Crustal and magmatic system structure along the eastern Lau spreading center

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While thin basaltic oceanic crust forms by decompression melting of the upper mantle beneath mid-ocean ridges, the origin of thick crust formed along back-arc spreading centers is less well understood. Geophysical observations along the Eastern Lau Spreading Center and Valu Fa Ridge, where abundant basaltic-andesites and andesites erupt, indicate that slab-derived water plays an important role in producing these evolved compositions as well as a vertically differentiated crust. Spreading centers located near the active Tofua Arc in the Lau basin produce oceanic crust that is somewhat thicker (8-9 km) than typical mid-ocean ridge crust, and with unusual vertical seismic (and by inference chemical) stratification. The seismic lower crust has high wave speeds indicating more ultra-mafic compositions than is typical for oceanic crust, whereas the upper crust has lower wave speeds than typical, in accordance with the evolved (and high porosity) lavas erupted along these near-arc spreading centers. Seismic imaging shows that the crustal magmatic system that produces the stratified crust is similar to magmatic systems found along fast-spreading mid-ocean ridges in that it is narrow, closely follows the ridge axis, contains a low melt fraction overall, and is capped by a thin shallow melt lens. The geophysical observations suggest that the presence of slab-derived water entrained in mantle melts strongly influences crustal level magma storage and differentiation. Despite having a magmatic system with a physical structure remarkably similar to a fast spreading mid-ocean ridge, the volcanic products of the near-arc magma system are much more evolved on average. The Valu Fa Ridge and southern segments of the Eastern Lau Spreading Center produce a more differentiated upper crustal volcanic layer without evidence of the extensive crustal interaction and chemical modification sometimes proposed for arc settings, where thick crust and intermittent magma supply create an environment ripe for crustal assimilation and magma mixing.