

## Melt migration under ocean ridges: inferences from reactive transport modelling of dunite bodies

G. Suhr

Max Planck Institut für Chemie 55020 Mainz, Germany

Tabular dunite bodies within the ophiolitic upper mantle are widely considered to locate pathways for melt transport under ocean ridges. They probably formed by in-situ transformation of mantle harzburgite to dunite along melt channels. In order for the melts to be reactive with the host mantle they cannot be locally derived but must come from greater depth without significant re-equilibration.

We have studied mantle hosted dunites in the Bay of Islands Ophiolite (BOIO), expecting that the dunites contain information about the nature of the melts feeding the spreading center (cf. Kelemen *et al.* 1995). Analysis of the rare clinopyroxene (cpx) grains of the dunites reveals a refractory trace element composition even though the average crustal signature in the BOIO is MORB-like in terms of the rare earth elements (REE). The analysed cpx grains are somewhat enriched with respect to the host harzburgite but dramatically depleted with

respect to MORB (Fig. 1). In the context of replacive dunite formation the question is whether during the reaction of harzburgite to dunite triggered by a relatively enriched melt (MORB in this case), the refractory trace element nature of the original harzburgite may be partially preserved.

A numerical scheme was developed to simulate melt-host reaction triggered by diffusive and advective transport of melt within a porous network. A melt channel carrying reactive melt acts as boundary condition. Exchange between melt and host occurs by diffusion and via solution-precipitation. The reaction proceeds with a finite, but fast reaction rate simulating the nearly grain scale transition observed between harzburgite and dunite. The reaction continues until a saturation concentration of silica is reached. With the chosen reactivity of the melt (1 unit melt converts 2.2 units of harzburgite to dunite) the velocity of the reaction front in an

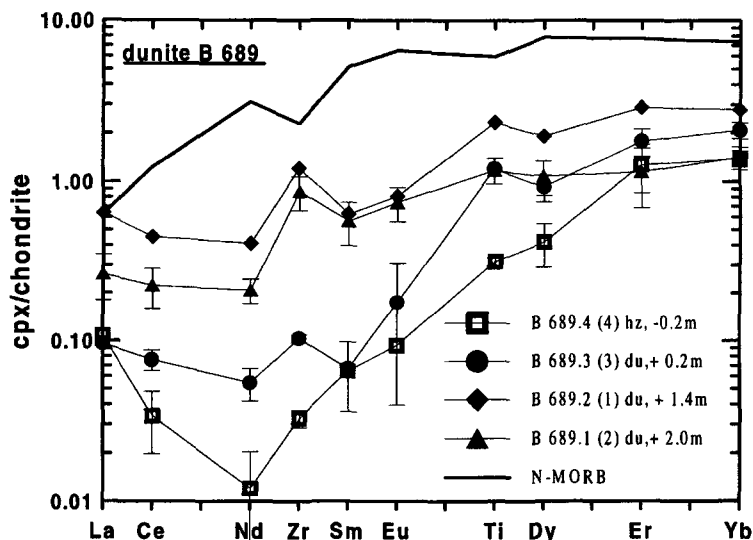


FIG. 1. REE concentration in cpx from a 4 m wide dunite and the adjacent host harzburgite B689.4. For comparison, a cpx derived from an N-MORB melt is shown. Other dunites (not shown) are similar depleted to B689.3. Analyses by S. Simakin, CAMECA 4F ion probe, Yaroslavl.

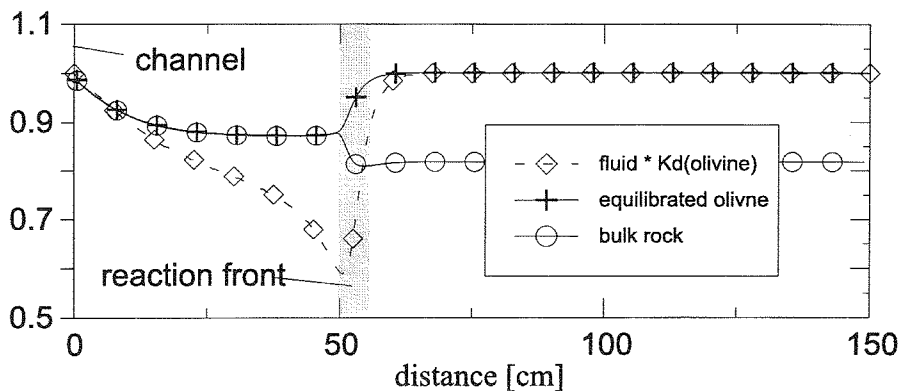


FIG. 2. Concentration change of Ni during a reaction of harzburgite (porosity 1%) to dunite (porosity 9%) according to  $1 \text{ en} + 0.04 \text{ di} = 1.02 \text{ fo} + \text{melt}$ . Dunite occurs upstream (to the left of) the reaction front (stipple), harzburgite on the downstream side. Simulated are 500 y of reaction with an advective velocity of 5 cm/y into the host including diffusion in the fluid. The depletion occurs because the system dunite + melt has a higher bulk distribution coefficient than the system harzburgite + melt ( $K_d(\text{melt}) = 1$ ) ('Ni-sink'). During the initial conditions, channel melt and interstitial harzburgite melt are in Ni-equilibrium.

advectively dominated system with an initial porosity of 1% is slow ( $\sim 1/50$  of the melt velocity). For a system controlled by diffusive transport of reactive components, the formation of a dunite with a half width of 2 cm takes about one year. This value is probably an upper limit because of poor constraints on the physical nature of the channel margin and acting physical processes in addition to the diffusive flux in this region. The trace element effects of the reaction  $1 \text{ en} + 0.04 \text{ di} = 1.02 \text{ fo} + \text{melt}$  are explored (e.g. for Ni, Fig. 2) and are compared with analytical solutions of the simplified system (Godard *et al.* 1995).

The simulation shows that for diffusive or infiltrative systems, the original refractory nature of the reactant (harzburgite) for the REEs is largely wiped out in the product (dunite) if the melt causing dunite formation is relatively enriched. In order to model the chemistry of the dunites, transport by advection of interstitial melt towards the dunite must have dominated at a later stage in their evolution. The dunite chemistry is then governed by the refractory melt carried from the harzburgite into the replacive

dunite and the formation of small amounts of cpx from this melt. This later evolution might be connected with the compaction of the matrix associated with the closing of the channels.

The proposed model cautions of a simple interpretation for the chemistry of tabular dunite bodies. Only where evidence for an infiltration event associated with dunite formation is preserved can the dunitic chemistry be related to the melt triggering the dunite formation. This, however, appears to be the exception rather than the rule in the BOIO. The model proposed is consistent with a mode of liquid aggregation via drainage of melt into dunite channels during progressive decompression melting of the mantle.

## References

- Godard, M., Bodinier, J.L. and Vasseur, G. (1995) *Earth Planet. Sci. Lett.*, **133**, 449–61.  
 Kelemen, P.B., Shimizu, N. and Salters, V. (1995) *Nature*, **375**, 747–53.