Geophysical Research Abstracts
Vol. 16, EGU2014-11701, 2014
EGU General Assembly 2014

Slab-derived water and the petrogenesis of distinct zones of oceanic crust along spreading centers in the Lau back-arc basin

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Back-arc basin crust formed along the Eastern Lau Spreading Center (ELSC) exhibits dramatic and abrupt changes in magmatic processes and crustal formation with proximity to the nearby Tofua Arc. Systematic variations in seafloor morphology, crustal thickness, seismic properties, and lava composition reflect a decreasing 'subduction influence' with increasing distance from the arc. Results from seismic tomography indicate that the crust that forms near the arc is abnormally thick and compositionally stratified, with a thick low-velocity upper crust and an abnormally high-velocity lower crust. As the ridge moves away from the arc, there is a step-like transition in crustal properties towards crustal velocities and thicknesses more typical of oceanic crust produced at mid-ocean ridges. Likewise, lava compositions exhibit abrupt changes in slab-derived volatiles and trace element enrichments, with silicic, arc-like compositions at the Valu Fa Ridge and southern half of the ELSC, located near the arc, and relatively depleted basalts along the northern ELSC, which is located further from the arc. We attribute the observed changes in the physical and chemical makeup of the crust to excess mantle melting coupled with higher degrees of crustal differentiation near the arc due to higher mantle water contents. We propose a model for the formation of the arc-proximal layered crust whereby water-rich basaltic melts stall and differentiate in the lower crust. High-pressure crystallization concentrates water in the residual melts, decreasing their viscosity and density. Eventually the lighter, more felsic residual melts are extracted from the lower crust, leaving behind a dense, mafic cumulate layer, and go on to produce a silica-rich, porous volcanic layer. We present results of thermodynamic modeling of phase equilibria and develop a petrological model for the formation of this unusual "hydrous" form of oceanic crust.