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Experimental constraints on percolation of late-stage H2O-bearing melts through solidified gabbro

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It is believed that a considerable part of the deep oceanic crust at South West Indian Ridge was modified by a permeable flow of late Fe-rich melts through the just solidified gabbro pile, causing both dissolution-precipitation reactions and diffusion-controlled processes in the primary mineral assemblages. We started an experimental simulation of these processes, by performing percolation experiments using a synthetic late-stage melt and a natural "pure" cumulate gabbro from Hole 735B. In the first series, the LS melt was pre-saturated with H2O at 1200°C and 200 MPa in Au80Pd20 capsule. The capsule was cut in several pieces (cylinders). The H2O-saturated cylinder of LS composition was placed under the drilled cylinder of natural gabbro and the resulting pair was closed shut in Au capsule, simulating scenario where hot gabbro interacts with H2O-rich late-stage melt. In the second approach, the dry powder of LS was placed in the capsule, followed by 5 wt.% bulk H2O and finally the cylinder of natural gabbro. Such an assembladge simulated an ineraction between partly crystallized LS magma, gabbro and free fluid phase present at the interface between LS melt and gabbro. Both systems were run at 200 MPa, 1050°C and fO2=QFM+1 for 48 hours.

For studying the three-dimensional distribution of the percolating melt within in the host gabbro, we applied an innovative new tool: High-resolution X-ray computed tomography (CT; collaboration with L. Baumgartner in Lausanne, Switzerland). The CT images show three different zones: (1) an inner core of unreacted gabbro; (2) a diffuse, some hundred microns broad reaction zone surrounding the gabbroic core; (3) the frozen late-stage melt surrounding the whole inner, gabbroic part of the cylinder. In the reaction zone Plagioclase, Olivine and Clinopyroxene remain the main phases even crystallizing from the LS melt. However, the composition of new phases is different. New PL is enriched in Ca and Fe, new OL has higher Ca content, while Cpx is enriched in Al when compared with protholite mineral compositions. Orthopyroxene and Amphibole are probably not stable at the experimental conditions. The rims of PLs from the reaction zone are composed of wide anortite-rich zones with simplectite texture. The width of the reaction rims is more than 100 μm in PL crystals and it can reach about 30 μm in Cpx crystals. The anorthite content inceases from 55 in relict PL to 80 in PL from simplectites. The combination of CT techniques and microanalytical analyses will lead to the determination of realistic rates of reaction and/or diffusion, enabling, the quantification of the time scales on late-stage melt percolation ongoing in the deep oceanic crust.