

## From mining wastes to mineral sources - investigating the REE-bearing occurrences in the Arburèse District (SW Sardinia)

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In recent years, the search for possible sources of REE minerals in Europe involved numerous old mine areas with high volumes of mining wastes that may offer significant amounts of Critical Raw Materials (CRMs). In some cases, strong evidence of CRMs anomalous concentrations arises from environmental characterization of wastes, so that an interesting problem is that of finding their sources, i.e., the original CRMs - rich mineral phases in the residual ore. An excellent example is provided by the Arburèse district of SW Sardinia, for about 150 years a major Pb-Zn source in Italy, now an area under study for remediation of its severe environmental problems, including >10 Mt of waste deposits. The district exploited a large system (>10 km) of low-temperature polymetallic veins hosted in Lower Paleozoic siliciclastic rocks belonging to the Variscan Nappe zone, arranged in two main geometrical trends relative to the late Variscan Arbus pluton: “peripheral” and “intersecting”. Recent investigations in the Montevecchio mine area discovered high Zn (up to 2.65 wt.%) and Pb (1.23 wt.%) grades in stratified tailing materials belonging to the Sanna old processing plant. Remarkably, ICP-MS analyses on the same materials revealed total REE+ Y contents attaining about 600 ppm. XRD studies confirmed a tailing composition essentially made of gangue minerals (quartz, siderite and micas) with goethite, baryte and traces of Zn carbonates and Pb sulfates. Chondrite-normalized REE patterns are coherent with the hydrothermal character of the source: however, both the REE mineralogical host(s) in tailings and in the Montevecchio ore are still undetermined. In the search of REE-bearing phases in the ores, some relevant insights are provided by studies on the southern branch of the Arburèse system, where the veins of “peripheral” system are hosted in late Ordovician-Silurian sedimentary sequences. In this part of the district the polymetallic veins assume the character of five-elements (Ni-Co-As-Bi-Ag) veins, with a rich Ni-Co-Fe arsenide – quartz association (1) overprinted by a Zn-Pb-Cu sulfide – siderite – quartz association (2), very similar to that dominating in Montevecchio. Investigations in the Pira Inferida mine sector highlighted the presence of LREE fluorocarbonates (synchysite-Ce and bastnaesite-Ce) and phosphates (monazite) associated with rutile and apatite. LREE minerals have been detected by SEM-EDS as tiny crystals in the quartz-sericitic gangue of the Montevecchio-type (2) mineral association. The same minerals are found in millimetric aggregates in the oxide zone of the veins, sporadically reported by mineral collectors in other mine sites of the same system. Overall, these occurrences, similar to those found in other low-temperature vein systems of Sardinia (e.g., Silius vein system), appear reliable mineral REE sources for Montevecchio mine wastes; they may be therefore used as proxies for REE exploration and assessment in the district.