Eclogite stability in MORB-type bulk compositions: New constraints from fluid-absent melting experiments on amphibolites

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Knowledge of P-T evolution of MORB-type rocks from amphibolite- or granulite-facies to eclogite facies are critical in understanding the thermal characterisitcs and conditions of magma generation in subduction zones . Although, the nature of this transition is well documented in a variety of basaltic compositions at temperatures >1000 °C, experimental data is lacking in the temperature range 800-1000 °C. Down-temperature extrapolation of anhydrous experimental results on a quartz tholeiite bulk composition indicate plag-out/eclogite-in at ~14 kbar at 800 °C [1]. This, however, is inconsistent with P-T estimates from many high pressure granulite terranes where plagioclase is stable under these conditions in mafic rocks [2].

We report the results of long duration experiments at 800-1050 °C in two high grade amphibolites (of differing Fe/Mg ratios) having compositions similar to average MOR-basalts. Our results indicate that typical MORB bulk compositions require pressures of at least 17.5 kbar (900 °C) and 20 kbar (850 °C) for complete disappearance of plagioclase and development of true eclogitic mineral assemblage. Plagioclase co-exist with a high-pressure granulitic (orthopyroxene-free garnet-clinopyroxene) assemblage through a broad pressure interval (~7 kbar). Our results imply a negative slope for plag-out reaction at temperatures ≤900 °C and a positive slope at >900 °C, under fluid-absent conditions. Therefore, down temperature extrapolation of plag-out boundary from experiments at temperatures >1000 °C may not be representative of amphibolite-eclogite transition in subducting oceanic crust. Another implication of our results is that in shallow, hot subduction zones partial melting processes may have occurred in the plagioclase-bearing, high-pressure granulite field rather than in the plagioclase-free eclogite field.

References

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Melt thermodynamics and divalent element partitioning between anorthite and CMAS liquids

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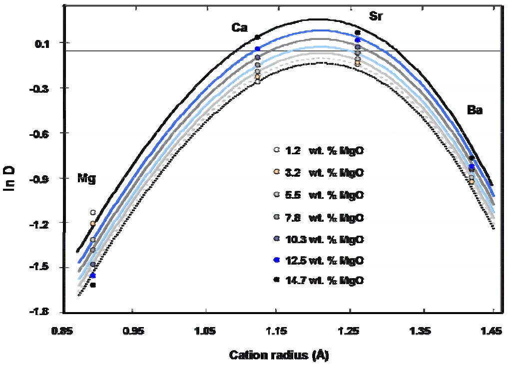
Quantifying the effect of melt composition on trace element partitioning in natural systems has been hampered by correlated variations in mineral chemistry, temperature, and pressure. We have isolated the influence of melt composition on divalent element (Mg, Ca, Sr, Ba) partitioning between stoichiometric anorthite and a range of synthetic melts. Data were obtained from electron microprobe analysis of anorthite rims from dynamic crystallization experiments. Melt compositions contain near constant SiO_2, CaO/Al_2O_3 ranging from 0.8-1.6, and MgO from 1-15 wt. %. Holding X_{mineral}, T, and P constant, we observe partitioning behavior that varies systematically with melt chemistry.

Writing equilibrium constants for mineral fusion and cation exchange using neutral species yields the following expression for the partition coefficient of oxide MO:

$$D_{MO}^{molar} = \frac{\gamma_{melt}^{MO}}{\gamma_{anorthite}^{MO}} a_{melt}^{Al_2O_3} (a_{melt}^{SiO_2})^2 e^{(\Delta G_{fusion} + \Delta G_{exchange}^{MO})/RT}$$

This treatment extends the lattice-strain predictive model of Blundy and Wood (1994) to predict the strain-free value, D_o, as a function of component activities in the liquid. Our data support treating the strain parameters E and r_o as functions only of X_{mineral}. The figure demonstrates that to good approximation $D \propto a^{Al2O3}(a^{SiO2})^2$ of melt. The residuals are proportional to the activity coefficients of trace oxides in the melt, which vary systematically with melt composition.



Reference

Blundy, J. and Wood, B., (1994), *Nature*, **372**, 452-454.