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Precious and critical metal potential of historic Cu-Au-As mine waste in the Eastern Alps

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For the world to transition from fossil fuels to renewable energies, we need both an amount and a diversity of raw materials the likes the world has never seen. For example, to build the required power grid to move to 'green' electricity we need to mine the same amount of copper in the next 30-40 years as we have in all of human history combined (Cathles and Simon, 2024). The impossibility of finding such a large amount of copper, and other critical metals, in such a short time requires us to identify alternative sources of these critical and strategic metals.

While we will likely not find such large quantities of these metals in new deposits, we note that during much of human history the extraction rates for many metals were less than 50%. This means that in the mine waste of historic districts we might have as metal much in the mine waste as was originally produced. This is particularly true of the historic Cu-Au-As mining districts of the Eastern Alps, which were partially mined from Roman times until the turn of the 19-20th century. Recovery rates for the produced metals such as copper and gold were between 50-66%, and with the rest, largely in the form of sulfide minerals, ending up as mine waste (Paar et al., 2006). This sulfide rich mine waste is both a source of groundwater contamination as well as a source of critical metals that tend to associate with Au and Cu (i.e. As, W, Bi, In, Te; (Gopon et al., 2019).

By combining whole rock geochemistry, geophysics, and advanced micro- to atomic-scale characterization techniques we have produced estimates of the raw material potential of the 4000+ Cu-Au-As mine dumps found throughout the Eastern Alps as well as determined how these metals are found within the waste. We will show examples from historic Cu-Au-As districts from the Hohen Tauern to the Fischbacher Alpen, and discuss what raw materials are present, in what form they are present, and how sulfide minerals are able to play host to such a diversity of important metals. The environmental impact of these sulfide rich mine wastes will also be discussed, as well as ongoing work to remediate these former mine sites by mining the mine waste.

The mining and metallurgical processes necessary to process such a weathered, low grade, and arsenic rich ore presents a significant challenge that needs to be overcome. However, the potential worth of the 70 largest mine dumps in the Eastern Alps (estimated at 1-2 billion euros), the environmental implications of leaving this waste, and the raw materials gap we aim to fill with this resource is such that this is a challenge that we must overcome.

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