

Experimental constraints on the origin of olivine-rich troctolites by melt-rock reactions

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Studies on oceanic lithosphere suggest that melt-rock reactions play a key role in the origin of olivine-rich troctolites. To provide experimental constraints on these processes, we performed reactive dissolution and crystallization high pressure experiments in a piston-cylinder apparatus. Experimental charges consist of three layers: (1) basalt glass powder, (2) fine powder of San Carlos olivine (Fo90) mixed with 9% of basalt, and (3) carbon spheres used as a melt trap. We used three synthetic MORB-type glasses with composition spanning from primitive to evolved tholeiite, ($Mg/(Mg+Fe) = 0.74, 0.62$ and 0.58). Experiments have been conducted at 0.5 GPa and 0.7 GPa, following an isobaric step-cooled temperature path (from 1300°C to 1150°C), to induce reactive dissolution of olivine and in-situ crystallization of interstitial phases from the reacted melt. Therefore, melt compositions and pressure effects can be investigated by evaluating the development of textures, and variations in resulting phases abundance and mineral chemistry.

Experiments are layered with a lithological sequence ranging from basal olivine-gabbro to troctolite, olivine-rich troctolite and dunite. Troctolites are the result of crystallization of reacted melts and show poikilitic textures, with plagioclase and clinopyroxene including both small rounded and euhedral olivines. Evidence of disequilibrium relations are testified by occurrence of resorbed embayed olivines consistent with dissolution processes.

In the troctolites and dunite layers greater abundance of interstitial phases are observed at lower pressure suggesting greater extent of melt-olivine reaction favoured by higher dissolution of olivine. On the other hand, higher pressure expands the stability of clinopyroxene at higher temperatures, therefore inhibiting melt-rock interactions by early crystallization of interstitial reacted melts.

Melt composition affects the abundance of interstitial phases with most primitive MORB leading to less clinopyroxene crystallization.

Mineral chemistry significantly varies along the experimental charge. Olivine ranges from Fo82 at the olivine-gabbro/olivine-rich troctolite interface to Fo90 in the olivine-rich troctolite layer. The same trend is observed in clinopyroxenes showing X_{Mg} increasing from 63 to 90. Fe-Mg partitioning between olivine and clinopyroxene is close to equilibrium. Plagioclase composition is An75 close to the interface, and decreases along the olivine-rich-troctolite layer reaching An50. Anorthite vs. Fo content in olivine deviates from fractional crystallization paths and, as expected, follows the trend observed in natural olivine troctolites, with large anorthite variations coupled with rather constant forsterite values.