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Regional patterns in arc magma composition in the Andean Central Volcanic Zone (13°S-28°S)

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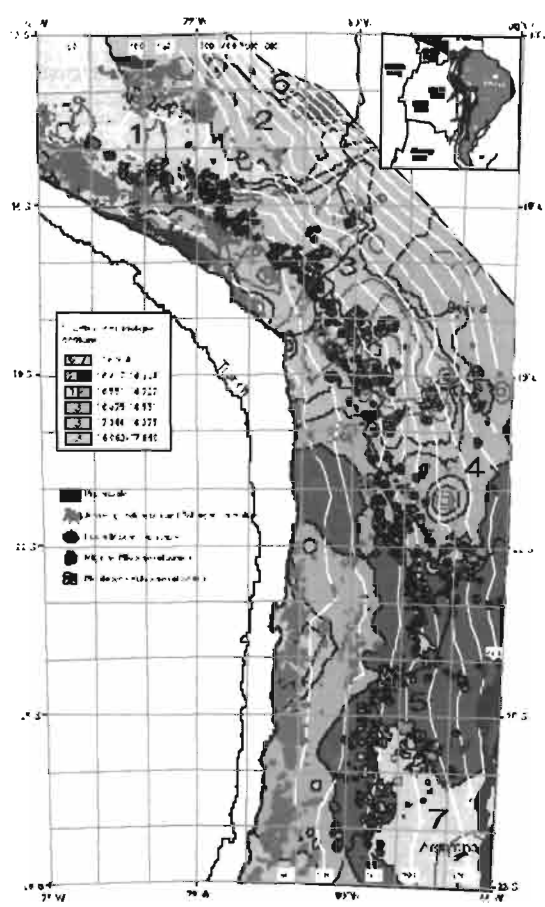
INTRODUCTION

Cenozoic volcanism in the CVZ formed on continental crust that changed thickness from less than 40 to > 70 km. Enhanced uplift between c. 30 and 15 Ma is documented by large clastic sediments wedges and ignimbrites at the Western Andean Escarpment (Wörner et al., 2000a). We evaluated >1100 rock samples for mayor and trace elements as well as a large subset for isotopes over 1600 km along the CVZ (Fig. 1), which we combine with selected published data.

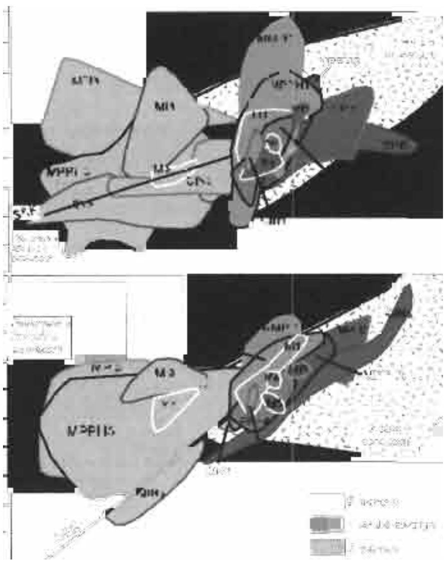
These samples fall into different geological and geochemical groups defined by Pb-Sr-Nd isotopic ratios, radiometric age (prior-during-after crustal thickening ~150 - 0 Ma), and incompatible elements (e.g. Sr/Y, Sm/Yb, Zr/Nb ratios) on a CVZ-wide scale. Pb-Sr-Nd isotopes are independent of SiO_2; they are dominated by Proterozoic and Paleozoic crustal assimilation and, especially Pb-isotopes delineate distinct basement domains. Miocene rocks (24 – 15 Ma) have lower incompatible trace element concentrations, Mio-Pliocene rocks (15 – 3 Ma) are slightly enriched in incompatible elements, and most of the Plio-Pleistocene-Holocene lavas (< 3 Ma) are variably enriched in incompatible elements. The incompatible trace element variations between Miocene and Mio-Pliocene-Pleistocene-Holocene lavas are caused by garnet in the residue of assimilation with Proterozoic crustal and/or during high-P fractional crystallization (Kay et al., 1999).

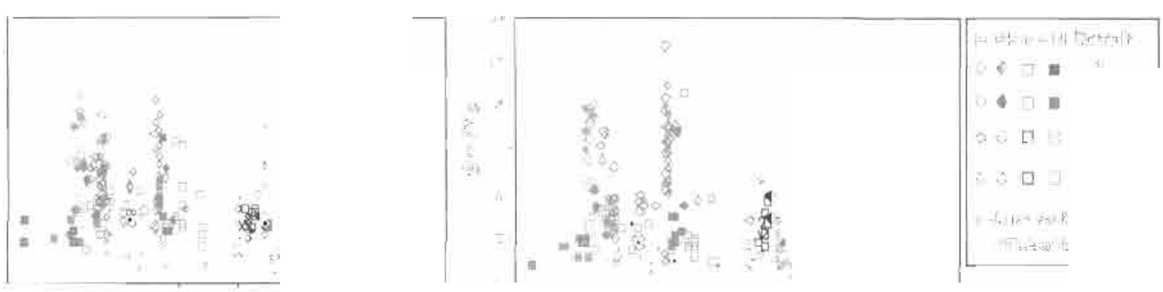


CENOZOIC VOLCANISM

Rocks between 24-15 Ma (Miocene) are syn-uplift volcanics and are calc-alkaline andesites, dacites, and rhyolites. They comprise stratovolcanoes and large volume ignimbrites that have been erupted from caldera complexes. Lavas from 15 to 3 Ma (Mio-Pliocene) are represented mostly by stratovolcanoes, dome-clusters and only minor and more local ignimbrites. Pliocene-Pleistocene and Holocene volcanoes (≤ 3 Ma) form the present volcanic chain of stratovolcanoes. Back-arc Neogene volcanic activity behind the main magmatic arc is limited to large faults, where rhyolitic ignimbrites to basaltic andesite flows have been erupted.

Fig. 1: Map showing the distribution of Neogene volcanoes and main Paleozoic and Mesozoic intrusion outcrops in their domain. Isotopic-map based on 834 $^{206}Pb/^{204}Pb$ ratios. White lines are the contours of the Wadati-Benioff zone with depth in kilometers.





CRUSTAL COMPOSITION VERSUS CRUSTAL THICKNESS AND BASEMENT AGE

Higher Sr/Y and Sm/Yb between Miocene and Pleistocene-Holocene volcanic rocks in domains 1-3 is mostly controlled by low Y and Yb in the younger rocks (< 6 Ma) caused by garnet in the residue of mafic lower crustal assimilation (e.g. granulites and amphibolites) and/or during high-P fractional crystallization after crustal thickening. Any involvement of slab melts to explain the "adakitic" signature is excluded. To the South in domains 4-5 Sr/Y and Sm/Yb are lower although crustal thickness is similar to domains 1-3. This difference may reflect the effect of more silicic crustal composition to the south and/or shallower crustal assimilation in thick crust. High Sr/Y and Sm/Yb ratios in a particular rock can thus not be simply taken as a proxy for thick crust as crustal compositions and depth of assimilation also must play a roll.

Nd-Sr-Pb isotopes and incompatible elements of rocks older than Miocene show limited evidence of crustal interaction not involving garnet, in accordance with a thin crust at these times.

The crustal contamination in Mio-Pliocene to Recent lavas (~11-0 Ma) increases to 20% after crustal thickening.

Regional differences exist in other trace element ratios as well. This supports the notion that the crust not only controls the isotopes composition of magmas but also their trace element patterns through variable mineralogies in a crustal residue during assimilation. Significant isotopic and trace element differences are also observed for rocks of the same age but at slightly different locations. Thus, caution needs to be applied when plotting any geochemical data vs. age for rocks from a wide regional distribution as local basement compositional control maybe more important than age in controlling their geochemical composition.

References

Bourdon, E., Eissen, J.P., Monzier, M., Robin, C., Martin, H., Hall, M.L., 2002. Adakite-like lavas from Antisana Volcano (Ecuador); evidence for slab melt metasomatism beneath the Northern Andean Zone. J. Petrol, v. 43-2, p. 199-217.

Davidson, J.P, McMillan, N. J., Moorbath, S., Wörner, G., Harmon, R.S., Lopez-Escobar, L., 1990. The Nevados de Payachata volcanic region (18°S/69°W, N. Chile) II. Evidence for widespread crustal involvement in Andean magmatism. Contributions to Mineralogy and Petrology, v. 105, p. 412-432.

Kay, S.M., Mpodozis C., Coira B., 1999. Neogene magmatismo, tectonism and mineral deposit of the Central Andes (22° to 33°S Latitude). In Skinner B.J. (ed) Geology and Ore Deposit of the Central Andes. Soc Econ Geol Spec Pub 7: 27-59.

Kay, S.M., Godoy, E., Kurtz, A., 2005. Episodic arc migration, crustal thickening, subduction erosion, and magmatismo in the south-central Andes. Geol. Society of America, v. 117, p. 67-88.

Stacey, J.S., and Kramers, J.D., 1975. Approximation of terrestrial lead isotope evolution by a two stages model. Earth Planetary Science Letters, v. 26, p. 207-221.

Stern, C.R., Killian R., 1996. Role of the subducted slab, mantle wedge and continental crust in the generation of adakites from the Andean Austral Volcanic Zone. Contrib. Mineral. Petrol., v. 123, p. 263-281.

Wörner, G., Hammerschmidt, K., Hemjes-Kunst, F., Lezaun, J., Wilke, H., 2000a. Geochronology (40 Ar-39Ar-, K-Ar-, and He-exposure-) ages of Cenozoic magmatic rocks from Northern Chile (18°-22°S). Implications for magmatismo and tectonic evolution of the central Andes. Rev. Geol. Chile 27, 205-240.