3.5.31

Avoiding chemical segregation in fluid-saturated experiments – a rocking multi-anvil

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High-pressure equilibria involving fluids suffer from intrinsically high solubilities of solid components in such fluids, as they become chemically zoned through Soret-diffusion. Entropy driven migration of the fluid together with a dissolution/reprecipitation process then causes strong zonations in the solid phase assemblages (as frequently observed, e.g. Stalder and Ulmer 2001, CMP), which renders interpretation of phase relations and equilibrium fortuitous. Additional complications arise, because fluid migration and dissolution/repricipitation are time- and fluid/rock ratio dependent. In fact, experimental determinations of high-pressure dehydration reactions from different groups are generally inconsistent (at least in $MgO-SiO_2-H_2O$ and in K-rich systems); a major part of which might be attributed to chemical segregation.

The problem can be overcome by inverting the capsule (i.e. the multi-anvil press) within the gravity field. This causes a density-stratified fluid to develop Rayleigh-Taylor instabilities and thus to rehomogenize upon tilting of the system. If rocking of the multi-anvil is frequent enough (1 turn/min) the chemical gradient in the fluid (caused by Soret-diffusion) is reset before dissolution/reprecipitation processes cause zonations, the result is an almost homogeneous systems that represents chemical equilibrium in the entire capsule.

First results of such equilibrium experiments in $MgO-SiO_2-H_2O$ demonstrate that there is a distinct but narrow stability field of clinohumite near the invariant point where phase A is replaced by phase E. Currently, we verify if several reactions involving phase E are hydration reactions with temperature, as suggested by Schreinemaker analysis of the newly defined stability relations of phase A – phase E – clinohumite.

Another set of experiments aims at determining fluid compositions in eclogite. The fluid is collected in diamond traps, which, at static conditions, are surrounded by cpx while garnet is concentrated far from the trap at the cold ends of the capsule. The rocking multi-anvil allows to maintain an unzoned solid with the diamond trap enclosed in an almost homogeneous eclogite thus leading to equilibration of the fluid with all residual phases.

3.5.32

Brine and carbonatitic melts in a diamond from Diavik– implications for mantle fluid evolution

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Micro-inclusions in diamonds provide pristine information on the composition of mantle fluids. We explored the composition of fluid and mineral micro-inclusions in coated diamonds from the Diavik mine in Canada. One peridotitic diamond provided a wide compositional range between carbonatitic melt and brine. The diamond is concentrically zoned; it exposes a transparent core, surrounded by alternating cavity rich layers and fibrous zones. TEM imaging revealed the internal structure of single inclusions. Detailed analysis of individual inclusions found halide to carbonate compositions and carbonate to silicate compositions in the inner and outer fibrous zones respectively. Both crystalline and amorphous phases were found. The cavities exposed dissolution features, They contain, mostly amorphous, Al-rich, Si-rich and some Ca-rich phases suggesting formation by immiscibility of parental melts.

Electron-probe analysis of 167 inclusions in the fibrous zones showed that the brine micro-inclusions reside in the inner fibrous zone and their end-member composition is $K_{19}Na_{25}Ca_5Mg_8Fe_3Ba_2Si_4Cl_{32}$ (mol%). Carbonatitic melt was found in the outer fibrous layer and the end-member composition is $K_{11}Na_{21}Ca_{11}Mg_{26}Fe_7Ba_2Si_{10}Al_3P_2Cl_5$ [1].

The transition in inclusion chemistry is accompanied by a change in the carbon isotopic composition of the diamond from -8.5‰ in the inner zone to -12.1‰ in the outer zone. We suggest that this transition reflects mixing between already evolved brine and freshly introduced carbonatitic melt of different isotopic composition.

The compositional range found in diamond ON-DVK-294 closes the gap between brine found in diamonds from South Africa [2] and carbonatitic melt analyzed in diamonds from Zaire and Botswana [3]. Thus, fluids trapped in micro-inclusions in diamonds from various continents plot along two arrays connecting the carbonatitic melt composition to either a hydrous silicic end-member or to a brine end-member.

References
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