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"Technical Support for Grassroots Public Interest Groups"

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RE: Black Butte Mining Operation Application

I have reviewed the following sections of the Black Butte Copper Project Mine Operating Permit Application ("Application") on geochemistry and water treatment plans: Chapters 1.1, 1.2, 1.4, 2.4, 3.5.4, 3.7.3, 4.2, 6.3.2, 6.3.3, and Appendices C and D.

Key findings

- Incomplete, inadequate, and missing data prevent a full understanding of potential impacts.
- Tailings will generate acid and mobilize metals with or without cement; cement binders only provide structural stability, and do not mitigate geochemical reactions. However, there is the potential for cement to degrade. The potential for this to allow or exacerbate wetting-drying cycles inside the CTF, and the resulting impact on water quality, were not discussed. Diffusion testing was not continued until the chemistry stabilized, limiting our understanding of reactions in the interior of the CTF.
- Representative geochemical sampling of waste rock lithologies, conducted until chemistry has stabilized, is needed to understand the range of seepage water quality and associated costs at the water treatment plant.
- SPLP leach tests did not work and possibly cannot be used to predict metal mobility from construction rock material, particularly if it is the Ynl lithology that is used for construction.
- The water treatment plant as proposed is undersized; the cost of an appropriately sized treatment plan needs to be provided.
- The application needs to provide information on whether the proposed RO reject water treatment is technically vetted and viable.

Mine site geochemistry

Relative to the 2013 PEA, a revised operation plan indicates that there will be significantly less of the Ynl lithology (now 4% of waste rock, rather than the 41%) and more with high potential acid generation (lithology USZ (Upper Sulfide Zone) will be 28% of the waste rock rather than the 11% previously estimated).

The USZ, Lower Zone Footwall (LZ-FW) and Ynlb lithologies will make up approximately 1/3 of waste rock each, with potential acid generation from both USZ and LZ-FW. Material from Ynl may be used as construction rock, and also has potential for acid generation – and therefore metal leaching.

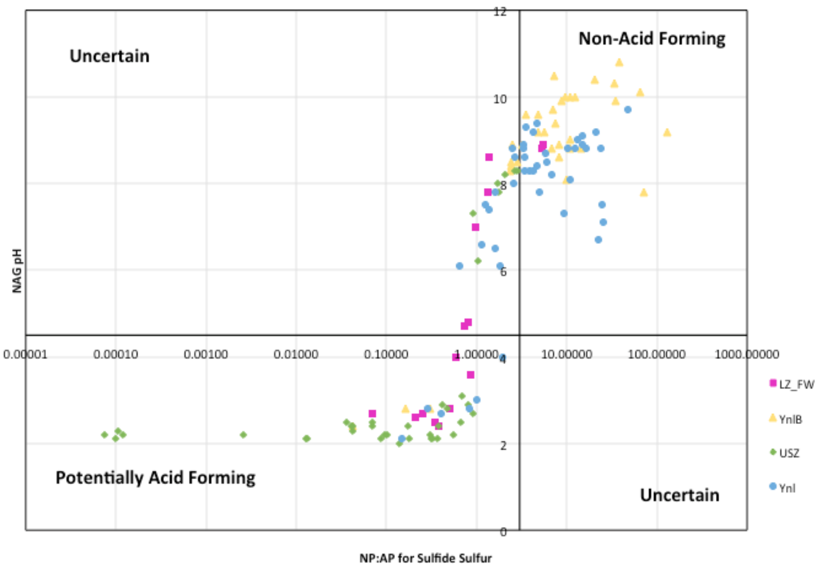

Figure 1. Potential acid generation of major waste rock lithologies. Figure 2-10 of the 2015 Black Butte Mining Operation Application.

<u>Incomplete, inadequate and missing geochemical data</u>

From testing that has been done to date, cemented tailings backfill in tunnels could release thallium or arsenic (and potentially some copper or nickel) into groundwater, as uncaptured seepage; waste rock seepage could release strontium and thallium above surface water and groundwater criteria (from USZ lithology)[1] and thallium above surface water criteria (Ynl and Ynlb lithologies).

However, inadequate HCT data prevents complete analysis of the potential tailings, waste rock, and construction rock seepage.

Tailings:

- No “diffusion” tests were conducted for 2% cemented tails.
- No humidity cell testing for cemented tailings binders with cement <2%, although Tintina states they intend to use 0.5% - 2% cement binder
- No modeling was done to determine the impacts of wetting/drying cycles on seepage from the CTF.

Waste rock

- Humidity cell testing does not capture the range of material in lithological units. No geochemical tests appear to have been conducted on the middle or lower sulfide zones (MSZ, LSZ), including the Lower Copper Zone. It is not clear whether zinc-rich zones were included in geochemical testing.

[1] The USZ waste rock material, under kinetic testing, released strontium (Sr) and thallium in levels that would exceed surface water and groundwater Water Quality Criteria for the entire length of the tests; cadmium, copper, and nickel exceeded surface water WQC through at least week 8 of the testing.

- 2015 humidity cell testing for other lithologies have less than 20 weeks of data, although some 2012 tests were conducted for 80 weeks; 2015 testing needs to continue until column chemistry stabilizes.

Construction rock

- No testing results are presented for granodiorite construction rock. 2015 humidity cell testing for Ynl lithology, which could be used for construction, is not presented

Further details are provided in the following sections.

<u>Geochemical considerations for the CTF</u>

A double lined "cement tailings facility" (CTF) will contain waste rock and will contain all tailings not backfilled into tunnels. The bottom layer of the CTF will be waste rock generated during construction of the decline (about 65% of all waste rock expected to be generated during mine life), covered with paste tails (dewatered tailings mixed with 0.5% - 2% binder of cement, fly ash, or slag). It will also contain potentially acid generating (PAG) cells of tails mixed with waste rock and 4% cement binder. At closure, tails will be mixed with 4% cement binder, and the CTF will be covered and revegetated. An underdrain will capture seepage.

Cement is provided for physical, not geochemical, stability – the cement will not neutralize acid generation. "Diffusion testing" – meant to provide information on what happens in the paste tails in the interior of the CTF buried under paste tail layers – was only conducted for two weeks, and chemistry had not stabilized. Humidity cell testing (HCT) of paste tails and waste rock mixed with 4% cement binder showed that cement "disaggregated" – therefore providing neither physical nor geochemical stability. Tintina argues that HCT is a "more aggressive" situation than what would occur, but the potential for cement to degrade cannot be brushed aside.

There will be a sump drain in the CTF to move seepage to the underdrain. Has modeling been done to determine if there is there potential that water will saturate some of the bottom waste rock layer and some of the upper layers of paste tails? There have been no tests to understand the impact on cement degradation or water quality under saturated conditions in the CTF; saturated HCT tests have only been conducted on raw tailings.

- ➢ Geochemically, a worst case situation arises if there is a flux of water causing wetting-drying cycles. This would be similar to HCT tests, and represents the condition most likely to generate acid, mobilize metals and release sulfate.

More work and discussion need to be provided on the timeline, key drivers, and water quality impacts of cement degradation in the CTF. More discussion needs to be provided on the potential for, and mitigation of, physical instability of the CTF if there is cement degradation.

Waste rock seepage

Missing data. Lack of representation was an issue in 2012, which Tintina sought to redress by taking more samples of the USZ and LZ-FW, stating that Ynlb, USZ, and LZ-FW would each make up roughly 1/3 of the waste rock. However, the LSZ (adjacent to the LZ-FW) and MSZ (within Ynlb) did not undergo any testing and the upper part of the Lower Newland formation, Ynla, did not go through testing, unless that material is now being referred to as “Ynl” going through tests in 2015. Results could potentially change the water treatment plant (WTP) design or capacity, and therefore the cost.

Variability within lithological units. Most of the lithological unit designations (Ynl, Ynla, Ynlb, USZ, LZ-FW, etc) consist of variable material, including dolomite and pyrite (Table 1). Setting up only 1-2 HCT tests for each is likely not going to provide a full representation of the potential water quality of seepage in tunnels or stockpiles.

Variability in acid and metals release between years. Variability can be observed in tests conducted on the same lithological unit in different years. Early 2015 HCT data indicates that water quality for the Ynlb lithology is about the same as it was in weeks 17-20 in 2012 HCTs, with the exception that 2012 data showed no water quality exceedances after the first month and 2015 data showed thallium (Tl) consistently exceeded surface water quality standards and lead (Pb) occasionally exceeded. Early 2015 water quality is worse for the USZ lithology (Table 2) and indicates a greater potential for metal release (Appendix D, Section 3.2.2.3).

- This suggests regulators should ensure that representative samples from all ore zones should undergo kinetic testing until chemistry stabilizes.

Table 1. Mineralogy by lithotype. Red “x”s are added where sections of the text indicate the mineral is present in the lithology. Adapted from 2015 Mining Permit Application, Appendix D, Table 1-4.

	Mineral	Formula	USZ	LZ-FW	Ynl B	Yc	Ynl
Silicates	Quartz	SiO_2	▯	▯	X	▯	X
	Chert	SiO_2	▯				
Carbonates	Dolomite	$CaMg(CO_3)_2$	▯	▯	▯		▯
	Calcite	$CaCO_3$	▯		▯		▯
	Strontianite	$SrCO_3$	▯				
Sulfides	Pyrite	FeS_2	▯	▯	▯	▯	▯
	Marcasite	FeS_2	▯				
	Chalcopyrite	$CuFeS_2$	▯	▯			
	Bornite	Cu_5FeS_4	▯				
	Tennantite	$Cu_{12}Sb_4S_{13}$	▯				
	Chalcocite	Cu_2S	▯				
	Galena	PbS	▯				
	Sphalerite	ZnS	▯				
	Siegenite	$(Ni,Co)_3S_4$	▯				
	Carrollite	$Cu(Co,Ni)_2S_4$	▯				
	Cobaltite	$CoAsS$	▯				
	Glaucodot	$(Co,Fe)AsS$	▯				
Sulfates	Barite	$BaSO_4$	▯	▯			X
	Celestine	$SrSO_4$	▯				

Table 3. Comparison of effluent chemistry parameters for HCT testing at weeks 15-20 in 2012 and 2015. Adapted from Appendix C.

		pH	Acidity	Alkalinity	Sulfate
USZ	2012	~7.3	<1	~21	~600
	2015	~5.9	~10	~7	~2000
Ynlb	2012	~7.5	<1	~20	~315
	2015	~7.2	<1	~27	~300

Construction rock

There is no information on 2015 Ynl kinetic humidity cell (HCT) testing. This is different than incomplete data on waste rock and ore, in that it could be used as construction material and therefore has the potential to impact surface water.

Static testing (ABA data, Table 4) indicates that Ynl and Ynlb contain PAG and neutralizing (NAG) material, with very high standard deviations from the median.

Table 4. ABA results for major lithologic regions. The 2015 operating plan expects Ynlb, LZ-FW, and USZ to each contribute about 1/3 of the total waste rock, with Ynl contributing ~4%. Ynl material will also be used for construction rock. Adapted from Table 3-3a of Appendix D.

		Range	Median	Std. Dev.	NAG	PAG	Uncertain
Ynl (n=44)	NP/AP	0-115	4	19	> 3	<1	1-3
	NNP	-312 to 852	133	218	>+20	< -20	-20 to +20
	% sulfide	0-11%	1%	2%			
Ynlb (n=34)	NP/AP	0-130	8	26			
	NNP	-95 to 370	189	131			
	% sulfide	0-5%	1%	1%			
USZ (n=39)	NP/AP	0-3	0.3	0.7			
	NNP	-1410 to 220	-431	496			
	% sulfide	2-43%	19%	14%			
LZ-FW (n=15)	NP/AP	0-6	0.8	2			
	NNP	-169 to 51	-8	56			
	% sulfide	0.1-9%	1%	2%			

While the most recent (although ongoing) 2015 HCT test results are provided for Ynlb and USZ (2015 Mining Application, Appendix C), we are not given the 2015 results for Ynl.

There are two areas where incomplete data could be an issue: impacts to groundwater from uncaptured seepage, and impacts to surface water from uncaptured seepage and construction rock leachate.

If the Ynl material is used as construction rock, it will be important to understand how leachate may impact the environment. The SPLP tests conducted in 2012 – including ones on Ynl that produced exceedances of aluminum and selenium – were determined to be inaccurate (Appendix D, Section 3.1.3).

- ➢ If SPLP tests cannot be used to determine potential leachate from Ynl as construction rock, and if Ynl as a unit contains very different types of minerals, how will material be sorted to use only that with minimal impacts?

Granodiorite is commonly used for road building, however since it is found in this mineralized zone, it would be appropriate to know if there are intrusions of minerals that could leach. A single SPLP test is ongoing for granodiorite. Why are results not available?

Water treatment plant

- The water treatment plant is undersized.
- It is unclear from the application whether the proposed RO reject water treatment system is technically proven.

The water treatment plant (WTP) is expected to need to treat 510 gpm, but only two reverse osmosis (RO) units are proposed to be used, with each able to treat 255 gpm (2015 Mining Permit Application, Section 3.7.3.5 and Section 4.2.2). The costs of additional units need to be included, as does the cost of trucking brine to an underground injection well in Utah. A "vibratory system" is proposed for use in treating RO reject water; if this is not in use at a similar mine treating similar water at similar or greater rates, it should undergo pilot testing. If there is no analogue or pilot testing, the application may be considered incomplete, unless a fully fleshed and costed alternative is also proposed.

Summary

Representative sampling from host rock and ore is necessary, and the long term ability of water to penetrate into the CTF and the associated chemistry, including wetting and drying cycles, should be better understood. Incomplete information may be relevant regarding metal mobility, the range of metals and concentrations that the water treatment plant will need to treat, and how that affects associated costs in the long term and potentially in perpetuity.

The operating application may be incomplete without test results on construction rock (granodiorite and Ynl). It may also be incomplete if the method for handling RO reject from the wastewater treatment plant is an untried method, and a traditional method has not been costed out.

Regards,

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