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Multi-Stage Fluid System Responsible for Ore Deposition in the Ossa-Morena Zone (Portugal): Constraints in Cu-Ore Deposits Formation

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Abstract—The Mociços Cu-deposit is part of a cluster of ancient copper mines in the Sousel-Barrancos metallogenic belt in the Ossa-Morena Zone at the SW Iberia. The orebodies develop along NNW-SSE quartz-carbonate-sulfides veins with pyrite and chalcopyrite as the main sulfide phases, and ore emplacement has been attributed to copper remobilization from the metasedimentary host-rocks, though no detailed studies were conducted. A novel multi-stage fluid circulation model is hereby proposed, supported by petrography and fluid inclusion data evidencing the *P–T–V*-x evolution of the deposit. Stage (i) is an early metamorphic stage with a predominance of carbonic fluids, identified in highly deformed milky quartz (Qz_I), with estimated pressures between 338 and 486 MPa compatible to the regional metamorphic events (greenschist facies). Stage (ii) corresponds to a late-metamorphic manifestation of $H_2O–NaCl–CO_2$ fluids, with low-salinity (eq. w(NaCl) from 0.4 to 5.0%) and CO_2 dominated. Stage (iii) in which ore emplacement took place and is characterized by dominant multisolid $H_2O–NaCl$ hypersaline, halite-bearing fluid inclusions (eq. w(NaCl) from 29.3 to 44.3%) with an $H_2O–NaCl–CO_2$ endmember and features indicative of magmatic-hydrothermal brines. Many of these inclusions homogenize by halite dissolution, with pressures as high as 320 MPa, and the coexistence of both fluids in the same fluid inclusion assemblages (FIA) could indicate phase separation caused by fluid pressure variations. Although there is no direct evidence of the magmatism responsible for these fluids, the geodynamic settings could favor deep-seated magmatism. Stage (iv) is characterized by low-salinity (eq. w(NaCl) from 0.18 to 15.57%) and low-temperature (68 to 160°C) primary two-phase fluid inclusions hosted by late-stage quartz (Qz_{IV}), suggesting a late-meteoric fluid circulation phase responsible for the leaching, oxidation and supergene enrichment observed at surficial levels. Throughout the *P–T* evolution of the system a decrease in pressure and temperature was registered, especially in fluid inclusions hosted in quartz from the sulfide bearing veins, suggesting that the transition from ductile to brittle regimes might have favored ore deposition.

Keywords: copper deposits, metallogenesis, fluid inclusions, hydrothermal brines, Ossa-Morena Zone, Sousel-Barrancos Metallogenic Belt

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INTRODUCTION

Throughout the last decades the study of Cu deposits has been widened in order to understand one of the most economically strategic metals. These studies are particularly important for future ore reserve perspectives, as the largest Cu deposits may have already been unveiled. The increasing demand for raw materials, particularly in the EU, urges the necessity of reassessing the potential of brownfield exploration areas. Therefore, future works should focus simultaneously on high-grade small-scale deposits and low-grade large-scale ones, recognizing the features that control the ore emplacement mechanisms, serving as exploration vectors for future projects. The study of these mechanisms could lead to metallogenic model revisions for key sectors from different geodynamic settings, such as, the Sousel-Barrancos Metallogenic Belt (SBMB) Cu deposits cluster in the Ossa-Morena Zona (OMZ).