Constraints on the Composition of the Lower Continental Crust from Joint Inversion of P- and S-wave Seismic Velocity Data

MARK D. BEHN[1]*, OLIVER E. JAGOUTZ[2], DONNA J. SHILLINGTON[3] AND PETER B. KELEMEN[4]

[1]*WHOI, Woods Hole MA, USA, mbehn@whoi.edu
[2]MIT, Cambridge MA, USA, jagoutz@MIT.EDU
[3]LDEO, Palisades NY, USA, djs@ldeo.columbia.edu
[4]LDEO, Palisades NY, USA, peterk@ldeo.columbia.edu

Seismic velocity data constitute one of the primary constraints on the bulk composition of the lower continental crust. P-wave velocity data are frequently used to infer the composition of the deep crust and to support petrologic models for the origin of the continental crust. Unfortunately, recent work has demonstrated that a large range of compositions can be associated with the same P-wave velocity, rendering the interpretation of these crustal velocity models to be highly non-unique. Alternatively, the ratio between P- and S-wave velocity (Vp/Vs) can be directly inferred from receiver function studies (though not the absolute P- or S-wave velocity). However, Vp/Vs ratios alone also lead to highly non-unique estimates for lower crustal composition.

In order to provide more robust constraints on lower crustal compositions, we calculate elastic properties for an expansive suite of crustal compositions (anhydrous and hydrous) and invert for major element chemistry as a function of P- and S-wave velocity over a range of pressure and temperature conditions. We show that the combination of P- and S-wave data significantly improves compositional resolution, particularly when *a priori* pressure and temperature constraints can be used to determine whether the lower crust resides in the alpha- or beta-quartz stability field.

We apply this inversion technique to a range of geologic settings with high quality P-wave S-wave data (e.g., cratonic North America, the African and Indian shields, and the Aleutian arc crust—which may represent a building block for continental crust). Compositional models for each region are derived based on expected crustal geotherms, along with complementary estimates for lower crustal physical properties including density and viscosity. These data are then used to test different models for crustal evolution.

Geodynamic implications from element fluxes in the Tonga-Lau system

CHRISTOPH BEIER[1], MARCEL REGELOUS[1] AND KARSTEN M. HAASE[1]

[1]GeoZentrum Nordbayern, Universität Erlangen-Nürnberg, Schlossgarten 5, D-91054 Erlangen, Germany, christoph.beier@fau.de

It is well known that lavas from active back-arc spreading centres contain a 'subduction component' (e.g. high Pb/Ce, U/Nb), the strength of which decreases with increasing distance of the spreading axis from the volcanic arc. However, it is not well understood how the Ba-, Pb- and U-rich subduction component is transported from the subducting plate to the shallow melting zone underneath the ridge axis. Many tectonic models for subduction zones assume vertical transport of fluid or aqueous melt from the surface of the subducting slab to shallower levels beneath the back-arc spreading axis, and the decreasing subduction signal with distance from the arc is thought to result from a decreasing fluid release from the subducting slab at greater depths. To test these hypotheses, we present new data from the Tonga-Kermadec arc, a 3000 km long arc in the southwestern Pacific, along with new and published data from the Valu Fa, Central and Eastern Lau back-arc basin spreading centres. The distance between the arc and back-arc increases from less than 10 km at ~23°S to ~150 km at 19°30'S, allowing the interaction between the arc and back-arc melting regimes to be constrained. Assuming that Nb is immobile in fluids, and that Ba/Nb, Th/Nb ratios are not fractionated during melting, we map out the subduction-related enrichment of Ba and Th underneath the Tonga Arc-Lau Basin system, and show using mass-balance arguments that the simplistic model of vertically rising fluids or melts is unrealistic. We suggest that the overlap in melting zones beneath the arc and beneath the back-arc spreading centre allows horizontal flow of melt from beneath the arc towards the back-arc (i.e. in the opposite direction to the flow of solid mantle induced by plate subduction) at shallow levels in the mantle, and this best explains a subduction zone signature underneath the back-arc. Our work demonstrates for the first time that melt can be focussed from the extreme edges of the melting zone underlying an active spreading ridge to the ridge axis, over distances of up to 200 km. Our model provides an alternative explanation for ($^{238}U/^{230}Th$) > 1 in back-arc lavas, and indicates horizontal melt flow velocities of 0.4-1 m/y.

DOI:10.1180/minmag.2013.077.5.2
www.minersoc.org