Partial melting triggered by water migration on grain boundaries in hot gabbros: Details of the reaction

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Hydrous partial melting of oceanic gabbro as a consequence of fluid/rock interaction at very high temperatures is regarded as important processes for the formation of felsic lithologies within the oceanic crust. In order to understand the principle reaction mechanism of hydrous partial melting in detail, we performed water-saturated partial melting experiments with mm-sized blocks of unmodified olivine gabbro ("microrocks") as starting material using an internally heated pressure vessel. The use of a coarse-grained starting material allows us to study the principle reaction mechanism of hydrous partial melting of oceanic gabbro in detail. Although far from global equilibrium, we observed phase relations and compositional trends as expected from a similar experimental survey designed for achieving global equilibrium using a fine-grained powder of the same starting gabbro.

One significant textural feature of the discontinuous hydrous partial melting reaction is that the reaction products form two different domains dislocated from each other: (1) the formation of anorthite-rich zones on plagioclase/plagioclase grain boundaries, and (2) interstitial growth of orthopyroxene and amphibole around primary mafic minerals. This is in contrast to corresponding equilibrium experiments using a fine-grained powder of the same starting gabbro, where the newly formed minerals are homogenously distributed within a melt phase.

Detailed petrographic observations in an olivine gabbro from the Wadi Rajmi of the Fizh block of the Oman ophiolite revealed that this gabbro represents a perfect example of a partial melting reaction. All grain boundaries between primary plagioclases are characterized haloes of anorthite-rich plagioclase, while the mafic primary minerals show reactive rims of "interstitial" orthopyroxene and pargasitic amphibole. The observed features imply a model on hydrothermal activity proceeding on grain boundaries within the deep oceanic crust at very high temperatures (900–1000°C) without any crack system, a prerequisite in current models for enabling hydrothermal circulation.