# Lattice-strain modeling of fluid compositions in subduction zones and the mid-ocean ridges

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Earth is the 'blue planet', with more than 70% of its surface covered in water and the equivalent of up to four oceans in its interior [1]. This abundance of water has a profound impact on the processes that operate on and in the Earth, from plate tectonics to the formation of ore deposits to the development of life [2-4]. Moreover, fluids are the most important agent of element transport and redistribution among the various Earth reservoirs of surface, crust and mantle. Despite their recog-nized importance, the properties and compositions of these fluids are largely unavailable, because direct samples of fluid are rare, especially for environments deep in the Earth and from its earliest history. In lieu of fluid samples, the rock record has been used to provide information on the associated fluids [e.g. 5, 6].

We have recently shown experimentally that minerals can be used to quantitatively reconstruct the trace element composition of aqueous fluids, based on the characteristic partitioning of elements among these phases [7]. This partitioning is systematic and obeys lattice-strain theory when speciation of elements in the aqueous solution is accounted for.

Partition coefficients are highly senstitive to changes in chemical and physical conditions, and fluid compositions can therefore only be reconstructed for those minerals and conditions for which they have been evaluated experimentally. However, lattice-strain theory brings a predictive component to partitioning and we here exploit this, together with results from partitioning experiments, to derive the mobility of trace elements in two key settings; interaction between ocean-crust and seawater at the mid-ocean ridges, and slab dehydration in subduction zones. Combined these environments control, to a large extent, the flux of elements from the surface of the Earth to the mantle, and our results therefore place important constraints on element cycling through our planet.

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# Generation of mantle heterogeneity by ocean crust recycling: Geophysical and geochemical constraints

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The evolution of the Earth's mantle is expressed in the complimentary observations from geophysics and geochemistry, where the geochemistry provides a time-integrated signal and the geophysics tends to see a recent snapshot of the Earth's interior. While the geophysical evidence tends to support a form of whole mantle convection that is moderated by rheological and phase changes in the transition zone, the geochemical observations have been generally used to support the presence of long-lived and isolated reservoirs. Recent dynamical modeling [1] employed high resolution finite modeling of mantle convection using an energetically consistent simulation of tectonic plates. A suite of models was developed with a dynamic vigor similar to that of the present day earth. The recycling of oceanic crust combined with a two-stage formation of the continental crust leads to a satisfactory match to the observed spread between HIMU-DMM-EM1 in multiple isotope systems without invoking recycling of continental crust. Due to the rheological contrast between upper and lower mantle there is a natural occurrence of a well-mixed upper mantle overlaying a chemically more heterogeneous lower mantle. The pooling of dense oceanic crust provides the formation of dense piles at the base of the mantle. Together with the occurrence of slabs that thicken and/or stagnate at the 670 discontinuity we find reasonable correspondence with the present day tomographic signatures. We explore in this study specifically the effects of compressible convection, which tends to increase the difference in dynamical properties of the upper and lower mantle.

[1] Brandenburg *et al*. (2008) *EPSL.*