# Effect of host mineral species on the fidelity of fluid inclusion compositions

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Prior to trapping in a host, a hydrothermal fluid's composition is controlled by simultaneous equilibria with several species of minerals. Once trapped within a specific host mineral, the isolated inclusion fluid can reequilibrate only with that species during uplift and cooling of the rock. Its room temperature composition is therefore affected by the solubility behavior of that host species during cooling.

An equilibrium modeling approach is used to predict the effects of different host mineral species on post-trapping chemical changes in fluid inclusions during uplift and cooling of hydrothermal ores. A fluid with a composition typical of Upper Mississippi Valley-type Pb-Zn ores is first equilibrated with a mineral assemblage containing quartz, barite, calcite, galena and sphalerite at $100^oC$. The fluid is then isolated and cooled to $25^oC$ in a stepwise manner in equilibrium with only calcite, quartz or sphalerite, respectively. Predicted changes in chemical and isotopic composition of the trapped fluids are derived.

The masses of crystals that precipitate or dissolve in the inclusions during cooling cannot be resolved optically, but have dramatic effects on fluid metal and isotopic compositions. Fluid in calcite hosts dissolves calcite and precipitate quartz, whereas fluids in quartz and sphalerite hosts become undersaturated in calcite and precipitate quartz and barite. Small amounts of metal sulfide minerals are also precipitated. Metal concentrations in calcite-hosted fluid decrease by $10^4$, while those in quartz- or sphalerite-hosted fluids decrease by $10^2$. In calcite, $\delta^{13}C$ of the fluid decreases by 2 permil and that of $CO_2$ gas by 7 permil. These effects, caused by calcite dissolution and a slight pH shift, make inclusions in calcite the least representative of the original fluid's composition. These predicted differences in post-trapping behavior among host minerals should be considered when sampling and micro-analyzing fluid inclusions to interpret the nature of hydrothermal fluids.

# Investigating the dynamic consequences of compositional density heterogeneity in Earth's lower mantle

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Seismic observations hint at compositional heterogeneity in the lower mantle, particularly in regions associated with the two large, low-velocity provinces beneath Africa and the Pacific, observed in shear-wave tomography. Several dynamic hypotheses have been developed in recent years to explain the possible cause of the low-velocity provinces, each of which has significant consequences for the nature of smaller-scale processes, Earth's heat budget, and the temperature and chemical structure of the mantle. These hypotheses typically involve the presence of lower mantle material that is intrinsically more-density dense than surrounding mantle. Large volumes of dense material may form large, long-lived, thermochemical piles or oscillating superplumes, whereas smaller volumes and/or a lower intrinsic density of this material may result in compositionally heterogeneous clusters of smaller plumes. Here, we investigate the utility of combining geodynamic predictions with seismic observations of shear-wave tomography, CMB topography, and location of the Ultra Low Velocity Zone (ULVZ) to test these different hypotheses in an attempt to constrain the nature of large scale mantle convection. We find that each hypothesis is expected to provide unique predictions that can be tested against observations. We also find that the source compositional heterogeneity (e.g., core-mantle reaction products, iron entrainment, segregation of basaltic crust, or primordial material) plays a significant role in the dynamic characteristics of these different scenarios.