APPENDIX S: Underground Geotechnical Summary Report

MDENG MEMO #1111-M1604-01 BLACK BUTTE PROJECT CROWN PILLAR REVIEW

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Mine Design Engineering

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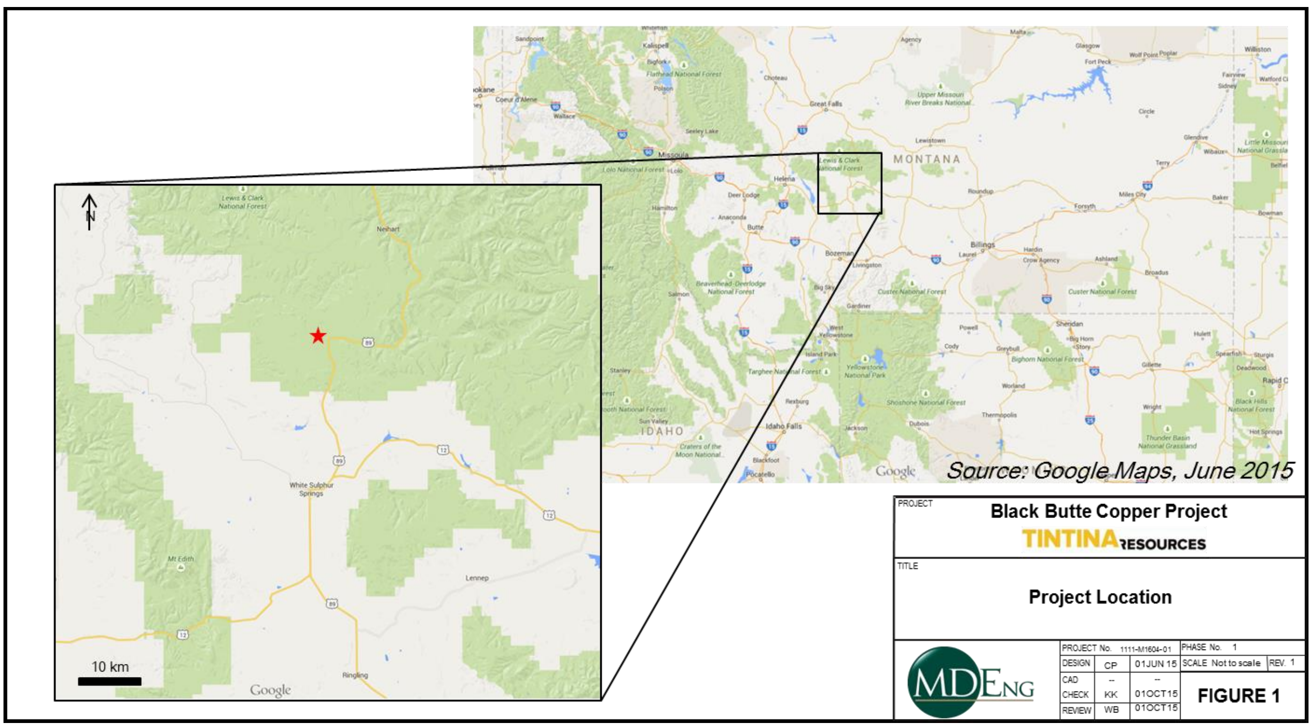
Mine Design Engineering (MDEng) of Kingston, Ontario, has been retained by Tintina Resources to assess the crown pillar susceptibility to caving and sink holes for the Black Butte Copper Project. This technical report summarizes relevant geological and geotechnical information (as summarized from MDEng, 2015) and the analysis results.

Background Information

Location

The Black Butte Property is located roughly 17 miles north of White Sulphur Springs, Montana (Figure 1). The project will involve a ramp accessed underground mining operation. Two ore zones have been considered in this study, the Jonny Lee Upper and Lower Zones (Figure 2).



Local Geology

The Lower Sulphide Zone (LSZ) is 2 to 16 m thick, dips at 20° to 37° towards the south and is 300 to 500 m deep. The Upper Sulphide Zone (USZ) is a flat, tabular ore zone ranging in depth from near 30 m to near 180 m. It is 3 to 26 m thick and dips 0° to 20° towards the south. The USZ has 2 ore lenses separated by 2 to 16 m of barren material. Figure 2 is a geological cross section of these two ore zones (a detailed description of the site geological setting can be found in the PEA (Tetra Tech, 2013)). The ore zones are hosted by massive sulphides, which themselves are hosted within the Newland Shale (consisting of interbedded dolomite, limestone and shale units). The project area is transected by the prominent Volcano Valley Fault (VVF), which is a major thrust feature truncating older normal faults, including the Buttress Fault which has been delineated in the footwall of the LSZ.

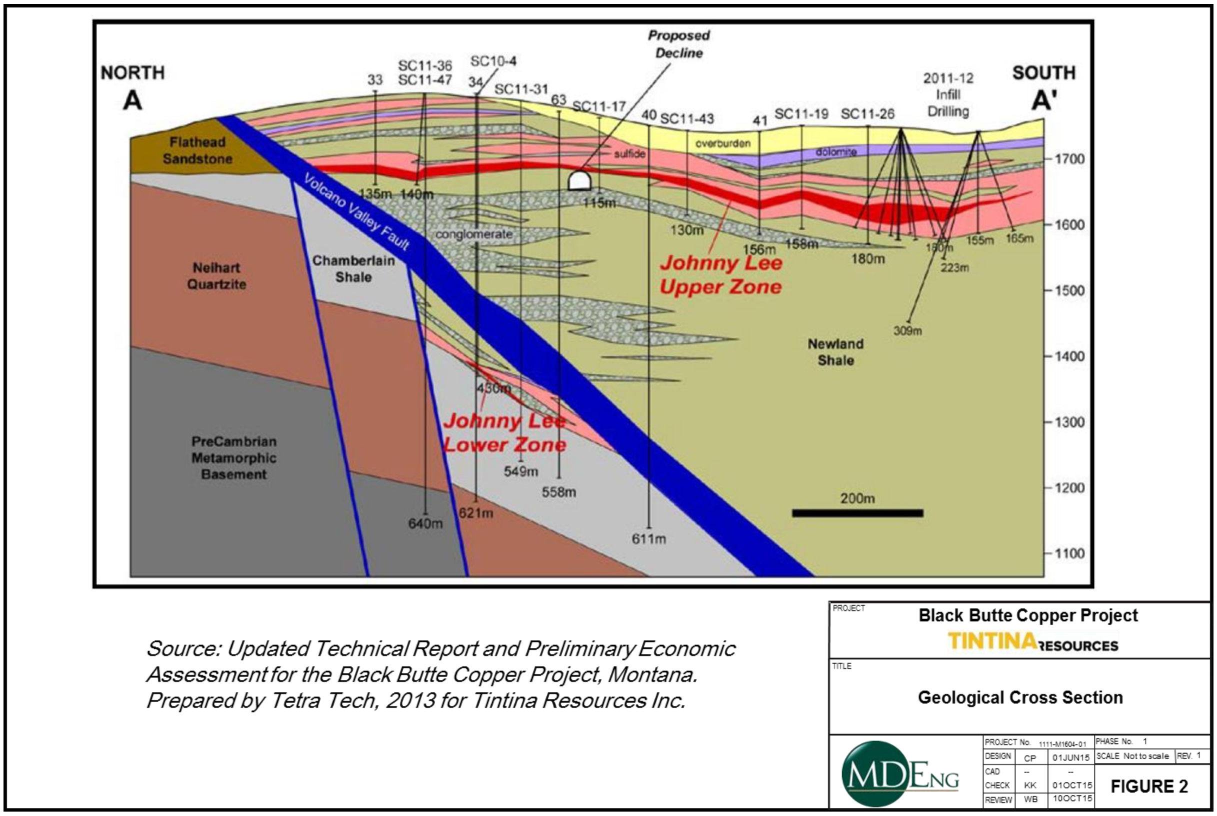


FIGURE 2

History of Instability

There is no history of instability as mining of the Black Butte Project has not yet begun.

Backfilling

The current mine backfill plans are for paste fill.

Geotechnical Data

Rock Mass Classification

The rock mass quality is considered to be poor to fair. Estimates of Q' for the geotechnical domains (by rock type) relevant to crown pillar stability are provided in Table 1. Geotechnical data currently available indicates that the USZ has slightly better rock mass quality than the LSZ. Adverse ground conditions are expected in and around the Volcano Valley Fault (very poor rock mass quality). For this assessment of crown pillar stability the lower bound 30th percentile Q' has been applied for thin pillars (<40 m bedrock cover) as it is reasonably expected that meteoric ground water has contributed to some deterioration of the rock mass quality. For crown pillars greater than 40 m thick the lower bound 50th percentile Q' is utilized for analysis. It is assumed that the crown pillars will be predominantly composed of Newland Shale.

Table 1: Q' Classification.

Geology	Q' mean	Q' 30th
LSZ	3.4-6.8	2.0-4.0
USZ	3.9-5.2	3.2-4.3
VVF	0.7-0.8	0.5-0.6
Ynl U (Newland Shale; upper zone)	5.7-7.6	3.6-4.8
Ynl L (Newland Shale; lower zone)	3.7-4.9	2.2-2.9

Generally speaking, the majority of the mine area is expected to have a shallowly dipping joint set parallel to bedding and two mutually perpendicular sub-vertical joint sets, as well as random jointing (this random jointing becomes more prevalent below the VVF). A detailed summary of rock mass conditions, intact material strengths and joint structural trends can be found in MDEng (2015).

In Situ Stress

Major and intermediate principal stress magnitudes are assumed to be horizontal, and the minor principal stress is vertical.

Stability Analysis

LSZ

The long term risk of crown pillar failure to surface over the LSZ is completely negated by the placement of paste backfill. The depth of potential cave over an underground void can be estimated by:

$$D_O = {D_V}/_{SF}$$

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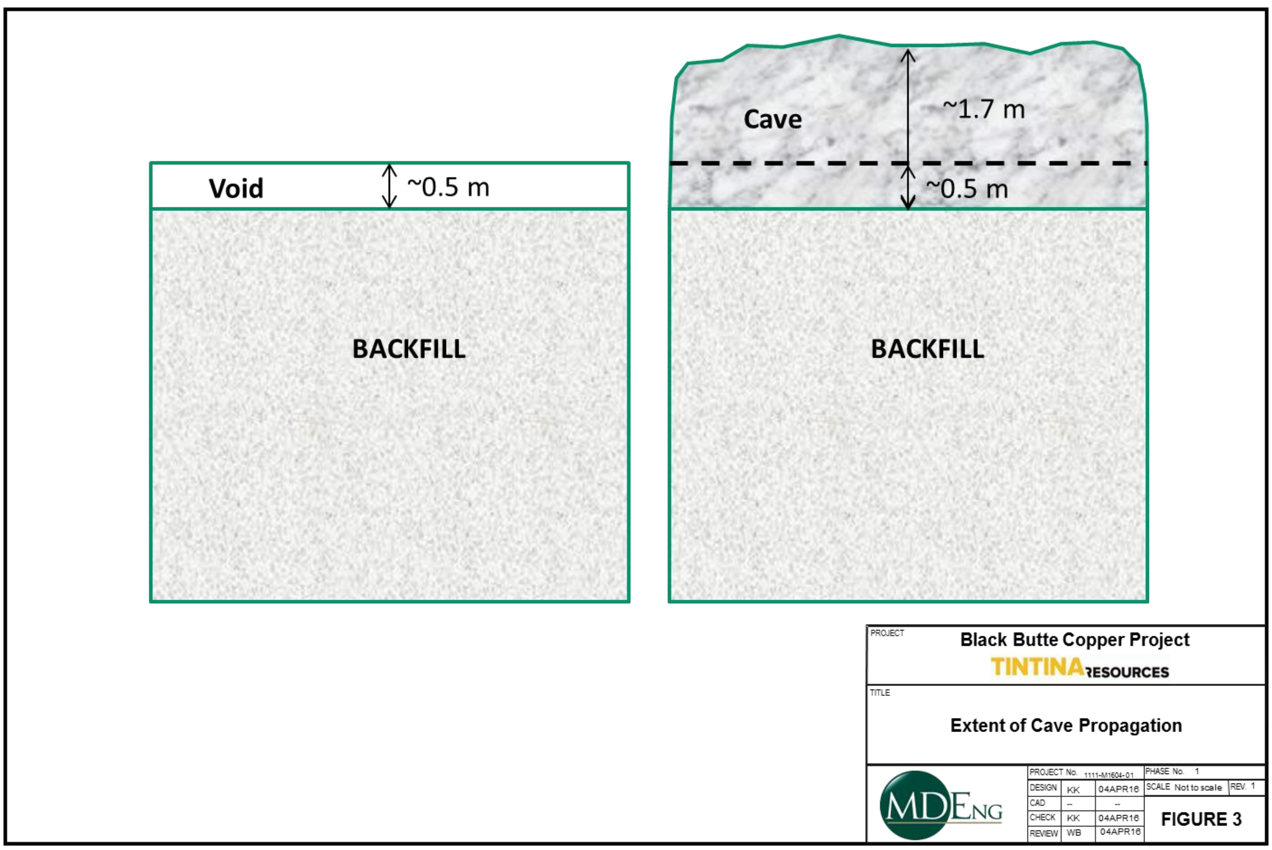
Where D_O is the estimated depth of overbreak, D_V is the void depth left between the backfill and the stope back, and *SF* is the swell factor of caved material.

For this study it is assumed that stopes will be backfilled filled to within roughly 0.5 m of the back (a conservative assumption as fill is easily placed with much less void) and that the bulking ratio of any material which caves from stope backs is about 30%.

$$D_O = {}^{0.5\,m}/_{0.3}$$

$$D_O = 1.7\,m$$

It is therefore estimated that the depth of cave, over the mined out and backfilled LSZ orebody, will propagate roughly 1.7 m into the back before becoming choked off (Figure 3), this equates to less than 1% of the total LSZ crown pillar thickness.



Based on the analysis presented here, it is the opinion of Mine Design Engineering Inc. that failure of the Black Butte Project LSZ crown pillar is extremely unlikely. There is no concern for long-term stability of the LSZ crown pillar, the risk of crown pillar failure is extremely low and consequence of such failure are therefore considered negligible. No rehabilitation measures will be necessary.

USZ

The Upper Sulphide Zone ore body is very shallow with minimum depths from topographic surface as small as 22 m, with little (<3m) or no bedrock cover between overburden (includes all soil, weathered and highly weather rock) and the ore body in some regions. The USZ is intended to be extracted by the drift and fill mining method and so maximum open spans of 5 m and 8 m have been empirically evaluated (Figure 4) assuming 100 m panel lengths to estimate critical bedrock thickness over open stopes (excluding overburden cover).

Figure 4 summarizes the design guidelines for pillar acceptability/service life of crown pillars. By these guidelines, a 20% probability of failure is an acceptable standard for service life in the order of 1 year.

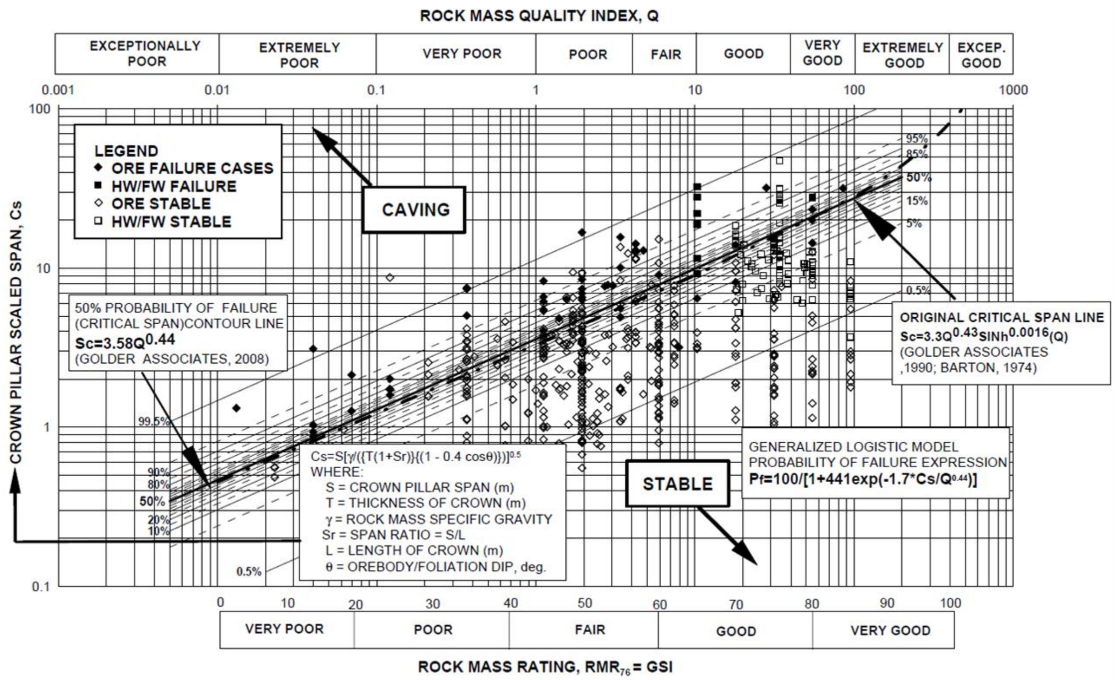
A 20% probability of failure is achieved for the following span to bedrock thickness ratios:

- 5 m span:15 m bedrock thickness
- 8 m span:35 m bedrock thickness

Risk of failure associated with this 20% probability criterion is mitigated by:

(1) Ground support installed in stope backs
(2) Rapid cycle time to minimize the necessary stand up time for critical crown pillar areas
(3) Continuous monitoring/instrumentation

Items 1 and 2 above are the most significant means to controlling stability while stopes are open, and are both in the mine plan. Since ground support is designed to maintain excavation stability during mine operations it is very unlikely that a sinkhole of collapse to surface will occur. Ground support and crown pillar design will have to be reviewed during the project feasibility study and during early underground construction as additional geotechnical data becomes available.



Class	Probability of Failure %	Minimum Factor of Safety	Maximum Scaled Span, Cs (= Sc)	ESR (Barton et al. 1974)	Design Guidelines for Pillar Acceptability/Serviceable Life of Crown Pillar				
					Expectancy	Years	Public Access	Regulatory position on closure	Operating Surveillance Required
A	50 – 100	<1	$11.31Q^{0.44}$	>5	Effectively zero	< 0.5	Forbidden	Totally unacceptable	Ineffective
B	20 – 50	1.0	$3.58Q^{0.44}$	3	Very, very short-term (temporary mining purposes only ; unacceptable risk of failure for temporary civil tunnel portals	1.0	Forcibly Prevented	Not acceptable	Continuous sophisticated monitoring
C	10 – 20	1.2	$2.74Q^{0.44}$	1.6	Very short-term (quasi-temporary stope crowns ; undesirable risk of failure for temporary civil works)	2 – 5	Actively prevented	High level of concern	Continuous monitoring with instruments
D	5 – 10	1.5	$2.33Q^{0.44}$	1.4	Short-term (semi-temporary crowns, e.g.under non-sensitive mine infrastructure)	5 – 10	Prevented	Moderate level of concern	Continuous simple monitoring
E	1.5 – 5	1.8	$1.84Q^{0.44}$	1.3	Medium-term (semi-permanent crowns, possibly under structures)	15–20	Discouraged	Low to moderate level of concern	Conscious superficial monitoring
F	0.5 – 1.5	2	$1.12Q^{0.44}$	1	Long-term (quasi-permanent crowns, civil portals, near-surface sewer tunnels)	50–100	Allowed	Of limited concern	Incidental superficial monitoring
G	<0.5	>>2	$0.69\ Q^{0.44}$	0.8	Very long-term (permanent crowns over civil tunnels)	>100	Free	Of no concern	None required

Source: Carter, T.G, Cottrell, B.E., Carvalho, J.L. and Steed, C.M. Logistic Regression improvements to the Scaled Span Method for dimensioning Surface Crown Pillars over civil or mining openings. 42nd US Rock Mechanics Symposium and 2nd US-Canada Rock mechanics Symposium. San Fransisco 2008.

PROJECT
Black Butte Copper Project
TINTINA RESOURCES

TITLE
Empirical Design Method

PROJECT No.	1111-M1604-01		PHASE No. 1	
DESIGN	KK	04APR16	SCALE Not to scale	REV. 1
CAD	--	--		
CHECK	KK	04APR16	**FIGURE 4**	
REVIEW	WB	04APR16		

Once paste backfill is placed the probability of crown pillar collapse (i.e. sink holes) is effectively 0 as there will be very limited open volume for material to collapse and propagation of a collapse to the topographic surface is unlikely. Assuming that a 0.5 m void will be left between stope backs and the paste fill, a 1.7 m cave is probable. A 0.5 m void is considered to be a very conservative worst case as it is reasonable to expect that operations can easily achieve the timely placement of tighter fill with a well-managed backfill program.

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References

Carter, T.G, Cottrell, B.E., Carvalho, J.L. and Steed, C.M. Logistic Regression improvements to the Scaled Span Method for dimensioning Surface Crown Pillars over civil or mining openings. 42nd US Rock Mechanics Symposium and 2nd US-Canada Rock mechanics Symposium. San Fransisco 2008.

MDEng, 2015. Report #1111-R1504-01 Titled Feasibility Level Geotechnical Design for Black Butte Project, Montana USA.