Mantle origin of basalts parental to tholeiitic differentiation products in the Andean Southern Volcanic Zone (SVZ): Confirmed by U-series disequilibria and $^{10}Be/^{9}Be$

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Some dominantly mafic volcanoes in a restricted part of the SVZ (37-41°S) have erupted basaltic andesites (52-56 % SiO2) with high Ti, Fe, and V that are the products of tholeiitic (TH) differentiation related to closed-system fractional crystallization and a high proportion of plagioclase in the fractionating assemblage. These volcanoes have not produced voluminous andesite with strong calc-alkaline (CA) affinities. Abundant CA andesite and dacite at volcanoes from 36.8-33°S are products of variable combinations of high-P (wet) fractionation and crustal assimilation. The most pronounced TH differentiates are young, crystal-poor lavas from Lonquimay (38.45°S: 2-3 ka to 1989; 53-64 % Si02). The most evolved have FeO∗/MgO 10, comparable to oceanic TH andesites. Major and trace element systematics eliminate open-system processes during differentiation, but the keys to linking these evolved magmas directly to mantle-derived parental basalts are U and Pa excesses, which we argue must be mantle signals. Lonquimay lavas have among the highest $^{10}Be/^{9}Be$ we have measured at six volcanoes in this arc segment. High ^{10}Be must also be mantle-derived. Nine Lonquimay magmas analyzed for U-Th-Pa-Ra activities have ($^{231}Pa/^{235}U$) 1.75-1.85, which is typical of basaltic magmas at Antuco, Llaima, Villarrica, Puyehue, and Osorno (1.5-2.1). These values extend to the most evolved Lonquimay magmas, verifying an absence of crustal contributions. Minor contamination (5-20%) of some historic eruptive products at Llaima is recorded by major and trace elements and diminished U, Ra, and Pa excesses. Elemental U/Th and ($^{238}U/^{230}Th$) are lower at Lonquimay (0.31, 1.15; 53-64 % SiO2) than in uncontaminated basalts at nearby Llaima (38.7°S; 0.37, 1.25), in accord with other distinctions. Evolved Lonquimay magmas have Sr-Nd-Pb isotopic compositions typical of mantle-derived, uncontaminated basalts in this part of the SVZ (e.g., 0.7039-0.7040), which are closely similar in terms of Sr and Nd isotopes to local Miocene granitoids. Inferred origins of TH magma series by partial melting of crustal lithologies under special circumstances, as has been proposed for Zao and Azuma volcanoes in the NE Japan Arc (Tatsumi et al., 2008; Takahashi et al., 2013), cannot be extrapolated to all TH differentiation trends in continental arcs.