

## Oyu Tolgoi Phase 2: Plans, Issues and Risks

An Overview of Oyu Tolgoi Phase 2 Mining Plans and some of the issues and risks associated with block cave underground mining, international metal price uncertainty, project power supply, and impacts on water resources used by herders



(Satellite image of Oyu Tolgoi Mine, November 2015, <http://landsatlook.usgs.gov>)

Prepared for  
CEE Bankwatch Network  
Prague, Czech Republic  
[www.bankwatch.org](http://www.bankwatch.org)  
and  
OT Watch  
<http://www.minewatch.mn/>

January 10, 2016

Prepared by Paul Robinson  
[sricpaul@earthlink.net](mailto:sricpaul@earthlink.net)  
Research Director, Southwest Research and Information Center  
Albuquerque, New Mexico 87107 USA  
[www.sric.org](http://www.sric.org)

## Tables of Contents

<b>Introduction</b>	<b>2</b>
<b>Who owns the Oyu Tolgoi (OT) Mine?</b>	<b>3</b>
<b>Where are the plans for OT Phase 2 described?</b>	<b>3</b>
<b>What is planned in the OT Phase 2 mine expansion?</b>	<b>4</b>
<b>What actions are needed to complete approval of the OT Phase 2 expansion?</b>	<b>14</b>
<b>What is Block Cave Mining?</b>	<b>16</b>
<b>Which Block Cave mines has Rio Tinto operated or planned?</b>	<b>18</b>
<b>What are the environmental Impacts of Block Cave Mining?</b>	<b>19</b>
<b>How large is the Subsidence Zone at the OT Hugo North Lift 1 underground mine predicted to extend?</b>	<b>30</b>
<b>What are Some of the Major Impacts of OT Phase 1 and 2 on Water Resources Used by Herders?</b>	<b>36</b>
<b>How do International Metal Market Prices affect Oyu Tolgoi Phase 2 Development and Funding Plan and Technical Reports?</b>	<b>42</b>
<b>How much have international metal market prices fallen since the OT Phase 2 Technical Report (OTTR 2014) was released?</b>	<b>43</b>
<b>What are some of the plans and issues associated with developing a power supply for OT Phase 2?</b>	<b>46</b>
<b>Are alternative sources of power possible for OT Phase 2?</b>	<b>49</b>
<b>Sources Cited</b>	<b>51</b>
<b>Brief Biography of the Author</b>	<b>55</b>

## Introduction

Oyu Tolgoi's Phase 2 plans to mine 1.5 billion tons of ore are described as the "Reserve Case Mine" in the October 27, 2014 Oyu Tolgoi Technical Report (OTTR 2014), the most detailed description of OT Phase 2 publically available. OTTR 2014 was prepared using the Canadian National Instrument 43-101 "Standards of Disclosure for Mineral Projects," which is required for mining companies listed on Canadian Stock Exchanges such as Turquoise Hill Resources (TRQ), 66% owner of Oyu Tolgoi LLC). (OTTR 2014 at P. i)

The "Reserve Case" ore to be processed during Phase 2 will come from two sources:

- 1) the Southern Oyu Tolgoi (SOT) open pit and
- 2) The deeper Hugo North "Lift 1" ore, mined using the underground block caving method.

Other mineral resources identified at the Oyu Tolgoi site but not proposed for the "Reserve Case" mine - "Phase 2" - are described as part of the long-term "Life of Mine Case" (OTTR 2014). "Life of Mine Case" deposits include: Hugo North "Lift 2" - an ore deposit beneath "Lift 1", the Hugo South, and the Heruga deposits. OTTR 2014 identifies a series of decision options related to the mining of the "Life of Mine Case" deposits during the next 10 years, and beyond, that could lead to development of these additional deposits, including extraction during the mining of the "Reserve Case" ore in the open pit and Hugo North Lift 1 in "Phase 2" that would be completed in the year 2055.

Development and financing plans for mining the OT "Reserve Case" ore is the subject of the May 18, 2015 Oyu Tolgoi Underground Mine Development and Financing Plan (OTUMDFP 2015) signed in Dubai by Government of Mongolia representatives and Oyu Tolgoi LLC's corporate owners. The OTUMDFP 2015 addresses a range of subjects including the cost of construction of OT Phase 2, OT Phase 2 impacts on the Mongolian economy, proposed schedules for action on development of a future OT power supply, an investigation of the economic viability of a copper smelter to refine the 30% copper concentrate currently produced at OT, and tax and financial accounting considerations, among other matters.

This report summarizes the mining activity proposed by OT in its Phase 2 development plan, describes the block caving underground mining technology planned for the large deep ore body to be mined in Phase 2, environmental impacts and reclamation potential of block cave mines, and issues and risks associated with a future OT power supply, international metal market price uncertainties, and OT Phase 1 and 2 impacts on water resources and herders and their livelihood in the region surrounding the OT mine license area.

### **Who owns the Oyu Tolgoi (OT) Mine?**

The Oyu Tolgoi copper and gold project (Oyu Tolgoi) is being developed by the Oyu Tolgoi Limited Liability Corporation (OT LLC).

OT LLC is 66% owned by Turquoise Hill Resources Ltd (TRQ) and 34% owned by Erdenes OT LLC. Rio Tinto plc (Rio Tinto) maintains a controlling interest in through its ownership of 51% of TRQ and is the manager of the OT project. The Government of Mongolia (GOM), through Erdenes OT LLC, owns 34% of OT. (OTUMDFP 2015)

### **Where are the plans for OT Phase 2 described?**

OT Phase 2 mining plans are described in the Oyu Tolgoi Technical Report released October 27, 2014 (OTTR 2014), a 547-page report prepared using the Canadian National Instrument 43-101 Standards of Disclosure for Mineral Projects, a mineral resource estimation and reporting regulation. On August, 27, 2015, OT announced it had submitted revisions of the schedules in its March 2015 Feasibility Study to the Mongolian Mining Council that “align” with the May 18, 2015 OT Underground Mine Development and Financing Plan (OTUMDFP 2015) and the OTTR 2014. (TRQ 8-2015)

Oyu Tolgoi has not made the March 2015 OT Feasibility Study available to investors or the public. It is not listed in SEDAR.com records of Canadian corporation public filing for OT along with previous NI43-101 compliant technical reports, or on the OT or TRQ websites. As OT’s March 2015 Feasibility Study is not available from the OT site or other publicly available sources, this Report relies on the OTTR 2014 as the most current available version OT’s plans for Phase 2. OTTR 2014 is available at [http://www.turquoisehill.com/i/pdf/2014-10-27\\_OyuTolgoiTechReport.pdf](http://www.turquoisehill.com/i/pdf/2014-10-27_OyuTolgoiTechReport.pdf) and [http://www.turquoisehill.com/s/oyu\\_tolgoi.asp?ReportID=379189](http://www.turquoisehill.com/s/oyu_tolgoi.asp?ReportID=379189)

Completion of an update to the March 2015 OT Feasibility Study is one of the obligations required under the OTUMDFP required before final approval by the Boards of Directors of the OT owners.

## **What is planned in Oyu Tolgoi's Phase 2 mine expansion?**

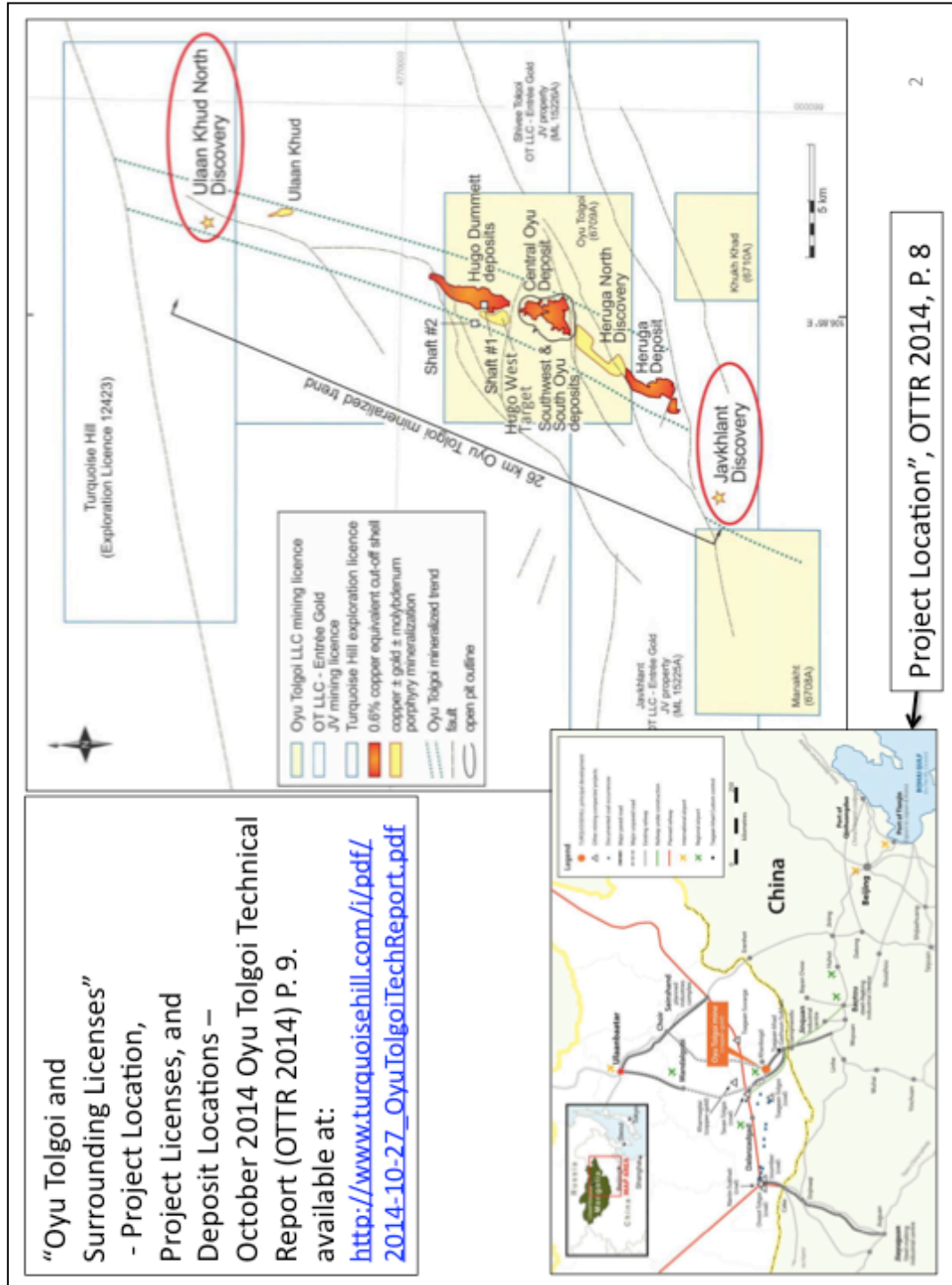
OT Phase 2 proposes the extraction and processing of ore from the currently operating Southern Oyu Tolgoi open pit (SOT) while also constructing and operating an underground mine using the block caving mining method to extract ore from a portion of the Hugo North ore deposit called "Lift 1" through the year 2055.

OTTR 2014 forecasts overall mine production during Phase 2, called the "Reserve Case" in OTTR 2014, continuing through 2055. OT Phase 2 ore production is projected to be average about 115,000 tons per day (tpd), equal to about 40 million tons per year, during the 2020 – 2039 period when the underground Hugo North Lift 1 block cave mine is proposed to operate. Future OT expansion that are not included in OT Phase 2 could involve additional underground mining at Hugo North Lift 2 beneath Lift 1, and underground mining at the Hugo South Deposit and the Heruga Deposits.

OT open pit ore production would fall from the current 100,000 tons per day to 20,000 tons per day during 2019 – 2039 period, when the Hugo North Lift 1 mine is projected to produce 95,000 tons ore per day. This proposed mix of open pit and underground ore is would keep the combined tonnage of OT ore processed to about 115,000 tons per day between 2019 when North Hugo "Lift 1" underground ore would begin to be extracted, and 2039 when ore extraction from the OT Phase 2 portion of the Hugo North underground mine would be completed.

OT Phase 2 plans, schedules and resource estimates are shown in Figures 1 – 9 that provide Figures from OTTR 2014 and an August 2015 OT Investor and Analyst Site Visit Presentation (TRQ 8-2015b) with annotations and commentary by the author..

Figure 1 - Oyu Tolgoi and Surrounding Licenses – Project Location



“Oyu Tolgoi and Surrounding Licenses” - Project Location, Project Licenses, and Deposit Locations – October 2014 Oyu Tolgoi Technical Report (OTTR 2014) P. 9. available at: [http://www.turquoisehill.com/ir/pdf/2014-10-27\\_OyuTolgoiTechReport.pdf](http://www.turquoisehill.com/ir/pdf/2014-10-27_OyuTolgoiTechReport.pdf)

Figure 2 - Location and Depth of Oyu Tolgoi Deposits

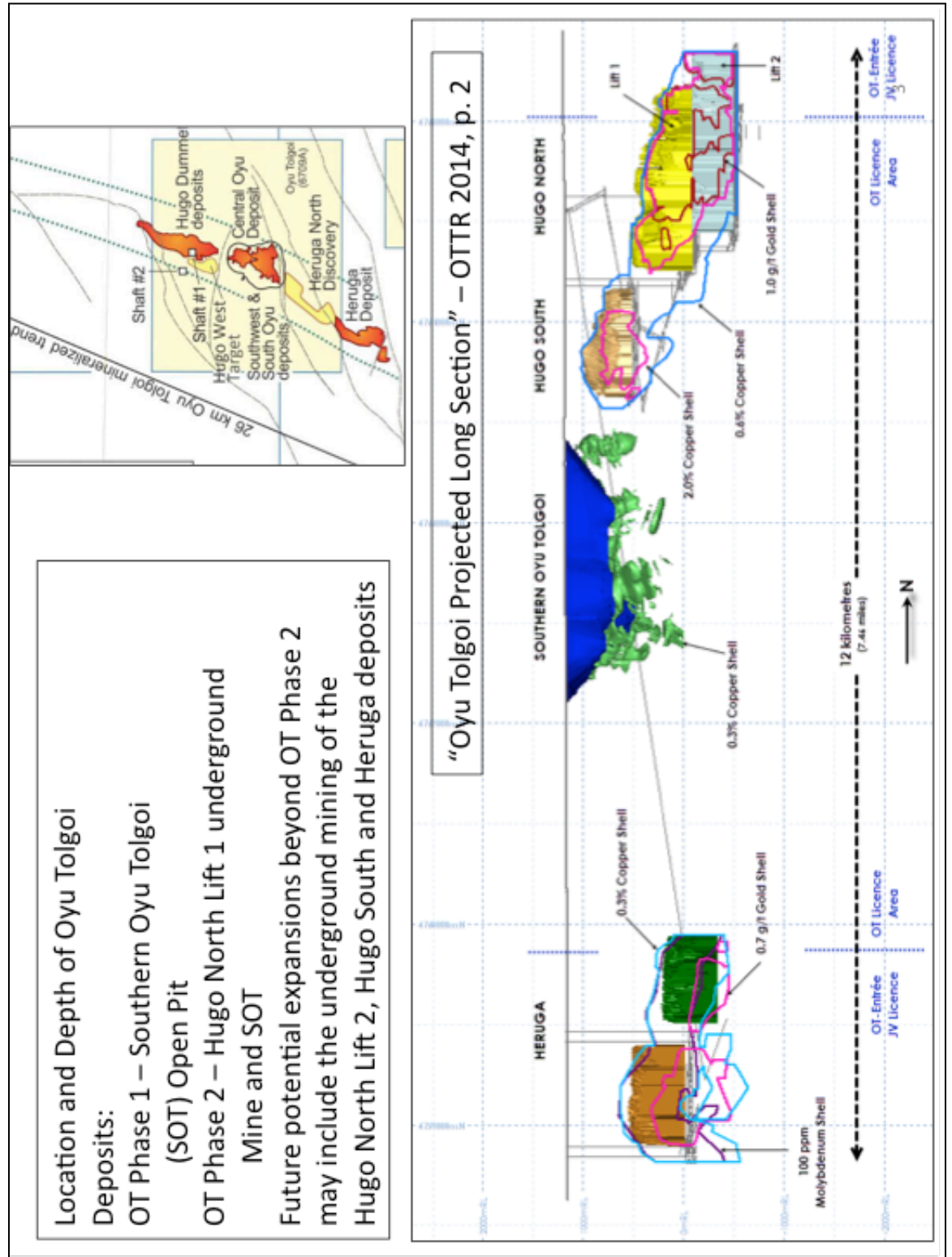




Figure 3 – OT Phase 2 Restart Milestones

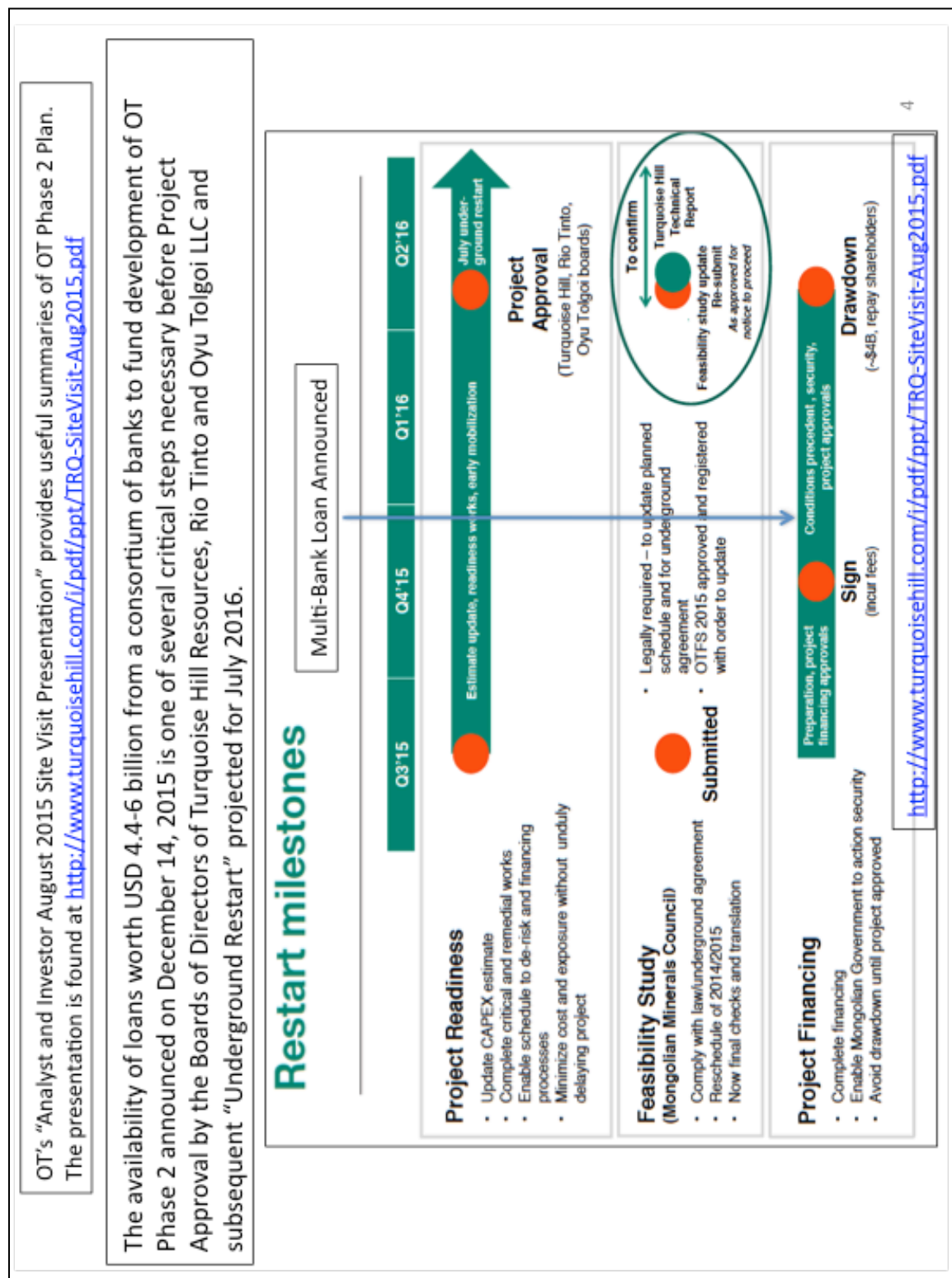
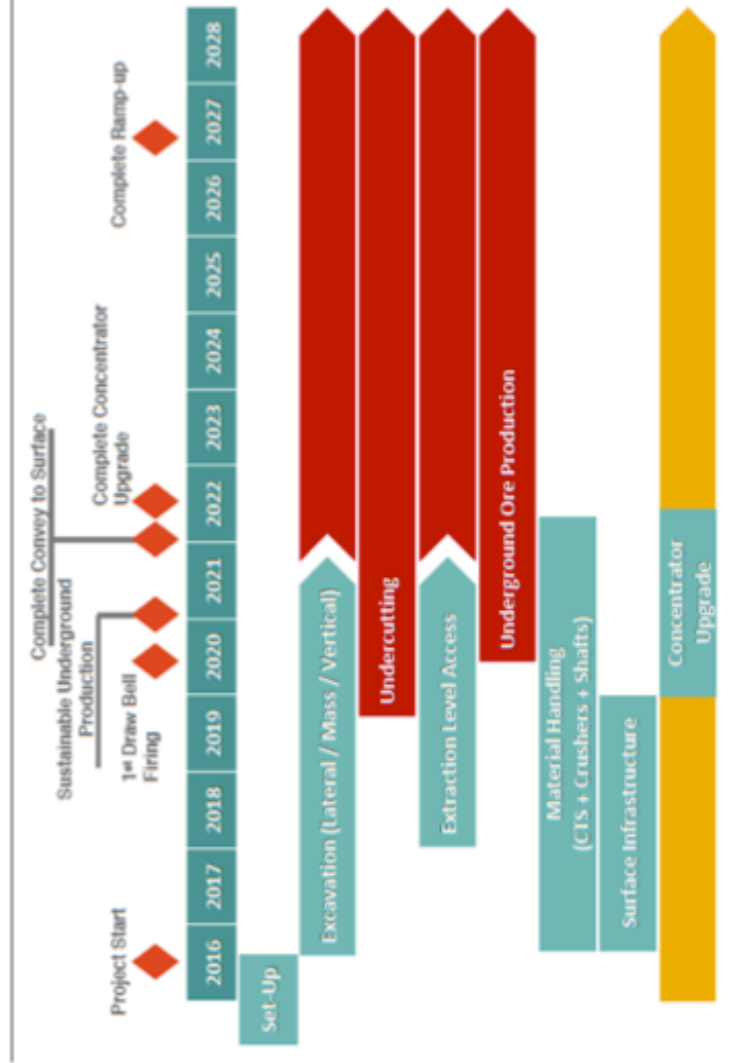




Figure 4 – OT Phase 2 Probable Development Schedule

Following Project Approval, The North Hugo Lift 1 underground mine is projected to take more than 10 years of construction to reach full production. The first underground ore production is anticipated in 2019, if project restart beings in 2016.

## Probable Development Schedule



<http://www.turquoisehill.com/i/pdf/ppt/TRQ-Site-Visit-Aug2015.pdf>

Figure 5 – OT Phase 2 Medium-Term Timeline – 2015-2026++

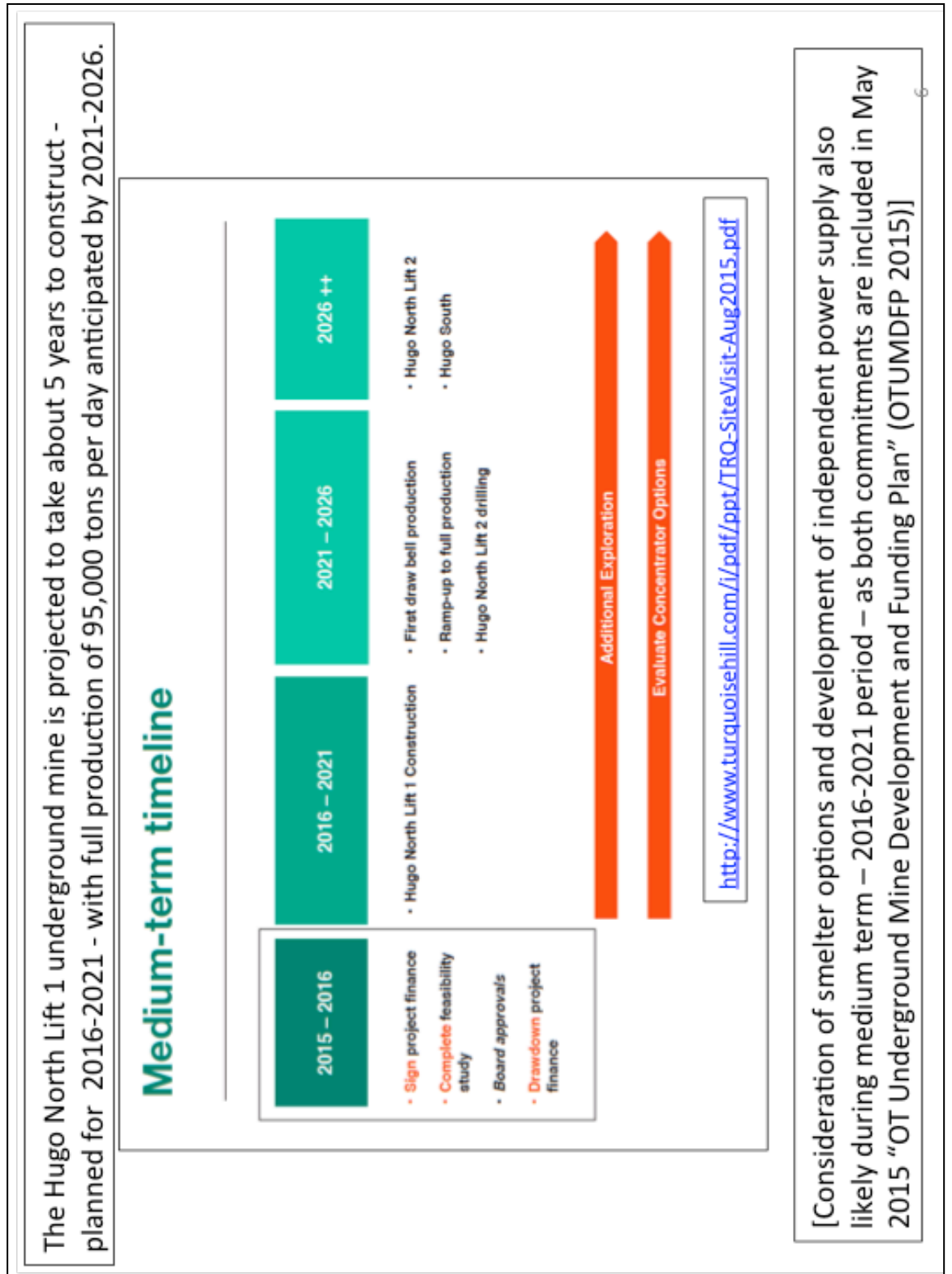


Figure 6 – OT Phase 2 Ore Description and Production Sequence

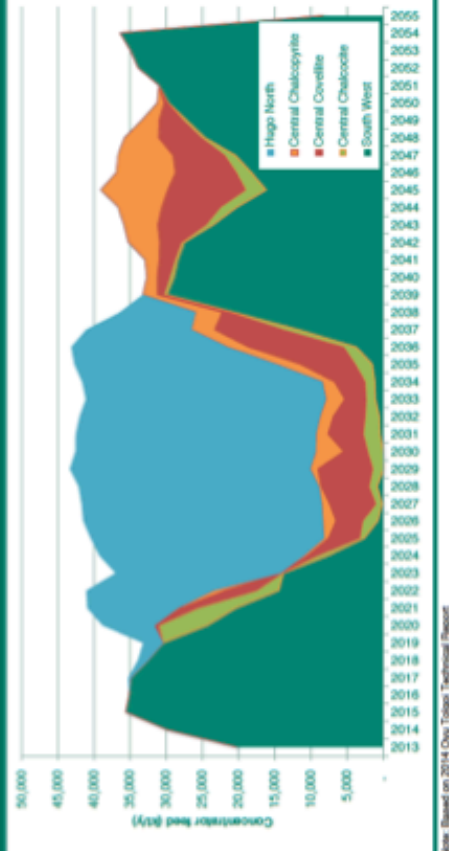
OT Phase 2 - “Reserve Case” - plans to mine 1.5 billion tons of ore from the Hugo North Lift 1 underground mine and the current Southern Oyu Tolgoi Open Pit. OT Phase 2 plans provide for production through 2055, with peak ore production of 40,000 tons per year (115,000 tons per day) during the years The Hugo North Lift 1 mine would be operating – 2020 – 2039.

	Units	2014 Reserve Case
Total Processed	Bt	1.5
Cu Grade	%	0.85
Au Grade	g/t	0.32
Ag Grade	g/t	1.94
Copper Recoverable	B lb	24.9
Gold Recoverable	Moz	11.9
Silver Recoverable	Moz	78.0
Life	Years	41
Expansion Capital	US\$B	4.9
NPV (8.0%) After Tax	US\$B	7.43
IRR After Tax	%	29%
Payback Period	Years	9

Notes:  
 US\$ amounts presented in real 2015 terms  
 (1) Expansion capital includes only direct project costs

### Production – Reserve Case

Reserve Case: Southern Oyu Open Pit / Hugo North Lift 1 Panels 0 to 2  
 Final year of processing in 2055



OT Phase 2 plans processing a mixture of Hugo North Lift 1 underground mine ore – shown in **Blue** – and open pit ore - shown in **Green, Red and Orange**.

<http://www.turquoisehill.com/i/pdf/ppt/TRQ-Site-Visit-Aug2015.pdf>

Figure 7 – OT Multiple Development Options beyond Phase 2

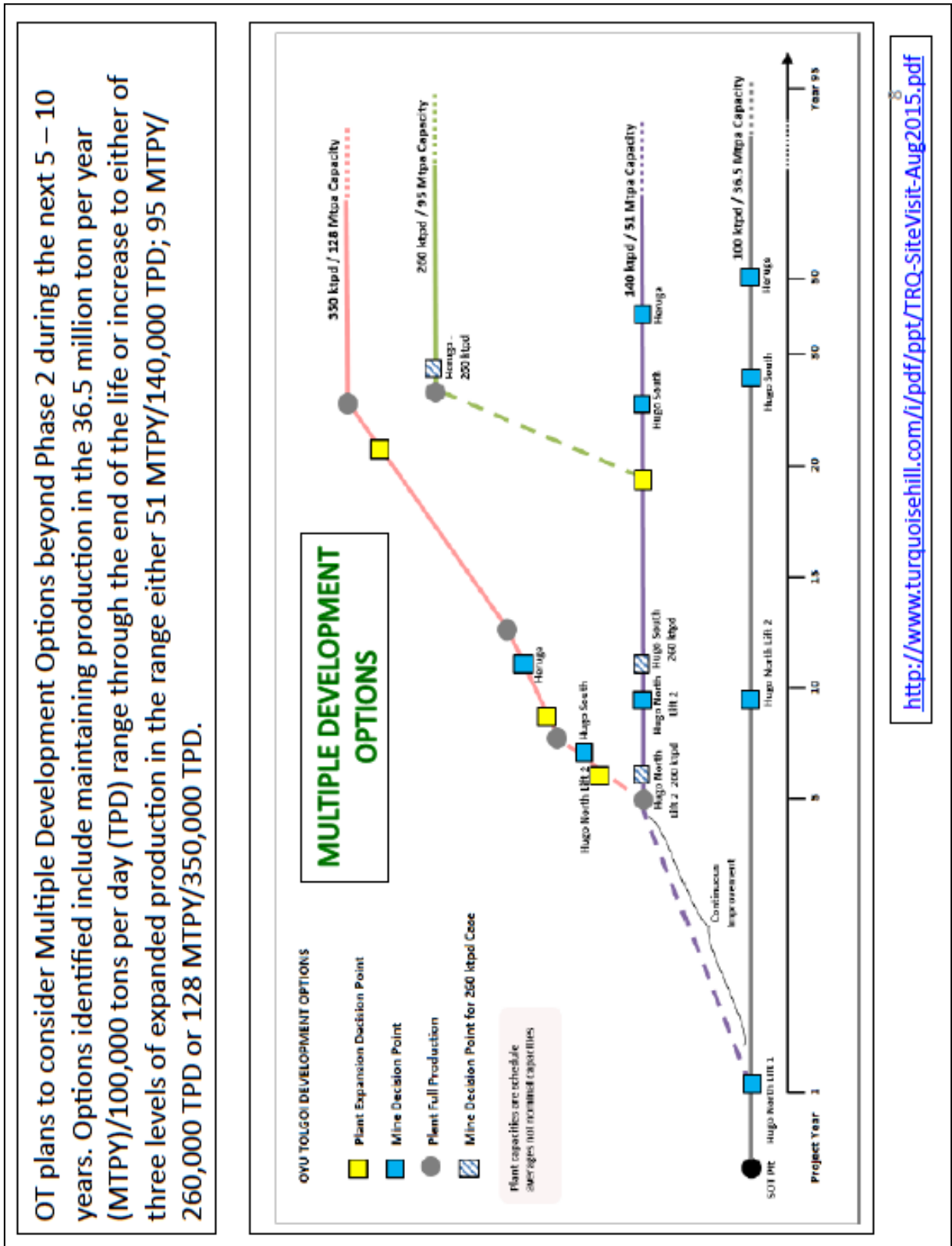


Figure 8 – Location of OT Phase 2 and OT “Life of Mine Case” deposits that may be mined in addition to the Phase 2 ore deposits in the future

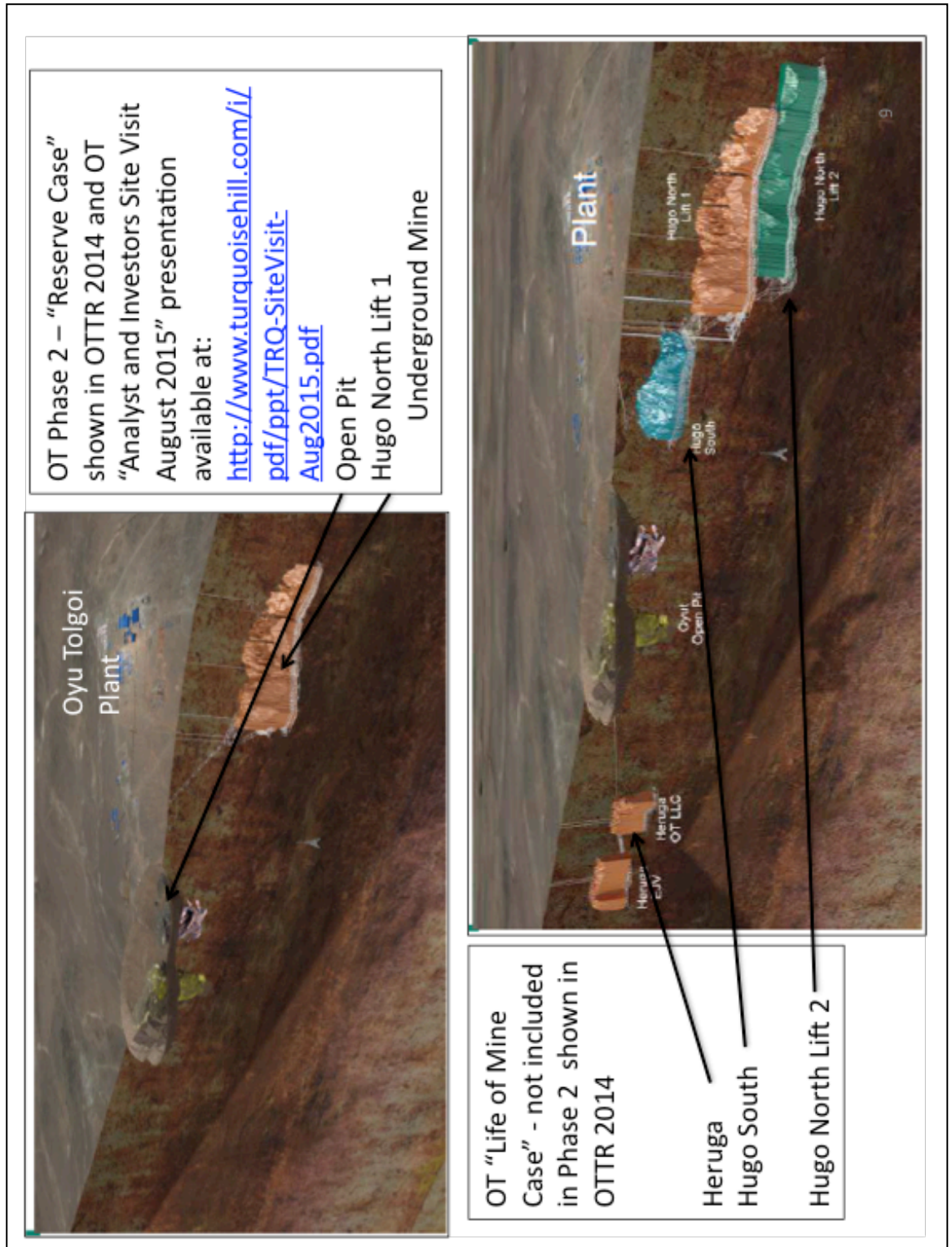
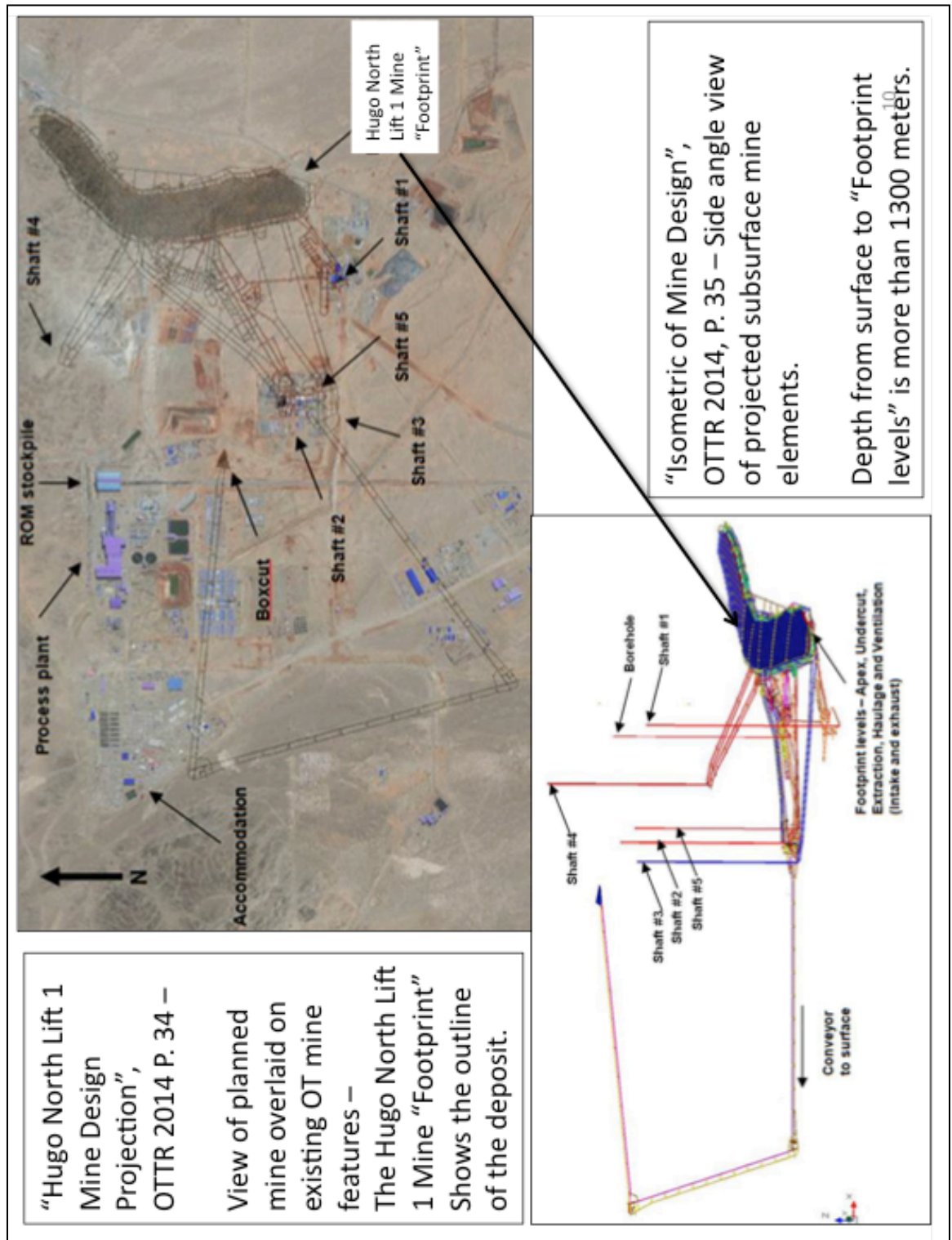




Figure 9 – “Hugo North Lift 1 Mine Design Project” and “Isometric [View] of Mine Design”





## **What actions are needed to complete approval of the OT Phase 2 expansion?**

The May 18, 2015 OTUMDFP Agreement between the Government of Mongolia and its partners in OT LLC (OTUMDFP 2015) identifies a series of steps needed to complete approval of OT Phase 2. The steps “required before the aspirations listed in that agreement can begin to be realized,” at section 4.7 on p. 6, include:

“ [The] Parties wish to proceed expeditiously with the construction of the Underground Stage. However, the Parties agree that construction of Underground Stage will commence only after:

(a) OT LLC has satisfied the requirements to obtain third party project finance to fund the Underground Stage (the “UG Project Finance”); and

(b) The Underground Stage is approved by each of the Boards of Rio Tinto, TRQ and OT LLC ”

At section 5.5.a. at p. 6, the May 2015 GOM-OT Agreement says,

“Up to USD \$6 billion of external funding will be raised through third party project financing (including UG Project Finance) and other bank finance, product off-take arrangements or other forms of financing.”

On December 14, 2015, Turquoise Hill Resources (TRQ) announced that the signing of a, “USD4.4 billion project financing facility”. (TRQ 12-2015). The facility provides loans through a group of international financial institutions and export credit agencies representing the governments of Canada, the United States and Australia, along with 15 commercial banks. The \$4.4 billion project finance facility OT’s owners signed provides a set of four loans with pay back terms of 12 – 15 years. The loans agreed to by OT LLC and the lenders have a debt capacity of \$6.0 billion for Oyu Tolgoi, providing the option for an additional \$1.6 billion.

Future steps to complete the loan process summarized by TRQ in its December 14, 2015 release are:

“Turquoise Hill, Rio Tinto and Oyu Tolgoi will now continue to work towards completing the 2015 feasibility study, including the updated capital estimate and securing all necessary permits for the development of the underground mine.

“Once these steps have been completed and subject to the boards of Turquoise Hill, Rio Tinto and Oyu Tolgoi approving a formal ‘notice to proceed’, the full \$4.4 billion facility will be drawn down by Oyu Tolgoi subject to satisfaction of certain conditions precedent typical for a financing of this nature.”

The May 2015 OTUMDFP Agreement at section 5.2 acknowledges that,

“Approval of UG Project Finance is a decision for the Boards of Rio Tinto, TRQ and OT LLC and the Shareholders of OT LLC. Oyu Tolgoi Board approval of UG Project Finance is required by the lenders under the Project Finance to be unanimous.”

The OTUMDFP at P. 3 identifies the Capital Cost of OT Phase 2 as \$6.7 billion USD, including \$4.7 billion in underground development capital, \$1.5 billion in sustaining and \$0.6 billion USD in Value Added Tax (VAT) and Duties on Capital.

The OTUMDFP 2015 and OTTR 2014 do not include plans for either a supplemental or a new Environmental and Social Impact Assessment (ESIA) for OT Phase 2.

OTTR 2014, at p. 446 says, “The [2012 OT] ESIA addresses a project with a 27-year design life.” OT Phase 2 is projected for a 40-year design life from feasibility studies and financial in 2016 through 2055. OTTR 2014, says,

“It is anticipated that the Project will continue in operation well after that date [of 2055], possibly at higher production rates. Such plans are still at an early stage, so while they are referred to in the ESIA, they are not evaluated in the ESIA because of the limited amount of information available.

“Similarly, a number of future developments of project-associated facilities are still under evaluation, and no clear decision has yet been made as to the preferred approach to be adopted by the Project,” including a railroad line and a power supply.

OT Phase 2 plans provide that,

“certain other activities and facilities are expected to be developed over time, either as part of or in support of the project, which 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 100–160 ktpd.
- 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.

While the impacts and management of these future Project elements are not directly addressed in the ESIA, they are considered in the cumulative impact assessment.” (OTTR 2014, P. 445)

## What is Block Cave Mining?

The 2005 Oyu Tolgoi Integrated Development Plan (IDP) Executive Summary describes the block cave underground mining method that will be used in OT Phase 2 to extract ore from the Hugo North Lift 1 underground mine as:

“[A] safe, proven, and highly productive method for extracting bulk ore tonnages from underground mines. It involves undercutting part of the orebody across a plan area, causing the overlying rock to collapse. The collapse of the ore, or “cave,” is “by design” and is accomplished in a deliberate, controlled, and predictable manner. Initially, the ore is undercut and induced to cave by blasting. Thereafter, the blasted ore falls into an array of drawpoints beneath the initial cave area and is removed by load-haul-dump (LHD) equipment. As broken ore is removed, the pile within the cave slumps, creating a void, which in turn promotes further caving.” (IDP ES 2005)

**“Block caving is expected to result in surface subsidence.** To preserve the integrity of the mine shafts and principal infrastructure, the shafts and infrastructure will be grouped together in a “farm” approximately 1,500 m due west of the centreline of the resource.” (IDP ES 2005 P. 47)(Emphasis added)

The SME Mining Engineering Handbook 2011 (SME 2011) describes Block Caving as, “[A] mass mining system that uses the action of gravity to fracture a block of unsupported ore, allowing it to be extracted through preconstructed drawpoints. By removing a relatively thin horizontal layer at the base of the ore columns using standard mining methods, the vertical support of the ore column above is removed and the ore then caves by gravity. As broken ore is removed from the ore column, the overlying ore continues to break and cave by gravity.”

“Although some relatively smaller block cave ore bodies are caved and mined as a single production block, most existing and planned block cave mines use either of the following:

- An extended block caving system that divides the deposit into discrete production blocks; or
- A single cave front (or series of fronts, or “panels”) advancing forward through the ore body, continually opening up new production areas as the earlier caved areas become exhausted.

“The block caving method typically allows for relatively large volumes of production after the mine has been developed and production ramp-up has been achieved. The preproduction development period can be significant (typically 5–10 years, depending on the length of time to achieve the initial access). The up-front capital required prior to any return on investment is very high because much of the production levels and infrastructure must be in place before caving can begin.

“After the mine has reached its sustained maximum production rate, the operating

cost tends to be very low with minimal additional infrastructure required to maintain the high production volumes. Block caving is generally the least expensive of all underground mining methods, and can in some cases compete with open-pit mining in cost.” (SME 2011 at P. 1356)

No revision of Oyu Tolgoi’s 2012 Environmental and Social Impact Assessment (ESIA 2012) is proposed to address OT “Phase 2” as defined by the “Reserve Case” in OTTR 2014. The Project Description portion of the ESIA 2012 provides an “Overview of Block Caving” that says,

An “Overview of Block Caving” is provided in the OT ESIA 2012 - Project Description (A4), at P.21 of 77:

“Block caving is a high-tonnage underground bulk mining method generally applied to large homogeneous ore deposits. Ideally, the ore to be caved should be structurally weak, and the waste overburden should be weak enough to collapse over the ore without inducement as the ore is extracted.

**“Block caving involves excavation of natural support from beneath the ore, causing the structure of the ore body to fail and collapse into the excavated void under the force of gravity and local geo-mechanical stresses. The broken ore is then pulled out from under the caved section through a drawpoint arrangement, subsequently removing support from ore and overburden at increasing height above the initial excavation, and eventually extending the cave upward to the surface.**

“The attractive aspect of block caving is that only a relatively small portion of the ore must be drilled and blasted prior to extraction. Once the cave initiates, production continues without further primary drilling and blasting until the ore column above is exhausted.

“The block cave mining sequence begins with access and infrastructure development, followed by excavation of the extraction level, and undercutting the ore. The sequence culminates in steady-state production from individual drawpoints.

“Ore in the column is diluted by material in adjacent columns and ultimately by overburden and adjacent waste rock. When the column drawdown is complete and drawpoint grade drops below a minimum value, the drawpoint is abandoned. Great care is taken in establishing uniform draw practices throughout the mine to maximise drawpoint life and minimise dilution and stress loading from underground workings.

“Block caving is a capital-intensive mining method, requiring significant investment early in the mine life for infrastructure and primary development. Once in place, the method’s high up-front costs are offset by high production rates and low operating costs (relative to other underground methods) over a considerable length of time, resulting in a low overall cost per tonne. Block cave mining is among the least costly of all underground mining methods per tonne of ore extracted.

“Block caving has a number of positive attributes including no waste rock storage on the surface and no large open pits. **One consequence of block cave mining, however, is the potential for surface subsidence or settling. Surface subsidence is caused as the material above the ore body gradually moves downward to replace the ore that has been mined**”.

### **Which Block Cave mines has Rio Tinto operated or planned?**

Five existing and proposed block cave mines are or have been owned in whole or in part by Rio Tinto, current majority owner of the Oyu Tolgoi, LLC. These include:

#### Closed

- Palabora copper mine, Limpopo Province, South Africa – 57% Rio Tinto, 26% public, 17% Anglo-American; currently closed. See, for example, “Palabora Mine Closure Fact Sheet” at [http://www.palabora.com/documents/factsheet\\_closure.pdf](http://www.palabora.com/documents/factsheet_closure.pdf)

#### Operating

- Northparkes copper and gold mine, Central New South Wales, Australia – formerly 80% China Molybdenum Co., Ltd. (acquired from Rio Tinto in 2013), 20% Sumitomo; See, for example, [http://www.geovia.com/sites/default/files/Australian\\_Journal\\_Mining\\_Jan2008\\_LR.pdf](http://www.geovia.com/sites/default/files/Australian_Journal_Mining_Jan2008_LR.pdf)  
- Deep Ore Zone (DOZ) block cave mine, Grasberg Mine, Papua, Indonesia – 40% Rio Tinto, 60% PT Freeport Indonesia; See, for example, Grasberg Block Cave”, at <http://www.infomine.com/publications/docs/InternationalMining/Chadwick2010k.pdf>

#### Planned

- Hugo Dummett North and South deposits, Oyu Tolgoi gold and copper project, South Gobi Region, Mongolia; and  
- Resolution Copper project, Superior, Arizona, US - 55% Rio Tinto, 45% BHP Billiton. See, for example, “Underground Mining” at <http://resolutioncopper.com/the-project/underground-mining/>)

## What are the environmental Impacts of Block Cave Mining?

Large-scale permanent surface subsidence above the extraction zone is the primary long-term environmental damage resulting from block cave mines. The surface collapse, subsidence and fracturing of the land surface above the mine resulting from extraction of ore using the block cave mining methods leads to environmental damage that is not amenable to topographic or biological reclamation to establish productive post-mining land uses because the damaged land surface affected by the block cave-induced subsidence is physically unstable.

As described in "Ore Body Access," *Mining Magazine*, 03 May 2011 says:

**"One of the primary disadvantages of block caving is that it removes much of the supporting rock from underneath the overburden, which often leads to subsidence of the surface. Caving induced subsidence may endanger mine infrastructure and is a major concern for operational safety."**

**Changes to surface landforms brought about by subsidence can be dramatic and may lead to a pronounced environmental impact. Therefore, the ability to predict subsidence has become increasingly important for operational hazard and environmental impact assessments."** (emphasis added) (Mining Mag. 2011)

Surface subsidence craters are a typical feature at block cave mines around the world. Thirty of the underground block caving mines around the world are summarized in "Characterization and empirical analysis of block caving induced surface subsidence and macro deformations," Woo, K., et al, ROCKENG09: Proceedings of the 3rd CANUS Rock Mechanics Symposium, Toronto, May 2009, (Woo 2009) at: <http://www.geogroup.utoronto.ca/rockeng09/proceedings/innerFrames/PDF/Session19/4044%20PAPER.pdf>.

Woo 2009 identifies three zones of surface impact from block caving, an inner "Caved Zone," a surrounding "Fractured Zone" and a "Subsidence" zone surrounding the inner zone of greater surface deformation.

Figures 10–17 demonstrate block caving mining impacts to the land surface above and surrounding the ore extraction zone, including:

- a "caved zone" directly above the block caving mining area, where the surface collapses into the void below the surface from which ore has been extracted;
- a "fractured zone" over the area around the "caved zone" affected by the collapse over the ore body where "tension cracks" develop at the surface and below the surface; and
- a "continuous subsidence zone" affected by surface disruption and instability.



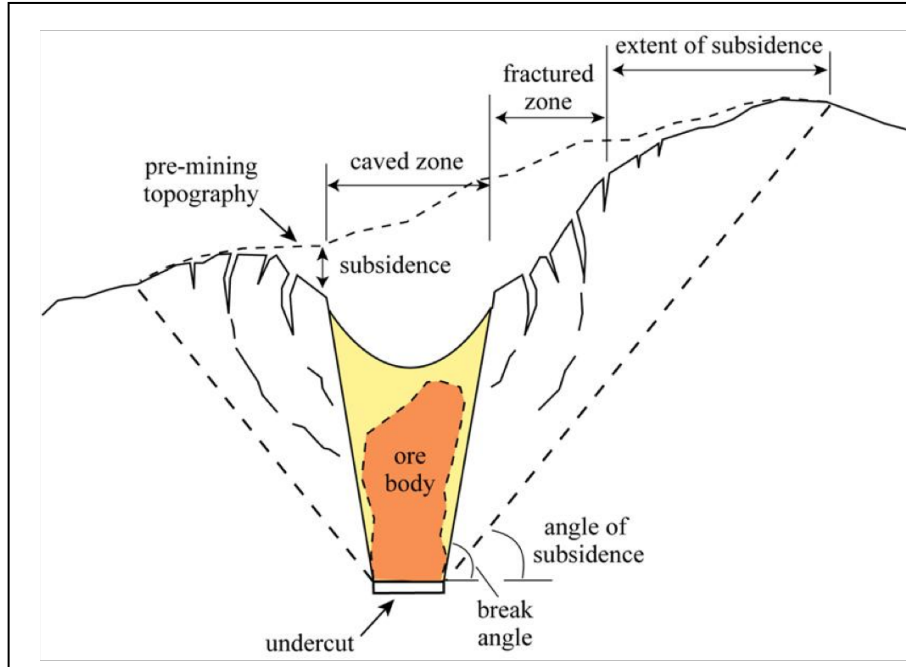


Figure 10 – (Included in Figure 12) “Definition of block caving subsidence zones and its quantification with respect to angles extending from the undercut” (Woo 2009)

The illustration of block caving from Woo 2009 is similar to the illustration of block caving in Oyu Tolgoi’s IDOP 2012 shown in Figure 11.

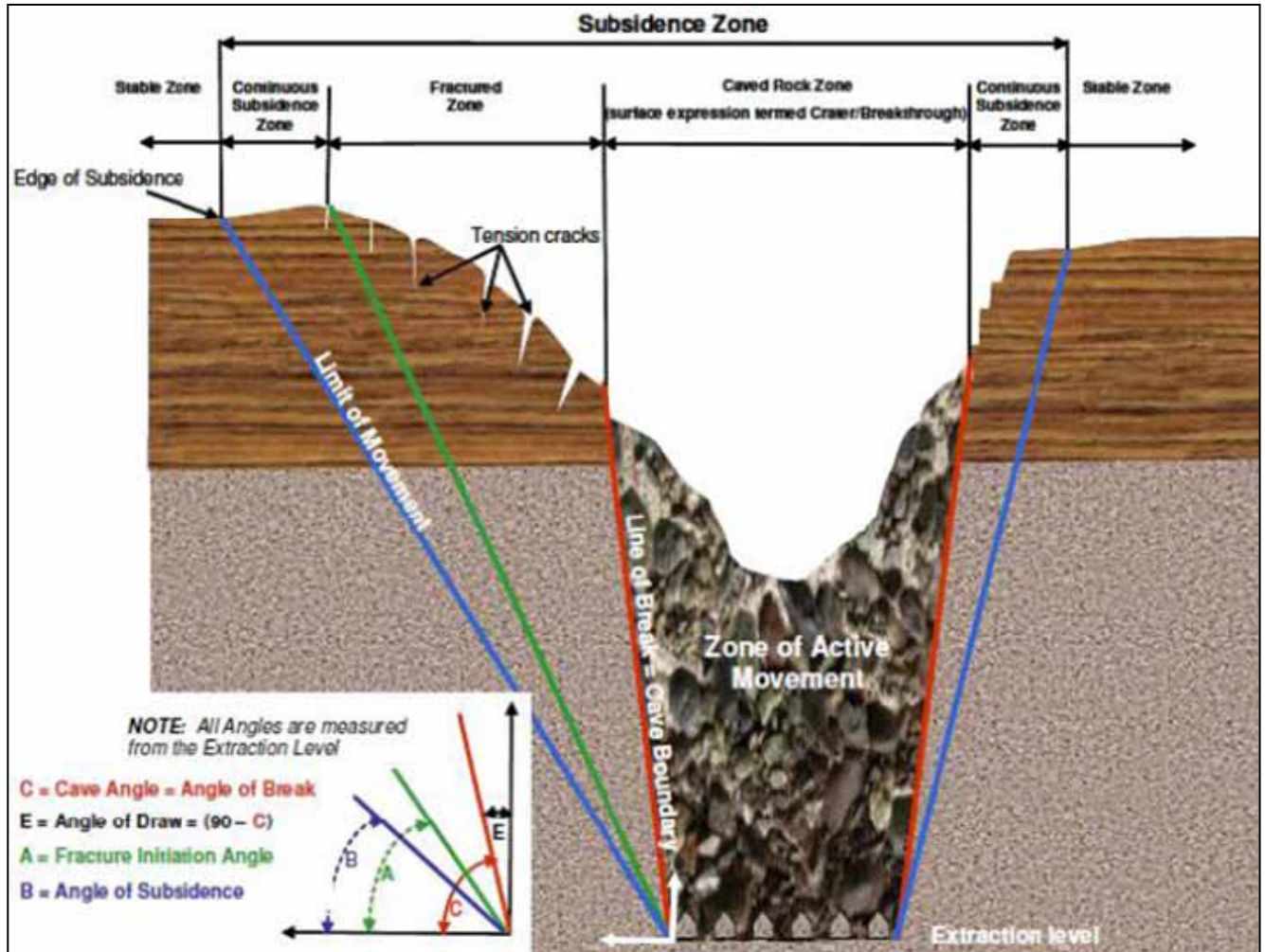


Figure 11 – (Included in Figure 12) “Definition of Subsidence Zone (after MMT – Permission from Rio Tinto)” from Oyu Tolgoi IDOP 2012, P. 325, - Figure 16.22

Figure 12 – 22 show the block cave mining method proposed by OT and the associated collapse and subsidence zones from OTTR 2014 and other sources identified in the Figures with annotations and commentary by the author.

Figure 12 – “Definition of Subsidence Zones”

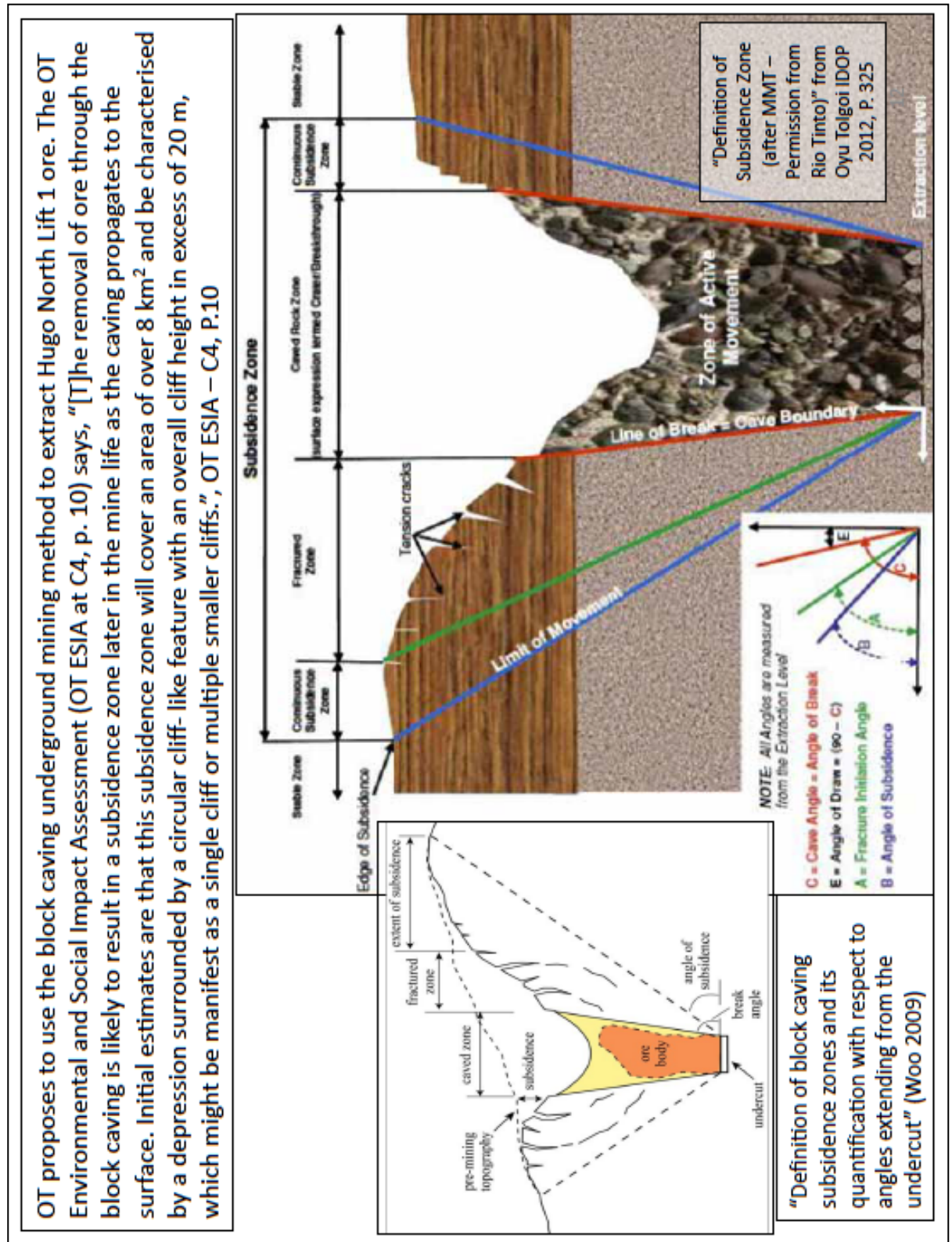




Figure 13 – Block Caving and Subsidence – “Most Probable Prediction of Subsidence for the Resolution Copper Mine, a Rio Tinto-BHP Billiton project in Arizona, USA

How long will subsidence at a block cave mine take to occur? The “probable subsidence prediction” prepared for Rio Tinto proposed Resolution copper mine in Arizona, USA provides an estimate of when surface subsidence occurs during the life of a mine.

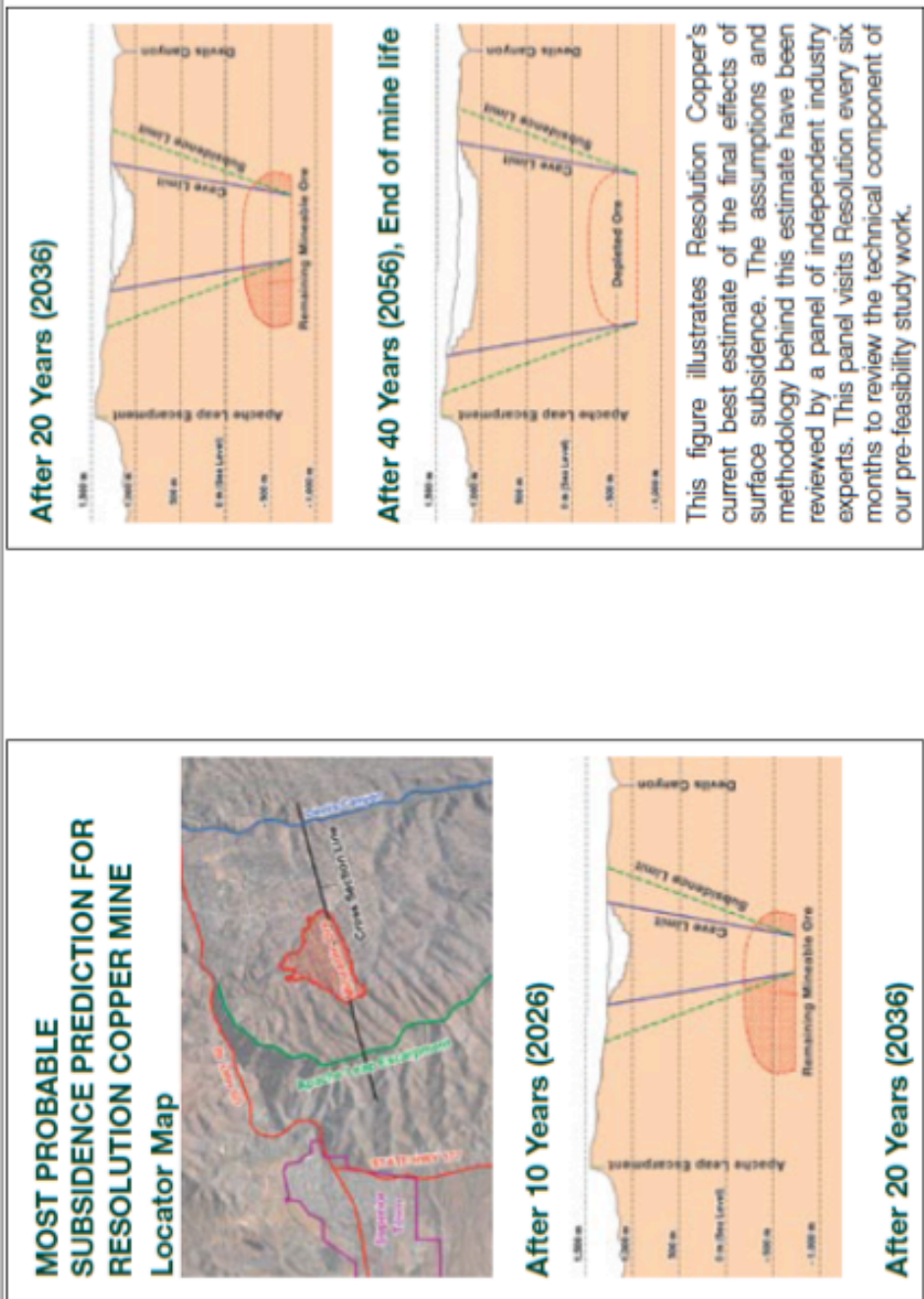


Figure 14 – Illustrations of OT Phase 2 “Ore Flow” and “Cave Monitoring,” and Surface Subsidence prediction at RT-BHP Resolution Copper Mine.

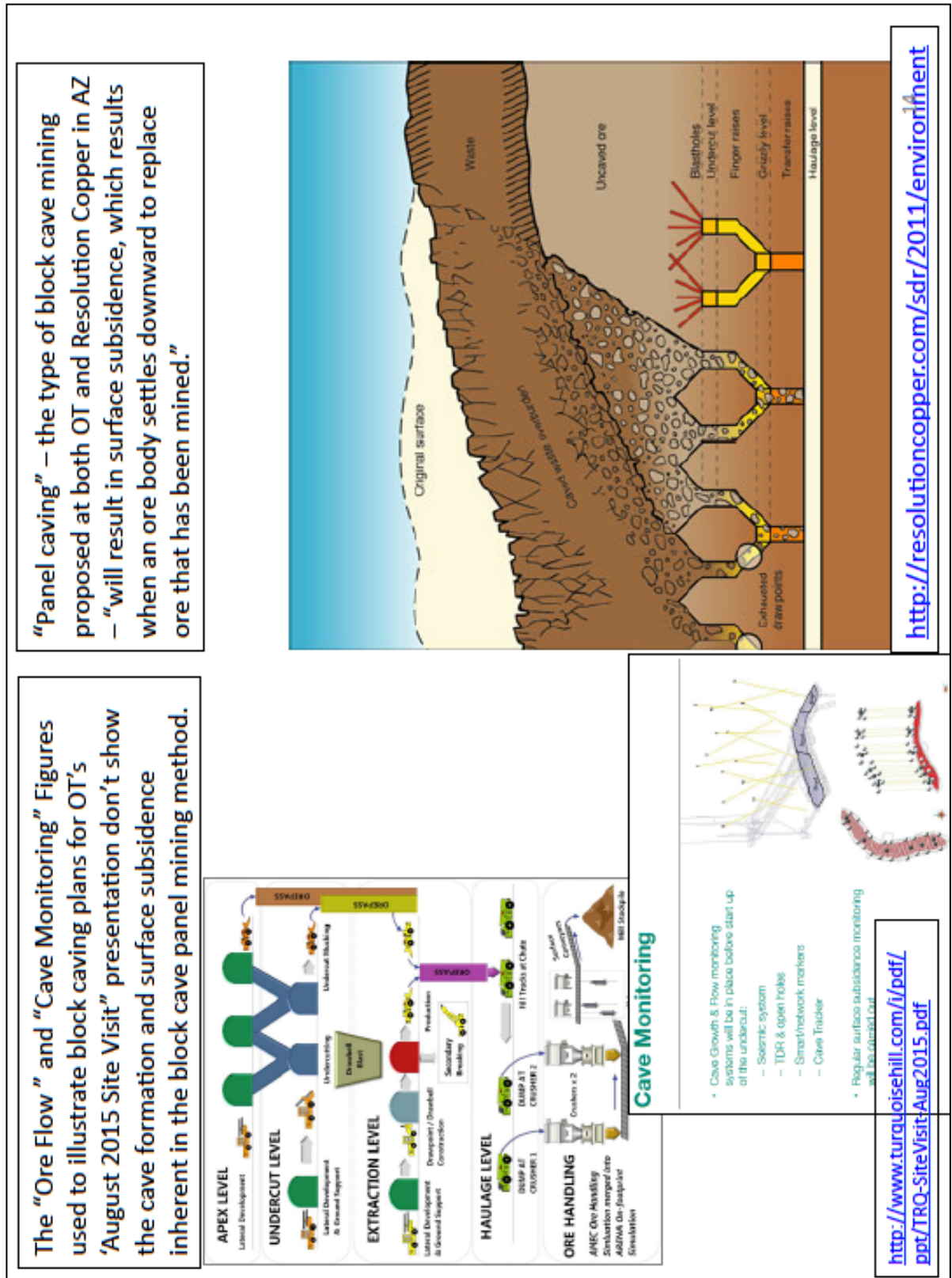


Figure 15 – OT Hugo North Lift 1 Subsidence Zone predictions from 2010 and 2012

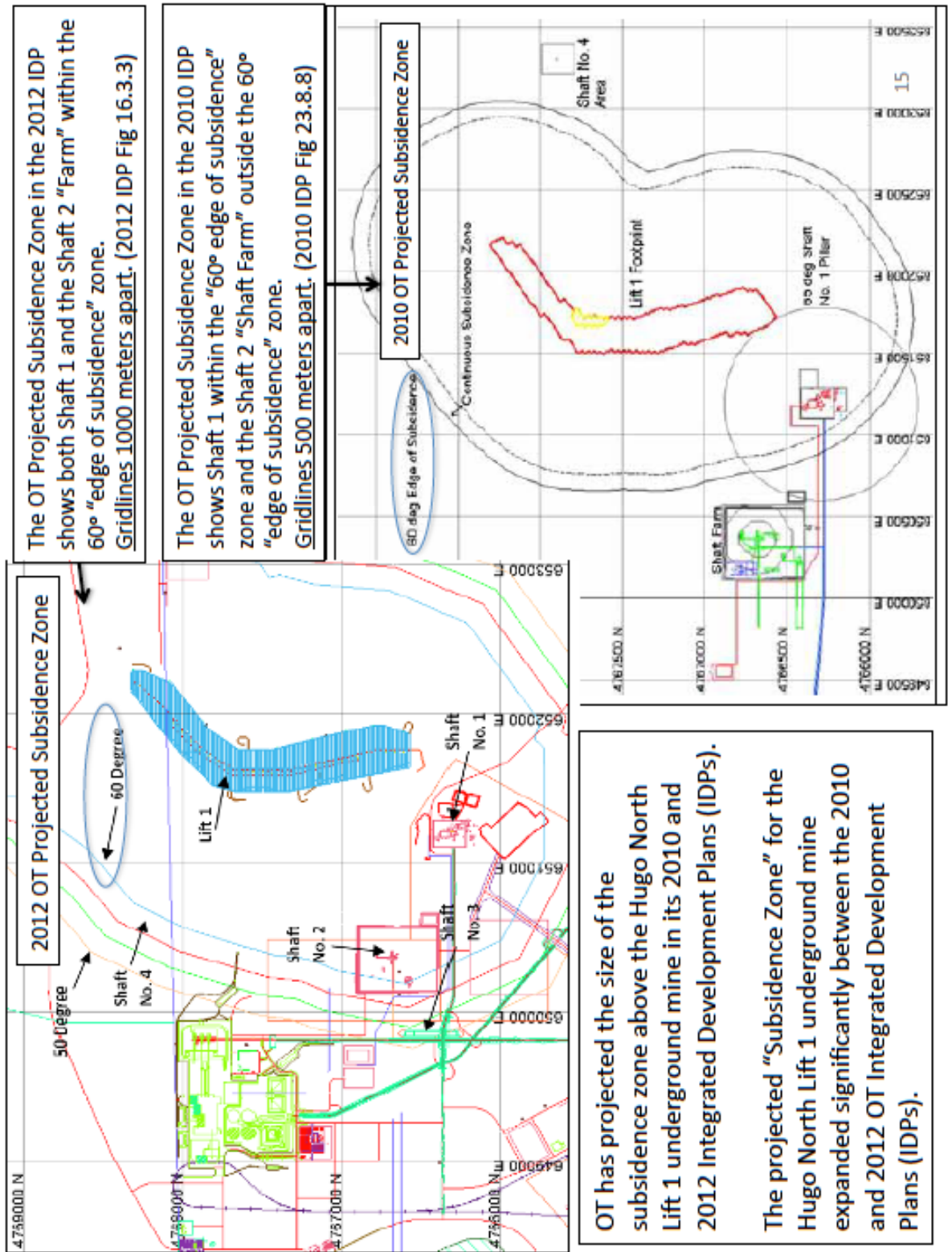




Figure 16 – Comparison of OT Phase 2 Subsidence Area predicted in 2012 and Central Ulaanbaatar.

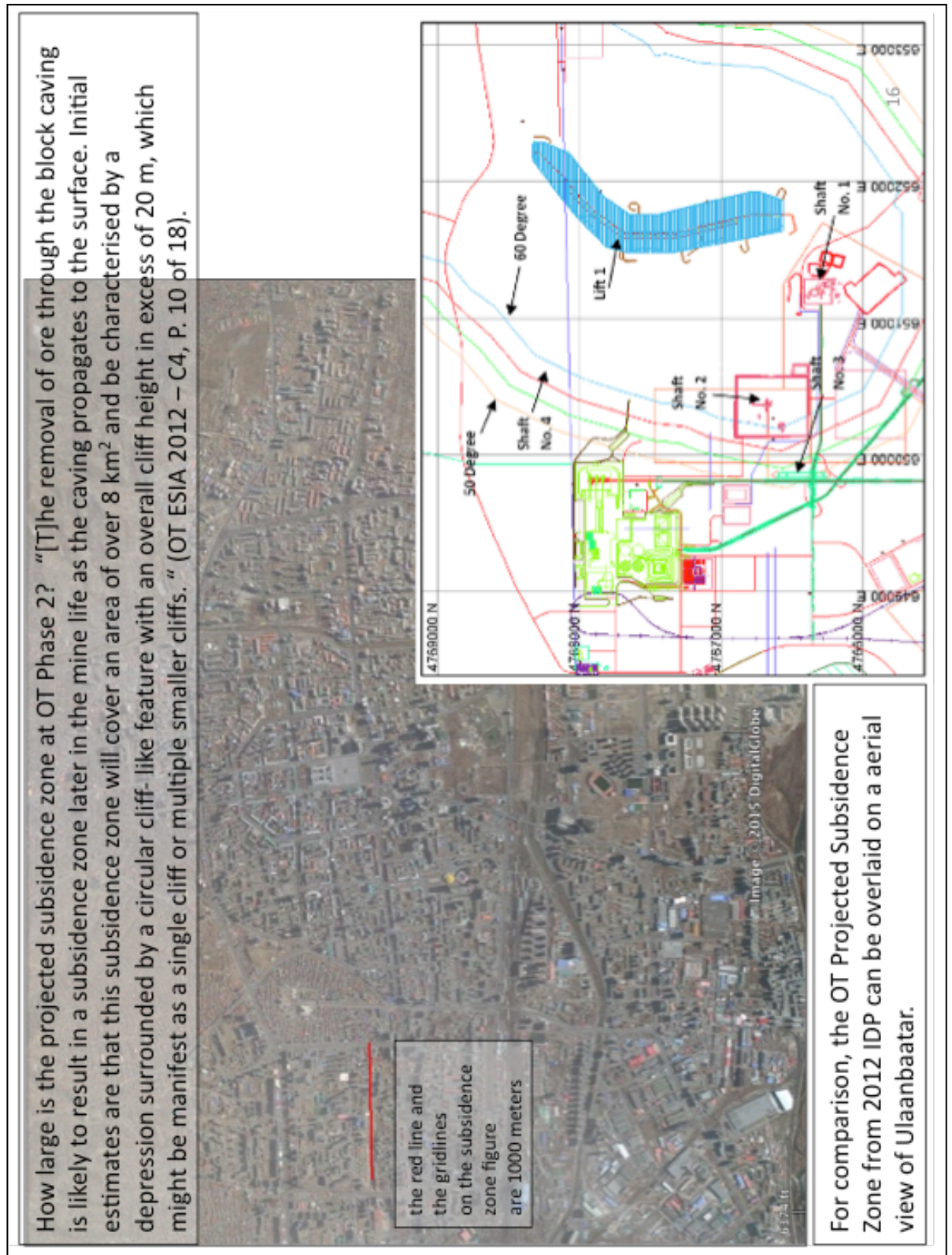
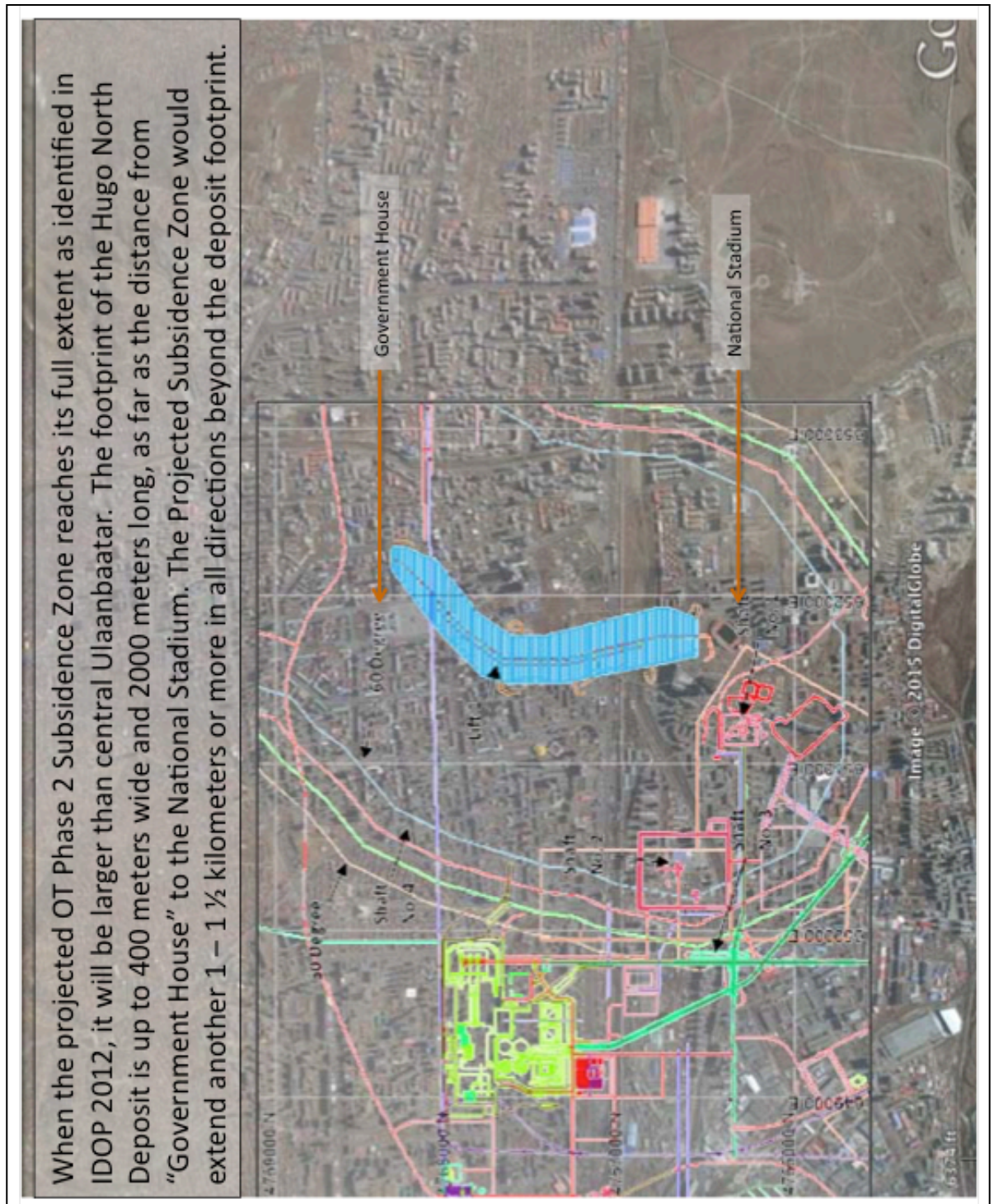


Figure 17 – Overlay of OT Phase 2 Subsidence Zone predicted in 2012 on Central Ulaanbaatar.



The surface subsidence resulting from block cave mining leaves a permanent hole in the ground above the mine where the surface collapses into the mine, a ring of continuous subsidence around the edge of the collapse zone, and ring of fracture land around the edge of the continuous subsidence zone.

Reclamation to reestablish topographically stable landscape with sustainable vegetation is not possible at block cave underground mines as the land surface above the block cave mine is physically unstable and unsafe for operation of reclamation equipment, and for people and animals entering the fractured rock or subsidence zone.

The extent of the “caved zone” is defined by a “cave angle” or “angle of break” illustrated in Figures 10, 11 and 12. The extent of the fracture zone is defined by an “angle of fracture initiation,” and the extent of the continuous subsidence zone is defined by an “angle of subsidence.”

Woo 2009 includes, in addition to an overview of the block caving mining method, descriptions and illustrations of the open cave zone and surrounding subsidence zone at operating mines at 30 block cave mines around the world, including images of collapse and subsidence zone at 18 block caving mines.

Figure 18 below (Woo 2009, Figure 5), shows satellite imagery of surface subsidence at block cave mines where topographic conditions have a small impact on the structure of the collapse zone.



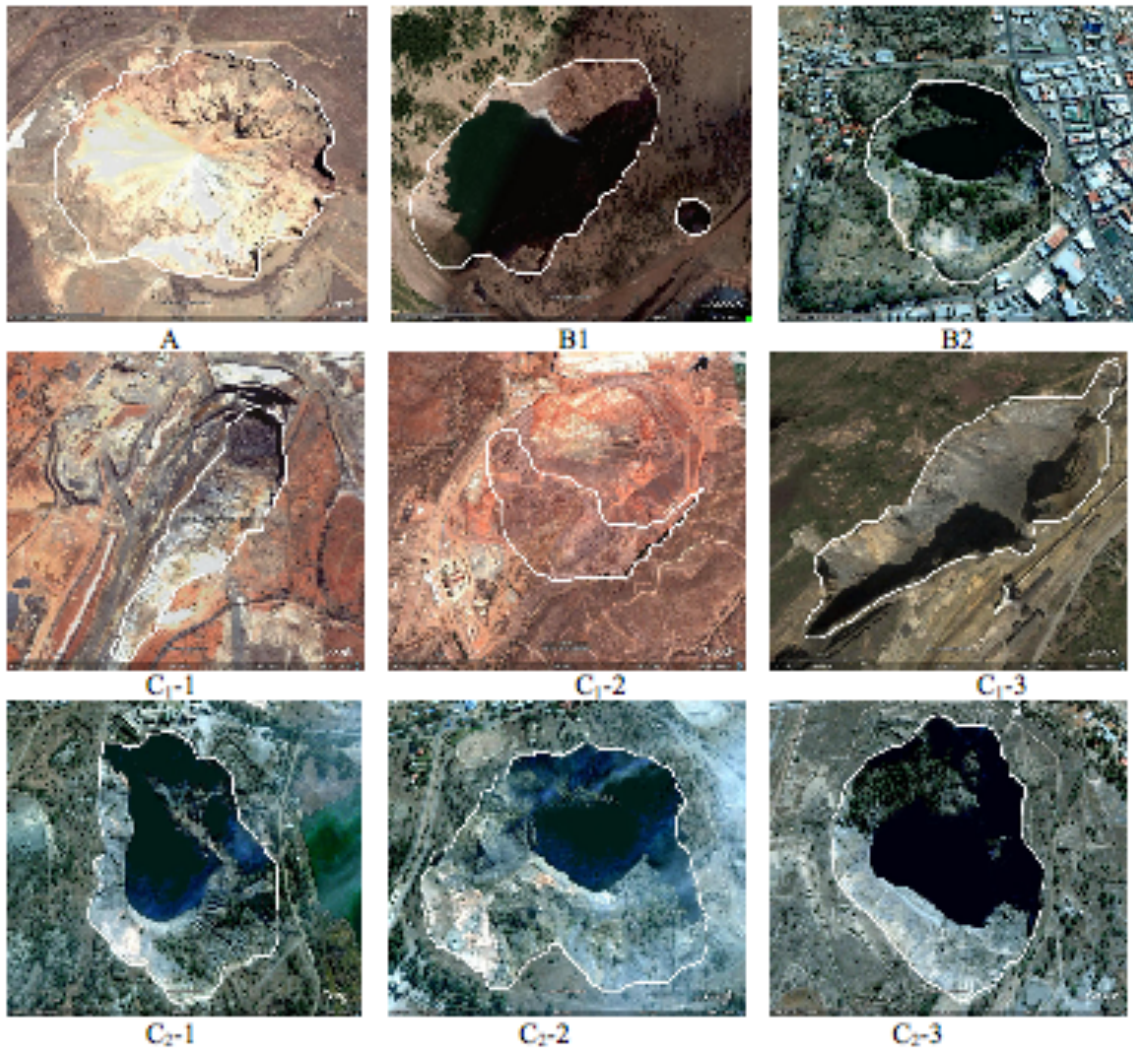


Figure 18 – “Macro deformation patterns observed in which topographic effects are minor” at block cave mines (Woo 2009)

The shape of the subsidence zones in the Figure show – the “macrodeformation patterns” – as identified in Woo 2009 are: Type A= circular, Type B = elliptical, Type C<sub>1</sub> = irregular with scarps, but without a distinct collapse zone, and Type C<sub>2</sub> = irregular with a distinct collapse structure/glory hole “where topographic effects are minor.”

No scale is provided for the images in Woo 2009.

## How large is the Subsidence Zone at the OT Hugo North Lift 1 underground mine predicted to extend?

Surface subsidence zone prediction maps for the Hugo North Lift 1 block cave mine have been included in the OT Integrated Development Plans from 2005, 2010 and 2012. The projected extent of the land area likely to be affected by the caved, fractured and subsidence zone at the Hugo North mine site increased substantially in the IDOP 2012 from that projected in IDP 2010.

The IDP 2010 projection of the caved, fracture and subsidence zones above the Hugo North Lift 1 underground mine below shows the “shaft farm” area – the site shaft 2 – outside the projected continuous subsidence zone.

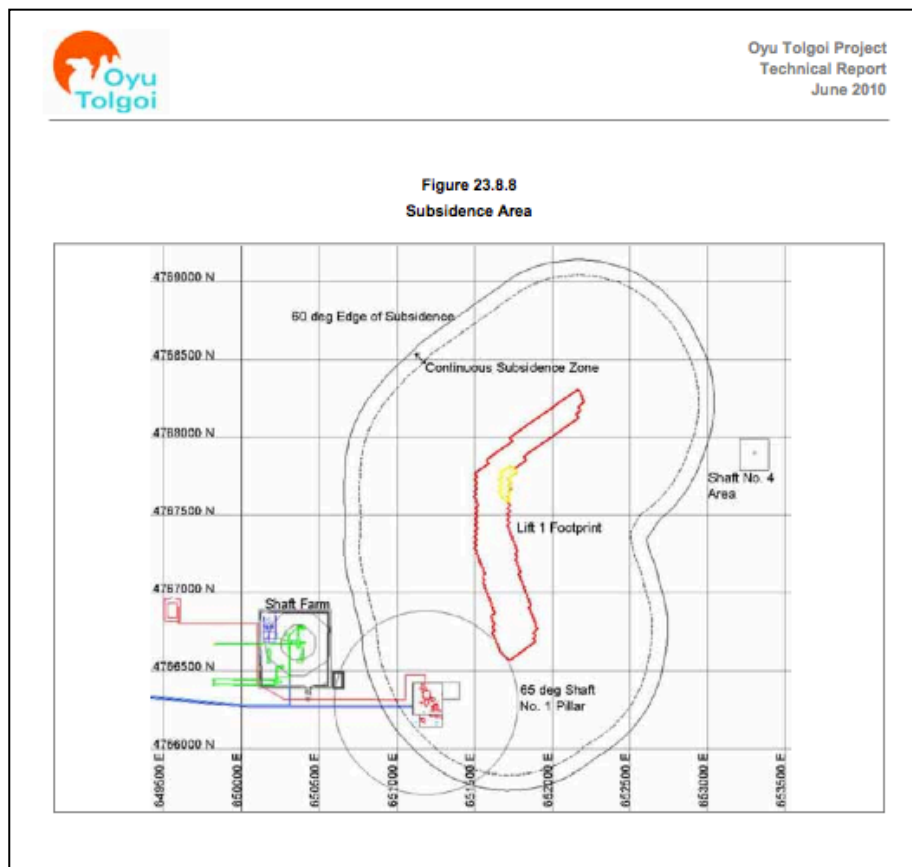


Figure 19 -(Also in Figure 15) “Projected Subsidence Zone” (IDP 2010, P. 373 (Figure 23.89.8) In this Figure, the grid lines are spaced 500 meters apart.

The projected Hugo North mine subsidence zone presented in IDOP 2012, shown in Figure 20 below, has expanded more 500 meters to the west resulting in the “Caved Zone” including the “Shaft Farm” area the Shaft 2 site and other infrastructure features well inside the inner ring – the projected “caved zone” of the subsidence zone – in addition to Shaft 1.

**Figure 16.33 Projected Subsidence Area**

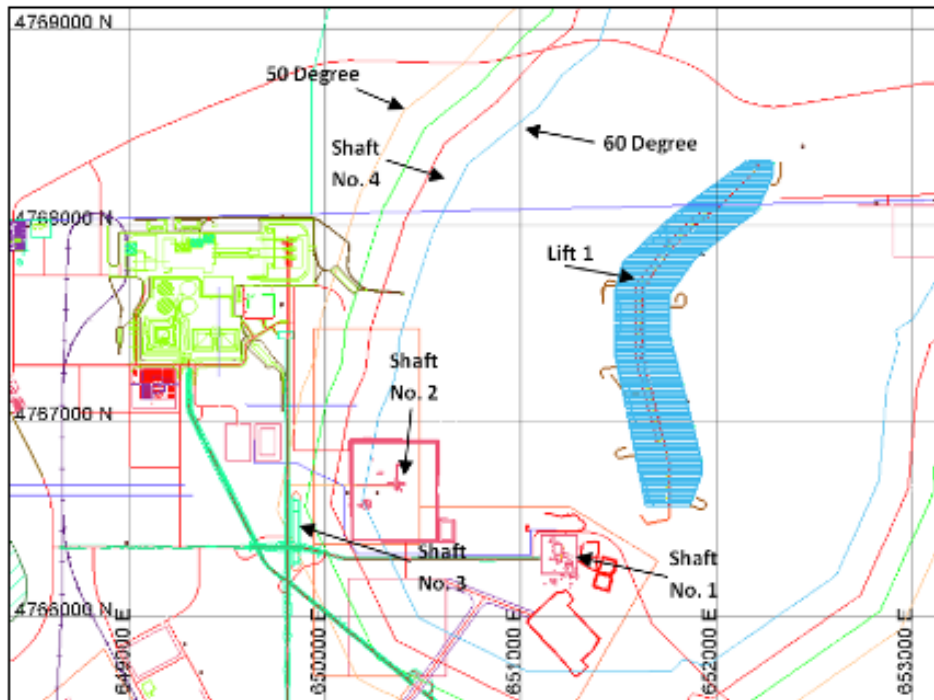


Figure 20 – (Also in Figures 15-17) Projected Subsidence Zone from IDOP 2012: “The projection shown in Figure 16.33 merely illustrates the extent of surface area that the generalized subsidence projections encompass. Further study is required to more accurately predict actual cave propagation.” (IDOP 2012, p. 358).

In this Figure, the grid lines are spaced 1,000 meters apart.

Propagation of the “Caved Zone” to include the Shaft Farm Area – the Shaft 2, Shaft 1 and other infrastructure features is also illustrated in the Project Description portion of the ESIA 2012, as shown in Figure 21, below.



Figure 21 – “Projected Block Cave Subsidence Zone,”  
(ESIA 2012 - Project Description Figure 4-10 p. 23 of 77)

Oyu Tolgoi’s IDP 2010 acknowledged the severity of the impact of the caved zone on Shaft 1 noting,

“The subsidence zone from the extraction level to the surface is projected at 60°, per SRK’s Recommendation [Figure 3 in this report](Figure 23.8.8). All planned infrastructure is outside this zone, except for Shaft No. 1. Shaft No. 1 is located inside the 60° subsidence area at the edge of 65° subsidence line. It is assumed that Shaft No. 1 will be stripped of all conveyances once full production is achieved and will be used for ventilation only.”

Oyu Tolgoi’s IDOP 2012 illustration of the project caved, fractured, and subsidence zones (Figure 20 in this Report), shows that the extent of the 60° subsidence area has expanded to include Shaft No. 2 and most of the Shaft Farm area. The 60° subsidence line indicated in IDOP 2012 is approximately 500 meters west of the location of the 60° subsidence line in IDP 2010, engulfing the Shaft No. 2 site.

Neither the IDOP 2012 nor the ESIA 2012 address consequences of the projected cave, fracture and subsidence zones on shaft No. 2, or the other infrastructure identified as within the projected subsidence zone. While the IDP 2010 asserted that all infrastructure other than Shaft No. 1 were to be located outside the 60° angle of subsidence zone to prevent impacts from caving, fracturing and subsidence, many OT mine facilities are shown within the 60° angle of subsidence shown for the mine in the IDOP 2012. These mine features include Shaft No. 2, and the “Shaft Farm,” among other infrastructure. The lack of



attention to the impacts of subsidence on areas within the 60° subsidence angle as projected in IDOP 2012 appears to be a significant defect in ESIA 2012.

While OTTR 2014 provides a discussion of block cave mining on the Hugo North Lift 1, it does not provide a figure or other information that illustrates the full projected subsidence zone from the OT Phase 2, the “Reserve Case” mine.

OTTR 2014 says,

“The predicted fracture limits (determined as the point of having a notable impact on key infrastructure such as hoisting shafts) by the end of mining Hugo North Lift 1 are shown by the red outline in Figure 16.13. A fence will be constructed 100 m outside this red outline to restrict access. The subsidence angles are predicted to be nearly vertical at the northern and southern limits of the cave, where confinement is highest, and are approximately 55° in the east and west, where confinement is lowest. All shafts and permanent infrastructure are planned to be situated outside the predicted fracture limits.

“Shaft 1 is closest to the fracture limits. Shaft 1 will be used as a hoisting shaft until the Shaft 2 loadout and primary crusher are commissioned by early 2019.

Thereafter the primary function of Shaft 1 is for intake ventilation. This provides additional contingency against an unexpectedly larger cave subsidence damage area, as a bald concrete lined shaft can withstand higher ground movement than a shaft reliant on the close tolerances of operating hoisting infrastructure.”

Constructing a fence 100 meters outside the subsidence zone – “the red line” in Figure 22 below – is the only reclamation measure, other than monitoring the extent of subsidence, identified in OTTR 2014.

Figure 22 below is a reproduction of Figure 16.31 in OTTR 2014. No scale is provided for the Figure in OTTR 2014 to allow comparison with the IDOP 2012 and ESIA 2012 Figures illustrating OT’s projected subsidence zone. The OTTR 2014 Figure appears to project a much smaller subsidence zone than 2012 IDOP based on the location of the “Shaft Farm” in the lower left of Figure 22.

No analysis is provided or cited for the revision of the OT Phase 2 subsidence zone in OTTR 2014 from that projected in the IDOP 2012 or ESIA 2012.

Figure 22 – “Figure 16.31 Subsidence Predictions from Modeling” OTTR 2014, p. 310



As is clear from a comparison of the subsidence zone illustrations from IDOP 2012 and OTTR 2014, the full extent of the subsidence zone is not shown in either of the documents.

As 2014 OTTR has so little detail about block caving methods or consequences and no ESIA update associated with it, the 2012 ESIA and supplement remain the sole available environmental impact assessment for Oyu Tolgoi’s open and underground mine plans.

**In the ESIA 2012, an eight square kilometer – 8 km<sup>2</sup> – caved, fractured and subsidence zone is predicted to developed above Oyu Tolgoi’s Hugo North Underground Block Caving Mine.**

ESIA 2012, in its discussion of the “Nature of the Impact” of proposed Oyu Tolgoi mine, in “SECTION C: IMPACT ASSESSMENT CHAPTER C4: TOPOGRAPHY, LANDSCAPE, GEOLOGY & TOPSOILS (“ESIA 2012 C4”, filename: ESIA\_OT\_C4\_Topography\_EN.pdf) projects the full area of the projected caved, fractured and subsidence zone above the Hugo North mine is projected as more than 8 square kilometers. ESIA 2012 – C4 at P. 10 of 18 states,

**“[T]he removal of ore through the block caving is likely to result in a subsidence**

**zone later in the mine life as the caving propagates to the surface. Initial estimates are that this subsidence zone will cover an area of over 8 km<sup>2</sup> and be characterised by a depression surrounded by a circular cliff-like feature with an overall cliff height in excess of 20 m, which might be manifest as a single cliff or multiple smaller cliffs. Depending on the nature of the surface manifestation of this feature, the impact will be on topography and landscape; and also on hydrogeology and hydrology (see ESIA 2012 Section C5), and potentially present a potential community safety issue if cliffs are unstable once herders are allowed back into the area following mine closure and restoration.”**

The ESIA 2012 adds that,

“the full extent of the subsidence zone is projected to more than three times the size of the open pit mine planned at the site, projected to be two square kilometers (2 km<sup>2</sup>)”, at ESIA 2012, C4 p. 10.

Figure 17 shows the extent of OT Phase 2 underground block caving mine and associated collapse and subsidence zone based on the 2012 IDOP “Projected Subsidence Area,” by overlaying the projected OT Phase 2 subsidence zone on an Google Earth image satellite image of central Ulaanbaatar.

OTTR 2014 does not identify specific efforts to continue investigations to delineate the OT Phase collapse and subsidence zone that would respond to the recognition in IDOP 2012 at P. 358 that “further study is required to more accurately predict actual cave propagation.” No supplemental or new ESIA is proposed by OT to address the block cave mine planned in OTTR 2014.

## **What are Some of the Major Impacts of OT Phase 1 and 2 on Water Resources Used by Herders?**

Issues related to the impacts of OT operations on water resources used by the herder families surrounding the mine area have been identified in “Independent Environmental Panel (IEP) Report – Executive Summary” developed from the investigation of Khanbogd Soum herd complaints filed to the International Finance Corporation (IFC) Compliance Advisor-Ombudsman (CAO) and in Independent Audit Reports available at <http://ot.mn/esia-audit-reports/>.

The Independent Expert Panel Report summarized in the Executive Summary have been prepared pursuant to two formal complaints filed by herders and herder support organizations with the International Finance Corporation (IFC) Compliance Advisor/Ombudsman (CAO) in 2012 and 2013. As of January 2016, only the IEP Report Executive Summary, rather than the full report, is publically available.

IFC is one of the lenders committing funds to OT Phase 2 identified in the December 14, 2015 announcement of the OT Phase 2 multi-bank funding facility. The herder complaints filed with the IFC CAO and associated documents are available at:

### **Mongolia/Oyu Tolgoi-01/Southern Gobi:**

<http://www.cao-ombudsman.org/cases/document-links/links-191.aspx>

and

### **Mongolia/Oyu Tolgoi-02/Southern Gobi:**

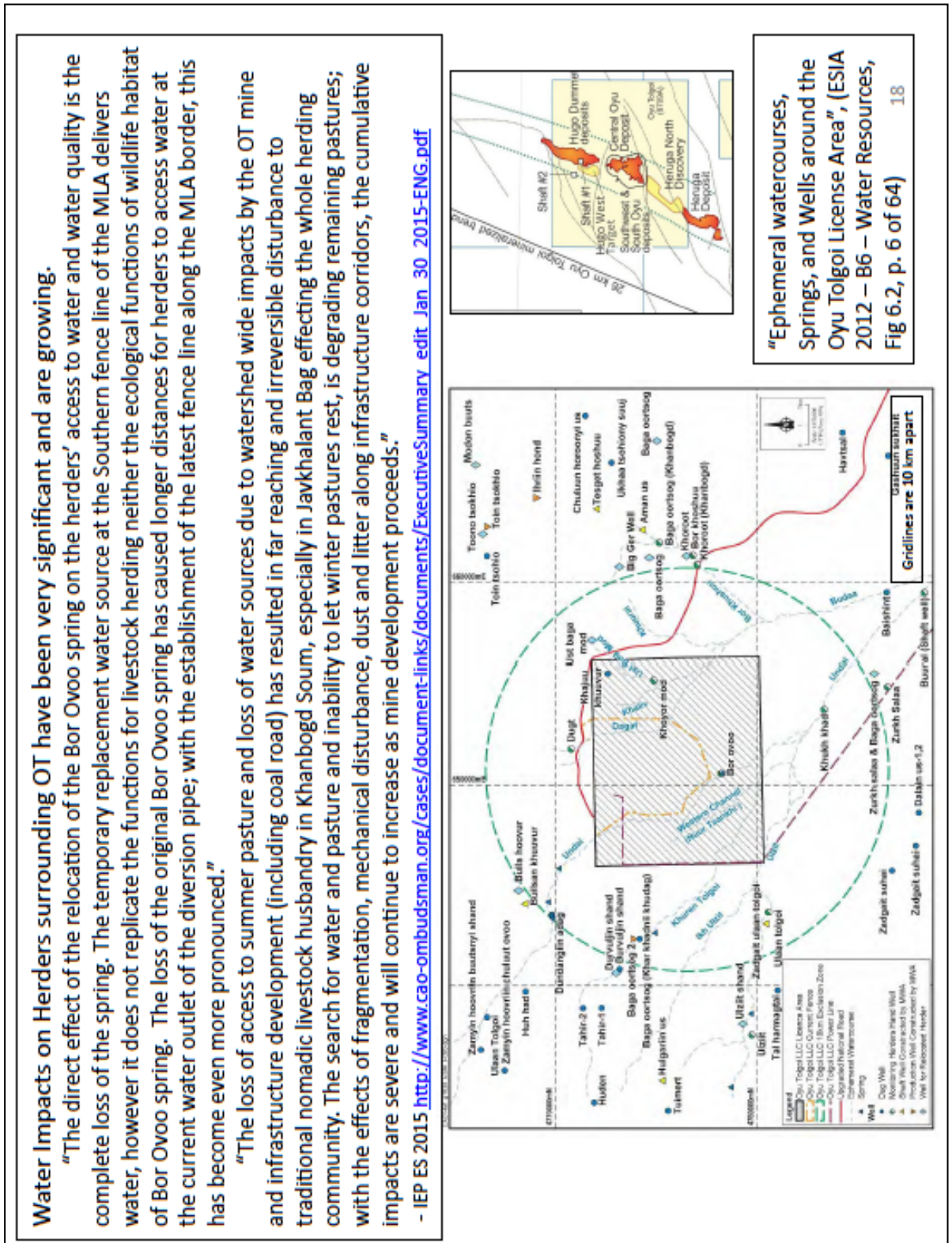
<http://www.cao-ombudsman.org/cases/document-links/links-196.aspx>

The Independent Audit Reports (IARs), prepared periodically since October 2013, identify issues associated with company performance to address of non-conformance with OT project commitments from the ESIA (See IAR April 2015, P. 18)

OTTR 2014 does not acknowledge or discuss the issues related to non-conformance with OT’s commitments addressed in the IARs or the IEP ES 2015. The “ENVIRONMENTAL STUDIES, PERMITTING AND SOCIAL OR COMMUNITY IMPACT” section of OTTR 2014, beginning at P. 441, summarizes the types of impacts identified in ESIA 2012 and Draft ESIA’s prepared to address OT operations. That section of the OTTR 2014 does not provide an assessment of the nature, extent of severity of impacts of OT operations to date or any changes to previous ESIA’s necessary to address impacts that have occurred.

Similarly, OTTR 2014 does not incorporate recently compiled information on water resource impacts of current OT operations or project how the impacts identified in the IARs, IEP ES 2015 and the full IEP Report will be addressed in the future, such as an ESIA for OT Phase 2.

Figure 23 – “Water Impacts on Herders surrounding OT have been significant and are growing”





The information gathered in the IAR and IEP reviews are critical to the public and investor awareness of OT's impacts on and risks to local water resources, socio-economic and cultural heritage conditions since the mine operations began. Updating water resource, socio-economic and cultural heritage conditions is necessary to address deficiencies or inaccuracies in baseline data compiled prior to OT start-up. Updating the assessment of impacts to these critically important elements of the lives of herders and their families surrounding OT is essential to determining are whether impacts have occurred as predicted or are more or less severe than predicted in the ESIA 2012.

The Independent Expert Panel (IEP) found impacts on herder water resources that affect herder socio-economic and cultural conditions significantly and more severely than previously identified. IEP ES 2015 reports that:

“The direct effect of the relocation of the Bor Ovoo spring on the herders’ access to water and water quality is the complete loss of the spring. The temporary replacement water source at the Southern fence line of the MLA delivers water, however it does not replicate the functions for livestock herding neither the ecological functions of wildlife habitat of Bor Ovoo spring.

“The loss of the original Bor Ovoo spring has caused longer distances for herders to access water at the current water outlet of the diversion pipe; with the establishment of the latest fence line along the MLA border, this has become even more pronounced.”

and

“The loss of access to summer pasture and loss of water sources due to watershed wide impacts by the OT mine and infrastructure development (including coal road) has resulted in far reaching and irreversible disturbance to traditional nomadic livestock husbandry in Khanbogd Soum, especially in Javkhalant Bag effecting the whole herding community. The search for water and pasture and inability to let winter pastures rest, is degrading remaining pastures; with the effects of fragmentation, mechanical disturbance, dust and litter along infrastructure corridors, the cumulative impacts are severe and will continue to increase as mine development proceeds.” (IEP ES 2015)

OTTR 2014 asserts that OT has not, “seen ... any connection between the deep aquifer and the shallow herders’ wells in near-surface streambed aquifers,” at P. 413, failing to acknowledge or ignoring the “interaquifer flow” between shallow herders’ wells and the deep aquifer caused by poor borehole construction identified in the IARs.

The April 2015 Independent Audit Report is described by its authors as a “Desktop Audit” as it was “conducted as a desk-top review of the documentation provided and teleconferences with OT site personnel” without supporting field observations, or interviews with area herders and other authorities. (IAR 4-2015, P. 18)

Water and Waste Management Non-Conformance Issues identified in the April 2015 IAR address continuing problems associated with the Undai River Diversion (Issue M1.1) and

Interconnected Hydrologic Units (Issue M1.5) associated with “cascading wells.” (See Schneider 2013, Bale 2014 among other sources)

Regarding the Undai River Diversion, the IAR 4-2015, at P. 19, identifies the continuing concern that,

“The Undai River Diversion has not been completed in accordance with the ESIA due to a delay in issuance of a Land Use Permit. A temporary approach (the Undai River Partial Adjustment and Protection Project) has been completed to divert surface flow and to capture and re-route groundwater flow from the Undai River and around the zone of influence of the open pit. The current Undai River Partial Adjustment and Protection Project does not fully meet the design requirements as specified in the ESIA. ”

Comments on this issue in the IAP 4-2015 as a result of the Desktop Audit include,

“The Undai River Diversion has not been completed in accordance with the ESIA due to a delay in issuance of a Land Use Permit. A temporary approach (the Undai River Partial Adjustment and Protection Project) has been completed to divert surface flow and to capture and re-route groundwater flow from the Undai River and around the zone of influence of the open pit. The current Undai River Partial Adjustment and Protection Project does not fully meet the design requirements as specified in the ESIA. ”

At P. 20, the IAP 4-2015 identifies the continuing concern that,

“Mitigations are required in the event of interconnection of hydrogeological units. These mitigations have not yet been implemented in all instances. OT is progressing efforts to abandon or convert to productive use these interconnecting bores. ”

Comments on this issue in the IAP 4-2015 as a result of the Desktop Audit include,

“Evidence exists of exploration bores interconnecting hydrogeological units within the Gunii Hooloi borefield, in the Galbyn Gobi region, and within the MLA. Future disposition of these wells is currently under evaluation by a workgroup established with the Khanbogd soum. There are some requests for conversion of the wells for community use; this request has been forwarded to the communities’ team.

“Best efforts are being made by OT to progress the sealing of interconnecting bores within and outside of the MLA, however the issue is outstanding. Per request from the workgroup OT has provided boring logs for all interconnecting bores. ”

OTTR 2014, at p. 24, says,

“Although it has a requirement to make its self-discovered water resources available to be used for household purposes, it is confirmed in the [OT Investment Agreement] IA that OT LLC holds the sole rights to use these water resources for the Project. OT LLC has the right under the IA for a water use right for the period of its mining licence.”

OTTR 2014, at P. 52 says,

“OT LLC will make its self-discovered water resources available to be used for household purposes, herder families, and agricultural activities of the local soum communities.”

Neither the IAR or OTTR 2014 describe the “best efforts” that OT is reported to be making to address the interconnected aquifer problems affecting shallow wells used by herders resulting from OT well construction, or how the performance of those best efforts will be evaluated.

OTTR 2014 does not identify whether, when, how, and in what amount, OT would “make its self-discovered water resources available to be used for household purposes, herder families, and agricultural activities of the local soum communities” through the life of the OT operation, or how OT self-discovered water resources will be used to address replacement of and compensation for losses to herder water resources in the Undai River watershed or areas of aquifer interconnection resulting from faulty borehole construction.

OT has not yet proposed a plan for use of “its self-discovered water resources available to be used for household purposes, herder families, and agricultural activities of the local soum communities” through the life of the OT operation.

Herders have been impacted by boreholes connecting shallow and deep aquifers – “cascading wells” – for many years. Cascading wells were first identified by herders in 2004. Herders’ livestock management and cultural patterns have been severely disrupted by the ineffectiveness of the Undai River Diversion and the Replacement Bor Ovoo spring since 2013 when the current Undai Diversion construction works were completed.

Development and implementation of plans to “make its self-discovered water resources available to be used for household purposes, herder families, and agricultural activities of the local soum communities” through the life of the OT operation would be appropriate to address:

“OT LLC . . . obligations with regard to water utilisation: [including]  
- Not reduc[ing] from the current level the quality and quantity of the existing potable and livestock water supplies used by existing users at the date of the IA [OT Investment Agreement 2009] within the water resources area defined in the DEIA Reports.” (OTTR 2014 P. 53)

Both the IAR consultants and IFC CAO Oyu Tolgoi-01 and Oyu Tolgoi-02 Complaint files acknowledge that a June 8, 2015 Memorandum of Understanding to form a Tri-Partite Council to has been agreed to by Khanbogd Soum administration, Representatives of Herders of Khanbogd Soum and OT LLC to address the Herder Complaints filed with the IFC CAO. The Council provides an important new venue where the parties can,

“consider, address, resolve, exchange information about, make proposals and recommendations in respect of, implement and relay to the appropriate levels, any

issues relating to herders, pasture and water and any other relevant issues...”  
associated with the Herders’ IFC CAO Complaints.”

Mongolian and English language versions of the June 8, 2015 MoU are available on the IFC CAO pages for the OT Complaints at: <http://www.cao-ombudsman.org/cases/document-links/links-191.aspx> and <http://www.cao-ombudsman.org/cases/document-links/links-196.aspx>

This recent development may provide a effective venue for airing and resolving herders and Soum Government complaints regarding OT impacts if funded adequately to provide sufficient support for sustained participation by herder and Soum representatives including their time and travel and sustained professional technical support.

## **How do International Metal Market Prices affect Oyu Tolgoi Phase 2 Development and Funding Plan and Technical Reports?**

All projections of the future value and economic impacts of OT Phase 2 presented in the May 18, 2015 Oyu Tolgoi Underground Mine Development and Financing Plan (OTUMDFP 2015) are based on the international market prices for the copper, gold and silver that would be extracted.

December 1, 2015 market prices for copper, gold and silver are significantly lower than the prices used in the development of OT Phase 2 expansion plans for copper, gold, and silver, the three metal commodities being produced at OT.

As long as lower metal prices last, the value of OT copper, gold and silver production will be reduced below the estimated OT Phase 2 income and value which were based on higher projected prices. Income derived from the mine and government payments associated with Current OT Phase 1 operations that reflect the value of mine production will also be reduced due to lower metal prices than those projected in the OTTR 2014.

The central role of international market prices in the assumptions regarding the future value and economic impact of OT Phase 2 as projected in OTUMDFP 2015, signed by OT's ownership on May 18, 2015 in Dubai, is shown at P. 4 in the table of "Impacts on the Domestic Economy" that are, "based on a number of assumptions relating to scope, costs, schedule, technical aspects and market conditions."

The OTUMDFP 2015 is an agreement between the "Government of Mongolia through Erdenes Oyu Tolgoi LLC" ("EOT" – the corporate entity created by the Government of Mongolia to represent its 34% share in the Oyu Tolgoi) and Oyu Tolgoi's corporate owners of the remaining 66% of the Oyu Tolgoi Mine: Turquoise Hill Resources Limited, THR Oyu Tolgoi Ltd and Oyu Tolgoi Netherlands B.V., (together "TRQ") and Rio Tinto International Holdings Limited ("Rio Tinto") and Oyu Tolgoi LLC ("OT LLC"). Rio Tinto controls the majority of shares in Oyu Tolgoi through its ownership of 51% of Turquoise Hill Resources Limited.

The OTUMDFP 2015 lists agreements "in principle" among OT's owners and notes, at P. 5, that the actual cost – using the word "quantum" for the estimated "actual amount" – "of funding requirements will be determined by a number of factors including the business performance of OT LLC and variances in the copper and gold prices."

The Dubai Agreement says at P. 5, that formal "Approval of [OT Phase 2 financing] is a decision for the Boards of Rio Tinto, TRQ and OT LLC and the Shareholders of OT LLC. Oyu Tolgoi Board approval of [OT Phase financing] is required by the lenders ... to be unanimous."

In addition to outlining agreements in principle and the actions necessary for formal approval of project financing to start OT Phase 2, the OTUMDFP 2015 includes



commitments related to progress on an OT power supply, research on a future OT copper smelter, and financial reporting and tax considerations and other activities.

Uncertainty regarding future prices for copper, gold and silver and other commodities reflects the global market uncertainty about whether the steep fall in prices for those metals since 2010 will be a long-term or short-term trend. As copper is the source of more than 75% of the value of Oyu Tolgoi Phase 2, this uncertainty focuses on questions regarding future copper price.

### **How much have international metal market prices fallen since the OT Phase 2 Technical Report (OTTR 2014) was released?**

December 2015 international market prices for copper, gold and silver are significantly: 20–30% lower than those used in OTTR 2014 resource evaluations and economic projects for OT Phase 2.

Copper, gold and silver prices have been dropping steady since the October 2014 release of OTTR 2014, which the May 2015 OT OTUMDFP and 2015 OT Feasibility Study (not disclosed to the public) have been “aligned” with (THR 2015). The “Reserve Case” is the term in the OTTR 2014 for the OT Phase 2 expansion. OT’s 2014 “Reserve Case” summary (OTTR 2014 at P. 4) projects the mining of 1.5 billion tons of ore at copper grade (“content”) of 0.83%, gold grade of 0.32 grams per ton and silver grade of 1.94 grams per tons. OT Phase 2 ore is estimated to contain 24.9 billion pounds of copper, 11.9 million ounces of gold and 78.0 million ounces of silver.

The value of recovered metal from OT Phase 2 used in OTTR 2014 are:

“[f]or mine planning...the metal prices used... were copper at \$3.01/lb, gold at \$1,250/oz and silver at \$20.37/oz and .... cost for the underground mine are based on \$15.32/t.” (OTTR 2014 at P. 20).

At those prices, the total value of the metal recovered from OT Phase 2 would be about \$88.4 billion dollars, of which more than 82% – \$74.7 billion – would come from copper sales.

Since OTTR 2014 was released, copper, gold and silver prices (and other commodities that are important to the Mongolian economy) have fallen significantly. If December 1, 2015 international market prices for copper - \$2.11/lb, gold - \$1,065/oz, and silver - \$14.21/oz, are used to calculate the value of the ore proposed for mining at OT Phase 2, the total value of the metal to be recovered would fall more than \$22 billion, from \$88.4 billion to \$66.1 billion, with the copper value falling from \$74.7 billion to \$52.4 billion, also more than \$20 billion.

Figure 24 – “Market Price Uncertainty” including “5 Year Copper Spot” – included 5-year trend in copper spot market prices shows copper sport market prices between November 2010 and December 2015.

Market Price Uncertainty - Market prices for the copper, gold and silver have fallen in value since OT Phase 2 mine plans were reported in OTTR 2014 where “metal prices used... were copper at \$3.01/lb, gold at \$1,250/oz and silver at \$20.37/oz” (OTTR 2014 P. 20). At those prices, the total value of the metal recovered from OT Phase 2 would be about \$88.4 billion dollars, of which more than 82% - \$74.7 billion - would come from copper sales.



Metal market prices from [www.kitco.com](http://www.kitco.com)

Copper prices, as well as gold and silver prices, have fallen steady for more than 5 years. Current, December 2015, market prices for copper, gold and silver are well below those used for OT Phase 2 mine planning in OTTR 2014. **If December 1, 2015 international market prices for copper - \$2.11/lb, gold - \$1,065/oz, and silver - \$14.21/oz, were used to calculate the value to be recovered from OT Phase 2 ore, the value of OT Phase 2 production would fall from \$88.4 billion to \$66.1 billion - a drop of more than 25%; with the copper value falling from \$74.7 billion to \$52.4 billion – a drop of 30%**

19

Source: The source for the “5 year Copper Spot Chart” [www.kitco.com](http://www.kitco.com), is also the source used for commodity metal prices on the Turquoise Hill Resources web site at [http://www.turquoisehill.com/s/commodity\\_metal\\_prices.asp](http://www.turquoisehill.com/s/commodity_metal_prices.asp).

The December 1, 2015 copper price of \$2.11/pound is 30% less than the OTTR 2014 planning price for copper of \$3.01.

The December 1, 2015 gold price of \$1,065/oz is 15% less than the OTTR 2014 planning price for gold of \$1,250/oz. (see [www.kitco.com](http://www.kitco.com) for gold price charts)

The December 1, 2015 silver price of \$14.21/pz is 30% less than the OTTR 2014 planning price for silver. (see [www.kitco.com](http://www.kitco.com) for silver price charts)

The reduction in total metal value for OT Phase 2 using December 1, 2015 metal prices instead of OTTR 2014 metal planning prices is about 25%, with the total value of the copper to be mined in the OT Phase 2 falling 30%.

How long the current depression in metal commodity prices relative to peak prices in 2010 and 2011 will last is not predictable with any certainty and is the focus of intense speculation by copper producers, investors, banks and copper consumers.

Metal market price uncertainty may influence the ultimate design, cost and corporate board approval of OT Phase 2, all of which are necessary before acceptance of the multi-bank loan facility offered to OT by a consortium of banks December 14, 2015.

OT management recognizes the change in metal prices during the recent years affect the projected value of OT. Turquoise Hill, Rio Tinto and OT management continue to be optimistic that investment in OT expansion will generate copper, gold and silver that will find an improved, higher price, market, when the OT Phase 2 expansion is completed.

Rio Tinto management's view on the effects of the recent fall in the copper price on OT are summarized in a November 26, 2015 article titled, "Copper prices may weigh on Rio Tinto's looming decision on Oyu Tolgoi expansion," that reports Rio Tinto's chief executive for copper and coal Jean-Sebastien Jacques's and Rio Tinto's belief that "the copper market is facing two or three years more of pain, it is the one commodity they expect to recover the fastest." (Mining 2015)

Similarly, Mr. Jacques was reported to have said that, "We are pretty bullish about the copper market in the long term and the reason is we expect a 6 to 8 million tonne shortfall [of copper] in the next 10 years," he said. "Oyu Tolgoi will be part of the solution to provide the copper that is required in China or any part of the world at that point in time." (INVEZZ 2016).

For perspective, OT Phase 2, the 24.9 billion pounds of copper OT Phase 2 is projected to produce is equal to 1,250,000 tons of copper allowing for an average of 31,250 tons per year for 40 years. The copper produced by OT Phase 2 will be in the form of copper concentrate, about 100,000 tons per year containing about 33% copper, unless and until a copper smelter or other copper refinery is constructed to further process the OT copper concentrate. While a very, very large mine, OT's annual copper production is less than 1% of the 6-8 million ton "shortfall" in copper supply projected by Mr. Jacques.

OT Phase 1 produces copper, gold, and silver from 100,000 tons of ore per day. OT Phase 2 will produce 115,000 tons per day of ore – 95,000 tons from the North Hugo Lift 1 Underground Mine once full production is reached. Full production at North Hugo Lift 1 is projected to be achieved in the early 2020s – about 5-7 years away. OT management projects that the low price conditions in the copper market will end after a couple more years, before OT Phase 2 has reached full production levels.

## **What are some of the plans and issues associated with developing a power source for OT Phase 2?**

A power supply source to operate OT Phase 2 at full capacity has not yet been built. OTTR 2014 discussion of the power supply needs focus on development of an “Independent Power Project” [IPP] including a coal-fired power plant using coal from the Tavan Tolgoi deposit west of OT. Power supply needs for OT are projected to grow from 145 Megawatts at start, to 246 MW when underground mine development is completed.

Development of a Tavan Tolgoi IPP in time to meet OT Phase 2 demand by the 2020-2022 period as projected in OTTR 2014 faces many obstacles including funding challenges, mixed political support and operating issues.

Alternative sources such as wind power may be able to be constructed in time to meet OT Phase 2 power demand and at lower cost, as at least five utility scale wind projects are involved in permitting or constructing more than 350 megawatts in Southern or Eastern Mongolia.

OT Phase 2 “Operating Assumptions,” as provided in OTTR 2014 at p. 24, include, “The supply of power has been recognised as being critical to the project execution of Oyu Tolgoi in the 2009 Investment Agreement]. 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. Signing of a PSCA with the GOM in August 2014 has reset the four years obligation while the opportunity for the establishment of an IPP at Tavan Tolgoi is studied. OT LLC has retained the right to construct a power station at Oyu Tolgoi. “ (OTTR 2014, P. 24)

OTTR 2014 recognizes that,

“The Oyu Tolgoi Project is energy-intensive, with requirements of a peak of 145 MW since start-up, increasing to 246 MW in the longer term after completion of the underground development. A reliable and stable power supply is essential for operations and safety.” (OTTR 2014, P. 383)

In its discussion of “Power” at P 30, OTTR 2014 says,

“OT LLC has a Power Purchase Agreement with the Inner Mongolia Power Corporation to supply power to Oyu Tolgoi. The term of this agreement covers the commissioning of the business plus the initial four years of commercial operations.

“In August 2014, OT LLC signed a Power Sector Cooperation Agreement (PSCA) with the GOM for the exploration of a Tavan Tolgoi-based independent power producer (IPP). The aim of the PSCA is to lay out a framework for long-term strategic cooperation between the GOM and OT LLC for a comprehensive energy plan for the South Gobi region. Participation in the PSCA meets OT LLC’s obligation in the IA to establish a long-term power supply within Mongolia within four years from the commencement of commercial production. Signing of a PSCA has reset the four

years obligation while the opportunity for the establishment of an IPP at Tavan Tolgoi is studied.

“The PSCA provides a framework for a broad range of power-related issues, including the establishment of a power generation source, transmission lines, and power imports. The centrepiece of the PSCA is an open, international tender process to identify and select an IPP to privately fund, construct, own, and operate a power plant to supply electricity, with Oyu Tolgoi as the primary consumer.

“Full evaluation of the IPP option is expected to take 9–12 months. OT LLC plans to actively participate in the processes of the PSCA to ensure that there is a timely and reliable power supply solution for Oyu Tolgoi and this approach is endorsed.”

OTTR 2014, at P.53 recognizes that,

“The Power Plant Project will implement the environmental protection provisions of the IA as described in the ESIA (July 2012). A Supplemental ESIA specifically for the Power Plant Project is forthcoming.”

The OTTR 2014 discussion of a Tavan Tolgoi Power Plant for OT Phase 2 do not acknowledge the many challenges currently the facing development of the Tavan Tolgoi Power Plant and the operation of the associated coal mine needed to feed the plant.

Some of these challenges have been recognized by Erdenes Mongol senior management, the officers of the Government of Mongolia corporation that holds a 34% share of OT LLC.

In August, 2015, three months after the May 18, 2015 OTUMDFP, Mr. Ch. Otgochuluu, Erdenes Mongol senior economist, said, “Turquoise Hill has issued a financial guarantee worth one billion US dollars for the construction of Tavantolgoi Power Plant. The Government has given directions to associated officials to launch development of the plant from spring of 2016.”

As no feasibility study for the Tavan Tolgoi Power Plant, or any alternative power supply for OT Phase has been released, it is unclear if the USD one billion financial guarantee from Turquoise Hill is sufficient for the construction of 246-megawatt power source OT says it needs from Tavan Tolgoi. At a cost of USD one billion, the 246-megawatt plant would cost about \$4.06/watt to construct.

Mr. Otgochuluu noted that full cost of the OT Phase 2 project is likely to rise significantly, noting that “[t]he first estimation of required investment for underground development is likely to increase from 5.7 billion to 7-8 billion US dollars.”

If Mr. Otgochuluu estimates are accurate, projected OT Phase 2 costs would rise to 17–33% more than the USD 6 billion maximum value of the multi-bank loans for announced December 18, 2015.



Development of the updated 2015 OT Phase 2 feasibility study and revised construction costs are critical steps that are required to be completed prior to the consideration of final OT Phase 2 project approval of the Boards of all of the OT LCC partners as required by the OTUMDFP 2015.

Significant additional power beyond OT Phase 2 demand will be necessary for operating any copper refining smelter considered by OT LLC or any future expansion beyond Phase 2. An investigation of the economic viability of adding a copper smelter to the OT complex is required by September 2016 in the OTUMDFP 2015. A copper smelter would be used to upgrade concentrate grade copper currently produced at OT with about 33% copper content to refined copper metal with 95 – 99%+ copper content - depending on the specific smelting, refining and/or converting processes selected. Currently the upgrading of OT concentrates to the more valuable 99%+ copper metal product is conducted at smelters in China.

Development of coal production capacity at the Tavan Tolgoi deposit that would feed a Tavan Tolgoi Power Plant is also facing significant difficulties and may be stalled for an extended period. In early September 2015, Forbes magazine reported that,

“Mongolian Minister Mendsaikhan Enkhsaikhan said that the long-delayed \$4 billion Tavan Tolgoi coal mine project was unlikely to go ahead, according to the Business Mongolia newsite, partly due to China’s slowing growth. “It’s not only because of parliament [where the project has faced opposition], but also because of the Chinese situation,” Mendsaikhan said. The newsletter notes that Mongolia relies on China to buy “nearly all of its minerals and petroleum,” which accounted for 86 percent of exports in the first half of 2015.” (FORBES 2015)

Just weeks later, the failure to secure loans to operate the Tavan Tolgoi coal mine was confirmed, casting a shadow over the likelihood of development of Tavan Tolgoi deposit on a large enough scale to power OT Phase 2 when that power is needed.

Later in September 2015, [www.mining.com](http://www.mining.com) reported,

“Mongolia struggles to develop its largest coal mining project, Tavan Tolgoi, with reserves of 7.4 billion tonnes of coal, after the Mongolian Government failed to secure \$4 billion in funds. Development of the mine, halted by politics and weak government institutions, reflects the resource curse as Mongolia’s Parliament failed to transfer ownership of the coal mine. The transfer of ownership to a consortium of Chinese and Japanese companies, was part of Mongolia’s plan to increase investors’ stake holdings in 2015 and 2016.

“Mongolia’s continuously developing mining sector and vast resources cause obstacles in managing Mongolia’s resources. The development of Oyu Tolgoi and Tavan Tolgoi represent a mining boom that could be short-lasting as the country experiences boom-bust cycles in line with international demand and international commodity market prices. Mongolia’s double-digit growth of the last few years and in 2014 slowed to 7.8%. In 2011, there was 17.3% GDP growth.” (Mining 9-2015)

The current downturn in copper pricing is a cause of a downturn in operations of many copper mines around the world though Rio Tinto management continue to investment in OT in anticipation of a upturn in copper prices in the next 2-3 years. (TRQ 8-2015)

### **Are alternative sources of power possible for OT Phase 2?**

While OTTR 2014 at P. 438 notes that, “Copper demand will also benefit from a greater long-term focus on renewable sources of energy and energy-efficient technologies such as wind turbines and electric/hybrid vehicles, which are of copper-intensive fabrication,” OTTR 2014 offers no renewable energy options for the OT power supply.

At the same time that Forbes 2015 was reporting on the long-term obstacles facing Tavan Tolgoi coal production, it was also reporting on energy production trends in China moving away from coal to renewable energy production. In September 2015 Forbes also reported that,

“Renewable energy is also key to China’s transition away from coal. China invested \$90 billion in clean-tech investments last year, according to Bloomberg New Energy Finance, far more than the U.S. Non-fossil fuel sources – solar, wind, hydro and nuclear – are expected to make up 20% of China’s energy mix in 15 years. China already has more wind-generating capacity than any country in the world and it is likely this year to overtake Germany as the world’s largest solar country, measured by installed capacity. By 2030, China’s non-fossil-fuel energy base alone will be almost equivalent to the total electrical capacity of the U.S. today.” (FORBES 9-2015b)

Options for wind power production in Mongolia at the industrial scale needed by OT are identified in the “Scaling Up Renewable Energy in Mongolia Investment Plan” summarized at the Mongolia National Renewable Energy Center’s webpage at:

<http://www.nrec.mn/web/data/main/main1441093417.pdf>.

TA-8757 MON Scaling Up Renewable Energy in Mongolia (Investment Plan), 28 August 2015 (NREC 2015)

The “Scaling Up Renewable Energy in Mongolia Investment Plan” (NREC 2015) identifies five active wind power development projects, with potential to generate a total of 350 MW, as follows:

- Oyu Tolgoi Wind Power Project by Qleantech LLC, 102 MW
- Sainshand Wind Park, Sainshand Wind Park LLC, 52 MW
- Choir Wind Farm, Aydiner Global LLC, 50.4 MW
- Tsetsii Wind Farm, Clean Energy Asia LLC, 50 MW and
- AB Solar Wind, AB Solar Wind LLC, 100 MW

NREC 2015 says that, “All have government approval and their readiness allows construction to start in 2016.”

OT's ownership should consider investment in renewable energy sources for the mine's future power supply. The wind projects listed have potential to come on line before a Tavan Tolgoi coal-fired power plant fed by Tavan Tolgoi coal and at potentially lower cost.

Progress on the Sainshand Wind Project through March, 2015, included an announcement by Ferrostaal Industrial Projects GmbH that it will begin construction of its Sainshand Wind Farm in April, slated to be Mongolia's second and largest when it is completed in 2016. The \$115 million park will have 27 towers and an installed capacity of 54 megawatts. It will deliver 54 megawatts to Mongolia's electrical grid, Oliver Schnorr, director of Sainshand Wind Park LLC, said in a text message. (BLOOMBERG 3-2015)

The Sainshand project would be the second utility scale wind project to be constructed in Mongolia. The first, the 50-MW Salkhit Wind Farm began operations in 2013.

If the \$115 million cost for 54 megawatt Sainshand wind project is accurate, the cost per watt for the project will be \$2.12/watt. European Bank for Reconstruction and Development (EBRD) reports that cost design and construction of the 50 megawatt Salkhit Wind Project, the only operating industrial scale wind farm in Mongolia, was \$123 million, a cost of \$2.46/watt. (EBRD 2013)

The project cost of Sainshand wind project would be only 53% per watt of the projected cost of a 246-megawatt Tavan Tolgoi Power Plant if it would cost \$1 billion, a cost of \$4.06/watt. If the more conservative cost of the Salkhit Wind Farm were used for comparison, the cost of wind power for OT Phase 2 would be 40% less than the cost per watt for Tavan Tolgoi power at \$4.06/watt.

In April 2015, Newcom LLC, developer of the Salkhit with funding from the European bank for Reconstruction and Development (EBRD) among other sources announced "The \$100 million Tsetsii plant received its permit from the National Dispatching Center, which manages Mongolia's grid." Newcom Chief Executive Bolor Jargalsaikhan said, "The wind farm is the first project of Clean Energy Asia LLC, which is 51 percent owned by Ulaanbaatar-based Newcom and 49 percent by Japan's SB Energy, which is SoftBank Corp.'s energy arm. The operators plan to expand power capacity from 50 to 250 megawatts within 10 years." (BLOOMBERG 4-2015)

## SOURCES CITED

- BALE 2014 “Massive Mongolian Mine Endangers Nomads Water, Way of Life”, Rachel Bale, September 30, 2014, <https://www.revealnews.org/article-legacy/massive-mongolian-mine-endangers-nomads-water-way-of-life/>
- BLOOMBERG 3-2015 “Ferrostaal set to begin work on Mongolia's biggest wind farm”, Michael Kohn, Bloomberg News, March 17, 2015, <http://www.bloomberg.com/news/articles/2015-03-17/ferrostaal-set-to-begin-work-on-mongolia-s-biggest-wind-farm>
- BLOOMBERG 4-2015 “Newcom, SB Energy Win permit for 50-MW Wind Farm in Mongolia”, Michael Kohn, Bloomberg News, April, 30, 2015, <http://www.bloomberg.com/news/articles/2015-04-30/newcom-sb-energy-win-permit-for-50-mw-wind-farm-in-mongolia>
- CAO IEP 2015 Mongolia/Oyu Tolgoi-01/Southern Gobi – with documents available at: <http://www.cao-ombudsman.org/cases/document-links/links-191.aspx> and Mongolia/Oyu Tolgoi-02/Southern Gobi - with documents available at: <http://www.cao-ombudsman.org/cases/document-links/links-196.aspx>
- EBRD 2013 “Development Impact Honors: Mongolia Salkhit Wind Farm” <http://www.ebrd.com/downloads/news/treasury-development-salkhit.pdf>
- ESIA 2012 “Environmental and Social Impact Assessment”, 2012, All sections available at <http://ot.mn/environmental-social-impact-assessment/>
- FORBES 9-2015b “China’s Economic Slowdown: We May Have Seen Peak Coal”, Mark Clifford, Forbes Magazine, September 3, 2015, <http://www.forbes.com/sites/mclifford/2015/09/03/chinas-economic-slowdown-we-may-have-seen-peak-coal/>
- IAR 4-2015 Report of the Independent Environment and Social Consultants – Oyu Tolgoi Project; Interim Report April 2015, prepared by D’Appolonia, S.p.A. , [http://ot.mn/media/ot/content/esia-audits/OT ESIA Audit report Apr 2015 EN.pdf](http://ot.mn/media/ot/content/esia-audits/OT_ESIA_Audit_report_Apr_2015_EN.pdf)
- IEP ES 2015 “IEP Executive Summary” – (CAO Independent Expert Panel Report – Executive Summary), January 30, 2015, [http://www.cao-ombudsman.org/cases/document-links/documents/ExecutiveSummary edit Jan 30 2015-ENG.pdf](http://www.cao-ombudsman.org/cases/document-links/documents/ExecutiveSummary_edit_Jan_30_2015-ENG.pdf)

- INVEZZ 2016 “Rio Tinto share price: Miner agrees \$4.4bn Mongolia mine financing”, Veselin Valchev Valchev, January 4, 2016 at <http://invezz.com/news/equities/21694-Rio-Tinto-share-price-Miner-agrees-4-4bn-Mongolia-mine-financing>
- IDP ES 2005 “Oyu Tolgoi Project, Mongolia - Integrated Development Plan - Executive Summary”, prepared by AMEC Ausenco Joint Venture, August 2005, Revision 1, [http://www.turquoisehill.com/i/pdf/IDP\\_ExecutiveSummary.pdf](http://www.turquoisehill.com/i/pdf/IDP_ExecutiveSummary.pdf)
- IDP 2010 “Oyu Tolgoi Project June 2010 Technical Report, prepared by AMEC Minproc, [http://www.turquoisehill.com/i/pdf/IDP10\\_June062010.PDF](http://www.turquoisehill.com/i/pdf/IDP10_June062010.PDF)
- IDOP 2012 Oyu Tolgoi Project IDOP [Integrated Development and Operating Plan] Technical Report, prepared by AMC Consultants, March 12, 2012 at [http://www.turquoisehill.com/i/pdf/IDOP\\_2012Mar29\\_Tech\\_Rpt.pdf](http://www.turquoisehill.com/i/pdf/IDOP_2012Mar29_Tech_Rpt.pdf)
- Mining 11-2015 “Copper prices weigh on Rio Tinto’s looming decision on Oyu Tolgoi Expansion”, Cecelia Jamasmie, November 26, 2015 at <http://www.mining.com/copper-prices-weigh-on-rio-tintos-looming-decision-on-oyu-tolgoi-expansion/>
- MINING 9-2015 “Mongolia struggles to develop Tavan Tolgoi coal mine”, Samantha Brletich, [www.mining.com](http://www.mining.com), September 21, 2015, <http://www.mining.com/web/mongolia-struggles-to-develop-tavan-tolgoi-coal-mine/>
- MINING MAG 2011 “Ore Body Access,” *Mining Magazine*, 03 May 2011 at <http://www.miningmagazine.com/equipment/orebody-access>)
- MONTSAME 2015 “OT Underground Mine funding to be settled next month,” B. Amarsaikhan, Montsame News, October 27, 2015, <http://en.montsame.mn/mining/ot-underground-mine-development-funding-be-settled-next-month-0>
- NREC 2015 “Scaling Up Renewable Energy Investment Plan” summarized at the Mongolia Renewable Energy Center’s webpage at: <http://www.nrec.mn/web/data/main/main1441093417.pdf>. TA-8757 MON Scaling Up Renewable Energy in Mongolia (Investment Plan), 28 August 2015
- OTTR 2014 Oyu Tolgoi 2014 Technical Report, prepared for OT LLC by OreWin Consultants, October 27, 2014 [http://www.turquoisehill.com/i/pdf/2014-10-27\\_OyuTolgoiTechReport.pdf](http://www.turquoisehill.com/i/pdf/2014-10-27_OyuTolgoiTechReport.pdf)
- OTUMDFP 2015 May 2015 Oyu Tolgoi Underground Mine Development and Financing



Plan, [http://www.turquoisehill.com/i/pdf/2015-05-18\\_OTUMDAFP.pdf](http://www.turquoisehill.com/i/pdf/2015-05-18_OTUMDAFP.pdf)

- TRQ 8-2015 “Oyu Tolgoi files revised schedules for 2015 feasibility study with Mongolian Minerals Council,” TRQ, Press Release, August 27, 2015, [http://www.turquoisehill.com/s/news\\_releases.asp?ReportID=720655](http://www.turquoisehill.com/s/news_releases.asp?ReportID=720655) [submittal of revisions to a March 2015 Phase 2 Feasibility Study for approval by the Mongolian Mining Council that “aligns” the 2015 Feasibility Study with both the OTUMDFP 2015 and OTTR 2014]
- SCHNEIDER 2013 “Mongolia Copper Mine at Oyu Tolgoi Tests Water Supply and Young Democracy”, Keith Schneider, November 5, 2013, <http://www.circleofblue.org/waternews/2013/world/mongolia-copper-mine-oyu-tolgoi-tests-water-supply-young-democracy/>
- SME 2011 “SME Mining Engineering Handbook Third Edition, Society for Mining, Metallurgy and Exploration, 2011, Darling, P. ed., available at [http://app.knovel.com/web/toc.v/cid:kpSMEMEHE5/viewerType:toc/root\\_slug:sme-mining-engineering](http://app.knovel.com/web/toc.v/cid:kpSMEMEHE5/viewerType:toc/root_slug:sme-mining-engineering)
- TRQ 8-2015 “Oyu Tolgoi files revised schedules for 2015 Feasibility Study with Mongolian Minerals Council”, August 27, 2015 corporate press release available at: [http://www.turquoisehill.com/s/news\\_releases.asp?ReportID=720655](http://www.turquoisehill.com/s/news_releases.asp?ReportID=720655). Includes:  
“Turquoise Hill Resources today announced that Oyu Tolgoi has filed revised schedules for the 2015 Oyu Tolgoi Feasibility Study (OTFS 2015) with the Mongolian Minerals Council (MMC). The filing also aligned OTFS 2015 with the Oyu Tolgoi Underground Mine Development and Financing Plan (Underground Plan), which was signed in May 2015. The MMC has already tentatively accepted OTFS 2015, originally filed in March 2015, pending a revision of schedules and alignment with the Underground Plan. OTFS 2015 is based on the same feasibility study and aligns with the 2014 Oyu Tolgoi Technical Report, which was disclosed in October 2014.”
- TRQ 8-2015b “Analyst and Investor Mine Visit” Presentation, August 25-27, 2015 <http://www.turquoisehill.com/i/pdf/ppt/TRQ-SiteVisit-Aug2015.pdf>
- TRQ 12-2015 “Oyu Tolgoi signs \$4.4 billion project finance marking historic milestone toward recommencement of underground development”, TRQ Press Release, December 14, 2015, [http://www.turquoisehill.com/i/pdf/news/2015-12-14\\_NR\\_TRQ\\_YFb2vv.pdf](http://www.turquoisehill.com/i/pdf/news/2015-12-14_NR_TRQ_YFb2vv.pdf)
- Woo 2009 “Characterization and empirical analysis of block caving induced surface subsidence and macro deformations,” Woo, K., et al, ROCKENG09: Proceedings of the 3rd CANUS Rock Mechanics Symposium, Toronto, May

2009, (Woo 2009) at:

<http://www.geogroup.utoronto.ca/rockeng09/proceedings/innerFrames/PDF/Session19/4044%20PAPER.pdf>.

5 Year Copper Spot Market Price Chart



Information on international market prices and trends is compiled from: [www.kitco.com](http://www.kitco.com), the source used for commodity metal prices on the Turquoise Hill Resources web site at [http://www.turquoisehill.com/s/commodity\\_metal\\_prices.asp](http://www.turquoisehill.com/s/commodity_metal_prices.asp).

Brief Biography of  
Paul Robinson  
[srcipaul@earthlink.net](mailto:srcipaul@earthlink.net)  
Research Director  
Southwest Research and Information Center  
PO Box 4524  
Albuquerque, New Mexico USA 87107  
[www.sric.org](http://www.sric.org)

William “Paul” Robinson works as Research Director at Southwest Research and Information Center in Albuquerque, New Mexico, a scientific and educational organization working to promote the health of people and communities, protect natural resources, ensure citizen participation, and secure environmental and social justice now and for future generations, where he has employed since 1976.

Paul has prepared peer reviewed technical papers, contract publications, and educational materials and expert testimony related to mines, mills, and mineral development policy throughout his 37-year career. His consulting clients have included local and international non-governmental organizations, law firms, industry trade associations, project developers, Native American Tribes in The US, First Nations Bands in Canada, and government regulatory and foreign assistance agencies.

Paul earned his Masters in Community and Regional Planning (a terminal degree) with an emphasis on Natural Resource Management from University of New Mexico (UNM) in 1992 and a BA from the Technology Assessment Program at Washington University, St. Louis, Missouri in 1974. The professional project for his Masters addressed “Planning for Reclamation of the Uranium Waste Sites in the Former East Germany.”

Paul’s peer reviewed professional papers have been published by; British Columbia Chamber of Mines, NM Bureau of Mining and Mineral Resources, CO School of Mines, Freiberg Technical Institute–Germany and European Union–Science and Technology Directorate.. Paul has coordinated three-country - Mongolia, Russia and US – educational and scientific exchanges addressing mine reclamation, water and renewable energy annually since 2007.

Paul’s technical reviews of environmental analyses and mine operating plans in Mongolia support of civil society organizations involvement in multi-lateral bank loan applications have addressed the Big Bend, Boroo and Gatsuurt gold mines and Oyu Tolgoi copper-gold mine. Paul provided an invited presentation on “Social and Environmental Responsibility in Mining: International Experience and Lessons Learned Regarding Accumulated Damage from Abandoned Mines, and Long-term Risks Associated with Waste Management, and Renewable Energy Use” at Conference on Social and Environmental Responsibility in the Mineral Industry in Russia in Moscow in October 2012 available at [http://www.wwf.ru/about/what\\_we\\_do/mining/conference](http://www.wwf.ru/about/what_we_do/mining/conference). With co-author Galina Anosova, Paul prepared a peer-review publication on “Mining and Mineral Development Policy in the Selenge River Watershed” for Science for Watershed Conservation: Multidisciplinary Approaches for Natural Resource Management Conference, Convened by United States Geological Survey (USGS), Institute of General and Experimental Biology, Siberian Division-Russian Academy of Sciences, and Mongolian Academy of Sciences, September, 2004, available at: <http://www.sric.org/mining/docs/USGS-siberia.pdf>. He prepared technical reviews as part of Public Expertiza Committee reports in Russia for the Dybycksa gold mine, Aginskoe Autonomous Okrug and the Khiagda uranium mine, Buryat Republic.

A full resume is available upon request.