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TO: Mr. Chris Garret, P.HGW.
SWCA Project Manager

FROM: Charles A. Kliche, P.E., PhD

DATE: January 29, 2020

RE: Response to "Comments on the Resolution Copper Draft Environmental Impact Statement," dated October 28, 2019 by Dr. David M. Chambers

I read through Dr. Chambers' Appendix A, "Comments from the Center for Science in Public Participation," dated October 28, 2019, with great interest.

I was also quite interested to see that Dr. Chambers included a brief Background statement of himself, to wit:

"David Chambers has 40 years of experience in mineral exploration and development – 15 years of technical and management experience in the mineral exploration industry, and for the past 25+ years he has served as an advisor on the environmental effects of mining projects both nationally and internationally. He has Professional Engineering Degree in physics from the Colorado School of Mines, a Master of Science Degree in geophysics from the University of California at Berkeley, and is a registered professional geophysicist in California (# GP 972). Dr. Chambers received his Ph.D. in environmental planning from Berkeley. His recent research focuses on tailings dam failures, and the intersection of science and technology with public policy and natural resource management."

From this statement, although it's brief, Dr. Chambers has experience in mineral exploration and (I will give him this) development, plus environmental advocacy. He does not have stated experience in ore reserve estimation and modeling; mine planning, mine design, and selection of appropriate mining methods; or the scheduling of the optimal extraction of the ore body (based upon economics [cost of mining utilizing the selected mining method, commodity price, recovery, dilution and other factors], ground conditions, location in space [within the mineralized zone] of a specific "block" of ore/waste, ore zone development factors [needed shafts, drifts, draw points, etc], equipment selection, ventilation requirements, and a host of other factors).

Dr. Chambers in the Alternative Mining Methods section of his report stated:

"Underground mining alternatives to block caving were eliminated from further consideration in the DEIS. These methods were eliminated from detailed consideration

in the DEIS based largely on two factors, the cost of mining and the feasibility of large-scale tailings backfill."

This, in my opinion, is a pretty bold statement, lacking facts to back it up.

The Resolution deposit is a deep, massive, relatively low grade (this will be discussed later), disseminated porphyry copper deposit. Most of the massive porphyry copper deposits in the southwest U.S. are relatively shallow and have been/are being mined by the open pit surface mining technique. Three exceptions are Henderson and Questa (both moly mines), and San Manuel, all of which were/are being mined by underground block caving.

In a nutshell, the decision to mine via some underground technique vs open pit mining is mainly an economic one: Theoretically, if the cost of removing a ton of ore via surface mining exceeds the cost of removing that ton of ore via the chosen underground technique (and the numerous underground techniques must be considered one-by-one), then underground mining is employed. It's a break-even analysis: At some point in surface mining it becomes too costly to support the removal of a ton of "ore" due to the cost of drilling, blasting, loading, hauling, associated waste removal, processing, G&A, etc. It then becomes necessary to look at underground techniques and whether this block will support its share of the cost of shaft sinking, drifting, drilling, blasting, significantly less waste removal, the mining method employed, processing, G&A, etc.

Because each underground mining method has a different cost associated with it, as well as significantly different development techniques, this will affect the cut-off grade (lowest grade of mineable material utilizing that technique), which, in turn, affects the tons above cut-off grade available for mining. A high cost technique will have a high cut-off grade and lower tons available; a low cost method will have a lower cut-off grade and more tons available above that COG.

Now, to say Resolution Copper failed to consider these things is also to accuse them of being negligent in their due diligence to their stockholders and to the public.

Often times experience rules out certain mining methods from consideration almost immediately (eg: stull stoping would be ruled out immediately due to its applicability, as would open stoping, and a number of other techniques [see Table 1, beginning on pg 3, of "Draft Technical Memorandum for Alternative Mining Methods, Resolution Copper Mining, LLC, Superior, AZ", C.A. Kliche, July 7, 2017]).

Dr. Chambers in the **Ore Resources** section of his report stated (3rd bullet point):

"The Kliche report identifies a number of significant **facts** (emphasis mine) about the proposed mine, including:

- **a loss**(emphasis mine) of 12 to 15% of the ore due to the block caving method."

On pg 9 of "Draft Technical Memorandum for Alternative Mining Methods, Resolution Copper Mining, LLC, Superior, AZ", C.A. Kliche, July 7, 2017, it is clear that this is a quote from Lewis and Clark's *Elements of Mining*, and pertains **to all block caving mines, in general**, according to the authors, and not specifically to the Resolution deposit. This loss depends a great deal on the edge shape and edge effects of the blocks/panels with respect to the draw points.

Dr. Chambers in the Resource Sterilization section of his report stated:

"Since the draw angle is relatively steep in the Resolution ore body (cave angles of 70 to 78 degrees – DIES (sic) 2019), then **in addition to the 12 to 15% of the ore that will be lost due to dilution in block caving** (emphasis mine), after mining at proposed levels has ceased, any ore located in the same horizontal horizon will also likely be lost to future mining. The ore located below the existing mining levels would still be accessible."

Dr. Chambers confuses *dilution* with *ore loss*. Plus, he jumps again to the conclusion that something stated in general for block caving pertains specifically to the Resolution mine.

Dilution - the contamination of ore with inferior grade ore and/or waste and/or backfill material.

Ore loss - a missed ore block that remains in the stope after conclusion of production.

Lewis and Clark's *Elements of Mining* is one of the go-to, older, respected textbooks on basic mining. However, one cannot attribute what Lewis and Clark say in general about block caving to Resolution Copper, specifically. I did not see any published figures from Resolution Copper on expected ore loss and dilution.

Furthermore, both ore loss and dilution are extremely important: dilution tends to reduce the head grade, and ore loss tends to reduce the recoverable tonnage of ore. I am quite certain the Resolution planning and mine design engineers have determined an expected percentage for both.

Dr. Chambers in the Ore Grade section of his report stated:

1- "Dr Kliche had to work without any data support from Resolution Copper. He noted that his estimate was:

“based on limited information provided by RCM, of the total tons of potentially mineable material above a cut-off grade of 2% which lies at or above the -2,500 ft level.” (Kliche 2017, emphasis added [by Chambers])

2- Dr Kliche also noted some data was taken from a report produced for Resolution Copper, *Geologic and Mineral Resource Model - Suitability for Declaration of Mineral Resources and Support for Mine Plans to Develop a Block or Panel Cave Mine, Letter prepared exclusively for Resolution Copper Mining (RCM), by Harry M. Parker, Amec Foster Wheeler E&C Services Inc., March 14, 2017*, which was not made available in the DEIS support documents. It too might provide more information on Resolution Copper's predicted production costs, but it is evidently not available for public review.

3- Dr Kliche notes in his introductory remarks that this is a “relatively low grade ... resource”. (Kliche 2017). This view underlies his mining cost analysis. But, this is not a low grade copper resource. In fact, Resolution Copper itself has called the deposit *“large, high-grade, hypogene copper-molybdenum deposit”* (Hehnke et al 2012, emphasis added [by Chambers])

4- Figure 9, from Mudd et. al. (2012), document that the average copper grade worldwide is decreasing with time, and in 2012 was approximately 0.5 – 0.7% Cu. The Resolution deposit is roughly three times this grade level.

Mudd et. al. (2012) rate Resolution as the 16th largest deposit of contained copper in the world, and the second largest in the US, behind the Pebble deposit. However, this is based only on the proposed mine. If the 2 billion tons of ore below existing deposit were included, Resolution would probably rise to the number seven position worldwide.

The proposed Pebble mine also plans to have an underground mine, at a similar depth to Resolution and utilizing block caving, but its deep ore grade is closer to 0.6% Cu equivalent. This suggests mining Resolution with block caving should be very lucrative.

A similar grade analysis to that of Mudd et. al. can be seen in, Figure 3, from Kloppenburg (2017), showing Resolution to be one of the highest grade copper porphyry deposits in the world."

I numbered Chambers' pertinent comments in the **Ore Grade** section 1 - 3 and will comment on each in turn.

Dr. Chambers seems to not like the words "limited" and "relatively" (both discussed below).

#1: This is patently false. I cannot say that I had unlimited access to all the data I needed for a perfect estimate of the grade/tonnage relationship for the Resolution Copper deposit, but I was provided, without hesitation, enough good data to make a reasonable estimate of that relationship. This information, in the form of horizontal slices at 100 ft intervals from bottom to top through the Resolution Copper block model showing grade classes of the blocks, was gracefully and without hesitation provided after a meeting on 3/23/17 between myself and Mses. Vicky Peacy and Kim Heuther, and Mr. Bill Hart (noted on pg 1 of "Draft Technical Memorandum for Alternative Mining Methods, Resolution Copper Mining, LLC, Superior, AZ", C.A. Kliche, July 7, 2017).

The reason, of course, for requesting this information from Resolution Copper was to try to estimate the tonnage available above various cut-off grades which may be available for mining via some other more costly mining method (ie: cut-and-fill).

The personnel I worked with on this at Resolution Copper could not release to me all of the data I requested due to its proprietary nature. We negotiated. And they released the best they thought they could, given the proprietary nature of the mine model and of the tonnage/grade distribution.

#2: I am surprised Parker's memo is not in the DEIS support documents library. It's attached. You should, though, make sure it can be released for public viewing.

#3: "relatively low grade resource" vs "large, high-grade, hypogene copper-molybdenum deposit".

It's a matter of semantics.

By definition, a porphyry copper deposit is low grade: According to *The Dictionary of Mining, Mineral, and Related Terms, 2nd edition*, a **porphyry copper deposit** is "A large body of rock, typically porphyry, that contains disseminated chalcopyrite and other sulfide minerals. Such deposits are mined in bulk on a large scale, generally in open pits, for copper and by-produce molybdenum. Most deposits are 3 - 8 km across and of low grade (less than 1% Cu)."

Dr. Chambers points out that the published tons and grade of the Resolution Copper deposit (1969M st at 1.54% Cu) when plotted on a figure taken from Kloppenburgh, 2017, shows it ranks right up there with Butte, Bingham Canyon, Grasberg, El Teniente and Chuqui at, however, a lower total tonnage but higher grade.

So, it **is** a high grade deposit compared to other large, disseminated porphyry copper deposits.

So what? The ore deposit is also much deeper than the others and the wall rock temperature plus water inflow at depth make mining the deposit difficult and expensive. And the others are all porphyry copper deposits mined either by open pit or block caving techniques... none of them are mined by cut-and-fill.

Furthermore, Resolution may have called the deposit a "large, high-grade, hypogene copper-molybdenum deposit" back in 2012, but on page 88 of Vol. 1, General Plan of Operations Resolution Copper, they described it as "... the deep, **relatively low-grade** (emphasis mine), and widely disseminated porphyry deposit that makes up the Resolution Project... ", which is also how I described it. It **is** relatively low grade, compared to a high-grade copper sulfide vein, like what was mined by cut-and-fill methods at the Magma Mine, Superior, AZ from 1911 through 1964 (about 4.75% Cu to almost 8.0% Cu).

Again: So what? It's a matter of semantics.

One final comment:

Dr. Chambers stated his position and the position of similar-thinking people via his comment in the Summary beginning at the bottom of page #7 through the top of page #8 of his report:

"For the operators of a large, rich, ore body to take into account a multitude of significant environmental and social resource losses that can be prevented **by conducting responsible mining** (emphasis mine) instead of maximizing economic profit, which will have little long-term benefit in the area of the mine, is not too much for a responsible land manager, like the US Forest Service, to require."

The bolded and underlined above ("by conducting responsible mining") is an elusive catch phrase I've heard over and over again by environmental advocates. But, what does it mean? And, who defines "responsible mining"?

According to best practices within the U.S. mining community, and according to the appropriate rules and regulations of the state and federal agencies involved in the permitting process, the Resolution Copper project will be conducted responsibly.

However, according to Dr. Chambers and the environmental community, unless Resolution Copper does mining their way, then they are irresponsible. Yet, the majority of the people stating such know absolutely nothing about the science, mechanics, and engineering practices of mining

In my opinion, that little phrase is the heart of the entire Chambers report.

Sincerely,

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