Arcs create or inherit the continents?

T. PLANK[1]

[1] Boston University, Department of Earth Sciences;
tplank@bu.edu

Since the "Andesite Model" [1] earth scientists have pointed to the chemical similarity between volcanic arcs and the continental crust as evidence for creation of the continents largely at subduction zones. An opposite interpretation, however, is that arcs resemble continents because they include recycled continental material in their source, derived from subducted sediment. Resolution of these conflicting interpretations requires scrutiny of the chemical relationships between subducting sediment and volcanism at each convergent margin.

A recent study develops Th/La as a chemical tracer of continent evolution [2]. The Earth has evolved to create continents with high Th/La (> 0.25) and upper mantle with low Th/La (< 0.1). Arc basalts and marine sediments vary between these extremes, but input and output correlate strongly from trench to trench. In the 13 regions with high quality Th-REE data in both arc basalts and nearby subducting sediments, arcs mix to Th/La that is identical within uncertainties to the local sediment. This means that arcs inherit Th/La from marine sediments, and that the high Th/La in continents is not created by modern subduction, but likely within the continents themselves.

The Nb anomaly presents a contrasting example. Here the presence of rutile as a residual phase during slab dehydration, melting, or supercritical liquid formation, provides a clear mechanism to fractionate Nb, which is strongly partitioned into rutile, from other trace elements in the subduction zone. This process would impart a negative Nb anomaly to both arc magmas and the continental crust they create. Most arcs, however, show correlated increases in Th/La and La/Nb, suggesting subducted sediments as a source of the Nb anomaly, and raising questions again as to inheritance. Indeed, Th/La – Nb/La arrays for some arcs (Tonga, S. Sandwich, and Honshu) are quantitatively described by mixing with bulk sediment, requiring no new fractionation in the subduction zone. Others (Aleutians and Marianas) do require such new fractionation to decrease Nb/La from that in the bulk sediment. The different behavior can be explained as a function of Ti/Fe in the sediment, where high values favor formation of rutile, and low values magnetite-ilmenite. Thus some subduction zones today actively magnify the continent's negative Nb anomaly, but continental inheritance is a dominant process in generating arc geochemical signatures.

References

[1] Taylor, *Tectono.* (1967). [2] Plank, *J.Pet.*, 2005.