Global geochemical insights from the Chilean Southern Volcanic Zone

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The Chilean Southern Volcanic Zone (SVZ) is a natural laboratory for studying chemical diversity among arc lavas, because SVZ lavas cover a large compositional range and multiple physical subduction parameters vary along strike of the arc. New analyses combined with literature data from the SVZ, filtered to minimize the effects of crustal processing, demonstrate coherent systematics among major elements, trace elements, and isotope ratios that mimic those seen among global arcs. Correlations among SVZ data overlap the global range, encompassing the upper half of global arcs in Na and other incompatible elements. SVZ along-strike variations include northward enrichment of incompatible elements, REE ratios, and depletion of Sc and Ca. Nd and Sr isotopes, as well as the trace element ratios Zr/Nb and Th/U follow a different along-strike pattern, with an inflection at ~38 °S.

Rear-arc volcanics provide an essential perspective on the origin of these variations. Rear-arc Sr, Nd, and Hf isotopes indicate a heterogeneous mantle, produced by mixing between Atlantic Mantle and EM1-type OIBs. SVZ arc-front variations mimic rear-arc trends. The signal from ambient wedge heterogeneity influences the ratios Zr/Nb and Th/U.

The along-strike variability is not produced by increasing levels of baseline contamination, as these would require a contaminant with an implausible composition. Trace element ratios sensitive to slab contributions do not vary along strike, indicating a fairly constant slab flux. Along-strike compositional trends produced by variable slab temperatures are inconsistent with thermal models of the SVZ slab, when considered in the global context.

Along-strike patterns are consistent with varying extents of melting of a heterogeneous mantle wedge and a generally constant slab flux. The trace element enrichment in the northern SVZ is consistent with lower extents of melting due to thick lithosphere and shallow slab dip. Quantitative modeling demonstrates the feasibility of generating these trends by a variable mantle thermal structure together with mantle enrichments similar to the Gough Island Basalts. Because the compositional systematics of the SVZ are a microcosm of the global systematics, these results bear on the mechanisms that generate compositional diversity among arcs worldwide.