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Positive feedback between strain localization and fluid flow at the ductile-brittle transition leading to Pb-Zn-Fe-Cu-Ag ore deposits in Lavrion (Greece)

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At the crustal scale, the ductile-brittle transition (DBT) might correspond to a physical barrier that separates a deep reservoir of metamorphic and magmatic fluids from a shallow reservoir of surficial fluids. Rock rheology, and thus the location of the DBT, is mainly governed by lithology, temperature and the presence/absence of fluids. Accordingly, the position of the DBT potentially evolves during orogenic evolution owing to thermal evolution and fluid circulation. In turn rocks are transferred across it during burial and exhumation. These processes induce connections between fluid reservoirs which might play a role on ore deposition. In this contribution, we discuss the impact of lithological heterogeneities on deformation, fluid flow and ore deposition based on the example of the Lavrion low-angle top-to-the-SSW detachment accommodating gravitational collapse of the Hellenides orogenic belt in Greece. The Lavrion peninsula, localized along the western boundary of the Attic-Cycladic Metamorphic Core Complex, is characterized by Pb-Zn-Fe-Cu-Ag ore mineralization mainly concentrated along a lithological contact (marble/schists) below and within a detachment shear zone. The mylonitic marble below the detachment shear zone is composed of white layers of pure marble alternating with blue layers containing impurities (SiO_2, $Al2O_3$, organic matter...). Development of the mylonitic fabric in competent impure blue marble is associated with its preferred dolomitization related to focused fluid infiltration. This mylonitic marble is cross-cut by several cataclastic horizons preferentially developed within the more competent impure blue marble and newly-crystallized dolomitic horizon. These cataclasites are invaded by fluorite and calcite gangue minerals showing locally Mn, Pb, Zn, Fe oxides and/or hydroxides, sphalerite, Ag-galena, Ag-sulfur and native Ag. Oxygen and carbon stable isotopes performed on marble sections point out decarbonation with magmatic contribution and fluid-rock interactions including organic matter present in the whole-rock during ore precipitation. These features show the positive feedback between localization of ductile-brittle deformation-recrystallization, fluid circulation and ore deposition. Accordingly, during orogenic gravitational collapse, the activation of mylonitic-cataclastic low-angle detachments, controlled at first order by temperature, are, at second order, influenced by lithologic heterogeneities that are determinant at localizing fluid circulation, allowing thus a multi-localization of the DBT and ore deposition.