

Carbon mobility by hydrous carbonate liquids at subduction zones

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More than half a gigaton of CO₂ per year is recycled in the Earth interior at convergent margins. At least 40% of this CO₂ returns to the atmosphere via igneous activity at subduction zones. Experimental and thermodynamic modelling of phase relationships at high pressure indicate that decarbonation or carbonate dissolution in fluids account for only a portion of CO₂ released, and that dry carbonate melts are feasible only if thermal relaxation occurs in a subduction environment.

The subducted oceanic crust includes a range of gabbroic rocks, altered on rifts and transforms, with large amounts of An-rich plagioclase. It has been shown that epidote disappearance with pressure depend on the normative anorthite content of the bulk composition considered; we therefore expect that altered gabbros might display a much wider pressure range where epidote persists, potentially affecting the location and the nature of volatiles release.

New experimental data from 3.7 to 4.6 GPa, 750 °C to 1000 °C are intended to unravel the effect of variable bulk and volatile compositions in model eclogites, enriched in the normative anorthite component (An₃₇ and An₄₅). Experiments are performed in piston cylinder apparatus and multianvil machine, using both single and, buffered, double capsule techniques.

Garnet, clinopyroxene and coesite form in all syntheses. Lawsonite was found to persist at 3.7 GPa, 750 °C, with both dolomite and magnesite; at 3.8 GPa, 775-800 °C, fluid saturated conditions, epidote coexists with kyanite, dolomite and magnesite. The anhydrous assemblage garnet, omphacite, aragonite, kyanite is found at 4.2 GPa, 850 °C. At 900 °C, fluid-rich conditions, a silicate fluid/melt of granitoid composition, a carbonatitic melt and Na-carbonate are observed upon quenching. Close to fluid-saturation, 3.8-4.2 GPa, 870 - 900 °C, garnet and Na-rich clinopyroxene coexist with a carbonatitic liquid, Mg-calcite/dolomite and aragonite. The carbonatitic melt is enriched in Ca compared to liquids previously obtained in dry carbonated experiments.

Sandwich experiments, at variable volatile content and variable CO₂:H₂O ratio, have been designed to demonstrate attainment of equilibrium and to challenge the suggested supercritical nature of the carbonate liquid produced. H₂O strongly depresses liquidus surface for Ca-rich carbonates allowing the generation of liquids efficiently scavenging volatiles, Ca and Si from the slab.

Hydrous silicate carbonate liquids are therefore feasible if a H₂O source is provided along a relatively warm subducting path. Such source may correspond to fluids flushed from the dehydrating serpentinized lithosphere or to an internal source, i.e. epidote. In warm subduction zones, the possibility of extracting hydrous carbonatitic liquids from a variety of gabbroic rocks offers new scenarios on the metasomatic processes in the lithospheric wedge of subduction zones and a new mechanism for recycling carbon. Such liquids are expected to be extremely reactive in a percolated mantle wedge, where they generate carbonate pyroxenites, a fertile CO₂ source for magmatism at subduction zones.

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