertaken. Subsequent to the mine planning work, the silver grades in the 2012 resource model were updated and have been reported in the current Mineral Resources for Southern Oyu. As discussed in Section 14, the silver grades in the current resource model are lower than the 2005 model silver grades. Silver is a by-product and this difference has been calculated to have an NSR value of approximately $0.10/t. AMC considers that this is within the accuracy of the study work and is not a material issue. AMC has therefore concluded that the Mineral Reserve is valid. However it is recommended that the Feasibility Study review the resource estimates for silver and that the updated mine planning work take account of any changes to silver and other elements.

Table 15.4 Southern Oyu Open Pit Mineral Reserve, 25 March 2013

Classification	Ore (Mt)	NSR ($/t)	Cu (%)	Au (g/t)	Ag (g/t)	Recovered Metal		
						Copper (Mlb)	Gold (koz)	Silver (koz)
Proven	433	31.09	0.53	0.42	1.37	4,175	4,388	14,860
Probable	616	21.46	0.40	0.24	1.13	4,462	3,378	17,264
Total Southern Oyu Open Pit Mineral Reserve	1,048	25.44	0.46	0.31	1.23	8,637	7,766	32,124

Notes:

1. Table shows only part of the Mineral Reserve.
2. Metal prices used for calculating the Southern Oyu open pit NSR and the Hugo North underground Net Smelter Return (NSR) are as follows: copper at $2.81/lb; gold at $970/oz; and silver at $15.50/oz, all based on long-term metal price forecasts at the beginning of the mineral reserve work. The analysis indicates that the mineral reserve is still valid at these metal prices.
3. The NSR has been calculated with assumptions for smelter refining and treatment charges, deductions and payment terms, concentrate transport, metallurgical recoveries and royalties.
4. For the open pit processing and general administration, the following operating costs have been used to determine cut-off grades: Southwest at $8.37/t, Central Chalcocite, Central Covellite, and Central Chalcopyrite at $7.25/t.
5. For the underground block cave, all mineral resources within the shell have been converted to mineral reserves. This includes low grade Indicated mineral resources and Inferred mineral resources, which has been assigned a zero grade and treated as dilution.
6. Only Measured mineral resources were used to report Proven mineral reserves and only Indicated mineral resources were used to report Probable mineral reserves.
7. EJV is the Entrée Joint Venture. The Shivee Tolgoi Licence and the Javkhlant Licence are held by Entrée. The Shivee Tolgoi Licence and the Javkhlant Licence are planned to be operated by OT LLC. OT LLC will receive 80% of cash flows after capital and operating costs for material originating below 560m, and 70% above this depth.
8. The base case financial analysis has been prepared using the following current long term metal price estimates: copper at $2.87/lb; gold at $1,350/oz; and silver at $23.50/oz. Metal prices are assumed to fall from current prices to the long term average over five years.
9. The mineral reserves reported above are not additive to the mineral resources.

15.1.2 Hugo North Underground Mineral Reserve

Mine planning work by OT LLC has continued since the previous Mineral Reserve estimate in 2012. The underground Mineral Reserve has increased by 53 Mt.

The Hugo Dummett underground deposit will be mined by panel caving, a safe, highly productive, cost-effective method. The deposit is comparable in dimension and tonnage to other deposits currently being developed by panel cave mining elsewhere in the world. The mine planning work has been prepared using industry-standard mining software, assumed metal prices as described above, and smelter terms as set forth in the 2013 OTTR. The Hugo North Mineral Reserve only considers Mineral Resources in the Indicated category because there are no Measured Resources in Hugo North. The engineering has been carried out to a pre-feasibility level or better to estimate the underground Mineral Reserve. To ensure that Inferred Resources do not become included in the reserve estimate, copper and gold grades on Inferred Resources within the block cave shell were set to zero and such material was assumed to be dilution. The block cave shell was defined by a $15/t NSR. Further mine planning will examine lower shut-offs. The Hugo North Mineral Reserve is on both the OT LLC Oyu Tolgoi licence and the EJV Shivee Tolgoi licence. Total Hugo North Mineral Reserves are shown in Table 15.5 and the OT LLC and EJV Mineral Reserves are shown in Table 15.6 and Table 15.7.

Table 15.5 Total Hugo North Underground Mineral Reserve, 25 March 2013

Classification	Ore (Mt)	NSR ($/t)	Cu (%)	Au (g/t)	Ag (g/t)	Recovered Metal		
						Copper (Mlb)	Gold (koz)	Silver (koz)
Proven	–	–	–	–	–	–	–	–
Probable	491	93.57	1.80	0.39	3.74	17,849	5,123	50,877
Total Hugo North Underground Mineral Reserve	491	93.57	1.80	0.39	3.74	17,849	5,123	50,877

Notes:

1. Table shows only part of the Mineral Reserve.
2. Metal prices used for calculating the Southern Oyu open pit NSR and the Hugo North underground Net Smelter Return (NSR) are as follows: copper at $2.81/lb; gold at $970/oz; and silver at $15.50/oz, all based on long-term metal price forecasts at the beginning of the mineral reserve work. The analysis indicates that the mineral reserve is still valid at these metal prices.
3. The NSR has been calculated with assumptions for smelter refining and treatment charges, deductions and payment terms, concentrate transport, metallurgical recoveries and royalties.
4. For the open pit processing and general administration, the following operating costs have been used to determine cut-off grades: Southwest at $8.37/t, Central Chalcocite, Central Covellite, and Central Chalcopyrite at $7.25/t.
5. For the underground block cave, all mineral resources within the shell have been converted to mineral reserves. This includes low grade Indicated mineral resources and Inferred mineral resources, which has been assigned a zero grade and treated as dilution.
6. Only Measured mineral resources were used to report Proven mineral reserves and only Indicated mineral resources were used to report Probable mineral reserves.
7. EJV is the Entrée Joint Venture. The Shivee Tolgoi Licence and the Javkhlant Licence are held by Entrée. The Shivee Tolgoi Licence and the Javkhlant Licence are planned to be operated by OT LLC. OT LLC will receive 80% of cash flows after capital and operating costs for material originating below 560m, and 70% above this depth.
8. The base case financial analysis has been prepared using the following current long term metal price estimates: copper at $2.87/lb; gold at $1,350/oz; and silver at $23.50/oz. Metal prices are assumed to fall from current prices to the long term average over five years.
9. The mineral reserves reported above are not additive to the mineral resources.

Table 15.6 OT LLC Hugo North Underground Mineral Reserve, 25 March 2013

Classification	Ore (Mt)	NSR ($/t)	Cu (%)	Au (g/t)	Ag (g/t)	Recovered Metal		
						Copper (Mlb)	Gold (koz)	Silver (koz)
Proven	–	–	–	–	–	–	–	–
Probable	460	93.45	1.80	0.37	3.74	16,759	4,602	47,647
Total OT LLC Hugo North Underground Mineral Reserve	460	93.45	1.80	0.37	3.74	16,759	4,602	47,647

Notes:

1. Table shows only part of the Mineral Reserve.
2. Metal prices used for calculating the Southern Oyu open pit NSR and the Hugo North underground Net Smelter Return (NSR) are as follows: copper at $2.81/lb; gold at $970/oz; and silver at $15.50/oz, all based on long-term metal price forecasts at the beginning of the mineral reserve work. The analysis indicates that the mineral reserve is still valid at these metal prices.
3. The NSR has been calculated with assumptions for smelter refining and treatment charges, deductions and payment terms, concentrate transport, metallurgical recoveries and royalties.
4. For the open pit processing and general administration, the following operating costs have been used to determine cut-off grades: Southwest at $8.37/t, Central Chalcocite, Central Covellite, and Central Chalcopyrite at $7.25/t.
5. For the underground block cave, all mineral resources within the shell have been converted to mineral reserves. This includes low grade Indicated mineral resources and Inferred mineral resources, which has been assigned a zero grade and treated as dilution.
6. Only Measured mineral resources were used to report Proven mineral reserves and only Indicated mineral resources were used to report Probable mineral reserves.
7. EJV is the Entrée Joint Venture. The Shivee Tolgoi Licence and the Javkhlant Licence are held by Entrée. The Shivee Tolgoi Licence and the Javkhlant Licence are planned to be operated by OT LLC. OT LLC will receive 80% of cash flows after capital and operating costs for material originating below 560m, and 70% above this depth.
8. The base case financial analysis has been prepared using the following current long term metal price estimates: copper at $2.87/lb; gold at $1,350/oz; and silver at $23.50/oz. Metal prices are assumed to fall from current prices to the long term average over five years.
9. The mineral reserves reported above are not additive to the mineral resources.

Table 15.7 EJV Hugo North Underground Mineral Reserve, 25 March 2013

Classification	Ore (Mt)	NSR ($/t)	Cu (%)	Au (g/t)	Ag (g/t)	Recovered Metal		
						Copper (Mlb)	Gold (koz)	Silver (koz)
Proven	–	–	–	–	–	–	–	–
Probable	31	95.21	1.73	0.62	3.74	1,090	521	3,229
Total EJV Hugo North Underground Mineral Reserve	31	95.21	1.73	0.62	3.74	1,090	521	3,229

Notes:

1. Table shows only part of the Mineral Reserve.
2. Metal prices used for calculating the Southern Oyu open pit NSR and the Hugo North underground Net Smelter Return (NSR) are as follows: copper at $2.81/lb; gold at $970/oz; and silver at $15.50/oz, all based on long-term metal price forecasts at the beginning of the mineral reserve work. The analysis indicates that the mineral reserve is still valid at these metal prices.
3. The NSR has been calculated with assumptions for smelter refining and treatment charges, deductions and payment terms, concentrate transport, metallurgical recoveries and royalties.
4. For the open pit processing and general administration, the following operating costs have been used to determine cut-off grades: Southwest at $8.37/t, Central Chalcocite, Central Covellite, and Central Chalcopyrite at $7.25/t.
5. For the underground block cave, all mineral resources within the shell have been converted to mineral reserves. This includes low grade Indicated mineral resources and Inferred mineral resources, which has been assigned a zero grade and treated as dilution.
6. Only Measured mineral resources were used to report Proven mineral reserves and only Indicated mineral resources were used to report Probable mineral reserves.
7. EJV is the Entrée Joint Venture. The Shivee Tolgoi Licence and the Javkhlant Licence are held by Entrée. The Shivee Tolgoi Licence and the Javkhlant Licence are planned to be operated by OT LLC. OT LLC will receive 80% of cash flows after capital and operating costs for material originating below 560m, and 70% above this depth.
8. The base case financial analysis has been prepared using the following current long term metal price estimates: copper at $2.87/lb; gold at $1,350/oz; and silver at $23.50/oz. Metal prices are assumed to fall from current prices to the long term average over five years.
9. The mineral reserves reported above are not additive to the mineral resources.

15.1.3 Key Mining Assumptions

Key assumptions are summarized below; other assumptions are documented in the 2013 OTTR:

- Metal prices used for calculating the Southern Oyu open pit NSR and the Hugo North Underground NSR are copper $2.81/lb, gold $970/oz, and silver $15.50/oz based on long-term metal price forecasts at the beginning of the Mineral Reserve work. Analysis indicates that the Mineral Reserve is still valid at these metal prices.
- The NSR has been calculated with assumptions for smelter refining and treatment charges, deductions and payment terms, concentrate transport, metallurgical recoveries, and royalties.
- For the open pit, processing and general and administration operating costs have been used to determine cut-off grades: Southwest at $8.37/t, Central Chalcocite, Central Covellite, and Central Chalcopyrite at $7.25/t.
- For the underground a footprint cut-off of $15/t NSR and column height shut-off of $15/t NSR were used to maintain grade and productive capacity.
- For the underground block cave, all Mineral Resource within the shell has been converted to Mineral Reserve. This includes low-grade Indicated Mineral Resource and Inferred Mineral Resource assigned zero grade treated as dilution.

- Only Measured Resources were used to report Proven Reserves and only Indicated Resources were used to report Probable Reserves.
- EJV is the Entrée Gold Joint Venture. The Shivee Tolgoi and Javkhlant licences are held by Entrée Gold. The EJV Shivee Tolgoi and EJV Javkhlant Licences are planned to be operated by OT LLC. OT LLC will receive 80% of cash flows after capital and operating costs for material originating below 560 m, and 70% above this depth.
- The Mineral Reserves are not additive to the Mineral Resources.
- The underground Mineral Resource cell models used for reporting the Mineral Reserves are the models reported in the Mineral Resource section of 2013 OTTR. A new resource model prepared by OT LLC has been used for the open pit Mineral Reserve.
- The processing schedule philosophy adopted for the mine planning work assumes feeding the open pit ore into the plant at an elevated cut off grade and stockpiling low grade material for later treatment. This philosophy provides some insulation against metal price cycles and reduces the risk that the Mineral Reserve size is overestimated.

15.1.4 Reconciliation with IDOP TR Reserves

Mineral Reserves were last publically reported in the IDOP Technical Report March 2012 (IDOP TR). A comparison of the IDOPTR and 2013 Mineral Reserves is shown in Table 15.8. The Mineral Reserves have increased by 144 Mt with a 6.1% decrease in Cu grade, a 4.2% decrease in gold grade, and a 3.2% decrease in silver grade. This is matched by a 4.4% increase in recovered copper, a 4.3% increase in recovered gold, and a 0.4% increase in recovered silver.

A comparison of the IDOP TR and 2013 EJV Mineral Reserves is shown in Table 15.9. The Mineral Reserves have increased by 4 Mt with a 9.4% decrease in Cu grade, a 15.1% decrease in gold grade, and a 10.5% decrease in silver grade. This is matched by a 4.5% increase in recovered copper, a 2.8% decrease in recovered gold, and a 3.3% increase in recovered silver.

Table 15.8 Mineral Reserve Reconciliation 2013 OTTR and IDOP TR

Case	Mineral Reserve	Ore (Mt)	NSR ($/t)	Cu (%)	Au (g/t)	Ag (g/t)	Recovered Metal		
							Copper (Mlb)	Gold (koz)	Silver (koz)
2013 OTTR	Proven	433	31.09	0.53	0.42	1.37	4,175	4,388	14,860
	Probable	1,107	53.46	1.02	0.30	2.29	22,311	8,501	68,141
	Mineral Reserve	1,539	47.17	0.89	0.34	2.03	26,486	12,889	83,001
IDOP	Proven	125	36.42	0.58	0.91	1.49	1,374	2,892	10,018
	Probable	1,270	37.46	0.98	0.30	2.16	23,995	9,465	72,635
	Mineral Reserve	1,395	37.37	0.94	0.35	2.10	25,369	12,357	82,654
Difference	Proven	308	–5.32	–0.05	–0.49	–0.12	2,801	1,496	4,842
	Probable	–164	15.99	0.04	0.01	0.13	–1,685	–964	–4,494
	Mineral Reserve	144	9.80	–0.06	–0.01	–0.07	1,117	532	348
% Difference	Proven	246.9%	–14.6%	–8.3%	–54.2%	–8.2%	204.0%	51.7%	48.3%
	Probable	–12.9%	42.7%	4.5%	2.9%	6.0%	–7.0%	–10.2%	–6.2%
	Mineral Reserve	10.3%	26.2%	–6.1%	–4.2%	–3.2%	4.4%	4.3%	0.4%

Notes:

10. IDOP Mineral Reserves have the effective date 29 March 2012.
11. 2013 Oyu Tolgoi Technical Report Mineral Reserves have the effective date 25 March 2013..
12. Metal prices used for calculating the Southern Oyu open pit NSR and the Hugo North underground Net Smelter Return (NSR) are as follows: copper at $2.81/lb; gold at $970/oz; and silver at $15.50/oz, all based on long-term metal price forecasts at the beginning of the mineral reserve work. The analysis indicates that the mineral reserve is still valid at these metal prices.
13. The NSR has been calculated with assumptions for smelter refining and treatment charges, deductions and payment terms, concentrate transport, metallurgical recoveries and royalties.
14. For the open pit processing and general administration, the following operating costs have been used to determine cut-off grades: Southwest at $8.37/t, Central Chalcocite, Central Covellite, and Central Chalcopyrite at $7.25/t.
15. For the underground block cave, all mineral resources within the shell have been converted to mineral reserves. This includes low grade Indicated mineral resources and Inferred mineral resources, which has been assigned a zero grade and treated as dilution.
16. Only Measured mineral resources were used to report Proven mineral reserves and only Indicated mineral resources were used to report Probable mineral reserves.
17. EJV is the Entrée Joint Venture. The Shivee Tolgoi Licence and the Javkhlant Licence are held by Entrée. The Shivee Tolgoi Licence and the Javkhlant Licence are planned to be operated by OT LLC. OT LLC will receive 80% of cash flows after capital and operating costs for material originating below 560m, and 70% above this depth.
18. The base case financial analysis has been prepared using the following current long term metal price estimates: copper at $2.87/lb; gold at $1,350/oz; and silver at $23.50/oz. Metal prices are assumed to fall from current prices to the long term average over five years.
19. The mineral reserves reported above are not additive to the mineral resources.

Table 15.9 EJV Mineral Reserve Reconciliation 2013 OTTR and IDOP TR

Case	Mineral Reserve	Ore (Mt)	NSR ($/t)	Cu (%)	Au (g/t)	Ag (g/t)	Recovered Metal		
							Copper (Mlb)	Gold (koz)	Silver (koz)
2013 OTTR	Probable (EJV)	31	95.21	1.73	0.62	3.74	1,090	521	3,229
IDOP	Probable (EJV)	27	79.40	1.91	0.74	4.17	1,043	536	3,127
Difference	Probable (EJV)	4	15.81	–0.18	–0.11	–0.44	47	–15	102
% Difference	Probable (EJV)	15.1%	19.9%	–9.4%	–15.1%	–10.5%	4.5%	–2.8%	3.3%

Notes:

1. IDOP Mineral Reserves have the effective date 29 March 2012.
2. 2013 Oyu Tolgoi Technical Report Mineral Reserves have the effective date 25 March 2013..
3. Metal prices used for calculating the Southern Oyu open pit NSR and the Hugo North underground Net Smelter Return (NSR) are as follows: copper at $2.81/lb; gold at $970/oz; and silver at $15.50/oz, all based on long-term metal price forecasts at the beginning of the mineral reserve work. The analysis indicates that the mineral reserve is still valid at these metal prices.
4. The NSR has been calculated with assumptions for smelter refining and treatment charges, deductions and payment terms, concentrate transport, metallurgical recoveries and royalties.
5. For the open pit processing and general administration, the following operating costs have been used to determine cut-off grades: Southwest at $8.37/t, Central Chalcocite, Central Covellite, and Central Chalcopyrite at $7.25/t.
6. For the underground block cave, all mineral resources within the shell have been converted to mineral reserves. This includes low grade Indicated mineral resources and Inferred mineral resources, which has been assigned a zero grade and treated as dilution.
7. Only Measured mineral resources were used to report Proven mineral reserves and only Indicated mineral resources were used to report Probable mineral reserves.
8. EJV is the Entrée Joint Venture. The Shivee Tolgoi Licence and the Javkhlant Licence are held by Entrée. The Shivee Tolgoi Licence and the Javkhlant Licence are planned to be operated by OT LLC. OT LLC will receive 80% of cash flows after capital and operating costs for material originating below 560m, and 70% above this depth.
9. The base case financial analysis has been prepared using the following current long term metal price estimates: copper at $2.87/lb; gold at $1,350/oz; and silver at $23.50/oz. Metal prices are assumed to fall from current prices to the long term average over five years.
10. The mineral reserves reported above are not additive to the mineral resources.

15.1.5 US SEC Industry Guide 7

The Mineral Reserve reported for NI 43-101 is also applicable for reporting the Ore Reserve under the US SEC Industry Guide 7. AMC estimated the Oyu Tolgoi Mineral Reserves for the NI 43-101 2013 OTTR which is based on feasibility study work. The definitions of the Mineral Reserve classifications under NI 43-101 are the Canadian Institute of Mining (CIM) Definition Standards – For Mineral Resources and Mineral Reserves, Prepared by the CIM Standing Committee on Reserve Definitions and adopted by CIM Council on 11 December 2005. The definitions below are quoted from the CIM Definition Standards – For Mineral Resources and Mineral Reserves, page 5.

After consideration of guidelines and other information regarding the declaration of Reserves for the United States Securities and Exchange Commission (US SEC) reporting, AMC considers that the 2013 OTTR is suitable for declaring a Reserve as defined in US Industry Guide 7.

Documentation underlying Mineral Reserves determined in accordance with Industry Guide 7 generally includes the following:

- A "final" feasibility study.
- Utilization of the historic 3 year average price for the commodity that expected to be mined in determining economic viability.
- Primary environmental analysis has been submitted to government authorities.

15.1.5.1 Bankable Study

OT LLC is in an advanced stage of project financing with a core lending group of financiers for a $4.0 billion project-finance facility. The core lenders group is comprised of European Bank for Reconstruction and Development, Export Development Canada, International Finance Corporation, BNP Paribas and Standard Chartered Bank, USEx-Im Bank and its adviser, Standard Bank, the World Bank Group's Multilateral Investment Guarantee Agency and the Australian Export Finance and Insurance Corporation. TRQ has advised AMC that the lenders have received reports from an independent engineering asssessement that indicates the studies are suitable to support the technical for consideration of the project financing.

TRQ has advised AMC that bids have been received from a number of banks that would allow the Company to achieve its project financing target and discussions are ongoing with the lenders to finalize the terms of those offers. The project financing is subject to the unanimous approval of the Oyu Tolgoi LLC Board of Directors which includes representatives from the Government of Mongolia. TRQ anticipates the closing of final binding documentation and project financing funding to occur in the first half of 2013. AMC therefore considered it reasonable to conclude that the bankable study test in US SEC Industry Guide 7 has been met.

15.1.5.2 Test Price for Commodities

The base case financial analysis has been prepared using current long-term metal price estimates of:

- Copper $2.87/lb
- Gold $1350/oz
- Silver $23.50/oz

The 2005 SME Guide Section 53 describes how the Test Price for commodities should be applied.

> "If a Mineral Reserve is reported using a price lower than the test price, the forward-looking discounted cash flow must be positive, and the Reserve Sensitivity Test (based on an undiscounted cash flow) need not be performed. When applicable, a statement should be made that a Reserves Sensitivity Test was completed, or that such a test was not applicable."

The metal prices for the previous 3 years, their average and the metal prices used for the Mineral Reserve estimates are shown in Table 15.10. The only metal price that is higher than the three year average is the forecast silver price. The three year average silver price is $19.83/oz Ag and the forecast price is $23.50/oz Ag. The sensitivity analysis using the 3 year averages shows the after tax NPV_8 of US$15,108 m compared to the base case US$9,877 m. The results are improved compared to the base case financial analysis, as the averages for the copper and gold prices are higher. This indicates that the Mineral Reserve is still valid at the 3 year average prices.

Table 15.10 Metal Price Summary

Year Ended	Cu ($/lb)	Au ($/oz)	Ag ($/oz)
2010	3.42	1,225	15.44
2011	4.00	1,572	12.89
2012	3.61	1,792	31.15
Average	3.68	1,703	19.83
Reserve NSR	2.81	970	12.00
Base Case Financial Analysis	2.87	1,350	23.50

15.1.5.3 Primary Environmental Analysis Submission

The 2007 SME Guide Section 56 describes how the permitting and legal requirements of US SEC Industry Guideline 7 should be applied. It indicates that:

> "To demonstrate reasonable expectation that all permits, ancillary rights and authorizations can be obtained, the reporting entity must show understanding of the procedures to be followed to obtain such permits, ancillary rights and authorizations. Demonstrating earlier success in getting the necessary permits can be used to document the likelihood of success."

Based on the understanding of the procedures and the history of permitting, it is considered reasonable to assume that the final environmental permitting will be granted without resulting in a change to the Reserve.

OT LLC has completed a comprehensive Environmental and Social Impact Assessment (ESIA) for the Oyu Tolgoi Project. The culmination of nearly 10 years of independent work and research carried out by both international and Mongolian experts, the ESIA identifies and assesses the potential environmental and social impacts of the project, including cumulative impacts, focusing on key areas such as biodiversity, water resources, cultural heritage, and resettlement.

The ESIA also sets out measures through all project phases to avoid, minimize, mitigate, and manage potential adverse impacts to acceptable levels established by Mongolian regulatory requirements and good international industry practice, as defined by the requirements of the Equator Principles, and the standards and policies of the International Finance Corporation (IFC), European Bank for Reconstruction and Development (EBRD), and other financing institutions.

Corporate commitment to sound environmental and social planning for the project is based on two important policies: TRQ's Statement of Values and Responsibilities (March 2010), which declares its support for human rights, social justice, and sound environmental management, including the United Nations Universal Declaration of Human Rights (1948); and The Way We Work 2009, Rio Tinto's Global Code of Business Conduct that defines the way Rio Tinto manages the economic, social, and environmental challenges of its global operations.

OT LLC has commenced the development and implementation of an environmental management system (EMS) that conforms to the requirements of ISO 14001:2004. Implementation of the EMS during the construction phases will focus on the environmental policy; significant environmental aspects and impacts and their risk prioritization; legal and other requirements; environmental performance objectives and targets; environmental management programs; and environmental incident reporting. The EMS for operations will consist of detailed plans to control the environmental and social management aspects of all project activities following the commencement of commercial production in 2013.The Oyu Tolgoi ESIA builds upon an extensive body of studies and reports, and DEIA's that have been prepared for project design and development purposes, and for Mongolian approvals under the following laws:

- The Environmental Protection Law (1995)
- The Law on Environmental Impact Assessment (1998, amended in 2001)
- The Minerals Law (2006)

These initial studies, reports and DEIA's were prepared over a six-year period between 2002 and 2008, primarily by the Mongolian firm Eco-Trade LLC, with input from Aquaterra on water issues.

The original DEIA's provided baseline information for both social and environmental issues. These DEIA's covered impact assessments for different project areas, and were prepared as separate components to facilitate technical review as requested by the GOM.

The original DEIA's were in accordance with Mongolian standards and while they incorporated World Bank and IFC guidelines, they were not intended to comprehensively address overarching IFC policies such as the IFC Policy on Social and Environmental Sustainability, or the EBRD Environmental and Social Policy.

Following submission and approval of the initial DEIA's, the Mongolian Government requested that OT LLC prepare an updated, comprehensive ESIA whereby the discussion of impacts and mitigation measures was project-wide and based on the latest project design. The ESIA was also to address social issues, meet Mongolian government (legal) requirements, and comply with current IFC good practice.

For the ESIA the baseline information from the original DEIA's was updated with recent monitoring and survey data. In addition, a social analysis was completed through the commissioning of a Socio-Economic Baseline Study and the preparation of a Social Impact Assessment (SIA) for the project.

The requested ESIA, completed in 2012, combines the DEIA's, the project SIA, and other studies and activities that have been prepared and undertaken by and for OT LLC.

15.1.6 Mongolian Commercial Minerals

Mongolia has its own system for reporting Mineral Reserves and Mineral Resources. OT LLC has registered a Mineral Reserve with the GOM. The system is based on a review by Mongolian experts in a number of disciplines. A significant difference between the Mongolian system and 43-101 is that, under the Mongolian system, resources and reserves are not valid until registered by the GOM. A committee of Mongolian experts examines a report prepared by the Owner using a set of guidelines and then, based on a consensus of nominated experts, a recommendation is made to the Minister for Mineral Resources and Energy. The recommendation to the Minister states the resources and reserves and any conditions. The Minister then issues an order registering the resources and reserves.

The reports examined by the experts must be in Mongolian language. OT LLC national staff and Mongolian consultants prepared the report under supervision of OT LLC personnel on secondment from Rio Tinto. The Mongolian Reserve included 43-101 Inferred Mineral Resource and is similar to the IDP10 Life-of-Mine (Sensitivity) Case. The Mongolian Reserve and IDP10 were prepared at different times and with different metal price assumptions for the analyses.

The Minister issued an order on 10 July 2009. OT LLC prepared the following translation of the order.

“Order Of The Minister For Mineral Resources And Energy, July 10, 2009, No. 167, Ulaanbaatar

On acceptance and registration of the revised reserve estimation of Southern Oyu deposits and the reserve report of Hugo Dummett deposits and Heruga deposit.

Pursuant to Article 48.4 of the Minerals Law, Clause 8, 9 and 14.2 of the Minerals Council Charter, and the Conclusion #15-01 of the Minerals Council extended meeting #15 held on 1 July 2009, it is resolved that:

- One. Revised Mineral Reserve estimation of Southern Oyu deposits, and Mineral Reserves of Hugo Dummett deposits and Heruga deposit in 2000-2008 exploration work report by Ivanhoe Mines Mongolia Inc LLC in Khanbogd soum, Umnugobi aimag are accepted as in the attachment to Conclusion summary #15-01.
- Two. Geological Research Centre (U. Borchuluun) is authorized to register the reserves quantity accepted under the Article 1 of this Order in the state minerals reserve inventory.
- Three. In relation to registration of revised Mineral Reserve of Southern Oyu deposits, the following copper and gold reserves of Southern Oyu to be mined with open pit operation registered in the state minerals reserve inventory with Conclusion #16-01 of the Minerals Council meeting #16 held on 30 July 2007 shall be removed from the state minerals reserve registration: 127 Mt ore or 0.658 Mt copper metal and 88.1 tonne gold in Measured (A) class, 803 Mt ore or 3.371 Mt copper metal and 148.3 tonne gold in Indicated (B) class.
- Four. Ivanhoe Mines Mongolia Inc LLC and MRAM (D. Batkhuyag) are assigned to implement the resolved issues in the Conclusion #15-01 of the Minerals Council extended meeting held on 1 July 2009.

Five. Ivanhoe Mines Mongolia Inc LLC is hereby assigned to submit exploration report and field study materials in electronic format (data CD) to Geological Information Center, within 5 working days from the Conclusion of the Minerals Council meeting and the Resolution by Minister of Mineral Resources and Energy issued in relation to it.”

16 MINING METHODS

16.1 Open Pit Geotechnical

16.1.1 Pit Slope Design

Operations in the first stage of the open pit have extended to a depth of about 80 m.

The last analysis of pit slope design angles and configuration was by Golder Associates, in a report dated September 2009.

The conclusions from this study and the plan for the open pit were included in the 2012 Technical Report.

This report includes a summary of the study, as previously reported.

16.1.1.1 Geotechnical Setting

With the exception of extensive surface weathering that extends to depths of approximately 50 m to 60 m, the rocks are generally hard and competent. Measured mean intact rock laboratory unconfined compressive strengths range from 113 to 206 MPa.

Hydrogeology investigations in support of water supply and pit dewatering estimates were carried out in a number of previous programs and provided information on the hydrogeology in the vicinity of the open pit:

- Shallow alluvial aquifers that increase in thickness from 0 to 15 m from the south-west toward the north-west side of the proposed pit exhibit a hydraulic conductivity on the order of 6×10^{-5} m/s, indicating a moderate capacity to transmit groundwater.
- A shallow bedrock hydro-stratigraphic unit that exists down to a depth of approximately 150 m below ground surface, and that is not dependent on lithology, exhibits a hydraulic conductivity of between 6×10^{-7} m/s and 1×10^{-6} m/s, indicating a moderate capacity to transmit groundwater.
- A deep bedrock hydrostratigraphic unit that includes various geological units found at depths of more than 150 m below the ground surface exhibits a hydraulic conductivity on the order of 6×10^{-9} m/s, indicating a low capacity to transmit groundwater.

Groundwater numerical modelling was carried out along three-cross sections as part of this review for the purpose of estimating groundwater pressures for modelling ultimate pit slope stability. Two sets of models were created based on the faults acting either as pathways or as barriers to the flow of groundwater perpendicular to the faults.

16.1.1.2 Analyses of Pit Slope Design

The various rock types contain well-defined and pervasive geologic structures in the form of joint sets and faults. The results of surface and shaft mapping, together with selected oriented core logging data, have been used to determine the orientations of the more continuous fault sets and the systematic joints sets.

The current inter-ramp slope angles are not based on a kinematic assessment of structural geology data but rather on an empirical correlation with rock mass quality. As rock mass quality appears to increase with increasing depth, the proposed inter-ramp angles also increase with depth.

Kinematic stability analyses were carried out as part of the 2009 pit slope design review to assess the stability of the individual bench faces and of multiple-benches with respect to planar and wedge failure along undercut joint sets and fault sets. The results of these analyses are independent of rock quality and consider the orientations of the more dominant structures that are expected to be undercut in the pit slopes. Consequently, these recommendations are not dependent upon depth in the pit but only on the wall orientation with respect to the dominant geologic structures.

The data in Table 16.1 are proposed design inter-ramp slope angles from the results of the kinematic analyses carried out as part of the 2009 review.

For the most part, the optimum inter-ramp slope angles recommended from the 2009 kinematic stability analyses also exceed the previous design inter-ramp angles for the upper parts of the Phase 1 to 7 slopes.The results of the kinematic stability analyses for the individual 15 m high bench faces indicate that optimum bench face angles are likely to be lower than 65° and 75°. This is due to a large number of systematic joint sets that appear to exhibit shallow to moderate dips. Until the interim slopes are excavated and the continuity of these structures can be determined, it will not be possible to confirm the optimum bench face angles, which could be lower. Therefore, it is recommended that the proposed single-bench configuration be maintained for design because this configuration and the inter-ramp angles for the Phase 1 to 8 pits are expected to provide sufficient catchment for any wedge or planar failures that may occur due to undercutting of the systematic joint sets.

Once the continuity of the dominant joint and fault sets are confirmed, it may be possible to adopt a double-bench configuration and increase inter-ramp angles in some of the pit sectors in Phases 1 to 7. However, the overall slope stability considerations will likely preclude the use of double-benching in the ultimate Phase 8 pit because of the higher ultimate walls.

Table 16.1 Phases 1 to 7 Design Inter-ramp Angles

Current Design Sector	Range of Approximate Sector Azimuths	Recommended Optimum Kinematic Inter-ramp Slope Angle(as per 2009 Review)
1	325° to 332°	59°
	333° to 025°	45°
2	215° to 296°	45°
	297° to 300°	53°
	301° to 312°	56°
	313° to 325°	59°
3	025° to 044°	45°
	045° to 110°	44°
4	110° to 135°	44°
	136° to 147°	47°
	148° to 190°	45°
5	270° to 296°	45°
	297° to 300°	53°
	301° to 312°	56°
	313° to 332°	59°
	333° to 360°	45°
6	360° to 045°	45°
7	140° to 147°	47°
	148° to 296°	45°
	297° to 300°	53°
	301° to 312°	56°
	313° to 320°	59°
8	080° to 135°	44°
	136° to 147°	47°
	148° to 230°	45°
9	065° to 135°	44°
	136° to 140°	47°
10	140° to 147°	47°
	148° to 220°	45°

The overall stability of rock slopes is also dependent upon the strength of the intact rock, the spacing and continuity of the rock fractures, and the surface quality of the rock fractures. Accordingly, the intact rock strength and fracture characteristics are combined to provide an empirical measure of the overall rock mass quality, which in turn is used to estimate the overall rock mass strength for the purpose of assessing overall rock slope stability. The Laubscher (1990) system has been used in previous studies to estimate the rock mass quality of the rocks that will be exposed in the Oyu Tolgoi open pit. On a scale of zero for very poor quality rock to 100 for very competent rock, the Laubscher rock mass ratings for the rock that will be exposed in the open pit vary from approximately 35 to 50 and can classified as poor to fair quality.

The stability of the proposed Phase 8 overall slopes has been assessed with respect to potential overall circular-type failures, which involve the development of failure through intact rock and pre-existing geologic discontinuities. Limit equilibrium stability analyses have been carried out along three cross-sections through the ultimate Phase 8 pit:

- Section 5 – West Wall (overall slope angle approximately 38°)
- Section 9 – East Wall (overall slope angle approximately 34°)
- Section 10 – South Wall (overall slope angle approximately 34°)

With the exception of Section 10 on the south wall of the Phase 8 pit, the proposed overall slopes are expected to exhibit factors of safety slightly greater than a recommended minimum design factor of 1.3 for the predicted ultimate pit groundwater pressures. The south wall is not expected to exhibit an adequate factor of safety if it is assumed that the Solongo Fault acts as a barrier to groundwater flow and will impede the drainage of the lower half of the south wall. This is concluded from drillhole data indicating that poor-quality QMD rock will be exposed at the toe of the south wall on the north side of the Solongo Fault. The results of the stability and groundwater modelling indicate that some form of artificial depressurization will likely be required along the lower part of the south wall to achieve adequate stability. A series of 200 m long drain holes penetrating the Solongo Fault on 50 m to 100 m spacing is expected to provide adequate depressurization.

Artificial depressurization is planned for most of the proposed walls but, with the exception of the south wall and other localized areas in the pit, may not be required. Consequently, with the possible exception of Sectors 7 and 8 in the Phase 1 to 7 pits, the proposed overall slope angles are expected to be achievable on the ultimate pit. The proposed design inter-ramp slope angles for Sectors 7 and 8 are steeper than the optimum angles recommended from the results of the kinematic analyses. Until the continuity of major structures can be confirmed in the interim pit excavations, it may be necessary to reduce the inter-ramp and overall slope angles in Sector 8 and along the southwest and south sides of Sector 7 in the Stage 1 to 7 pits.

Several major, steeply dipping faults cut through the deposit. The intersections of these faults will form steeply dipping wedges that will not be undercut by the proposed pit walls. However, localized bench-scale instability can be expected along the intersection of these faults with the pit walls.

16.1.2 Proposed Field and Analytical Program

A field strategy has been developed for undertaking hydrogeological and geotechnical field programs in parallel. All geotechnical drillholes will be exploited to gain greater understanding of the hydrogeological conditions. The hydrogeological outcomes will be fully integrated into the geotechnical analysis, using 2D and 3D numerical techniques. The objective is to provide pit wall design parameters that are compatible with achievable depressurization targets relative to the mine excavation schedule.

16.1.2.1 Geotechnical

Most of the geotechnical drilling carried out to date has been near the centre of the proposed pit, and none has been done behind the proposed pit walls. The rock quality and structural conditions in the exterior rocks will probably be similar to those encountered near the centre of the pit, but it is recommended that a number of confirmatory, oriented geotechnical drillholes be drilled in the major rock types behind the ultimate pit walls. Consideration should be given to using either the Ace or Ezy-Mark core orientation tools and to carrying out packer testing at various intervals in the core holes. In addition, a core hole to confirm the existence of poor-quality QMD rock at the toe of the south wall of the ultimate pit is also recommended.

The geotechnical field program will consist of both acoustic televiewer logging and manual logging in addition to sampling of core from 13 diamond holes to depths of between 350 m and 610 m, for a total meterage of 6,145 m. Downhole packer testing will be undertaken to quantify the permeability of targeted structures and also the rock mass fabric. Each borehole will be completed by cementing vibrating wire pressure transducers into the rock mass at targeted intervals to help assess the pre-mining groundwater pressure regime. Laboratory assessment of rock material characteristics will be carried out to supplement historical testing of samples from both the Hugo North and South Oyu deposits. A 3D geotechnical model will be updated. The geotechnical and hydrogeological field study results will be fully integrated through numerical analyses.

16.1.2.2 Hydrogeology

The hydrogeological study will focus on understanding the hydrogeological conditions directly within the mine footprint and also external to the ultimate pit. The key objectives of this program are to develop a predictive pore pressure capacity, which will be used in the assessment of pit wall stability and also of external impacts on, or by, the Undai River and tailings storage facility. The hydrogeological field program will include 2,548 m of reverse circulation percussion drilling. Each hole will involve in situ downhole testing to quantify the hydrogeological characteristics of targeted fault/dyke structures and the rock mass fabric. Each hole will be completed with either standpipe monitoring wells or cemented vibrating wire pressure transducers.

On completion of the field program, a 3D district hydrogeological model will be developed to provide a predictive capacity for assessing groundwater conditions. The requirements for depressurization of the pit walls will be assessed, water inflows will be predicted, and strategies will be developed for pit water management and depressurization.

16.1.2.3 Further Analyses of Pit Wall Design

Experience from excavation of the open pit will provide information on the response of the rock types and major geological structures to their exposure in a pit wall. This and the information from further investigations by drilling and monitoring will provide a basis for ongoing updates of the geotechnical design parameters for the open pit.

The kinematic sliding analysis, on which the current design of the pit wall is based, incorporates only a limited range of the information on rock conditions that will be available. The method is not generally accepted as a primary analytical method for estimating design slope angles.

As information accumulates from the open pit and ongoing field investigations, there needs to be a review and update of the geotechnical design parameters for the staged pit walls, based on the observed mechanism of behaviour of the exposed rock in the pit walls.

16.2 Open Pit Mining

OT LLC carried out the pit optimization, mine planning, and scheduling work for the Oyu Tolgoi open pits. This work included the integration of the underground plans.

16.2.1 Pit Optimization

The pit optimization was completed by OT LLC using the current resource model. Only resources classified as Measured or Indicated were used in the optimization. Inferred resources were treated as waste.

The model grades were used to calculated the net smelter return (NSR). The NSR is the revenue paid for the concentrate at the “mine gate”, and excludes costs for mining, processing, and G&A. The NSR is the in situ value after allowances have been made for:

- Recovery to concentrate
- Smelter deductions
- Concentrate transport
- Smelter treatment and refining charges
- Royalties

The resulting NSR values were used to classify the ore blocks in the pit optimization.

16.2.2 Mining Model

The mining model was created from the resource model. The recovered copper, gold, and silver grades, and the NSR were calculated for each block. Subsequent to the initial release of the resource cell model to the OT planning team, the arsenic and silver grades were replaced with grades from the previous cell model.

The NSR values for 2013 OTTR were calculated using the parameters described in Table 16.2. The NSR calculation does not includes penalties for impurities such as arsenic and fluorine. The penalties have been minimized through blending in the production schedule and are accounted for in the financial analysis.

Table 16.2 Base Data Template 29

Payment and Deductions	Cu	Au	Ag
Metal Prices	US$2.81/lb	US$970/oz	US$15.50/oz
Payment Levels	96.0% of full Cu content	<1 g/dmt, 0%	If >30 g/dmt then 90% of full Ag content
	–	<3 g/dmt, >1 g/dmt, 90% of Au content	–
	–	<5 g/dmt, >3 g/dmt, 94% of Au content	–
	–	<10 g/dmt, >5 g/dmt, 95% of Au content	–
	–	<15 g/dmt, >10 g/dmt, 96% of Au content	–
	–	<20 g/dmt, >15 g/dmt, 97% of Au content	–
	–	>20 g/dmt, 97.5% of Au content	–
Deductions	Minimum 1 unit/dmt	n/a	All <30 g/dmt
Treatment and Refining			
Treatment (Concentrate)	–	$80/dmt	–
Refining	$0.080/lb	$8.00/oz	$0.50/oz
Penalties	Arsenic: No penalty to 0.3%. Thereafter $2.00/dmt penalty per 0.1%. Rejection level 0.5%.		
	Fluorine: No penalty to 300 ppm. Thereafter $2.00/dmt penalty per 100 ppm. Rejection level 1000 ppm.		
Royalties			
Mongolian Government	5% of payable metal value		
Transport			
Moisture Content	8%		
Transportation	$51.00/dmt		

16.2.3 Mine Design

The open pit design work has focused on the Southwest and Central orebodies of the Southern Oyu region. The deposits fall within the following pit phases:

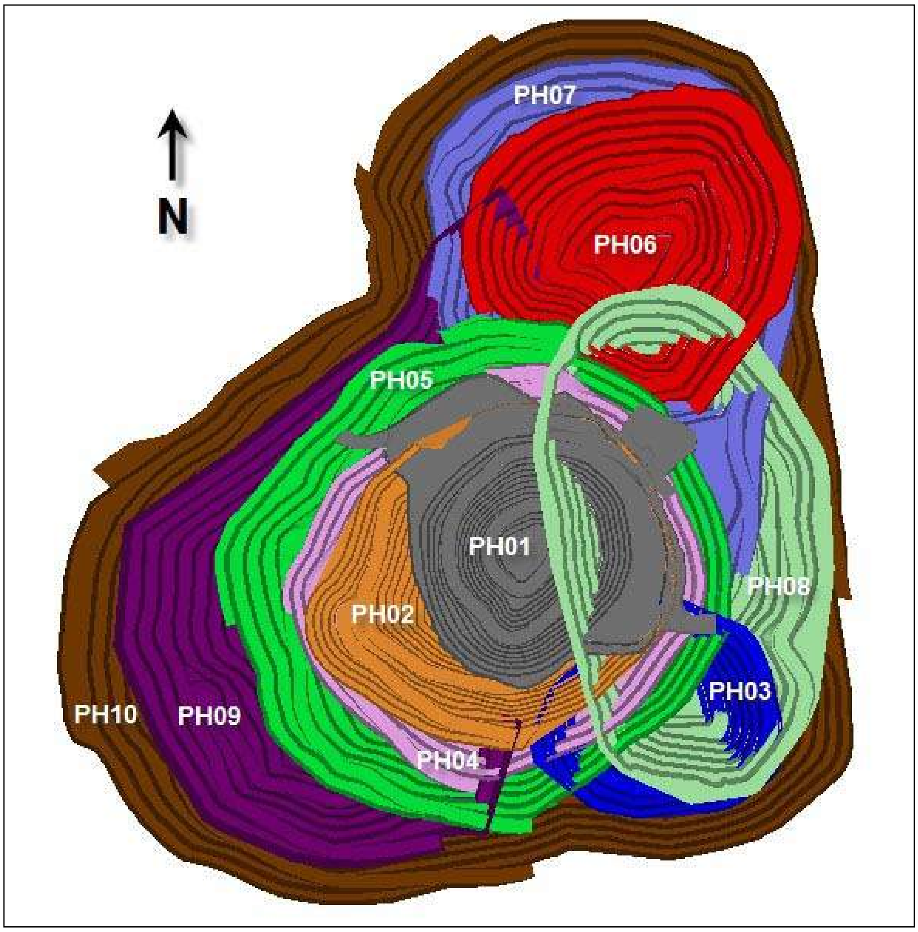
- Phase 1 Southwest
- Phase 2 Southwest
- Phase 3 Southwest
- Phase 4 Southwest
- Phase 5 Southwest
- Phase 6 Central
- Phase 7 Central
- Phase 8 Southwest
- Phase 9 Southwest
- Phase 10 All Southern Oyu deposits

The objective of the phase design strategy was to minimize the early mining costs and maximize the economic return. The following design objectives were also considered for the design of the internal pit phases:

- The first five phases were limited to the Southwest orebody. This allows for the prioritization of the Southwest ore in the schedule.
- A minimum mining width of 80 m between each phase.
- Two exit haul roads per phase.
- General haul road design parameters of 40 m haul road width and 10% haul road gradient.
- Pit slope angles as recommended in Section 16.1. In general, standard 15 m high benches and 6 m to 12 m wide berms.

A plan view of the 10 pit phases is shown in Figure 16.1.

Figure 16.1 Open Pit Phase Designs



16.2.4 Open Pit Mining Inventory Summary

The open pit mining inventory is summarized by pit phase in Table 16.3.

Table 16.3 Summary of Total Material by Pit Phases

Phase	Ore Mt	NSR $/t	Grade					Waste (Mt)	Strip Ratio	Total Material (Mt)
			Cu %	Au g/t	Ag g/t	As ppm	F ppm			
Phase 1 SW	41	38.40	0.51	0.74	1.39	10	2,086	31	0.76	73
Phase 2 SW	70	35.29	0.49	0.64	1.34	11	1,993	79	1.13	148
Phase 3 SW	40	28.88	0.57	0.16	1.75	71	1,899	48	1.19	88
Phase 4 SW	88	25.82	0.41	0.39	1.23	19	1,727	113	1.29	201
Phase 5 SW	151	24.10	0.40	0.34	1.21	32	1,606	242	1.60	392
Phase 6 Central	91	25.64	0.63	0.09	1.40	233	2,142	76	0.83	167
Phase 7 Central	69	21.60	0.50	0.12	1.03	137	1,767	105	1.53	174
Phase 8 SW	19	18.17	0.41	0.04	0.92	89	1,629	85	4.57	103
Phase 9 SW	61	18.29	0.32	0.27	0.97	18	1,412	283	4.61	344
Phase 10 SW & Central	419	24.56	0.45	0.30	1.20	88	1,757	848	2.03	1,267
Total/Average	1,048	25.44	0.46	0.31	1.23	77	1,779	1,910	1.82	2,958

16.2.5 Open Pit Operation and Equipment

The open pit mining operations are scheduled for nominally 350 days per annum. It was assumed that 15 days per annum will be lost due to unscheduled delays such as weather conditions. The open pit equipment will operate 24 hours per day in two 12-hour working shifts.

16.2.5.1 Labour

Based on operational requirements, OT LLC has prepared a comprehensive labour roster that includes local and expatriate personnel. Table 16.4 shows the required personnel.

Table 16.4 Open Pit Labour Profile

Labour Category	2013	2018	2023	2028	2033	2038	2043	2048
Expatriate	58	28	–	–	6	2	2	2
Local	464	588	26	26	587	674	739	785
Total Labour	**522**	**616**	**26**	**26**	**593**	**676**	**741**	**787**
National Hire Ratio	89%	95%	100%	100%	99%	100%	100%	100%

16.2.5.2 Mining Equipment

The open pit mine is a conventional shovel and truck operation. OT LLC's workforce carries out the drilling, loading, hauling, and dumping. The equipment maintenance is conducted under Service Agreements with the original equipment manufacturers in-country dealers.

The 2013 OTTR was based on the use of 34 m^3 diesel hydraulic shovels, 56 m^3 electric rope shovels, and 290 tonne class diesel trucks. The equipment estimates are based on the specifications and data provided by the equipment suppliers in their submissions to the OT LLC tender process. The equipment fleet requirements for 2013 and at five-year intervals are listed in Table 16.5.

Table 16.5 Open Pit Mining Equipment in Service

Equipment Units	2013	2018	2023	2028	2033	2038	2043	2048
Shovel – 34 m^3 Hydraulic Diesel	2	2	–	–	–	2	2	1
Shovel – 495 HR Rope Electric	2	2	2	2	2	2	2	2
Truck 290 t – 930E-4SE	28	32	11	12	13	27	40	27
Production Drill – Electric	2	2	2	2	2	3	4	3
Production Drill – Diesel	2	2	–	–	–	–	–	–
Dozer – D375 – 6	4	6	3	3	3	6	6	5
Dozer – D475 – 7	2	2	2	2	2	2	2	2
Grader – 16M Cat	3	3	2	2	2	3	3	3
Grader – 24M Cat	1	2	1	1	1	2	1	1
FEL – WA1200 18 m^3	2	2	1	1	1	2	2	2
Wheel Dozer – WD600	2	2	1	1	1	6	6	5
100 t Water cart	4	4	2	2	2	4	4	4
Tire Changing Forklift	1	1	1	1	1	1	1	1
Integrated Tool Carrier	2	2	1	1	1	2	2	1
Excavator 4 m^3	1	1	1	1	1	1	–	–
Cable Truck	2	2	1	1	1	2	2	2
Blasters and support vehicles	4	4	2	2	2	4	4	4
Flat Bed Crane	2	2	1	1	1	2	2	2
Low Loader Tractor/Trailer (110 t)	1	1	1	1	1	1	1	1
Lighting Towers	37	40	39	39	39	39	39	39
Personnel Carriers	5	5	2	2	2	5	5	5
Forklift	7	7	3	3	3	7	7	7
Mine Lube/Fuel Truck	2	2	1	1	1	2	2	2
Light Vehicles	30	30	11	12	11	30	29	10
Pit Pump	2	12	4	4	4	18	18	18
Crane (120 t)	–	1	–	–	–	–	–	–
Low Bed Trailer/Tractor (250 t)	1	1	1	1	1	1	1	1
Telescopic boom	3	3	1	1	1	3	3	3
Maintenance Service Vehicles	10	10	4	4	4	10	10	5
Heavy maintenance/welding truck	3	3	1	1	1	3	3	1

16.2.5.3 Drilling and Blasting

Production blast hole drilling is 17 m deep and 305 mm diameter. OT LLC conducts the blast designs, shot-firing, and monitoring while a contractor carries out the down-the-hole services, including the supply and storage of explosives. It is assumed that ammonium nitrate fuel oil (ANFO) will be used in dry holes and heavy ANFO in wet holes. Given the prevailing conditions, 90% of the blasting is expected to be dry.

The blasting estimates are considered appropriate for the 2013 OTTR. In operation the parameters will need to be refined for the conditions. All material is assumed to be blasted. Free digging may be possible in the first or second benches but detailed work to define the extent of this has not been done. Delaying purchases to account for the possibility of free-digging is not recommended due to the long lead time for major equipment supply.

Due to the timing of the power station construction and the required start-up flexibility, the initial two productions drills are diesel units. Additional drills are assumed to be electric units. In addition to the primary production drills, a secondary drill has been included in the life-of-mine (LOM) estimates and will be used for pre-split, secondary, and horizontal drain hole drilling.

16.2.5.4 Loading and Hauling

The primary loading fleet consists of two 34 m^3 hydraulic shovels and two 56 m^3 electric rope shovels. Generally, one of the shovels will be used to mine ore from the lower pit benches and the others will be used to strip waste for the development of the next phase. Also in operation are two 18 m^3 front-end loaders (FEL).

The loading equipment in service is shown in Figure 16.2 and the trucks in service in Figure 16.3. The 2013 OTTR takes into account the increased distances of the haul roads as the pit deepens over time.

Figure 16.2 Loading Equipment in Service

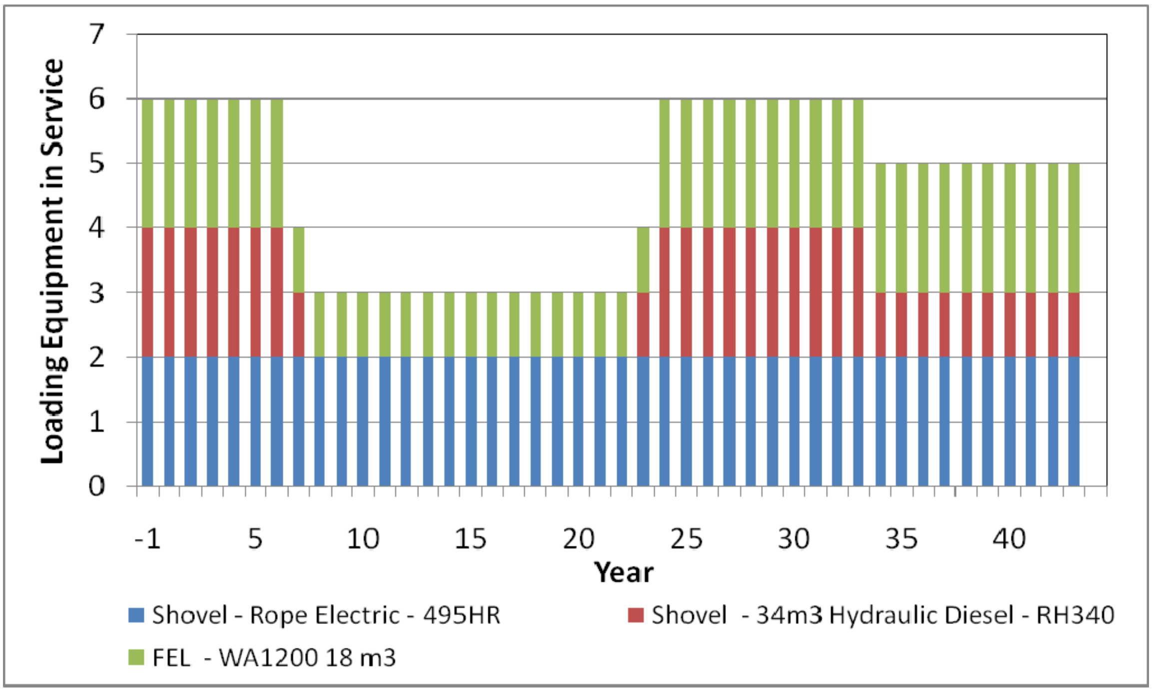
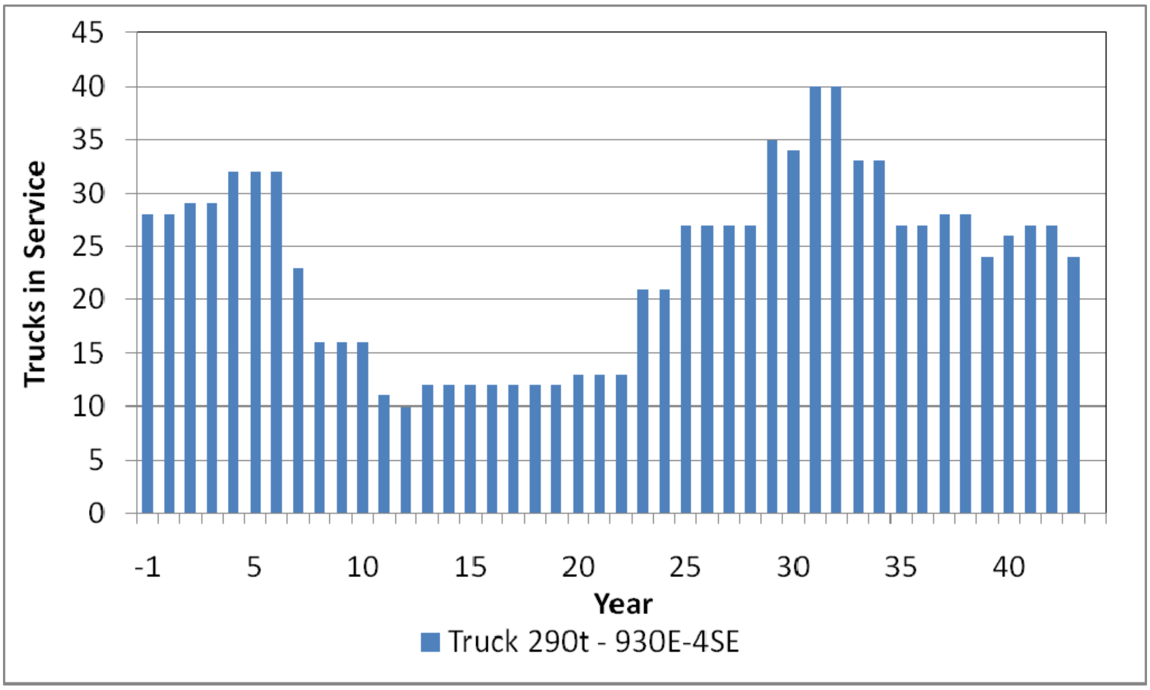


Figure 16.3 Trucks in Service



16.2.6 Waste Dump

The designs for active waste dumps assume a swell factor of 30% for the material delivered from pit benches, considering natural sorting and compaction in the dumps. It is also assumed that the blasted waste rock will settle at a natural angle of repose of 37°. The plan is to build the dumps in 10 m high lifts, forming 20 m high benches with 40 m wide haul roads at 10% grade. The dump height is designed to a maximum of 70 m or the 1,230 mRL. This is based on the Environmental Impact Assessment (EIA) submitted to the GOM in 2007. However, an additional 10 m lift was needed on the Near South dump for additional capacity to provide flexibility for the placement of non acid forming (NAF) and the tailings stockpile.

The design criteria consider selective placement of rock on the dumps, ensuring that waste dumps are located so that potentially acid forming (PAF) waste is isolated from stream sediments to eliminate the risk of off-site migration of ARD post closure. The designs include the following:

- Placement of a 3 m thick initial NAF lift on the western half of the dumps, an area where the surface does not contain clay.
- Placement of a 1 m to 3 m thick NAF cap on the reclaimed dump surface to mitigate the effects of erosion.

The following dumps have been designed:

- Tailings Stockpile (East dump) – This dump stores NAF oxide and sediment material to be used in the construction of the tailings storage facility (TSF). This stockpile is dynamic, with material dumped from the open pit being removed for TSF construction as required.
- West waste dump – This dump overlies some clay material and the adjacent Undai River; primarily used for storing PAF material.
- South waste dump – This dump is split into two areas, Stage 1 and Stage 2. Approximately half of these dump areas overlie clay and so do not require the NAF bottom lift. This dump can be managed to store different types of material depending on cycle times and waste rock characteristics.

The West dump and the Stage 1 and Stage 2 South dumps will accept a mix of NAF and PAF material. The Tailings Stockpile dump will be empty by 2032 after the third tailings cell is constructed and can be used to store both PAF and NAF rock. The voids within and separating these three dump areas need to be filled to complete the final dump. This will be done at the end of the mine life according to a dumping strategy determined at the time of material placement.

Oxide material mined out from the top oxidized benches is stockpiled in an oxide material (SOM) dump north-east of the open pit.

The optimized mine plan requires raising the milling cut-off grade, which relies on the ability to stockpile the ore mined to date from the open pit. As of the end of 2012, approximately 9.5 Mt of ore have been stockpiled. The stockpile has been divided into three categories: high grade (HG), medium grade (MG), and low grade (LG).

The LG and MG stockpiles are part of the mine planning strategy to optimize project value and are categorized as mining reserves. These stockpiles will continue to grow, while the HG ore will be fed to the concentrator on start-up.

The waste dump and stockpile designs consider an overall slope angle of 18° after reclamation. The designs and a cross-section of the dump design geometry are shown in Figure 16.4 and Figure 16.5, and Figure 16.6 is an illustration of the open pit stockpile.

The ultimate capacities of the dumps and stockpiles are shown in Table 16.6.

Figure 16.4 Waste Dump Designs

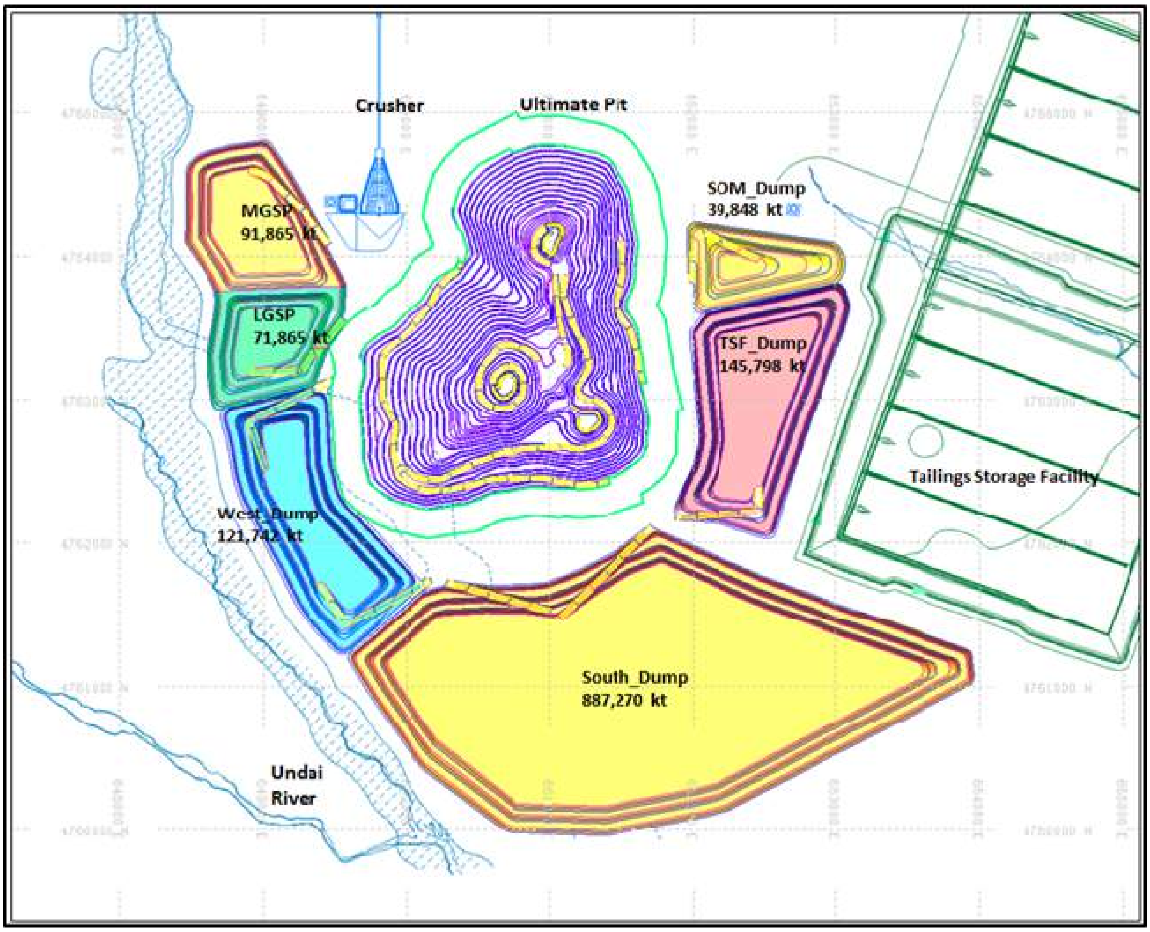


Figure 16.5 Cross-section Showing Dump Design Geometry

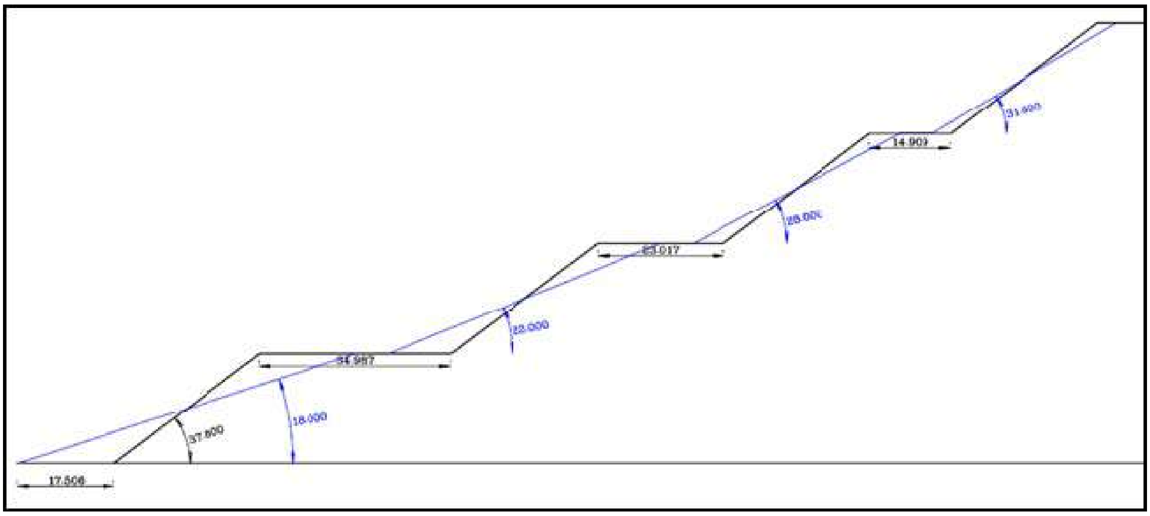


Figure 16.6 Current Progress of Pit Ore Stockpiles

Table 16.6 Ultimate Open Pit Waste Dump and Stockpile Capacities

Waste Dump	Capacity (kt)
TSF Dump (East)	145,798
West Dump	121,742
South Dump	887,270
SOM Dump	39,848
Total Waste	**1,194,658**
Low Grade Stockpile	72,000
Medium Grade Stockpile	92,000
Total Stockpile	**164,000**

16.3 Underground Geotechnical

16.3.1 Introduction

This section relies on reports for the Feasibility Study of underground mining. Two reports particularly were relied on:

- "Oyu Tolgoi Feasibility Study – Geotechnical & Cave Design Studies" by Rio Tinto Technology and Innovation, dated 29 May 2012. Numerous notes and reports of studies were appended to this report.
- "Oyu Tolgoi Project Mongolia – Underground Feasibility Study", Chapter 4: Geotechnical, by Oyu Tolgoi LLC, dated December 2012. Chapter 4 comprised a summary of the Rio Tinto report.

The previous Technical Report, "Oyu Tolgoi Project, IDOP Technical Report", dated March 2012, was based on results and assessments for the Pre-feasibility Study (PFS) of the Oyu Tolgoi Project. Since the PFS, there has been a substantial programme of investigations and analyses for the Feasibility Study (FS), which was undertaken during 2012.

Particularly for the FS, investigations and analyses comprised:

- A programme of drilling and logging of cores that were drilled in fans across the orebody and host rocks from the underground development off Shaft No.1.
- Additional measurements of in situ stress at several sites from underground development, and an updated interpretation of the in situ stress field for the Hugo North orebody and environs.
- A characterisation drive across the orebody, which was the first underground exposure of the orebody. Results from the development and support of the drive, and of associated measurements of the response of the rock to development were assessed.
- Numerical analyses of all facets of proposed cave mining, undertaken to provide a basis for estmation of geotechnical design parameters for cave mining.

Investigations and studies have continued since the FS, but there has not been a material change in geotechnical design parameters for the proposed cave mining.

The FS was confined to the Hugo North orebody, Lift 1. It did not consider a possible Lift 2 of Hugo North mineral resources or the Hugo South mineral resources. This section deals with only cave mining of Lift 1 of the Hugo North orebody.

In this section, the terms geotechnical, geomechanics and engineering geology are considered equivalent. The term geotechnical will be applied.

16.3.2 Characterisation of Rock Units

16.3.2.1 Geological Setting

Hugo Dummett mineralization, which includes the Hugo North orebody, is a porphyry copper-gold style of mineralization, associated with an intrusion of quartz monzodiorite into a deformed sequence of sedimentary and volcanic rocks.

Mineralization is elongate, trending north to north-east over a length of about 3 km. Although mineralization is continuous over this length, a major fault toward the southern end, termed the 110 Fault, striking east-west, dipping north, displaced host rock units north side down. This fault separates the Hugo South and Hugo North deposits, at 4 766 400 N.

The main host rock units that will affect cave mining of Lift 1 of Hugo North are, from youngest to oldest:

- Basaltic lava flows, intercalated breccias and tuff (BasL).
- Basaltic lapillic tuff (Bat).
- Basaltic andesitic lava flows (AndL).
- Volcanic sandstone, carbonaceous siltstone, sandstone, and conglomerate.
- Andesitic ash flow tuff (Andign).
- Basaltic flow breccia and derived coarse volcanoclastics (L).
- Carbonaceous shale and laminated siltstones, sandstones and conglomerates.
- Dacitic block ash tuff (Vbx).
- Dacitic ash flow tuff (ignimbrite) (Ign).
- Augite basalt flows and breccias (Va).

Additionally, felsic to mafic dykes occur throughout the mineralised and surrounding rock. The most significant of these are biotite granodiorite (BiGd) and porphyritic quartz monzodiorite (Qmd) intrusives. Qmd dykes are genetically related to the porphyry copper-gold system.

All of those rock units and dykes that are greater than 10 m thickness were modelled as 3D solids, based on drilled core data.

Mineralization occurs within or adjacent to quartz monzodiorite porphyry intrusions. There are multiple intrusions and associated breccias. Mineralization is associated with hydrothermal alteration of the intrusive bodies and intruded host rocks. A majority of mineralization occurs in zones of veining and stockwork, with minor amounts of disseminated and replacement mineralization throughout the hydrothermally altered rock.

Hydrothermal alteration is zoned, similar to other porphyry copper deposits, principally advanced argillic alteration. Pyrite is the dominant sulphide. Quartz-sulphide veins comprise at least 15% and up to 90% of the volume of the rock.

Mineralization is bounded by three major faults:

- WestBat fault, subvertical, west of the mineralization.
- Contact Fault, east-dipping, east of the mineralization. Above the extraction level the fault extends up and over the mineralization, meeting the WestBat fault, defining the top of the resources.
- 110 Fault, subvertical, south of the mineralization, separating Hugo North from Hugo South.

16.3.2.2 Sources of Data on Rock Units

Surface Drilling

Initially, all information was from cores drilled from the surface. All cores were steep-plunging. Most cores were drilled to the east or west, across strike. These cores had unavoidable directional bias. The Pre-feasibility Study was based on data from these cores.

Underground Drilling

Diamond drilling of cores from underground was done during 2011 and 2012 (Figure 16.8). It was concentrated on coverage of the orebody, for data on mineral resources and rock conditions of the cave's footprint at undercut and extraction levels. Drilling was in fans of subhorizontal holes. Some cores included sites of mine infrastructure. The Feasibility Study incorporated data from this drilling.

A total of 19,779 m of core was drilled to November 2011. Drilling to February 2012 took the total to 24,725 m of core. The layout of cores is shown in Figure 16.8.

Underground Development

All underground development has been geologically and geotechnically mapped. Initial development was of Shaft 1 and level stubs off it. Recently, there has been progressive development of the 1300 level off Shaft 1, which has all been mapped.

16.3.2.3 Domains of Rock Conditions Based on Rock Units

Domains of rock units comprise rock types (lithology) and extensive (major) faults.

The current interpretation of rock units is shown on following plans and sections.

Some key aspects of the geology of the Hugo North orebody (Figure 16.7) are directly relevant to mining of the orebody (Figure 16.9 to Figure 16.11):

- Sedimentary-volcanogenic (Devonian age) rock units in the hangingwall-east of Quartz monzodiorite and biotite granodiorite, upper to lower (Figure 16.12) Volcanogenic siltstone-sandstone
  - Basaltic volcanic flow breccia (L)
  - Hangingwall fault
  - Laminated siltstone-conglomerate
  - Dacitic ash flow (Vbx)
  - Augite basalt (Va)
- Intrusives (Figure 16.12):
  - A core of biotite granodiorite
  - Flanked east and west by quartz monzodiorite, divided into lower and upper parts: 1) lower (below 0 RL to -100 RL), red quartz monzodiorite, with intense sericite alteration, hosting higher-grade gold; and 2) upper, quartz monzodiorite, with intense sericite alteration, hosting higher-grade bornite and molybdenite.
  - Quartz monzodiorite, to the east-hangingwall, of sericite-altered monzodiorite with intense quartz veining, hosting >2.5% copper.
- West Bat Fault (Figure 16.10 and Figure 16.11) to the west of intrusives, forming a sharp western contact between monzodiorite and intruded rock units.
- Sediments-volcanogenics to the west of West Bat fault (Figure 16.12)
  - Basaltic volcaniclastic and flows (BasL)
  - Sediments, fine to course
  - Andesitic ash flow tuff (Andlgn)

Figure 16.7 Plan View of the Hugo North Resource Model at -100 RL

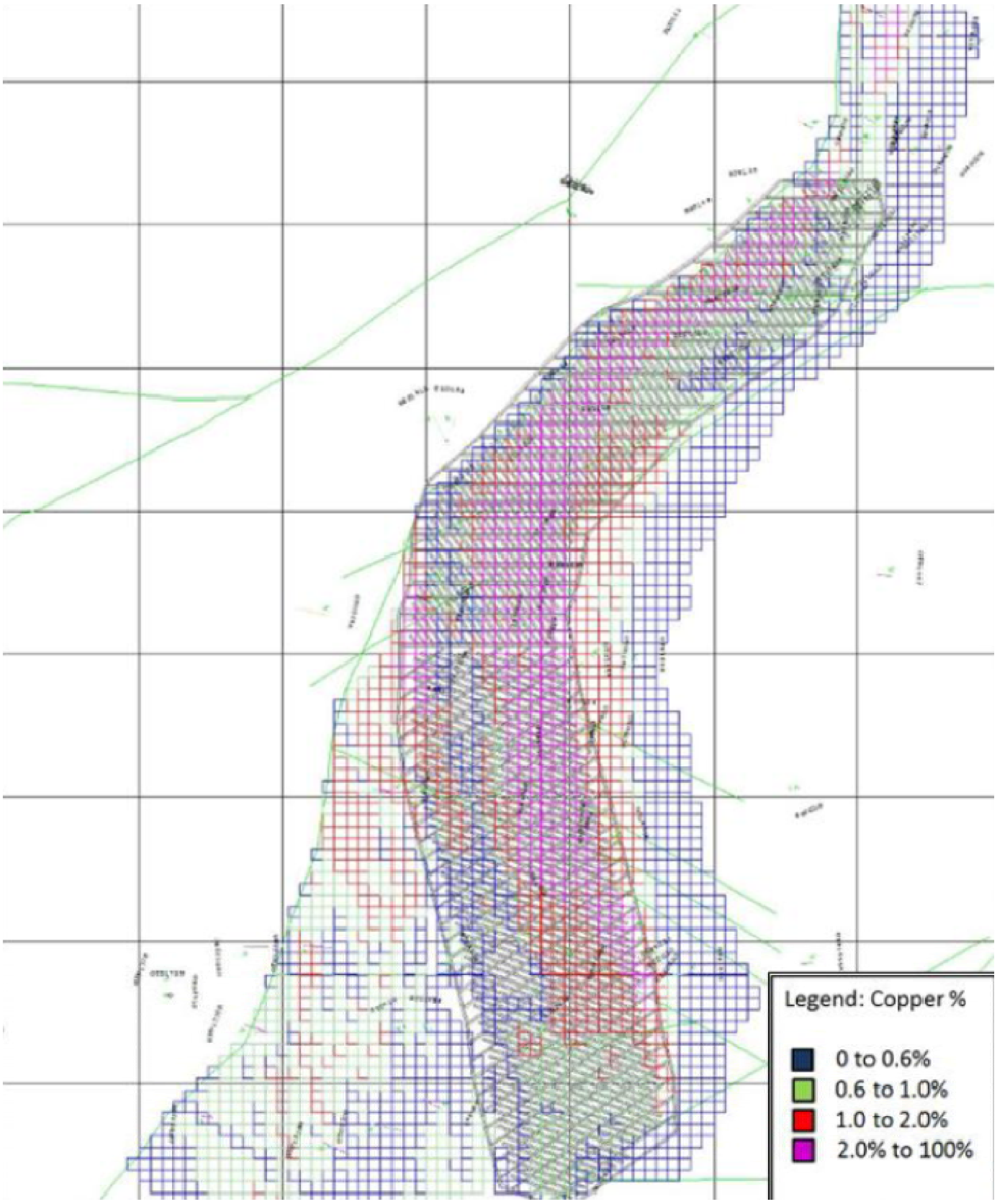


Figure 16.8 Plan of Diamond Drilled Holes at 1300 Level, to November 2011, with Colour-coded Lithology Along Their Paths (Blue Line Outlines the Resource Model)

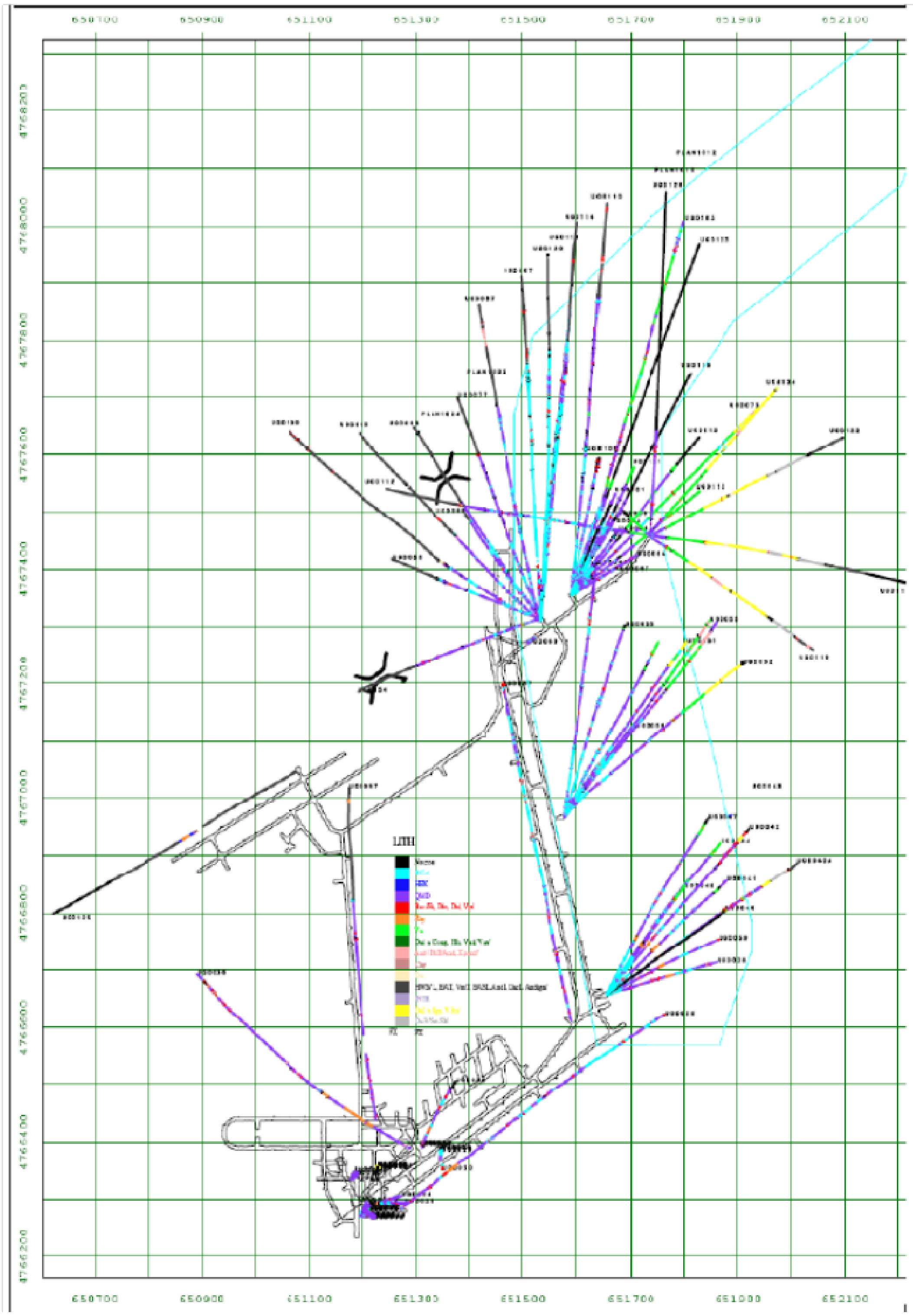


Figure 16.9 Plan of Geology of the Footprint of the Cave (with Planned Drilling)

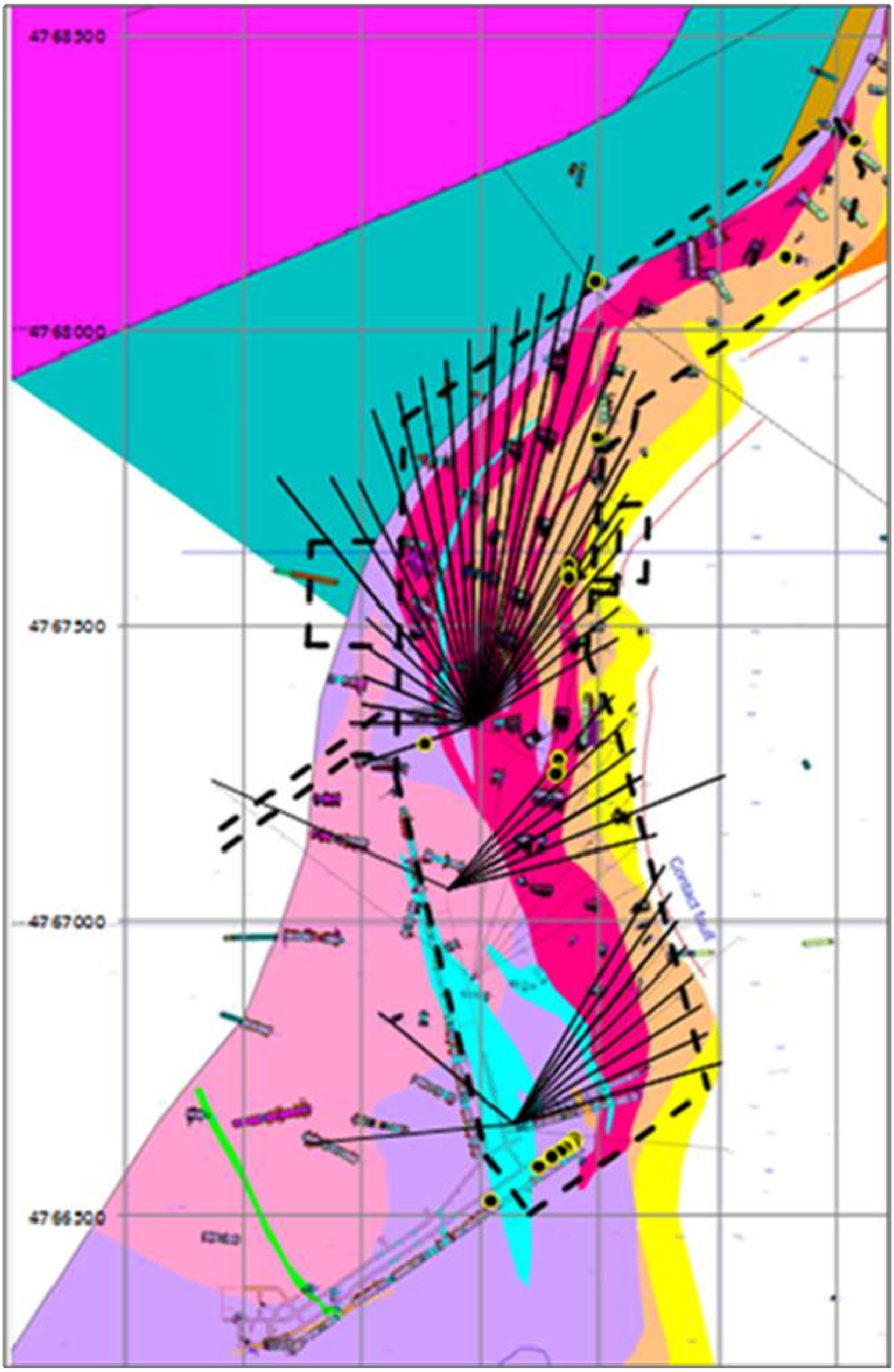


Figure 16.10 Plan of Interpreted Major Faults at the Footwall of the Cave, with the Planned Footprint and Infrastructure Development

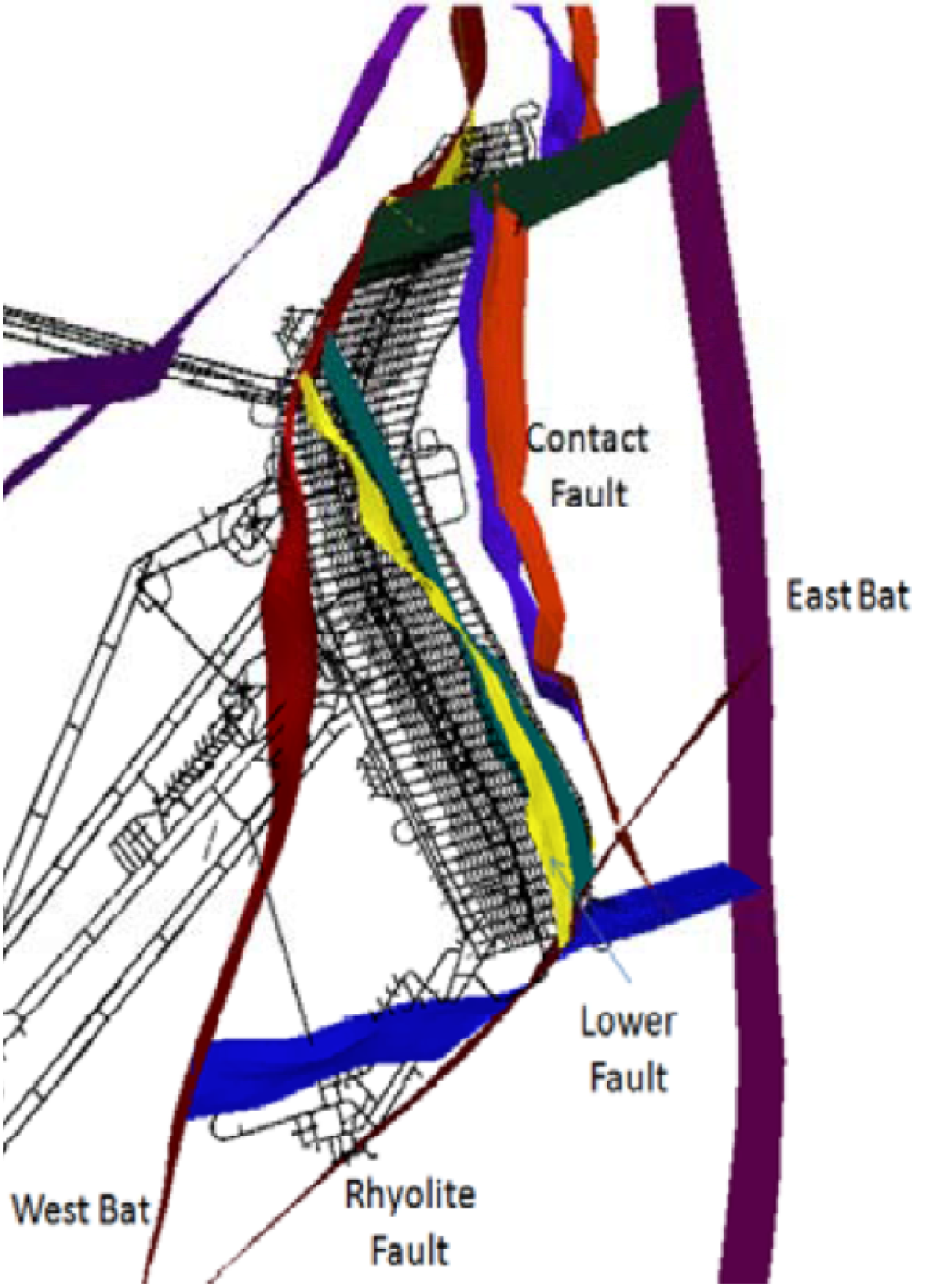


Figure 16.11 Geological Cross-section Through Hugo North, Looking North, at the Kink Between the North and South Sectors (4767400 N), (Prior to Underground Drilling)

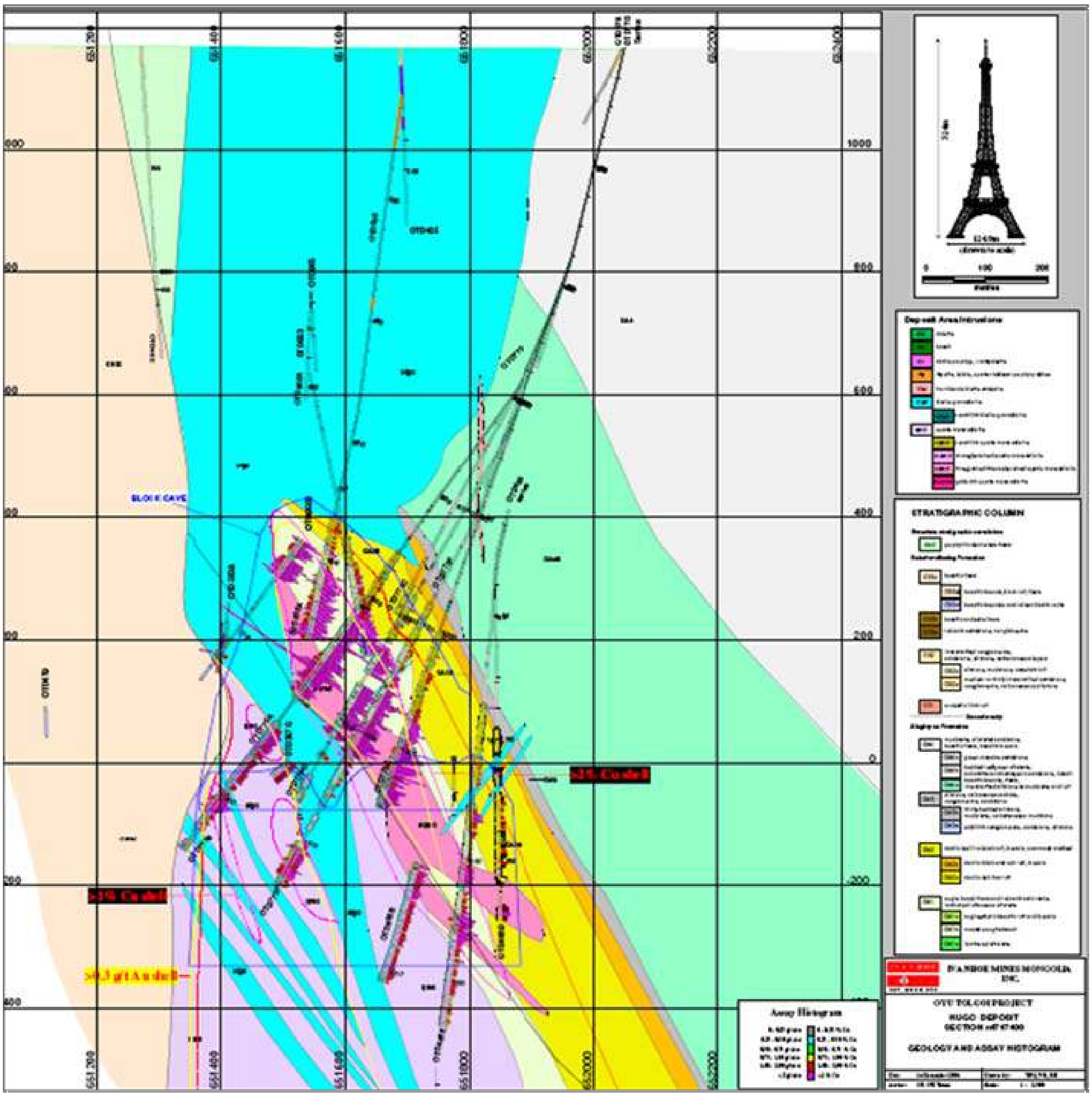
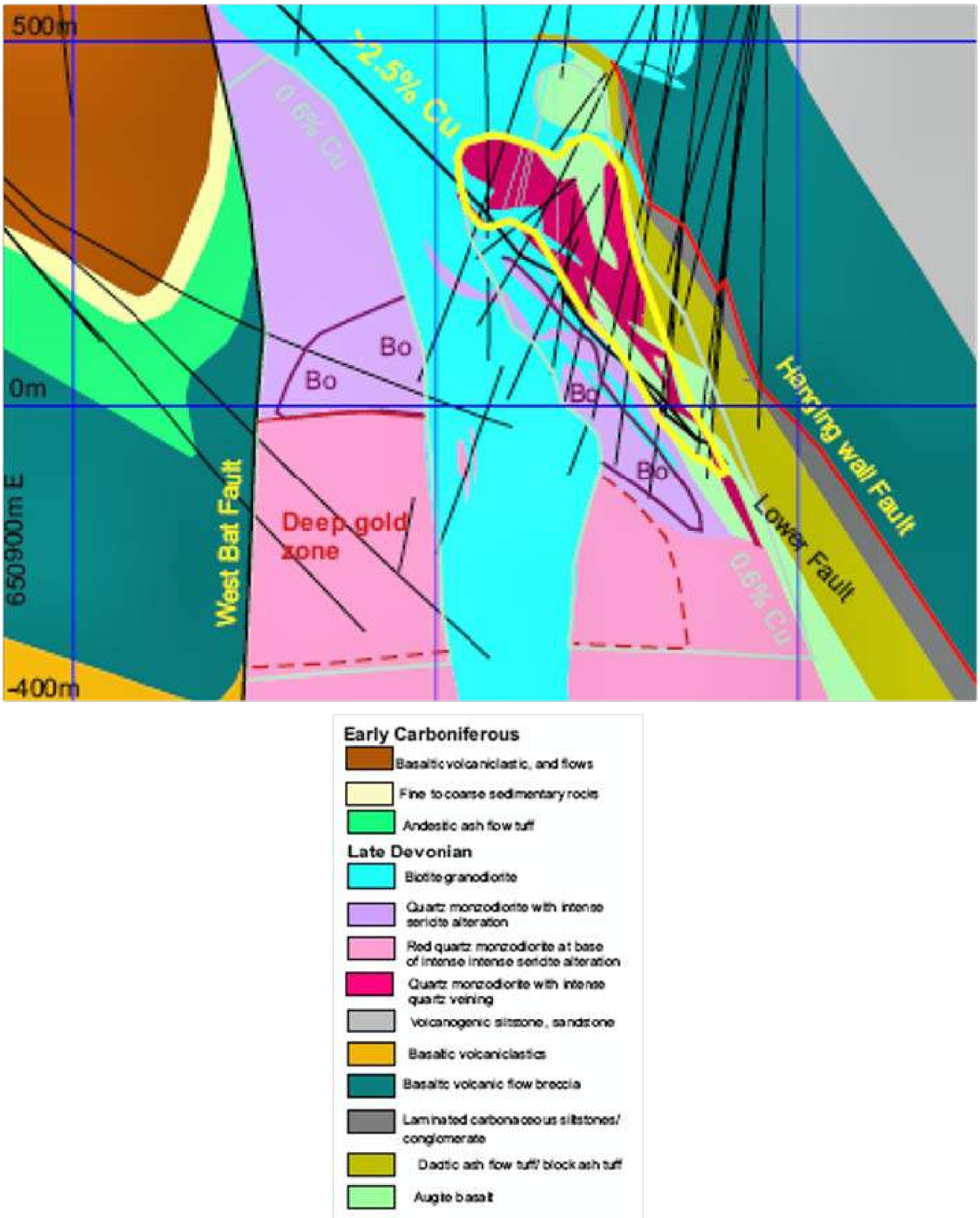


Figure 16.12 Cross-section of Hugo North Orebody, at Approximate Mid-length ofthe Southern Sector (4766945), Looking North



16.3.2.4 Strength of Rock Materials

An intensive programme of measurements of the properties rock materials was undertaken for the Feasibility Study, to better characterise the dominant lithologies. This included additional measurements of unconfined (UCS) and confined (triaxial) compressive strength, and of tensile strength (UTS).

Additional measurements of triaxial strength were undertaken on six rock types, to better account for effects of microfractures and veins on strength.

Results from measurements of UCS were divided into those samples that failed through solid rock with an axial fracture (Table 16.7), and those that failed on an identified structure. Mean UCS and UTS are compared in Table 16.7 and Figure 16.13.

Qualitative estimates of strength, from logs, of cored "fault rock" were associated with their host lithology as a means to account for the range of strength of material in each lithologic unit. These measures of strength were not adopted as input for analyses unless there was no other reliable data.

Table 16.7 Mean UCS and UTS by Lithology

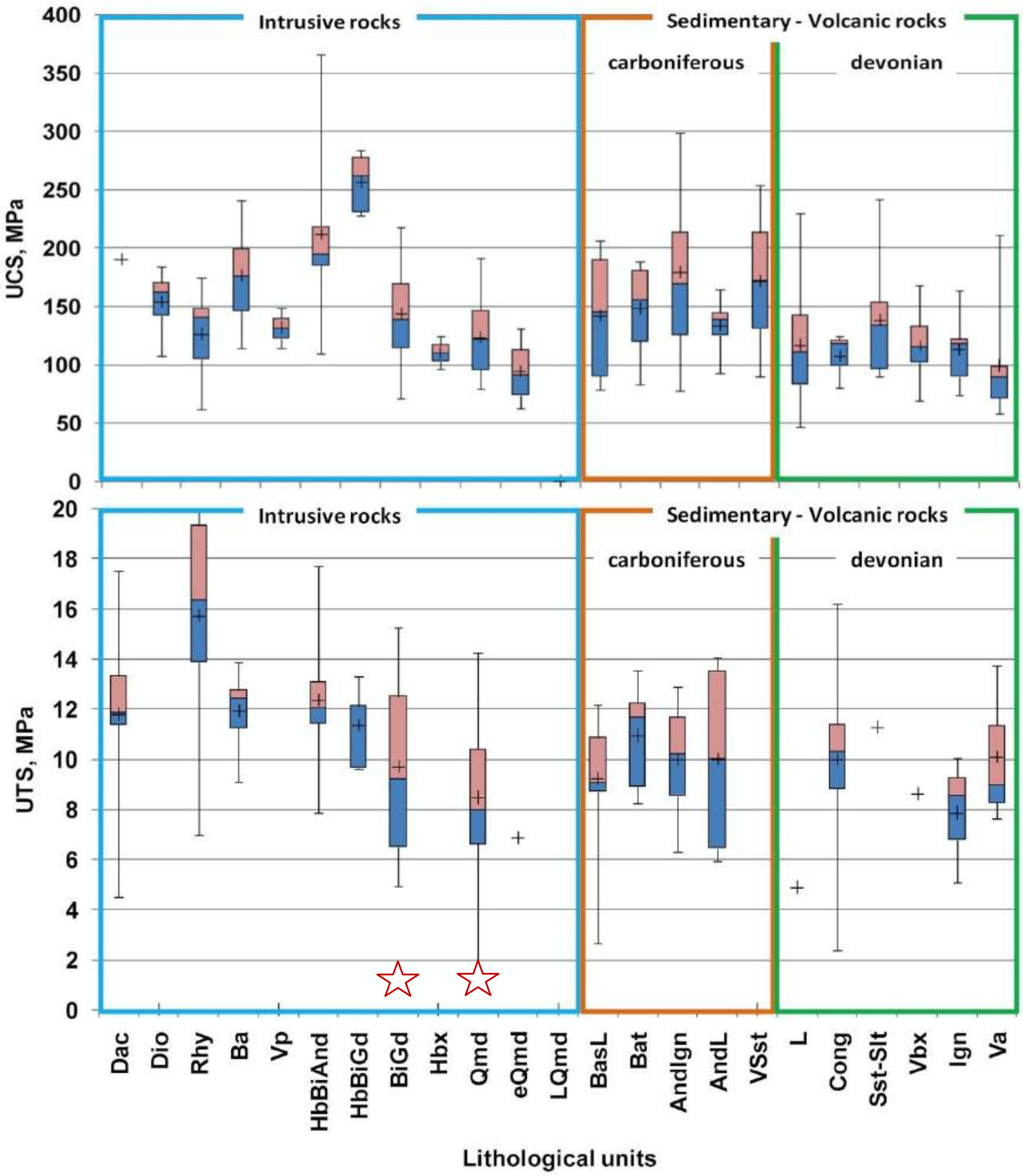
Lithology	UCS (MPa) (solid rock)	UTS (MPa) (Brazilian)
Biotite granodiorite (BiGd)	145	9.7
Quartz monzodiorite (QMD)	125	8.4
Ignimbrite (Ign)	120	7.8
Basalt (Va)	100	10.1
Sediments (SED)	135	11.2

Point Load measurements were undertaken in 2010 and 2011. Over 540 samples were tested.

For a majority of lithological units, point load strengths, expressed as equivalent UCS, were lower than UCS measured directly on samples, for failure through rock material. However, the dispersion of values from point load measurements was generally greater than those from direct UCS measurements.

For the two dominant intrusive lithologies – biotite granodiorite and quartz monzodiorite – point load strengths from samples with a moderate to low degree of alteration (sericitic, chloritic, argillic) were higher or similar to strengths for unaltered samples. This conclusion was claimed to be consistent with previous results (2007) from direct measurements of UCS.

Figure 16.13 Mean and Dispersion of Strength by Lithology



16.3.2.5 Geologic Structures – Faults

Fault structures have been interpreted within, around and in the vicinity of the Hugo North orebody.

Hugo North orebody is bounded and transacted by numerous faults. These faults are likely to influence caving and fragmentation of the ore, the stability of associated excavations, and subsidence at the surface.

The location of major, extensive faults at the footprint of the Hugo North orebody is shown in Figure 16.14, with the common strike-trends of these and other interpreted faults.

- In the northern sector, designated Zone 1 and Zone 2 (transition), the common strike trend of faults is north-east. This is typified by the West Bat fault, along the north-western margin of orebody.
- In the southern sector, designated Zone 3 and Zone 2 (transition), the common strike trend is north-north-west. This is typified by the Contact fault and the Lower fault, along the eastern margin of the orebody.

For both north and south sectors, the dominant strike-trend of faults is subparallel to the strike-trend of rock units and the orebody.

The report for the feasibility studied remarked on the “high intensity of faulting transecting the rock mass”, and that the “Hugo deposit ... is the most strongly faulted porphyry style deposit the writers have seen”. (“Strongly” meant the intensity of occurrence of faults, not their strength.) Intersections of faults in drilled cores to 2007 are shown in Figure 16.15. In 2010, faults in core were estimated to comprise 3% of the length of core. A majority of these intersections could not be directly modelled as fault surfaces or zones, but rather were accounted as part of the fabric and strength of the rock mass.

Figure 16.14 Plan of Traces of Interpreted Major Faults

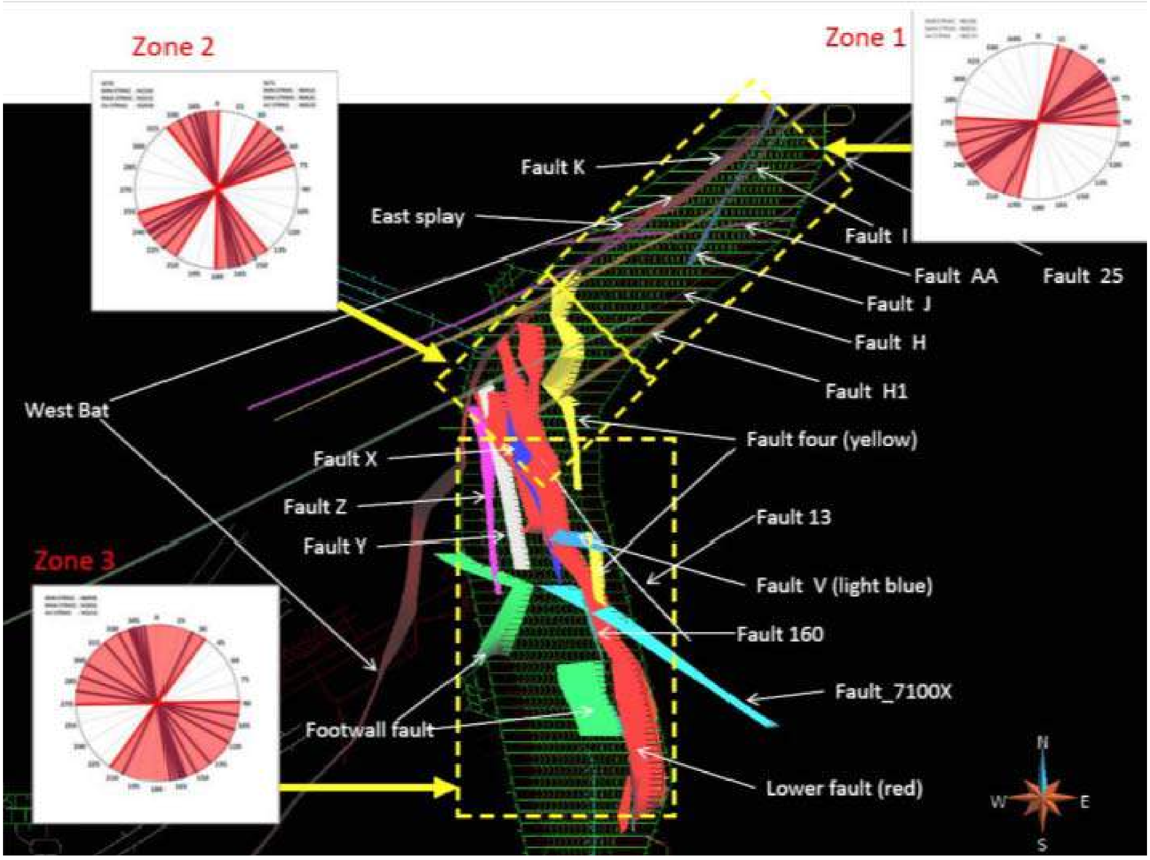
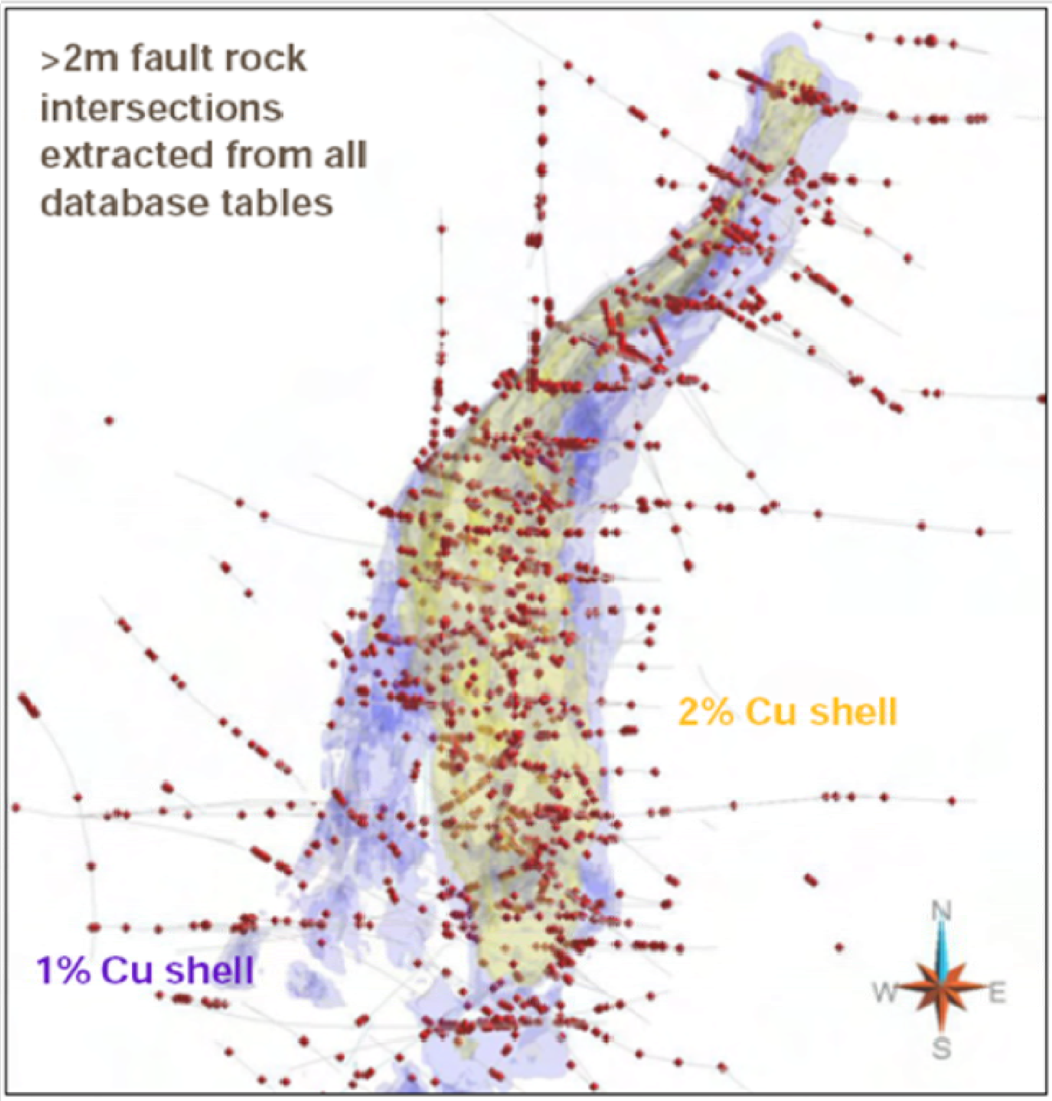


Figure 16.15 Plan Projection of the Occurrence of Intervals of Faults Logged from Cores



16.3.2.6 Geologic Structures – Fractures, Joints, Veins

A clearer picture of the occurrence of tunnel-scale and core-scale structures in rock units within and around the orebody emerged from the programme of underground fan drilling.

These structures, principally fractures in the rock (also called joints), but also veins, will affect the fragmentation of caving rock and the response of the rock mass around underground development.

Logs of cores included the orientations of fractures, where core was orientated during drilling. From that, the sets of fractures and the condition of the surface of fractures was estimated, by rock unit (Table 16.8).

The frequency of occurrence of fractures along drilled core was claimed (in the report of the FS) to represent a highly-fractured rock mass. The condition of fracture surfaces was claimed to be typically low, representing low-friction, planar or slightly undulating surfaces.

Table 16.8 Nature and Condition of Geologic Structures In Dominant Units

Rock Unit	Number of fracture sets (1)	Fracture frequency (per metre)	Fracture condition (2)	Vein frequency (per metre)
Biotite granodiorite (BiGd)	3	4.5	14	9.9
Quartz Monzodiorite (QMD)	5	5.3	13	8.9
Ignimbrite (Ign)	5	4.3	13	10.7
Augite Basalt (Va)	5	4.0	12	9.2
Sediments (Sed)	–	2.6	–	13.7

(1) As identified by OT LLC in Table 3.1 of "Geotechnical & Cave Design Studies".
(2) As defined by Laubscher 1990.

16.3.2.7 In Situ Stress

In situ stress is the natural stress due to geologic processes that exists in the rock mass before disturbance by mining.

Magnitudes and directions of in situ stress are critically important for mining the Hugo North orebody, where the undercut, extraction, and haulage levels are at 1,200 m to 1,300 m depth below the ground surface, and high magnitudes of stress are expected.

In situ stress for Hugo North was been measured in two campaigns:

- An initial programme of measurements at six levels off Shaft 1 as it was being sunk (Figure 16.16). Results were reported and reviewed by AMC Consultants Pty Ltd in 2008.
- A subsequent programme of measurements for the feasibility study of underground mining, at three sites across the 1300 level development, off shaft 1. Broadly, they covered the footprint of the Hugo North cave. Results were reported and reviewed by Mirarco in 2012.
- There are no other valid measurements at the Oyu Tolgoi site.

All direct measurements of stress were by overcoring of CSIRO Hollow Inclusion (HI) cells, by the same contractor, Mine Measurement Services. This is regarded as the most accurate and reliable method of measuring in situ stress in mines.

Measuring stress with the HI cell has proved to be “challenging” (as stated in the geotechnical FS report) because much of the core has included microfractures, as well as the usual core-scale and larger fractures. The HI cell, as with all overcoring methods, requires solid uncracked core for successful measurements. For Oyu Tolgoi there were more measurements at each site than there would have been for typical rock conditions elsewhere, but there remained a high degree of variability amongst individual measurements at a site and between sites of measurements.

Stress-induced spalling from the wall of the exploratory hole at the centre-line of shaft 1 was measured by a downhole acoustic televiewer (ATV). Results were compiled and assessed in the report by AMC.

Measurements from Shaft 1

AMC interpreted the mine-scale stress field for Hugo North from the results of the measurements at six levels of the shaft. Calculations of stress were as a single result for each level. Figure 16.16 shows a cross-section, looking north, through shaft 1, showing the location of measurements of stress at levels off the shaft, with their geologic setting. Figure 16.17 shows a plot of magnitudes of principal stress by depth (left) and directions (right) for measurements of stress at levels off shaft 1. Table 16.9 shows the interpreted depth-stress relationship for the magnitudes of principal stresses measured at levels off shaft 1. All stress inputs for numerical modelling for the feasibility study were with this stress field.

Figure 16.16 Shaft 1 Stress Measurement Locations

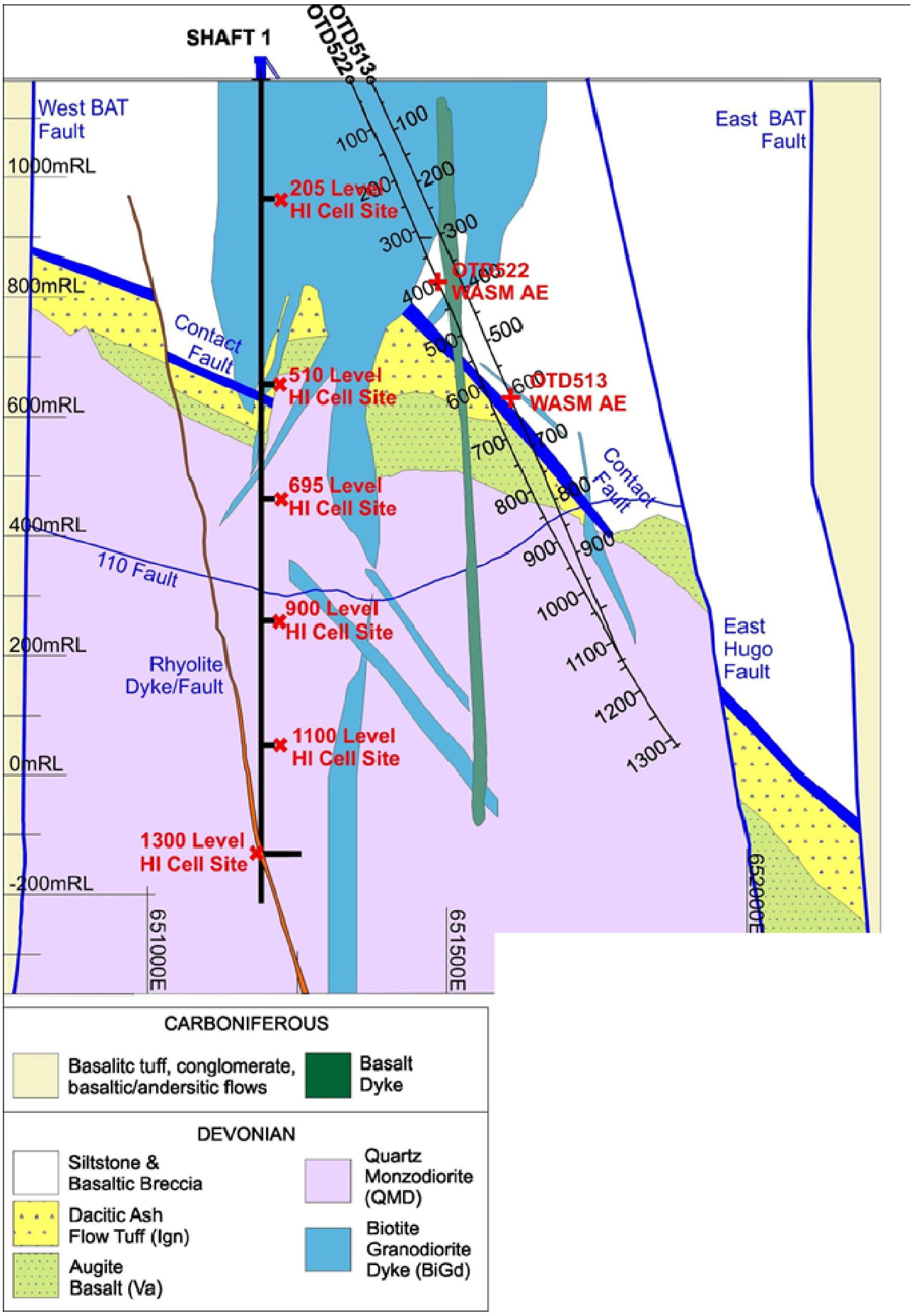
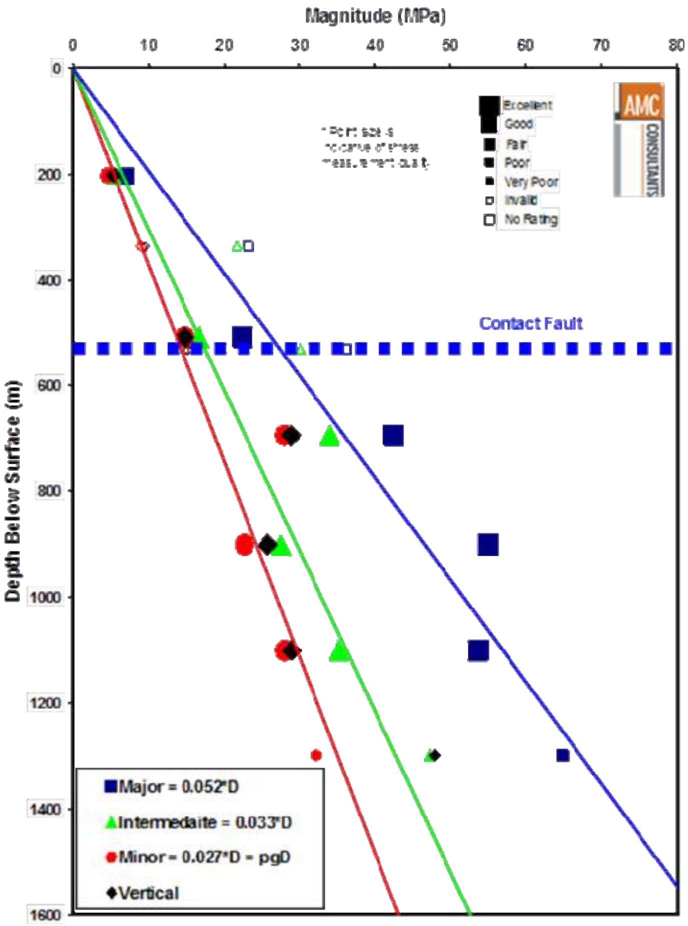
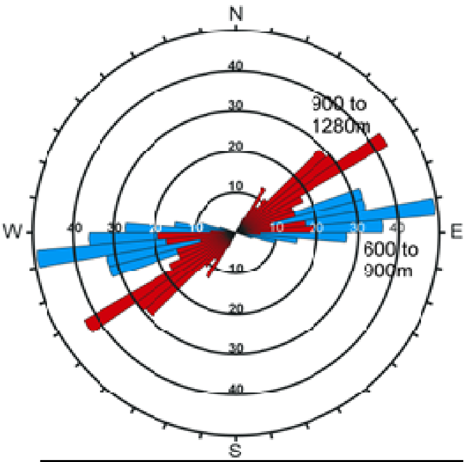
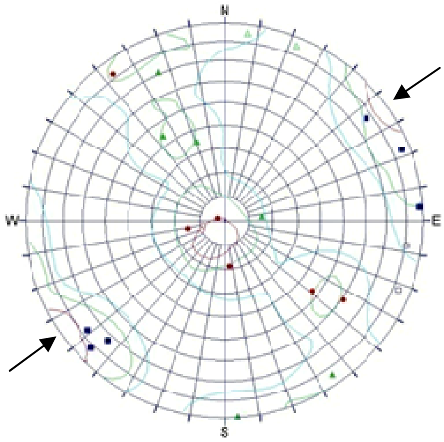


Figure 16.17 Plot Of Magnitudes of Principal Stress by Depth (Left) and Directions (Right) for Measurements of Stress at Levels off Shaft 1





Directions of major principal stresses from borehole breakouts at Shaft 1



Directions of major principal stresses from HI cell measurements at Shaft 1

Table 16.9 Interpreted Depth-Stress Relationship for the Magnitudes of Principal Stresses Measured at Levels off Shaft 1

Principal Stress	Magnitude (MPa)	Plunge (°)	Bearing (°)
$\sigma 1$	0.052*D	00	055
$\sigma 2$	0.033*D	00	145
$\sigma 3$	0.027*D	90	055

D = depth below surface (m)

Plunges are below the horizontal. Bearings are measured clockwise from Oyu Tolgoi Grid North.

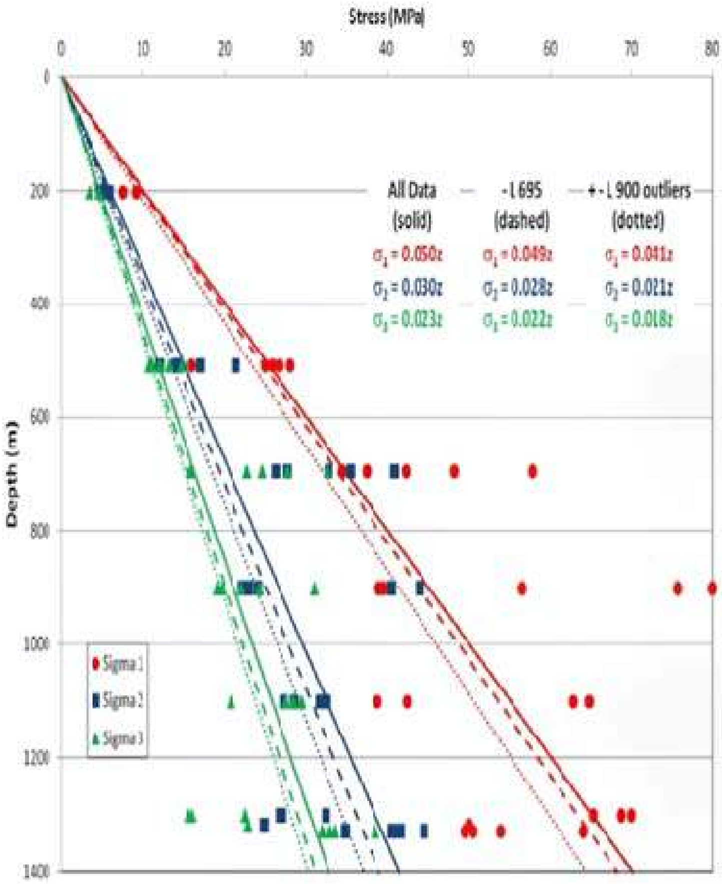
Additional Measurements from 1300 Level Development

After completing the measurements from lateral development at 1300 level, in 2011, all of the results of measurements with the HI cell (ie those from the shaft and lateral development) were referred to the Geotechnical Technical Advisory Board in 2011, as part of the feasibility study.

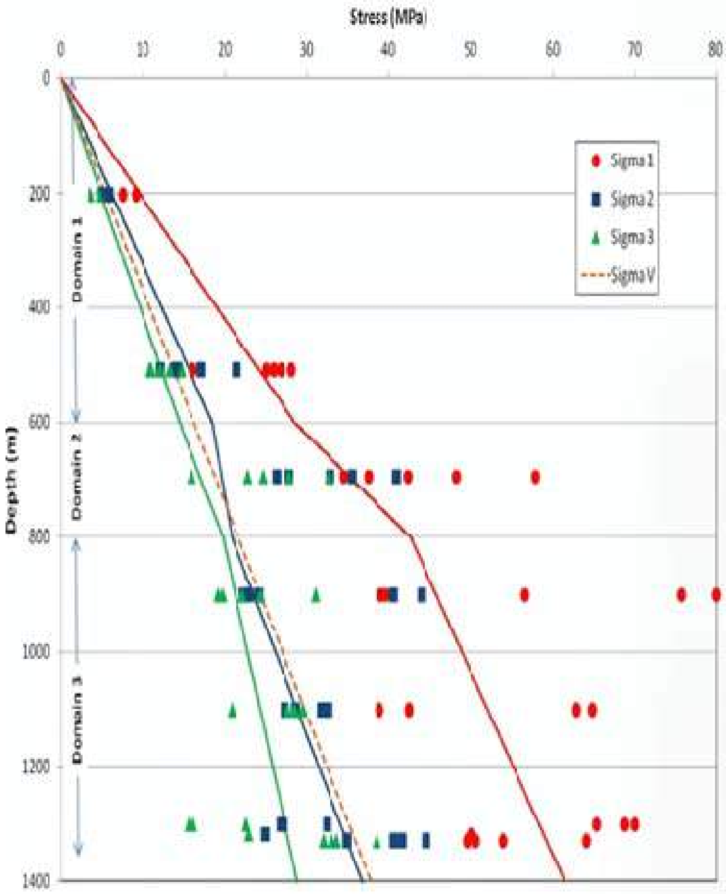
The Board concluded that the results were consistent with effects of current tectonism at depths below approximately 700 m. Figure 16.18 is a plot of magnitudes of principal stress by depth for all measurements of stress at Oyu Tolgoi. Plotted Plot of Magnitudes of Principal Stress by Depth for all Measurements of Stress at Oyu Tolgoi. Plotted Points are for Each Overcored HI Cell. At shallower depth the results were consistent with relief of stress from near-surface rock. A revised tabulation of magnitudes of stress with depth was proposed (Table 16.10). The Board concluded that the direction of the major principal stress was 055° (Figure 16.19), the same as for the results from the shaft alone.

OT LLC have accepted the conclusion of the Board. This interpreted stress field will be used as input for all future numerical modelling. One of the effects of accepting this stress field is a reduction of the estimated magnitude of the major principal stress at 1,300 m from the previous estimate of 67 MPa to 57 MPa, a reduction of approximately 15% from the previous estimate.

Figure 16.18 Principal Stress by Depth



Interpretation of magnitudes of stress as a linear relationship with depth, through the origin.



Interpretation of magnitudes of stress as a bi-linear relationship with depth, reflecting the domains of depth for relief, transition and tectonism.

Figure 16.19 Orientations of Principal Stresses

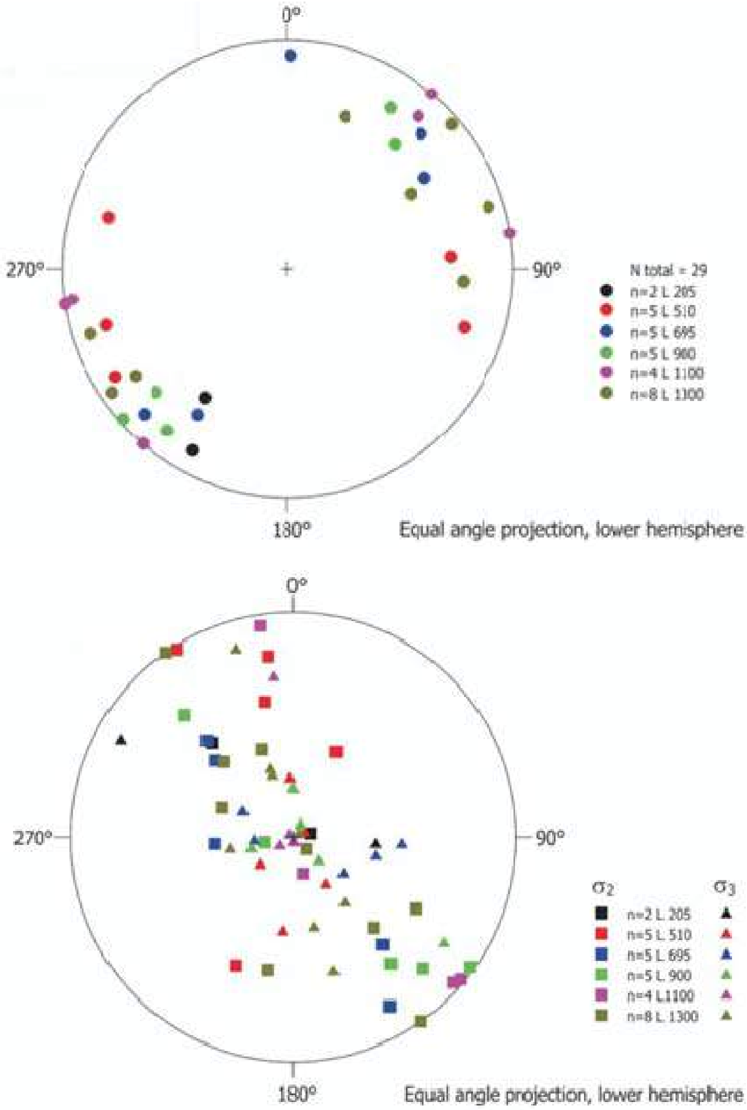


Table 16.10 IDepth-stress Relationship for Principal.

Principal Stress	Magnitude (MPa)	Plunge (°)	Bearing (°)
$\sigma1$	25 + 0.025*D	00	055
$\sigma2$	6 + 0.024*D	00	145
$\sigma3$	4 + 0.022*D	90	055

D = depth below surface (m).

Plunges are below the horizontal Bearings are measured clockwise from Oyu Tolgoi Grid North.

16.3.2.8 Strength and Rating of the Rock Mass

The rock mass comprises the combination of geologic structures – fractures, veins, layering – and the rock material – the solid rock between structures. The compressive and tensile strength of rock materials, and the nature of fractures and faults has been covered.

The rock mass is weaker, in compression and tension, than rock materials, and deformability is lower than rock materials.

Geological Strength Index (GSI)

GSI was developed to estimate the peak strength and deformability of rock masses. For Oyu Tolgoi, the GSI of rock units was estimated with the Cai et al 2004 method. It is based on estimated dimensions of in situ blocks of rock, which in turn is based on the results of logs of cores and exposures. Estimated values are in Table 16.11.

Table 16.11 Estimates of Rock Mass Properties for the Principal Rock Units

Lithology	GSI (mean)	GSI (range)	RMR90 (mean)	RMR90 (std. dev.)
Biotite granodiorite (BiGd)	75	19-41	45	4
Quartz monzodiorite (QMD)	76	18-38	43	4
Ignimbrite (Ign)	79	18-41	45	3
Basalt (Va)	79	22-43	46	3
Sediments (SED)	82	21-43	53	3

Note: RMR was also calculated for a wider range of rock types

Laubscher RMR(90) System

Values of RMR(90) were calculated from logs of cores. Results are in Table 16.11.

Values are relatively low, and the rock mass is classified as fair.

Discrete Fracture Network (DFN) Model

Representative DFN models were developed from joint (fracture) fabric models.

Measured Tunnel Displacements

Deformations of the walls of tunnels were measured at a number of locations by multi-point extensometers as a tunnel advanced, when the 1300 Level was developed. Displacements were analysed by a numerical model to estimate the tunnel-scale properties of the rock around the tunnel. Estimated properties were related to the GSI at the locations, estimated from parallel pre-drilled cores. Overall, estimated rock mass strengths were 50% to 70% of GSI.

The Geotechnical Technical Advisory Board proposed that measurements of tunnel displacements with an advancing face be undertaken at more sites.

16.3.3 Undercut and Extraction Level Design Parameters

16.3.3.1 Introduction

This section deals with the geotechnical investigations and recommendations that formed the basis for the design and sequencing of the footprint of the cave, comprising the undercut, draw bells, extraction level, and ore tipping points.

The content of this section, and those that follow, is drawn largely from the OT LLC report on the “Underground Feasibility Study” of caving of the Hugo North orebody. This, in turn, was based on the Rio Tinto report on the “Geotechnical & Cave Design Studies” for the Feasibility Study of underground mining of the Hugo North orebody.

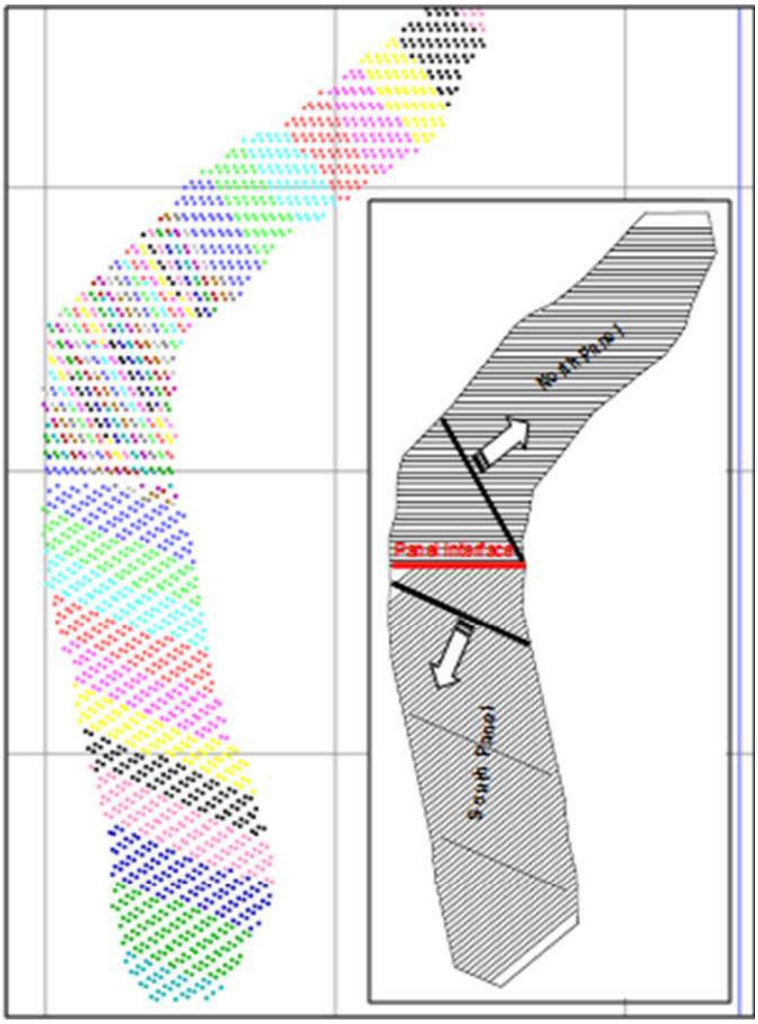
16.3.3.2 Panelling Strategy and Initiation

The footprint of the undercut is divided into two panels: Panel 1 (north cave) and Panel 2 (south cave) (Figure 16.20).

The benefits of the two-panel strategy include:

- The ability to maintain an acceptable undercut advance rate during the first five years of production ramp-up, significantly reducing the risk of a major undercut pillar failure and/or extraction level pillar failure associated with slow-moving undercuts.
- The geologic structures in panel 1 and panel 2 areas of the cave are different. The two-panel strategy allows the designs and cave advance direction to be optimized for the orientations of the major geological structures and major principal stress.
- An opportunity for production and technical personnel to develop an understanding the response of the rock mass to undercutting, construction, and production in a smaller, more manageable initiation area.
- For the first four years, the cave front will progress to the north, where stress effects are predicted to be lower and mining conditions less challenging than for the panel 2 cave front.

Figure 16.20 Two-Panel Strategy, Cave Initiation, and Advance Sequence



Although the two-panel strategy introduces a panel boundary that complicates the undercutting process and may introduce dilution earlier at the interface, it provides a more manageable and less risky undercutting solution.

Based on analysis of the geological structures and the geometric layout of the orebody, an initiation point on the west side of panel 1 was recommended as the best direction to manage cave face lengths and undercut rate. The columns on the west side of the cave are higher than those on the east, minimizing the dilution potential due to rilling.

Cave initiation on the east side of the cave was recommended for panel 2. This change of direction is based on improving drive and pillar stability by orientating the undercut and cave face perpendicular the principal stress direction rather than parallel with principal stress. In addition, this rotation aligns the undercut and extraction drives with principal stress, further improving drive and pillar stability. Figure 16.20 illustrates the cave initiation points.

16.3.3.3 Cave Front Profile

Modelling of stress and closure have highlighted undercut stability management as a high priority. The cave front angle is recommended be adjusted from 45°, as recommended in the pre-feasibility study, to 55° (Figure 16.21). The major benefit of the flatter undercut face is a reduction in undercut lead-lag distances.

Undercut cave faces shorter than 350 m are considered ideal, which is achieved with the northern cave face. In panel 2, the cave face increases up to 450 m. Although this is beyond the ideal length, it has a scheduled advance rate of 6 m/month/undercut drive and is considered acceptable at this stage of design.

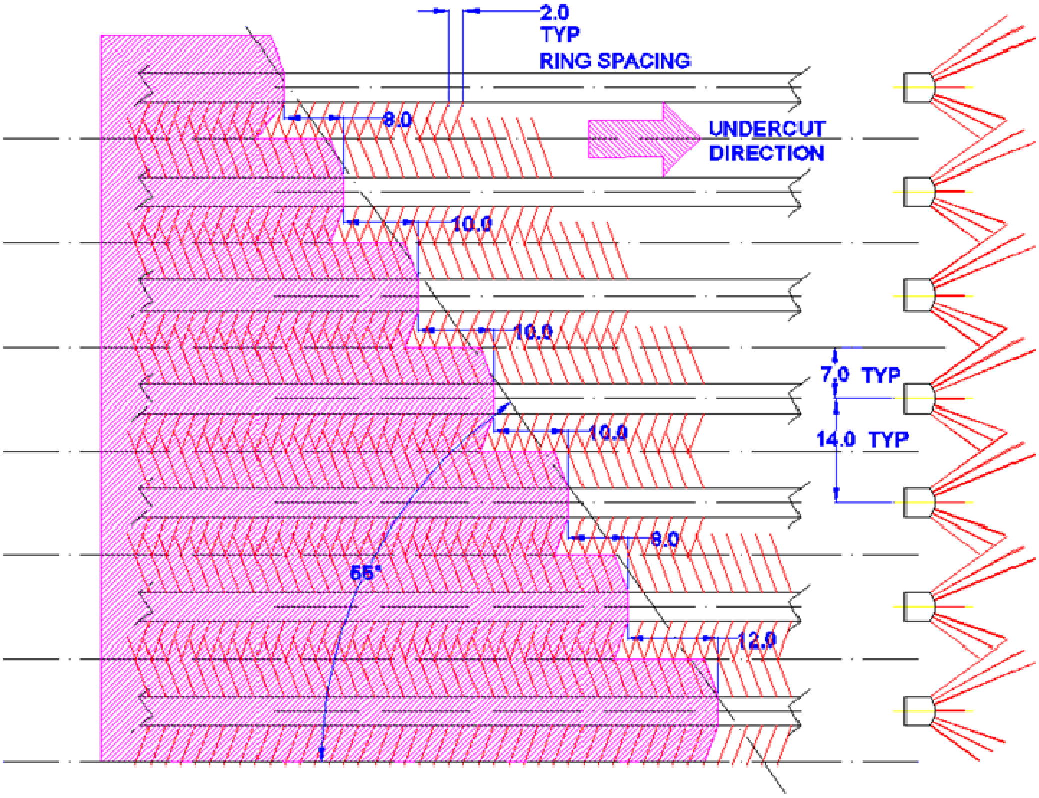
An inverted "V"-shaped (in plan view) undercut advance will be used for the first four years of undercutting in panel 1 to promote faster undercut ramp-up.

16.3.3.4 Undercut Sequence

Both empirical and numerical modelling support the advanced undercut sequence selected for Hugo North. In this sequence, drawpoints and drawbells are developed after the undercut has passed over, so that the abutment stresses are located in the massive rock mass, with only the extraction drives —and two short rounds to form the drawpoint take-off— developed on the extraction level. Damage to the extraction level is reduced by developing the drawpoints and drawbells in de-stressed ground.

Development of the drawpoint drives is recommended to begin 45° behind the undercut face and that full drawbell excavation begin at least 60° behind the undercut face.

Figure 16.21 Undercut and Cave Front



16.3.3.5 Extraction Level Layout

Analysis of drawbell spacing and comparison of the Herringbone and El Teniente type layouts was undertaken as part of the study. Although recovery was an integral component of the analysis, focus was placed on stability through extensive numerical modelling work. From a mining perspective, elements of development, construction, and production were considered against the production schedule and business value case. The recommendation was the 15 m x 28 m drawbell spacing associated with an El Teniente drawbell layout.

The increase in spacing over the minor apex was driven by the benefits of greater pillar stability. The El Teniente design, regarded as having a better drawcone packing layout than herringbone, was a supporting factor in retaining interactive draw for fragmentation predictions. Numerical modelling of the new layout indicated that the rock would be stable enough to support drives and pillars. Figure 16.22 illustrates stress levels from modelling on the final layout, and Figure 16.23 shows numerical modelling results indicating the additional support capacity of the El Teniente design to handle stress loading.

Figure 16.24 illustrates the El Teniente layout for Hugo North. The El Teniente drawpoint drives are orientated at 55°, based on benchmarking and aligning with the undercut face.

Figure 16.22 Major Principal Stress in 15 m x 28 m El Teniente Layout (at 10 MPa far-field vertical stress)

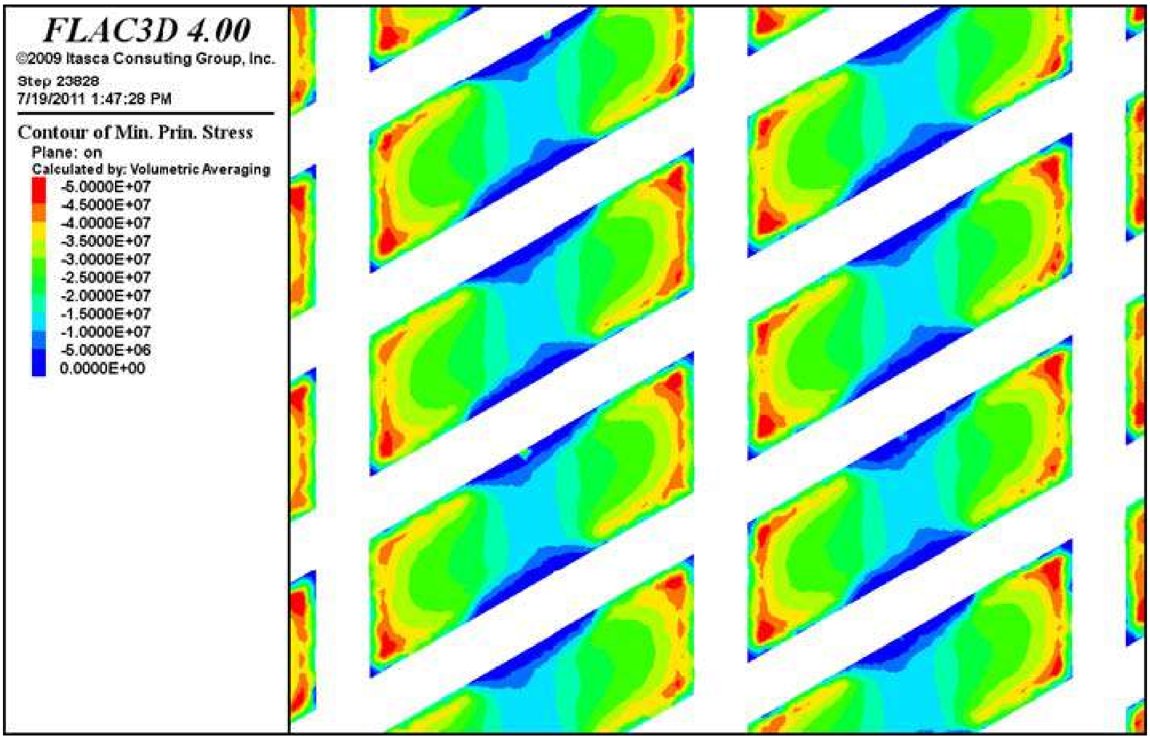


Figure 16.23 Peak Stress Capacity of El Teniente versus Herringbone Layouts when Compressed Vertically

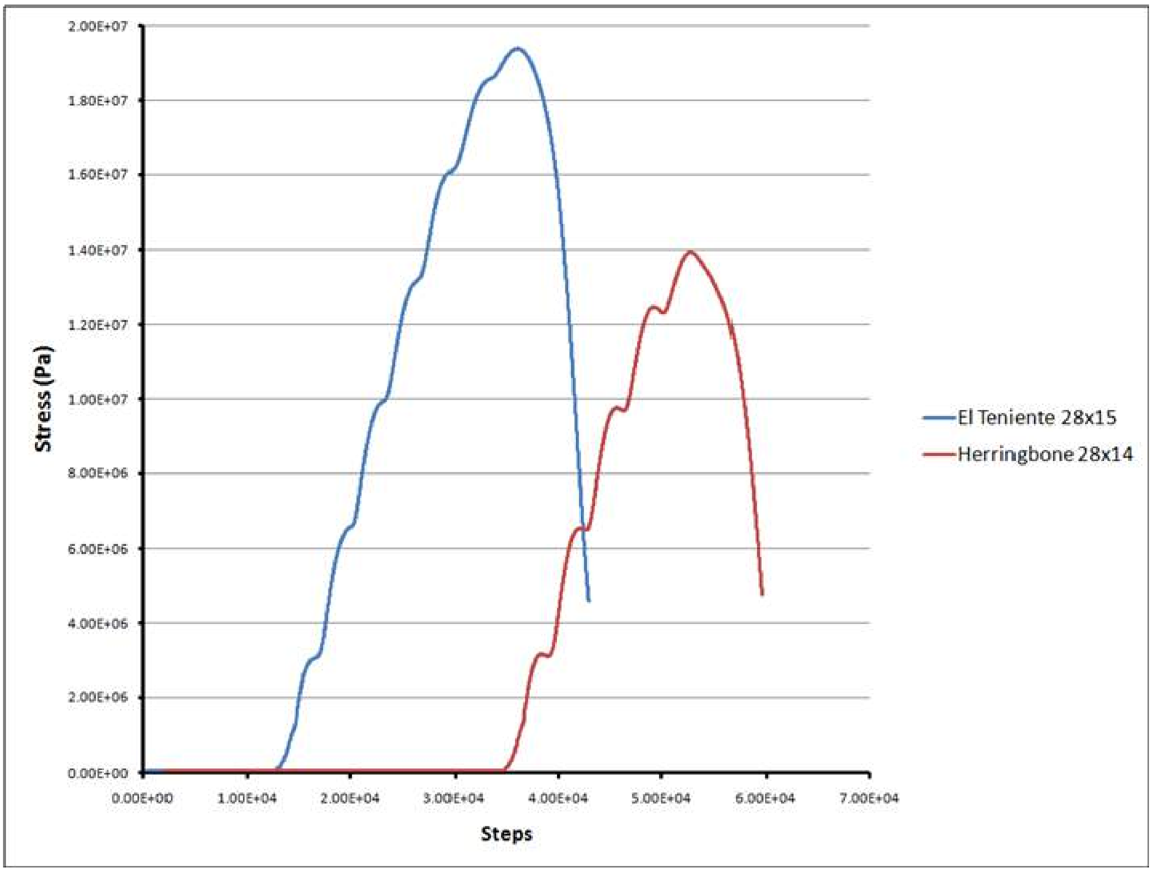
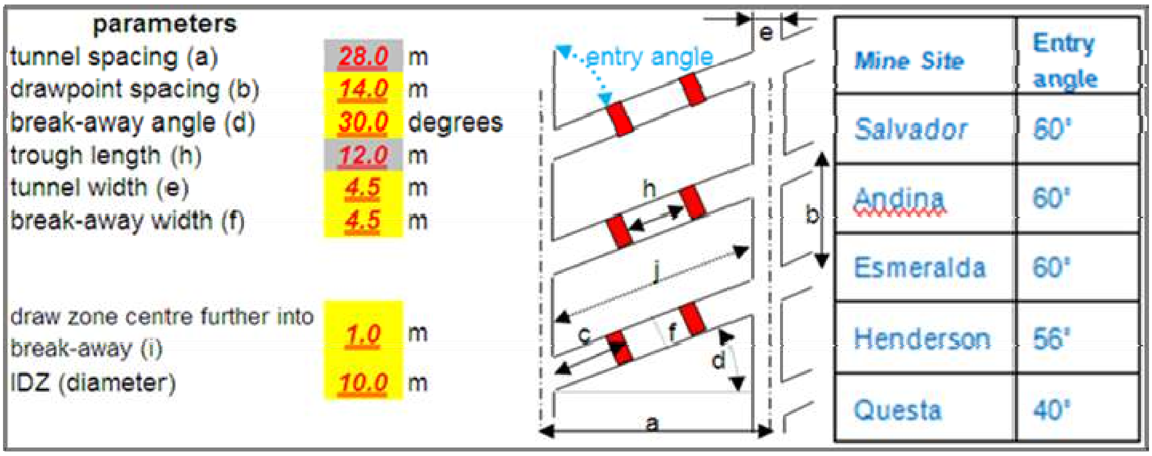


Figure 16.24 El Teniente Layout for Hugo North

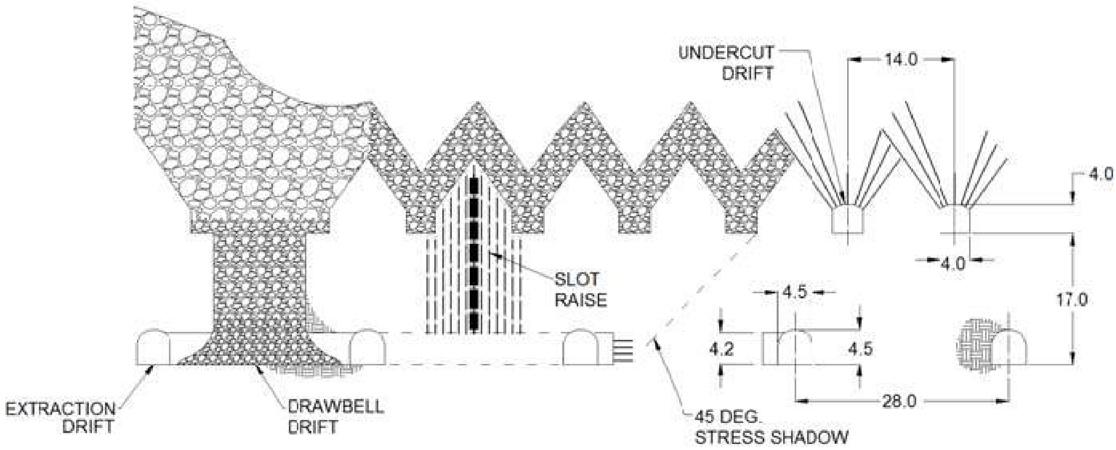


16.3.3.6 Undercut Level Layout

Undercut level drives are spaced on 14 m centres and orientated parallel with the extraction level drives.

The small "W"(cross-section) undercut shape is recommended, as illustrated in Figure 16.25. The main benefit of the W shape over a flat undercut is the inclination of the blastholes over the major apex, which assists in preventing the formation of "pillars" on top of the major apex; blastholes are essentially "self cleaning" when their incline is steeper than the frictional properties of the broken ore.

Figure 16.25 Cave Section Perpendicular to Extraction Drift



16.3.3.7 Undercut Face Lead-Lag (Plan View)

Undercut extraction involves "half blasting" the pillar between adjacent undercut drives to permit a stepped sequence in establishing the desired undercut face. In this sequence, blasting in one undercut drive "leads" the blasting in one of its adjacent drives and "lags" it in the other adjacent drive. Both mining experience and review of the induced stresses suggest that sharp changes to, or large irregularities in, the shape of the advancing undercut face should be avoided and that the lead-lag distances should be minimized.

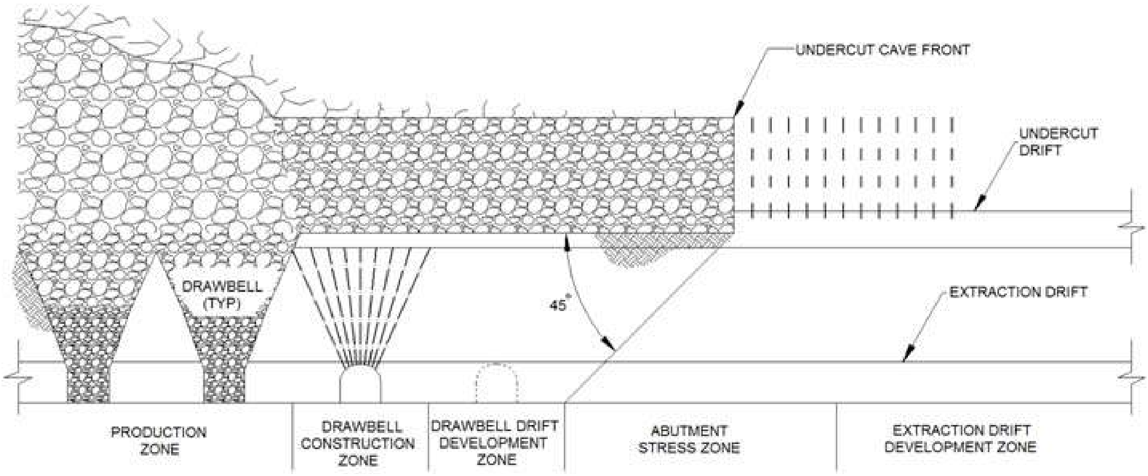
Based on benchmarking and prior experience, a 10 m long half-blasted pillar, or 10 m lead-lag, is recommended as the maximum average lead-lag distance to set up the 55° cave front angle (Figure 16.21). Efficient operation of an undercut requires some flexibility in the lead-lag distance. The recommended maximum lead-lag for Hugo North ground is 14 m, with an operational range of 6 m to 14 m.

16.3.3.8 Undercut to Drawbell Lead-Lag (Vertical Section View)

On the extraction level, a safety zone running the length of the undercut face will be established underneath the advancing face. This zone will be 34 m wide, starting 17 m, or 45°, in front of the undercut, and ending 17 m, or 45°, behind the undercut face. Figure 16.25 above shows a cave section perpendicular to an extraction drift, and Figure 16.26 shows a cave section parallel for an extraction drift. No development will be undertaken within this zone; all extraction drive development will be completed in front of it, and all El Teniente drawpoint and drawbell development will be occur behind it. At an undercut rate of 6 to 8 m/month, there will be a two to three-month lag between the time that undercut blasting passes a particular point on the extraction level and the start of drawpoint development at that point.

After the two- to three-month lag, drawpoint and drawbell development will commence, followed by raise-boring, longhole drilling, steel set installation, and concrete road construction activities in series, before a drawbell is charged and blasted.

Figure 16.26 Cave Section Parallel to Extraction Drift



The risk of recompaction at Hugo North is considered to be low, and the planned 65 m to 80 m drawbell lag is recommended. If recompaction and stress related damage were to occur, then the length of the verandah could be reduced; however, this would likely have an impact on the drawpoint construction rate if the extraction level activities had to be carried out in a smaller, more congested area.

16.3.3.9 Undercut Rate

The undercut rate will match the rate of drawbell construction and drawbell draw.

- An undercut rate consistently in excess of drawbell construction rate will increase, in section view, the ‘overhang’ or verandah distance between the undercut cave front and the extraction level blasted drawbell front. This can increase the stress build up and risk of ground convergence and collapse in the area in front of the undercut cave front.
- An undercut rate consistently less than the drawbell construction rate can reduce the stress shadow protection that the undercut provides to extraction.

Undercut rates greater than 6 m/month/undercut drive are recommended at Hugo North.

Ideally no more than two rings should be blasted at a time. The rock mass responds in a more stable fashion, and it allows the operators to inspect for any pillars formed due to unsuccessful blasting and to take corrective action if required.

The undercut abutment stresses reach their maximum magnitude when the undercut area equates to the critical hydraulic radius (CHR) of the block, which is 22 m for Hugo North. Stress-induced damage is expected to increase once the undercut area reaches half of the CHR of the block.

16.3.3.10 Stress Overcut

Numerical models of the undercut and extraction levels predict very high (>100 MPa) abutment stresses acting on the extraction level peripheral and rim drives. In particular, elevated horizontal stress levels were noted wrapping around the undercut and affecting the extraction level region at a point two to three drawbells in from the north and south boundaries. FLAC® 3D models were built specifically to investigate stress and stability conditions at the extraction level boundary and rim drive locations. The modelling illustrated that extending the undercut by 30 m, and tucking the extraction level rim drive underneath the stress overcut, reduced the stress exposure, reduced drive closure, and reduced concerns around drive instability.

Figure 16.27 illustrates the stress overcut concept. Two drives are shown on the extraction level: one drive at 70 m from the last drawpoint represents the conventional case where the extraction level rim drive is located outside the high stress zone, and the other a drive at 20 m from the last drawpoint represents the feasibility case where the rim drive is tucked in underneath the stress overcut.

In addition to reducing overall stress loading, the stress overcut reduces the risk of extraction drive rockburst or collapse from stress transmitted along vertical geologic structures near the cave boundaries within a high-abutment stress zone. An example of this is at the north-west boundary of the footprint, where the West Bat Fault runs parallel and very close to the last line of drawpoints (Figure 16.28).

Figure 16.27 Stress Overcut Concept

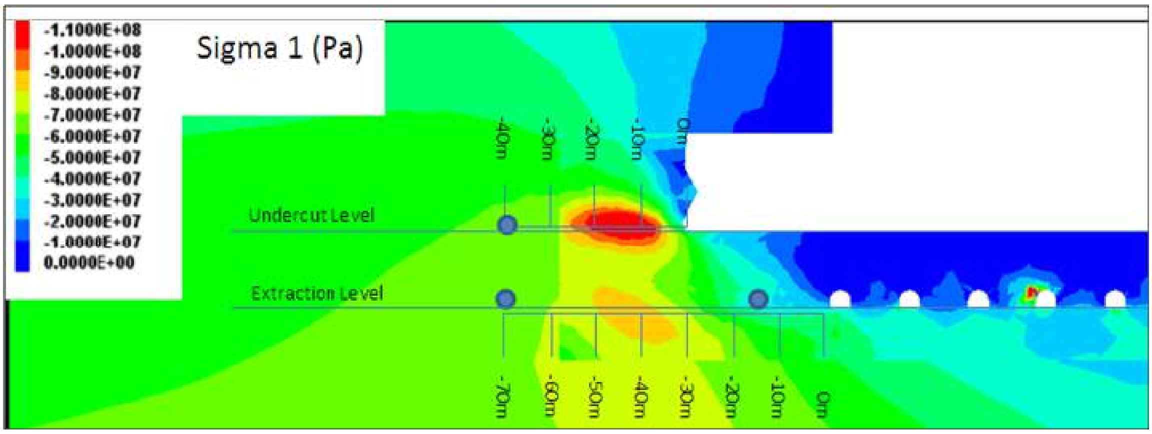
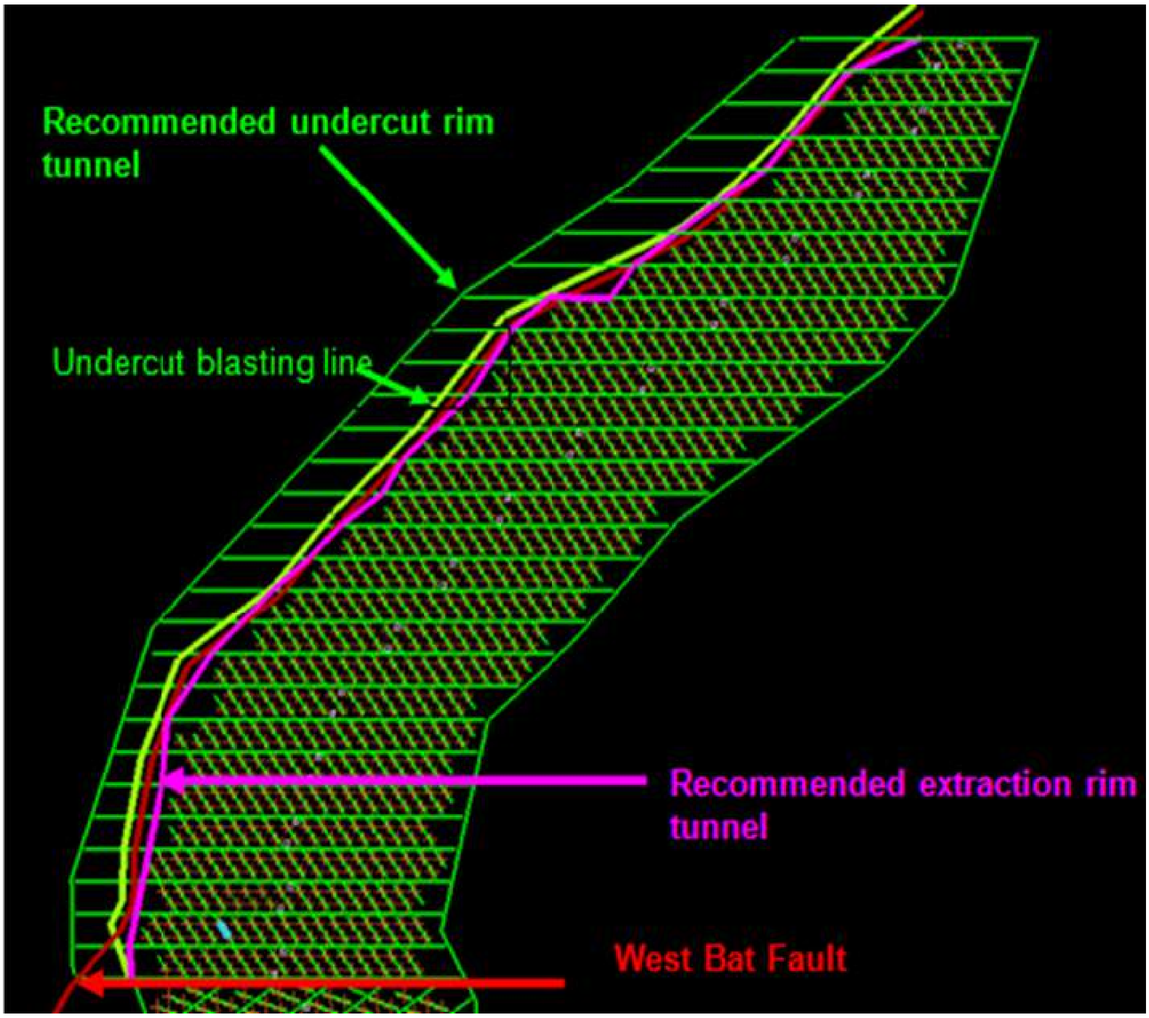


Figure 16.28 Extraction Rim Drive in Relation to West Bat Fault



For the conventional rim drive case, the extraction level rim drive north-west of the West Bat Fault would be located in an area modelled with high abutment loading, requiring each extraction drive to cross through the West Bat Fault to access the orebody.

The risk of continual transmittal of abutment stress along the West Bat Fault was reduced by moving the extraction level rim drive closer to the orebody and bringing the undercut blasting over the extraction drive rim and through the West Bat Fault.

Further work is recommended to optimise the locations and geometries of the drives and areas proposed to be overcut.

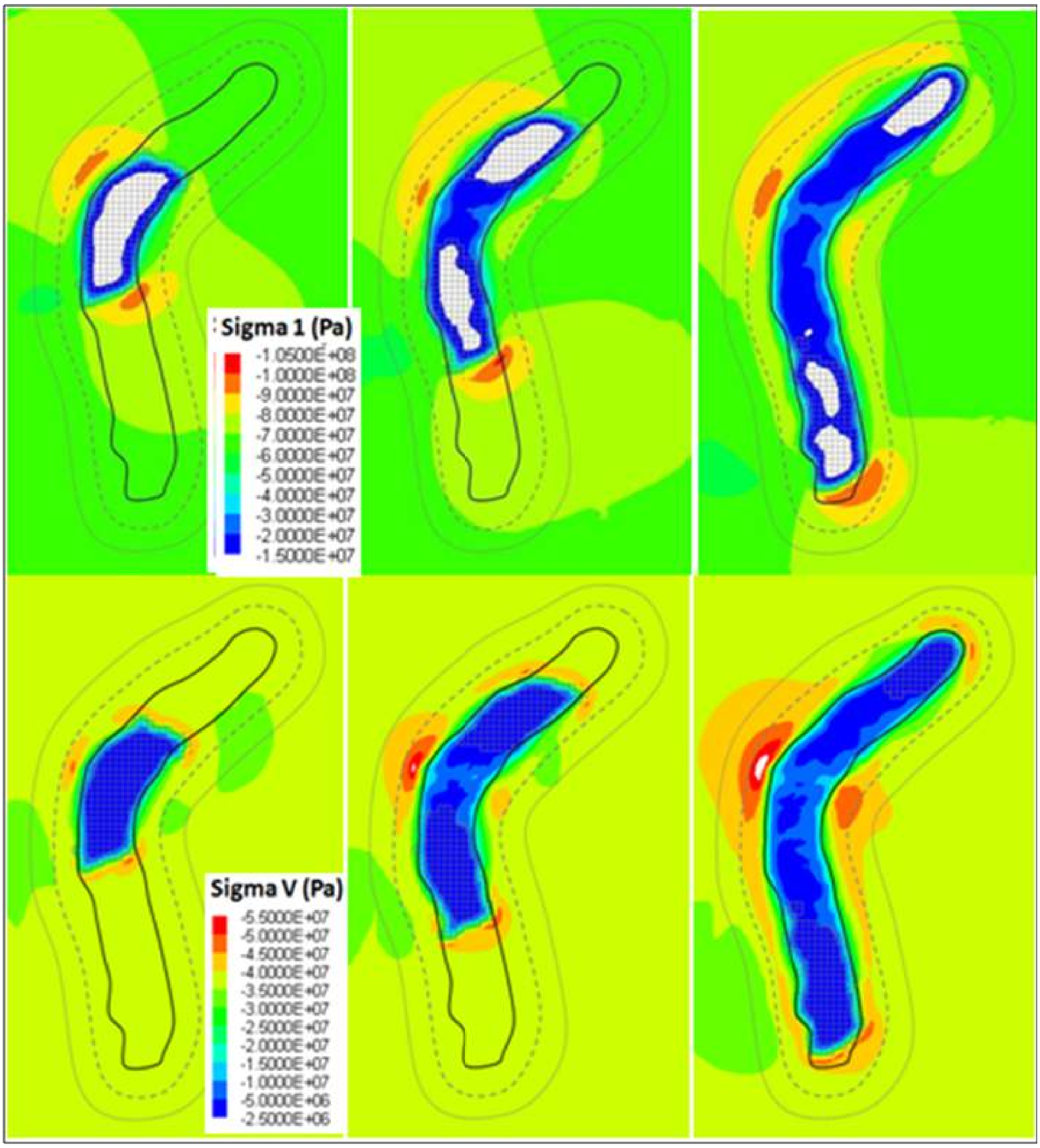
16.3.3.11 Footprint Stability Modelling – Undercut

A cave-scale model and an infrastructure model were used extensively to predict stresses and closure strains on footprint development and infrastructure.

The cave-scale model was used initially to examine induced vertical stresses on undercut pillars and drives. Figure 16.29 Figure 16.29 shows plots of vertical stress on the undercut level from the base case model for Years 6, 10, and 15. The plot suggests that undercut pillars next to the advancing cave front are likely to experience vertical stresses on the order of 40 to 45 MPa. This zone of elevated vertical stress extends approximately 50 m from both panel 1 and panel 2 cave faces during the early years of caving up to Year 5. The width of this zone remains relatively constant at the northern face over time but increases to ~100 m at the southern face by Year 10.

The 4 m wide x 4 m high undercut drives spaced at 14 m are considered to be supportable and adequate for the Feasibility Study design. The analysis indicates that risks related to high stress conditions and drive closure are present.

Figure 16.29 Induced Vertical Stresses and Induced Major Principal Stress on Undercut Level in Base Case Model in Years 6, 10, and 15



16.3.3.12 Footprint Stability Modelling - Extraction Level

The cave-scale model was used to examine induced vertical stresses on the extraction level pillars and drives. The extraction level is expected to experience similar vertical stress magnitudes as those for the undercut level, i.e., 40 to 45 MPa approximately 50 m to 100 m ahead of the advancing cave front. It suggests the extraction level will undergo an average vertical stress of 2.5 to 5 MPa beneath the actively drawn cave; and increase to 5 to 10 MPa under exhausted regions of the cave. The extraction level will be subject to much higher subhorizontal stresses caused by the redistribution of the maximum horizontal stress (σ_H) around the advancing faces and beneath the cave. Sigma 1 levels are expected to reach 90 to 100 MPa immediately ahead of the southern cave face on the extraction level. Sigma 1 levels are expected to reach 70 to 80 MPa ahead of the northern face.

Modelling predicts that pillar stresses below the leading edge of the undercut will be 70 to 80 MPa and that stresses will remain high in the pillars at the east and west edges of the cave (~90 to 100 MPa).

At least 60% of the undercut material is recommended be mucked after blasting, to ensure adequate void is created. The Feasibility Study plans to remove 80% of the swell on average.

Numerical modelling was used to predict closure strains in the extraction drives and drawpoints. Closure strains of ~2% to 4% can be expected when the extraction drives are first excavated under in situ stress levels. Since the vertical stress at the leading edge of the undercut is in the order of 10 MPa higher than in situ, not much additional closure is expected when the undercut passes over.

16.3.3.13 Panel Boundary

Splitting the footprint into two panels – beginning with panel 1 and starting panel 2 four years later – will result in the formation of a panel boundary. This will present a two-fold challenge, one from an ore recovery viewpoint and the other with regard to rock mass stability.

The undercut extraction is continuous between the two panels. A boundary pillar has not been designed between the two panels as this would result in significant ore loss and act as a stress concentrator.

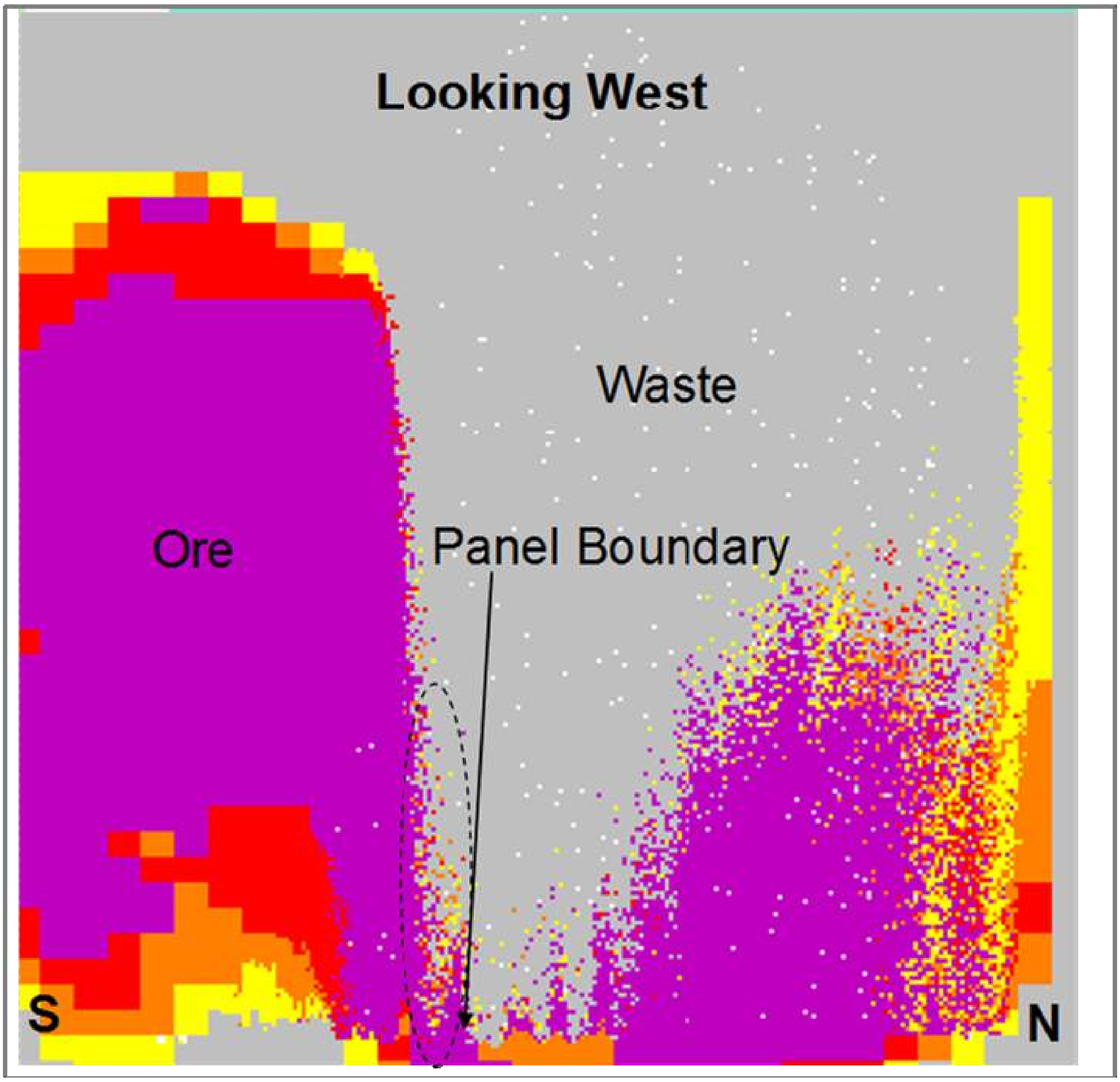
Further work is required to optimise the panel boundary layout and sequences.

Ore Recovery

The different extraction drive orientations of panel 1 and panel 2 layouts meet at the panel boundary, but due to geometry, some drawzones do not overlap. Production in panel 2 starts four years after production in panel 1, which creates the potential for early waste dilution in panel 2 boundary drawpoints. Flow modelling (Figure 16.30) assisted in understanding the magnitude of this risk.

Ore recovery can be maximized through good interactive draw control practice such as reducing extraction from panel 1 boundary drawpoints so that they remain active but still contain ore while panel 2 boundary drawpoints are in operation.

Figure 16.30 Panel Boundary Dilution Modelling

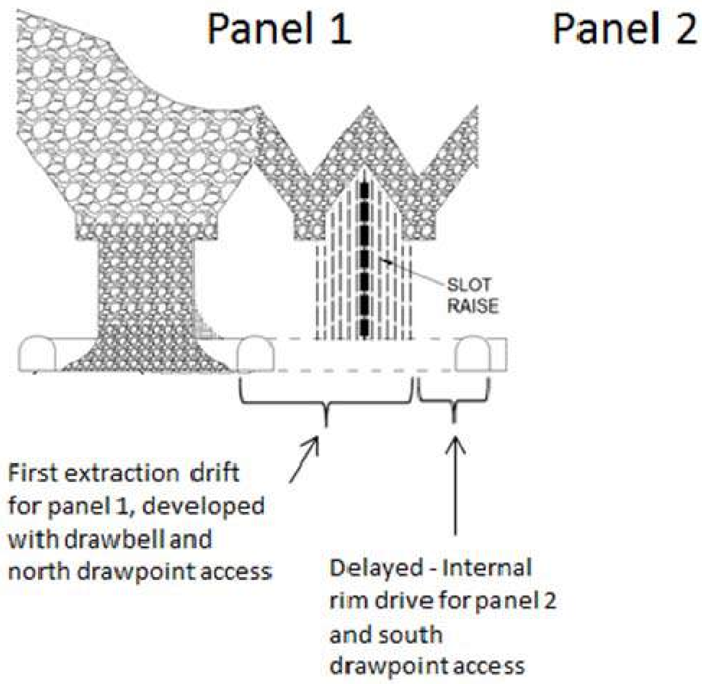


16.3.3.14 Excavation Stability

The planned division of the footprint into two panels poses a challenge to the stability of excavations close to the boundary between the two caves. Abutment stresses from an operating cave onto development for a new cave could require additional tunnel support. Numerical modelling work undertaken to assess the stress conditions around the boundary has predicted high but manageable closure strains.

To preserve the stability of panel 2 development, any extraction and undercut development associated with panel 2 should be delayed until cave propagation is underway in panel 1 and abutment stresses from panel 1 are pushed further from the cave boundary. In panel 1, the drawbells in the first east-west extraction drive would be blasted to both the north and south of the drive. Those drawpoints to the south would be blasted as full drawbells, but developed with single drawpoint access. A schematic plot is shown in Figure 16.31.

Figure 16.31 Panel Boundary Section Looking East



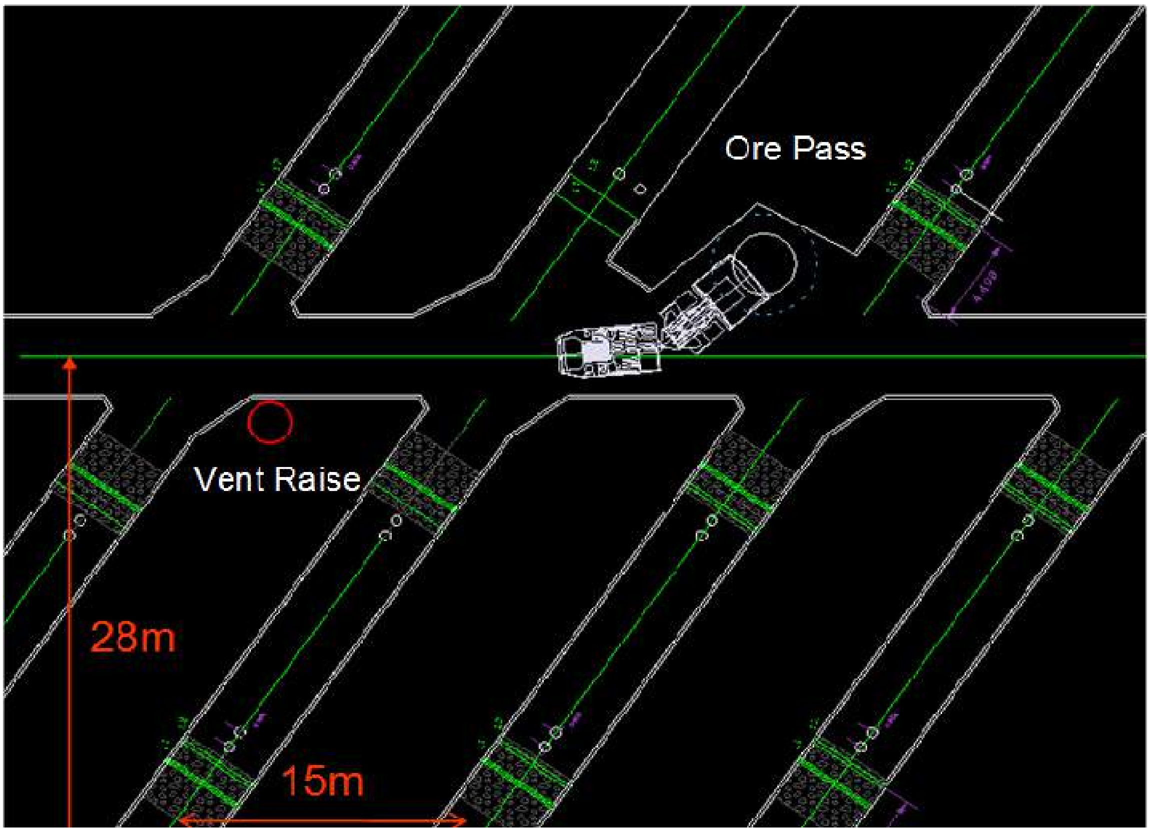
16.3.3.15 Orepass Tipple Excavation

The Feasibility Study design includes central tipping to achieve the production tonnage rate. The central tipping excavation required to house the orepass and grizzly will be developed and supported before the undercut passes over, so the central orepass and truck chute system is operational to support production mucking requirements. Ground support in this area will be increased to handle the abutment loading. The tipping layout is shown in Figure 16.32.

Recommendations for the central tipping design:

- Do not excavate the ventilation raise on the opposite side of the orepass location, but offset it to the next pillar to avoid large spans across the extraction drift.
- Move the orepass as close as possible towards the centre of the extraction drive to decrease the loss of pillar area.
- Increase the local drawpoint spacing over the orepass minor apex from 15 m to 17 m, and move the steel sets of the two surrounding drawpoints slightly deeper into the bell to ensure their stability.
- Design the orepass layout with the maximum LHD tipping position angle to reduce the orepass excavation.

Figure 16.32 Orepass Design on the Extraction Level



16.3.3.16 Key Points in Summary

- Cave initiation in the west is recommended, along with splitting the footprint into two panels, panel 1 (north cave) and panel 2 (south cave), advancing the panels by mining in the direction of the long axis of the footprint.
- A cave front angle of 55° is recommended, primarily to reduce the lead-lag distances on the undercut. The cave front was rotated to best position both the cave advance and tunnel orientation to the major principal stress direction (Figure 16.21).
- An advanced undercut should be employed, where drawpoint development commences only when 45° behind the undercut face, and drawbells are blasted when at least 60° behind the undercut face (Figure 16.26).
- The El Teniente extraction level layout with 28 m x 15 m drawpoint spacing and undercut spacing on 14 m centres is recommended.
- The small “W” undercut profile is recommended to produce a more even lead-lag spacing and maximize undercut tunnel stability under the conditions of high abutment stress predicted by the modelling.
- An average lead-lag of 10 m, with operational variation of 6 m to 14 m, is recommended on the undercut level, in line with the criterion that a maximum of two rings should be blasted at any time.
- An undercut rate of more than 6 m/month/undercut drive is recommended, with faster rates preferable. Panel 1 and panel 2 cave faces average 8 and 6 m/month/undercut drives, respectively. When in conflict, the lead-lag spacing rule takes precedence over the undercutting rate.
- A 30 m “stress overcut” on the undercut level, along with moving the extraction level rim drive underneath the stress overcut, is recommended as a means to preserve the integrity (stability) of the extraction level rim tunnel, the extraction drives leading to the drawpoints, and the outermost drawpoints.
- A lag of six to eight drawbells between the undercut face and drawbell blasting is recommended based on stress management. The risk of ground recompaction at Hugo North is low, but this drawbell lag may need to be reduced if significant recompaction were to occur.
- The boundary between panel 1 and panel 2 will present challenges in managing dilution and drive stability; however, these are believed to be manageable and of much less risk than the alternative of not dividing into the two panels.
- The central orepass tipple will be excavated in front of the stress shadow to ensure that the orepass and truck chute system will be commissioned for production mucking use after the stress shadow passes. The excavation size has been minimized, heavier support installed, and pillars enlarged in the orepass area to ensure stability.

16.3.4 Haulage Level and Infrastructure Design Parameters

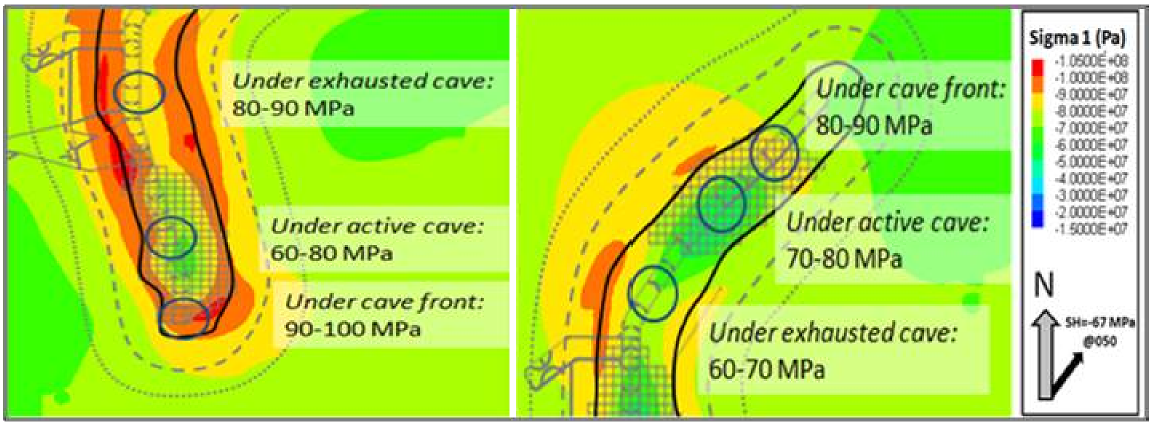
16.3.4.1 Haulage Level

The cave-scale model was used to examine haulage level abutment stresses. Modelling suggests the haulage level excavations in panel 2 will be subject to abutment stresses of 90 to 100 MPa associated with the leading edge of the cave. These stresses can be seen advancing down panel 2 over time in Figure 16.33. Higher stresses of >100 MPa are located immediately below the haulage, suggesting that the haulage drives are near the bottom of the stress shadow beneath the cave.

Stress levels along the haulage drives drop to 60 to 70 MPa underneath the active cave, then rise back to 80 to 90 MPa once draw ceases. Because of its orientation relative to σ_H, stresses at the north limb haulage level are approximately 10 MPa lower than at the south limb for all stages.

High stresses predicted at the perimeters of the cave support the design of the central truck haulage loop. The haulage level was elevated as far as practical to reduce the impact from high stresses under the cave.

Figure 16.33 Abutment Stress on Haulage Level as a Function of Position Relative to Region of Active Draw



16.3.4.2 Orepass and Truck Chute

The final truck chute arrangement is shown in Figure 16.35. Based on the iteration considered in Figure 16.34, the pillar between the two orepasses was almost doubled, from 6 m to 11 m, and the height of the excavation was reduced by 3 m. In the modified design, each orepass has its own truck chute and is operated independently.

The number of truck drive-through chambers doubled, reducing from 56 m chamber spacing to 28 m spacing, and the length of each truck chamber was reduced. Geotechnically the larger pillar spacing of the final truck-chute arrangement (Figure 16.35) was preferred.

Orepass angles are designed at or close to 70° inclination. Each orepass will be steel-lined both for stability and to handle the impact and abrasion of an expected 9 Mt of ore throughput.

Figure 16.34 One Iteration of Orepass and Truck Chute Layout

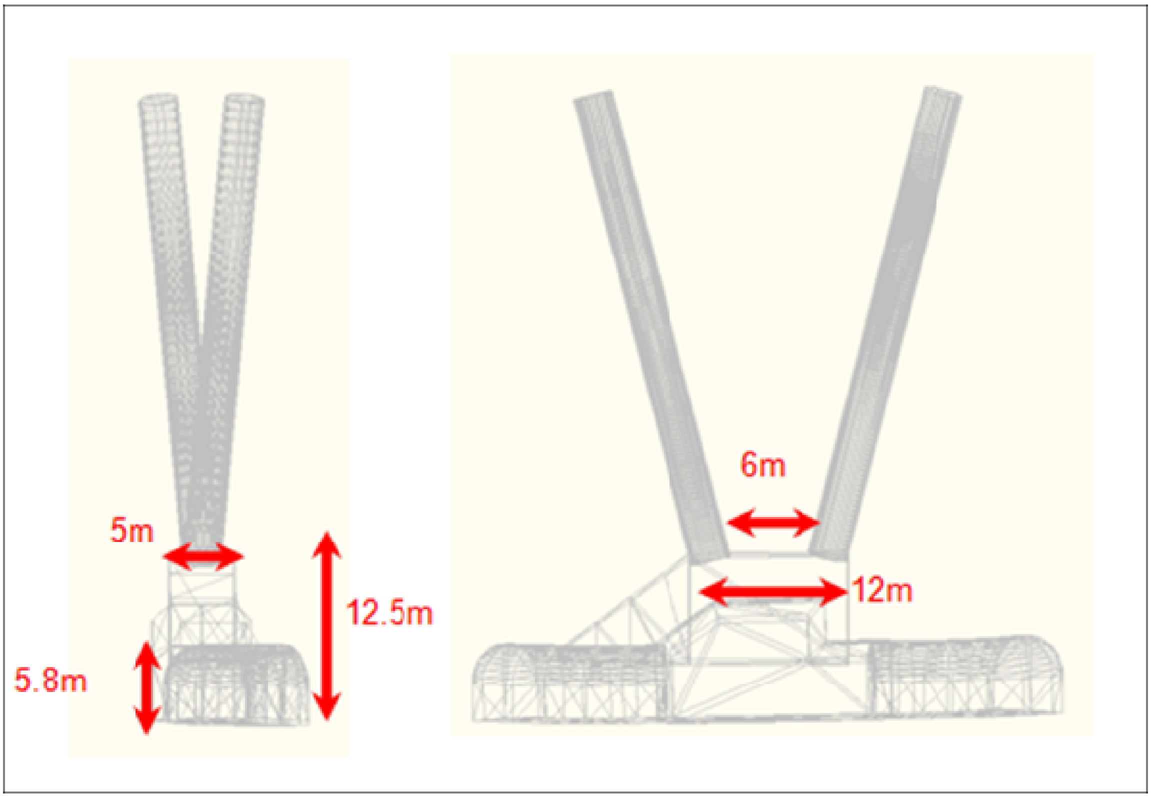
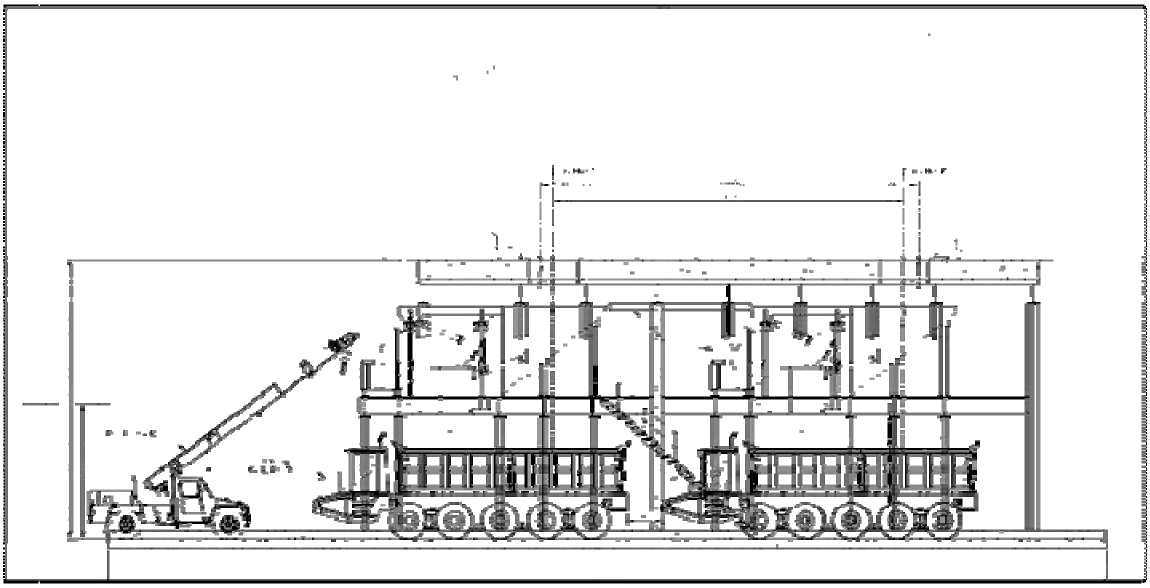


Figure 16.35 Final Orepass and Truck Chute Design



16.3.4.3 Orepasses

Orepasses will be raise-bored at 3 m diameter with a dip angle of between 70° and 75°. Steeper orepasses can suffer from higher wear as a result of higher impact energy from ore dumping, ore becoming packed in the muck pile at the bottom of the orepass, or the generation of more dust at the extraction level due to the “piston” effect. Shallower orepasses can have drilling issues and greater risk of hang-up. The average length of the central orepass will be 40 m, and the average rim orepass will be 60 m long.

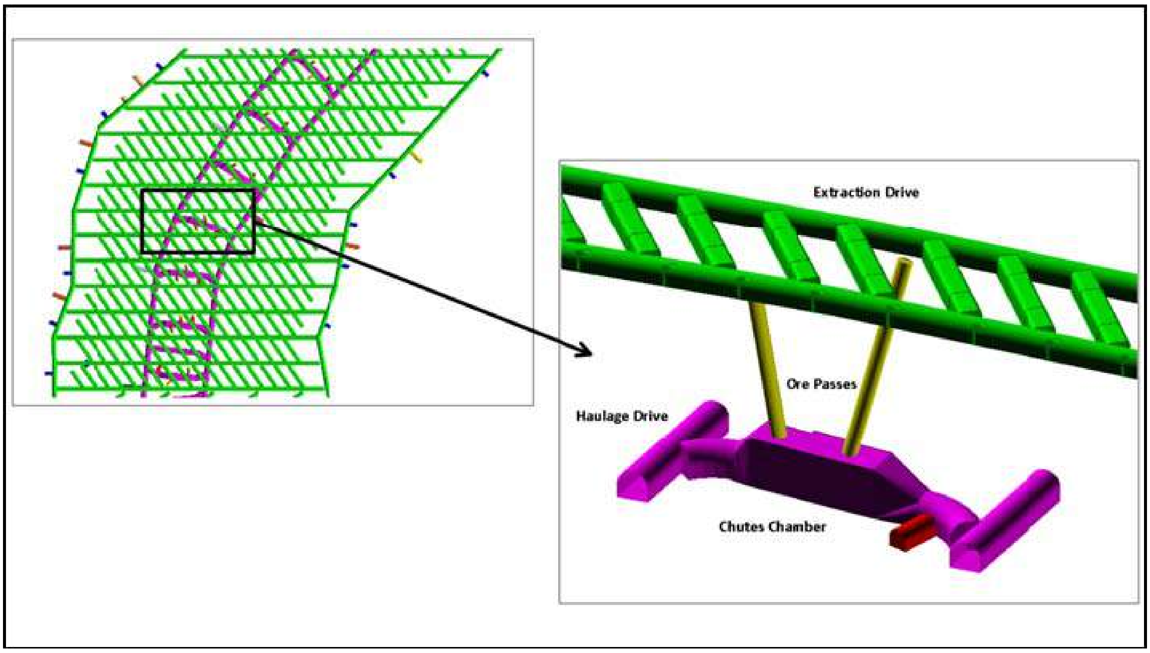
Development Procedure

A diamond drill investigation hole will be drilled before raiseboring begins. If a poor ground zone is identified during drilling, then the hole will stop and be pressure-grouted before drilling continues. On completion of the hole, core, and drilling conditions will be assessed. Most of the raisebores are expected to be excavated with a standard downhole pilot hole and backream methodology. Poor ground conditions may dictate that a modified approach be taken to improve stability:

- Drilling holes around the circumference area of the raisebore to be reamed and then pressure-grouting them with cement or resin-type grouting.
- Cable bolting pre-support around the base of the planned raise or targeting areas along the raise identified as requiring stabilization.
- Dividing each raise into two segments, each 15 m to 20 m in length. This would require a short development access from the exhaust level. A shorter raise reduces the time exposure of the ground before installing raise support.
- Longhole drilling and blasting of the raise in lifts, with in-cycle remote shotcrete.
- In isolated cases, using an entry method of raise excavation and support in-cycle, such as a mechanical raise climber (Alimak).

After being excavated, the orepasses will be lined with a 20 mm thick rolled-steel plate capable of handling rock flow wear in excess of 18 Mt of ore.

Figure 16.36 Isometric of Central Orepass and Truck Chute Design



Further Work

Orepassses are a critical component of cave production. They are proposed to be developed in a high and changing stress environment, which carries risks for their development and operation. A specific geotechnical analysis has not been undertaken for the proposed method of development and support of orepasses. Protocols for identifying and dealing with “poor ground” have not yet been developed.

There is a significant risk that a proportion of orepasses may not be developed at the rate required for planned rates of advance of the cave undercut and draw.

Further geotechnical investigations are required to examine the interaction of rock conditions, stress, development and support of orepasses. Clear protocols, based on experience, need to be developed for decisions on the siting, raiseboring, and support of orepasses.

16.3.4.4 Crusher Stability Analysis

The crusher chamber design is based on a large gyratory crusher accommodating direct tipping using 80 tonne side-tip trucks, with two dumping at any one time.

The crusher was moved from the cave to reduce abutment effects and also to distance it somewhat from the H Fault identified from diamond drilling investigation holes near the originally proposed crusher site. In addition, the size of the crusher chamber excavation was reviewed and subsequently decreased by changing the crane orientation and removing hydraulic oil storage and electrical infrastructure into supporting cuddies.

16.3.4.5 Loading Station and Bins

The design for the Shaft 2 conveyor loadout arrangement is based on one loadout conveyor feeding skips through a diverter cart system. The excavation width, 6.5 m, significantly reduces the risk of delays due to ground remediation and allows single-pass development for most of the loadout, significantly reducing the time to excavate and install ground support, with associated cost savings.

Numerical modelling of the Shaft 2 skip loading area, focusing on the loadout and the area around the two 10 m diameter bins, resulted in a recommendation to space the bins 50 m apart centre to centre, providing a 40 m pillar.

16.3.4.6 Key Points in Summary

- General design considerations are to avoid abutment stress conditions, and to develop normal to major structures where possible.
- The haulage level is a critical excavation and thus should remain centrally located to avoid the very high abutment stresses near the boundaries of the footprint. The stability of the haulage is very sensitive to the width of the cave. The design footprint width for Hugo North, along with the “stress overcut” will help to drive high stresses below the haulage level.
- The design of an orepass system feeding directly to truck chutes, significantly reduces stability risk compared to other chute designs.
- Orepasses are a critical component of cave operations, but there has not been a specific geotechnical study of their location, design, development and support. This study is required before a commitment to central orepasses.
- The crushers are located away from the orebody, and the size of the excavation has been optimized to decrease the predicted closures to supportable levels.
- Modelling of the stresses and closures around the 10 m diameter ore bins at the shafts identified no significant issues. Bin spacing of 50 m centre to centre is recommended.
- The spacing of twin developments and other excavations that were not explicitly modelled are typically set at three times the combined diameter to minimize the interaction between those excavations. Wherever possible, all excavations should be aligned with the major principal stress to maximize stability.

16.3.5 Ground Support

16.3.5.1 Introduction

The long-term stability of development, both on and off footprint, is recognized as one of the most critical issues facing the successful operation of the mine. Understanding the deformations that are occurring in current excavations is key to validating any predictive numerical models. Considerable effort has been invested in benchmarking the tunnel stability.

Ground support has been recommended for the various excavations, based primarily on Barton's Q system, using rock mass parameters derived from the underground drill core data; experience from the existing underground development; and evaluation of expected stress conditions predicted from numerical modelling.

Primary support is installed during or immediately after excavation to ensure safe working conditions during subsequent excavation and to initiate the process of mobilizing and preserving rock mass strength by controlling boundary displacements. Any additional support or reinforcement installed thereafter is termed second-pass (secondary). Second-pass support is typically in the form of strapping, cable bolting, and/or the application of additional shotcrete. Second-pass support is designed to handle high induced stresses and stress changes resulting from mining activities.

At present, ground conditions are inferred through modelling. Further definition is required based on drilling data and the rock mass conditions encountered during development.

16.3.5.2 Tunnel Closure Estimation

The rock mass strengths of the orebody units were divided by a range of mining stress levels as inferred from the cave-scale modelling: isolated tunnels under in situ stresses (65 MPa), average abutment stresses (80 MPa), and high abutment stresses (100 MPa). Results showed that closure strains in the order of 5% were possible from high abutment stress loading on the extraction and undercut levels. The advanced undercut reduces the risk of squeezing and/or collapse on the extraction level, and heavy ground support is required.

16.3.5.3 Support Regimes

The proposed infrastructure has been separated broadly into either "on-footprint" or "off-footprint" development as well as high-stress and normal-stress regimes.

Profile dimensions for each of the regimes were specified.

For these profiles, two main support categories are specified, relating to "Good" ground (MRMR>30) and "Poor" ground (MRMR<30). For on-footprint development, 80% of the ground is classified as Good and 20% as Poor. For off-footprint development, 90% of ground is classified as Good and 10% as Poor.

For on-footprint areas, support has been increased to handle high abutment stress and cave loading. Support levels have also been increased in off-footprint development areas within a 100 m of the cave boundary (extent of undercut blasting) to withstand high abutment stress.

16.3.5.4 Ground Support Elements

The following ground support elements are inferred for all ground support designs.

Rock Bolts

- Rock bolts are threaded type.
- Rock bolts (rebar) are fully encapsulated, resin-grouted with a minimum yield strength of 200 kN; bolt lengths are typically 2.4 m and 3.0 m.
- All rock bolts have a standard bearing and/or domed face plate of 150 mm x 150 mm x 10 mm as a minimum.
- All rockbolts are galvanised except short-term development and excavation support such as undercut drill drives and drawbell drives.

Cable Bolts

- Single-strand cables, which are easier to install and provide better quality control than double strand, are recommended. For 18 mm and 22 mm single-strand cable, the minimum yield strength is 331 kN (33.7 tonnes) and 510 kN (52 tonnes), respectively.
- For zones of high deformations such as on-footprint or strainburst-prone rock masses, cables should be installed with a 2 m debonded section at the collar and pre-tensioned to 8 tonnes.
- All cable bolts should be installed with a high tensile face plate of 200 mm x 200 mm x 16 mm as a minimum.

Straps

- The preferred strap is the OSRO strap design, which can better accommodate higher deformations, both static and dynamic, than both weldmesh and steel plate straps.
- The installation of mesh straps and cable slings around the bullnoses/camel backs serve to minimize the amount of pillar dilation. Cable slings are able to withstand larger ground deformations in comparison to straps.

Fibre-Reinforced Shotcrete (FRS) and Mesh-Reinforced Shotcrete (MRS)

- FRS comprises Portland cement concrete containing aggregate and fibre reinforcement, non-metallic, 30 mm minimum length, applied from a spray nozzle.
- MRS comprises FRS with mesh installed between successive layers, or applications, of FRS.

- The FRS is to have a minimum UCS of 20 MPa in 72 hours; 30 MPa in 7 days; and 40 MPa in 28 days.
- The FRS to have a toughness of 375 J as determined by the Round Determinate Panel (RDP) test; or 900 J as determined by the European Federation of National Associations Representing producers and applicators of specialist building products for Concrete (EFNARC) panel test.
- Shotcrete is to be applied to the backs and walls in-cycle. The use of in-cycle shotcrete of the face is recommended in areas exhibiting high stresses, as recognized through rock noise and/or rock ejection, or poor ground conditions, as defined by the geotechnical face mapping. In-cycle FRS is known to reduce the occurrence of strainbursts, and its early application will limit the development of stress-induced fracturing.

Additional Mesh

- In high stress environments exhibiting significant rock mass deformations, it is not possible to prevent shotcrete cracking. Although cracked FRS will continue to support the rock mass, its ability to effectively contain the rock mass during a dynamic event is reduced. Installing mesh over cracked and damaged FRS in poor rock mass and strainburst-prone areas is recommended.
- Wall cables – 8 m long x 21.8 mm diameter single-strand cable bolts with a minimum yield strength of 60 tonnes installed on a 2 m x 2 m pattern.
- A final layer of 100 mm fibre-reinforced shotcrete. Care must be taken to ensure the cable “barrel and wedge” is free of shotcrete (needs a protective covering of grease and/or silicone) to prevent the wedge from “gripping” and cables from pulling though when they come under strain.

16.3.6 Caveability and Subsidence

16.3.6.1 Introduction

Various authors have described different “forms” of caving characterized by different rock mass failure mechanisms. These failure mechanisms depend on the rock mass strength, the cave-induced stresses, and the presence of significant structures.

Three caveability assessments were undertaken for the Feasibility Study:

- The first, and most commonly used, is an empirical method based on the Laubscher Modified Rock Mass Rating (MRMR) system and involves the use of Laubscher’s Stability Chart.
- The second empirical method uses the “Extended Matthew’s Stability Chart,” based on Matthews “N” value (a derivative of the Norwegian Geotechnical Institute (NGI) Q system).
- The third technique involves numerical modelling analyses, namely FLAC® 3D.

Given the intense faulting and high stress/strength ratio at Hugo North, stress caving will likely be dominant. However, the existing empirical caveability analysis methods do not contain quantifiable mechanisms to adequately incorporate the influence of significant structures. Therefore, the results of these assessments are considered conservative, and caving could happen earlier and at a faster rate than predicted. The Matthews method was run as an alternative check against the Laubscher method, and confirmed that caveability of the rock mass is unlikely to prove problematic.

Caveability, cave growth, and subsidence work based on numerical modelling and benchmarking information was undertaken to confirm empirical work and to provide boundaries for assessing current surface infrastructure, locating future surface infrastructure, and locating long-term underground infrastructure such as the main conveyor system.

- Modelling predicted that shaft 2 stability would not be affected and that shaft 1 would remain serviceable as a ventilation shaft (which will be its primary purpose after 2018) beyond 2036.
- Subsidence analysis indicates that shaft 1 could remain operational as a hoisting shaft beyond 2030, providing additional flexibility to operations or exploration of Hugo South.
- Modelling predictions confirmed design locations for shaft 3, shaft 4, and underground conveyor infrastructure.

Caving performance will be monitored during operations to better understand the rock mass response to caving and to calibrate subsidence predictions.

The risk of issues associated with caveability is considered to be low, even though the lift height of the Hugo North cave, from undercut to surface, is one of the largest in the industry. High stress conditions, a highly fractured rock mass, and large caving footprint are key factors. Extensive instrumentation and cave monitoring, integrated with cave draw control, will be employed as key components of the cave management system.

16.3.6.2 Laubscher Caveability Assessment

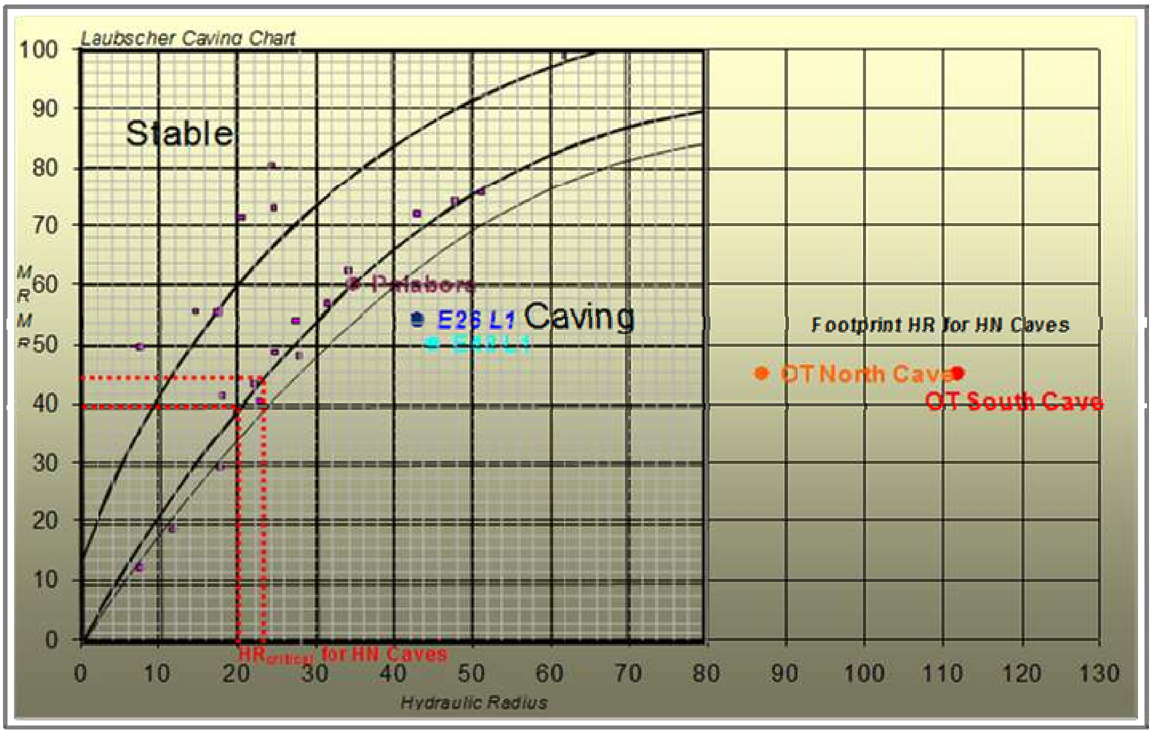
Results from the Laubscher assessment are summarized in Figure 16.37, which shows the range of median MRMR values to reach critical hydraulic radius (CHR) and also the footprint hydraulic radius of panel 1 (north cave) and panel 2 (south cave). The rock mass of MRMR 40–45 is caveable at HR > 20-23, or at approximate dimensions of 80 m x 80 m to 100 m x 100 m.

Key points from the analysis include:

- The rock mass is caveable, with a predicted critical hydraulic radius (CHR) of around 20 m to 23 m to sustain continuous caving for median rock mass conditions. The calculated hydraulic radius for the panel 1 and panel 2 footprints is significantly beyond the typical hydraulic radius plotted on Laubscher's stability chart, indicating ready caving.
- The influence of major faulting cannot be satisfactorily quantified using Laubscher's stability chart method.

- Using Laubscher's modified "major structure chart," an adjustment of approximately 10% has been estimated.
- Stress caving is likely to dominate the cave propagation, although the impact of the high block height combined with intense faulting is likely to complicate the mechanisms of failure, resulting in the formation of irregular cave back profiles (shapes) and increasing the risk of chimney-type caving.
- The caveability of the QV90 (high quartz vein) zone is not expected to be problematic.

Figure 16.37 Laubscher's (2000) MRMR Stability Graph and Hugo North Values



16.3.6.3 Numerical Model

Numerical modelling, conducted by Itasca Consulting, allowed cave growth and subsidence to be studied in greater detail. Models were based on Hugo North geotechnical conditions, mine design, and production plans. The sensitivity of these predictions to mine design/planning (production rate and profile, undercut direction) was examined. In addition, the impact of uncertainties in rock mass properties (strength, brittleness) on these predictions was evaluated to aid in assessing potential risks associated with the designs.

Modelling showed that caveability and surface subsidence are insensitive to minor production schedule changes and that fine-tuning of production schedule details could be carried out without concern for caveability.

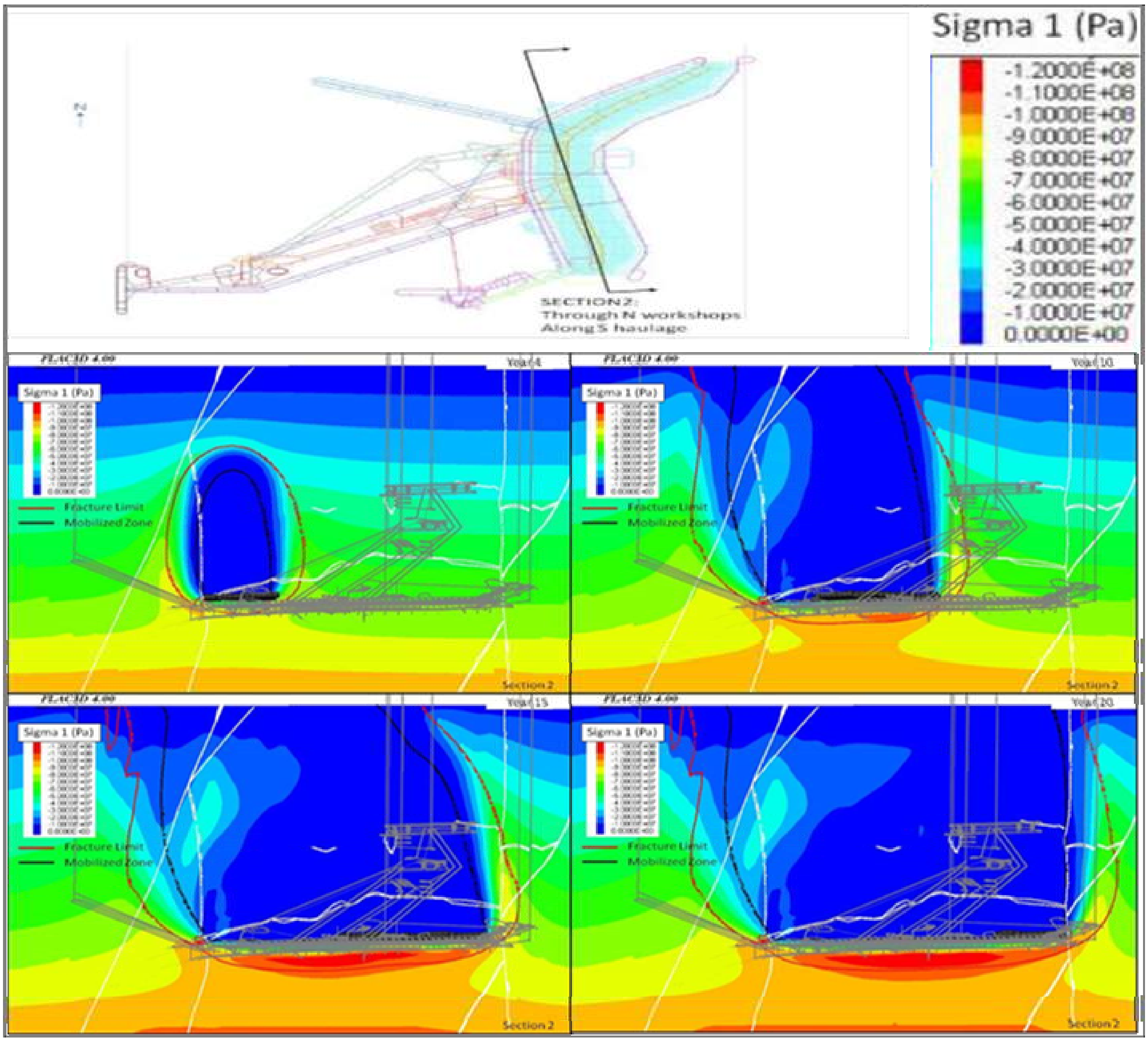
Numerical caving simulations suggest good caveability. Continuous upward growth is predicted, post-CHR, due to the high ratio of in situ horizontal stress to rock mass strength.

16.3.6.4 Cave Growth and Subsidence

Figure 16.38 illustrates the results of modelling from one north-south section through the cave, the evolving limits of active draw, and the proposed layout.

Modelling showed that fracture limits extend away from the cave boundary at a shallower angle in the east and west. This is attributed to the geometry and redistribution of in situ stresses to the north and south around the developing cave, resulting in a large stress shadow at low confinement to the east and west that fractures and mobilizes more readily.

Figure 16.38 Modelling Results for North-South Section of Advancing Cave



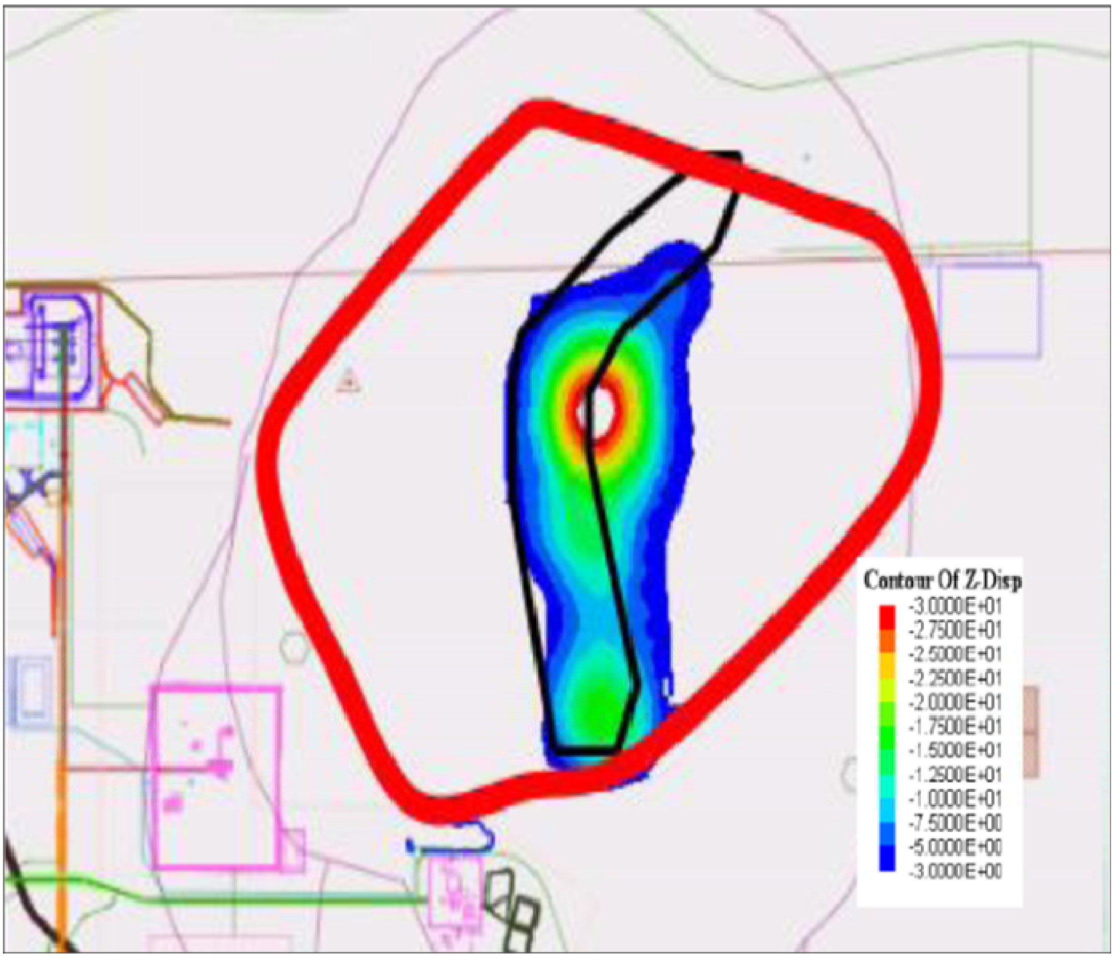
Note: Shows limits of fracturing (red), mobilization (black), and stress distribution on Section 2 as a function of production over time

Modelling also showed that fracture limits extend away from the cave boundary at a steeper angle, almost vertically upward from the advancing face, in the north and south. This is more characteristic of a block cave. This is attributed to the low ratio of advance rate to production rate at Hugo North, which promotes upward growth of the yield zone faster than lateral advance.

Modelling of the cave propagation and cave subsidence revealed that cave growth is more likely to be affected by the presence of major faults than by variations in rock mass strength or in situ stress. One area of note is in the north-west where the North Boundary Fault acts as a barrier, limiting cave growth.

The surface crater predicted to exist by the end of Lift 1 in the base case model is shown by the outline of the blue area in Figure 16.39. It is modelled to have a maximum depth of approximately 30 m near the kink in the orebody and a depth of 3 m near the limits of the orebody. The crater could be more extensive than that shown by modelling if rapid vertical caving, influenced by structure, were to occur. The fracture limits are illustrated by the thick red line. For the “limit of movement” contour for siting permanent surface infrastructure, a 100 m safety buffer is placed outside the fracture limit contour.

Figure 16.39 Subsidence Predictions from Modelling



Note: Footprint = black line, depth of crater >3m = blue area, fracture limits = thick red line

16.3.7 Fragmentation Assessment and Cave Flow

16.3.7.1 Introduction

Fragmentation is divided into primary and secondary processes. Primary fragmentation results from blocks detaching from the boundary of the rock mass around the mining cavity. Secondary fragmentation occurs as these blocks travel down the draw column.

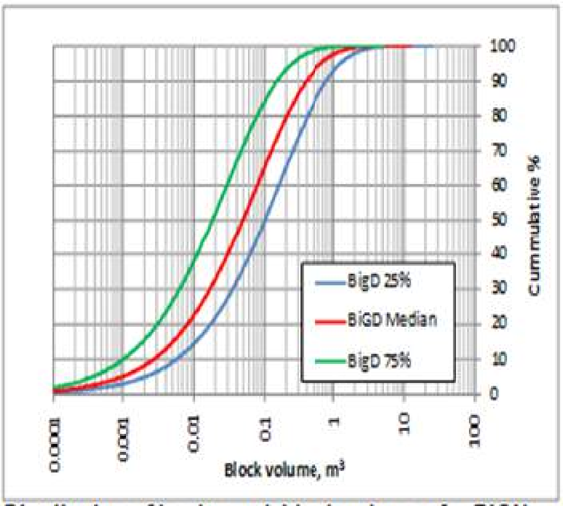
BCF software incorporating an updated dataset and parameters was used for the fragmentation analysis for the Feasibility Study. This analysis confirmed that the fragmentation will be fine. The analysis highlighted the risk that secondary fragmentation predictions do not take into account the full impact of comminution on high columns (up to 500 m high); as such, actual fragmentation may be finer than modelled. Finer fragmentation could lead to narrower drawzones, an important element in ore recovery and dilution entry predictions. Narrower drawzones may result in greater consolidation of material between active drawzones, increasing the risk of point loading.

16.3.7.2 In Situ Fragmentation

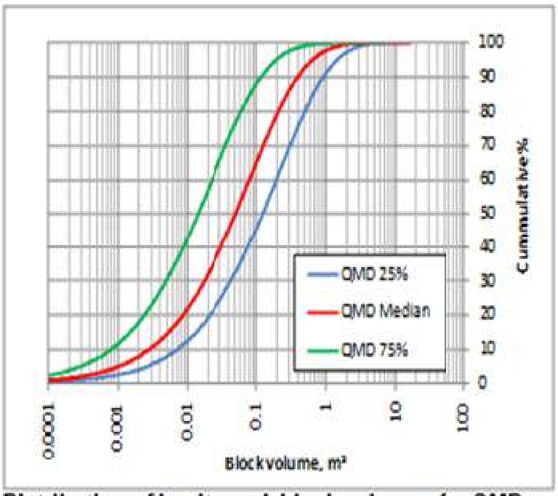
In situ fragmentation analysis was carried out using the DFN models developed for synthetic rock mass modelling (SRM) and ubiquitous joint rock mass modelling (UJRM) to estimate a range of rock mass blockiness for each domain.

Cumulative in situ block volume distributions for studied domains are given in Figure 16.40. Modelling results indicate that average in situ block volumes for the geotechnical domains are in the range of 0.02 to 0.28 m^3.

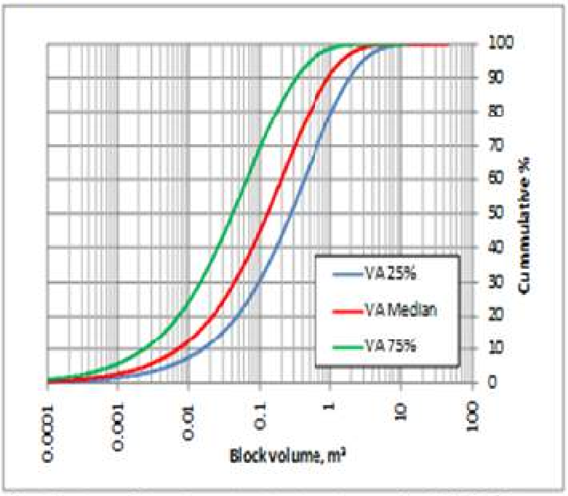
Figure 16.40 Distribution of In Situ Block Volumes for Dominant Geotechnical Domains



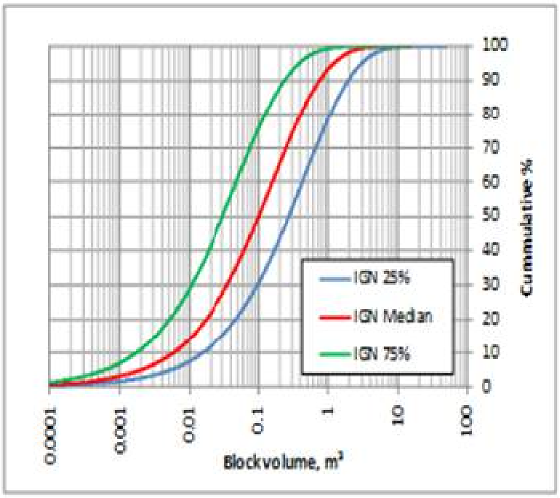
Distribution of in-situ rock block volumes for BiGN DFNs



Distribution of in-situ rock block volumes for QMD DFNs.



Distribution of in-situ rock block volumes for VA DFNs.



Distribution of in-situ rock block volumes for IGN DFNs

16.3.7.3 Primary Fragmentation

The stress inputs for the BCF software were derived from a combination of the FLAC® cave-scale modelling results and Esterhuizen's stress curves based on 3D stress modelling of hypothetical cave geometries under various stress conditions.

From BCF, the results of the primary fragmentation size distributions are fairly uniform within the deposit, although there is a trend of decreasing block size with depth below surface due to increases in stress-induced fracturing. The VA domain consistently produces the coarsest fragmentation, closely followed by the QMD, BiGD, and IGN domains, respectively. The mass % of primary blocks <2 m^3 ranges from around 83% near surface to around 99% within the cave column (500 m above the undercut), as summarized in Table 16.12.

Table 16.12 Primary Fragmentation % <2 m^3 for Dominant Geotechnical Domains

Draw Height	BiGD	IGN	VA	QMD
100 m	99	96	90	92
300 m	96	96	85	87
500 m	92	96	83	91

16.3.7.4 Secondary Fragmentation

BCF secondary fragmentation analysis was undertaken for all dominant geotechnical domains for increasing heights of draw from the undercut through to surface at 100 m intervals. Only fragmentation for the first 500 m is reported, as this is relevant to the economic draw column height to be extracted.

The secondary fragmentation process (comminution) simulated within BCF does not significantly reduce the fragmentation size, as anticipated for the high blocks. This is most likely because the primary fragmentation is already fine. Table 16.13 shows secondary fragmentation % <2 m^3 that can be classified as "fine."

Table 16.13 Secondary Fragmentation % <2 m^3 for Dominant Geotechnical Domains

Draw Height	BiGD	IGN	VA	QMD
100 m	100	99	90	96
300 m	100	100	92	97
500 m	100	100	100	98

16.3.7.5 Oversize and Hang-up Predictions

Oversize rocks are by definition not easily moved from the drawpoint, and they prevent the load-haul-dump (LHD) from drawing its required tonnage. Consequently, oversize rocks require secondary breaking or some form of double-handling and are therefore recorded as an "event."

Table 16.14 shows the BCF prediction for oversize and hang-ups that was used for the study. Predictions are considered conservative are because they do not account for the fines component.

Table 16.14 Oversize and Hang-up Predictions Using BCF Software and Northparkes-Palabora Fragmentation Database

	BCF			Database	
HOD	Tonnes/OS Rocks	Tonnes/Hang-up		Tonnes/Event	Tonnes/Hang-up
100	287	864		130	576
300	502	1,510		138	1,077
500	7,988	24,044		390	16,029

Note: The oversize and hang-up predictions do not include the fines component, which may exceed 11% by mass. This will serve to significantly improve the drawpoint productivity rates and increase the tonnage per oversize and hang-up.

16.3.7.6 Grizzly and Crusher Fall Through

BCF was used to estimate the percentage passing for the grizzlies installed above the internal orepasses (0.8 m x 0.8 m), the F80 size for the crusher feed, and the crusher aperture setting (0.216 m). Because the BCF prediction of aspect ratio (AR=1.6) is considered conservative, an 11% by volume fines component was added to account for the more cubic rock shape (closer to AR=1) expected from comminution in the cave.

A figure of 90% passing, or one grizzly blockage per 10 LHD buckets, to 95% passing, or one grizzly blockage event every 20 LHD buckets, was considered a conservative to central case, and has been used as the basis for the study.

16.3.8 Cave Flow

Cave flow analysis is used to determine the drawpoint spacing required for the extraction level layout to ensure interaction between the draw columns, to determine how the cave is expected to propagate, and to calculate orebody recovery and production schedule grades.

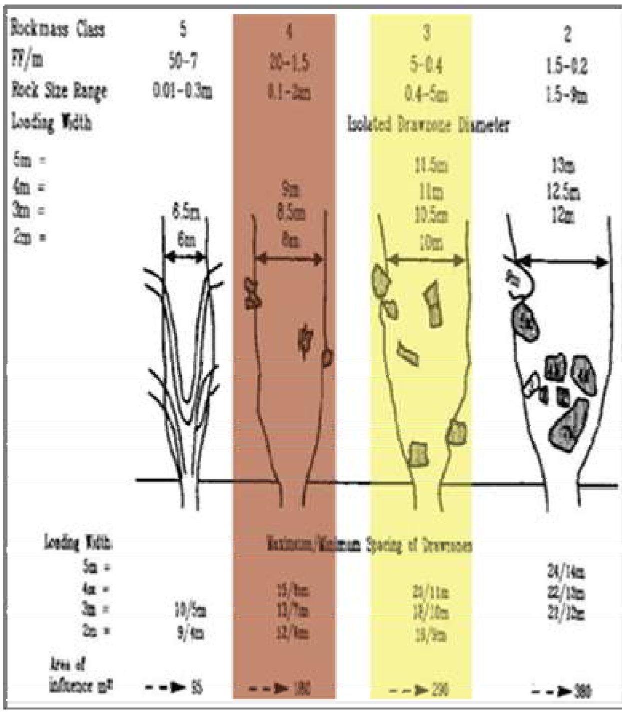
16.3.8.1 Laubscher Methodology

Laubscher's Empirical method is an industry standard for calculating drawpoint spacing. Fragmentation is the key input into this calculation. Laubscher starts with defining an isolated draw zone (IDZ). Figure 16.41 shows Laubscher's categories and criteria with Hugo North rock conditions colour-coded to Laubscher's system. Hugo North's IDZ diameters are estimated to vary between 9 m and 11.5 m and to average 10 m.

Laubscher's interactive draw spacing calculation is shown in Figure 16.42. Interactive drawzones are spaced to touch (interact) within a drawbell, resulting in a 1.5 times growth to produce an individual drawbell zone.

On this basis, analyses recommended a drawpoint spacing of 15 m x 28 m.

Figure 16.41 Laubscher Classification System (left) and Hugo North's Rock Mass Rating (right)



Rock Type	Year	Modified Rock Mass Rating (MRMR) Lower Quartile	Modified Rock Mass Rating (MRMR) Median	Modified Rock Mass Rating (MRMR) Upper Quartile	Fracture Freq. (ff/m) Median	Primary Frag (base)	Sec Frag (base, 120m)	Sec Frag (fine, 120m)
IGN	5							
	10	33	37	40	3.8	0.45	0.37	0.27
	15	35	39	40	3.3	0.27	0.27	0.22
	20	39	40	41	2.8	0.52	0.39	0.22
Va	5	36	41	45	3.2	0.34	0.31	0.00
	10	34	38	42	3.7	0.37	0.31	0.22
	15	34	40	42	3.1	0.48	0.39	0.27
	20	37	42	45	2.5	0.52	0.43	0.31
QMD	5	35	42	46	2.9	0.46	0.41	0.22
	10	34	40	44	3.5	0.6	0.52	0.22
	15	34	38	43	3.7	0.51	0.45	0.27
	20	34	38	43	4.3	0.78	0.65	0.34
BIGd	5	34	36	41	4.6	0.53	0.48	0.22
	10	33	37	41	4.5	0.81	0.73	0.41
	15	35	37	42	4.9	0.41	0.34	0.22
	20	17	37	38				

Figure 16.42 Laubscher Drawzone Growth Methodology

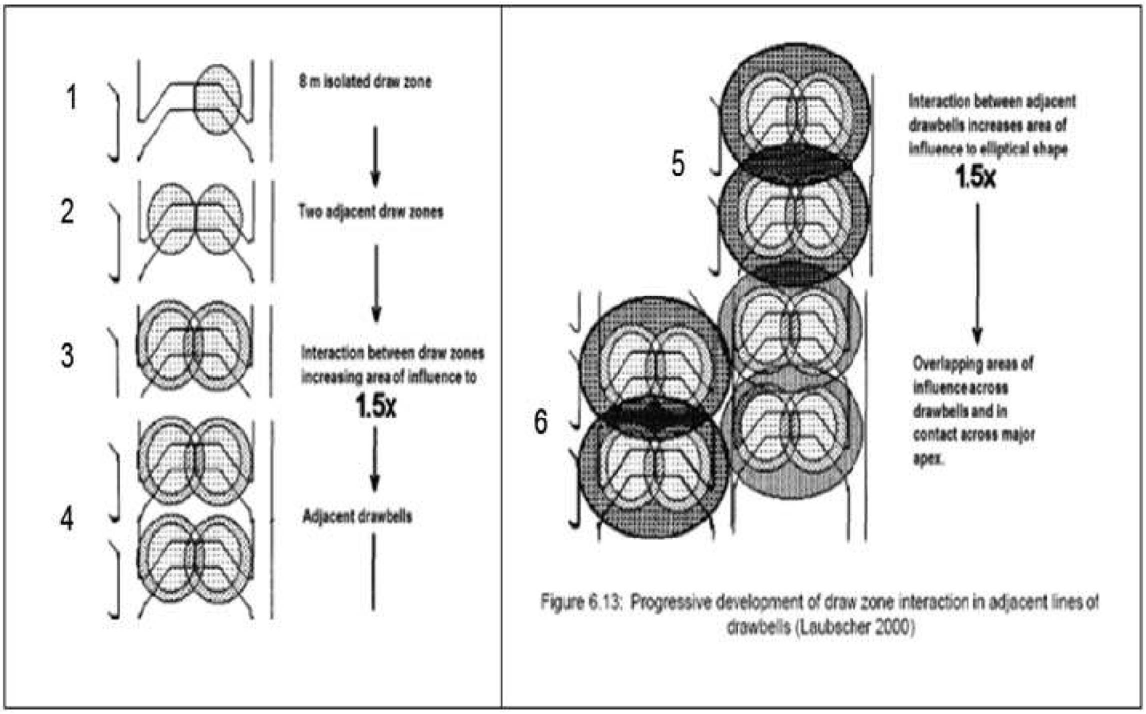


Figure 6.13: Progressive development of draw zone interaction in adjacent lines of drawbells (Laubscher 2000)

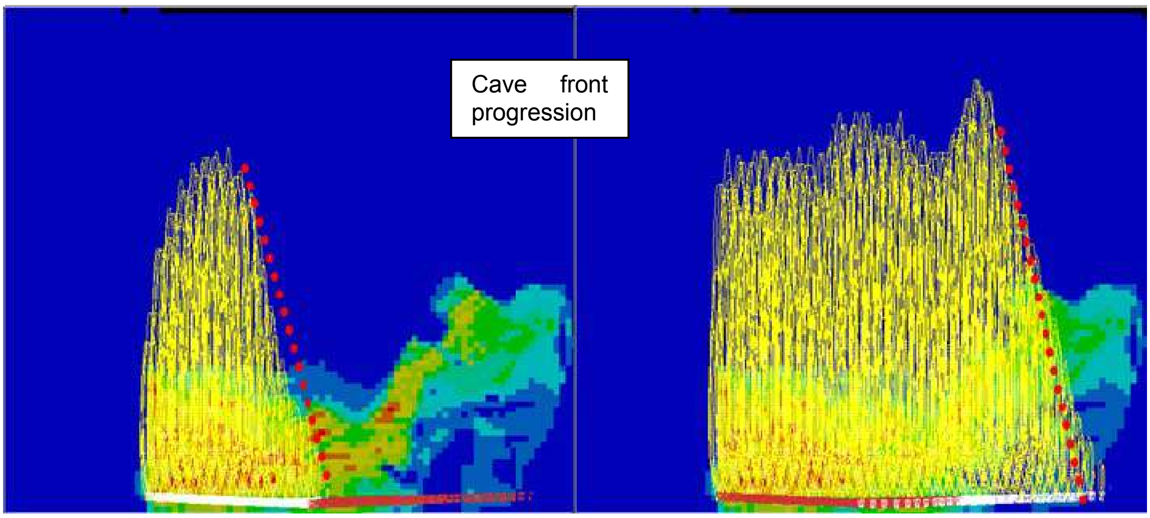
16.3.8.2 REBOP®, PCGA®, and Benchmarking

Laubscher's method is based on information from traditional caves with significantly lower column heights than at Hugo North. The high block height of the Hugo North cave (draw columns up to a maximum of 500 m, average 390 m) will serve to drive the secondary fragmentation processes, resulting in fine fragmentation, and to promote large tangential stresses around drawcones to retard their lateral expansion. This combination of fine fragmentation and high overburden stresses within the muckpile could translate into more isolated draw and less draw interaction, which could result in earlier dilution entry.

The REBOP® results indicate interactive draw for all scenarios investigated, ranging from assumed finer QMD, VA, and IGN material to switching on/off the fines migration and secondary breaking logic in REBOP®. All REBOP® simulations yielded similar but slightly lower ore recoveries than those in the Personal Computer Block Cave (PCBC) model based on the Laubscher methodology.

During production ramp-up, the maximum daily draw rate from a particular drawpoint is constrained by the drawpoint construction rate. This coupled with high draw columns results in a relatively steep depletion front, as shown in Figure 16.43. Studies are ongoing within Rio Tinto to further assess the effect of rilling along steep depletion fronts, and further REBOP and Cellular Automata simulations are recommended to cross-check with PCBC output in analyzing rilling potential and dilution entry.

Figure 16.43 Illustration of Hugo North's Depletion Front



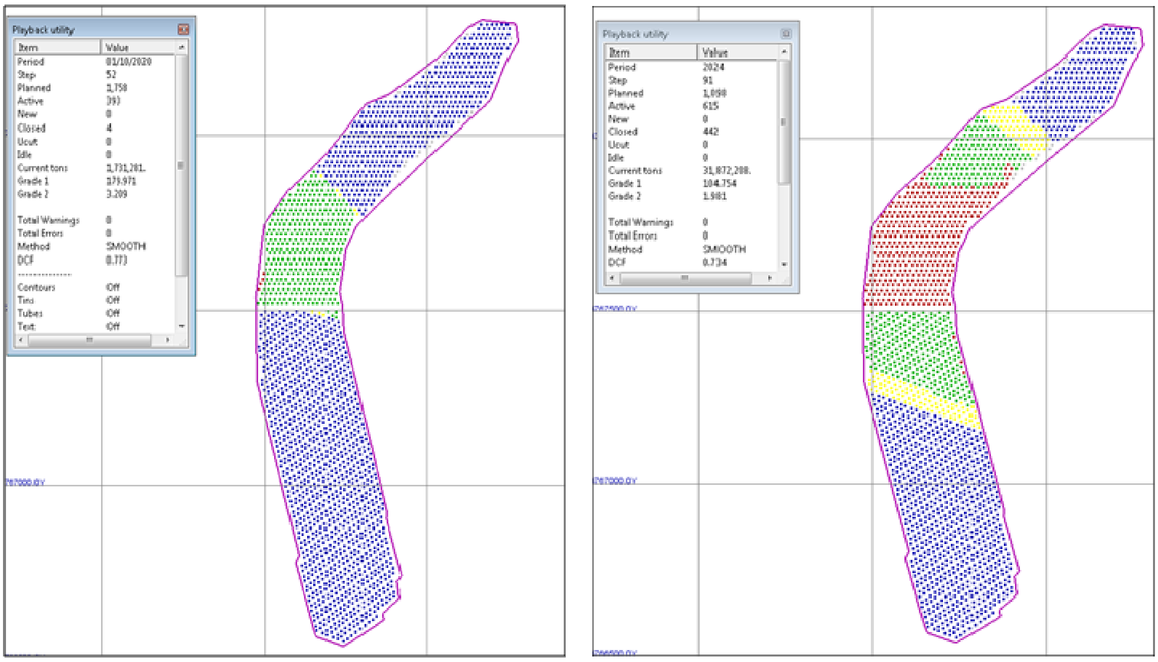
16.3.8.3 Gemcom PCBC™ Scheduling

Production scheduling was undertaken in Gemcom's PCBC™ software. PCBC takes the cell model above a footprint and divides it into vertical cylinders above each drawpoint. The diameter of the vertical cylinders is a critical input into PCBC. From Laubscher's 10 m IDZ and the interactive draw growth process, a PCBC diameter of 25 m was used to represent interactive draw. It is of note that PCBC is not used as a flow modelling tool to determine interactive draw; conditions supporting interactive draw are derived from Laubscher methodology and supporting programs, and these conditions are then represented in PCBC for production scheduling.

The height of interaction zone (HIZ) is another important PCBC input. The HIZ defines the height above the footprint where mixing occurs; material above this HIZ is believed to exhibit mass flow behaviour, moving evenly downwards with no mixing. For Hugo North, the PCBC HIZ has been estimated at 150 m, consistent with PCBC modelling undertaken for other projects.

On the extraction level, approximately one bucket per drawpoint per day (12 tonnes) will be removed pre-CHR. This minimal removal of material will be for the purpose of stress relief only and there will be no ramp-up in production during this time. The production ramp-up rate for a given drawpoint post CHR is recommended to start at 50 mm/d and to increase to a steady state of 300 mm/d, over a 12 month period or 16% of the column height. This will ensure that the stresses have time to fail the rock mass above the cave back and cause the cave to propagate vertically upwards, minimizing the formation of any overhangs and irregular cave growth. Cave monitoring and management will be used to ultimately determine the rate of draw. The high stress conditions and fine fragmentation predicted at Hugo North may provide higher rates of caving and an opportunity to increase draw rates.

Figure 16.44 Area Opened when Select Drawpoints can Increase to 400 mm/d



* Panel 1 area is shown on left figure, Panel 2 area is shown on right figure

16.3.9 Cave Monitoring

16.3.9.1 Cave Monitoring Systems

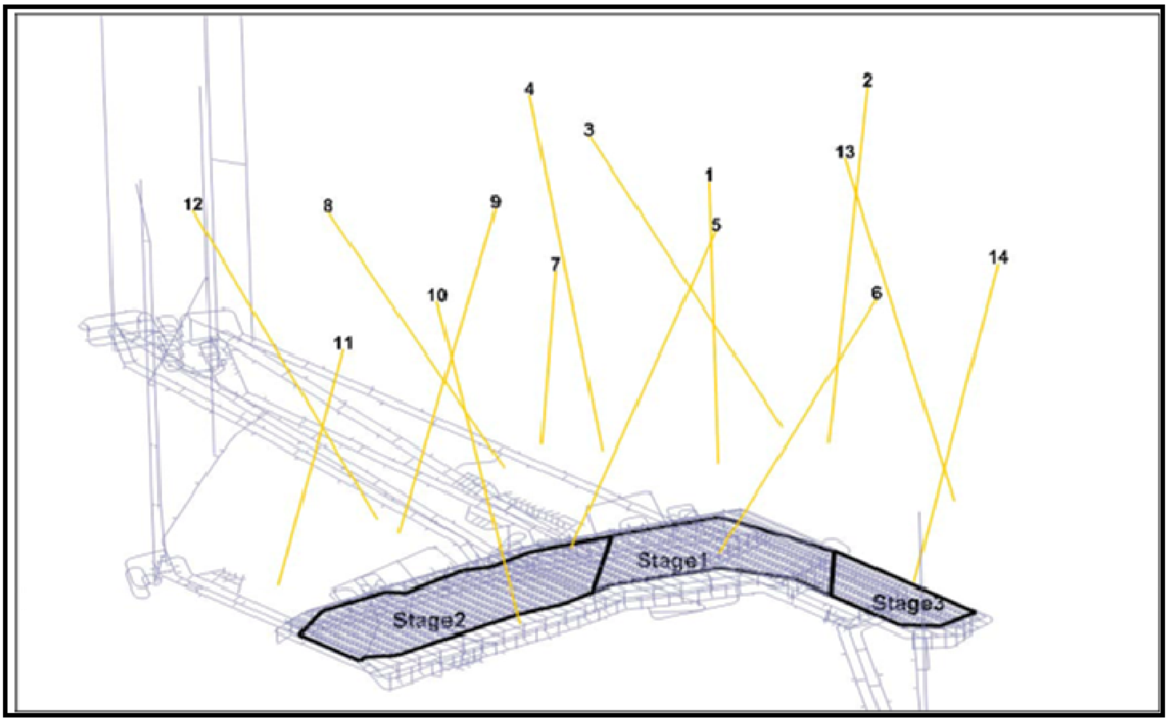
Monitoring provides valuable information on cave initiation, caving rate, shape of the cave back, and intensity of stress fracturing. The monitored caving rate can be used as a basis for production scheduling to minimize the risk of air blast. Monitoring is also useful for identifying areas that have stalled and may require cave induction.

The proposed cave monitoring system includes a micro-seismic system, Time Domain Reflectometers (TDR), extensometers, and open drillholes. All of the data recorded from these systems are analyzed and stored in a geotechnical database. The interpreted cave back and muckpile positions are consequently uploaded into the mine design software package for the construction of a 3D model of the cave.

The micro-seismic monitoring system is used to track the inelastic response of the rock mass to mining activities.

Golder Associates was engaged to provide a preliminary design concept of the micro-seismic system for Hugo North. Figure 16.45 is an illustration of the proposed holes that would contain the seismic sensors.

Figure 16.45 Proposed Holes Containing All Seismic Sensors for the Mine



16.3.9.2 Undercut Monitoring

Monitoring of the undercut will include seismics, convergence (real-time extensometers and convergence stations), and stress change through hollow inclusion cells.

16.3.9.3 Extraction Level Monitoring

As with the undercut, monitoring of drive stability is critical in terms of stress loading but also for managing the cyclic loading induced through cave draw. The ramifications of any unsuccessful blasting of the undercut and pillar formation are quickly transmitted to the extraction level because the pillars act as point loads that can very easily crush drives and/or drawpoints. One set of convergence stations and one set of three extensometers (two in the extraction drive sidewalls, one in the back) should be installed adjacent to every second or third drawpoint to provide sufficient coverage to detect rock mass response to cave draw.

16.3.9.4 Major Excavation Monitoring

All major excavations, such as the shafts, workshops, crushers, and bins, require deformation monitoring to ensure timely respond timely to any adverse rock mass movement. Seismics and convergence monitoring will be employed for this purpose.

16.3.9.5 Cave Flow Monitoring

The use of Elexon's Smart Marker System has proved successful at the Northparkes and other caving operations. Markers are placed in surface drillholes across the orebody at recorded coordinates and are drawn down through the cave during operation. When mucked out of a particular drawpoint by LHD, the marker is trammed to the central orepass where a reader picks up and records the marker's unique identity number. It is then possible to extrapolate the flow path of the marker and gain an understanding of the cave flow characteristics.

16.3.9.6 Subsidence Monitoring

The subsidence zone is subdivided into a No-Go zone, where no person may enter, and a fenced-off Restricted Access Zone, where geotechnical monitoring and inspections are permitted. After breakthrough, the No-Go zone should be redefined periodically, typically based on aerial photogrammetry, prism monitoring, and extensometers.

16.3.10 Major Hazards

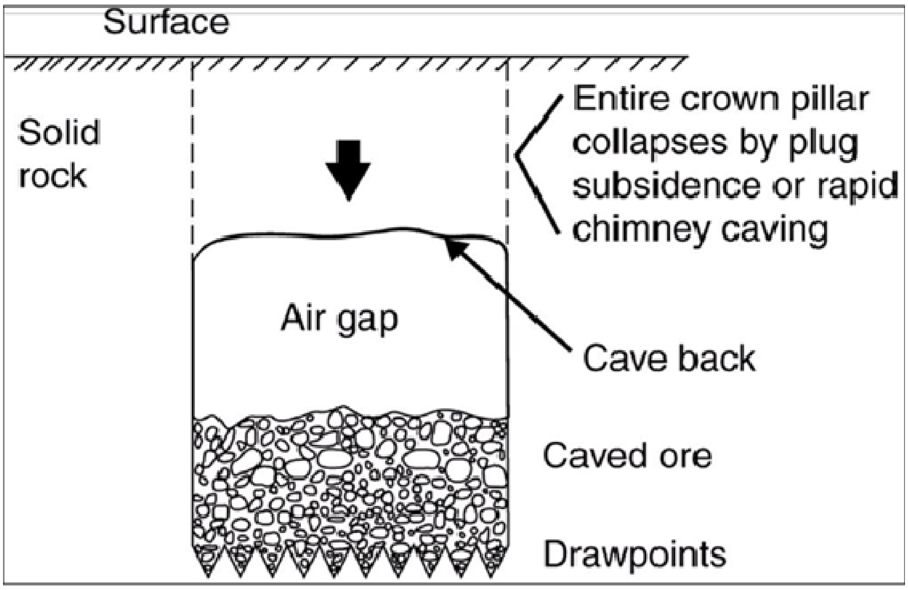
16.3.10.1 Ground Collapse and/or Crown Pillar Failure

Figure 16.46 illustrates a situation where the expansion void grows into a significant air gap because the rate of draw is greater than the rate of caving.

A significant air gap accompanied by a large failure of the cave back could result in an underground air blast through either the drawpoints or any other open connection into the cave.

Strict draw control practices in conjunction with geotechnical monitoring of the cave back will ensure that the expansion void required to promote continuous cave propagation does not transform into a significant air gap. A minimum amount of broken material needs to be left in the cave above the drawpoints and undercut level to ensure that no voids or paths are open between the cave and personnel locations where air, fines, or rocks could be ejected. All development intersecting the cave will contain air blast barriers.

Figure 16.46 Uncontrolled Crown Pillar Collapse



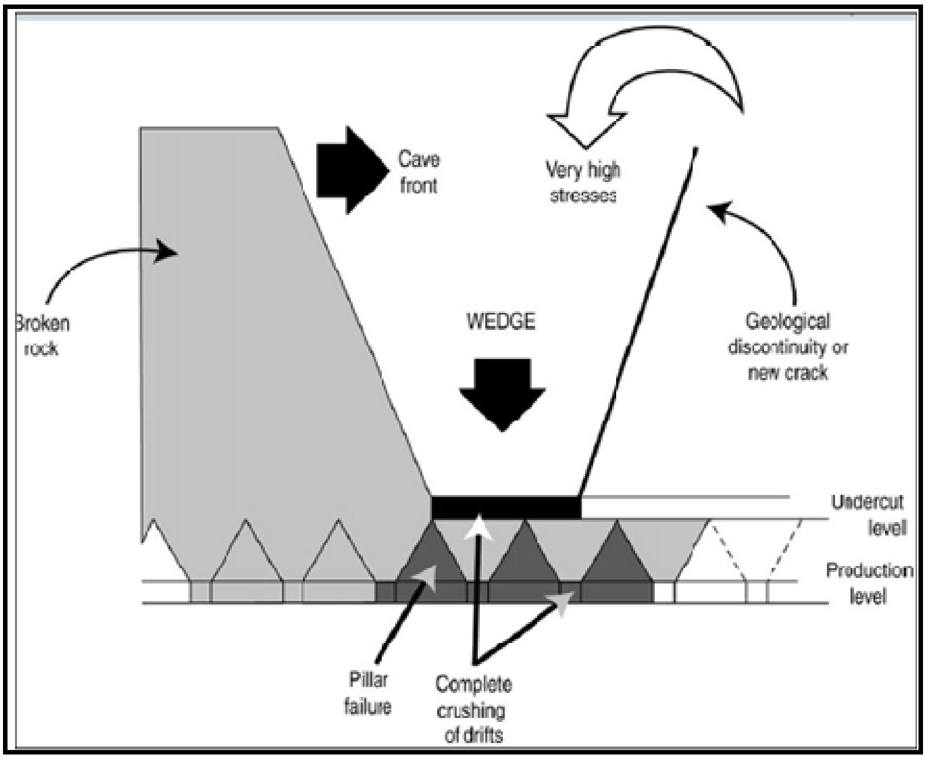
Note: After Brown (2000)

16.3.10.2 Column Loading

Column loading results from the weight of the overlying ore column or from arching stresses, which are often created at the sides of an active draw ellipsoid. Over time this has the potential for point loading and damage to drives and drawpoints (Figure 16.47).

Sound draw control practice is recognized as the best means of avoiding stress concentrations. Geotechnical monitoring (convergence, cracking, pillar dilation) will detect the onset of loading before any significant drive deformation.

Figure 16.47 Column Loading



Note: After Florez (1993)

16.3.10.3 Mudrush

Mudflows in block caves are generally limited to caves situated in high-rainfall areas or where the orebody contains a large amount of fines or clay-bearing minerals. A detailed mudflow risk assessment has yet to be been conducted for Hugo North; however, the risk for mud flow is considered to be low due to the lack of significant volumes of water. A large rainfall event after the cave breaks through to surface would present the highest probability of occurrence.

16.3.10.4 Rockbursts and Slip on Major Structure

Detailed regional seismic hazard assessments have been carried out by the Research Center of Astronomy and Geophysics (RCAG) in Mongolia and by Knight Piésold Consulting Ltd. in 2005. Fluor Canada reviewed this work in 2010 for the design of the tailings storage facility and performed some seismic hazard assessments.

Itasca was asked to employ the Excess Shear Energy methodology utilizing 3DEC. This is frequently used at South African mines to assess the risk of large-scale seismicity on faults and dykes induced by longwall mining at great depth. Because of the soft nature of the major faults included in the model for Hugo North, no dynamic slip was shown on those structures.

Modelling indicates that the West Bat Fault will be the most active, followed by the Hugo Rhyolite Fault and the East Bat Fault.

16.3.10.5 Cave Subsidence Risks

Numerical modelling along with benchmarking indicates that the risk of shaft 2 being affected by subsidence through mining of panel 1 and panel 2 is very low. Subsidence monitoring will be carried out to understand ground movement relative to caving and to recalibrate subsidence models to ensure the most accurate predictions are available.

16.3.10.6 Isolated Draw

Isolated draw could occur if the material is finer than predicted because of either underestimated primary fragmentation related to ground conditions and stress effects, or underestimated secondary fragmentation related to comminution from high ore columns. Production schedule runs with isolated draw scenarios show that these could have a significant impact on project value through both lost recovery and the inability to produce at the planned 95,000 t/d production rate.

Good draw control practices are the key for maximizing interaction and recovery. Given the current pillar stability concerns, it is not considered feasible at this stage of study to reduce drawpoint spacing further to reduce the risk of isolated draw.

16.3.10.7 Further Work

Further measurements of in situ stress within the orebody's host rocks – granodiorite and monzodiorite – are required to provide confidence in the interpretation of the stress field where cave mining will occur. This may mean applying measuring techniques supplementing or replacing the HI cell method.

Then, the interpretation of the in situ stress field for the Hugo North orebody and environs requires reconsideration. There is an arguable case that active tectonism is not occurring at depths below 700 m, but rather that it has all been subjected to uplift, erosion and relief of stress to much greater depths. This has significant implications for the magnitudes of stress at the footprint of cave mining.

The present geological interpretations are acceptable for the geological and resource models at the levels of confidence stated. However, cell models for the Hugo Dummett deposit models, which were created in 2007, have not been updated since. The geological interpretations and models are likely to change as the project proceeds to detailed mine design and construction.

From 2010 to 2012, OT LLC reviewed and re-evaluated much of the data collected in support of mine design and construction. These reviews included consideration of additional drilling completed in the project area, incorporation of revised, and more detailed, structural and lithological interpretations, consideration of changes in interpretation of the evolution and genesis of the Oyu Tolgoi deposits, and the results of preliminary geotechnical reviews. A number of areas were identified that could benefit from targeted work programs, particularly in the areas of structure and rock mechanics.

The result was development of a proposed work program for 2012–2013 that addressed geological issues that could directly affect the mine design and construction.

The OT LLC work program is likely to include the following:

- Developing a standard set of cross-sections and level plans on the mine grid that can be used to support geotechnical assessment, mine planning, and metallurgical assessment. These sections will replace the variably oblique section lines used previously.
- Incorporating additional drill data completed since the last update into the resource models.
- Undertaking drill testing of structural discontinuities identified in the structural and geotechnical reviews. Results of such testwork would be incorporated into the cell model.
- Reviewing the updated resource models to pinpoint areas where there are gaps in knowledge concerning lithology, alteration, structure, and mineralization that require targeted drill testing. Such gaps are considered more likely to occur on the orebody margins or in areas where high-grade mineralization is in direct contact with areas interpolated as waste.
- Assessing likely criteria for the most appropriate drill spacing to support classification of measured mineral resources for the proposed block cave areas.
- Building a 3D district geological and structural model that will assist in further exploration and in the definition of additional drill targets in the near-mine environment.
- Exploring further opportunities and options for the overall development after resource development work on lift 2, Hugo Dummett North, commences within the next couple of years.
- Evaluating future work at Hugo South to further enhance the understanding of the overall resource development strategy.
- Completing drilling and the quantification of the mineralized inventory within Heruga North.

16.4 Underground Mining

The Hugo Dummett underground deposit will be mined by block caving which is a highly productive and cost effective method. The deposit is comparable in dimension and tonnage to other deposits currently operating by block-cave mining elsewhere in the world. OT LLC designed the block cave based on the Hugo North Lift 1 Mineral Reserve.

16.4.1 Mine Design

The mine design consists of 194 km or lateral development, 16 km of vertical development which includes 5 shafts, and 140,500 m^3 of mass excavation. A total of 2,155 drawpoints are planned for developed within the current footprint, which will be accessed from 63 extraction drives. The mine will produce 493 Mt of ore at the full production rate of 95,000 t/d, with 491 Mt processed and 2 Mt stockpiled. A plan view of the mine is shown in Figure 16.48. Key mine design details are given in Table 16.15 and the shaft details are in Table 16.16.

Figure 16.48 Mine Layout

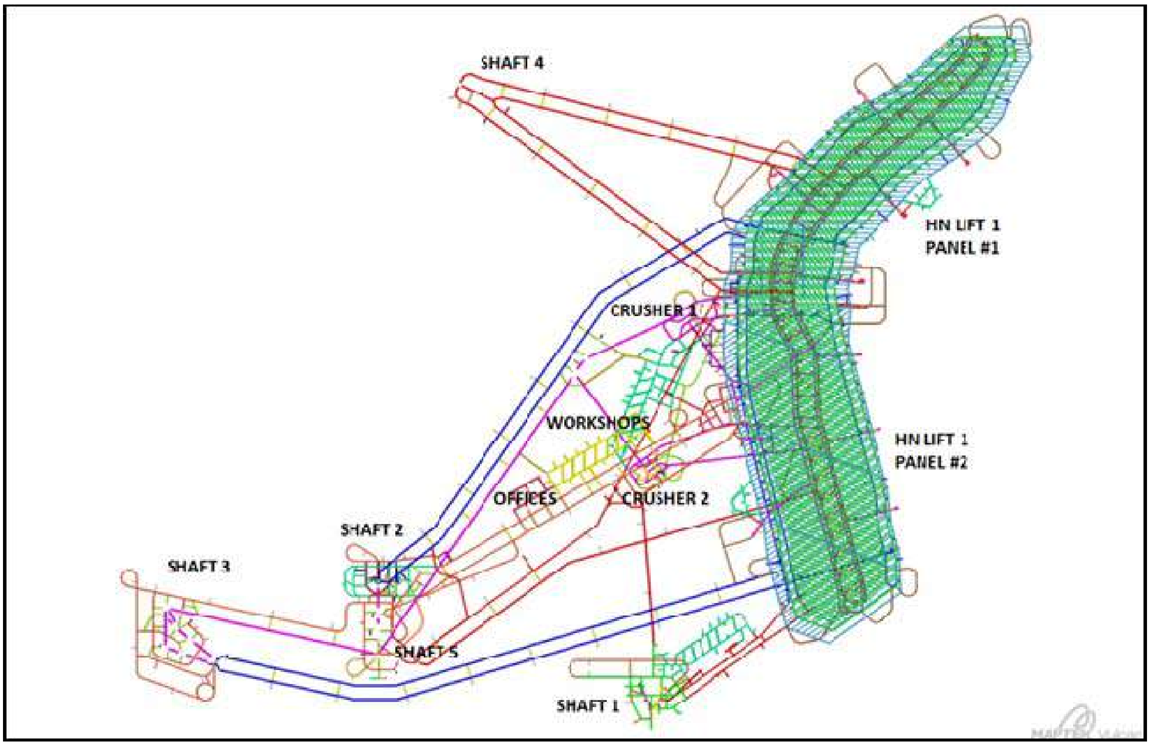


Table 16.15 Key Mine Design Details

Extraction Level		Undercut Level	
Layout	El teniente	Sequence	Advanced
Spacing (m)	28 x 15	Drive Spacing	14
Drive size excavated (m)	4.5 wide x 4.5 high	Drive size excavated (m)	4.0 wide x 4.0 high
Loader type	14 t diesel	Profile	Inclined “W” style
Orepass layout, diameter (m)	Central, 3.0	Face angle (plan)	55
Grizzly (m)	0.8 x 0.8	Lead/lag (m)	10
No. of drawpoints	2,155	Total area (m^2)	641,000
Hole diameter (mm)	76	Hole diameter (mm)	89
Drilling per drawbell (m)	1,375	Ring Spacing (m)	2.0
Concrete road surface	80 MPa	Metres per ring (m)	78
Steel sets	Yes	Tonnes per ring (80% swell)	210
Haulage Level		**Conveyer and Loadout**	
Haulage method	Truck to crusher	Drive size excavated (m)	6.8 wide x 5.5 high
Truck type	80 t diesel, side tip	Max. inclination (%)	18
Haulage loop	One way	Transfer method	Shuttle chute
Truck loading (production)	Drive through	Number of shaft bins	6
Chute style	LKAB	Bin diameter (m)	10
No. of chutes	56	Bin length (m)	45
Drive size excavated (m)	6.1 wide x 6.0 high	Total bin capacity (t)	30,000
Number of crushers	2	Skip loadout	Conveyor

Table 16.16 Shaft Details

Shaft No.	Diameter (m)	Depth (m)	Hoist Capacity (t/h)	Vent Capacity (m^3/s)	Function
Shaft 1	6.7	1,385	240	460	Pre-production development, intake vent
Shaft 2	10.0	1,250	1,630	950	Cage access, production hoisting, intake vent
Shaft 3	11.0	1,180	3,768	1,100	Production hoisting, intake vent
Shaft 4	11.0	1,220	–	1,900	Exhaust vent
Shaft 5	6.7	1,195	–	680	Exhaust ven

Figure 16.49 is a section through the footprint showing the relationship between the 5 main levels. Figure 16.50 shows the extraction level layout. Panel 1 has extraction drives orientated east-west, and panel 2 has extraction drives orientated at 055 strike. A close up of the El Teniente 28 m by 15 m layout illustrates centrally located orepasses and ventilation raises. The orientation of the undercut level layout development is similar

to that for the extraction level with two undercut drives for each extraction level drive. Figure 16.51 illustrate the drill-and-blast excavations for the undercut and drawbells.

Figure 16.49 Section View Through Footprint

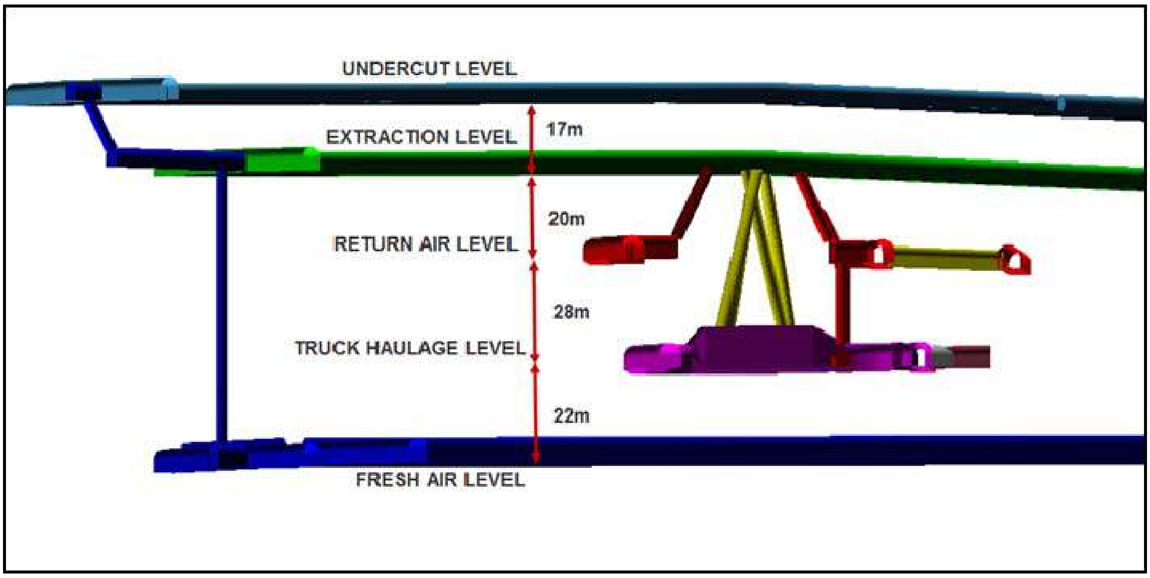


Figure 16.50 Extraction Level Layout

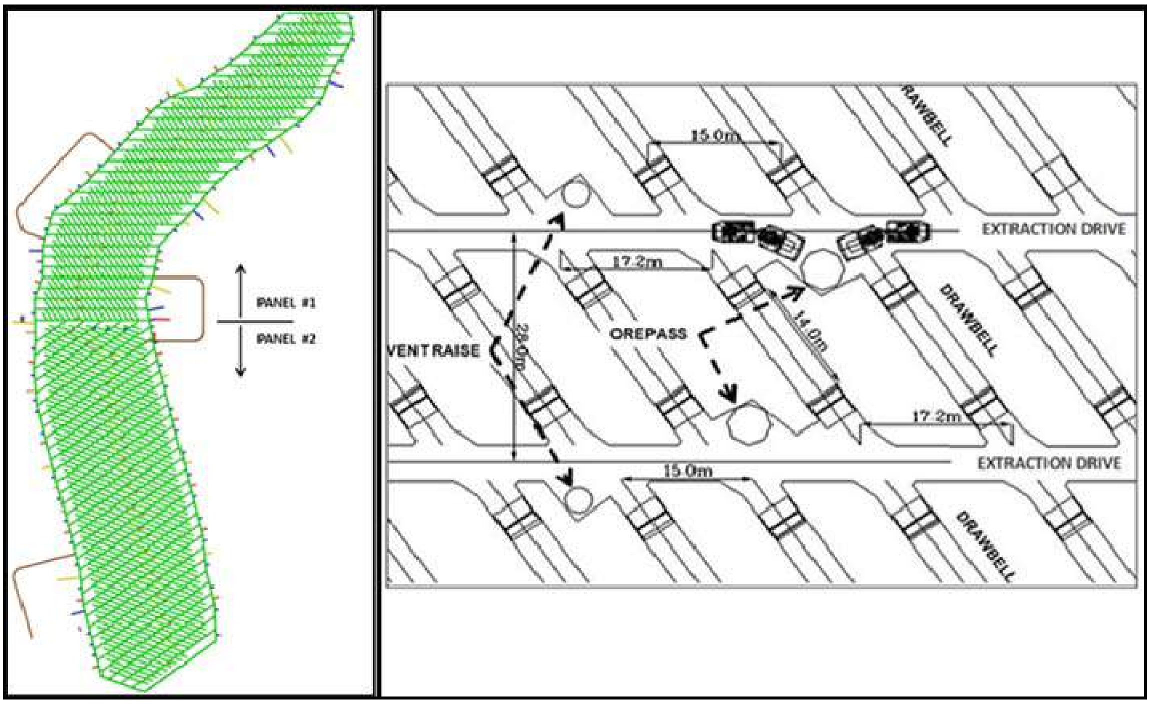


Figure 16.51 Undercut Drawbell Excavation

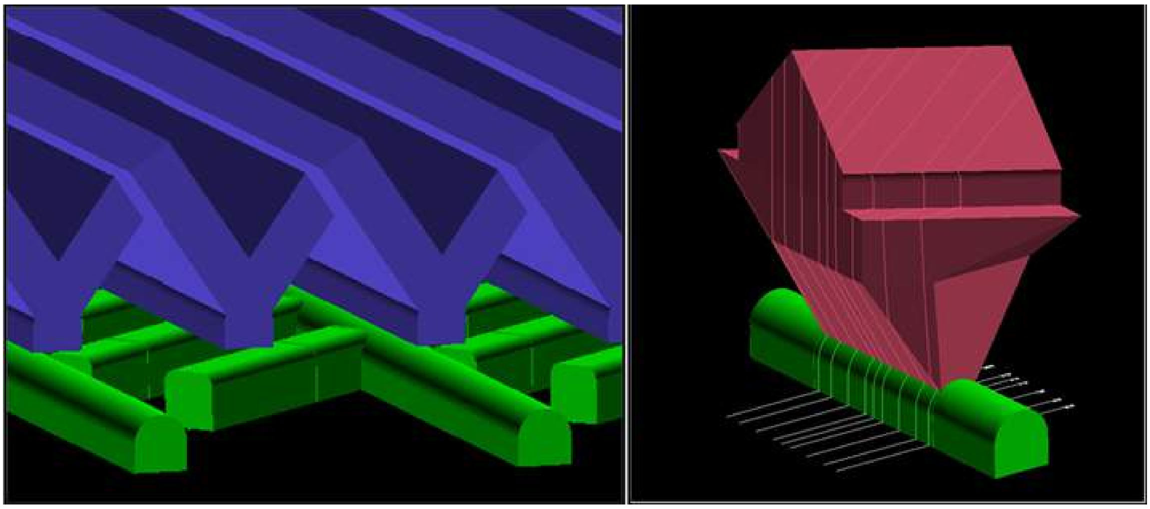
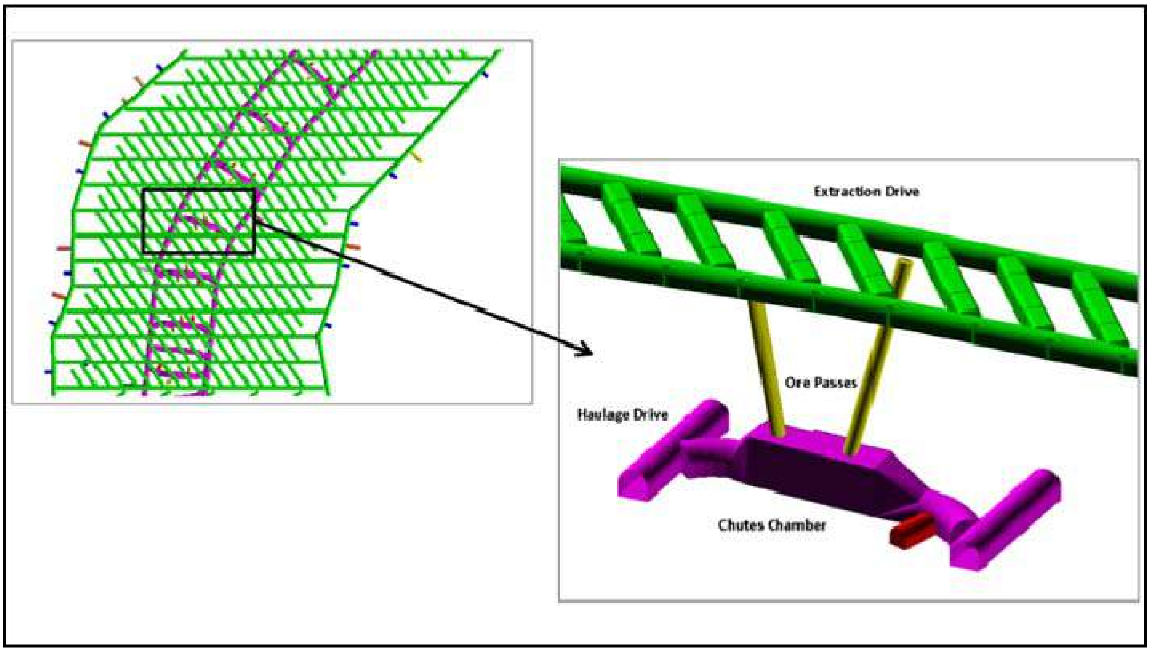


Figure 16.52 shows a section of haulage level development (purple) that is 45 m below the extraction level development (green). The figure also shows the connection between the centrally located production orepasses and drive-through truck-loading chambers. Extraction drives are sized to accommodate 14 tonne LHDs and the haulage drives are sized to accommodate 80 tonne side-tip trucks.

Figure 16.52 Extraction Level to Haulage Level Arrangement



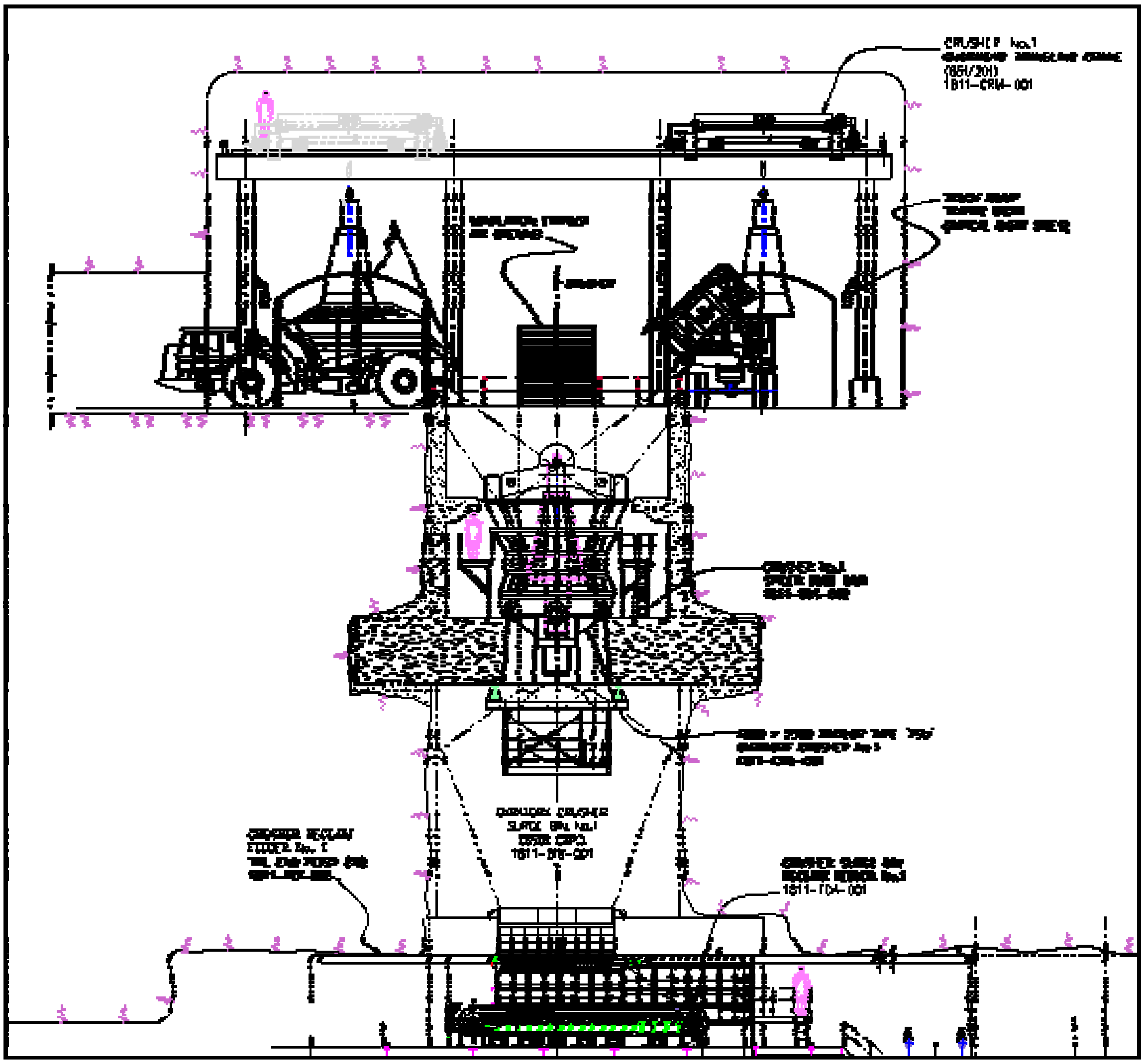
16.4.2 Ore Handling System

16.4.2.1 Crusher

The selected 1,600 mm by 2,400 mm gyratory crusher with installed power of 750 kW has a split shell configuration for shaft and underground transport to the crusher stations. Design capacity is 4,000 t/h each for the two crushers. A section through the crusher 1 chamber is shown in Figure 16.53.

Trucks will tip into a 160 tonne bin that feeds directly into the gyratory crusher with an open side setting of 203 mm. A 650 tonne surge bin under the crusher will feed onto a sacrificial belt via an apron feeder to provide for steel removal. The crusher will be controlled remotely. The spare mantle has been removed from the crusher chamber to reduce excavation size, and a separate mantle and concave workshop facility has designed adjacent to the haulage workshop.

Figure 16.53 Crusher Station General Arrangement



16.4.2.2 Conveyors

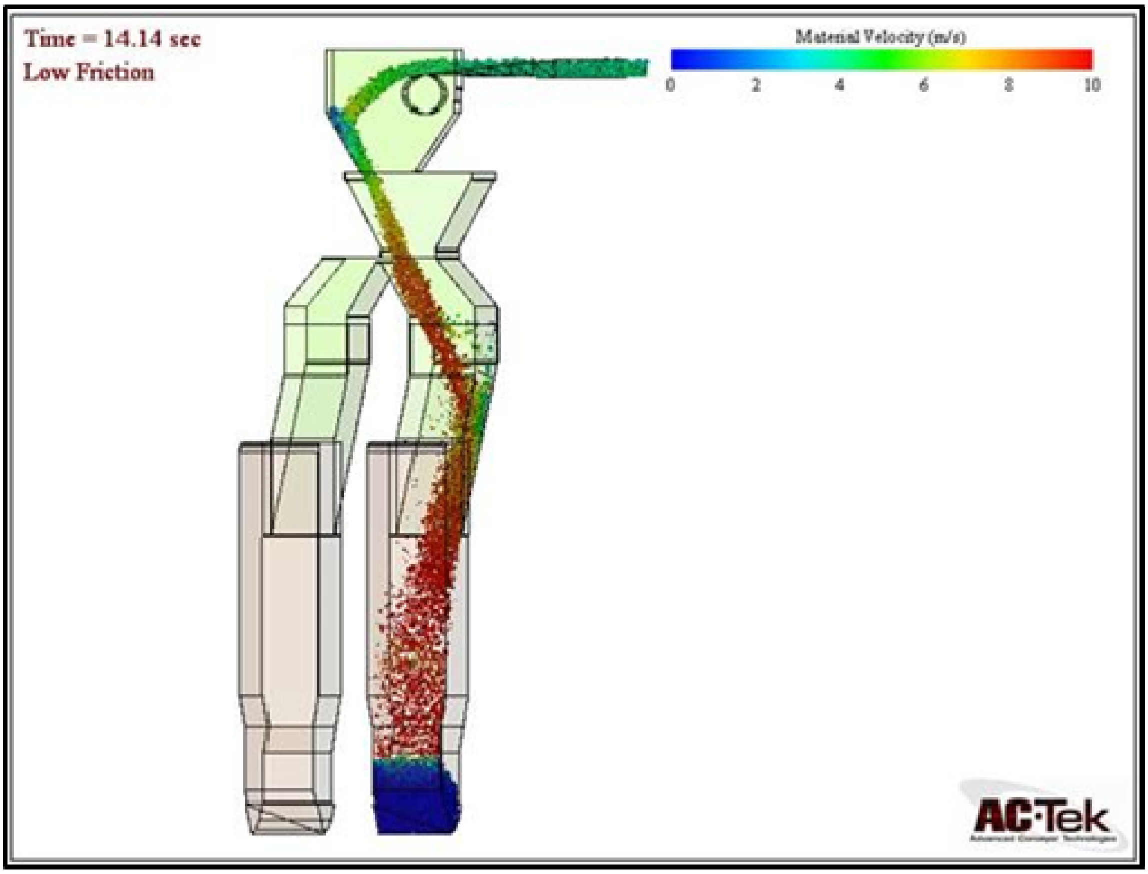
The sacrificial conveyor from Crusher 1 will discharge crushed ore onto a 2,200 mm wide incline transfer conveyor (ST-1600 steel cord). The conveyor has a design capacity of 4,800 t/h, a belt speed of 3.0 m/s, a maximum inclination of 18%, and is fitted with a single 1,320 kW drive assembly at the head pulley. A similar transfer conveyor arrangement will be in place for Crusher 2. Both transfer conveyors will feed onto the 2,200 mm wide x 1,141 m long incline conveyor 1 having a maximum inclination of 18% for a belt lift of 194 m. This conveyor has a design capacity of 9,600 t/h at a belt speed of 3.5 m/s, ST-6300 steel cord belting, and three installed 2,500 kW drives. Advanced Conveyor Technologies (AC-Tek) performed a dynamic analysis of incline conveyor 1 and confirmed the design. The primary flow of ore from incline conveyor 1 will discharge into a two-way diverter chute, which will direct the ore to either the shaft 2 loading bins via a short horizontal conveyor or to the Shaft 3 loading bins via incline conveyor 2.

16.4.2.3 Shaft Bins and Skip Loadout

Two ore storage bins are provided at shaft 2 and four are provided at shaft 3. Each bin will have a live operating capacity of 4,200 tonnes while maintaining an 800 tonne bed of material (dead bed) to prevent falling rock from impacting the reclaim feeder below. Shaft 2 will contain one skip loading system. Ore from one of the two ore storage bins will be measured by an apron feeder and weightometer system onto a loadout conveyor. Ore will then discharge through a diverter chute into one of two skips. Shaft 3 will contain two skip loading systems; each arrangement is similar to that described for Shaft 2.

AC-Tek performed a discrete element modelling (DEM) analysis for the skip loading operation and a dynamic analysis for the shaft 3 loadout conveyor. The DEM was used to analyze conveyor discharge trajectories into the skips, to identify any plugging effects in the chute, to simulate the overall ore travel time within the chute, and to confirm that the skip docking time is feasible. Figure 16.54 is a snapshot of the skip loading DEM.

Figure 16.54 Snapshot of Skip-Loading Discrete Element Modelling



16.4.2.4 Shaft and Surface Conveying

Shaft 2 contains one Koepe production winder and two 60 tonne capacity skips operating in counterbalance with fixed guides. The shaft 3 hoisting arrangement contains two Koepe winders (of the same type as shaft 2) and four 63 tonne skips operating with rope guides. Each pair of skips will discharge into a 200 tonne capacity surface bin. Ore will be reclaimed from each bin by an apron feeder to the overland and stockpile feed conveyors, which will be adjacent to the existing open pit conveying system.

16.4.2.5 Simulation

An Arena® discrete element simulation model of the ore handling system, from crusher to surface stockpile, was developed to estimate the required capacities of the crushers and the skip ore bins to achieve the target production rate of 95,000 t/d. The model was used to establish the baseline production capacity for the ore handling layout and to undertake trade-offs to improve productivity and equipment utilization, and ultimately to verify that the ore flow circuit was capable of delivering the planned tonnage. The outcome of the ore handling simulation run over a two-year period averaged 95,000 t/d wet delivered to the mill stockpile. To achieve this, the hoists need to operate at their combined instantaneous hoisting rate of 5,400 t/h for an average of 17.5 h/d.

16.4.3 Infrastructure and Services

16.4.3.1 Ventilation

At full production, fresh air will enter the mine through three intake shafts and exit through two dedicated exhaust shafts. The primary ventilation system will be a “pull” design with main exhaust fans on exhaust shafts. At the start of production in 2016, 730 m^3/s of airflow will be available underground. At full production, 2,300 m^3/s will be available (0.024 m^3/s per t/d).

The intake air must be heated during the winter months. Hot water from the project central heating system will be used to transfer heat to glycol heating units at shaft 1, shaft 2, and shaft 3. During pre-production, before the connection to the central heating system is ready, a combination of diesel-fired units and a local hot water boiler will be used for air heating at Shaft 1.

Air cooling during production is required only on the undercut level, where localized refrigeration units will be installed; airflow in other mine areas is sufficient to manage heat build-up. A surface refrigeration plant at shaft 1 will cool all intake air during pre-production to maximize the use of available ventilation during the critical mine establishment phase.

The Hugo Dummett deposit is high in silica, and occupational exposure limits (OEL) for dust will therefore be low in order to meet the OEL for silica. The dust control strategy for the ore handling system begins at the extraction level where spray bars are fitted to each drawpoint. A ventilation raise connecting directly to exhaust airways is provided adjacent to each central tipping LHD orepass. On the truck haulage level water sprays are provided at each truck loading station along with a ventilation raise connecting directly to an adjacent exhaust airway. At the crusher dump location, water spray dust suppression systems will be provided as well as an adjacent ventilation raise connecting directly to exhaust airways. A dry type dust collector will be provided below the crusher. All conveyor transfer points will be enclosed and fitted with water sprays. The top of each ore bin, along with skip loading and unloading points, will be fitted with air extraction units connected to high-efficiency particulate air (HEPA) filters.

Fire modelling was undertaken to review the robustness of the ventilation models, to determine the appropriate locations for fire doors, and to examine escape plans.

16.4.3.2 Infrastructure

Major underground infrastructure includes shops, offices, lunchrooms, and other permanent facilities.

Shop facilities will be built to support the planned maximum fleet of 233 units of underground mobile equipment, including light vehicles. The underground maintenance shops will consist of service bays/garages, auxiliary storage, and warehouse facilities for maintenance of the underground mobile equipment and the fixed plant equipment. The maintenance facilities are summarized in Table 16.17.

Table 16.17 Underground Mine Maintenance Shops

Shop	Location	Main Service
Shaft 1 Shop	Near Shaft 1 on 1300 Level	Development, construction, and service equipment
Main Shop	Extraction Level	Production equipment and general fleet
Haulage Truck Shop	Haulage Level	80 tonne haul trucks
Drill Shops (2)	Undercut Level (NE and SW)	Undercut drills and development equipment

Major equipment overhaul and rebuilds will be done in central service facilities on the surface. Tire repairs and recapping will be done in a central tire shop on the surface.

Permanent fuel stations will be established near the Shaft 1 shop, the main shop, and the haulage shop. Mobile fuel and lube trucks will service remote and slow moving equipment such as drills and shotcrete sprayers.

Permanent lunchrooms and office facilities will be built adjoining the main shop, the haulage shop, and the Shaft 1 shop. The lunchrooms are designed to serve hot lunches to the crews at mid-shift, to be used as training areas, and to support supervision and technical services office requirements during the life of the mine.

Refuge stations will be strategically located in areas of the mine that can be easily accessed in the case of an emergency. These will include both permanent and a network of portable 20-person refuge stations.

16.4.3.3 Services

The mine will be equipped with a service distribution network to provide compressed air, service water, fire protection, electric power distribution, communications, instrumentation, and data system.

After shaft 2 is commissioned all primary service supply will be through shaft 2 with backup through shaft 1. All services will be through a “ring main” style distribution system connecting the shafts, main shops, material handling system, and western edge of the footprint. Branch feeders from the ring main will distribute services to the active workings.

- Shotcrete and Concrete

  Concrete will be delivered from surface batch plants through slicklines in shaft 1 and shaft 2. During the construction phase of the mine, when the concrete and shotcrete needs are the highest, additional slicklines will be installed in sacrificial boreholes near the footprint to reduce congestion at the shaft station and improve construction rates. Concrete haulers will deliver concrete and shotcrete from the slickline stations to the working place.

- Mine Dewatering

  The mine is expected to be dry and will require continuous service water make-up. At maximum demand, the mine will require 196 m^3/h of service water. Dewatering will be needed only occasionally in the event that the mine water recycling system is not operational, the water quality has deteriorated beyond re-use, or a high rainfall event near the end of mine life introduces significant quantities of water through the cave.

- Mine Logistics

  The mine will depend on shaft 1 and shaft 2 to deliver all personnel, equipment, materials, and supplies to the mine. Shaft 1 will be operating at maximum capacity just before shaft 2 is commissioned in early 2015, during the period of maximum construction and development activity. After shaft 2 has been commissioned, excess capacity will be available to manage and control shaft logistics operations.

16.4.4 Operations Plan

Benchmarking and experience from other caving operations were widely used to support the operating approach. Arena® dynamic simulation modelling was used extensively to develop designs and operating plans, to examine value levers to optimize production, and to manage system bottlenecks and production risks.

Operation productivities are based on 350 work days per year and two 12-hour shifts per day with an available 9.5 working hours per shift.

16.4.4.1 Undercut Operation

In steady state, the undercut will require two development crews to maintain access ahead of the undercut cave face. Five longhole rigs, a boxhole machine, and five 10 tonne loaders will be used to maintain the average undercut cave retreat of 3,500 m^2 per month between the two panels. Satellite workshops on the undercut will be used for maintaining slow-moving drill rigs.

16.4.4.2 Extraction Level Operation

The extraction level will require three development crews to maintain access ahead of the drawbell construction fronts. Four longhole rigs and two boxhole machines will be used to maintain the drawbell construction rate of seven drawbells per month between the two panels. Steel sets will be installed in all drawpoints, and 80 MPa concrete roadways will be provided for all production mucking areas. Twenty-three 14 tonne diesel production loaders will operate at full production. Drawpoint sprays at the brow of each drawpoint will operate automatically as the loader enters and exits a drawpoint. Development orepasses on the rim drives will be available as a backup for production LHDs.

Oversize material will be managed by a fleet of twelve machines: four larger single-boom drill rigs fitted with drill-index-charge capability for breaking hang-ups within a drawbell; four small single-boom drill rigs fitted with non-explosive rock breaking technology for oversize removed from the drawpoint by an LHD; and four mobile rockbreaker units for breaking rocks either in the drawpoint or on the 800 mm x 800 mm grizzly.

Extraction level equipment will be maintained in the main workshop on the extraction level horizon and will be fuelled at the extraction level fuel facility. LHD draw quantity and sequence will be managed through the dispatch system. Draw control will be managed by an integrated cave management system along with monitoring of seismic system, open holes, extensometers, and flow markers installed in the cave. Samples will be taken from each active drawpoint twice per week.

16.4.4.3 Haulage Level Operation

The haulage level will require one development crew to maintain access ahead of the expanding haulage loop. Twenty 80-tonne side-tip production trucks will operate at full production. Truck operators will use remote control to load from truck chutes. The haulage roadway will be constructed of a compacted rock roadbase and maintained by grader during crusher maintenance times or shift change. Dispatch and the traffic management system will coordinate truck movements. Haulage level equipment will be maintained in the truck haulage workshop on the haulage level horizon and will be fuelled at the haulage level fuel facility. The truck haulage workshop will also be used to support sustaining construction and ore handling operation and maintenance crews. Sustaining construction crews will ensure that items such as grizzlies, orepasses, and truck chutes are installed ahead of production requirements.

16.4.4.4 Ore Handling Operation

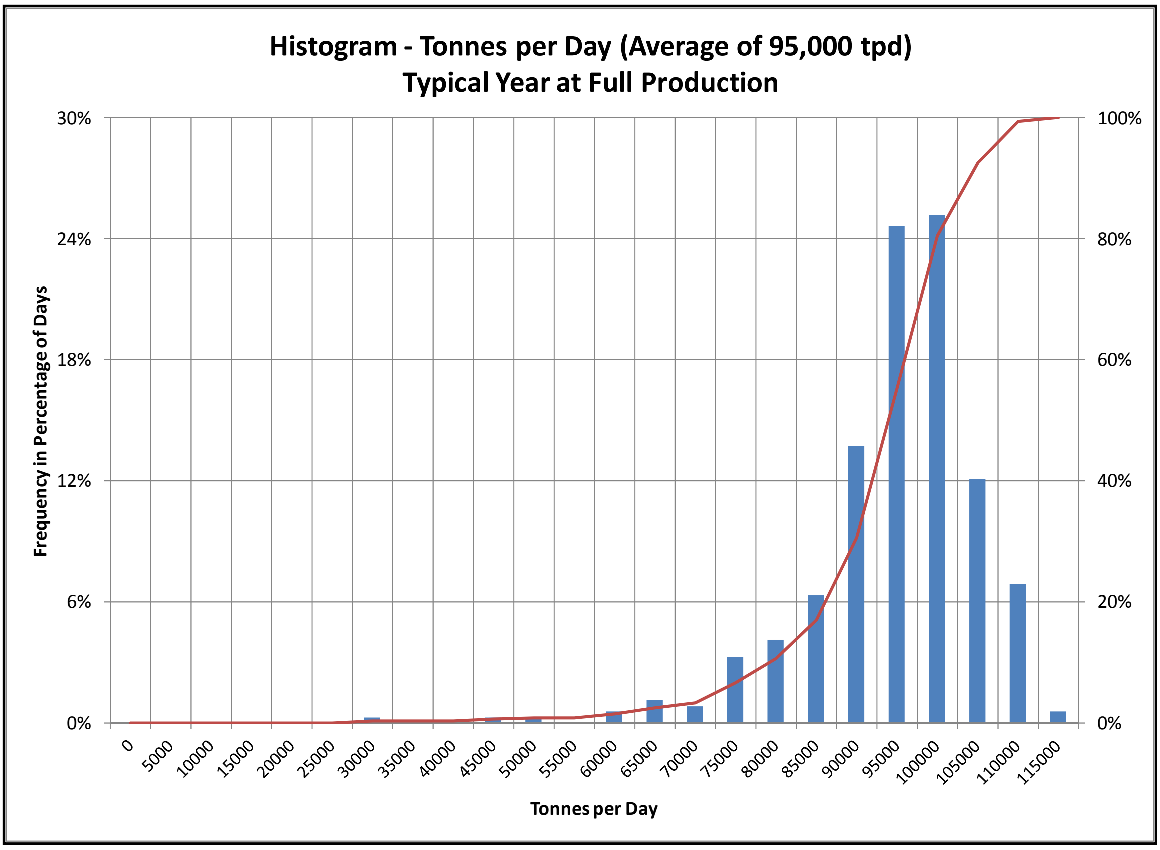
The two crushers and conveyor system will be remotely operated. Cameras at each crusher will assist in managing ROM bin blockages or tramp steel. Material from the fine ore transfer bin under the crusher will feed via apron feeder onto a sacrificial belt, where any steel passing through the crusher will be removed before entering the main conveyor system. Each crusher will be shut down for planned maintenance for one shift every week. Conveyors transferring rock from crushers to shafts will have vehicle access (small boom truck) along one side for operations and maintenance personnel. The main conveyor transfer chamber, at the head end of incline conveyor 1 near Shaft 2, will contain a spare shuttle chute on a quick change-out system to minimize maintenance downtime. The shaft ore bins will provide approximately 3 hours of production capacity buffer between the hoisting system and the cave delivery. The diverter chute between the each of the three load-out conveyors and associated skips will also contain a spare chute on a quick change-out system.

Surface conveyors will be remotely operated and maintained by the concentrator team managing the parallel open pit conveyor system.

16.4.4.5 Production System Capacity

To achieve an average full production rate of 95,000 t/d, the production system has the capacity to produce in excess of 120,000 t/d. Figure 16.55 is a histogram of the production tonnage variability per day over a one-year period as modelled by the Arena® simulation. Truck and crusher available operating time is 9.5 hours per shift, and hoisting remains operational during shift change if mechanically available and if ore is available in the ore bins. To average 95,000 t/d, the production system is simulated to operate at or above 100,000 t/d for 44% of the available production days.

Figure 16.55 Histogram of Production Tonnes per Day



16.5 Mining Production Schedules

The 2013 OTTR has examined production from open pit mining of the Southern Oyu deposits and underground mining from Hugo North. OT LLC has prepared both the open pit and underground mining work and schedules. The case adopted for 2013 OTTR assumes no plant capacity expansion, is based on Mineral Reserves Only, does not include Inferred Mineral Resources, and does not include underground mining areas other than Hugo North Lift 1.

16.5.1 Scheduling Assumptions

The following scheduling methodology was used to balance mine, mill, and stockpile quantities:

- Underground ore is designated as the priority feed. After the available underground ore is fed to the plant, the additional capacity is met with open pit ore.
- Plant throughput capacity is determined by calculated the available mill hours after the underground ore is processed.
- Ore feed for concentrator start-up in in early 2013 is exclusively from the open pit. Underground ore is processed starting in December 2014.
- Ramp-up factors were applied to the Year 1 processing production.
- The production schedule is based on Proven and Probable Mineral Reserves only. No Inferred resources were used.
- The open pit schedules were based on mining inventories by bench reported within the pit stages.
- The total movement from different pit stages was balanced to smooth waste and ore production rates and to match the load and haul capacity.
- Low-grade stockpiling was used to balance the mining rate where necessary.
- Total movement capacity includes re-handle from stockpiles.

The throughput rate algorithm shown in Table 16.18 was developed by SGS. This formula was applied to all the blocks in the mining model. The average throughput rates are shown in Table 16.19.

Table 16.18 Plant Throughput Rates

$P_{80} = 113 \times Ci^{0.26} \times SPI^{-0.6} \times BM^{0.88}$ Max P_{80} 220 µm
$t/h(instantaneous) = 29320 \times Ci^{0.19} \times SPI^{-0.36} \times BM^{-0.24}$ Max TPU 5,500 t/h

Table 16.19 Average Plant Throughput Rates

Metallurgical Ore Type	Deposit	Throughput Rate	
		t/d	Mt/a
1	Southwest (including South and Far South)	97	32.7
2	Central – Chalcocite	132	44.3
3	Central – Covellite	132	44.5
4	Central – Chalcopyrite	119	40.1
6	Hugo North	119	40.1

The scheduling periods used for the production schedule are:

- Years 2012, 2013, and 2014 by month.
- Years 2015 to 2017 by quarters.
- 2018 and on, by year.

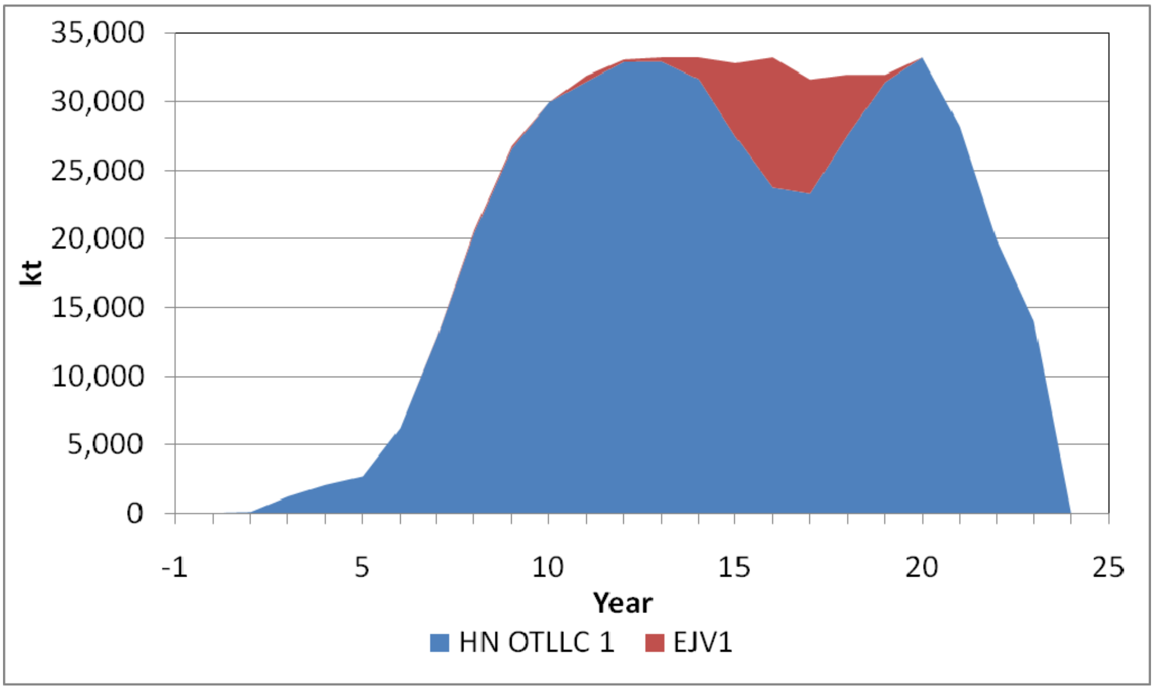
The following parameter values are carried in the detailed schedule:

- NSR $/t
- Cu %
- Au g/t
- Ag g/t
- As ppm
- Throughput Hours per kt
- F ppm
- S %
- Recovered Copper Grade %
- Recovered Gold Grade %
- SPI SAG Power Index
- MB Modified Bond Index
- CI rusher Index
- P80 80% Passing microns
- Fe %
- Mo ppm
- PAF % potentially acid forming (ore 100%, waste varies)

16.5.2 Underground Production Schedule

Hugo North Lift 1 encompasses two production areas which are reported separately: OT LLC Lift 1 and EJV Lift 1. The latter is the OT LLC Entrée Joint Venture area.

Figure 16.56 Total Underground Material Movement



16.5.3 Open Pit Production Schedule

The annual total movement from the open pit by pit phase including the stockpile re-handle is shown in Figure 16.57, and the open pit ore mined including re-handle is in Figure 16.58.

Figure 16.57 Total Open Pit Material Movement Including Re-handle

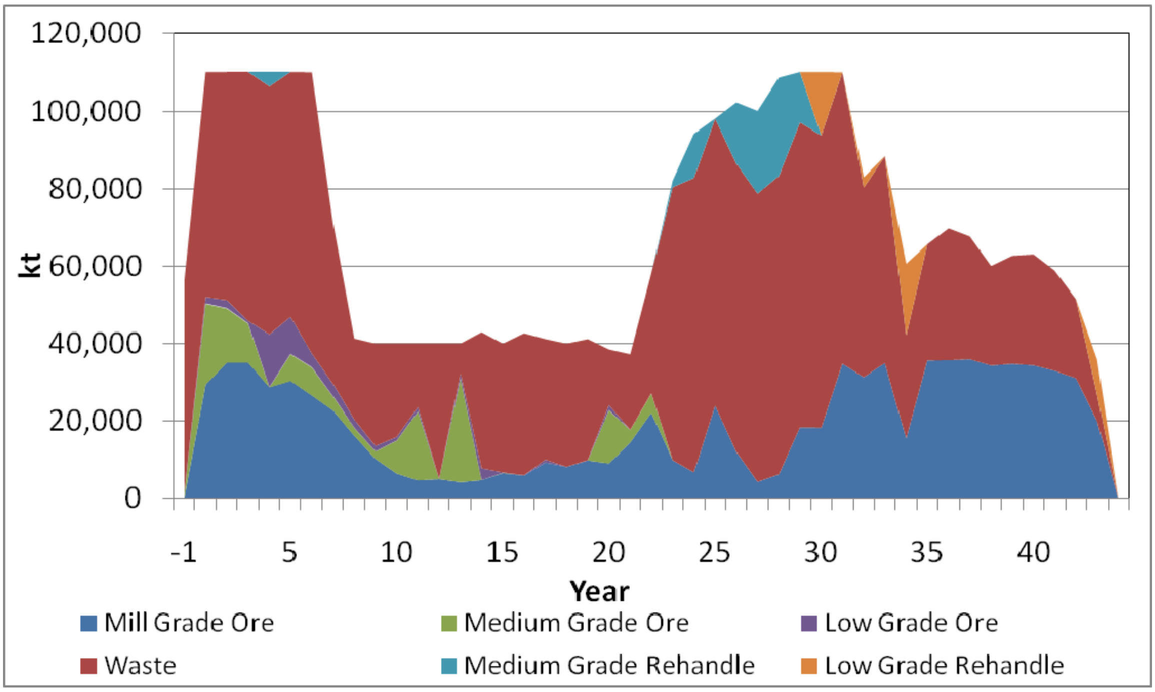
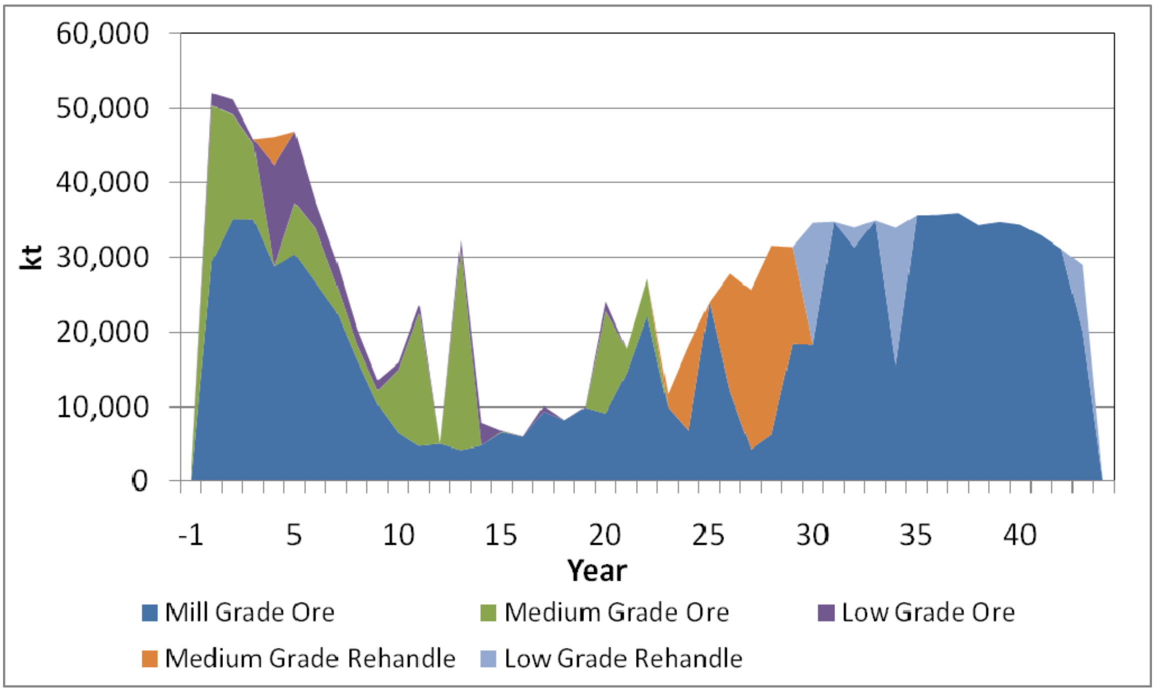


Figure 16.58 Open Pit Ore Mined Including Re-handle



Highlights of the production schedule are summarized below:

- The open pit reaches full annual production in January 2013.
- Southwest open pit ore is the main concentrator feed during the first seven years of operations. The first Central ore is mined in 2024.
- During the 2019 to 2035 the underground reaches a steady state production rate of 95 ktpd, open pit production is maintained to provide the remaining concentrator capacity,
- The underground will be completed in 2035 and open pit production is increased to fill the concentrator untill the open pit is completed in 2055.

16.5.4 Processing Schedule

The processing schedule was balanced to meet the available mill hours after the underground material was processed. The ramp-up assumptions to full production are summarized in Table 16.20.

Table 16.20 Process Ramp-up to Full Production

Month	Full Production (%)
Month 1	11
Month 2	34
Month 3	47
Month 4	82
Month 5	92
Month 6	100

The processing schedule by metallurgical ore type with the copper and gold feed grades are shown in Figure 16.59. Total concentrate production by ore type is shown in Figure 16.60. The recovered copper, gold, and silver production is in Figure 16.61 to Figure 16.63.

Figure 16.59 Ore Processing and Grade by Ore Type

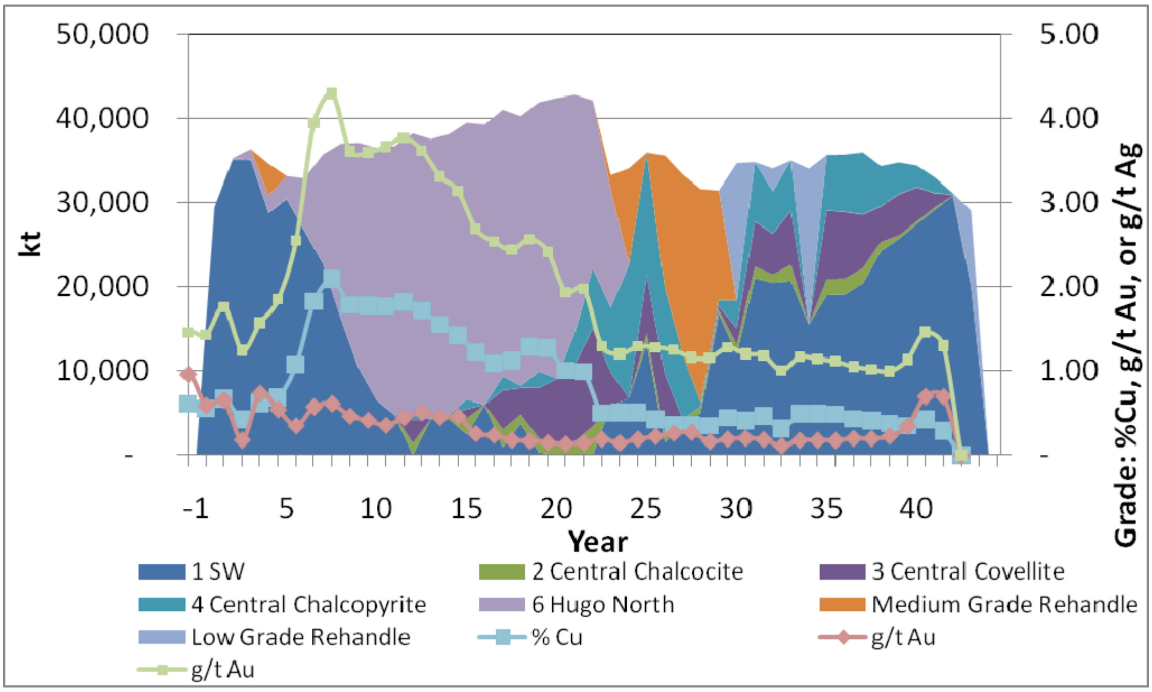


Figure 16.60 Concentrate Production by Ore Type

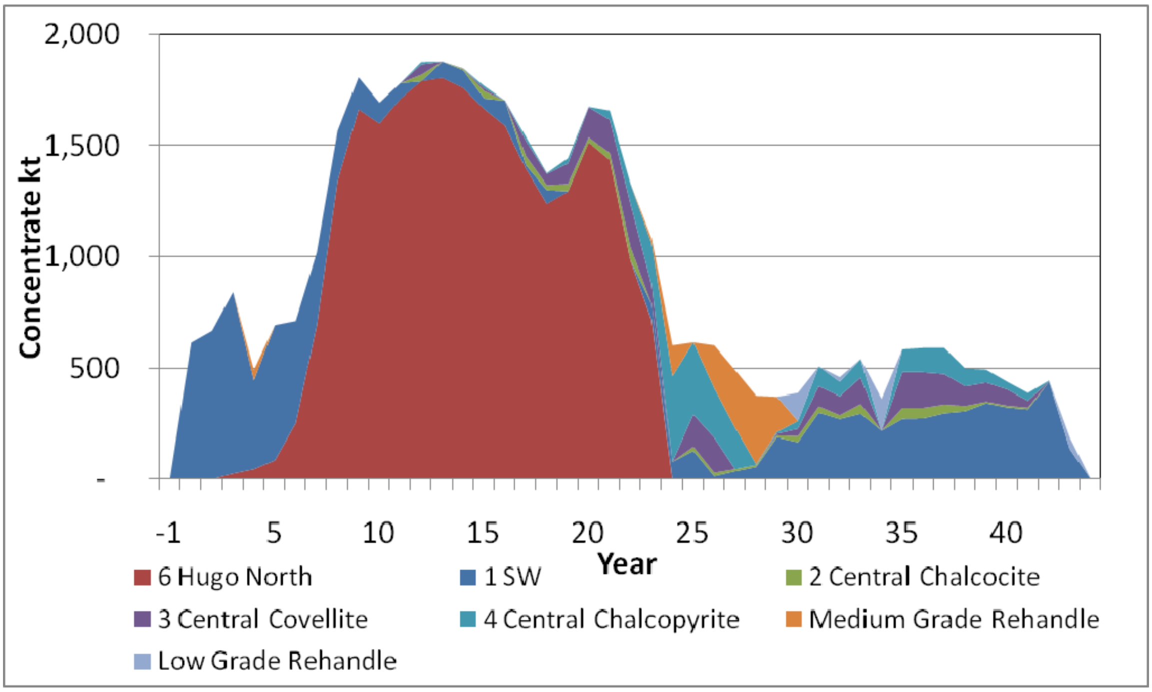


Figure 16.61 Recovered Copper Production

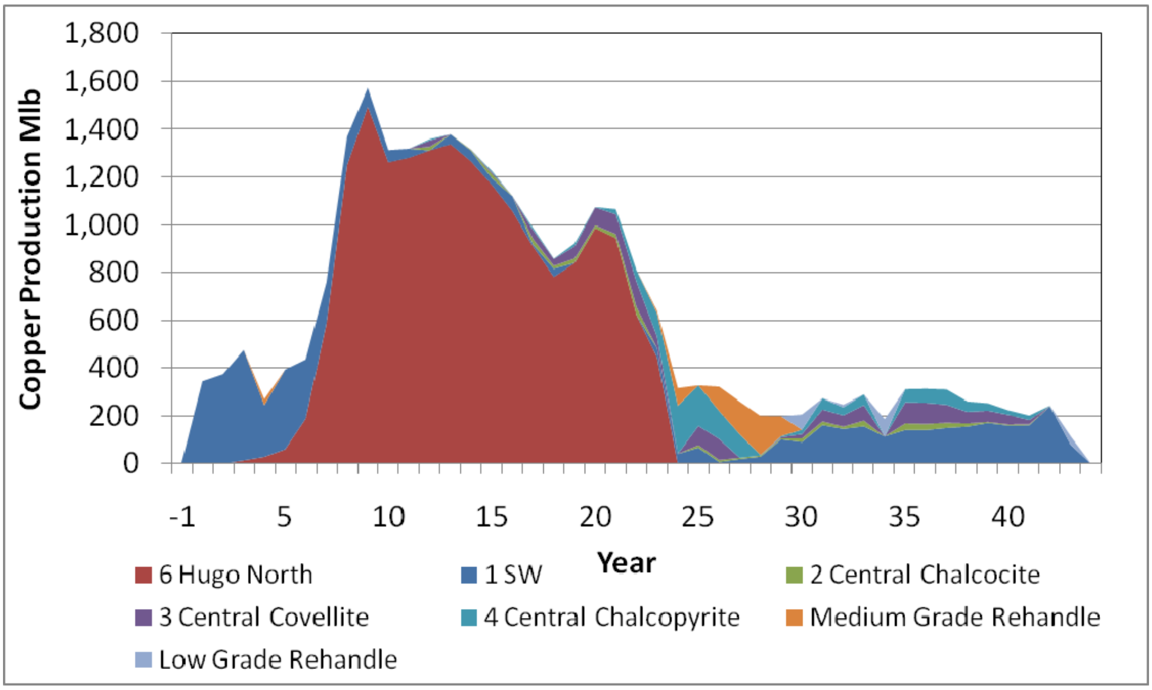


Figure 16.62 Recovered Gold Production

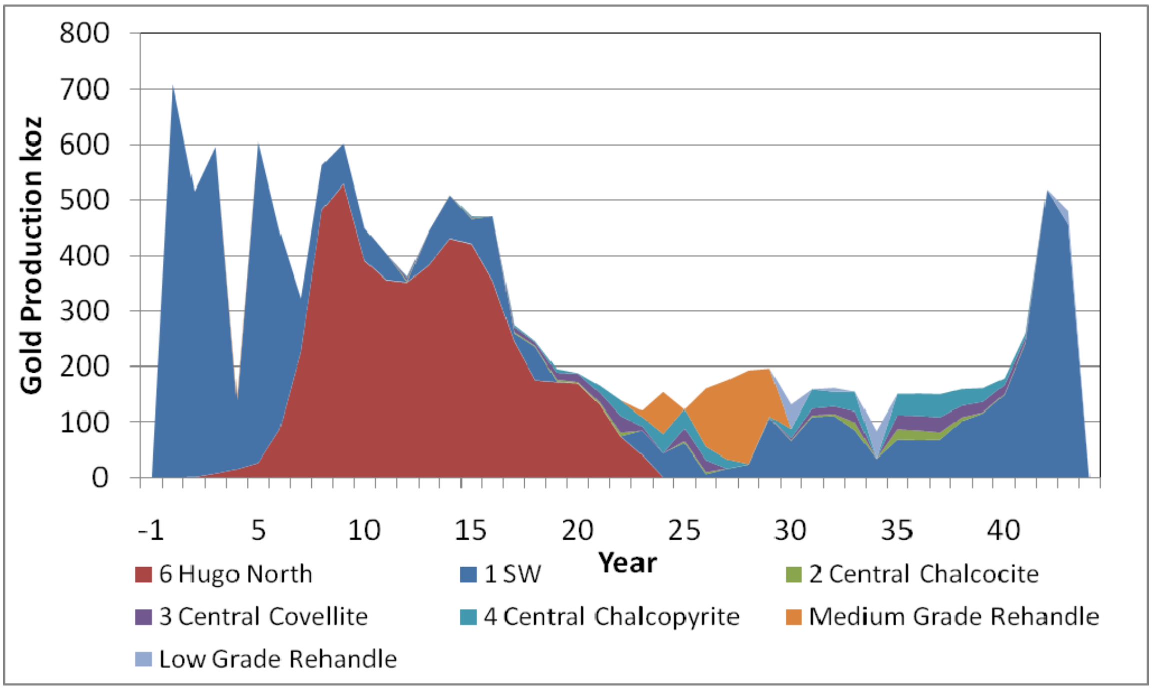


Figure 16.63 Recovered Silver Production

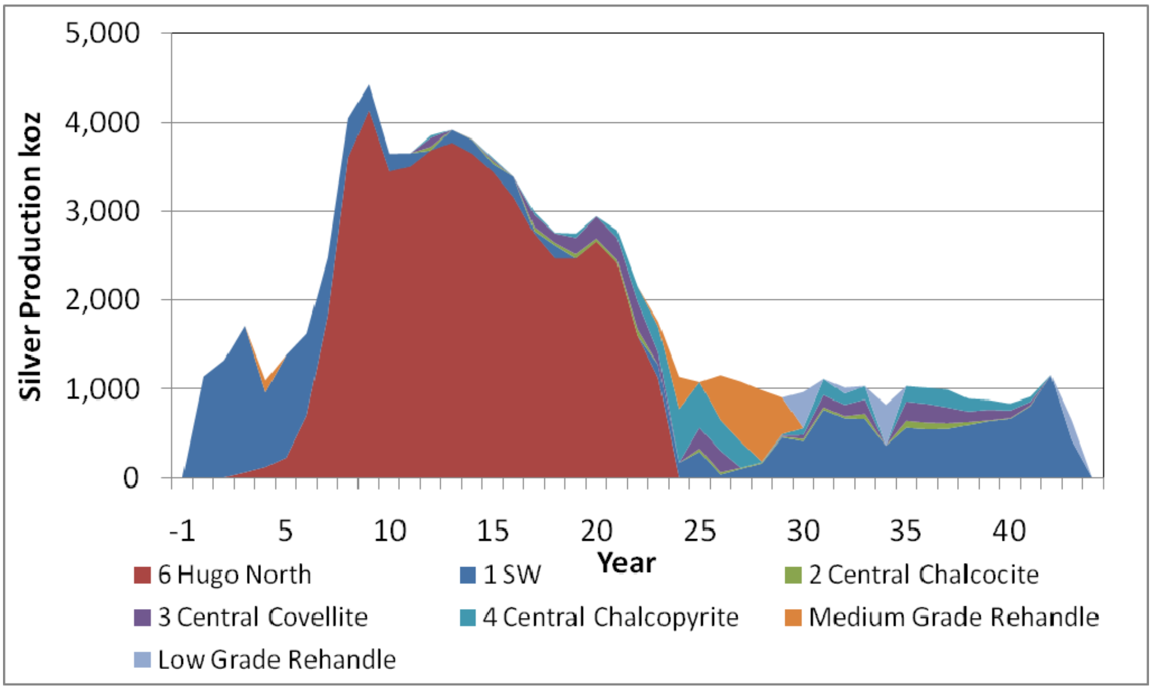


Table 16.21 Production Schedule Years -1 to 43

			Year													
Description	**Unit**	**Total**	**–1**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Open Pit Ore	Mt	1,048	2	52	51	46	42	47	37	30	20	14	16	24	5	32
Open Pit Waste	Mt	1,905	55	58	59	64	64	63	72	41	21	26	24	16	35	8
Total Open Pit	Mt	2,953	57	110	110	110	106	110	110	71	41	40	40	40	40	40
U/G Ore	Mt	491	–	–	0.1	1	2	3	6	13	21	27	30	32	33	3
Total Ore Mined	Mt	1,539	2	52	51	47	44	50	44	42	41	40	46	56	38	66
Re-handle	Mt	189	–	–	–	–	4	–	–	–	–	–	–	–	–	–
Total Material including Stockpiles	Mt	3,142	57	110	110	110	110	110	110	71	41	40	40	40	40	40
Total Process Feed	Mt	1,539	1	30	35	36	35	33	33	36	37	37	36	37	38	38
Parameter Values	NSR $/t	47.17	33.15	48.33	37.46	44.18	20.49	41.62	40.41	56.05	98.23	112.81	95.25	92.37	91.17	96.60
	Cu %	0.89	0.54	0.60	0.55	0.67	0.42	0.62	0.69	1.07	1.83	2.09	1.78	1.78	1.77	1.82
	Au g/t	0.34	0.43	0.96	0.59	0.65	0.18	0.73	0.54	0.35	0.57	0.61	0.47	0.41	0.36	0.45
	Ag g/t	2.03	1.10	1.45	1.43	1.76	1.24	1.57	1.85	2.55	3.95	4.29	3.61	3.60	3.67	3.77
	Conc kt	40,655	9	615	669	842	492	694	713	1,020	1,567	1,809	1,694	1,783	1,878	1,879
	Con Cu %	29.6	26.8	25.5	25.5	25.7	24.9	25.8	27.8	33.8	39.6	39.5	35.2	33.6	32.9	33.3
	Con Au g/t	9.4	18.4	35.8	23.9	22.0	9.3	27.1	17.3	9.6	10.8	10.0	7.9	6.7	5.8	7.1
	Con Ag g/t	65.0	51.3	57.6	61.6	63.3	69.3	62.0	72.7	77.2	81.5	77.1	67.7	64.5	64.7	65.6
	Con As ppm	1,712	272	243	478	1,016	678	392	658	1,068	1,153	854	728	828	1,405	1,277
	Con F ppm	301	251	317	301	298	217	261	215	235	266	283	298	324	345	344
	Copper m lb	26,486	5	346	376	476	271	395	437	761	1,369	1,575	1,314	1,320	1,360	1,380
	Gold koz	12,889	5	708	515	596	148	605	445	322	563	602	448	403	361	443
	Silver koz	83,001	15	1,140	1,324	1,714	1,096	1,383	1,626	2,480	4,053	4,436	3,652	3,658	3,861	3,924

		Year															
Description	**Unit**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**
Open Pit Ore	Mt	8	7	6	10	8	10	24	18	27	10	7	24	12	4	6	18
Open Pit Waste	Mt	35	33	37	31	32	31	14	19	31	70	76	74	74	74	77	79
Total Open Pit	Mt	43	40	43	41	40	41	38	37	58	80	83	98	86	79	83	97
U/G Ore	Mt	33	33	33	32	32	32	33	28	20	14	–	–	–	–	–	–
Total Ore Mined	Mt	41	40	39	42	40	42	57	46	47	24	7	24	12	4	6	18
Re-handle	Mt	–	–	–	–	–	–	–	–	–	9	27	12	24	29	25	13
Total Material including Stockpiles	Mt	43	40	43	41	40	41	38	37	58	90	110	110	110	108	109	110
Total Process Feed	Mt	38	39	39	41	40	42	42	43	42	33	34	36	36	33	32	31
Parameter Values	NSR $/t	94.67	89.81	83.28	63.27	54.60	55.38	63.46	61.87	47.69	44.54	23.46	22.55	23.88	21.65	20.01	20.08
	Cu %	1.71	1.55	1.42	1.22	1.09	1.12	1.29	1.27	1.00	0.99	0.50	0.51	0.50	0.43	0.35	0.36
	Au g/t	0.51	0.45	0.46	0.26	0.24	0.18	0.17	0.15	0.13	0.15	0.19	0.15	0.19	0.22	0.26	0.27
	Ag g/t	3.62	3.31	3.14	2.69	2.54	2.44	2.56	2.42	1.93	1.98	1.30	1.20	1.29	1.28	1.25	1.16
	Conc kt	1,849	1,770	1,704	1,540	1,378	1,444	1,676	1,659	1,330	1,086	603	617	603	492	377	372
	Con Cu %	32.3	31.4	29.8	29.1	28.3	29.0	29.1	29.2	27.7	26.8	23.8	24.2	24.3	24.0	24.1	24.3
	Con Au g/t	8.3	8.0	8.3	5.4	5.3	4.1	3.4	3.0	3.1	3.5	8.0	6.4	8.3	10.9	15.6	16.4
	Con Ag g/t	64.9	64.1	62.8	61.2	63.2	60.0	55.3	53.2	51.7	51.8	60.9	57.3	60.6	69.7	82.7	80.0
	Con As ppm	1,357	1,425	1,305	1,747	1,500	2,012	2,339	2,582	2,366	2,362	4,306	4,630	3,791	2,880	662	930
	Con F ppm	349	356	374	367	332	298	321	352	361	407	268	269	260	240	196	185
	Copper m lb	1,316	1,226	1,121	987	859	922	1,075	1,067	811	641	317	329	323	260	201	199
	Gold koz	509	470	470	275	245	195	188	166	139	120	154	122	160	175	193	196
	Silver koz	3,819	3,602	3,393	2,995	2,762	2,754	2,949	2,794	2,158	1,760	1,136	1,078	1,155	1,083	987	904

Note: Minor figure differences may occur due to rounding errors.

		Year													
Description	**Unit**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**
Open Pit Ore	Mt	18	35	31	35	16	36	36	36	34	35	34	33	31	20
Open Pit Waste	Mt	75	75	49	53	27	30	34	32	26	28	29	26	20	7
Total Open Pit	Mt	94	110	80	88	42	66	70	68	60	63	63	59	51	27
U/G Ore	Mt	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Total Ore Mined	Mt	18	35	31	35	16	36	36	36	34	35	34	33	31	20
Re-handle	Mt	16	–	3	–	18	–	–	–	–	–	–	–	–	9
Total Material including Stockpiles	Mt	110	110	83	88	61	66	70	68	60	63	63	59	51	36
Total Process Feed	Mt	35	35	34	35	34	36	36	36	34	35	34	33	31	29
Parameter Values	NSR $/t	16.95	22.03	20.83	22.86	14.65	23.70	23.75	23.33	21.37	20.56	19.27	20.95	32.92	42.73
	Cu %	0.34	0.44	0.41	0.47	0.31	0.49	0.49	0.48	0.43	0.41	0.37	0.35	0.42	0.28
	Au g/t	0.17	0.19	0.20	0.19	0.11	0.18	0.18	0.18	0.20	0.20	0.23	0.34	0.70	0.69
	Ag g/t	1.15	1.28	1.20	1.18	1.01	1.17	1.14	1.11	1.05	1.02	0.99	1.13	1.46	1.30
	Conc kt	389	509	461	542	363	586	592	592	500	494	440	389	445	189
	Con Cu %	24.1	24.5	24.4	24.3	23.4	24.2	24.1	23.9	23.7	23.3	23.1	23.6	24.8	27.8
	Con Au g/t	10.1	9.4	11.0	8.6	8.2	7.8	7.8	7.8	10.8	10.2	12.6	19.9	34.4	43.8
	Con Ag g/t	81.3	72.7	72.1	62.5	75.2	59.1	58.6	58.2	62.8	62.4	64.4	77.9	88.8	98.8
	Con As ppm	2,180	3,337	2,852	3,242	1,568	3,421	3,368	3,167	2,569	2,685	2,363	1,234	351	329
	Con F ppm	183	213	207	231	170	239	242	250	237	241	230	198	222	125
	Copper m lb	207	274	248	291	187	313	315	312	261	254	224	202	244	116
	Gold koz	131	159	161	154	83	150	151	150	159	161	178	259	519	480
	Silver koz	965	1,114	1,017	1,033	822	1,033	1,014	994	891	876	836	913	1,157	646

Note: Minor figure differences may occur due to rounding errors.

17 RECOVERY METHODS

17.1 Processing

17.1.1 Introduction

The Oyu Tolgoi processing plant will commence operation with two grinding lines and two flotation lines. This is sufficient for processing ore arising from the Southwest open pit. However, when Hugo North block cave Lift 1 is developed and comes on-line a third grinding line is necessary to process the additional ore.

As the copper mineralogy changes so does the concentrate grade that can be generated and the recoveries that are expected. This complexity has led to a set of equations describing grades and recoveries for the various ore types and for copper, gold and silver.

These equations have been used as part of the mine planning process and are consequently inherent in the 2013 Reserve Case ore delivery schedule. Equipment selection has been based around the design criteria and the duty as determined through the ore delivery schedule.

17.1.2 Metallurgical Parameters

The metallurgical parameters used for the 2013 OTTR were issued in Base Data Template 29. The relevant metallurgical data and formulae are shown in Table 17.1 to Table 17.5. These parameters were used for the 2013 Mineral Reserve estimate.

The parameters used for Hugo North were applied to all Hugo North including the Entrée (Shivee Tolgoi) ore. Although only limited testwork has been carried out on the EJV area it is considered that the results indicate the Entrée area is similar to the rest of Hugo North.

The throughput rate algorithm is as used in IDP10 and was developed by SGS from regression analysis of CEET simulation runs for 30,000 SW blocks over Years 1 to 30 and the SGS database of projects. This formula was applied to all the blocks in the mining model and used for production scheduling.

Table 17.1 Base Data Template 29 Copper Recovery

All Ores				
a*[(b*Cu)/(1+b*Cu)] * [1–exp(–b*Cu)]				
Southwest a = 98 b = 14.5	Central Chalcocite a = 82 b = 15	Central Covellite a = 85 b = 15	Central Chalcopyrite a = 98 b = 12.2	Hugo North a = 95 b = 15

Table 17.2 Base Data Template 29 Gold Recovery

Southwest Ore	All Other Ores
6.8 + 0.8 * (Cu Recovery)	9.8 + 0.8 * (Cu Recovery)

Table 17.3 Base Data Template 29 Silver Recovery

All Ores
13 + 0.8 * (Cu Recovery)

Table 17.4 Base Data Template 27 Copper in Concentrate

Southwest	Central Chalcocite and Covellite	Central Chalcopyrite	Hugo North
$-3.6 * (Cu:S)^2 + (12.8 * Cu:S) + 21$	25	$-3.6 * (Cu:S)^2 + (12.8 * Cu:S) + 22.5$	2.9 * (Cu) + (11.4 * Cu:S) + 15.3

AMC notes that the algorithm for the prediction of arsenic levels in the Central concentrate has been updated in order to reflect the varying proportion of enargite in the Central ore types.

Table 17.5 Base Data Template 29 Arsenic in Concentrate

Central Chalcocite, Covellite, and Chalcopyrite	Southwest and Hugo North
0.7837 * (%Cu in conc/%Cu in feed) * As in feed (ppm)	55 + 20.6 * As in feed (ppm)

The throughput rate algorithm shown in Table 17.6 was developed by SGS from these relationships and the SGS database of projects. This formula was applied to all the blocks in the mining model and used for production scheduling.

Table 17.6 Plant Throughput Rates

$P_{80}=113 * Ci^{0.26} * SPI^{-0.60} * BM^{0.88}$
max P_{80} 220 µm
$t/h\ (instantaneous)=29320 * Ci^{0.19} * SPI^{-0.36} * BM^{-0.24}$
max throughput = 5,500 t/h

17.1.3 Metallurgical Predictions

The metallurgical predictions for throughput, metal recovery and concentrate grade have been modeled by experts in their field and validated through peer review.

17.1.3.1 Throughput Modeling

60” x 113” FFE Primary Gyratory Crusher – FFE Model

The 60” x 113” Primary Crusher throughput estimate was based on a FLSmidth model and is provided in their September 2006 Performance Warranty. The ROM blasting requirement and primary crusher feed size was taken from Scott Mine Consulting Services – Blasting Requirements for the Oyu Tolgoi Open Pits 15NOV04 report.

The crusher work index was based on laboratory scale testwork conducted at Lakefield Research and AMMTEC.

- t/h = 4,880 (with crusher work index of 19.9 kWh/t and F80,500 mm, throughput range 4,250 to 5,350 t/h). Fluor design criteria = 5,293 t/h.
- P_{80} = 152 mm (range 140–152 mm).

SAG, Pebble Crusher and Ball Mills – SGS CEET Model

SGS’s CEET model was used to predict throughput based on laboratory scale ore characterization carried out at Lakefield Research and AMMTEC. The CEET model predictions were verified by JKSimMet modeling and pilot plant testwork. The cell model was populated with the hardness values to predict throughput by ore type and mining period. The throughput and grind algorithms applied to the cell model are shown above in Table 17.6.

OT LLC concluded that the SGS predictions were justified and used their predictions in the 2013 Reserve Case model.

17.1.3.2 Flotation Modeling

Optimum Primary Grind

In IDP05, primary grind size determination analysis was carried out for each of the production-period composites from the Southwest, Hugo South, and Hugo North deposits and the ore-type composites from the Central deposit. In 2007, Aminpro validated the primary grind sizes of the existing ore types, and made additional predictions for the new HN-SLC and Entrée reserves. The criterion for P_{80} selection was the size that resulted in the highest project net present value (NPV).

The plant design is based on the optimum grind of Southwest and Hugo North. With the power requirement set to achieve an optimum grind, throughput-grind trade-offs were conducted through optimizing production scheduling.

Table 17.7 Optimum Primary Grind Size for Each Ore Type (P_{80})

Deposit/Composite	IDP05	Aminpro 2007
Southwest	180	180
Hugo South	150	–
Hugo North	140	116
Central (average)	138	179
SLC (average)	–	125
Entrée (average)	–	133

Another review of optimum grinds was conducted by OT LLC and AMEC in 2011 using updated metal prices and head grades.

The primary source document for capacity prediction for the current grinding circuit is SGS Mineral Services' "Comminution Section for Oyu Tolgoi June 2007 IDP," which states that the grinding circuits will be SAG-mill limited for 75% of the time with Southwest ore. SGS predicted that capacity could be increased by another 4,000 t/d in this period by increasing closing screen aperture from the current design of 13 mm to 17 mm, and by another 3,500 t/d by increasing ball charge from 15% to 17%. The net 7,000 t/d increase, if achieved as modelled, would be sufficient to meet the 96,000 t/d average in Years 1 to 3 after the initial ramp-up.

In the current study, it is considered unrealistic to expect a new plant with 80% to 90% national hire of generally inexperienced personnel to operate so closely to the design limits of a grinding circuit immediately after the initial ramp-up. The mill shell is structurally capable of accepting a 20% ball charge, but measurements are imprecise, and caution is recommended until media wear and liner wear are predictable and instrumentation is known to be reliable by field calibration on each shutdown and grind-out. Despite the advantages in terms of NPV and IRR, it is unusual to promote a base case in which a plant is run over the nominal capacity so soon after start-up.

At present; however, the design criteria have a design volumetric limit of 110,000 t/d for the two-line concentrator. Because the SAG mills are not power-limited on Central ore, it is expected that this tonnage can be processed in 2025 after 13 years of operating experience on the Phase 1 circuits. When the available SAG power is not a limitation, it is possible to use the upset flow volumetric design point of 60,000 t/d for a single SAG mill. The volumetric flows in grinding and flotation in 2025 fall within design limits when ball mill cyclone feed and overflow densities are increased by about 3% solids so that the circulating loads are decreased and the grind is coarsened from 180 to 200-210 µm.

AMMTEC estimated the lost operating margin by coarsening a 180 µm grind to 200 µm at $0.12/t for Central covellite ore and $0.50/t for Central chalcocite ore. It will clearly be cash flow positive to mill the additional tonnage available from the mine schedule. Since the capital costs for Phase 1 are effectively sunk, these losses will be taken into account when considering overall project NPV and the overall capacity of Phases 1 and 2 in the feasibility study. A further round of primary grind optimization will be undertaken on Hugo North, Southwest, and Central ores based on updated economic parameters from the control estimate and the latest project metal price forecasts.

Optimum Regrind Size

A metallurgical prediction of the optimum regrind size was carried out for IDP05, by AAJV and later data analysis was carried out by AMEC Minproc and Aminpro. The grind size was further reviewed in 2011 by OT LLC. The optimum regrind size is based on a recovery-concentrate grade trade-off, and the production of a saleable concentrate including impurities.

Table 17.8 Optimum Regrind Size (P_{80}µm)

Deposit/Composite	IDP05*	AMEC Minproc	Aminpro 2007**	OT LLC
Southwest	25	25	45	30
Central	25	–	–	30
Hugo North	25	30	45	30
Hugo South	25	–	–	–

* Production composite sample of Southwest, Central, Hugo North and Hugo South.

**Production composite modeling of 2008 production schedules.

Aminpro's prediction of the number of regrind mills for the 96,000 tpd Phase I plant was four to six VM 1500 HP mills and this will achieve Aminpro's target regrind sizes. AMEC Minproc's prediction was eight mills based on the finer regrind sizes. AMEC Minproc estimated that four regrind mills will be capable of achieving average regrind P_{80} values of 37 to 40 µm.

Crescent Technologies Inc., the Owner's project management consultant for the concentrator design, requested Owner's input to the design criteria. The expansion study team carried out a review of past work and commissioned additional QEM. SCAN work on Southwest and Hugo North composites. It was concluded that a 30 µm regrind would initially require six mills and would yield a payback of one year, based on improved grade/recovery response and reduced fluorine penalties. An analysis of past variability testwork also indicated wide scatter around the mean value for fluorine recovery used in the mine model to predict fluorine in concentrate at a given regrind level. Regrind to 30 µm would yield a 20% reduction in mean fluorine content relative to a 40 µm regrind and would reduce the concentrate storage and blending requirements needed to avoid occasional rejections on shipments above 1,000 ppm. The work is reported in an OT LLC memorandum, with accompanying spreadsheets and Powerpoint presentation ("Review of the optimum regrind level and the initial number of regrind mills to be installed for processing of Oyu Tolgoi's Southwest Orebody," 14 June 2010).

While the Phase 1 regrind power requirement is based on the Owner's team prediction, space for an additional five regrind mills is provided in the layout. This is likely to be enough to accommodate all the regrind required in the Phase 2 expansion case but is an area of ongoing metallurgical testwork on the Hugo north composites now being tested.

Fluor has included the capital cost of six mills in the October 2010 control estimate for construction.

17.1.4 Flow Sheet Development

Flow sheet development began with IDP05 for a 70,000 tpd concentrator capable of producing 1,900 tpd of concentrate. IDP05 also included a Phase II 85,000 tpd concentrator. In 2008, the plant's processing rate was increased to 96,000 tpd with a concentrate production rate of 2,850 tpd.

17.1.4.1 Comminution

IDP05

Laboratory-scale hardness testwork was conducted at MinnovEX and AMMTEC. In addition, a SAG pilot-plant test program was carried out at SGS-Lakefield. Circuit simulation work was conducted with CEET and JKSimmet. Details of the testwork and modeling are provided in IDP05. Figure 17.1 provides the overall IDP05 comminution testwork plan.

Figure 17.1 Overall IDP05 Comminution Testwork Plan

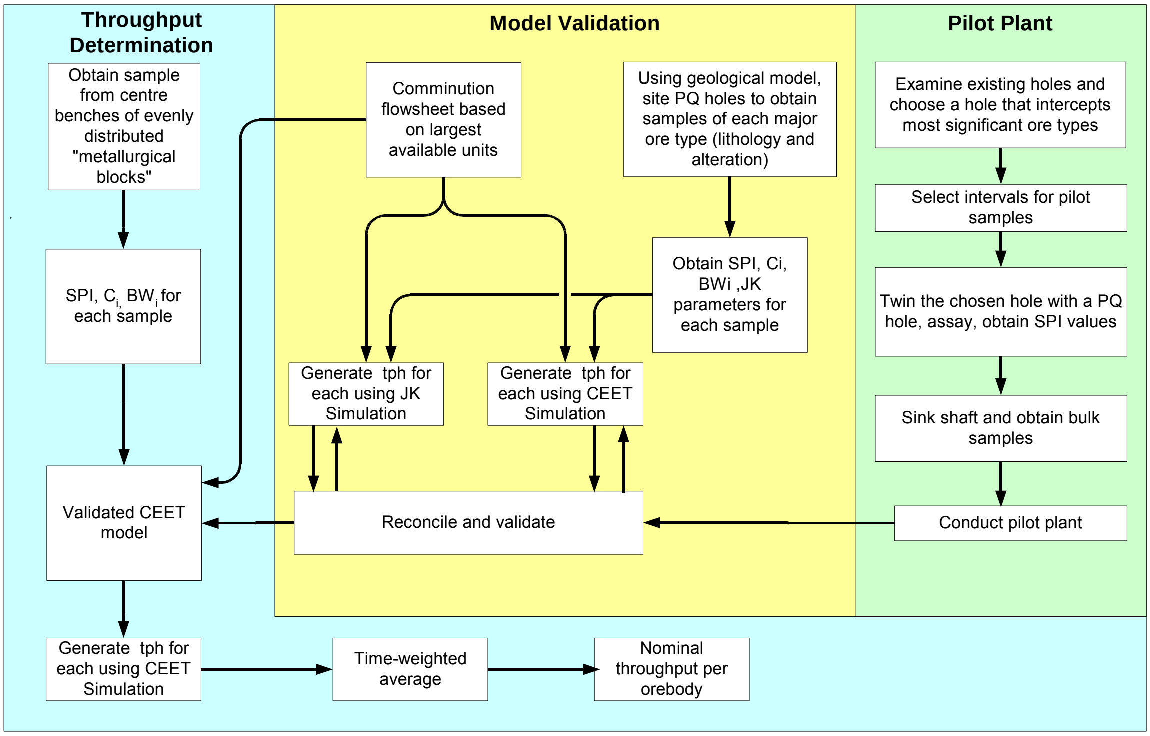


Figure 17.2 and Figure 17.3 are a summary of the ore hardness frequency distributions for Southwest, Hugo North, Central, and Hugo South.

Figure 17.2 Cumulative Frequency Distribution of SPI Values Over the Southwest, Central, and Hugo Deposits(2003 to 2005 Testwork Program)

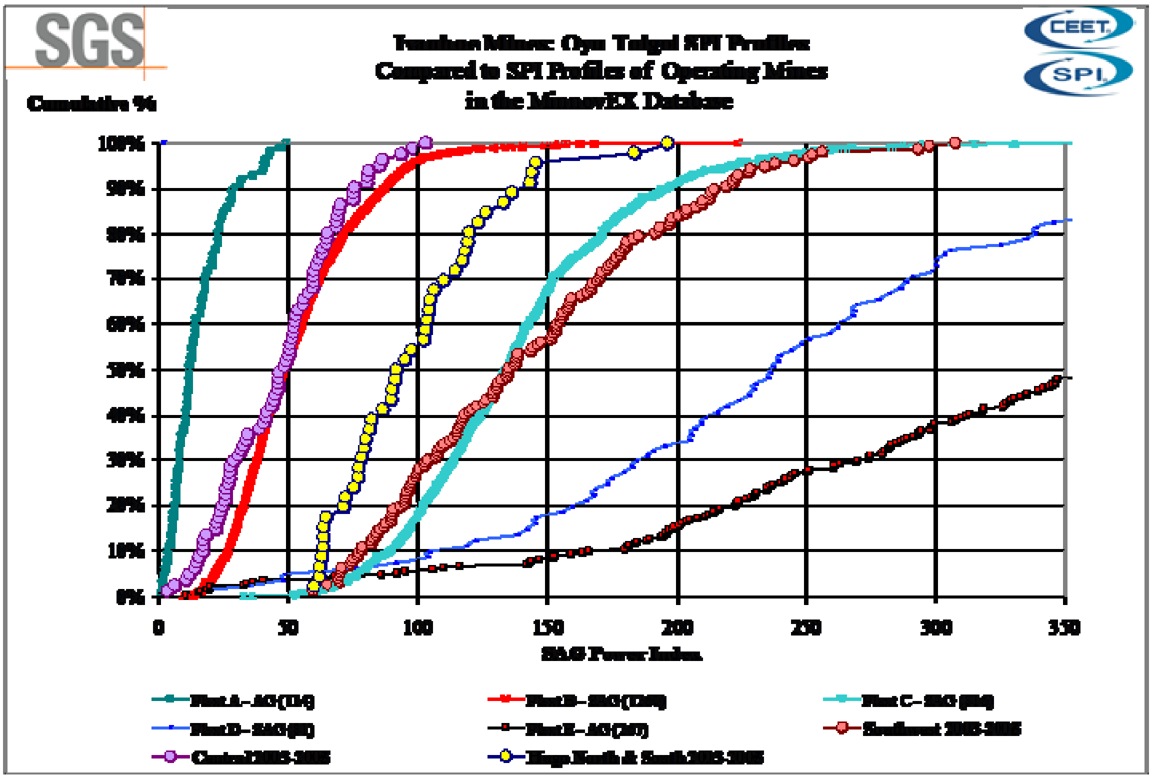
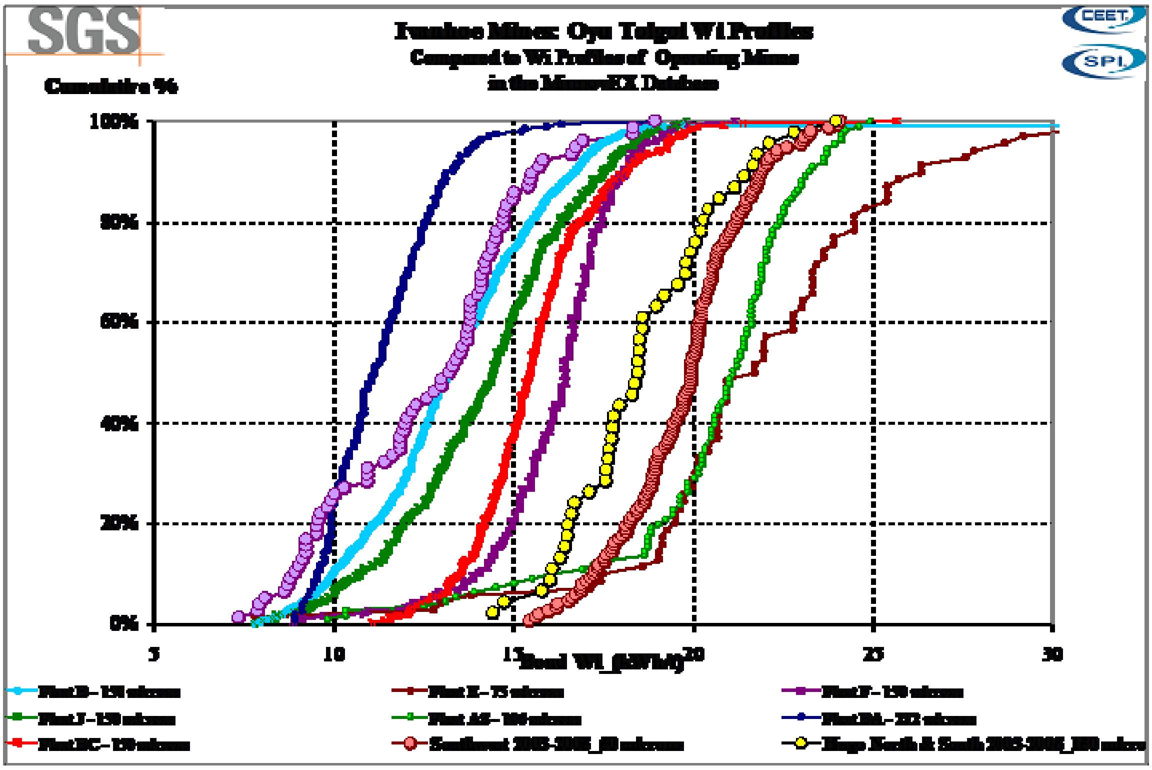


Figure 17.3 Cumulative Frequency Distribution of BWI Values Over the Southwest, Central, and Hugo Deposits(2003 to 2005 Testwork Program)



After running the CEET model with a number of circuit alternatives, the optimum IDP05 grinding flow sheet was based on a single SAG line utilizing the largest commercially proven mills, with secondary and pebble crushers, and utilized the maximum installed power. Subsequent testwork and simulation was performed to validate the choice and predict the throughput at the desired primary grind for the different ore deposits.

Production Scheduling and Geostatistics on Ore Hardness Data

SGS Minerals Services conducted a geostatistical study of the grindability data from the Southern area of the Project comprising the Projected open pit areas known as Southwest, South, Central and the Wedge (between Southwest and South). The geostatistical study was conducted Geostats International. The hardness data was distributed to each mine block and annual mining periods according to the details of the geological and mine plans.

For the Southern Open Pit area, 219 useable samples that were tested for SPI, Bond Work Index and Crusher Index measurements were available for the geostatistics study. These 219 samples were used to estimate 59,661 ore reserve blocks, representing a total tonnage of about 930 Mt. It was found that the grindability values could be attributed to most blocks with reasonable precision.

The geostatistical study determined hardness SPI and BWi values for each year of processing the ore. In this manner, the throughput and grind was determined by production period.

Flow Sheet – 96,000 tpd Concentrator

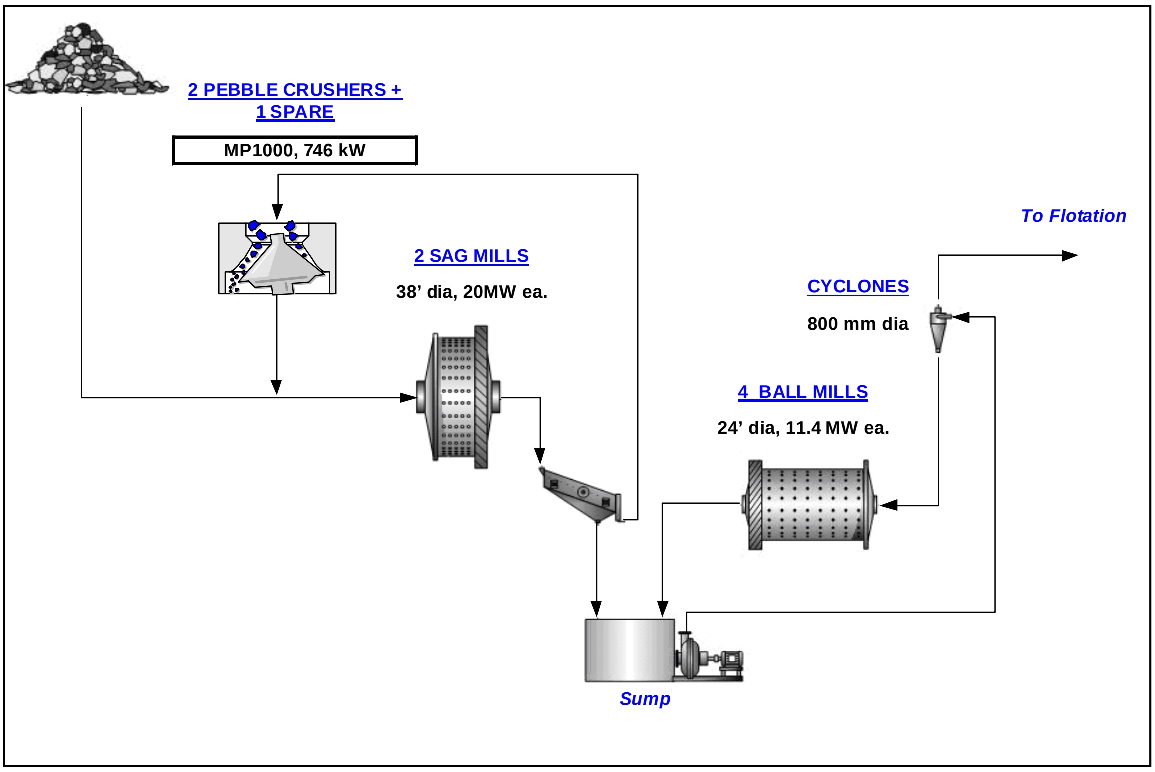
Development of the Phase I flow sheet was conducted with the same laboratory ore hardness data from Southwest and Hugo North.

In November 2005, the comminution circuit was changed to a conventional SABC and documented in Fluor's 2005 Review and Strategic Plan (RSP); Technical Decision Memorandum, TDM003. This change led to the removal of secondary crushing and increased the 40' SAG mill motor from 24.6 MW to 28 MW. The decision reduced capital cost and increased revenue. It was also felt that the conventional SABC was a lower production risk to the less conventional secondary crushing SAG circuit. This decision was made after IDP05, and maintained the plant capacity at 70,000 tpd.

In October 2006, a decision was made to increase the plant capacity from 70,000 tpd to 96,000 tpd. The increase in plant capacity led to a second change in circuit configuration documented in Fluor's PCN 21. The circuit remained as a SABC but changed from a single grinding line to a dual grinding line. This change increased the throughput rate and capital cost, and also the revenue and economic benefit. Additionally, it was felt that a second grinding line would also reduce the production risk through increased equipment redundancy.

The above changes were modelled and again optimized by running CEET. The new optimum flow sheet consists of two SAG mills in parallel, as shown in Figure 17.4. The two SAG mills are each 38 ft diameter and most of the simulations conducted to date have assumed a 21 ft EGL mill drawing peak power of 18.2 MW and maximum sustainable power (over periods of a few hours on hard ore) of 17.25 MW. (The SAG mills are assumed to have 20 MW motors with a service factor of 1.0.) The four ball mills have been assumed to draw a total of 43.3 MW (10.83 MW each) with two 5.7 MW motors per mill (11.4 MW total installed power per mill, 45.6 MW installed power for four mills) with motor service factors of 1.0.

Figure 17.4 Grinding Circuit Flow Sheet



Predictions for Hugo North, Hugo South, and Entrée

The results from the geostatistical distribution of the grindability data from the Southern open pit areas and the CEET block output for each of the 59,661 ore blocks were used to establish useful correlations between SPI, Ci and BWI and predicted tph and P_{80} for the specific 2-line grinding circuit option, as described above.

For initial prediction purposes, these correlations present a rapid means of tph and P_{80} estimation for Hugo North (SLC S1, S2 and S3), Hugo South and Entrée samples for production forecasting purposes, prior to additional testwork and geostatistics being completed on these deposits.

Again, the throughput and grind by period were determined with the geostatistical cell model populated with the ore characterization hardness data.

Equipment Requirements

A comparison of the IDP05 and IDOP flow sheet equipment is provided in Table 17.9.

Table 17.9 Flow Sheet Equipment Comparison

Flow Sheet	IDP05	IDOP
	Phase I	Phase I
Ore, '000 t/d	70	96
Feed Grade, %Cu	0.67	0.66-2.28
Primary Crusher	1	1
	1.52 m x 2.26 m gyratory, 600 kW	1.52 m x 2.87 m gyratory, 746 kW
Secondary Crusher	2	–
	MP1000; 746 kW	–
SAG Mill	1	2
	12.2 m dia x 7.47; 24.6 MW	11.6 m dia x 6.9 m, 20 MW
Pebble Crusher	2	3
	MP1000; 746 kW	
Ball Mill	2	4
	8.2 m dia x 13.1 m, 18.6 MW	7.3 m dia x 11 m, 11.4 MW
Rougher Flotation	2 x 7	4 x 8
	160 m^3 Tank Cells	
Regrind Mill	4	6 - 8
	Vertimill VTM 1500, 1119 kW	
Cleaner Flotation	2 x 4	3 x 4
	160 m^3 Tank Cell	
Cleaner Scavenger Flotation	2 x 4	3 x 4
	160 m^3 Tank Cell	
Column Flotation	4	4-8
	4.5m dia x 14m Column Cell	5.5 m dia x 16m Column Cell
Con. Thickeners	2	2
	20 m dia High Rate	
Concentrate Filters	2	2-3
	144 m^2 Pressure Filter	
Tails Thickeners	2	2
	125 m dia Conventional	85 m dia High Compression

17.1.4.2 Flotation

IDP05

The IDP05 flotation flow sheet was developed based on the metallurgical test program conducted between 2001-2005 at SGS-Lakefield and AMMTEC. The results from locked-cycle tests were analyzed to derive kinetic data, and modified flotation tests (MFT) were performed on the seven production-period composites from the Southwest deposit for MinnovEX's FLEET simulator. MinnovEX also performed rougher-cleaner tests, based on a single-stage rougher and three-stage cleaner circuit, and used FLEET to determine cleaner kinetics. Conventional and Column Pilot Scale tests on Southwest and Hugo North verified the FLEET results.

- Rougher flotation – three banks of seven 160 m^3 cells, 26 minute residence time.
- Regrind – (4) VTM 1500, P_{80} 25 µm.
- First cleaner – two banks of four 160 m^3 cells, 28 minute residence time.
- Cleaner scavenger – two banks of four, 160 m^3 cells, 34 minute residence time.
- Recleaner columns – four columns, each 4.5 m diameter, 22 minute residence time.

Details of the metallurgical testing program and FLEET modeling are provided in IDP05 Appendix 10.A.

2009 Startup Flow Sheet

Amelunxen Mineral Processing (Aminpro) also reviewed and validated the MinnovEX flow sheet and equipment. Aminpro established flotation kinetics from the original AMMTEC locked-cycle testwork on the seven production-period composites, and the additional 2006 cleaner tests conducted at SGS. The Aminpro-Flot Simplex (AFS) model was based on rougher and cleaner kinetics derived from standard laboratory testwork and was calibrated to laboratory locked cycle testwork (LCT). The resultant kinetics indicated lower rate constants than those developed by MinnovEX. Slower kinetics lead to an increase in the size of the flotation circuit.

The AFS model was set up to treat a nominal plant feed of 100,000 t/d. The number of rows and cells per row were determined through trials observing the performance of the circuit and measuring the outcome by estimating the Net Smelter Return on a per-ton of feed basis. This approach led to the formulation of a circuit that operated at the highest economic returns.

Aminpro recommended an identical flow sheet to IDP05 with the following equipment:

- Three rows of eight 160 m^3 roughers.
- Four regrind vertimills, 45 µm grind.
- Two rows of four 160 m^3 first cleaner cells.
- Two rows of four 160 m^3 cleaner-scavenger cells.
- Four 5.5 m diameter x 16 m cleaner columns.

Aminpro confirmed that the flow sheet proposed by MinnovEX is both adequate and robust and will handle large fluctuations in ore grades and tonnages. The AFS model was used for development of the 2009 flotation flow sheet, equipment requirements, and mass balance, and also to validate the metallurgical predictions and production schedule.

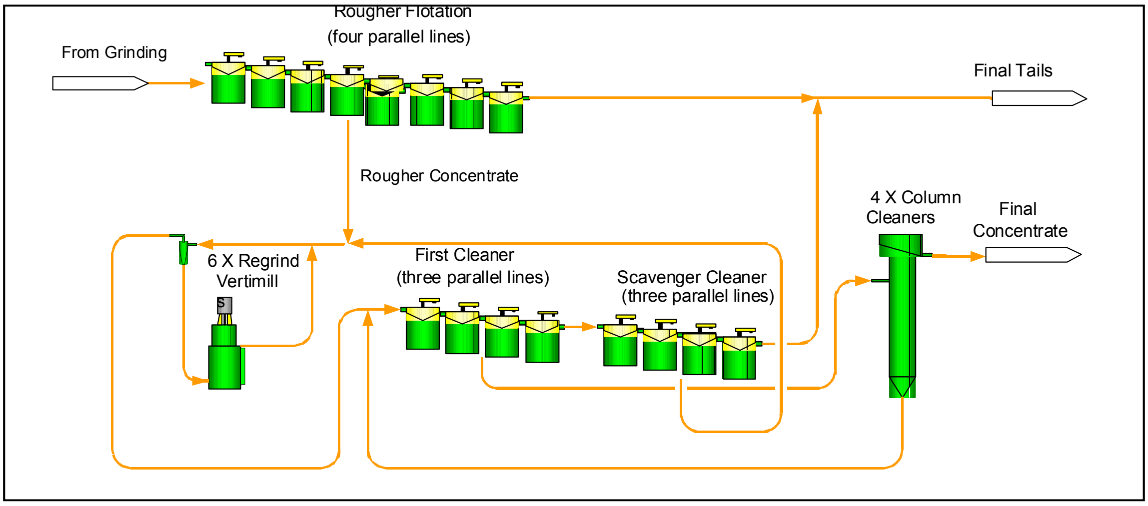
After Fluor's design review of the 2009 flow sheet, an additional row of roughers and an additional row of cleaners and cleaner scavengers was added to the flow sheet for hydraulic constraint reasons. The 2009 flow sheet major equipment is provided below, and the 2009 flow sheet is provided in Figure 17.5:

- Rougher flotation – four banks of eight 160 m^3 cells, 25 minute residence time.
- Regrind – four VTM 1500, 45 µm regrind.
- First cleaner – three banks of four 160 m^3 cells, 12 minute residence time.
- Cleaner scavenger – three banks of four, 160 m^3 cells, 14 minute residence time.
- Recleaner columns – four columns, each 5.5 m diameter.

Start-up Flowsheet

The flowsheet is shown in Figure 17.5 and is the same as the 2009 circuit but with the addition of two more VTM 1500 regrind mills to achieve a 30 µm sizing for new feed to the cleaning circuits, as described in Section 17.1.3.2. The additional liberation minimizes the potential for rejection of concentrate due to fluorine content beyond the specification for import and allows for a reduction in circulating load around the cleaning circuits. This reduction will allow higher head grades to be treated than those in the current design, which will increase the amount of Hugo North ore that can be processed before the cleaning circuits require additional banks of cells.

Figure 17.5 Flow Sheet



OT LLC has reviewed the circuit proposed by Aminpro and Fluor and found it to be adequate to achieve the design criteria at plant startup.

17.1.5 Further Work

A Feasibility Study will be conducted to determine the requirements and costs of the concentrator expansion to add a third grinding line and increase plant production by approximately 60,000 t/d. The work will include an analysis of comminution options and further characterization of the ore types from the various deposits. The aspects to be investigated are listed below.

17.1.5.1 Plant Design/Production Scheduling

Throughput/Comminution:

- Phase 2 160,000 t/d design criteria.
- Additional HN ore hardness characterization/representation.
- Estimation of the optimum primary grind using the economic model parameters, CEET, FLEET, and liberation data.
- Estimation of the optimum SAG mill/ball mill power split.
- Primary crusher feed size (blasting) and product size (OSS) optimization, together with SAG feed size optimization (CEET).

Roughers

- Collector, frother, and pH optimization.
- Blending opportunities – Southwest with Hugo North.
- Arsenic/enargite depression testwork on high As zones (Hugo North and Central).
- FLEET modelling.

Cleaners

- Hugo North regrind size and cleaner kinetics optimization.
- Optimization of fluorine liberation and rejection.
- Arsenic/enargite depression testwork on high As zones (Hugo North and Central).
- FLEET modelling for cleaner and cleaner-scavenger sizing optimization.
- Circuit reconfiguration to use excess SW cleaner capacity to treat high-grade ore.
- Update locked-cycle versus open circuit cleaner performance.

General

- Simulation of process water quality.
- Impact of reclaim water (process + raw water) on flotation performance.
- Refinement of the metallurgical performance algorithms in the cell model.
- Extended variability work on HN composites in conjunction with block cave schedule.
- Production of additional tailings samples for further humidity cell testing on Southwest, Hugo North, Central, and blends over a wider range of ore types.

17.1.5.2 Reserve Ore Characterization/Feasibility Studies

Central

Confirmatory testing of all three Central ore types will be conducted, including locked-cycle, synergy, and variability.

Hugo South

Although Hugo South is not included in the 2013 Reserve Case schedule, it is a potential component of alternative schedules. A metallurgical program is required for Hugo South to bring it to feasibility study standards.

Heruga/Molybdenum Recovery

As with Hugo South, the Heruga deposit is not part of 2013 Reserve Case schedule. Ongoing pre-feasibility studies of Heruga are in progress. The molybdenum head grades for Heruga are substantial, and the economic viability of its separation from the other valuable minerals should be investigated.

17.2 Metallurgical Plant

17.2.1 Summary

The concentrator design is based on processing 35 Mtpa of ore from the Southwest open pit and Hugo North block cave underground deposits..

For the first 3 years, Hugo North development ore will be added to enrich the feed to the concentrator as it is produced. The following 2 years, development will advance and as production from the Hugo North block cave increases, ore from the Southwest open pit will be displaced. This progressive replacement of the Southwest ore with Hugo North Ore will significantly increase the copper head grade. This change in head grade requires an increment of additional flotation and concentrate handling equipment in Years 3 and 4.

This equipment upgrade, required in Year 3, has been identified and the capital requirements for these changes are considered as sustaining infusions and have been considered in the financial analysis.

The Hugo North block cave will reach full production in 2021 and will continue until 2035. During this time approximately 80% of the ore processed will be from Hugo North with the remainder coming from the Southern Oyu open pit. Open pit ore will fully replace the underground ore in 2036 and will feed the plant until the end of mine life in 2055.

The following Concentrator Process Plant description provides details of 2013 Reserve Case including the processing schedule, design criteria, circuit, and equipment description.

17.2.2 Process Design Criteria

The process design criteria for the facilities are based on the extensive metallurgical program described in Section 13 are summarized below.

- Geometallurgical modelling of grinding parameters jointly conducted by OT LLC and SGS Mineral Services.
- Annual mine production plan based grinding capacity and product size determinations provided by SGS Mineral Services.
- Review of the Oyu Tolgoi flotation testing data base and testwork directed by Amelunxen Mineral Processing Ltd (AMINPRO).
- Testwork performed by Process Research Associates Ltd.
- Flotation simulation balances and analysis conducted by AMINPRO.
- Testwork performed by Dorr Oliver Eimco.
- Water balances developed by Klohn Crippen.
- Testwork supervised by AAJV and performed at AMMTEC using samples obtained during the 2004/2005 sampling campaign.
- Testwork performed at MinnovEX Technologies Inc., Toronto, Ontario.
- Testwork performed by the following subconsultants, based on samples generated at AMMTEC:
  - GL&V Australia Pty Ltd, Belmont, Western Australia.
  - G&T Metallurgical Consultants, Kamloops, British Columbia.
  - Metso Minerals Industries Inc., York, Pennsylvania.
- Data for site conditions supplied by Knight Piésold.

The grinding and flotation circuit capacity was modelled by SGS Mineral and AMINPRO and confirmed to match production from annual mine plans available at the time.

Optimum economic grind was estimated using AMINPRO-Flot for all ore types and used as guidance in sizing the grinding circuit. Throughput-recovery trade-offs provided the optimum economic throughput and grind for mill sizing.

The primary crusher, SAG and ball mills and pebble crusher circuits were modelled using SGS Mineral's CEET simulator and the geostatistical cell model ore characterization data. CEET was used to determine the grinding power, and optimum capacity simulations were developed based on iterations of the mine production plan. These simulations determined that the plant should treat 96,000 tpd of Southern Oyu and Hugo North ores.

The flotation mass balance and equipment requirements were obtained with AMINPRO's flotation simulator. The basis for the model inputs were: OT LLC IDP05 standardized data, including locked-cycle test results from testwork at AMMTEC; kinetic data measured at MinnovEX's Toronto laboratories; and on data generated at Process Research Associates in 2007. This data was used to derive flotation response relationships for each ore type. The general flotation flow sheet defined during IDP05 was retained, with retention times, and equipment capacities adjusted, as required, to satisfy the output of the simulator.

With the flotation feed size determined for each production period, generated by CEET, the AFS simulator loaded with the flotation response parameters of each ore type, nominal and design grades for the period, and proportional contributions to mill feed of each ore type, generated full flotation circuit mass balances. The resultant flotation mass balances were then compared to the specified retention times and capacities of the circuit to determine if additional units were required. In the case of rougher, cleaner and cleaner-scavenger flotation, an additional row of cells was added to the flow sheet for each stage above that estimated by AMINPRO for reasons of hydraulic limitations.

The 2013 OTTR is based on a different ore delivery schedule to that used by AMINPRO and Fluor in the above design work. Consequently the Fluor design criteria was used by AMEC Minproc to firstly confirm that the startup equipment selections remained sufficient to treat the initial ore delivery blend and, secondly, estimate a new set of plant expansion requirements to match the schedule.

The equipment requirements to achieve the production schedule, and the period in which the equipment is required to be operational, are identified in Table 17.10. Note the capital expenditure should happen in the year before the equipment is required to be operational.

The production values in the IDP10 Reserve Case were used to generate the equipment requirements. The sizes and number of units selected in Year 1 is as determined by the CEET and AFS simulations and the design factors contained in the Process Design Criteria. The phased equipment requirements in Table 17.10 were determined by AMEC Minproc using the predicted process flows and duties that arise from the IDP10 Reserve Case schedule and the application of critical equipment design factors taken from the Fluor process design criteria.

Table 17.10 Time Phased Equipment Requirements

Equipment	Year						
	1	4	5	6	7	8	9
Primary crusher	1	–	–	–	–	–	–
Underground ore overland conveying	–	1	–	–	–	–	–
SAG mills	2	–	–	3	–	–	–
Ball mills	4	–	–	6	–	–	7
Rougher banks	4	–	–	5	–	–	6
Cl and Cl scavenger banks	3	–	–	4	–	–	6
No. of column cells	4	8	–	12	–	–	–
No. of vertical regrind mills	4	–	–	6	–	–	–
Concentrate filters	2	–	3	–	–	4	–
Concentrate thickeners	2	–	3	–	–	–	–
Concentrate storage tanks	2	3	–	–	–	4	–
Covered concentrate storage (t)	16,000	–	32,000	–	–	48,000	–
Tails thickeners	2	–	–	–	3	–	–

17.2.2.1 Design Factors

The primary crushing and overland conveyor facilities from the open pit mine to the coarse ore stockpile will be scheduled to operate on a continuous basis, 365 dpa, with an instantaneous capacity of 7,000 tph and utilization factor of 69%, or an average of 16.5 hours per day. The conveying facilities from the underground mine has been designed to operate on a continuous basis, 365 dpa, with an instantaneous capacity of 7,000 tph and utilization factor of 75%, or an average of 18 hours per day. The greater utilization of the underground crushing and ore handling system is achievable due to the replicated crushing and multiple hoisting shafts.

Mine drill patterns and "powder factors" were determined by Scott Blasting Consultants from the available data during IDP05. These values were used to support the capacity estimate of the primary crusher. As gyratory crusher volumetric capacity is defined by the proportion of its feed finer than the open side set, it is understood that actual blasting data, obtainable during pre-stripping, may require adaptation of the blasting plan to achieve fragmentation in the feed to the primary crusher required to produce the desired feed size distribution to the SAG mills.

The live capacity of the twin grinding line stockpile is 70,000 t with a total capacity of about 340,000 t. This provides a live capacity of about 16.8 hours during initial operation. Expansion to a three line grinding circuit will require an extension of the stockpile structure, increased storage volume, and construction of an additional reclaim tunnel.

Grinding, flotation, thickening, and tailings disposal facilities were scheduled to operate on a continuous basis, 365 dpa, with a utilization factor of 92%. For these plant unit operations, the design limits are 115% of nominal mass balance values.

The nominal head grade of 0.66% Cu was selected to be the highest annualized head grade for the first three years, and 2.28% Cu nominal for the next 4 years. The design head grade of 115% of the nominal head grade was applied for the first 5 years.

The process design criteria are summarized in Table 17.11.

Table 17.11 Summary of Comminution Process Design Criteria Years 1 to 5

Parameter	Unit	Design
Annual Ore Treatment		
- Years 1 to 5 (96 000 t/d)	ktpa	35,070
Crusher/Conveyor Utilization	%	69
Grinding and Flotation Availability	%	92
Ore Characteristics		
- Copper Head Grade	% Cu	0.766
- Moisture	% H_2O	3.0
- Hardness – Southwest Ore	–	–
Crushing Work Index	kWhpt	16.3
SAG Performance Index (SPI)		
Average	min	138
Range	min	59–293
Abrasion Index	–	0.08–0.274
JK "A"		
Average	–	79
Range	–	61–100
JK "b"		
Average	–	0.48
Range	–	0.21–0.86
JK "A x b"		
Average	–	36
Range	–	21–54
JK "ta"		
Average	–	0.61
Range	–	0.29–0.95
Hardness – Hugo North Ore		
Crushing Work Index	–	–
Average	kWhpt	23
Range	kWhpt	8.1–39
Bond Rod Mill Work Index		
Average	kWhpt	18.6
Range	kWhpt	14.4–24.0
SAG Performance Index (SPI)		
Average	min	100
Range	min	60–196

Parameter	Unit	Design
ROM Ore		
- Maximum size 98% passing	mm	1,200
80% passing	mm	500
Passing 150 mm	%	37
- Overland Conveyor Capacity	tph	5,293
- Stockpile Capacity, live	t	70,000
- Stockpile Capacity, total	t	340,000
Ore Reclaim Feeders (each SAG Mill Line)		
- Type	–	Apron
- Lines	–	2
- Number per Line	–	3
- Capacity, each	tph	1,123
SAG Mill Feed Conveyors (each)		
- Fresh Ore	tph	2 175
- Recycled pebbles	% new feed	30
- Recycled pebbles	tph	653
- Total mill feed	tph	2,829
- Particle size F_{80}	mm	140
SAG Mills 1 and 2		
- Diameter	M	11.6
- EGL	M	6.9
- Ball charge	–	–
Nominal operating	% v/v	15
Maximum, mechanical design	% v/v	20
- SAG mill load	–	–
Nominal operating	% v/v	28
Maximum, mechanical design	% v/v	32
- Drive Type	–	Wrap-around
- Speed range	% critical	75–80
- Power, installed	MW	20.0
- Power utilization, average	%	90
SAG Mill Discharge Screens		
- Trommel screen aperture	mm	13 x 39
- Vibrating screen aperture	mm	14 x 40
Pebble Crusher Circuit	Each	3
- Feed to pebble crusher	% new feed	30
- Maximum feed size	mm	75
- Crusher	–	Cone
Capacity, each	tph	667
Product size, P_{80}	mm	13
Transition Size SAG Mill Circuit to Ball Mill Circuit T_{80}	µm	2,400

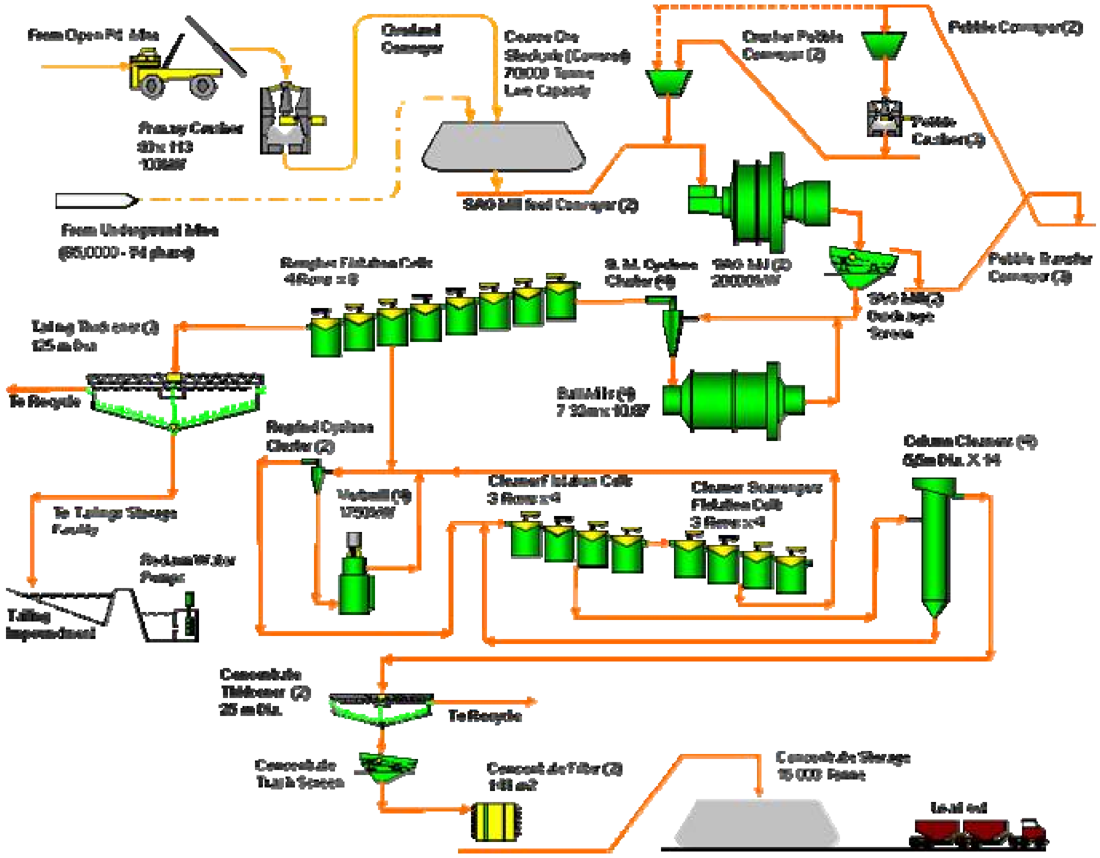
Parameter	Unit	Design
Ball Mills Lines 1 and 2		
- Number installed (each line)	–	2
- Diameter	m	7.3
- EGL	m	11.0
- Ball charge, nominal operating	% v/v	33
- Installed power, each	MW	11.4
- Power utilization, nominal, each	%	95
- Circulating load, ball mill, nominal	%	350
- Ball mill circuit, final product P_{80}	µm	159
Primary Cyclones		
- Cyclone diameter	mm	800
- Cyclone overflow pulp density	% w/w	33

17.2.3 Process Description

The process is based on conventional technology and proven equipment, where possible single equipment streams have been chosen to minimize the number of equipment units and reduce footprint and complexity. The concentrator will be at the forefront of modern large porphyry-copper gold mills. A simplified process flow sheet is shown in Figure 17.6.

In briefest terms, the flow sheet consists of primary crushing and coarse ore stockpiling followed by SAG and ball milling with pebble crushing. Rougher flotation is followed by concentrate regrinding and two stages of cleaning, the second stage being column flotation. Final concentrate is thickened and filtered before being transported by truck or rail. Rougher and cleaner scavenger tails are thickened and disposed of in a tailings impoundment.

Figure 17.6 Oyu Tolgoi – Simplified Process Flow Sheet



18 PROJECT INFRASTRUCTURE

18.1 Power Supply and Distribution

The Oyu Tolgoi project will be energy-intensive, with electrical power requirements of more than 200 MW on start-up, increasing to around 310 MW in the longer term. A reliable and stable power supply is essential for operations and safety.

A number of studies have been completed since 2004 to investigate the advantages and disadvantages of various power supply alternatives, taking into account the terms of the IA, which allow OT LLC to obtain power from established sources in China until the end of Year 4, and important stakeholder issues related to the GOM desire to electrify the south Gobi and the substantial proportion of total country demand represented by OT LLC.

OT LLC have a 220 kV interconnection between Bayainhanggai in Inner Mongolia, China, and the Oyu Tolgoi site to provide the power supply for Oyu Tolgoi until Year 4. A double-circuit, 170 km long transmission line was constructed between Bayainhanggai.

TRQ announced on 5 November 2012, that Oyu Tolgoi LLC had signed a binding Power Purchase Agreement with the Inner Mongolia Power Corporation to supply power to the Oyu Tolgoi mine. The term of this agreement covers the commissioning of the business plus the initial four years of commercial operations. Distribution at 220 kV and 35 kV is through a central substation approximately 500 m south of the concentrator facility. A second 220 kV switchyard and substation will be constructed adjacent to the production headframes for shafts 2 and 3.

During operations, all critical process and other equipment, heating and lighting, communications, and computer systems will be kept in operation by switching automatically to standby power supply from the diesel plant in the event of failure of the main power plant.

The Oyu Tolgoi Investment Agreement recognized that the reliable supply of electrical power is critical to the mine. The agreement also confirmed that TRQ has the right to obtain electrical power from inside or outside Mongolia, including China, to meet its initial electrical power requirements for up to four years after Oyu Tolgoi commences commercial production. The agreement established that a) Turquoise Hill has the right to build or sub-contract construction of a coal-fired power plant at an appropriate site in Mongolia's South Gobi Region to supply Oyu Tolgoi and b) all of the mine's power requirements would be sourced from within Mongolia no later than four years after the start of commercial production. TRQ continues to evaluate several options to meet its commitment to sourcing power from within Mongolia including the development of a dedicated power plant and ownership and funding options to meet this requirement.

18.1.1 Access

18.1.1.1 Access Roads

Approximately 26 km of internal access roads for small vehicles and general normal road transport trucks will be constructed to Mongolian, international, and AASHTO Standards. Construction features will include 35 culverts, one river crossing, and three overpasses. The roads will be constructed of graded gravel. Side-drain ditches will be provided for stormwater drainage.

Access to the water borefield is via a gravel service road from the plant site. Haul roads in the mining areas were developed separately as part of the mine designs.

To support the project development, an existing, 105 km access road from China to Oyu Tolgoi is being upgraded. As measured from the OT site, km 0 to km 25 will be private road, and km 25 to km 105 will be public road. Construction of off-site facilities and infrastructure were behind schedule at the end of 2012 due to slower progress in the building of the Oyu Tolgoi-Gashuun Sukhait road to the Mongolia-China border. Road work has been suspended for the winter although there should be no impact upon the transporting concentrate to the border.

The access road development will include upgrading the roads linking the existing Mongolian customs facility at Gashuun Sukhait to the Chinese customs facility at Ganqimaodao. A working group has been established to obtain agreement on the maintenance of the “OT Road.”

Beyond Ganqimaodao, a reasonable-quality provincial road approximately three years old connects to the Jingzang Expressway via the towns of Hailiutu and Wuuyan, if required. The road has deteriorated slightly but overall is acceptable for copper concentrate hauls.

A gravel road has been completed to the town of Khanbogd; OT proposes to build a mine bypass road to detour public traffic around the project to the town of Khanbogd and beyond.

18.1.1.2 Concentrate Shipment and Handling by Truck

The project will begin producing copper concentrate at an estimated rate of 600,000 to 1,000,000 t/a. With no rail service in this undeveloped region of southern Mongolia, copper concentrate will need to be transported by truck from the Oyu Tolgoi mine to an OT transload facility at the Ganqimaodao border crossing, from where customers would normally be responsible for further transport.

The rail line in northern China is currently being extended to Ganqimaodo, and while customers would likely prefer to accept delivery to rail head there, the line is still under construction and Chinese railway officials have indicated that there is no excess capacity in the existing rail system. As a result, customers may have to arrange to deliver the concentrates by truck to a railhead in Baotou or Hohhot within China for transfer, or possibly directly to the ultimate destination.

The trucking of this volume of product across southern Mongolia and northern China, combined with international border issues, will be a significant challenge. Border-crossing protocols and customs-clearance procedures are still developing as the border transitions from a small bilateral boarder to a large international border. The Governments of China and Mongolia have completed a bi-lateral transportation agreement, but this is being applied unevenly in favour of Chinese drivers operating in Mongolia. Neither Mongolia nor China appears to monitor or enforce load limitations with any regularity.

Safety will be a major area of concern for this operation, and a training program will need to be developed for the drivers. Skilled labour and management staff will need to be hired from other areas of the Inner Mongolia Autonomous Region (IMAR) and beyond in Mongolia.

A major support facility will need to be established for staff accommodation and to service the anticipated fleet of tractor-trailer equipment. An area of approximately five acres will be needed, which could be set up on the Mongolian side of the border crossing. There are no other maintenance facilities between OT and the Ganqimaodao border crossing, although the existing level of service improves slightly on the Chinese side of the border.

To ensure a reliable and efficient transportation strategy, OT could manage and operate the haul internally, or it could help a local haulage contractor that has provided services to OT in the past to develop into a bulk commodity transportation company. The latter is likely to be more successful in dealing with border issues to prevent serious delays or transportation stoppages.

18.1.1.3 Airstrip

A new airport is has been constructed at Oyu Tolgoi to replace the temporary facility for the transportation of people and goods to the site from Ulaanbaatar. The new airport is 11 km north of the Oyu Tolgoi mine lease area and has been sited to avoid flight paths over existing camp areas and structures. The runway is concrete-surfaced, 3,250 m long, aligned with the prevailing north-west-south-east wind direction, and has a projected life of 30 years. Design criteria were established to suit commercial aircraft up to the Boeing 737-800 series arriving and departing twice per day.

Facilities at the terminal include standard check-in counters, a security checkpoint, a departure lounge sized for 100 persons, and an adjacent car park for 40 vehicles. Electricity is provided from an independent diesel generator equipped with a standby unit. No aircraft refuelling capability is provided. The permanent airport work was completed in January 2013 and began operating in February 2013.

18.1.2 Main Site Infrastructure Buildings

18.1.2.1 Accommodation Facilities

Accommodation facilities for the first 10–15 years of operations will be constructed adjacent to the existing main construction camp. These will be pre-fabricated, dormitory-style buildings, all equipped with sprinkler and fire-detection systems and central utility and housekeeping rooms on each floor. Seven buildings with single-occupancy rooms for senior staff and seven buildings with double-occupancy rooms for junior staff will be provided.

The complex will be complete with kitchen-dining area, TV/Internet, and other recreation facilities.

The existing construction camp will be used as long as possible, including the ger VIP, senior staff, and junior staff rooms, modular camp mess, laundry facilities, modular construction offices, and HSES, fire-fighting, and emergency medical facilities.

18.1.2.2 Truckshop Complex

The truckshop complex is approximately 1 km north-west of the primary crusher, within the maintenance complex, adjacent to the bonded customs storage yard to the north-east and the main fuel storage facility to the south-east. It will cover a land area of approximately 225 m x 175 m, or 4 ha. This space are occupied by outdoor facilities and three self-contained structural steel, pre-engineered buildings designed with the required facilities for repair, maintenance, and rebuild of the open pit mining equipment; storage space for spare parts and consumables; and administration offices. No mine personnel change facilities are included in this complex.

The maintenance building proper will have ground floor space for 10 service bays and related workshops and a second-floor mezzanine for IT, office, and meeting rooms.

Cast rails are embedded in the floor of two of the repair bays for protection when repairing tracked equipment. Serviced with parallel, dual-rail 100 tonne and 25 tonne overhead cranes, the bays are sized to provide for the full dump height of a 360 tonne capacity haul truck. The current open pit mine plan is based on the use of the smaller Komatsu 930-4SE, 290 tonne, haul trucks. A 6 m aisle-way down the centre of the building, between the bays, will provide forklift access directly from the tool crib and warehouse.

Space is provided for lube storage, vehicle wash, and a welding/machine/tire shop. A pipe rack will connect the shop to the lubricant storage building. Recovery systems and holding tanks are provided to store waste oil and coolant products for recycling or disposal.

The wash bay is a stand-alone building north-east of the workshop. Floor- and catwalk-mounted monitors will provide high-pressure water streams to thoroughly wash the mobile equipment. Wash water is recirculated through a large sump outside the building, where solids will settle out before the water is recycled back to the wash bay.

Any oil in the recycled water will pass through an oil skimmer to remove hydrocarbons prior to re-use.

18.1.2.3 Administration Building

The administration building serves as the central, primary office space for all operations staff on site, including executive, supervisory, and support personnel. The building is equipped with all necessary communication support and is the main data centre for the site, including most of the ICT management and storage equipment. An emergency response area in the main conference room will serve as the command point in the case of an area-wide emergency. The building is two-story, pre-engineered, and steel-framed, with a total floor area of 5,000 m^2. The building is cooled in summer by the air-conditioning system and heated in winter by the same system using hot water rather than by chilled water. The data centre will need to be cooled in both summer and winter.

18.1.2.4 Mine Dry

The mine dry is a centralized, permanent operations facility whose primary purpose is to provide all site staff with a place to shower and change into work clothes and back into clean street clothes. Spaces are also available for various other activities such as office/meeting room, laundry service, and muster rooms where mining crews will assemble to receive shift instructions before departing for their respective work sites.

The male change rooms will consist of “clean” side and “dirty” sides with approximately 1,200 wire mesh lockers and bench-seating areas on each side, separated by showers and other toilet amenities designed to support the largest number of staff per shift change. A separate women’s change room will accommodate approximately 125 women. VIPs and visitors will have access to a separate room with single lockers that can support up to ten people at a time.

18.1.2.5 Plant Infrastructure Buildings

A basic laboratory facility has been built on site, comprising standard facilities comprising sample preparation, wet laboratory, fire assay and and instrumental laboratory with atomic absorption and mini XRF. This is operated by SGS and supported by the SGS laboratory in Ulan Bataar for multi-element analysis through ICP, diagnostic leaches (which may involve cyanide solutions) and metallurgical test facilities (still to be set up).

AMC considers this laboratory facility to be small, cramped and with poor workflow. Moreover it is inadequately equipped to support a concentrator of the size of OT and with significant geometallurgical issues.

AMC also notes that, in contrast to the substantial truck wokshop to service the mine, there is no maintenance workshop for the concentrator. AMC understands that it is planned to carry out concentrator maintenance activities either within the concentrator buildings or in containers, and also rely on rotables and off-site maintenance. AMC believes that this is unduly influenced by the Kennecott Copper approach and not adequate to support the concentrator operation effectively, especially in the Mongolian situation with a severe winter climate and limited off-site resources.

18.1.2.6 Tailings Storage Facility

Summary of Work to Date

A number of options have been investigated for design of the tailings storage facility (TSF) for Oyu Tolgoi since 2002. These have included the identification of alternative sites, layouts, and the evaluation of various tailings deposition densities up to 70% solids by weight.

The initial development work in 2002 was conducted by Knight Piésold (KP) and proposed a two-cell facility with perimeter deposition and central decants in each cell. The design was for a total tonnage of 739 Mt of tailings storage capacity and a throughput of 25.6 Mtpa at a slurry solids content of 55% by weight.

In 2004, KP completed a location options study that was carried out in several stages. Options were evaluated against cost, technical, and environmental criteria.

In 2005, Golder Associates completed an alternative TSF design with central discharge of a tailings paste thickened to densities as high as 70% solids. The capital and operating costs, and operational complexities, of a paste tailings system were found to be high compared to those associated with conventionally thickened tailings, and the reduction of water consumption by using paste was small. Therefore, this option was not pursued further.

Klohn Crippen Berger Limited (KCB), the design consultant, continued numerous field assessments, laboratory and site investigations throughout 2006 and 2007.

Upon review of the various alternative option studies, KCB amended the design concept to simplify the embankment sections and replace the flow-through embankment decants with an internal decant pond and barge-mounted pumping facilities for process water reclaim.

During 2007–2008, KCB completed an additional alternatives assessment for the tailings storage facility and considered five sites. In early 2010, a number of variants on the preferred alternative were considered with regard to potential further pit and subsidence zone expansions in addition to the previously analysed variables. Other work included modifying the alignment of the TSF to provide additional buffer zone for potential expansions. This re-alignment required additional site investigation activities, which were completed in July 2010. The feasibility study, which includes the current design concept, was completed and submitted in an updated version in August 2011, after being reviewed by the Oyu Tolgoi Independent Technical Review Board (ITRB).

Subsurface Conditions at the TSF Location

The proposed TSF site is approximately 2 km east of the open pit and 5 km south-east of the plant site. The facility area has a mild surface gradient of 0.3% to the south-east. The ground is covered by limited grassland, and surface water drains via a series of shallow, braided drainages. Ultimately, all drainage in the area reports to the Undai River, which receives run-off from most of the mine site. Stream flow is ephemeral and occurs only a few times a year following rainfall events.

Three main units have been identified in the subsoil profile at the TSF area, as follows:

- Unit 1 – fluvial and aeolian deposits overlying most of the TSF footprint to thicknesses up to 4.0 m and 0.2 m, respectively.
- Unit 2 – cretaceous clay of deltaic-lacustrine origin that dominates most of the TSF area, overlying the weathered bedrock, ranging from 0 m to 30 m in thickness.
- Unit 3 – Weathered bedrock and residual soils, ranging in thickness from 2 m to 10 m, that overlies deeper intact bedrock. Free water is often encountered at the clay/bedrock contact, although perched water tables can occur above this contact.

Groundwater in the vicinity of the TSF typically ranges from 5 m to 15 m below ground surface, and the aquifer is considered to be largely unconfined.

Tailings Characteristics

Gradation testing on the tailings indicates the material is a typical copper tailings sandy silt with 45% to 65% fines (less than 74 µm) and clay-sized material (less than 2 µm) ranging from 6% to 16%, with an estimated average density of 1.5 t/m^3 for the ultimate facility.

Geochemical test work predicts that tailings from Central Oyu, the Wedge Zone, Hugo South, and Heruga will be strongly potentially acid forming (PAF). Non-acid-forming (NAF) tailings are predicted from Southwest Oyu, Hugo North, the Shaft Farm area, and Hugo North Extension.

Design Criteria and Design Basis

The design criteria and design basis prepared by KCB include site climatic and hydrology conditions, design throughputs and total storage requirements, operating requirements, and environmental considerations. Minimum standards for geotechnical and hydro-technical design include return periods for design precipitation events, required factors of safety for seismic events, and allowable deformations under seismic loading conditions. Design features are as follows:

- The design tonnage, based on the current estimate of tailings production over the mine life, is 1,418 Mt. The feasibility level TSF design provides storage for 720 Mt of tailings to be produced during the first 15 years of the project; conceptual designs provide storage for all mine tailings.
- The facility is designed to store tailings produced from a concentrator constructed to process 160,000 t/d.

- Based on the consequence classification set by the Canadian Dam Association 2007 Dam Safety Guidelines, the feasibility design is based on a "Very High" consequence classification.
- Deposition methods will be selected such that run-off is collected into a reclaim pond and water recirculation is maximized.
- The behaviour of the Cretaceous clay foundation soils was taken into consideration in selecting the design criteria for stability analyses of the embankment. Minimum required static factors of safety were based on strength of foundation clay and pore pressure conditions and therefore ranged from 1.1 to 1.5 depending on the combination of these conditions and the dam configuration – starter dam or ultimate dam configuration. The minimum required factor of safety for both pseudo-static and post-earthquake conditions was set at 1.1.
- The site area is classified as a moderate seismic zone. The Maximum Credible Earthquake (MCE) loading at the project site, based on a deterministic assessment for the fault, is estimated to be an M7 earthquake with a Peak Ground Acceleration (PGA) of 0.32 g.
- Based on CDA guidelines, the flood criteria for a dam of "Very High" consequence category are two-thirds between the 1,000-year return period event and the Probable Maximum Flood (PMF). The estimated 24-hour Probable Maximum Precipitation (PMP) is 184 mm.

Facility Description

The facility will consist of two cells, each approximately 2 km x 2 km in size (4 km^2 area each) and having a storage capacity of 720 Mt of tailings. The facility will be constructed in two stages, starting with Cell 1 initially and then continuing with Cell 2. Each cell will be divided into four 500 ha subcells by berms running the length of the TSF.

The tailings will be pumped at a target density of 64% solids, forming an assumed overall beach slope of 1.0%. The tailings will be deposited alternately among the subcells to minimize evaporative losses and promote water run-off toward the reclaim pond and to maximize water recovery. Water will be reclaimed from the pond by a floating barge and pumped back for re-use in the process plant.

Earthfill and rockfill embankments will be constructed to store the tailings. Embankments will be up to 70 m high and will have one of three typical sections (reclaim pond section, dry section, or wet section), depending on their location and water management regimes around the perimeter of each cell.

Dues to low-strength clay deposits in the foundations, buttressing berms will be required at certain locations, ranging in width up to 500 m, with a resulting overall downstream slope between 2.5H:1V to 10H:1V.

The TSF will consist of engineered earthfill and rockfill embankments. The starter dam will be developed from locally borrowed general fill and clay materials. The clay material will also be used for lower-permeability liners where Cretaceous clay is not present and within core zones.

Most of the embankment will be constructed of various mine waste rock materials and will include a) oxide waste rock, which is up to 25% NAF, b) sedimentary waste rock, which is NAF, and c) random waste rock, which will be segregated, with NAF-only material to be used for the perimeter embankments. Dam zoning to incorporate some PAF rock is therefore a key strategy.

Water Management

Water management is one of the major drivers of the design and operational planning for the TSF. Water will be supplied from a well field some distance from the mine site and is expensive. Water conservation is a major objective of the current design and operating plan, and the concept of depositing tailings in subcells is intended to minimize evaporation losses and promote water release from tailings by consolidation.

Water will be reclaimed from the eastern side of the impoundment by a pump barge that will return supernatant water back to the process plant. The water balance indicates that an expansion of the raw water supply to 1,200 L/s is planned as part of the Phase 2 works.

Run-off and seepage collection ditches located at the toe of the embankment and around the TSF, designed for a 24-hour, 100-year return period precipitation event, will direct water to seepage collection ponds to maximize recirculation.

Future Work

Recommendations for future work have been outlined, based on the current TSF design for the Oyu Tolgoi Project, to optimize the facility and maximize water conservation. Key recommendations include:

- Review the layout and design of the facility expansion to ensure tailings storage capacity can support continued mining beyond the first 15 years, to account for storage of up to 1.5 Bt of tailings in total.
- Optimize embankment slopes and specifically evaluate pore pressure response during operation; consider relocating the northern wall farther north on thinner clay.
- Review, based on the observational approach during operations, the beach formation, beach slopes, and water recovery.
- Further investigate the geochemistry and leaching behaviour of various rock types used in the embankment construction and their interaction with the stored tailings.
- Optimize operational aspects to minimize dust emissions and potential environmental impacts such as acid generation and its effect on regional groundwater flow and geochemistry.
- AMC recommends a review of testwork on tailings rheology and water release properties to support the the 64% solids assumption for tailings pumping/deposition, the overall water balance and therefore the raw water demand to confirm the assumptions and conclusions. AMC recommends that some contingency be built into the raw supply facilities to support any shortfall of tailings return water generated from the tailings storage facility.

18.1.3 Water Systems

18.1.3.1 River Diversion

The Undai River channel runs through the proposed open pit area and so must be diverted. Subsurface flow in the river channel is constant, but surface flows are also present occasionally, though usually only after heavy rainfall. The proposed diversion system consists of a dam, diversion channel, and subsurface diversion designed to divert all subsurface and surface flows around and to the north of the South Oyu open pit. Potential seepage from the diversion will be cut-off by keying the main dam below the fluvial gravel. The dam and associated hydraulic structures are designed to ICOLD standards. Both groundwater and surface flood flows will be returned to the Undai River channel downstream.

18.1.3.2 Site Water Supply System

Raw Water

Raw water for project requirements are met by pumping groundwater to the site from the Gunii Hooloi aquifer basin. The raw water borefield and pipeline designs are at “Issued for Construction” (IFC) status. Detailed engineering design of the pipeline —inclusive of bore pump stations, collector tank pump stations, break-tank pump stations, emergency storage lagoons, access road, and 6.3 kV power distribution— is underway.

Water Storage and Treatment

A permanent water treatment and bottling plant has been constructed to treat raw water from the Gunii Hooloi borefield to drinking (potable) and domestic water standards.

One section of the building houses two raw/firewater storage tanks, two domestic water tanks, the camp fire water pump station, and domestic water pump station. Each raw water/firewater tank has a capacity of 400 m^3 for a total volume of 800 m^3, including a combined independent firewater capacity of 324 m^3. The remaining water can feed the treatment plant for up to 10 hours at full demand rate in the event of a loss of raw water supply. The two domestic water tanks have a combined capacity of 800 m^3, sufficient to supply water at full demand for 16 hours in the event of a loss of raw water supply.

The other area of the building houses the water treatment plant, bottled water storage, a laboratory/office, equipment storage, and chemical storage. Waste water is automatically and regularly discharged into the sewer system by a dedicated pump station in this room.

Potable water intended for routine drinking will meet Mongolian Standards and WHO guidelines for drinking water quality. Raw water is pumped to the treatment plant for dosing, multi-media and granular-activated carbon filtration, micro-filtration, reverse osmosis treatment, ultraviolet sterilization, and ozone disinfection prior to bottling in 20 L bottles and onward distribution. The total output of the treatment facility is 8 m^3/h.

Domestic water for use in washing, cleaning, flushing toilets, etc., although not intended for routine drinking, is treated to potable standards. Domestic water is treated at an average flow rate of 70 m^3/h (peak rate 125 to 150 m^3/h) before distribution to the construction camp and the rest of the Oyu Tolgoi site via utility pipes.

Firewater Distribution System

Firewater storage tanks is installed in the concentrator, and pump stations and dedicated fire mains complete with hydrants will be established in the main functional areas of the site. The fire mains also serve sprinkler systems and fire hose reels at the warehouse, operations camp, north gatehouse, and concentrator office. Fire extinguishers will be provided at all facilities as a first line of defence. Fire detection and alarm systems will be installed at key facilities and will report alarms to the mill area control room in the process plant or to the main gatehouse, which will be manned 24 h/d.

Wastewater Treatment Plant

An existing wastewater treatment plant, installed within the construction camp, was upgraded from 800 equivalent people (EP) capacity to 4,000 EP capacity in 2006 and is now fully operational. All sewage generated on site will either be pumped directly to the plant or transported there by truck for treatment by mechanical biological activation using a sequencing batch reactor (SBR). The plant is designed for an inflow of 600 m^3/d at a daily pollution load of 240 kg BOD_5. Maximum inflow is expected to be between the hours of 5 pm and 9 pm each day.

Treated wastewater will eventually be recycled into the industrial processes to minimize water make-up from natural resources. Sludge will be aerobically stabilized in storage tanks and will require no further processing. Thickened sludge will be finally disposed of in the waste management centre.

18.1.4 Information and Communications Technology (ICT) Systems

Communications systems throughout the Oyu Tolgoi infrastructure and operations facilities will be state of the art complete with information, security, data, and voice communications. The principal components of the ICT systems will include a fibre-optic communications backbone, local area network (LAN), and Voice over Internet Protocol (VoIP) system to support the voice mail system and auto attendant function. Security systems will consist of a closed-circuit television (CCTV) system connected to the local server and control centre and access security system based on card access for building entrance, security turnstiles, vehicle gates, and fence surveillance.

The fire alarm system will consist of thermal flame detectors, ionization smoke detectors, and manual pull stations in site-wide fire-detection zones. The central fire alarm panel will be installed in the north gatehouse, and local fire alarm panels will be provided in ICT rooms or electrical rooms throughout the plant, interconnected via the Ethernet LAN network.

A digital trunk radio system will permit voice communications between individuals carrying hand-held radios, base stations, and mobile vehicles. A designated emergency channel, GPS tracking, and monitor display of individual radios will allow users to notify support authorities in the event of an emergency or safety issue.

Additional communications and control systems are provided for the open pit and underground mines. The wireless open pit truck dispatch system will include links to each truck, GPS transmitters, automatic vehicle locator display, and two-way radio transceivers. The underground leaky-feeder coax system will provide network connectivity in underground shafts and tunnels, emergency paging systems, personnel and underground rail dispatch and tagging, remote control of rails and LHDs, and Gai-tronics phones in rescue chambers.

18.1.5 Other Support Facilities and Utilities

- Gatehouse

  The north gatehouse complex is located at the northern boundary of the mine lease area and serves as the main security control point for the Oyu Tolgoi mine. The complex is a single-story building with facilities for a security and logistics checkpoint, site-wide security monitoring, and fire response. Safety and orientation sessions for new employees and/or visitors, as well as special community relations functions, are held there. A separate building will serve as a bank for employees of the mine and the general public. Depending on final agreements for road construction, a south gatehouse may be required to support concentrate transport traffic.

- Warehouse

  The main site warehouse for operations was constructed adjacent to the construction warehouse to provide heated storage for process equipment parts, spares, critical piping, and valves. A fenced, external storage area will include a dedicated space for hazardous chemicals (HAZCHEM).

- Medical Centre

  The Oyu Tolgoi medical centre is designed for both walk-in patients and ambulance access for stretcher patients. It will have a reception area, consultation offices with diagnostic equipment, two resuscitation/treatment beds, two ward beds, and a pharmacy. All controlled prescription drugs are required to be registered to monitor use and stock level. Hard and electronic copies of medical reference material are available for all clinic staff and medical providers on site.

  First aid posts are stationed throughout the site to provide initial response in the event of an incident. If required, personnel are moved to the medical centre under the supervision of senior medical staff. Two Toyota ambulance vehicles fully equipped with emergency beacons/sirens are available.

  The Medical Mongolia clinic in Ulaanbaatar and the International SOS Global Medical Services (GMS) in Beijing will provide ongoing support for patients requiring medical evacuation.

- Fire Station

  The fire station is in the warehouse compound and be in continuous communication with all operations via a digital trunk radio within a 15 km radius. A fully equipped, dedicated fire crew of four fire-fighters will provide fire and emergency response on the project and be trained to meet the Mongolian statutory requirement for Airport Fire Response. The primary fire truck is fitted with a 7,000 L water tank, an 800 L foam tank, and a roof-mounted foam monitor, supported by 6,000 L water truck. A dedicated fire water supply line with central fire pumps will provide large-fire response support in the main camp.

- Heating

  A central coal-fired boiler plant is under construction to provide hot water heating for all surface facilities at the plant site plus the mine air heating systems in the shaft 1 and 2 areas. Hot water is supplied and returned through a primary circulation loop to the various secondary circulation and heating loops complete and dedicated hot water/glycol heat exchangers to provide heating to the end users.

- Underground Utilities

  Basic engineering design of underground utility services for raw water, fire water, domestic water, sewer water, return water, and treated water has been completed and battery limit interfaces tentatively agreed among all involved parties for infrastructure facility areas, the concentrator, mining, and the power plant.

- Waste Disposal Facilities

  Wastes generated during the development and operation of the Oyu Tolgoi mine are collected and disposed of in accordance with Mongolian and international laws. The waste management centre will include a non-hazardous waste landfill, leachate management, and a waste incinerator/oil burner.

  The landfill is prepared with a clay-geomembrane composite liner system overlain by a protective geotextile fabric. Exposed waste is routinely covered with soil to satisfy hygienic and visual needs and surrounded by secure perimeter fencing. Leachate is collected and gravity-fed to adjacent evaporation ponds fully contained by a composite clay-geomembrane liner system on prepared ground with engineered embankments. Given the arid climate at Oyu Tolgoi, no other treatment is required.

  The small amount of suitable hazardous wastes, waste oils, and other combustibles that cannot be directly placed in the landfill is burned in an incinerator designed and operated to international standards to adequately pacify, neutralize, or vaporize the varieties of waste being burned. Ash residue is properly disposed of in the landfill.

- Fuel Storage

  During the construction period a contract agreement was established with a Mongolian supplier, Petrovis, to store 25 ML of pre-purchased fuel to reduce site storage requirements. The supplier will truck the diesel fuel to site and unload it into storage tank farms. Three diesel fuel storage and dispensing facilities are strategically placed close to the users:

- A general vehicle fuel facility immediately south of the main construction camp, containing two 50 kL gasoline fuel tanks and two 400 kL diesel fuel tanks, to cater to four-wheel drive light vehicles, road haulage trucks, mobile cranes, and general purpose site tricks.
- A second facility with two 400 kL diesel fuel tanks for fuelling the mine fleet south of the truckshop, in an area that provides access for the heavy mine trucks operating in the open pit.
- A third fuel facility with four 50 kL diesel fuel tanks at the diesel power station just south of the central substation.
- Construction of the fuel storage facilities and dispensing systems is well progressed and scheduled for completion in December 2011.

• Core Storage Facility

The site engineering department has completed the conceptual design of the pre-engineered building that will serve a core storage shed.

• Toyota Workshop

Toyota has constructed a light-vehicle maintenance facility for its fleet of vehicles at the site. The facility is complete and fully functional.

• Fencing

The entire site boundary is surrounded by a mine lease perimeter fence with security gates at entrance/exit points. The fence is a conventional post-and-chain mesh, wide-type, approximately 2 m in high. Supplementary security fencing may be required at individual infrastructure facilities. Temporary security fencing is already established at the project, but it does not cover the entire site boundary, including some development facilities.

19 MARKET STUDIES AND CONTRACTS

Long-term sales contracts have been signed for 75% of the Oyu Tolgoi mine's concentrate production in the first three years, while 50% of concentrate production is contracted for ten years (subject to renewals). In addition to the signed contracts, in early November 2012, Oyu Tolgoi committed in principle, subject to the conclusion of detailed sales contracts, up to 25% of concentrate available for export would be made available at international terms to smelters in Inner Mongolia for the first 10 years.

OT LLC has developed a marketing plan and currently includes consideration of the following factors:

- Location value to customer compared to imported material landed at Chinese ports.
- Precious metals recovery and payment.
- Length of contract.
- Percentage of off-take to smelters versus traders.
- Percentage of tonnage on contract versus spot.
- Percentage of feed for any one smelter.
- Number of smelters for a given scale of operation.
- Management of concentrate quality and volume during commissioning and ramp-up.
- Alternate off-shore logistics and costs.
- Delivery point and terms.
- Packaging.

A detailed timeline has been developed for marketing, logistics, and contract-to-cash functions. OT LLC's Sales and Marketing are supported by Rio Tinto Copper Marketing, led by its Chief Marketing Officer. The marketing team will oversee and execute all sales and marketing activities on behalf of OT LLC.

20 ENVIRONMENTAL STUDIES, PERMITTING AND SOCIAL OR COMMUNITY IMPACT

20.1 Environmental and Social Impact Assessment

OT LLC has completed a comprehensive ESIA for the Oyu Tolgoi Project. The culmination of nearly 10 years of independent work and research carried out by both international and Mongolian experts, the ESIA identifies and assesses the potential environmental and social impacts of the project, including cumulative impacts, focusing on key areas such as biodiversity, water resources, cultural heritage, and resettlement.

The ESIA also sets out measures through all project phases to avoid, minimize, mitigate, and manage potential adverse impacts to acceptable levels established by Mongolian regulatory requirements and good international industry practice, as defined by the requirements of the Equator Principles, and the standards and policies of the IFC, EBRD, and other financing institutions.

Corporate commitment to sound environmental and social planning for the project is based on two important policies: TRQ's Statement of Values and Responsibilities (March 2010), which declares its support for human rights, social justice, and sound environmental management, including the United Nations Universal Declaration of Human Rights (1948); and The Way We Work 2009, Rio Tinto’s Global Code of Business Conduct that defines the way Rio Tinto manages the economic, social, and environmental challenges of its global operations.

OT LLC has commenced the development and implementation of an EMS that conforms to the requirements of ISO 14001:2004. Implementation of the EMS during the construction phases will focus on the environmental policy; significant environmental aspects and impacts and their risk prioritization; legal and other requirements; environmental performance objectives and targets; environmental management programs; and environmental incident reporting. The EMS for operations will consist of detailed plans to control the environmental and social management aspects of all project activities following the commencement of commercial production in 2013.The Oyu Tolgoi ESIA builds upon an extensive body of studies and reports, and DEIA’s that have been prepared for project design and development purposes, and for Mongolian approvals under the following laws:

- The Environmental Protection Law (1995)
- The Law on Environmental Impact Assessment (1998, amended in 2001)
- The Minerals Law (2006)

These initial studies, reports and DEIAs were prepared over a six-year period between 2002 and 2008, primarily by the Mongolian firm Eco-Trade LLC, with input from Aquaterra on water issues.

The original DEIAs provided baseline information for both social and environmental issues. These DEIAs covered impact assessments for different project areas, and were prepared as separate components to facilitate technical review as requested by the GOM.

The original DEIAs were in accordance with Mongolian standards and while they incorporated World Bank and IFC guidelines, they were not intended to comprehensively address overarching IFC policies such as the IFC Policy on Social and Environmental Sustainability, or the EBRD Environmental and Social Policy.

Following submission and approval of the initial DEIAs, the Mongolian Government requested that OT LLC prepare an updated, comprehensive ESIA whereby the discussion of impacts and mitigation measures was project-wide and based on the latest project design. The ESIA was also to address social issues, meet Mongolian government (legal) requirements, and comply with current IFC good practice.

For the ESIA the baseline information from the original DEIAs was updated with recent monitoring and survey data. In addition, a social analysis was completed through the commissioning of a Socio-Economic Baseline Study and the preparation of a Social Impact Assessment (SIA) for the project.

The requested ESIA, completed in 2012, combines the DEIAs, the project SIA, and other studies and activities that have been prepared and undertaken by and for OT LLC.

A summary of the previous DEIAs prepared for the Oyu Tolgoi Project is shown in Table 20.1.

Table 20.1 Previous DEIA Studies for the Oyu Tolgoi Project

EIA Study Title	Description	Date	Status
Oyu Tolgoi Project Environmental Baseline Study	This study covers geography, geological, hydrology, hydrogeology, soil, climate, air quality, flora and fauna, the socio-economic status and infrastructure of the Oyu Tolgoi Project site and its surrounding areas.	2002	Submitted November 2002 as DEIA. Screening approval not required for baseline study.
Oyu Tolgoi Project EIA Volume I: Transport and Infrastructure Corridor from Oyu Tolgoi to Gashuun Sukhait	EIA of the original road and power line proposal from Gashuun Sukhait (GS) to Oyu Tolgoi via the western route. See Chapter A5 Figure 5.6. Provides approval for access through the South Gobi Strictly Protected Area (SGSPA).	2004	Approved May 2004.
Supplementary EIA Volume I: For Route Changes to the Oyu Tolgoi to Gashuun Sukhait Transport Corridor	Assessment of the revised Eastern route to GS and includes an assessment of existing environmental damage caused to the western route from coal traffic. See Chapter A5 Figure 5.6.	2006	Approved March 2007.
Oyu Tolgoi Project EIA Volume II: Water Supply from the Gunii Hooloi (GH) and Galbyn Gobi (GG) Groundwater Aquifer Areas	Provides an evaluation of the proposed aquifers for the provision of a sustainable water supply to the Oyu Tolgoi Project.	2005	Approved September 2005.
Supplementary EIA Volume II: Supplementary EIA of GH and GG Groundwater Aquifer Areas	Provides an update of the approved EIA Volume II from 2005. Updated assessment of potential impacts and risks, and upgrade of groundwater monitoring in GH area reflecting higher water demand.	2010	Initial Screening by MNET in December 2009. Final review and approval by the Water Authority and MNET in March 2011.

EIA Study Title	Description	Date	Status
Supplementary EIA Volume II: Supplementary EIA for GH bore field pipelines and associated infrastructure.	The report was updated further based on an engineering report of Dec 2008. The report covers pipelines, wells, pumps, ponds, lagoon, power supply and access roads from the GH Borefield to the Oyu Tolgoi site.	2009	Initial draft 2008. Updated December 2009. Approved March 2010.
Oyu Tolgoi Project Volume III: Oyu Tolgoi Mining and Processing Facilities	EIA of the open pits, underground, and concentrator, tailings, and all facilities and support infrastructure located within the Oyu Tolgoi Mine Licence Area. The assessment was largely based on the 2005 Integrated Development Plan (IDP), but reflected the general permitting layout of May 2006. The maximum production rate was assumed to be 85,000 tpd.	2006	Approved December 2007.
Oyu Tolgoi Project Volume IV: Coal Fired Steam Power Plant	EIA documentation drafted for a 3 x 100 MW coal fired power plant in 2006.	2006	Draft Technical Summary & DEIA completed but not submitted.
Oyu Tolgoi Project Volume V: Domestic Airport Re-location.	The project includes the construction of a temporary gravel Airstrip 10 km north of the Oyu Tolgoi Mine Licence with 2,000 m runway, taxiway, safety end-strip, apron, control tower, passenger terminal, car parking, 15 x 15 m waiting hall, illumination of runway, electric power that is supplied by 40 kVA power generator, surface water drainage system and fence. This EIA covers the new airport construction and operation. This facility is a temporary facility and will be replaced by the Permanent Airport.	2007	Approved September 2007.
Environmental Impact Assessment for the Permanent Airport	EIA for the construction and operation of the Permanent Airport.	2011	Approved 2011.
Undai River Diversion Detailed Environmental Impact Assessment	EIA for the diversion of the Undai River	2011	Awaiting approval by MNET (as of April 2012).

Additional environmental studies that relate to specific components of the project and that have not required a full-scale DEIA have been undertaken to achieve regulatory approvals. These are summarized in Table 20.2.

Table 20.2 Additional Environmental Approvals, Studies, and Environmental Impact Assessments for Oyu Tolgoi Project

Project EIA Component	Description	Date	Status
Petrovis Temporary Fuel Station Facility at Oyu Tolgoi Site	Completed for the fuel facility built in 2004 within the Licence Area	2005	Approved 2005
Oyu Tolgoi Fuel Depot and Fuel Station	The fuel station expanded in 2008 and a new fuel depot was constructed. The fuel station is 2.0 ha, and has 4 half-concealed tanks of 25 m^3 capacity for A-92, A-80 fuel type, 10 tanks of 50 m^3 capacity for diesel, and 2 dispensers.	2010	Submitted to MNET on 18 February 2010 and approved 13 September 2010
Shaft 1	EIA of the shaft, headframe facilities, waste rock, and water disposal	2005	Approved June 2005
Shaft 2	EIA of the shaft, headframe facilities, waste rock, and water disposal	2006	Approved December 2007
Waste Water Treatment Plant	Supplementary documentation for the construction camp waste water treatment plant with a 4,000 person equivalent capacity	2007	Approved May 2007
Quarry Batch Plant and Quarry	Assessment of the existing hard rock quarry, concrete batching plant, and crusher located at the northern boundary of the Licence Area	2007	Approved April 2007
20 MW Diesel Power Plant	The assessment included the initial development of 6 x 2 MW diesel power station (DPS) followed by a stage two addition of 4 x 2 MW diesel generators to the DPS.	2007	Approved September 2007
Chemicals	Covers the importation and use of chemicals for construction and development	2008	Approved April 2008

20.1.1 Scope of the Environmental and Social Impact Statement

The IFC and the EBRD have similar, but different, definitions for the scope of an impact assessment. Both institutions frame assessments in terms of a project's "area of influence." The guidance provided by both IFC and the EBRD and IFC was utilized in defining the scope of the ESIA. Key elements of the scope of the ESIA are set out below.

20.1.1.1 Project Elements Directly Addressed in this ESIA

For the purposes of the ESIA, the "project" constitutes the direct activities that are to be financed and/or over which the project can exert control and influence through its project design, impact management, and mitigation measures. This includes:

- All Oyu Tolgoi Project facilities within the Mine Licence Area and surrounding 10 km buffer zone, including the following key features:
  - Open pit mining facilities.
  - Underground mining facilities.
  - Accommodation camps.
  - Construction-related activities and facilities, including concrete batch plant, quarry, and laydown areas.

  - Power generation facilities.
  - Heating plant and boilers.
  - Crusher.
  - Concentrator.
  - Tailings storage facility.
  - Water management facilities (including diversion of the Undai River).
  - Waste water management facilities for camps and mining operations.
  - Waste management facilities (municipal and industrial).
  - Waste rock storage facilities.
  - Access roads within the Mine License Area.
  - Vehicle and equipment maintenance and repair facilities.
  - Fuel storage facilities.
  - Electrical power distribution.
  - Administration buildings and catering facilities.
- Airport facilities, including a temporary and permanent airport and associated local access roads to the Oyu Tolgoi site.
- Contractor accommodation camps adjacent to Khanbogd.
- Potential dedicated off-site worker accommodation planned for Khanbogd
- Gunii Hooloi water abstraction borefield and the water pipeline supplying the mine, as well as maintenance roads, pumping stations, construction camps, storage lagoons, and other support infrastructure.
- Infrastructure improvements (and associated resource use) by Oyu Tolgoi between the mine site and the Chinese border, including the 220 kV power transmission line, the access road that will be used for concentrate export, construction camps, local water boreholes, and borrow pits.
- Dedicated border crossing at Gashuun Sukhait for the exclusive use of the Oyu Tolgoi Project.
  - The concentrate will be sold by Oyu Tolgoi at the Mongolia/China border crossing at Gashuun Sukhait. The point of sale marks a key boundary to the project area.
  - Infrastructure Components that may be Transferred to Third-Party Ownership in the Future.

A number of infrastructure components of the project considered within the ESIA will be constructed by OT LLC but may be transferred at some stage to public or third party operation and/or ownership. Transfer of these infrastructure components to public operation and ownership will limit the degree of control that OT LLC can exert over their management and operation.

These infrastructure components may be owned and operated by the Government and will or may be used by members of the public and/or other commercial operations, and include:

- The permanent airport, which is planned to be handed over to the Government after the completion of the project construction phase.
- The road from Oyu Tolgoi to the Chinese border at Gashuun Sukhait, which follows the alignment for the designated national road and is planned to be handed over to the Government upon completion of the project construction phase.
- The dedicated border crossing facility at Gashuun Sukhait, which will be operated by the Mongolian authorities.
- The 220 kV electricity transmission line from the Chinese border to Oyu Tolgoi, which may become owned by the Government of Mongolia.
- Future Project Elements not Directly Addressed in the ESIA.
- In addition to the project elements identified above, certain other activities and facilities are expected to be developed over time, either as part of or in support of the project, that do not constitute part of the project for the purposes of the ESIA. These include:
  - Project expansion to support an increase in ore throughput from 100,000 t/d up to 160,000 t/d.
  - Long-term project power supply. Under the terms of the IA, OT LLC will source electricity from within Mongolia within four years of the commencement of project operations. OT LLC may develop a coal-fired power plant within the Oyu Tolgoi Mine Licence Area to provide the required power from Mongolian sources. This development is considered to be an Associated Facility (as defined in IFC PS1) of the Oyu Tolgoi Project and is the subject of an ESIA that will be supplemental to the ESIA for the Oyu Tolgoi Project.

While the impacts of these future project elements (and their mitigation and management) are not directly addressed in the ESIA they are considered in the cumulative impact assessment of the ESIA.

20.2 Government and Community Relations

A number of substantive issues have recently been raised by the Government of Mongolia relating to implementation of the IA, the companion Shareholders' Agreement and project finance.

TRQ and Rio Tinto continue to have productive discussions with the Government of Mongolia on a range of issues related to the implementation of the IA, including project development and costs, operating budget, project financing, management fees and governance. While progress on these issues has been made, all parties have agreed to continue discussions during March 2013 with a goal of resolving the issues in the near term.

The Oyu Tolgoi LLC Board has approved continued funding to progress the project as discussions with the Government proceed. Oyu Tolgoi is expected to reach commercial production by the end of June 2013 subject to the resolution of the issues being discussed with the Government.

In October 2012, the Company, Rio Tinto and Oyu Tolgoi LLC, rejected a request from the Government of Mongolia to renegotiate the Oyu Tolgoi IA. The rejection followed the receipt of a letter from the Minister of Mining requesting the parties renegotiate the landmark agreement that was signed in October 2009 and became fully effective in March 2010.

In its proposed 2013 budget, the Government of Mongolia has included revenue from the application of a progressive royalty scheme to Oyu Tolgoi. However, the IA provides a stabilized royalty rate of 5% over the life of the agreement and specifies that new laws made after its signing will not apply to Oyu Tolgoi. Any change to Oyu Tolgoi's royalty rate would require the agreement of all parties to the IA.

As recently as October 2011, the Mongolian Government reaffirmed that the IA was signed in full compliance with all laws and regulations of Mongolia.

21 CAPITAL AND OPERATING COSTS

21.1 2013 Reserve Case Cost Summary

The capital and operating costs are based on the Oyu Tolgoi project financing costs. The operating costs are based on the designs of the mines and plant. The cost estimates were generally based on actual costs expended to date and on contracts and supplier quotations for the construction and operation of the project and were applied to the design quantities, equipment schedules, labour numbers and consumption rates and productivity assumptions. Labour costs reduce over time as it is assumed that expatriate labour is reduced and more roles are carried out by Mongolian nationals. The methodology for the cost estimation is described in the following section.

A direct comparison of the IDOP and 2013 OTTR costs is complex because the terms of refernce are different. Analysis indicates that the estimates show approximately 30 percent increase in the direct capital costs after adjusting for scope change.

In order to provide an analysis of the 2013 Reserve Case, costs to December 2012 were treated as sunk. The capital costs for the Project are detailed in Table 21.1 and Table 21.2 provides a breakdown of operating costs and revenue in the 2013 Reserve Case.

Table 21.1 2013 Reserve Case Operating Costs and Revenues

	US$M	$/t Ore Milled		
	Total 2013 Reserve Case	**5 Yr Avg**	**10 Yr Avg**	**LOM Avg**
Revenue				
Gross Sales Revenue	**93,016**	**59.27**	**82.12**	**60.43**
Less: Realization Costs				
Concentrate Transport	3,578	1.69	2.55	2.32
Treatment and Refining	4,733	2.21	3.55	3.07
Government Royalty	4,650	2.96	4.11	3.02
2% Ex BHP Payment	1,680	1.11	7.43	1.09
Total Realization Costs	**14,641**	**7.97**	**17.64**	**9.51**
Net Sales Revenue	**78,375**	**51.30**	**64.49**	**50.92**
Less: Site Operating Costs				
Mining (all sources)	8,917	7.74	7.66	5.79
Processing	13,721	8.78	8.93	8.91
Tailings	1,270	1.02	1.20	0.82
G&A	1,934	4.97	3.23	1.26
Operations Support	1,713	3.01	2.18	1.11
Infrastructure	2,010	2.18	2.03	1.31
Entrée JV Fees	525	–	0.01	0.34
Government Fess & Charges	3,664	3.46	3.20	2.38
Management Fees	2,486	3.23	2.61	1.62
Total Site Operating Costs	**36,240**	**34.39**	**31.04**	**23.54**
Operating Margin	**42,136**	**16.91**	**33.44**	**27.37**

Notes:

1. 2% Ex BHP Payment is shown as a realization cost but modelled to be non-tax deductible.
2. Other operating costs include payments estimated to be made to the EJV as calculated in the Financial Model.

Table 21.2 Total Project Capital Cost– 2013 Reserve Case

US$M	Total Pre-2013	Phase 1 & 2 From 2013	Sustaining	Total
Direct Costs				
Open Pit	423	–	535	958
Underground	495	2,348	1,094	3,937
Concentrator	944	131	275	1,350
Infrastructure	1,204	67	154	1,426
Power Station	9	–	–	9
Tailings Storage Facility (TSF)	60	–	57	117
Subtotal	**3,134**	**2,546**	**2,038**	**7,796**
Indirect Costs & Allowances				
Indirect Costs	221	193	–	414
Freight	215	107	–	322
Construction O&M, Commissioning, Spares	492	297	–	789
Subtotal	**929**	**597**	**–**	**1,525**
Contractor Execution				
Contractor Margins	162	84	–	246
E/EPCM/PMC	598	394	–	992
Subtotal	**760**	**477**	**–**	**1,238**
Owner Execution				
O&M, Commissioning, Owners Teams, Spares	792	281	15	1,088
Subtotal	**792**	**281**	**15**	**1,088**
GOM Fees & Charges				
Mongolian Customs Duties	113	84	53	250
Mongolian VAT	346	347	165	858
Other Mongolian Fees, Taxes & Charges	2	29	–	31
Subtotal	**461**	**460**	**218**	**1,139**
Contingencies				
Contingencies	121	740	–	861
Subtotal	**121**	**740**	**–**	**861**
Total Development Program	**6,198**	**5,101**	**2,349**	**13,648**

Notes: Capital includes only direct project costs and does not include non-cash shareholder interest, management fees, foreign exchange gains or losses, forex movements, tax pre-payments, T Bill purchases or exploration phase expenditure.

.

21.2 Capital Costs

Capital costs have been allocated into the following categories:

- Mining
  - Open Pit
  - Underground
- Processing and Infrastructure
  - Indirects & EPCM
  - Construction & Operations
- Mongolian Government Payments

Customs and VAT costs in the Phase 1 capital estimates have been included in direct costs and shown separately for the remainder.

21.2.1 Open Pit Capital Costs

The open pit mine capital costs include the following:

- Heavy mobile equipment (HME)
- Minor equipment
- Explosives and diesel
- Mining software and systems
- Spare shovel bucket
- Spare FEL bucket
- Truck tray re-liner package
- Dewatering
- Pit dispatch system
- Global positioning system for mine surveying
- Blasting contractor set-up
- Maintenance system
- Pit power distribution
- Training simulator

HME capital costs are based on supplier quotations and allowances for the number of equipment units required. The HME prices include start up spares, delivery to Oyu Tolgoi site, assembly, and commissioning. Prices for small support equipment, such as light vehicles, personal carriers, cranes, and the mine fuel truck, include start up spares, and on site delivery costs, and exclude assembly and commissioning costs. As a result of the update on HME productivity assumptions, additional equipment units were allowed for in the 2013 OTTR.

Final contract prices were agreed for the equipment and the equipment purchase price assumptions were updated, showing a decrease in drilling and loading and a slight increase in hauling price compared to the previous analysis completed in early 2010.

21.2.2 Underground Capital Cost

Underground capital costs are divided into the following two categories:

- Capital Development – includes all pre-production and production build-up development and infrastructure required to initiate production and undercut the cave.
- Sustaining Capital – includes work required for long-term development, facilities, or systems to sustain full production operations, but not direct production costs.

Capital development began in Year –5 and are planned to end in Year 2 (pre-production). Production starts in Year 2 and production build-up continues through Year 8. The first year of full production is Year 8, and full production continues through Year 21. Production ramps down from Year 22 to Year 23. All planned development following first production, but not included in major life-of-mine infrastructure, is categorized as sustaining development. Many of the tasks falling into the capital development and sustaining capital categories are identical. Task classification into either of the two capital categories is purely a matter of timing relative to production status.

The design of the underground incorporates 4 shafts and 5 raises to ventilate the mine.

The components of capital development and sustaining capital are further defined below.

- Drifting and Excavating
  - Rock handling – truck haulage, conveyor drift, and crosscut development and associated rock handling excavation.
  - Ramps and accesses – access ramp, level access, and level development.
  - Fixed facilities drifting – infrastructure excavation (i.e. material staging area, shops, lunchrooms, etc).
  - Extraction and undercut drifts – perimeter drift, panel drift, drawpoint drift, and drawbell drift development.
  - Ventilation drifts and accesses – dedicated intake and exhaust airways (lateral only).
  - Mass excavations – large excavations required for facilities and installations.
- Shafts and Raises
  - Intake and exhaust raise development.
  - Ore pass and waste pass development.
  - Service and production shaft development.
  - Ventilation shaft development.

- Equipment and Infrastructure
  - Truck haulage infrastructure – supply and installation of truck haulage-related fixed equipment and infrastructure.
  - Ore flow infrastructure – supply and installation of conveyors grizzlies, ore chutes, crushers, etc.
  - Drawpoint construction – drawpoint related excavation and construction activities, including construction of drawpoints, slot raise excavation, drawbell and undercut drilling and blasting, and undercut swell mucking.
  - Mobile equipment – production LHDs, production drills, haulage trucks, development jumbos, bolters, trucks, utility vehicles, etc. This includes the initial supply, materials for major rebuilds, and replacement of mobile units.
  - Fixed facilities infrastructure – ventilation facilities, pumping systems, shops, offices, lunchrooms, storage areas, fuel and lube areas, explosives magazine.

21.2.3 Project Capital Costs

The Phase 1 construction of the Phase 1 plant and infrastructure is substantially complete.

21.2.4 Scope of Work

The scope of work for the Phase 2 PEP relates primarily to the underground mine, on which development has commenced. The Phase 2 execution plan will be developed during the underground mine Feasibility Study and will include lessons learned and advancements in ongoing project activities from Phase 1.

The scope of work for Phase 2 includes the following elements:

- Completing infrastructure not finished under Phase 1.
- Conducting work related to the power plant.
- Carrying out regional development work.

21.3 Operating Costs

- Mining
  - Open Pit
  - Underground
- Processing
- Tailings
- G&A
- Other
  - Government Fees and Charges
  - Management Fees

21.3.1 Open Pit Operating Costs

The detailed monthly and LOM production plans have been developed to optimize open pit mine production and to determine the necessary equipment hours.

Benchmark productivity assumptions were used to determine the unit costs for the various mining activities. Labour costs are based on the salary and wages structure provided by OT LLC Human Resources. Ore control costs are based on estimates for assaying and required consumables.

The main operating cost driver is haulage, followed by loading and labour. Additional haulage costs result from dividing the TSF into two cells. It is currently assumed that Cell 1 will be constructed with NAF waste material as soon as open pit mining starts. The East waste dump behaves as a temporary storage for NAF waste. The production plan uses this dump as final destination. Therefore, additional haul profiles have been added to the cycle times to account for the travel times between the East NAF dump (TSF stockpile) and the cell construction dikes as mining progresses.

As the pits deepen, haulage costs increase with greater haulage distance. Labour costs reduce over time as it is assumed that expatriate labour is reduced and more roles are carried out by Mongolian nationals. The unit cost in the last production year is higher because mining operation is shut down before the end of the year. The total unit operating costs for the open pit are in Table 21.3.

Table 21.3 Open Pit Unit Operating Costs

Operating Costs	$/t
Loading	0.30
Hauling	0.79
Drilling	0.05
Blasting	0.20
Ancillary & Support Equipment	0.23
Labour	0.21
Other Mining Costs	0.09
Total	**1.87**

21.3.2 Underground Operating Costs

Operating costs include direct and indirect costs associated with the production of ore. Production is defined as pulling ore from drawpoints and delivering it to the main overland conveyor and all activity directly supporting this process. Operating costs include the following items:

- Production
  - Production mucking – production haulage by LHDs from drawpoint to extraction level ore passes.
  - Truck haulage and ore flow – truck operation, chute maintenance, apron feeder maintenance, crushing and conveying system operation, and conveyor spill cleanup.
  - Secondary breaking – fixed and semi-mobile rock breakers, rock breaker operators, breaking of drawpoint oversize, and relieving low and medium hang-ups.
- Ground Repair
  - Drawpoint repair.
  - Sill concrete repair.
  - Ore pass repair.
- Indirects – costs not directly allocated to production.

21.3.3 Process Operating Costs

Concentrator operating costs were developed using the template used by AMEC Minproc for IDP10. Data for all areas were updated to the latest available as of November 2010. All prices were in 2013 US dollar terms, except where noted. Process plant operating costs have been developed for the main ore sources on an annual basis. The cost areas making up the process operating costs are:

- Workforce
- Reagents and Consumables
- Maintenance Materials
- Concentrator Administration Costs
- Miscellaneous and Contractor Costs

Labour has been modelled on an annual basis. Administration and miscellaneous costs have been considered 100% fixed. Power, maintenance consumables and reagents, grinding media and filter cloths have been treated as fully variable on an annual basis for the 2013 Reserve Case.

Concentrator operating costs were calculated based on testwork data, calculation of consumables, and unit rates developed from various sources, including:

- IDP10.
- Updated quotations for supply of goods and services from AMEC and Rio Tinto Procurement.
- OT LLC's and AMEC's database and experience from similar projects.
- Labour rates and numbers provided by OT LLC.

OT LLC has created a detailed labour estimate on a period-by-period basis in order to apply labour costs over the life-of-mine. This includes changes in personnel numbers as production levels change, and maintenance of at least 90% Mongolian national hire for all of OT LLC in advance of the IA mandated schedule. The process operating costs are seen in Table 21.4.

Table 21.4 Process Operating Costs

Processing Costs	Total US$M	Unit Cost $/t
Employee Related Costs	1,059	0.69
External Services	117	0.08
General Consumables	12,292	7.99
Miscellaneous Expenses	252	0.16
Total	**13,721**	**8.91**

21.3.4 General and Administration Operating Costs

The G&A costs cover all costs not directly associated with mining and processing. The areas included were:

- Executive Management
- Human Resources and Training
- Business Readiness and Integration
- Health, Safety and Security
- Regional Development & Communications
- Government Relations
- Commercial

The following is a list of cost elements included in the cost estimate of each area:

- Employee Related Costs
  - FIFO Travel
  - FIFO Accommodation
  - Relocation Cost
  - Recruitment Cost

  - R&R Travel
  - Housing Cost
  - In-country Costs
- External Services
- Inward freight
- Consultants
- Legal Fees
- General Consumables
- Mobile Equipment
  - Site Transport
  - UB transport
- Safety, First Aid & Medical Supplies
- Utilities
- Fuel and Energy
- Contractors
- Operating Leases and Rent
- Telecommunications
- Office Accommodation Costs
- Advertising, Promotions and Donations
- Subscriptions & Memberships
- Rates, Taxes & Licences
- Travel Expenses
- Asset Purchases

21.3.5 Other Operating Costs

Other costs that are treated as operating costs in the 2013 Reserve Case are:

- Government Fees and Charges
- Management Fees
- Entrée JV fees

22 ECONOMIC ANALYSIS

22.1 Key Assumptions

The 2013 OTTR is an update of the Reserve Case previously presented in IDOP. The results of the 2013 Reserve Case show an after tax NPV_8 of US$9.9 B. The case exhibits an after tax IRR of around 43% and a payback period of around 7.5 years. An initial capital cost of US$6.2 B will be expended before production can commence.

The key economic assumptions for the analyses are shown in Table 22.1. Metal prices are assumed to fall from current prices to the long-term average over five years.

Table 22.1 Economic Assumptions

Parameter	Financial Analysis Assumptions	
Copper Price	$2.90 avg ($2.87 long-term)	per lb
Gold Price	$1,398 avg ($1,350 long-term)	per oz
Silver Price	$23.96 avg ($23.50 long-term)	per oz
Treatment Charges	$70.00 long-term	per dmt concentrate
Copper Refining Charge	$0.07 long-term	per lb
Gold Refining Charge	$5.00	per oz

22.1.1 Investment Agreement and Taxation Assumptions

Both the process of negotiation and the final agreement of the IA presented an opportunity to confirm how the laws of Mongolia should be interpreted in their application to the Project and provided for some specific terms to apply to the Oyu Tolgoi Project. For OT LLC, the agreement has provided the confidence in the stability of the terms the Project will operate under and reliably assess its intended investment in the Project. The agreement itself is effective for an initial term of 30 years with an available extension of a further 20 years.

In accordance with the requirements outlined in the 2006 Minerals Law of Mongolia, upon execution of the IA and the fulfillment of all conditions precedent, the GOM has become a 34% shareholder in OT LLC through the immediate issue of OT LLC's common shares to a shareholding company owned by the GOM. Upon a successful renewal of the IA after the initial 30-year term, the GOM also has the option to increase its shareholding to 50%, under terms to be agreed with TRQ at the time.

A number of conditions precedent were set down in October 2009 and were required to be met before the IA terms came into effect. These were met and confirmed by the GOM in March 2010, triggering the issue of the GOM's equity share in the Project and bringing the IA into full effect.

Despite its role as an equity owner, the GOM will not be required to contribute to the initial capital cost of the Project. TRQ, as the parent company, retains the right to fund the Project by way of a combination of debt, redeemable preference shares and common shares provided the debt to equity ratios fall within the 3:1 ratio required by Mongolian law.

In the case of shareholder debt, loans (including existing shareholder loans at the time of the agreement) initially attracted an interest rate of 9.9% (real) per annum with corresponding adjustments to be made to the outstanding balance to reflect increases in US CPI during each period. The coupon rate applicable to redeemable preference shares was to be 9.9% (real) and carry the same escalation terms. All principal and interest outstanding on shareholder debt, outstanding coupon payments on redeemable preference shares and the face value of those redeemable preference shares must be paid in full prior to any dividends on common shares being paid.

In 2011, an Amended Shareholders Agreement was concluded which reduced the applicable rate from 9.9% to LIBOR plus 6.5%. In addition, an in principle agreement was reached to convert the balance of preference shares into ordinary shares. Both adjustments were to take place based on the 31 January 2011 balances, although the preference share conversion had not occurred by 31 December 2011.

Under the authority of the Shareholders Agreement, TRQ has the right to act as or appoint a Management Team to oversee the construction and operation of Oyu Tolgoi. The management team is compensated with a Management Services Payment equal to 3% of total operating and capital costs prior to commencement of operations and 6% of operating and capital costs during operations. This payment is included in the economic analysis as a project expense and is confirmed as tax deductible in the IA.

OT LLC is required to achieve commencement of production within 7 years of the effective date of the IA.

Under the terms of the IA, a range of key taxes has been identified as stabilized for the term of the agreement at the rates and base currently applied. The following taxes comprise the majority of taxes and fees payable to the GOM under Mongolian law and are shown with their stabilized rates:

- Corporate income tax 25%
- Royalties 5% (gross sales value)
- Value added tax 10%
- Customs duties 5%

In accordance with the Excess Profits Tax invalidating law, as from 1 January 2011, the taxpayer will not be subject to the excess profits tax or any similar windfall tax.

OT LLC is also only subject to those taxes currently listed in the General Taxation Law and not taxes introduced at any future date. These taxes are collectively noted as non-discriminatory taxes and as such cannot be imposed on OT LLC in any manner other than that applied to all taxpayers.

OT LLC may also apply to take advantage of any future law or treaty that comes into force and which would apply any rates lower than those specified in the IA.

The GOM recently enacted amendments to the legislation governing the carry forward of income tax losses. The loss carry forward period has been extended to 8 years and if sufficient, can be applied to offset 100% of taxable income. This contrasts with the previous law in which losses carried forward for 2 years and were subject to a 50% limit.

The agreement also provides OT LLC with the benefit of a 10% tax credit for all capital investment made during the construction period. The amount of this credit can be carried forward and credited in the three subsequent profitable tax years. It is noted in the agreement that if VAT payments, which are currently non-refundable, become refundable in the future, the availability of the investment tax credit will cease from that point. In that event, past earned investment tax credits will still be applied.

22.2 Operating Assumptions

Although it has a requirement to make its self discovered water resources available to be used for household purposes, it is confirmed in the agreement that OT LLC holds the sole rights to use these water resources for the Project. The contract for the utilization of water with the GOM water authority is in effect for 30 years with subsequent 20-year periods of renewal.

The supply of power has been recognized as being critical to the execution of the Oyu Tolgoi Project in the IA. OT LLC has been given the right to import power initially but must secure power from sources within Mongolia from the fourth year of operation.

OT LLC also has the right to construct roads for the transport of its product and airport facilities to suit the Project's needs. The GOM has committed to providing OT LLC with non-discriminatory access to any railway constructed between Mongolia and China if such a railway is constructed.

22.3 Project Results

A summary of the 2013 Reserve Case project financial results is shown in Table 22.2 and the mining production statistics are shown in Table 22.3.

The estimates of cash flows of the Project have been prepared on a real basis based at 1 January 2013 and discounted back to a current day NPV at a rate of 8%. Long-term metal prices used for the analysis are copper $2.87/lb, gold $1,350/oz, and silver $23.50/oz.

Table 22.2 2013 Reserve Case Financial Results

		Before Taxation	After Taxation
Net Present Value (US$M)	Undiscounted	33,153	27,825
	5.0%	16,525	14,294
	6.0%	14,509	12,611
	7.0%	12,770	11,150
	8.0%	11,263	9,877
	9.0%	9,953	8,763
	10.0%	8,812	7,787
Internal Rate of Return	–	**43.27%**	**42.64%**
Project Payback Period (Years)	–	**7.41**	**7.41**

Table 22.3 2013 Reserve Case Mining Production Statistics

		2013 Reserve Case	5-Year Average	10-Year Average	LOM Average
Quantity Ore Treated	Mt	1,539	33.8	34.8	35.8
Copper Feed Grade	%	0.89	0.57	1.06	–
Gold Feed Grade	g/t	0.34	0.61	0.56	–
Silver Feed Grade	g/t	2.03	1.49	2.42	–
Copper Recoveries	%	88%	87%	90%	–
Gold Recoveries	%	78%	77%	79%	–
Silver Recoveries	%	83%	82%	85%	–
Copper Concentrate	Mt (dry)	40.68	0.66	1.01	0.95
Copper Concentrate Grade	%	30%	26%	33%	–
Contained Metal in Concentrate					
- Copper	Mt	12.0	0.2	0.3	0.3
- Copper	Blb	26.5	0.4	0.7	0.6
- Gold	Moz	12.9	0.5	0.5	0.3
- Silver	Moz	83.0	1.3	2.3	1.9

2013 Reserve Case Processing and concentrate and metal production are summarized in Figure 22.1 and Figure 22.2 respectively.

Figure 22.1 2013 Reserve Case Processing

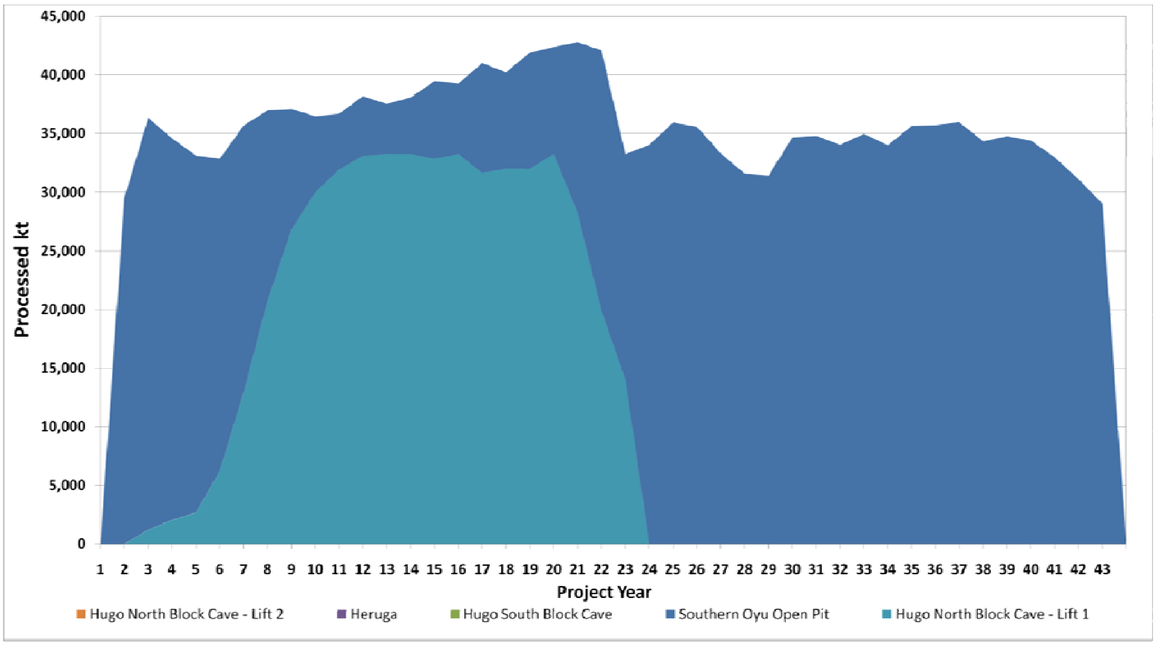
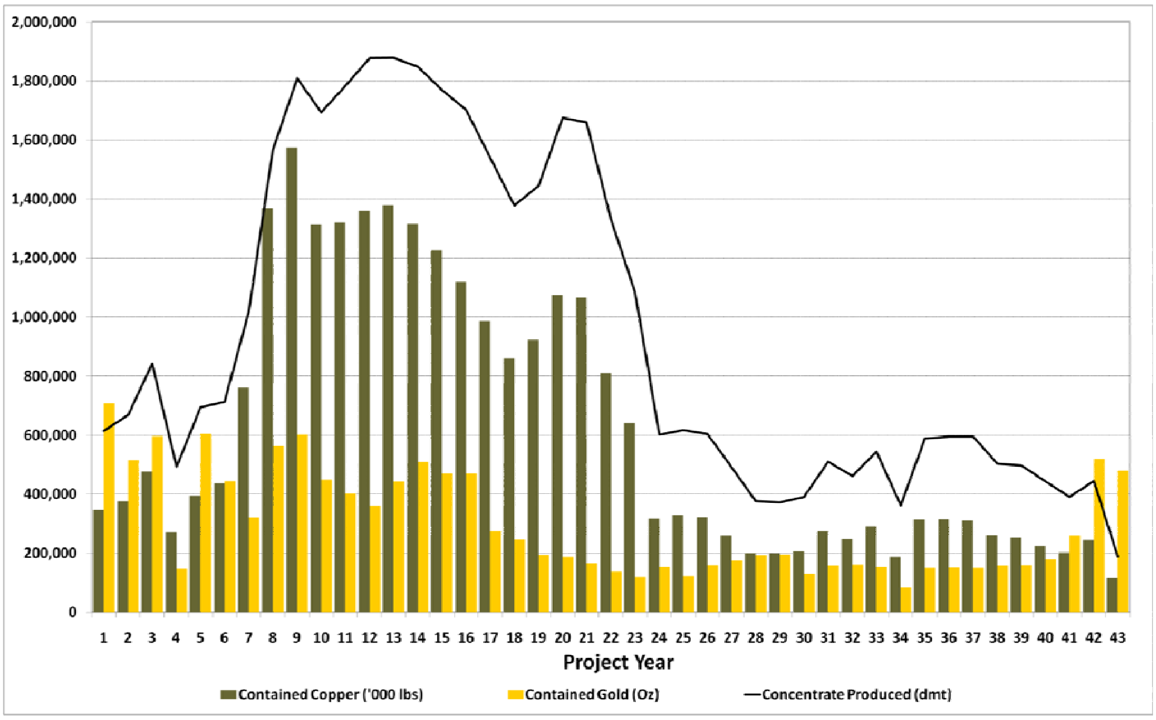


Figure 22.2 2013 Reserve Case Concentrate and Metal Production



Mine site cash costs are shown in Table 22.4. Those costs relating to the direct operating costs of the mine site, namely:

- Mining
- Concentration
- Tailings
- General and administrative (G&A) costs
- Government fees and charges (excluding corporate taxation)
- Management fees

In addition, realization costs are shown which depict the actual realizable value of Payable Copper produced after accounting for the transport treatment and royalties payable on these sales.

Table 22.4 2013 Reserve Case Unit Operating Costs by Copper Production

	$/lb Payable Copper			
	2013 Reserve Case	**5 Yr Avg**	**10 Yr Avg**	**20 Yr Avg**
Mine Site Cash Cost	1.37	3.09	1.47	1.08
Treatment Charges, Refining charges (“TC/RC”s), Royalties and Transport Cash Cost	0.51	0.65	0.50	0.49
Total Cash Costs Before Gold Credits	**1.88**	**3.74**	**1.97**	**1.57**
Gold Credits	0.59	2.22	1.00	0.64
Silver Credits	0.07	0.10	0.07	0.07
Total Cash Costs After Credits	**1.22**	**1.42**	**0.89**	**0.86**

Notes: Payments made directly to TRQ from the Project, principally 50% of the management fee as specified in the terms of the IA and a 2%NSR based payment (2% ExBHP Payment)arenot included in the Mine Site Cash Cost per pound of payable copper. These payments due to TRQ add to around 0.11 $/lb over the 2013 Reserve Case.

The revenues and operating costs have been presented in Table 22.5, along with the net sales revenue value attributable to each key period of operation.

Table 22.5 2013 Reserve Case Operating Costs and Revenues

	US$M	$/t Ore Milled		
	Total 2013 Reserve Case	5 Yr Avg	10 Yr Avg	LOM Avg
Revenue				
Gross Sales Revenue	**93,016**	**59.27**	**82.12**	**60.43**
Less: Realization Costs				
Concentrate Transport	3,578	1.69	2.55	2.32
Treatment and Refining	4,733	2.21	3.55	3.07
Government Royalty	4,650	2.96	4.11	3.02
2% Ex BHP Payment	1,680	1.11	7.43	1.09
Total Realization Costs	**14,641**	**7.97**	**17.64**	**9.51**
Net Sales Revenue	**78,375**	**51.30**	**64.49**	**50.92**
Less: Site Operating Costs				
Mining (all sources)	8,917	7.74	7.66	5.79
Processing	13,721	8.78	8.93	8.91
Tailings	1,270	1.02	1.20	0.82
G&A	1,934	4.97	3.23	1.26
Operations Support	1,713	3.01	2.18	1.11
Infrastructure	2,010	2.18	2.03	1.31
Entrée JV Fees	525	–	0.01	0.34
Government Fess & Charges	3,664	3.46	3.20	2.38
Management Fees	2,486	3.23	2.61	1.62
Total Site Operating Costs	**36,240**	**34.39**	**31.04**	**23.54**
Operating Margin	**42,136**	**16.91**	**33.44**	**27.37**

Notes:

1. Turquoise Hill 2% Ex BHP Payment is shown as a realization cost but modelled to be non-tax deductible.
2. Other operating costs include payments estimated to be made to the EJV as calculated in the Financial Model.

The Total Project direct capital costs required are shown in Table 22.6, divided between the investment required to commence production at 100 ktpd and complete shaft 2 (Total pre-2013), the power station and completion of the underground mine to 54 ktpd (Costs Remaining), and the sustaining capital to support ongoing operations.

The pre-2013 capital shown in Table 22.6 includes only direct project costsand does not include non-cash shareholder interest, management fees, foreign exchange gains or losses, tax pre-payments, T Bill purchases or exploration phase expenditure.

The changes in financial results for a range of copper and gold prices are shown in Table 22.7. Cumulative cash flow for the 2013 Reserve Case is depicted in Figure 22.3 and a complete cash flow is provided in Table 22.8.

Figure 22.3 2013 Reserve Case Cumulative Cash Flow

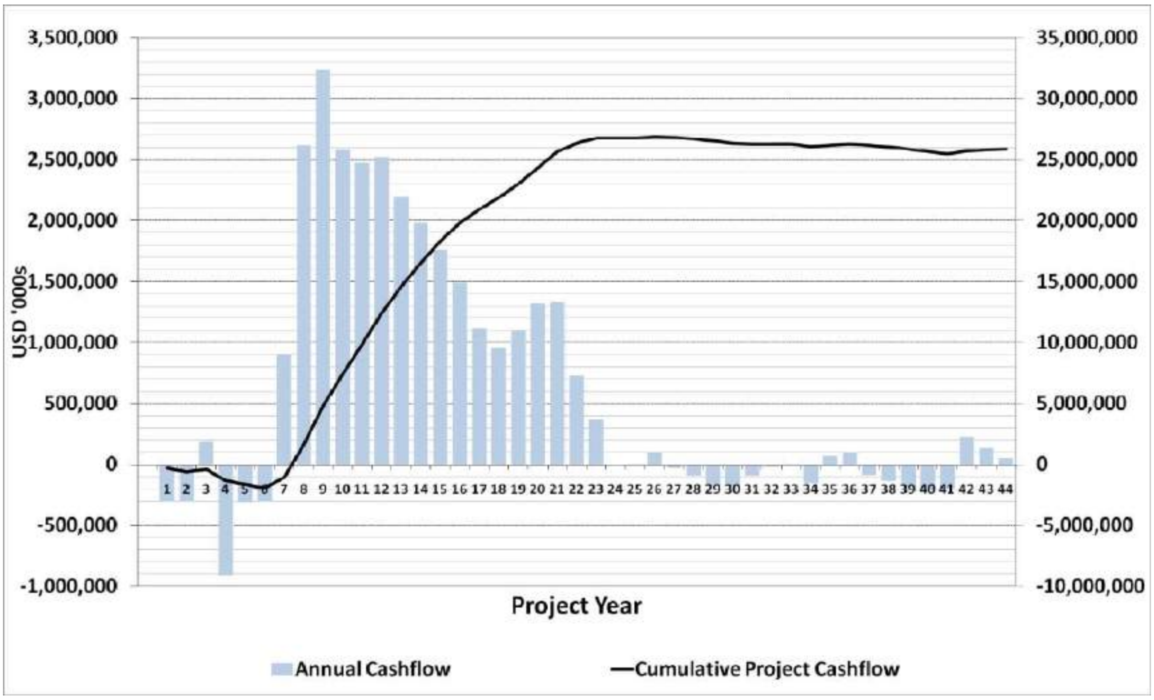


Table 22.6 Total Project Capital Cost– 2013 Reserve Case

US$M	Total Pre-2013	Phase 1 & 2 From 2013	Sustaining	Total
Direct Costs				
Open Pit	423	–	535	958
Underground	495	2,348	1,094	3,937
Concentrator	944	131	275	1,350
Infrastructure	1,204	67	154	1,426
Power Station	9	–	–	9
Tailings Storage Facility (TSF)	60	–	57	117
Subtotal	**3,134**	**2,546**	**2,038**	**7,796**
Indirect Costs & Allowances				
Indirect Costs	221	193	–	414
Freight	215	107	–	322
Construction O&M, Commissioning, Spares	492	297	–	789
Subtotal	**929**	**597**	**–**	**1,525**
Contractor Execution				
Contractor Margins	162	84	–	246
E/EPCM/PMC	598	394	–	992
Subtotal	**760**	**477**	**–**	**1,238**
Owner Execution				
O&M, Commissioning, Owners Teams, Spares	792	281	15	1,088
Subtotal	**792**	**281**	**15**	**1,088**
GOM Fees & Charges				
Mongolian Customs Duties	113	84	53	250
Mongolian VAT	346	347	165	858
Other Mongolian Fees, Taxes & Charges	2	29	–	31
Subtotal	**461**	**460**	**218**	**1,139**
Contingencies				
Contingencies	121	740	–	861
Subtotal	**121**	**740**	**–**	**861**
Total Development Program	**6,198**	**5,101**	**2,349**	**13,648**

Notes: Capital includes only direct project costs and does not include non-cash shareholder interest, management fees, foreign exchange gains or losses, forex movements, tax pre-payments, T Bill purchases or exploration phase expenditure.

Table 22.7 After Tax Metal Price Sensitivity – 2013 Reserve Case

After Tax Values	**Gold ($/oz)**				
Copper ($/lb)	1,000	1,150	1,300	1,500	1,750
Project Net Present Value at 8% ($M) After Tax					
2.50	6,945	7,358	7,834	8,186	9,339
2.75	8,410	8,759	9,217	9,563	10,709
2.87	9,074	9,418	9,877	10,217	11,362
3.00	9,790	10,131	10,585	10,926	12,067
3.50	12,510	12,851	13,308	13,650	14,766
Project Internal Rate of Return (IRR%) After Tax					
2.50	34.1%	35.5%	37.3%	38.7%	43.3%
2.75	37.9%	39.2%	41.0%	42.3%	46.7%
2.87	39.6%	40.9%	42.6%	43.9%	48.3%
3.00	41.4%	42.7%	44.4%	45.7%	49.9%
3.50	47.7%	48.9%	50.5%	51.8%	55.7%
Project Payback (Years)After Tax					
2.50	7.98	7.87	7.72	7.62	7.32
2.75	7.72	7.62	7.50	7.42	7.17
2.87	7.61	7.52	7.41	7.34	7.11
3.00	7.51	7.43	7.33	7.26	7.04
3.50	7.21	7.15	7.07	7.02	6.65
Total Cash Costs (after Credits) – First Ten Years					
2.50	1.00	0.95	0.87	0.87	0.62
2.75	1.01	0.96	0.88	0.88	0.63
2.87	1.02	0.97	0.89	0.89	0.64
3.00	1.03	0.97	0.89	0.89	0.64
3.50	1.03	0.98	0.90	0.90	0.65

Table 22.8 2013 Reserve Case Cash Flow

US$M	Year								Total
Cash Flow Statement	**1**	**2**	**3**	**4**	**5**	**6 to 10**	**11 to 20**	**21 to Life of Mine**	
Gross Revenue	2,483	2,167	2,429	1,011	1,914	18,561	37,334	27,095	92,994
Realization Costs	294	282	334	165	271	2,733	6,018	4,545	14,641
Net Sales Revenue	**2,189**	**1,886**	**2,095**	**846**	**1,643**	**15,828**	**31,316**	**22,550**	**78,353**
Site Operating Costs									
Mining	215	203	206	345	338	1,356	2,341	3,913	8,917
Processing	299	298	298	293	293	1,627	3,349	7,265	13,721
Tailings	29	27	34	35	47	246	341	510	1,270
G&A	482	456	295	261	222	868	1,547	1,525	5,657
Other	–	–	–	–	–	3	522	–	525
Total Site Operating Costs	**1,025**	**985**	**833**	**934**	**900**	**4,100**	**8,100**	**13,212**	**30,089**
Operating Surplus / (Deficit)	1,163	901	1,262	–88	744	11,729	23,215	9,337	48,264
Indirect Costs (inc Depreciation)	231	279	250	255	247	1,027	1,833	3,176	7,298
Net Profit Before Income Tax	**933**	**621**	**1,012**	**–343**	**497**	**10,702**	**21,382**	**6,161**	**40,965**
Income Tax	–	–	–	–	–	–	3,591	1,736	5,327
Net Profit After Income Tax	**933**	**621**	**1,012**	**–343**	**497**	**10,702**	**17,791**	**4,425**	**35,638**
Capital Expenditure	815	1,088	928	782	733	1,444	1,052	756	7,597
Other Cash Adjustments	266	-90	14	–175	69	133	–312	309	215
Net Cash Flow After Tax	**–148**	**–377**	**71**	**–950**	**–306**	**9,125**	**17,051**	**3,359**	**27,825**

22.3.1 Alternative Production Cases

The mine designs and production schedules available for the alternative production cases are:

• Southern Oyu Open Pits	(2013 Mineral Reserve)
• Hugo North Lift 1 Block Cave	(2013 Mineral Reserve)
• Hugo North Lift 2 Block Cave	(Inferred)
• Hugo South Block Cave or Open Pit	(Inferred)
• Heruga Block Cave	(Inferred)

Under the NI 43-101 guidelines, Inferred Mineral Resources are considered too speculative geologically to have the economic considerations applied to them that would allow them to be categorized as Mineral Reserves. There is no certainty that the alternative production cases will be realized.

Currently the designs for Hugo North Lift 2, Hugo South Block Cave and Heruga are the same as those in IDP10. The Hugo South open pit designs were updated in 2012. From the designs two sets for long-term production sheduling can be prepared, one with Hugo South as underground and one as open pit. The two sets are shown in Figure 22.4 and Figure 22.5. The work on the alternative production cases is not complete, in particular the definition of the expansion sizes and costing of the cases.

Figure 22.4 Alternative Production Design Set 1

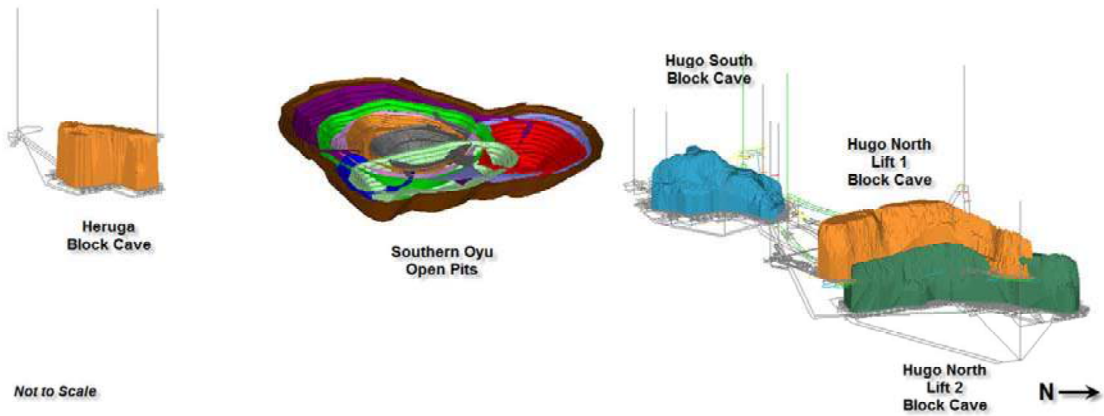
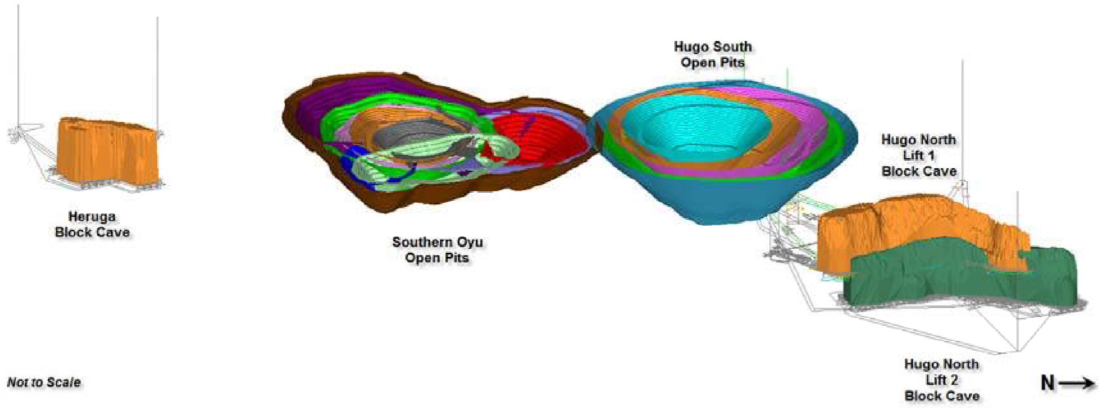
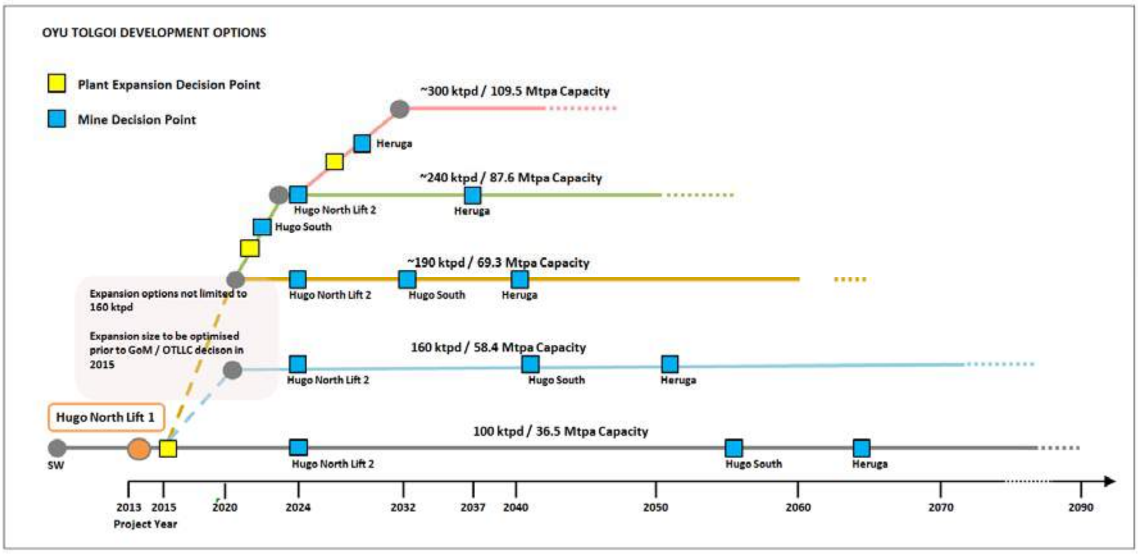


Figure 22.5 Alternative Production Design Set 2



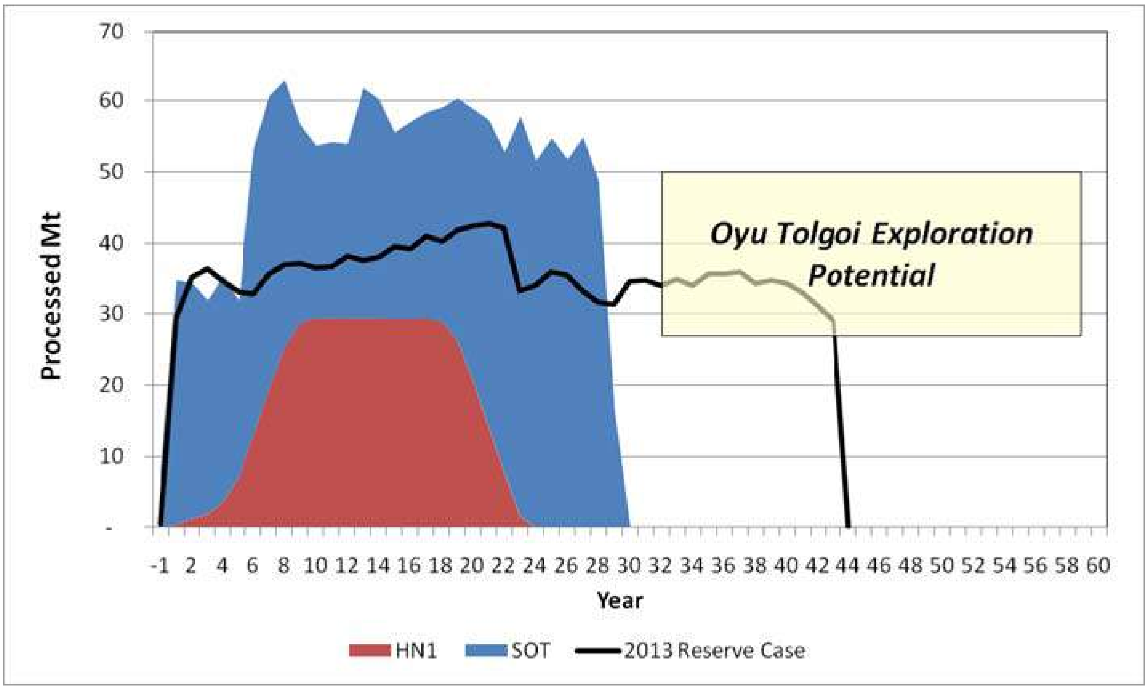
These cases will be part of the strategic planning that is being undertaken by OT LLC. This work will examine the plant capacity for expansions. Figure 22.6 shows an example of the potential decision tree for the potential development options at Oyu Tolgoi.

Figure 22.6 Oyu Tolgoi Development Options



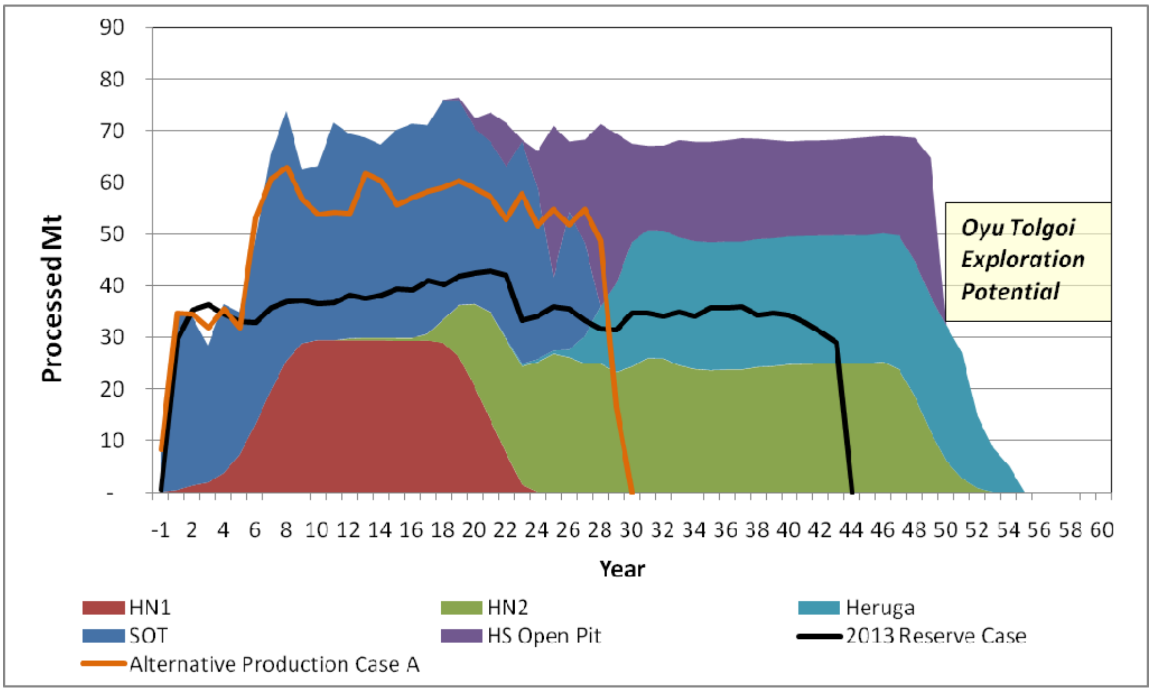
To date several alternative production cases were developed by OT LLC to explore the potential plant expansions and the flexibility inherent in the Heruga and Hugo South deposits. These cases and others will be examined and refined by OT LLC as part of the strategic planning process. In the first case, the mining inventory remains the same as the 2013 Reserve Case but with a plant expansion in Year 6. This case is only at a conceptual level and costings have not been prepared. Alternative Production Case A is depicted in Figure 22.7. Total annual production is 59.0 Mtpa from the Southern Oyu open pit and Hugo North Lift 1. The 2013 Reserve Case production is included in black for comparison.

Figure 22.7 Alternative Production Case A



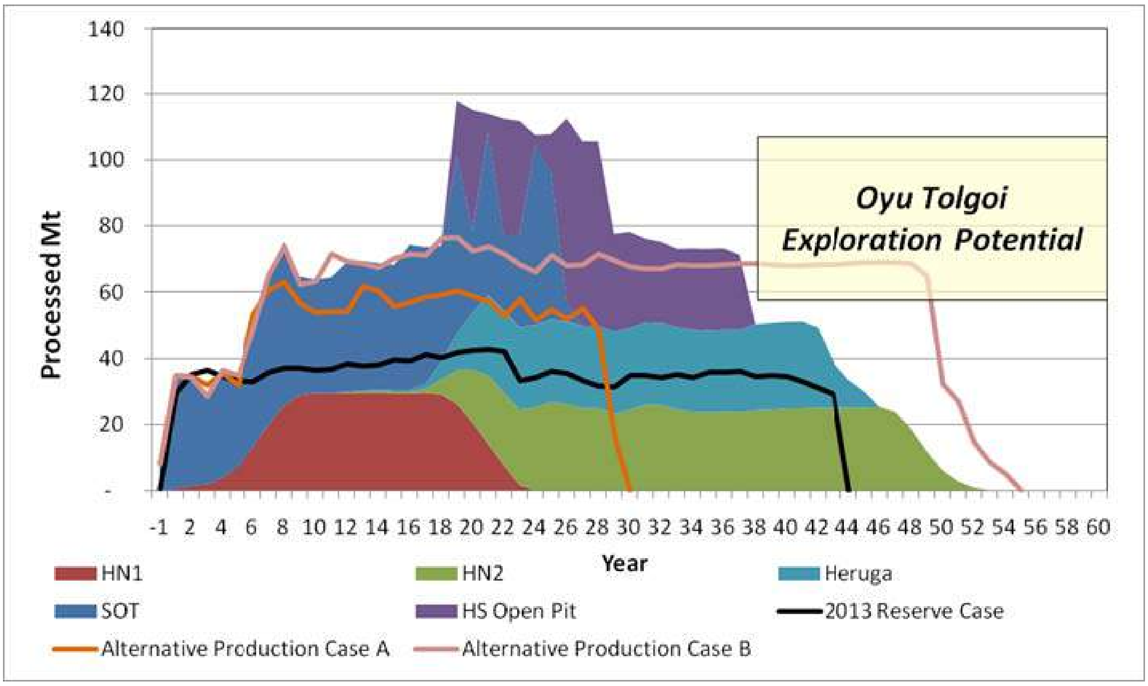
In Alternative Production Case B, Hugo North Lift 2, Heruga, and Hugo South open pit are added to the schedule. A plant expansion occurs in Year 7. This case is only at a conceptual level and costings have not been prepared. The ultimate production rate for Alternative Production Case B is 68.1 Mtpa and is shown in Figure 22.8. This case uses Heruga as a 25 Mtpa operation and Hugo South as an open pit mine. The 2013 Reserve Case (black) and Alternative Production Case A (orange) are included for comparison.

Figure 22.8 Alternative Production Case B



The third case is Alternative Production Case C and, again, is only at a conceptual level and costings have not been prepared. The ultimate production rate for Alternative Production Case C is 110 Mtpa and is shown in Figure 22.9. The case also uses Heruga as a 25 Mtpa operation and Hugo South as an open pit mine. The 2013 Reserve Case (black), Alternative Production Case A (orange), and Alternative Production Case B (pink) are included for comparison. There is a significant amount of study work to be carried out to verify the alternative production cases to increase the Mineral Resource confidence and identify suitable infrastructure capacities such as water. These cases are discussed as it is considered that they demonstrate the options for the direction the Project's long-term mine planning could take.

Figure 22.9 Alternative Production Case C



22.3.2 OyuTolgoi Dynamic DCF / Real Option Development Alternatives Review

Turquoise Hill has retained Ernst & Young LLP (Ernst & Young) to review a range of development alternatives for the OyuTolgoi Project and their associated metal price risk exposure using Dynamic DCF and Real Option ("RO") methods. In this context, Ernst & Young is providing on-going analysis to Turquoise Hill for Turquoise Hill's private and confidential use.

The objective of the Ernst & Young analysis is to provide insight into how a sequence of project development decisions may be adapted in response to changes in the metal price environment. The analysis combines the use of stochastic Monte Carlo simulation to model the effects of metal price uncertainty with a decision tree to describe the sequence of possible development decisions to assess how investing in various capacity expansions and choice of different deposit development sequences changes across a range of metal price environments. Both DCF and RO methods are used in the analysis to estimate project NPV so as to determine if development decisions differ between the two NPV methods. Both NPV methods are also used to assess whether the application of the RO method provides additional insights into characteristics of the Project that influence long-term cash flow uncertainty and Project NPV. The analysis will also consider how the different development alternatives transform metal price uncertainty into overall project risk exposure by different development decisions.

22.3.3 OTLLC Strategic Production Planning & Advanced Valuation Techniques

It is the intention of TRQ that the existing expansion cases and the work completed by Ernst and Young will be provided to the team engaged by OT LLC to conduct the Strategic Production Planning & Advanced Valuation Techniques program.Strategic Production Planning is Rio Tinto's accepted approach for evaluating resource-driven investment opportunities. Uncertain global conditions and sensible capital discipline demand this type of rigorous trade-off approach to identify and rank the right investment descisions. This work will be completed as part of the ongoing feasibility study work of OT LLC.

23 ADJACENT PROPERTIES

This section is not used.

24 OTHER RELEVANT DATA AND INFORMATION

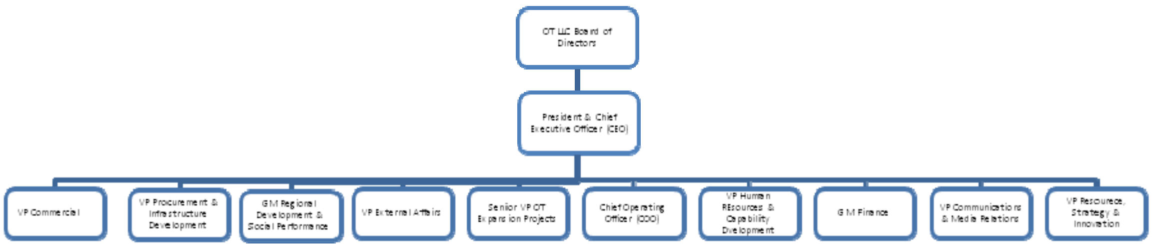
24.1 Management

The operations plan sets out the various roles and responsibilities required to successfully manage the operating aspects of the Oyu Tolgoi project. It includes the overall workforce development strategy and other operations planning aspects related to supply and logistics; environment, health, and safety policies and procedures; and concentrate shipment and handling. OT LLC has developed an Operational Readiness Plan to ensure that all facilities and personnel are in place to support the successful transition from project construction to mine operations. The operations plan is current as of December 2010 and may be subject to change as planning advances for operations.

24.1.1 The Organization

OT LLC's aim is to develop a proficient and reliable workforce possessing the productivity and skills associated with international best practice to support its overall goal of high operations efficiency. The organizational structure of the Oyu Tolgoi project is expected to evolve from a more hierarchical structure to one that is a flatter, more global-type structure. This evolution will be tied to the development of professional management ability and advanced skills within the OT LLC workforce. The overall OT LLC management organizational structure is presented in Figure 24.1.

Figure 24.1 Organization Chart for Overall OT LLC Management



24.1.2 Training and Human Resources

OT LLC recognizes that employment, benefits, and training are vital to meeting project goals for operations. OT LLC has made commitments and developed plans related to training and human resources as part of its corporate commitments and stewardship of the project.

Human resources functions for national, regional, and site requirements will be managed centrally in Ulaanbaatar, supported by permanent recruitment offices in Dalanzadgad and Khanbogd, to maintain consistency through the recruitment, hiring, and training processes. Recruitment and training will be linked to the project development schedule and strategy to ensure successful workforce ramp-up.

To meet the needs of construction and operations, fixed rosters have been developed as part of the work rotation strategy. There are four principal rosters for construction and two principal rosters planned foroperations. These rosters will guide the work rotation of the OT LLC workforce at site, regional offices, and in Ulaanbaatar.

24.1.3 Workforce Development

Present planning provides for an operations workforce consisting of both expatriates and Mongolian nationals. This is largely owing to a lack of Mongolian exposure to the particular technical and trades skills that will be required for the Oyu Tolgoi operation. It is anticipated that the requirements for an expatriate workforce will decline as the operation matures and Mongolian staff skill levels improve to international best practice standard through training and on-the-job experience. This phased reduction will follow the commitments outlined in the IA with the GOM.

24.1.4 Supply and Logistics

The volumes of incoming freight for the operations phase have not yet been established, but quantities will be much lower than those required for construction.

OT LLC's procurement standards and processes have been developed to ensure that the manner in which the procurement function is conducted is transparent and understood by all key stakeholders. The Statement of Procurement Practice (October 2010) sets out a range of expectations and commitments relating to how business will be conducted between the Oyu Tolgoi Procurement team, its internal customers (or other departments within the Oyu Tolgoi business), and suppliers to the business. An annual external audit will ensure OT LLC is at all times meeting the commitments outlined under the Statement of Procurement Practice.

24.1.5 Concentrate Shipment and Handling

Copper concentrate will be sold in-bond free-on-board at a bonded yard on the Chinese side of the border in Ganqimaodao. The proposed copper concentrate transport strategy assumes the existence of a bi-lateral concentrate export/import agreement to allow concentrate to be shipped across the border directly and without having to operate a cross-border shuttle service for full and empty containers.

The Chinese railway is planning to construct an extension of its network to Ganqimaodao. Once this rail line becomes operational, copper concentrate will be exported in bulk to a small truck reload facility at Ganqimaodao for those customers requiring truck delivery.

24.1.6 Environment, Health, and Safety

Oyu Tolgoi Health & Safety Management System (H&S MS) has been developed to provide Management with clear direction on health and safety management and to ensure compliance and provide the basis for driving improvements.

24.1.7 Operational Readiness Plan

The detailed Operational Readiness Plan covers all operating aspects of the Oyu Tolgoi project. It includes an overview of OT LLC's operational framework and operating philosophy and descriptions of the pertinent strategy, plans, and procedures for 21 identified functions across the project, both on- and off-site.

24.2 Risk Assessment

Risk analysis was undertaken for IDOP with the assistance of Rio Tinto Technology and Innovation (RT T&I) which updated the previous risk analysis that was conducted in September 2011. The risks identified in IDOP remain current, the summary below includes discussion based on the current status of the Project.

24.2.1 Summary

RT T&I was asked by OT LLC to facilitate a series of risk analysis workshops to assist in the process of identifying and evaluating risks associated with various key aspects of the Oyu Tolgoi project. The workshops were conducted on and between 25 and 29 October 2010 in Vancouver, Canada. The scope of work for these activities is described in a September 2010 document to Rio Tinto Copper Projects (RTCP)/OT LLC from RT T&I. Key project staff and consultants who were unable to attend the risk workshops were remotely accessed via telecommunications hook-ups, primarily from the project administration office in Ulaanbaatar, Mongolia.

RTCP/OT LLC requested the semi-quantitative risk analysis to identify and analyse the various threats and opportunities associated with the project as viewed and perceived at the time the risk workshops were conducted. The October 2010 risk analysis represents an update to a previous risk analysis conducted by Rio Tinto in September 2009. Earlier risk analyses were also carried out in November 2008 and September 2007. For continuity purposes, all risks identified in the September 2009 risk register were carried over in the current risk register. All September 2009 risks that were deemed to be still applicable were reassessed for likelihood and consequence impacts; if the risk was deemed to be no longer applicable, it was so indicated by being greyed out in the latest risk register.

24.2.2 Key Assumptions

The risk analysis focussed on threats rather than opportunities as the significant opportunities at Oyu Tolgoi were included within the risk analysis assumptions. Five key assumptions were made in the risk analysis of Oyu Tolgoi:

- Business values, in terms of capital expenditures, operating costs, and productivity, can be achieved by the Project.
- The Project will be delivered on time and on a budget that is in an acceptable plus/minus range under the current status of the Project.
- Acceptable safety, health, and environmental performance maintained throughout the Project.
- Maintain excellent relationship with GOM and approval bodies.
- Uphold acceptable management of community and social concerns and expectations of the Project.

24.2.3 Recommendations

To achieve the objectives of the risk analysis, Rio Tinto recommended the following:

- Fully understand the results of the risk analysis and manage the identified risks – particularly the Class III and Class IV risks, which require active management – in a manner that is consistent with the candidate risk-management measure(s) recorded in the risk register.
- Confirm Risk Owners assigned to each risk and ensure that the designated individuals are provided the financial resources, authority, and managerial support to successfully execute the agreed upon candidate risk-management measures. If needed, Risk Owners need to assign Task Owners to assist them with their risk-management duties and responsibilities.
- Appoint a senior-level person as a “Risk Champion” to assure that all assigned Risk Owners fulfil their risk-management responsibilities.
- At the appropriate time, develop implementation plans and schedules for each candidate risk-management measure that has been assigned; particularly, the Class III and Class IV risks, which require active management.
- Conduct periodic and detailed reviews of the risk register, as applicable, to gauge progress and identify and address any gaps in the risk-management program or problems with the proposed risk-management actions that were identified in the risk register. Typically, such reviews are carried out at:
  - A quarterly basis
  - Upon any developments that alter the nature and/or size of the risks, and/or
  - As key project milestones are reached.

  Such reviews and updates can be used to evaluate and refine the risk register due to real or anticipated changes implemented since the original risk analysis was completed.

This is particularly important for Oyu Tolgoi, since a number of key assumptions made during the focused risk workshop may need to be altered and or revised as the Project progresses forward at a relatively rapid pace.

24.2.4 Risk Areas

The following key development features identified for IDOP identify the areas for which the main risks have been reported by the risk analysis process:

- Investment Agreement
- Environment
- Marketing
- Water Supply and Management
- River Diversion
- Infrastructure
- Workforce for Operations
- Schedule Risks
- Power Supply
- Financing

24.2.4.1 Investment Agreement and Taxation Assumptions

The risk analysis was carried out prior to the signing of the IA and many of the risks related to unknowns in relation to the terms of the IA at the time of the analysis work and addressing the issues that are now part of the IA conditions precedent. The signing of the IA has allowed many of the issues to be clarified and will provide a better understanding of potential risks as well as identifying opportunities in the next stage of the continuous risk analysis process. The IA has been signed by all parties and became effective at 31 March 2010 as a number of conditions precedent before terms come into effect were completed to the satisfaction of all parties.

24.2.4.2 Environment

To date, no environmental issues have been identified that cannot be managed through normal mining practices. Both environmental and social monitoring activities are ongoing for the Project. The revised ESIA is planned for completion in April 2012 to International Finance Corporation and European Bank for Reconstruction and Development standards.

The environmental baseline assessment for the project was prepared by drawing upon the wide range of internal and independent studies that have been prepared since 2003. The existing information was reviewed and assessed for accuracy, consistency and validity. Where additional environmental baseline data became available in 2010 before the draft ESIA was produced, these were incorporated into the ESIA.

Further data collection studies have been commissioned and started and commitments have been made in the corresponding management plans to ensure that collection of baseline data continues to improve and that the results of ongoing monitoring will be integrated into updated and revised management plans and procedures.

The baseline chapters presented in the ESIA are, necessarily, a summary of an extensive body of research and assessment that has been ongoing over many years.

24.2.4.3 Marketing

Current consumption trends for copper suggest that Oyu Tolgoi is well positioned to sell its product. A diversified strategy will be needed to evaluate and encourage the development of greater smelter capacity in geographically favourable regions of China and elsewhere in Asia as concentrate production at Oyu Tolgoi increases beyond 1.5 Mtpa.

As part of the IA, OT LLC has made a commitment to undertake a feasibility study for the construction of a copper smelter in Mongolia to service Oyu Tolgoi. This study must be completed within 5 years of commencement of production. OT LLC is not committed to finance or build a smelter itself under the terms of the IA.

Non-binding memoranda of understanding for concentrate sales to two large Chinese smelters were agreed to during Q3 2011. Contracts are expected to be finalized with these smelters over the coming months. In addition, non-binding agreements on principal sales terms have been reached with two international trading companies; conversion of these agreements to binding contracts is under discussion. Most of the concentrate initially produced at Oyu Tolgoi is expected to be delivered to customers in China.

24.2.4.4 Water Supply and Management

The development of a borefield to access groundwater reserves within the Gunii Hooloi aquifer basin has been established as the most cost-effective option to meet the raw water demand for the project. Water from the borefield will be required for process water supply, dust suppression in the mining areas, and potable use.

Close monitoring of aquifer behaviour, calibration of models, and monitoring of relevant surface features will become priorities as operations commence.

Entry into the region by other resource companies and increased demand due to population increases will heighten the competition and sensitivities associated with water supply.

Preliminary estimates of total site water demand for a future processing rate of 160 ktpd are 918 L/s average and 1,081 L/s peak, both figures incorporating a conservative design development contingency of 25%. These estimates assume a Phase 1 peak design processing rate of 110 kt/d at 92% plant availability, 64% tailings density, and 0% mine dewatering. Although some mine water could become available at certain stages of mining, the amount would be limited and has been conservatively excluded from design assumptions.

Water consumption in the process plant represents more than 90% of the total demand, estimates of total site water demand for the Phase 2 processing rate of 160 ktpd are 918 L/s average and 1,081 L/s peak, both figures incorporating a conservative design development contingency of 25%.

OT LLC currently has an approved GOM licence for the abstraction of 870 L/s from Gunii Hooloi and plans to seek an increase for the project expansion based on revised yield numbers that were developed after pump-testing the borefield in 2011.

The Oyu Tolgoi Environmental Management System, currently under development in accordance with ISO14001 standards, will include water conservation as one of the key areas of continuous improvement during the operations period.

24.2.4.5 River Diversion

The existing Undai River channel runs through the future open pits. Subsurface flow in the river channel is constant, but surface flow is sporadic, occurring only after heavy rainfall. The river must be diverted to prevent the mining hazard represented by water inflows to the pit and to ensure continued supply to downstream users. Because the near-surface water in the river flows in a perched water table, separated from the underlying groundwater table, the river flow is not expected to be affected by the drawdown associated with mine dewatering.

24.2.4.6 Infrastructure

Oyu Tolgoi is located in an isolated region of Mongolia, with little developed infrastructure. The site is; however, only 80 km from the Chinese border, where resources do exist to support the Project in the energy, transportation, manufacturing, and construction areas. The development plan for the Project is based on the principle of maximizing Mongolian content while involving and realizing the benefits of the resources in China. Balancing the dual objectives is seen as achievable.

It is also assumed that the Chinese road and rail transportation systems can accommodate the movement to site of imported materials required for construction and operations and the shipment off site of all concentrate produced at the process plant. This will need to be confirmed.

24.2.4.7 Tailings Storage Facility

The TSF analysis concluded that the current design is acceptable for reporting purposes and there are opportunities to further simplify the TSF design and operating plan to achieve a lower net present cost for tailings management.

24.2.4.8 Workforce for Operations

OT LLC plans to maximize Mongolian employment levels and achieve a 90% national operating workforce. Mongolian exposure to the specific technical and trade skills required for the Project has been limited, and an extensive training program will be required to achieve this level of local participation.

24.2.4.9 Schedule Risks

IDOP noted that there are risks associated with large scale mining (both open pit and underground) and processing development, construction, and operating that may occur because of changes to the assumptions and could cause delays to the project.

The most significant schedule risk that has currently been identified are from delays to the underground production. OT LLC is actively managing these issues and has plans in place that are mitigating the issues.

The design of the underground incorporates 4 shafts and 5 raises to ventilate the mine. The intended method of construction for the 5 ventilation raises is by raise boring. There has proven difficult and has suffered delays, the primary reason for schedule slippage has been due to poor ground conditions. Completion of the ventilation raises is on the critical path to production from the underground mine as the raises are required to meet the ventilation requirements for development and provide alternative means of egress should Shaft 1 be unavailable.

24.2.4.10 Financing

Timely development of the Oyu Tolgoi Project depends upon Turquoise Hill's ability to maintain an adequate and reliable source of funding. Under the MOA, Turquoise Hill and Rio Tinto agreed to a comprehensive financing plan for the completion and start-up of the Oyu Tolgoi Project; however, volatility in capital markets and other factors may adversely affect Turquoise Hill's ability to acquire the remaining project finance component to OT Project Financing. Turquoise Hill operates in a region of the world that is prone to economic and political upheaval and instability, which may make it more difficult to obtain sufficient debt financing from project lenders. Failure to obtain sufficient additional financing would likely have a materially adverse impact on Turquoise Hill's ability to maintain the current development schedule for the Oyu Tolgoi Project and could jeopardize Turquoise Hill's ability to meet its contractual commitments to third parties in respect of the Oyu Tolgoi Project, including those in respect of the Investment Agreement and the Shareholders' Agreement. Turquoise Hill may be able to partially mitigate the risk of failing to obtain additional financing by selling some or all of its non-core assets but there is no assurance that the proceeds of any such sale would be sufficient to meet all Oyu Tolgoi Project expenditure requirements.

24.2.4.11 Power Supply

The IA recognized that reliable supply of electrical power is critical to the Project. The agreement also confirmed that Ivanhoe has the right to obtain electrical power from inside or outside Mongolia, including China, to meet its initial electrical power requirements for up to 4 years after Oyu Tolgoi begins commercial production. The agreement further established that (i) Ivanhoe has the right to build or sub-contract construction of a coal-fired power plant at an appropriate site in Mongolia's South Gobi region to supply the Project; and (ii) that all of the project's power requirements would be sourced from within Mongolia no later than 4 years after the start of commercial production.

The Oyu Tolgoi project will be energy-intensive, with electrical power requirements of more than 200 MW on start-up, increasing to around 310 MW in the longer term. A reliable and stable power supply is essential for operations and safety..

TRQ announced on 5 November 2012, that Oyu Tolgoi had signed a binding Power Purchase Agreement with the Inner Mongolia Power Corporation to supply power to the Oyu Tolgoi mine. The term of this agreement covers the commissioning of the business plus the initial four years of commercial operations.

The Oyu Tolgoi IA recognized that the reliable supply of electrical power is critical to the mine. The agreement also confirmed that TRQ has the right to obtain electrical power from inside or outside Mongolia, including China, to meet its initial electrical power requirements for up to four years after Oyu Tolgoi commences commercial production. The agreement established that a) TRQ has the right to build or sub-contract construction of a coal-fired power plant at an appropriate site in Mongolia's South Gobi Region to supply the Oyu Tolgoi mine and b) all of the mine's power requirements would be sourced from within Mongolia no later than four years after the start of commercial production. TRQ continues to evaluate several options to meet its commitment to sourcing power from within Mongolia, including the development of a dedicated power plant and ownership and funding options to meet this requirement.

Power will be delivered to the infrastructure, underground mines, and concentrator via a twin-circuit 220 kV transmission line system and be distributed at 220 kV and 35 kV as required through a central substation approximately 500 m south of the concentrator facility. A second 220 kV switchyard and substation will be constructed adjacent to the production headframes for shafts 2 and 3.

In November 2011, the GOM provided OT LLC a cabinet resolution allowing for the future construction by OT LLC of a coal-fired power plant in Mongolia dedicated to the Project. Such a plant would require certain GOM permits, the negotiation of commercial agreements with the GOM and coal suppliers, and the arrangement of financing for construction. There is no provision for a plant in the current capital cost estimates for 2013, and the additional financing that would be required for such a plant is not contemplated as part of the Company's current financing plan.

25 INTERPRETATION AND CONCLUSIONS

25.1 Mineral Resource

- The geology of the Project is well understood.
- The deposits are considered to be examples of a copper–gold porphyry system and related high-sulphidation types of deposits.
- The deposits are grouped into three areas: Heruga, Southern Oyu and Hugo Dummett.

The exploration program relies strongly on geophysical survey data (IP and magnetics), and other target anomalies still remain within the Project land holdings.

25.1.1 Southern Oyu Deposits

Four deposits are known in the Southern Oyu system, each of which are potentially mineable by open pit methods. In the current Technical Report, the resource estimate has been re-estimated in 2012. The base case assumes a CuEq cut-off of 0.22% but includes the results of alternative scenarios down to 0.2% CuEq cut-off. The base case CuEq cut-off grade assumption was determined using cut-off grades applicable to mining operations exploiting similar deposits.

The Southwest Deposit consists primarily of pyrite–chalcopyrite mineralization related to biotite-magnetite alteration, overprinted by chlorite–sericite alteration. Mineralization is characterized by high gold contents with gold-copper ratios (g/t Au to % Cu) of about 1:1 in the main part of the deposit, rising to 3:1 in the core of the system and at depth. Gold in the Southwest Oyu deposit is closely associated with chalcopyrite and occurs intergrown with chalcopyrite, as inclusions and fracture infills within pyrite, or on grain boundaries of pyrite. The deposit is essentially hosted in augite basalts.

Oyu South Deposit mineralization is hosted in quartz monzodiorite in the south-west and basalt throughout the central portion of the deposits. Chalcopyrite is the principal copper sulfide, but in higher-grade areas bornite locally exceeds chalcopyrite. Alteration in basaltic rocks consists of chlorite, biotite, hematite–magnetite, and weak sericite. Quartz monzodiorite has been altered by advanced argillic alteration. Small zones with elevated gold values occur locally.

Mineralization in the Central Deposit is characterized by an upward-flaring high-sulfidation zone that overprints and overlies porphyry-style chalcopyrite–gold mineralization. A secondary enriched supergene chalcocite blanket tens of metres in thickness overlies the high-sulfidation covellite–pyrite zone. The high-sulfidation portion of the Central Oyu deposit contains a mineral assemblage of pyrite, covellite, chalcocite–digenite, enargite, tennantite, cubanite, chalcopyrite, and molybdenite. Dominant host rocks are dacite tuff and quartz monzodiorite. Higher-grade mineralization is associated with disseminated and coarse-grained fracture-filling sulfides in zones of intensely contorted quartz stockwork veins and anastamosing zones of hydrothermal breccias. Chalcopyrite–gold mineralization is dominant on the south and western margins of Central within either basalt or quartz monzodiorite adjacent to intrusive contacts with basalt. The high-sulfidation part of the Central deposit lacks

significant gold. Alteration in the Central deposit shows a close spatial relationship to mineralization and original host lithology. Biotite–chlorite and intermediate argillic alteration coincide with chalcopyrite–gold mineralization within basalt. Advanced argillic and sericite alteration coincide with the high-sulfidation mineralization within quartz monzodiorite, and ignimbrite.

The Wedge Deposit contains a zone of high sulfidation mineralization hosted principally in dacite tuff, grading downward and southward into chalcopyrite mineralization in basalt and quartz monzodiorite host rocks. High-sulfidation mineralization consists of pyrite, chalcopyrite, bornite, enargite, covellite, and primary chalcocite in advanced argillically-altered host rocks. The high-sulfidation mineralization grades downward into chalcopyrite, with lesser bornite within basalt host rocks, and pyrite + chalcopyrite mineralization in quartz monzodiorite. Gold is absent, except locally in drillholes adjacent to the South Fault.

25.1.2 Hugo South Deposit

Copper mineralization at the Hugo South deposit is centred on a high-grade (typically >2% Cu) zone of intense quartz stockwork veining, which in much of the deposit is localized within narrow quartz monzodiorite intrusions and extends into the enclosing basalt and dacite tuff. The intense stockwork zone has an elongate tabular form, with a long axis plunging shallowly to the north-north-west, and an intermediate axis plunging moderately to the east. Copper grades gradually decrease upwards from the stockwork zone through the upper part of the basalt and the dacite tuff, and a broader zone of lower copper grades occurs below and to the west in basalt and quartz monzodiorite.

25.1.3 Hugo North Deposit

The highest-grade copper mineralization in the Hugo North Deposit is related to a zone of intense stockwork to sheeted quartz veins. The high-grade zone is centred on thin, east-dipping quartz monzodiorite intrusions or within the upper part of the large quartz monzodiorite body and extends into the adjacent basalt. In addition, moderate– to high-grade copper and gold values occur within quartz monzodiorite below and to the west of the intense vein zone, in the Hugo North gold zone. This zone is distinct in its high gold (ppm) to Cu (%) ratios (0.5:1). Bornite is dominant in the highest-grade parts of the deposit (3% to 5% Cu), and is zoned outward to chalcopyrite (2%). At grades of <1% Cu, pyrite–chalcopyrite ± enargite, tennantite, bornite, chalcocite, and rarely covellite occur, hosted mainly by advanced argillically altered dacite tuff.

Elevated gold grades in the Hugo North deposit occur within the up-dip (western) portion of the intensely veined high-grade core, and within a steeply dipping lower zone cutting through the western part of the quartz monzodiorite. Quartz monzodiorite in the lower zone exhibits a characteristic pink to buff colour, with a moderate intensity of quartz veining (25% by volume). This zone is characterized by finely disseminated bornite and chalcopyrite, although in hand specimen the chalcopyrite is usually not visible. The sulfides are disseminated throughout the rock in the matrix as well as in quartz veins. The fine-grained sulfide gives the rocks a black “sooty” appearance. The red colouration is attributed to fine hematite dusting, mainly associated with albite.

The Hugo North Deposit is characterized by copper–gold porphyry and related styles of alteration similar to those at Hugo South. This includes biotite–K-feldspar (K-silicate), magnetite,chlorite–muscovite–illite, albite, chlorite–illite–hematite–kaolinite (intermediate argillic),quartz–alunite–pyrophyllite–kaolinite–diaspore–zunyite–topaz–dickite (advanced argillic), and sericite–muscovite zones.

25.1.4 Current Resource Estimation

The current Hugo North and Hugo South resource models were developed using industry-accepted methods and are considered acceptable for incorporation into resource estimates. The updated Southern Oyu model has been developed using a 2D level-plan projection method. It is recommended that a wireframe solid grade shell approach be used for further updates. If OT LLC continue to use the 2D level-plan projection method then a separate a wireframe solid grade shell approach should also be prepared to allow a comparison of the resource estimate and provide a confirmation of the results. AMC concurs with OT LLC's conclusion that the estimates for Ag, As and Mo may require review and revision. Revision of the Ag estimate may even result in an increase in grade relative to the 2005 model. OT LLC has reported the grades for Ag from the 2012 resource model for Mineral Resources but has used the Ag grade from the 2005 model for Mineral Reserves.

The Mineral Resources were classified using logic consistent with the CIM definitions referred to in NI 43-101. The mineralization of the Project satisfies sufficient criteria to be classified into Measured, Indicated, and Inferred Mineral Resource categories.

25.1.5 Heruga Deposit

The Heruga project, which lies within the Javkhlant MEL, contains a large zone of porphyry copper-gold-molybdenum mineralization that has been subject to ongoing systematic drilling by OT LLC.

The copper-gold-molybdenum porphyry-style mineralization at Heruga is hosted in Devonian basalts and quartz monzodiorite intrusions, concealed beneath a deformed sequence of Upper Devonian and Lower Carboniferous sedimentary and volcanic rocks. The deposit is cut by several major brittle fault systems, partitioning the deposit into discrete structural blocks. Internally, these blocks appear relatively undeformed, and consist of south-east-dipping volcanic and volcaniclastic sequences. The stratiform rocks are intruded by quartz monzodiorite stocks and dykes that are probably broadly contemporaneous with mineralization. The deposit is shallowest at the south end (approximately 500 m below surface) and plunges gently to the north.

The alteration at Heruga is typical of porphyry style deposits, with notably stronger potassic alteration at deeper levels. Locally intense quartz sericite alteration with disseminated and vein pyrite is characteristic of mineralized quartz monzodiorite. Molybdenite mineralization seems to spatially correlate with stronger quartz sericite alteration.

Copper sulfides occur at Heruga in both disseminations and veins/fractures. Mineralized veins have a much lower density at Heruga than in the more northerly Southern Oyu and Hugo Dummett deposits.

Modelling of mineralization zones for resource estimation purposes revealed that there is an upper copper-driven zone and a deeper gold-driven zone of copper-gold mineralization at Heruga. In addition, there is significant (100–1,000 ppm) molybdenum mineralization in the form of molybdenite. Locally high gold grades (exceeding 50 g/t) appear to be associated with base metal ± molybdenite in late stage veins.

The Mineral Resource estimate for the Heruga deposit was prepared by Stephen Torr of Ivanhoe Mines under the supervision of Scott Jackson of Quantitative Group. A close-off date of 21 June 2009 for all survey (collar and down hole) and assay data incorporated into the database.

Ivanhoe created three dimensional shapes or wireframes of the major geological features of the Heruga deposit. To assist in the estimation of grades in the model, Ivanhoe also manually created three dimensional grade shells (wireframes) for each of the metals to be estimated. Construction of the grade shells took into account prominent lithological and structural features, in particular the four major subvertical post-mineralization faults. For copper, a single grade shell at a threshold of 0.3% Cu was used. For gold, wireframes were constructed at thresholds of 0.3 g/t and 0.7 g/t. For molybdenum, a single shell at a threshold of 100 ppm was constructed. These grade shells took into account known gross geological controls in addition to broadly adhering to the abovementioned thresholds.

QG checked the structural, lithological, and mineralized shapes to ensure consistency in the interpretation on section and plan. The wireframes were considered to be properly constructed and honoured the drill data.

Resource estimates were undertaken using Datamine® commercial mine planning software. Interpolation domains were based on mineralized geology, and grade estimation based on ordinary kriging. Bulk density was interpolated using an inverse distance to the third power methodology. The assays were composited into 5 m down hole composites; block sizes were 20 m x 20 m x 15 m.

QG also built a model from scratch using the same wireframes and drill data used in the Ivanhoe model. Gold, copper, and molybdenum were interpolated using independently generated variograms and search parameters. QG compared the two estimates and consider they are well within acceptable limits thus adding additional support to the estimate built by Ivanhoe.

The Mineral Resources for Heruga were classified using logic consistent with the CIM definitions required by NI 43–101. Blocks within 150 m of a drillhole were initially considered to be Inferred. A three dimensional wireframe was constructed inside of which the nominal drill spacing was less than 150 m. The shape aimed to remove isolated blocks around drillholes where continuity of mineralization could not be confirmed. Within the 150 m shape there were a small number of blocks that were greater than 150 m from a drillhole. These were included because it was considered that geological and grade continuity could be reasonably inferred within the main part of the mineralized zone. Of the total tonnes classified as Inferred, approximately 95% are within 150 m of a drillhole while the average distance of the Inferred blocks is approximately 100 m.

25.2 Mineral Reserve

The Mineral Reserves in this Study are based on feasibility study level work carried out for Oyu Tolgoi in 2013 OTTR. Measured and Indicated Resources have been converted to Proven and Probable Mineral Reserves. The study work has been used to support project financing and meets requirements for Mineral Reserve reporting under the NI 43-101 Standards of Disclosure for Mineral Projects and those of US Industry Guide 7. This result meets the main objective of the Study.

OT LLC identified a probem with the Ag grade in the resource model and reverted to the 2005 Ag grade for mine planning work. As discussed in Section 14, the silver grades in the current resource model are lower than the 2005 model silver grades. Silver is a by-product and this difference has been calculated to have an NSR value of approximately $0.10/t. AMC considers that this is within the accuracy of the study work and is not a material issue. AMC has therefore concluded that the Mineral Reserve is valid. However it is recommended that the Feasibility Study review the resource estimates for silver and that the updated mine planning work take account of any changes to silver and other elements.

25.3 Metallurgy and Mineral Processing

The Oyu Tolgoi orebody has been extensively tested and modelled and the South West and Hugo North porphyry-style ore is expected to perform in accord with its generally simple, straightforward mineralogy, although fluorine levels will incur smelter penalties. However the Central ore, being a high sulphidation style, exhibits greater mineralogical complexity and arsenic levels in particular, related to the enargite content, will create significantly elevated levels of arsenic in the concentrate, potentially reaching rejection limits.

It is planned to blend the Central ore with Hugo North ore to mitigate the effects of elevated arsenic, but as the Hugo North ore has shown significant grade - recovery variability in testwork and in itself has some areas with enargite occurring, it will be essential to build a comprehensive geometallurgical model in order to effectively support this blending strategy.

The concentrator design and installation is appropriate to the ore treatment requirements but AMC notes that laboratory and maintenance facilities are not of the standard expected to support the treatment of an ore that at times will be geometallurgically complex and in an environment with limited off-site engineering and maintenance capability.

26 RECOMMENDATIONS

Recommendations have been stated throughout the text of the report. OT LLC has commenced production from the open pit, the concentrator is expected to reach commercial production in mid 2013 and the underground mine at Hugo North is being developed. OT LLC intends to use this experience and apply it to the continued sudy and operation of the project. AMC concurs with this plan. The key recommendations for further work are:

26.1.1 OT LLC Value Engineering

OT LLC plans to undertake engineering studies of expansion options in the continuing Feasibility Study for Oyu Tolgoi. This will include examining all production scenarios and associated expansion options. OT LLC plans a focused and structured review of the study work to be used in the capital approvals process as the operation developments. AMC believes that further design work could identify opportunities to improve project economics via cost reductions and mine plan optimization.

The Phase 2 Project Expansion Plan should continue to be studied to identify the capacity and definition of the project expansion requirements, infrastructure, power supply, water permitting, concentrate marketing, the underground feasibility study, and further work on mine closure and reclamation plan. A detailed execution plan is being developed for Phase 2 that includes lessons learned and incorporates tools and advancements from the Phase 1 project execution.

26.1.2 Alternative Production Cases

The mine designs and production schedules available for the alternative production cases are:

- Southern Oyu Open Pits (2013 Mineral Reserve)
- Hugo North Lift 1 Block Cave (2013 Mineral Reserve)
- Hugo North Lift 2 Block Cave (Inferred)
- Hugo South Block Cave or Open Pit (Inferred)
- Heruga Block Cave (Inferred)

Under the NI 43-101 guidelines, Inferred Mineral Resources are considered too speculative geologically to have the economic considerations applied to them that would allow them to be categorized as Mineral Reserves. There is no certainty that the alternative production cases will be realized.

Currently the designs for Hugo North Lift 2, Hugo South Block Cave, and Heruga are the same as those in IDP10. The Hugo South open pit designs were updated in 2012. From the designs two sets for long-term production scheduling can be prepared, one with Hugo South as underground and one as open pit. The two sets are shown in Figure 26.1 and Figure 26.2. The work on the alternative production cases is not complete, in particular the definition of the expansion sizes and costing of the cases.

Figure 26.1 Alternative Production Design Set 1

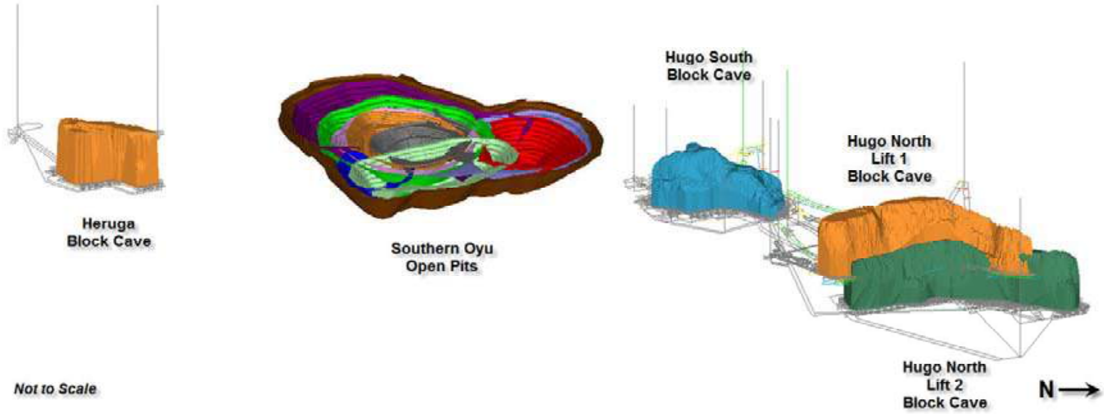
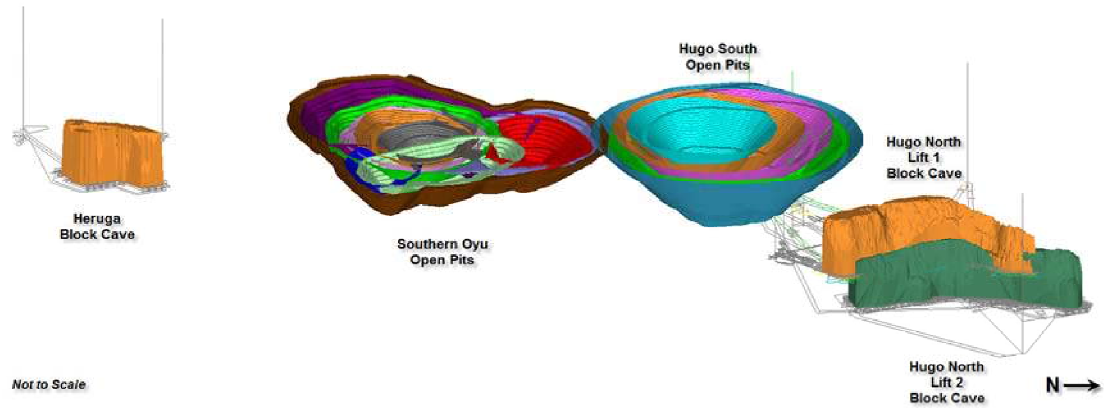
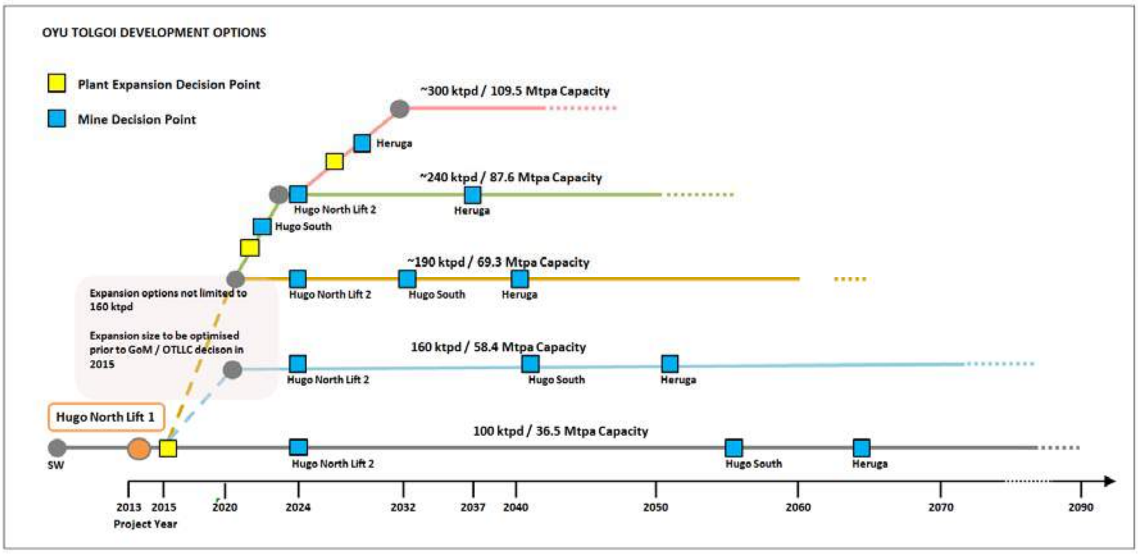


Figure 26.2 Alternative Production Design Set 2



These cases will be part of the strategic planning that is being undertaken by OT LLC. This work will examine the plant capacity for expansions. Figure 26.3 shows an example of the potential decision tree for the potential development options at Oyu Tolgoi.

Figure 26.3 Oyu Tolgoi Development Options



26.1.3 Power Supply Determination

The supply of power has been recognized as being critical to the execution of the Oyu Tolgoi Project in the IA. OT LLC has been given the right to import power initially but must secure power from sources within Mongolia from the fourth year of operation.

The PPA is now in place to allow power to be imported from Inner Mongolia. The next phase of the IA is for OT LLC to source power from Mongolia by the fourth year of operation in accordance with the terms of the IA.

There is no provision for a plant in the current capital cost estimates and the financing that would be required is not contemplated as part of the Company’s current financing plan.

OT LLC is currently considering a range of options to ensure a reliable and efficient power supply after Year 4.

26.1.4 Water Permit

OT LLC’s strategy is to obtain approval for increases to the currently approved water reserve ahead of any mine expansion plans. The objective of the study will be to assess the impact if any on the concentrator expansion on water demand and to determine the need for obtaining GOM approval for any substantial increase in the approved water demand from the Gunii Hooloi aquifer.

The current estimate of average water demand for the concentrator expansion to 160 ktpd is 918 L/s, which is marginally above the rate of 870 L/s that has already been approved by the GOM.

26.1.5 Concentrate Marketing

Long-term sales contracts have been signed for 75% of the Oyu Tolgoi mine's concentrate production in the first three years, while 50% of concentrate production is contracted for ten years (subject to renewals). In addition to the signed contracts, in early November 2012, Oyu Tolgoi committed in principle, subject to the conclusion of detailed sales contracts, up to 25% of concentrate available for export would be made available at international terms to smelters in Inner Mongolia for the first ten years.

OT LLC has developed a marketing plan and currently includes consideration of the following factors:

- Location value to customer compared to imported material landed at Chinese ports.
- Precious metals recovery and payment.
- Length of contract.
- Percentage of off-take to smelters versus traders.
- Percentage of tonnage on contract versus spot.
- Percentage of feed for any one smelter.
- Number of smelters for a given scale of operation.
- Management of concentrate quality and volume during commissioning and ramp-up.
- Alternate off-shore logistics and costs.
- Delivery point and terms.
- Packaging.

A detailed timeline has been developed for marketing, logistics, and contract-to-cash functions. OT LLC's Sales and Marketing will be supported by Rio Tinto Copper Marketing, led by its Chief Marketing Officer. The marketing team will oversee and execute all sales and marketing activities on behalf of OT LLC.

26.1.6 Socio-economic Aspects of Mine Closure Plan

The preliminary mine closure and reclamation plan includes provisions to ensure that adverse socio-economic impacts of mine closure are minimized and positive impacts are maximized. To this end, OT LLC has planned that allowances will be incorporated into the annual mine operations budget starting 10 years before mine closure to address the costs of:

- Lost employment by the mine workforce.
- Adverse effects on supply chain businesses and downstream businesses, affected communities, public services, and infrastructure.
- Promoting ongoing sustainability among affected stakeholders and communities.

The details of additional socio-economic aspects of a conceptual mine closure plan have not yet been fully developed and are the subject of work to be done in the near future.

26.1.7 Infrastructure

OT LLC has advised that it expects revisions to the project scope which may include:

- Operations camp expansion.
- Border facilities upgrade.
- Concentrate bagging plant upgrade.
- Power substation expansions.
- Central maintenance complex.
- Central control room.
- Borefield expansion.
- Operations warehouse expansion.
- Core storage warehouse.

There may be additions to scope beyond these items and all items and updated cost estimates will be included in further studies.

26.1.8 Documentation and File Management

The Oyu Tolgoi project has been developed quickly and as a result clear audit trails for work have not at times been maintained. It is recommended that systems and procedures be developed and implemented for the storage of the latest versions of data, with accompanying documentation and labelling, to ensure that the most up-to-date and correct files are always readily available to all concerned without any possibility of mistakenly accessing and using incorrect data.

26.1.9 Resource Model Updates

The updated Southern Oyu model has been developed using a 2D level-plan projection method. It is recommended that a wireframe solid grade shell approach be used for further updates. If OT LLC continue to use the 2D level-plan projection method then a separate a wireframe solid grade shell approach should also be prepared to allow a comparison of the resource estimate and provide a confirmation of the results.

27 REFERENCES

References to other reports and information have been identified throughout the report in the sections to which the references relate.

Table 27.1 Table of Abbreviations

'	Minute (plane angle)
"	Second (plane angle)
%	Percent
<	Less than
>	Greater than
°C	Degrees Celsius
µm	Micrometre (micron)
a	Annum (year)
bt	Billion tonnes
cm	Centimetre
cm^2	Square centimetre
cm^3	Cubic centimetre
d	Day
d/wk	Days per week
dmt	Dry metric ton
g	Gram
g/t	Grams per tonne
h (*not* hr)	Hour
ha	Hectare (10 000 m^2)
kg	Kilogram
kg/m^3	Kilograms per cubic metre
kg/t	Kilograms per tonne
km	Kilometre
km/h	Kilometre per hour
km^2	Kilometre squared
km^2	Square kilometre
Koz	Kilo Troy Ounces
kt	Thousand tonnes
ktpd	Kilo Tonnes per Day
L	Litre
lb	Pound(s)
m	Metre
M	Million
m/s	Metres per second
m^2	Square metre
m^3	Cubic metre

masl	Above mean sea level
masl	M above sea level
mg	Milligram
Mlb	Million pounds
mm	Millimetre
mmph	Millimetres per hour
Moz	Million Ounces
MPa	Megapascal
Mt	Million tonnes
oz	Ounce
ppb	Parts per billion
ppm	Parts per million
SG	Specific gravity
t	Metric ton (tonne)
t	Tonne (1,000 kg)
t/a	Tonnes per annum
t/d	Tonnes per day
t/m^3	Tonnes per cubic metre

Table 27.2 Glossary

2013 OTTR	
AAS	Atomic Absorption Spectroscopy
AB	Multiple Current Electrode IP
ABA	Acid Base Accounting
AC-Tek	Advanced Conveyor Technologies
AFS	Aminpro-Flot Simplex
AIF	Annual Information Form
AMC	AMC Consultants Pty Ltd
AMINPRO	Amelunxen Mineral Processing Ltd
ANFO	Ammonium Nitrate Fuel Oil
ARD	Acid Rock Drainage
ATV	Acoustic Televiewer
BCF	Proprietary Software
BiGd	Biotite Granodiorite
BWI	Ball Mill Work Index
CCTV	Closed-Circuit Television
CEET	Comminution Economic Evaluation Tool
CHR	Critical Hydraulic Radius
CIM	Canadian Institute of Mining
CuEq	Copper Equivalent
DDH	Diamond Drillhole

DEIA	Detailed Environmental Impact Assessments
DEM	Discrete Element Modelling
DFN	Discrete Fracture Networks
DFN	Discrete Fracture Network
DIDOP	Detailed Integrated Development Operations Plan
EBRD	European Bank for Reconstruction and Development
EFNARC	European Federation of National Associations Representing producers and applicators of specialist building products for Concrete
EIA	Environmental Impact Assessment
EJV	Entrée Joint Venture
EMS	Environmental Management System
Entree LLC	A subsidiary of Entree-Gold Inc
EP	Equivalent People
EPCM	Engineering, Procurement, and Construction Management
ESIA	Environmental and Social Impact Assessment
FEL	Front-End Loaders
FIFO	Fly-in-Fly-out
FLEET	Flotation Economic Evaluation Tool
FRS	Fibre-Reinforced Shotcrete
FS	Feasibility Study
G&A	General and Administration
GIS	Geographic Information System
GOM	Government Of Mongolia
GSI	Geological Strength Index
H&S MS	Health & Safety Management System
HEPA	High-Efficiency Particulate Air
HI	Hollow Inclusion
HME	Heavy Mobile Equipment
HSE MS	Health, Safety, and Environment Management System
IA	Investment Agreement
ICP-OES/MS	Inductively-Coupled Plasma Optical Emission Spectroscopy/Mass Spectrometry
ICT	Information and Communications Technology

IDOP	Integrated Development Operations Plan
IDOPTR	IDOP Technical Report
IDP05	Integrated Development Plan 2005
IDP10	Integrated Development Plan 2010
IDZ	Isolated Draw Zone
IFC	International Finance Corporation
IFC	Issued for Construction
IMMI EIA	Ivanhoe Mines Mongolia Incorporated Environmental Impact Assessment
IP	Induced Polarization
IRMR	In Situ Rock Mass Ratings
IRR	Internal Rate of Return
IRR	Internal Rate of Return
ITRB	Oyu Tolgoi Independent Technical Review Board
JORC	Australasian Joint Ore Reserves Committee Code
JV	Joint Venture
LAN	Local Area Network
LCT	Locked Cycle Testwork
LHD	Load-Haul-Dump
LIBOR	London Interbank Offered Rate
LOM	Life-of-Mine
MCE	Maximum Credible Earthquake
MEL	Mineral exploration licence
MFT	Modified Flotation Tests
MNE	Mongolian Ministry of Nature and Environment
MNET	Mongolia's Ministry Nature, Environment and Tourism
MRAM	Means the Mineral Resources Authority of Mongolia
MRMR	Mining Rock Mass Ratings
MRS	Mesh-Reinforced Shotcrete
MS	Mass Spectrometry
MT	Magnetotellurics
NAF	Non-Acid Forming
NGI	Norwegian Geotechnical Institute
NI 43-101	Canadian National Instrument 43-101 Standards of Disclosure for Mineral Projects
NN	Nearest Neighbour
NPV	Net present value

NSR	Net Smelter Return
OCDB	Oracle Content Database
OEL	Occupational Exposure Limits
OK	Ordinary Kriging
OT LLC	Oyu Tolgoi LLC
PAF	Potentially Acid Forming
PCBC	Personal Computer Block Cave
PEP	Project Execution Plan
PFS	Pre-feasibility Study
PIMA	Portable Infrared Mineral Analyzer
PMF	Probable Maximum Flood
PPA	Power Purchase Agreement
QA/QC	Quality Assurance and Quality Control
QMD/Qmd	Porphyritic Quartz Monzodiorite
QP	Qualified Person
RC	Reverse Circulation
RCAG	Research Center of Astronomy and Geophysics
RDP	Round Determinate Panel
ROM	Run of Mine
RQD	Rock Quality Designation
RSP	Review and Strategic Plan
RTCP	Rio Tinto Copper Projects
SAG	Semi-Autogenous Grinding
SBR	Sequencing Batch Reactor
SG	Specific Gravity
SGSPA	Small Gobi Strictly Protected Area
SIA	Social Impact Assessment
SLC	Sub-Level Cave
SMU	Selective Mining Unit
SOM	Stockpiled in an Oxide Material
SPI	SAG Performance Index
SPI	SAG Power Index
SRG	North-Seeking Gyro
SRM	Synthetic Rock Mass Modelling
SWIR	Short-Wave Infra-Red
TDR	Time Domain Reflectometers
TEC	Trace Elements Composites
TEM	Telluric Electromagnetic
TR	Technical Report
TRQ	Turquoise Hill Resources Ltd.

TSF	Tailings Storage Facility
UCS	Unconfined Compressive Strength
UG FS	Underground feasibility study
US CPI	United States Consumer Price Index
US SEC	United States Securities and Exchange Commission
UTS	Unconfined Tensile Strength
VAT	Value Added Tax
VoIP	Voice over Internet Protocol