6th International Symposium on Andean Geodynamics (ISAG 2005, Barcelona), Extended Abstracts: 420-423

Tertiary to Recent evolution of Andean arc and backarc magmas between 36°s and 38°s and evidence for Miocene shallowing of the Nazca plate under the Neuquén basin

Suzanne Mahlburg Kay

INSTOC, Dept. Earth and Atmospheric Sci., Snee Hall, Cornell University, 14853, USA, smk16@conell.edu.

KEYWORDS: Andes, magmatism, shallow subduction, Neuquén Basin, Southern Volcanic Zone

Shallowing of segments of the subducting Nazca plate has been a common process along the Andean margin since at least the Oligocene. The best known shallow subduction zones are the nearly horizontal segments under the modern Chilean (Pampean) and Peruvian flatslab regions. Other transient shallow zones have been proposed in the Oligocene under the southern Altiplano (James and Sacks, 1999) and in the early to middle Miocene under the northern Puna (Kay et al., 1999). Here, another transient shallow segment is suggested based on the backarc magmatic and structural evolution of the Neuquén basin north of ~38°S and east of the Southern Volcanic Zone arc. Support for transient shallowing during the Miocene comes from the spatial and temporal distribution, chemical and isotopic characteristics, and structural setting of Paleogene to Holocene magmatic rocks between ~36°S to 38°S (Fig. 1). New $^{40}Ar/^{39}Ar$ ages, major and trace element chemical analyses (Fig. 2), and Sr, Nd and Pb isotopic ratios from this region are in Kay et al. (2006a and b) and Kay and Copeland (2006). The case for Miocene shallowing (Fig. 3) is reinforced by parallels with Miocene to Pliocene magmatic and deformational styles long correlated with shallowing of the Nazca plate under the modern Chilean flat slab from ~ 28° to 33°S (see Kay and Mpodozis, 2002).

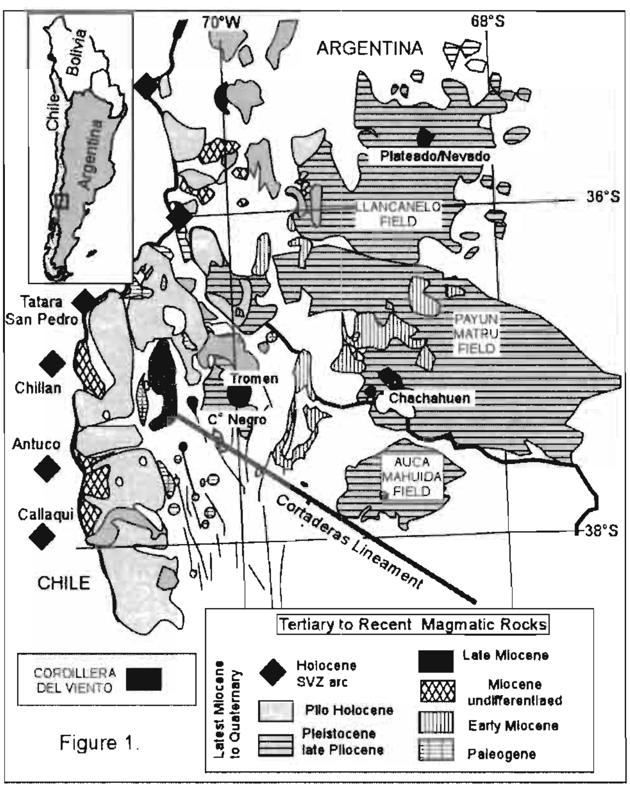


Figure 1.

Tertiary magmatism between 36°S and 38°S began with the eruption of Paleocene to Eocene magmas with strong arc chemical affinities in the near frontal arc region (Fig. 2a). In the mid-Eocene, the arc front moved some 15 km east (east of Cordillera del Viento; Fig. 1). These pre-Miocene magmas all intruded Mesozoic Neuquén basin strata affected by late Cretaceous contractional deformation. Importantly, none of the Cretaceous to early Tertiary magmatic or deformational events significantly affected the backarc region. The pre-Miocene history ended with a magmatic lull that lasted from ~ 40 to 26 Ma. Subsequently, magmatic activity reinitiated with ~26 to 20 Ma mafic to acidic volcanic rocks with arc chemistry erupting in the Cura Mallín intra-arc basin and ~24 to 20 Ma alkali olivine basalts with intraplate chemistry (Fig. 2b) erupting across the backarc. Evidence for any subduction components in the backarc basalts decreases from almost none (La/Ta < 15) to none (La/Ta < 11) as the distance to the modern trench increases to ~ 500 km. This picture changed after ~ 20 Ma when ~ 20 to 15 Ma basaltic andesite to dacitic magmas with weak arc signatures (La/Ta ~ 15 – 25, Fig. 2b) erupted in the mid backarc. The intensity of the arc signature strengthened in the ~ 11.7 Ma Cerro Negro andesites in the near

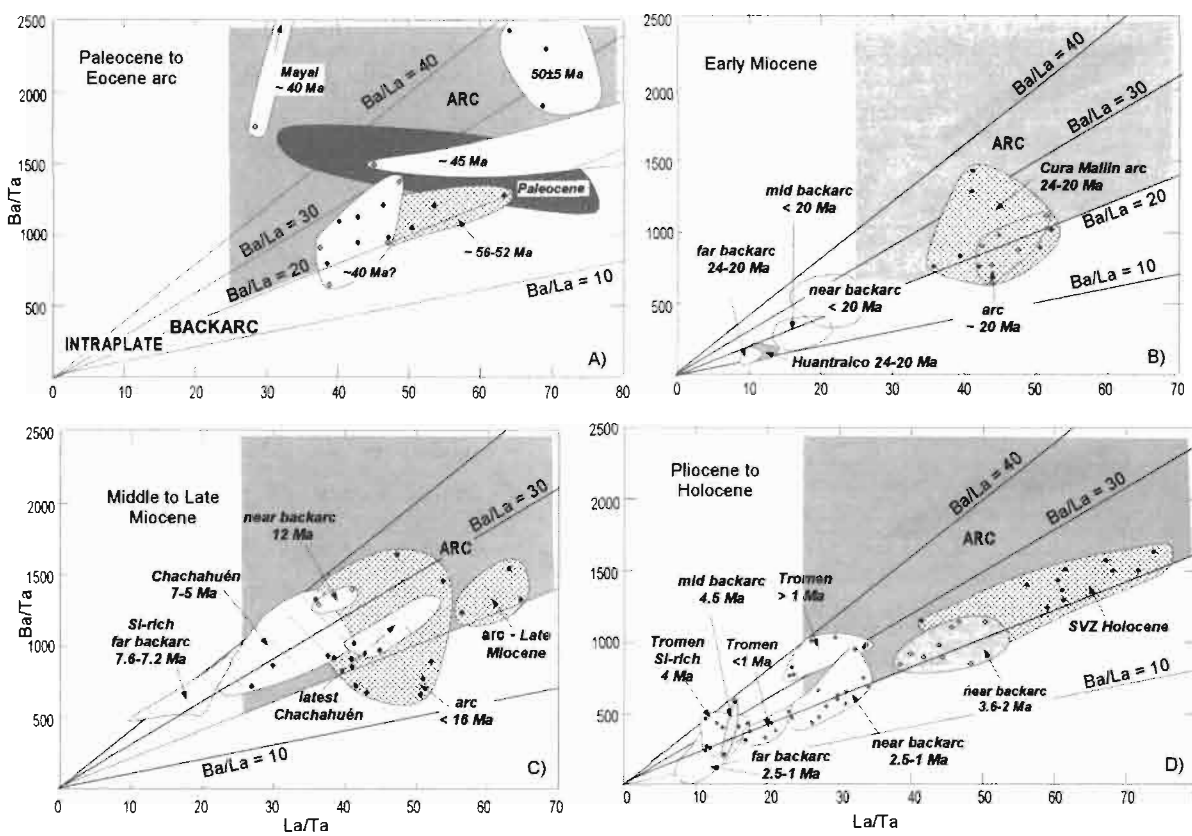
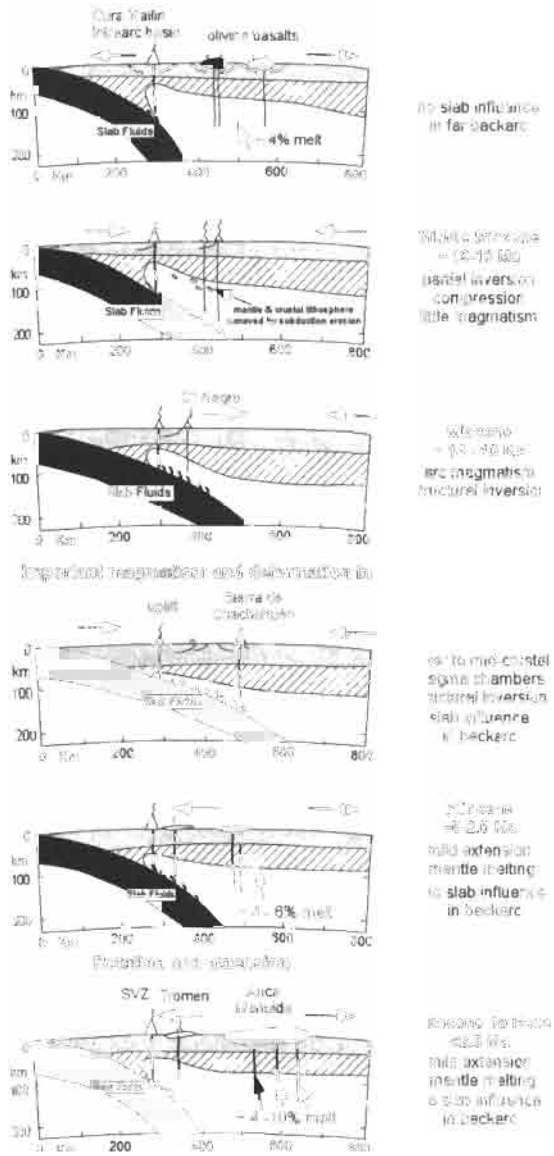


Figure 2. Ba/Ta versus La/Ta ratios for Neuquén basin magmatic rocks. Data sources in Kay et al. (2006b).

backarc and reached a peak in the ~ 7.6 to 4.8 Ma Chachahuén volcanic complex emplaced in the Sierra de Chachahuén, some 500 km east of the trench (Fig. 2c). The Chachahuén magmas erupted from a nested caldera complex that is notable for its high-K basaltic to rhyodacitic composition (49 – 68% SiO_2), domination by amphibole-bearing andesites and dacites, and arc-like chemistry that peaks in young mafic flows. Field evidence along with residual mineral assemblages calculated from REE and other trace element data in near backarc late Miocene to Pliocene andesites of the Tromen region (Fig. 1) are consistent with crustal thickening and uplift of basement blocks on inverted normal faults after 11 Ma and before 4 Ma. The Sierra de Chachahuén also experienced uplift in this period. The picture again changed dramatically in the middle Pliocene when the alkaline rocks that form the extensive far backarc Payún Matrú and Auca Mahuida (~ 1.9 to 0.9 Ma) volcanic fields (Fig. 1) began erupting. Their intraplate chemical signatures (La/Ta <15; Fig. 2d) differ from those of nearby early Miocene flows in showing an imprint of fluid mobile elements suggesting a residual subduction zone influence (Ba/La ratios up to 40; Fig. 2d). Pliocene to Holocene volcanic rocks associated with normal faults in the Tromen region to the west exhibit a pattern of decreasingly less arc-like affinities with the 0.175±0.025 Ma Cerro Tromen "escorial" andesite flow from Cerro Tromen being among the least arc-like.


olivine basalts
km
Slab Fluids
~4% melt
no slab influence
in far backarc
partial inversion
compression
little magmatism
mantle & crustal lithosphere
removed by subduction erosion
Slab Fluids
arc magmatism
Slab Fluids
magma chambers
slab influence
mild extension
mantle melting
no slab influence
in backarc
Slab Fluids
~4 - 6% melt
SVZ
Tromen
mild extension
mantle melting
in backarc

rocks erupted in the uplifted Sierra de Cordoba that is located ~ 700 km east of the trench over the Chilean flat-slab. Magmatic similarities with the Cerro Plateado/Nevado volcanic complexes (Bermudez, 1991) near 35°S (Fig. 1) are consistent with a transient period of shallow subduction under that region as well.

Two questions regarding shallowing events are the geographic limits of the Miocene shallow subduction zone under the Neuquén basin and its cause. With regard to the first, the northwest-trending Cortaderas lineament that projects into a transition zone in the SVZ (Fig. 1) is suggested to be the southern boundary as it marks the southern limit of Neogene backarc magmatism. The northern limit is more difficult to determine. Similarities in timing and character of Miocene magmatic and deformational events under the Neuquén basin and the Chilean flat-slab between 28°S and 33°S could indicate that shallowing in both regions was linked to a common cause. The two regions became distinct by the Pliocene as the Nazca plate reached its near present geometry under the Chilean flat-slab region, but steepened under the Neuquén basin. What is clear is that shallowing under the Neuquén basin cannot be explained by the popular model that links shallowing under the Chilean flatslab to subduction of the Juan Fernandez Ridge near 33°S (e.g., Yáñez et al. 2001). A possible explanation is that the common timing is a coincidence as a smaller segment of thickened oceanic crust subducted under the Neuquén basin could have produced less extreme shallowing of the Nazca plate at the same time. Nevertheless, subduction of thickened segments of oceanic crust could be local perturbations on a regionally shallowing subducting plate as the maximum shallowing under the Neuquén Basin and Chilean flat-slab coincide with major changes along much of the Andean margin (e.g., Kay et al. 1999) and beyond.

References

Bermúdez, A., 1991, Sierra del Nevada, el limite oriental del arco volcánico neógeno entre los 35°30'-36°00'S, Argentina, VI Congreso Geológico Chileno, p. 318-322.

James, D. E., and Sacks, S. I.., 1999, Cenozoic formation of the Central Andes: a geophysical perspective. In Skinner, B., ed., Geology and Ore Deposits of the Central Andes: Society of Economic Geology Spec. Pub. 7, p. 1-25.

Kay, S. M., and Copeland, P.C., 2006, Geochemistry and tectonic setting of early Miocene backarc magmas of the southern Andes between 36°S and 38°S: A story of slab retreat, advance and shallowing. In Kay, S. M., and Ramos, V.A., Tectonic and Magmatic Evolution of the Andean Margin and the Neuquén Basin (36-39°S), Geol. Soc. America Special Paper, in press.

Kay, S.M., Burns, W.M., Copeland, P.C., and Mancilla, O., 2006a, Late Cretaceous to Recent magmatism over the Neuquén basin: Evidence for transient shallowing of the subduction zone under the Neuquén Andes (36°S to 38°S latitude). In Kay, S.M. and Ramos, V.A., Geol. Soc. America Special Paper, in press.

Kay, S. M., Mancilla, O, and Copeland, P., 2006b, Evolution of the late Miocene Chachahuén volcanic complex over a shallow subduction zone in the southern Andean backarc near 37°S. In Kay, S.M. and Ramos, V.A.., Geol. Soc. America Special Paper, in press

Kay, S.M. and Mpodozis, C., 2002, Magmatism as a probe to the Neogene shallowing of the Nazca plate beneath the modern Chilean flatslab: Journal of South America Earth Sciences, v. 15, p. 39-58.

Kay, S. M., C. Mpodozis, and B. Coira, 1999, Magmatism, tectonism, and mineral deposits of the Central Andes (22°-33°S latitude. In Skinner, B., ed., Geology and Ore Deposits of the Central Andes: Society of Economic Geology Spec. Pub. 7, p. 27-59.

Yáñez, G.A., Ramiro, C., von Huene, R., and Diaz, J., 2001, Magnetic anomaly interpretation across the southern central Andes (32°-34°S): The role of the Juan Fernández Ridge in the late Tertiary evolution of the margin: Journal of Geophysical Research, v. 106, p. 6325-6345.