Critical metal enrichments in the Fe-Zn skarns of the historical Perda Niedda-Arenas mining areas, Iglesiente, SW Sardinia

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The historical Perda Niedda and the nearby Arenas-Tiny mine districts host mineralization related to a late-Variscan skarn system stretching across the Iglesiente-Sulcis region in SW Sardinia. Mineralization at the poorly known Perda Niedda (PN) district consists of several Fe-Zn-rich skarn occurrences developed in the Cambrian limestones along the SE margin of the Oridda monzogranite stock, satellite to the 289 Ma Mt. Linas plutonic complex. The W margin of the stock hosts the original extensive Pb-Zn-rich skarns of the Arenas mine. Recent and ongoing studies in both areas are redefining mineral assemblages and outlining previously unreported features of these skarn ores, which are different in spite of proximity. Metals were enriched mainly during retrograde, F-rich skarn stages, while prograde skarn facies were dominated by Ca garnets and clinopyroxenes. At PN the dominant magnetite-sphalerite-cassiterite ore facies is associated with hydrous and F-B-bearing assemblage (fluorite, amphibole, Mn-axinite, chlorite, quartz, calcite) deeply replacing prograde andraditic garnet and hedenbergite-johannsenite skarn. Peculiar Fe-Zn-Sn wrigglite and rare Sn-rich endo-greisen occur along exposed granite contacts. At Arenas galena-sphalerite-chalcopyrite, with minor magnetite, are intergrown with amphibole-vesuvianite-chlorite-calcite-quartz overgrowing prograde grossular-andradite, hedenbergite and wollastonite-fluorite skarn. The retrograde sulfide-oxide mineralization is polyphasic, as suggested by compositional variations in sphalerite, magnetite and cassiterite in orebodies across the whole district. The new researches reveal enrichments of critical metals like major Sn and In and accessory Co and W. At PN cassiterite and Fe-sphalerite are the main hosts of In, although, as revealed by EPMA and in-situ LA-ICPMS analyses, both Sn and In are also substantially enriched in andraditic garnets (also host to Nb-Ta oxide inclusions). Retrograde silicates (e.g., amphiboles, axinite, vesuvianite) partly inherit the Sn endowment. Especially at PN the abundant, polyphasic magnetite displays complex zoning involving Si, Al, Mn as well as Co, Sn, Zn and W, similar to patterns observed in IOCG silician magnetite (Tunnell et al., 2022). At Arenas sphalerite is In-poor and Sn phases were not yet found but both andraditic garnet and magnetite are enriched in Sn. Ca garnets from various skarn bodies in the PN area display trace element contents and both LREE- and HREE-enriched patterns, thereby suggesting locally variable conditions during early skarn development and proximity to the intrusion (Xu et al., 2020). Skarn retrogression and hydrothermal alteration played a major role in the concentration of metals, partly released from prograde minerals. In this sense, garnets seem to be a major early reservoir for metals directly emanated from granitic magma and they may control subsequent polyphase critical metal enrichment and redistribution in ores.

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