Geophysical Research Abstracts
Vol. 15, EGU2013-13722, 2013
EGU General Assembly 2013

Fluid mixing and ore deposition during the geodynamic evolution of the Sierra Almagrera (Betics, Spain)

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Marine and continental intramountaineous basins developed during the Neogene orographic evolution of the Betico-rifan orogenic wedge, as well as the related uplifted ranges within the Sierra Almagrera Metamorphic Core Complexes (MCC). The NNE-SSW striking trans-Alboran transcurrent fault system crosscuts the MCC post-dating the extensional exhumation stages recorded in the metamorphic fabric. Iron ores (± Pb, Cu, Zn) are encountered either as stratabound ore deposits in the Neogene basins or as vein networks crosscutting the metamorphic fabric of graphitic phyllites from the Sierra Almagrera. These Late Miocene ore deposits are related to the activity of the N-S striking Palomares fault segment of the Trans-Alboran fault system. Three sets of quartz veins (Vα, V$\alpha\beta$ and Vβ) and one set of mineralized vein (Vγ, siderite, barite) are distinguished. The Vα and V$\alpha\beta$ respectively are totally or partially transposed into the foliation. The Vβ and Vγ veins are discordant to the foliation.

The problem addressed in this study concerns the nature of the fluids involved in the metal deposits and their relationships with the main reservoir fluids, e.g. the deep metamorphic fluids, the basinal fluids, and eventually the recharge meteoric fluids.

This study focuses thus on the evolution of the fluids at different stages of ductile-brittle exhumation of the metamorphic ranges (Sierras) and their role during the exhumation and later on in relation with the hydrothermalism and metal deposition at a regional scale.

Paleofluids were studied as inclusions in quartz, siderite and barite from veins by microthermometry and Raman spectroscopy, and a stable isotope study is in progress. Earliest fluids recorded in (V$\alpha\beta$) quartz veins are H_2O-NaCl + CaCl2 (17 wt. %) - (traces of CO_2, CH4, N2) metamorphic brines trapped at the ductile brittle transition at a minimum trapping temperatures (Th) of 340 °C. Older metamorphic fluids in (Vα) veins were lost during the complete recrystallization of the original quartz grains during transposition. The second fluid type is characterized by very low salinity inclusions (1.2 wt.% NaCl) found in veins discordant to the foliation (Vβ), and precedes brines (23 wt. % NaCl + CaCl2 with Th of 320 °C) trapped in transgranular fluid inclusion planes (FIP). The NW-SE to N-S directions of these FIP appears coherent with shortening directions related to Tortonian and Messinian basin development (Montenat, 1990). The halogen signatures of the latest brines confirm that they derive from primary brines issued from sea water evaporation. Fluid inclusions in barites and siderites from (Vγ) veins display a Br/Cl ratio more typical of secondary brines and a rather large range of salinities, this indicating distinct fluid movements and the dissolution of evaporates by dilute fluids may be of meteoric origin. Fluids in siderites show the lowest trapping temperature conditions around 190 °C. The existence of a sea water component in fluids was previously mentioned by Morales Ruano et al. (1995) indicate a δ34S of 22,1-23.9 ‰ for barite from Sierra Almagrera.

In conclusion, during the Neogene multistage evolution of the Almagrera MCC, fluids of different origins e.g. basinal, meteoric and metamorphic fluids have circulated within the crust, and locally interacted with evaporites. The resulting brines formed Fe-(Ba, Pb, Cu) ores in discontinuities affecting both the metamorphic and sedimentary rocks.

Morales Ruano, S., Both, R., and Fenoll Hach-Ali, P., 1995, Fluid evolution and mineral deposition in the Aguilas – Sierra Almagrera base metal ores, southeastern Spain.: Mineral Deposits, p. 365-368.

Montenat, C., 1990, Les Bassins néogènes du domaine bétique oriental (Espagne), Documents et Travaux IGAL n°12-13, 392 p.