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The roots of volcanism in the Central Andes

Gerhard Wörner
Abteilung Geochemie, Geowissenschaftliches Zentrum, Universität Göttingen, Goldschmidtstr. 1, 37077 Göttingen, Germany

Alexander von Humboldt travelled to South America still under the impression of Abraham Gottlieb Werner's dogma of neptunism about the oceanic source of basalts. When he returned, he had realized (and later almost convinced Johann Wolfgang von Goethe) that the size, spacing and alignment of volcanic edifices demanded a deeper and genetically connected source. This is vividly shown in drawings of geological cross sections in his famous book "Kosmos".

The unifying theory of plate tectonics and decades of research in volcanology and magmatic petrology in general, and in the Andes in particular, on the origin and compositional evolution of magmas at depth has resulted in the concept of "transcrustal magmatic systems" that are fed by basaltic magmas from the upper mantle.

The Central Andes have the thickest crust anywhere on our planet where subduction-related magmas must ascent through, and interact with, up to 70 km of continental crust The Andes are thus a natural laboratory where to study the different "regimes" of such magma systems as they evolve with time or change with recharge rates from below. The general scheme of operation of transcrustal magmatic systems comprises primary magmas that ascent from the mantle into the crust, stagnate, cool, differentiate and mix at various levels within the crust before they are erupted to the surface as chemically evolved. In the Central Andes, the predominant products of this magma processing are archetypal andesites with two distinct modes of composition. These characterize two distinct types of Andean stratovolcanoes resulting from different magmatic regimes: One system produces uniform mafic andesite that erupts at high rates and forms the iconic conical stratovolcanoes with relatively short life times of a few hundred-thousand years. A second regime forms long-lived ($>$ 1 Ma) dome and flow complexes of silicic andesite composition. Both dominant lave types show petrographic evidence of magma mixing. The end-members of mixing are characterized by magmas that differentiate from basaltic magmas derived by flux-melting of the mantle wedge of the subuction zone. A second end-member forms by interaction of mantle magmas with continental crustal melts at depth and a third shows evidence of melting enriched mantle sources, possibly derived from the lithospheric mantle. Different types of magmatic regimes are controlled by different rates of recharge from mantle depths into the crustal magmatic system and some volcanoes show regime changes when recharge rates vary and a threshold is passed from one "stable" regime to another.

When recharge and magma input from the mantle increases further, e.g. due to steepening of the subducted plate, the high magma flux results in the formation of highly differentiated magmas ($>$68% SiO_2) that erupt in so-called ignimbrite flare-ups. These magmas contain a significant proportion of melted crustal materials ($>$50%) and magma volumes of thousands of km^3 are erupted in single explosive events.

The thick-crust active continental margin of the Central Andes thus is an important setting for intra-crustal differentiation and this tectonic setting represents a major mode of processing and growth of continental crust on our planet.