

Spatio-temporal evolution of fluid composition with increasing deformation in the vicinity of a major detachment fault, Betic Cordillera (Spain)

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Large amounts of fluids are released in rocks along successive dehydration reactions during burial. The release of a free fluid phase in rocks has crucial effects not only on the scale of mass transfer and fluid-rock interactions, but also on rock rheology and deformation processes. There is in particular a strong link between fluid-driven mass transfer and deformation mechanisms, mainly because the scale of fluid circulation is partly controlled by the size and connectivity of deformation structures. In high-pressure rocks, fluid circulation is often mainly restricted to high-permeability highly deformed zones, in which fluids are channelized.

To better constrain this major feedback, we tracked the evolution of fluid composition and mass transfer with space and time in rocks located close to a major detachment (0-500 m) responsible for the exhumation of the Nevado-Filabrides complex (Betic Cordillera, Spain). This study focused on 4 sites with similar homogeneous metapelitic composition, for which P-T-t-deformation paths had been previously established. Based on their crosscutting relationships with deformation structures (cleavages C1, C2 and shear zones S3), 3 successive quartz vein generations were identified. For each vein, successive generations of fluid inclusions (FI) were characterized and studied by microthermometry, Raman spectroscopy and LA-ICP-MS.

In all sites, FI recorded both a progressive shift from CH₄- to CO₂-dominated gas content and a salinity increase with time (with halite crystals in the latest generation). The closer to the detachment, the earlier this change in salinity and gas content. These results illustrate a progressive opening of the fluid system with increasing deformation during exhumation along the detachment: a locally-derived, internally-buffered fluid at first, followed by infiltration of increasing amounts of CO₂-rich external fluids, and late arrival of descending Triassic rock-derived NaCl-rich fluids channelized by the detachment.