Petrogenesis and crustal structure along Lau back-arc spreading centers

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Proposed models for crustal formation in water-rich back-arcs share similarities with models for crustal petrogenesis at arcs, where highly differentiated lavas are common and high-velocity lower crustal layers have been imaged locally. Seafloor spreading at back-arc spreading centers leads to thinner crust without the long-term accumulation of the thick volcanic piles found at arcs, limiting the amount of crustal interaction and geochemical modification that may occur and making the water-rich Lau back-arc basin a useful setting for quantifying the effects of water on crustal formation. Results from seismic studies in the Lau back-arc basin indicate that crust formed near the Tofua Arc is abnormally thick (8-9 km) and compositionally stratified, with a thick low-velocity upper crust and an abnormally high-velocity (7.2-7.4+ km/s) lower crust [1]. Lava samples from this area show arc-like compositional enrichments and tend to be more evolved than typical mid-ocean ridge basalts, with an average MgO of ~3.8 wt%. We propose that slab-derived water entrained in the near-arc ridge system not only enhances mantle melting, as commonly proposed to explain high crustal production in back-arc environments, but also affects magmatic differentiation and crustal accretion processes. Results from phase equilibria modeling using MELTS indicate that the high water contents found in near-arc parental melts can lead to crystallization of an unusually mafic, high velocity cumulate layer. Best-fit model runs contain initial water contents of ~0.5-1.0 wt% H_2O in the parental melts. These model runs successfully reproduce geochemical trends of the erupted lavas while crystallizing a cumulate assemblage with calculated seismic velocities consistent with those observed in the near-arc lower crust. The resulting residual melts are also lower density than their dry equivalents, which aids in the extraction and eventual eruption of unusually evolved magmas. We present results from petrologic modeling of Lau back-arc crustal formation that successfully predict the unusual crustal stratification imaged in the near-arc regions of the Lau basin, as well as the highly fractionated andesites that erupt there.

[1] Arai & Dunn (2014), *EPSL* **390**, 304-317.