Exhumed vs active geothermal systems: faults controlling ore deposits in Las Minas area as a key for the deep exploration in the Los Humeros geothermal field (Mexico)

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The investigation of the deep geothermal systems is a challenging task in active geothermal systems. In order to decrease the mining risk, the study of the analogue exhumed systems sheds light on the relationships between fluid circulation and geological structures through the analyses of faults and ore deposits distributions. In the Las Minas area (Central Mexico), ore deposits are quite diffuse at the boundary between crystalline and sedimentary rocks and in fault zones. This is a consequence of the interaction between cooling of Miocene felsic magmas, hydrothermal fluids and coeval fault activity. We investigated the role of the faults in channeling the hydrothermal fluids by fieldwork and analysis of fractures at outcrops. The field mapping was carried out at 1:10000 scale (60 km2). When possible, kinematic data on recent fault planes influencing the permeability and geothermal fluid paths were collected. This includes information on the main structural trends and the orientation of the intermediate kinematic axis. The evolution and origin of the hydrothermal fluids circulating in the exhumed geothermal system of Las Minas area (Central Mexico) were investigated by i) structural and minero-petrographic studies and, ii) fluid inclusion and isotopic analyses carried out on skarn and hydrothermal alteration minerals. Two families of faults have been recognized, NNW-SSE and SW-NE oriented, respectively. The SW-NE trending faults often controlled the emplacement of dykes, indicating that the magmatic fluid was channeled and driven by the faults induced permeability. Their activity is at least encompassed between Miocene and Quaternary. The kinematic relation between these two fault systems could be explained in an extensional framework, assuming that the NNW-SSE fault system acted as transfer faults. Fluid inclusions recorded the circulation of: 1) high-temperature (up to 650°C), high-salinity (up to 60 wt.% NaCl equiv.) fluid of magmatic origin; 2) high-temperature (470-650°C)
aqueous-carbonic fluid produced during fluid-rock interaction with carbonate basement rocks and 3) relatively low-salinity (up to 2 wt.% NaCl equiv.) fluid of meteoric origin. A general evolution from high- to low-temperature fluid circulation characterized the geothermal system.