Invisible metals for a green future: Au associated critical elements in historic mining districts Murtal (Styria)

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Green technologies require metals like antimony, bismuth, cobalt, lithium, platinum group elements (PGEs), thallium, tantalum, tungsten and many others that are rarely mined in Europe. The transition to renewable energy production is leading to a massive increase in the demand for these 'green' metals. One of the pillars of EU raw policy is to foster production from local sources of these raw materials, in order to support and revive the mining industry in Europe, as well as to make the EUs climate future more self-reliant. Recent work has shown that gold and a sub-group of critical metals (hereafter referred to as precious metal associated critical metals or PMaCMs) can occur trapped within sulfide minerals often in invisible form. This previously overlooked source of precious metals and PMaCMs holds much promise for a ready source of precious metals within the EU. Our study is part of a larger project investigating the potential of historic mine tailings in Styria, as a possible source of those metals. We will present initial results from the tailings piles of three historical gold mining districts in Upper Styria, i.e. Flatschach, Pusterwald and Kothgraben. They are mesothermal vein type deposits, occurring in medium to high-grade metamorphic Austroalpine units and their mines were operated, on and off, from the 15th century up to the early 20th century. The primary focus of our work is to determine in which quantities PMaCMs are found within these deposits (using whole rock geochemistry) and to quantify their abundance. Not all metals in these deposits are visible with the optical microscope or electron microscope techniques (EPMA, SEM), and we report the occurrence of invisible gold within arsenic rich pyrite from at least one of the three deposits (Flatschach). Ongoing work is focusing on other sulfides in these deposits potentially hosting gold and PMaCMs (using LA-ICP-MS and EPMA). Atom probe tomography will be applied to characterize the atomic-scale link between arsenic (and other minor elements), gold, and PMaCMs. Additionally, we plan to constrain the timing of ore formation and to investigate the trace elemental signature of the ore minerals to determine if there is a geochemical and/or temporal link between these deposits that occur in comparable geological settings. EPMA and LA-ICP-MS techniques will be used to determine the trace elemental signature and critical metal content of the ore minerals. We will also be doing U-Pb dating of calcite, which is a rather novel method for dating this type of mineralized veins.