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Implications of multiple fluids in the deposition of the Amensif Zn-Cu (Pb-Ag-Au) distal skarn deposit in the western High Atlas, Morocco: Evidence from O, C, S isotopes

MR. ABDESSAMAD JINARI, PHD[1], LARBI RDDAD[2], EL MOSTAFA MOUGUINA[1], MOHAMED IDBAROUD[1] AND ABDELMALEK OUADJOU[3]

[1]Laboratory "Dynamics of the Lithosphere and Genesis of Mineral "DLGR", Department of Geology, Faculty of Sciences Semlalia M.B.2390, Cadi Ayyad University, 40000 Marrakesh

[2]Earth and Planetary Division, Department of Physical Sciences, Kingsborough Community College of the City University of New York, 2001 Oriental Boulevard, Brooklyn, New York, NY 11235-2398

[3]Groupe MANAGEM, Twin Center, Tour A, Angle Boulevard Zerktouni et Massira Khadra, BP 5199, Casablanca

Presenting Author: abdessamad.jinari@ced.uca.ma

The lower Cambrian sedimentary carbonates of the western High Atlas area host numerous Zn-Cu-Pb (Ba-Au-Ag) deposits, with the Amensif Zn-Cu (Pb-Ag-Au) deposit being one of the most significant. This ore deposit shows two types of ore style: open-space fillings and replacement, with the ore primarily occurring principally in open-space fillings such faults, fractures, and stockwork. The ore mineralogy is simple and comprises sphalerite, chalcopyrite, pyrite, and galena with subordinate amounts of barite. The wall-rock alteration associated with the ore is characterized by hydrothermal dolomitization and silicification.

The $\delta^{34}S$ values for pyrite and sphalerite are uniform, ranging from of 6.4‰ to 14.1-14.4‰ respectively, while the $\delta^{34}S$ values for chalcopyrite vary from 10.5 to 14.0‰. These S isotopic signatures suggest that the sulfur derived from a mixture of sources (magmatic sulfur and lower Cambrian carbonate-derived sulfur) in almost equal proportions.

The $\delta^{18}O$ and $\delta^{13}C$ values for the pre-ore dolomite, ore stage I dolomite, and the limestone host rock range from 13.0 to 26.8 ‰ and -10.2 to -0.7 ‰, respectively. These C-O isotopic compositions suggest that there was an exchange between the ore-forming fluids and both the carbonate host rock and black shales

The data presented in this study propose that magmatic-hydrothermal fluids, which exsolved from a hidden magma or possibly from the nearby Azegour granite, migrated upward through major NE-SW- and ENE-WSW-striking faults and mixed with an external cooler fluid. This fluid-mixing, along with fluid-rock interactions, resulted in the precipitation of sulfide ores.