AOGS 2005

Large silicic magmatic systems in oceanic arcs: are they fundamentally different from continental systems?

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A widely accepted paradigm is that continental crust is generated in subduction systems at continental margins where an important process is the generation of large volume silicic magmas by crustal anatexis. By contrast oceanic subduction systems are considered to produce mainly mafic magma compositions in the compositional range basalt to basaltic andesite. Detailed examination of oceanic arcs suggests that this general conception is not valid and one of the clearest examples of this is the Tonga-Kermadec Arc in the Southwest Pacific.

The Tonga-Kermadec Arc is a chain of volcanoes nearly 3000 km long marking the convergent boundary between the Australian and Pacific plates. It is almost entirely oceanic; only at its southern end does it impinge on the continental crust of the New Zealand continental fragment. The arc is represented by the subaerial volcanoes of Tonga and the Kermadec Islands and by the large number of submarine volcanoes, many of them only known from recent submarine mapping.

A surprising feature of the subaerial volcanoes and also of dredge sampling of submarine portions of the arc is the extent of silicic materials, most of which are the products of eruptions in recent times. These are commonly associated with caldera structures formed during eruptions that are comparable in size to many continental silicic eruptions. The occurrence of siliceous caldera-forming eruptions is correlated with segments of the arc that are underlain by thicker crust. Petrological modelling suggests that siliceous magmas are generated by anatexis of underplated arc crust as the thermal regime evolves toward conditions in which amphibole breakdown provides a fluid flux to trigger melting. In this model, siliceous magmatism in oceanic arc settings is a predictable consequence of the temporal thermal evolution of the sub-arc crust as subduction generated magmas transfer thermal energy from the mantle into the crust.

Although the continental segment (the Taupo Volcanic Zone) of the Tonga-Kermadec Arc differs in some details from the oceanic parts, a consistent conclusion is that the scale of felsic magmatism is comparable to that of the continental portion and we suggest that the processes driving these systems are also comparable. In this case the continental parts of the system are not fundamentally different to the oceanic part and both have a role in the formation of continental crust.

Keywords: Oceanic arc, siliceous system, Tonga-Kermadec Arc, continental crust