Origin of the Aït Abdellah Copper Deposit (Bou Azzer, Anti-Atlas, Morocco): Perspectives from Mineralogical, Stable Isotope, and Fluid Inclusion Analysis

Mohamed Ait Addi[8], Ismail Bouskri[4,5], Ali El-masoudy[5,6], Moha Ikenne[1], Said Ilmen[2], **Marieme Jabbour**[1], Lhou Maacha[5], Mohamed Oulhaj[5], Ilya Prokopyev[7], Mustapha Souhassou[4], Basem Ahmed Zoheir[3]

[1]Laboratory Of Applied Geology And Geo-environment, Ibn Zohr University, Agadir, Morocco, [2] Polydisciplinary Faculty of Ouarzazate, Ibnou Zohr University, Agadir, Morocco, [3]Department of Geosciences, King Fahd, University of Petroleum and Minerals (KFUPM), Dhahran, Saudi Arabia, [4]Laboratory, Polydisciplinary Faculty of Taroudant, Ibnou Zohr University , Agadir, Morocco, [5]MANAGEM Group, Twin Center, Casablanca, Morocco, [6]Applied Geology Laboratory, Moulay Ismail University, Er-Rachidia, Morocco, [7]Sobolev Institute of Geology and Mineralogy, Siberian Branch of the Russian Academy of Sciences, Novosibirsk , Russia, [8]Department of Geology, Moulay Ismail University, Meknes, Morocco

The Aït Abdellah copper deposit, situated within the Bou Azzer-El Graara inlier in the Moroccan Anti-Atlas, represents a significant case of mineralization controlled by structural and lithological factors. This study integrates structural, petrographic, geochemical, isotopic, and fluid inclusion analyses to better understand the origin of copper mineralization. The mineralization primarily occurs in feldspathic sandstones of the Tiddiline Group, which lie above the Bou Azzer ophiolite. It is confined to a NE-SW trending shear zone featuring mylonitic textures, calcite veins, and fracture networks, formed by an initial ductile deformation followed by a brittle phase with faults, brecciated veins, and stockwork zones. These tectonic features facilitated fluid migration and copper sulfide precipitation, with the mineralization consisting mainly of chalcopyrite, bornite, pyrite, chalcocite, digenite, covellite, as well with Cu-bearing carbonates and silicates such as malachite, azurite, and chrysocolla. Sulfur isotope values range from 5.9‰ to 22.8‰, indicating sulfur contributions from both ophiolitic and volcano-sedimentary sources. Carbon and oxygen isotopes suggest fluid interactions with marine carbonates and meteoric waters, possibly linked to the Snowball Earth glaciation during the late Neoproterozoic. Fluid inclusion data reveal a wide range of homogenization temperatures and salinities (195°C to 310°C, 5.7 to 23.2 wt.% NaCl equiv.). Fluid mixing between magmatic-hydrothermal and volcano-sedimentary fluids is proposed as the main mechanism for ore formation. Overall, this study enhances our understanding of copper deposit formation in the Bou Azzer inlier, highlighting the importance of the Precambrian basement and tectonic-volcanic processes in driving mineralization.