

Geology and Metallogenic Evolution of the Polymetallic Deposits of the Alcudia Valley Mineral Field, Eastern Sierra Morena, Spain

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Abstract

The Alcudia Valley is intensely mineralized, with a large number of Pb-Zn-Ag-Cu deposits hosted by Neoproterozoic and Paleozoic sedimentary rocks. Five distinct types of deposits have been recognized. The most significant mineralizing events were related to the two major phases of deformation (H_{D1} , H_{D2}) and granite emplacement during the Hercynian orogeny. Stable isotope and lithochemical data demonstrate that the metals, as well as sulfur and carbon, were sourced from the local sedimentary rocks.

Type A deposits are minor occurrences of strata-bound mineralization with $Zn > Pb$, occurring as disseminations and small veins in Late Ordovician limestone. A syndiagenetic origin is suggested by the limited stratigraphic distribution of the mineralization and anomalous base metal contents of Late Ordovician-Early Silurian black shales overlying the mineralized limestone. Minor remobilization of disseminated sulfides into joints took place during late diagenesis or early Hercynian deformation.

Types B, C, and D are syntectonic deposits with $Zn > Pb$. Type B deposits are strongly deformed veins in H_{D1} fractures in Ordovician rocks. A process involving local mobilization of metals by a surface-derived fluid is indicated by depleted metal contents of host rocks adjacent to the veins, the similarity of $\delta^{34}S$ values of ore sulfides with disseminated pyrite in the host rocks, and the $\delta^{18}O_{H_2O}$ values. Type C deposits exhibit a greater variation in morphology and degree of deformation compared to other types and are found in both H_{D1} and H_{D2} fractures in Late Ordovician and Silurian rocks. The stratigraphic distribution and $\delta^{34}S$ values of sulfides are similar to type A deposits, suggesting that localized hydrothermal systems either remobilized type A mineralization or derived metals and sulfur from the same source. Type D deposits occur in H_{D2} shear fractures in Neoproterozoic rocks. The $\delta^{13}C$ values of carbonate gangue and the similarity of $\delta^{34}S$ values of ore sulfides and disseminated pyrite in the host rocks indicate that black shales of the Neoproterozoic sequence are the major source of sulfur and carbon. Mixing of a metamorphic fluid with a surface-derived fluid is suggested by fluid inclusion and oxygen isotope data.

Type E deposits, the most abundant and economically most important type, are post-tectonic $Pb > Zn$ veins occupying H_{D2} fractures and are widely distributed through the district in rocks ranging from Neoproterozoic to Late Ordovician. Mineral assemblages and Ag contents of the veins show a zonal relationship with respect to monzogranite outcrops, indicating that late Hercynian magmatism was the source of heat driving fluid migration through the fracture system. Fluid inclusion and oxygen isotope data are typical of basinal brines. Reaction of the fluid with black shales of the Neoproterozoic sequence is suggested by $\delta^{34}S$ values of sulfides and $\delta^{13}C$ values of carbonates of the main stages of the paragenetic sequence. The final paragenetic stage consists of barite, calcite, and pyrite, which may have been deposited during a later hydrothermal event, probably in the Early Triassic.

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