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New geochemical and geochronological data for the Atacazo-Ninahuilca volcanic complex (Ecuador)

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Introduction

Recent studies on the Quaternary Ecuadorian volcanic arc (EVA) reveal the occurrence of calc-alkaline and adakitic magmas (Monzier et al., 1997; Beate et al., 2001; Bourdon et al., 2002; Samaniego et al., 2002). A transition from older calc-alkaline edifices to younger mostly adakitic volcanoes, is also observed. However, geochronological data remain scarce. The aim of this work is to constrain the geochemical evolution observed in the Atacazo-Ninahuilca Volcanic Complex (ANVC), located in the volcanic front of the EVA.

Geological Setting

The ANVC is located in the Western Cordillera of Ecuador, 10 Km South-West of Quito. It is built over a Cretaceous assemblage of oceanic plateau basalts and ultramafic rocks belonging to the Pallatanga Terrane and sandstones and mudstones of the Yunguilla Formation (Hughes and Pilatasig, 2002). The Middle to late Eocene volcaniclastic rocks, calc-alkaline andesites and dacites of Tandapi beds and Silante Formation are also found in this area (Reynaud et al., 1999). The complex can be subdivided into an old edifice (Carcacha and Atacazo volcanoes), and a young edifice consisting in two groups of dacitic domes. The Atacazo volcano is the biggest of the complex; it suffered a destabilization event, which produced a caldera type depression (7 km long x 5 km wide x 400 m depth). The first group of post-collapse dacitic domes is located in the external part of this edifice, to the East (La Viudita and Omoturco) and to the North (Gallo Cantana). The second group grew inside the caldera depression (Arenal I and II, La Cocha and Ninahuilca Chico I and II) (Fig.1).

Geochronological data

Ages of 0.41 ± 0.05 and 0.32 ± 0.05 My BP have been obtained for the lavas of the Atacazo edifice (INECEL-OLADE, 1980). Our new $^{40}Ar/^{39}Ar$ geochronological data give a preliminary age of 1.5 Ma for the Carcacha edifice and 0.1 Ma for the most recent lavas of the Atacazo. Age determination for the base of Atacazo and for external domes is now under process. The intra caldera domes activity produced several plinian tephra-fall and pyroclastic flow deposits. Almeida (1996) reported 6 different tephra levels (N1 to N6). ^{14}C dating performed by INECEL-OLADE (1980) indicates that the last eruption took place 2370 ± 70 a BP.

Geochemical and mineralogical data

133 major and trace element whole-rock analyses of samples of lava flows, domes and pyroclastic deposits, have been carried out at the Université de Bretagne Occidentale. Analytical procedure is described in detail in Cotten et al. (1995).

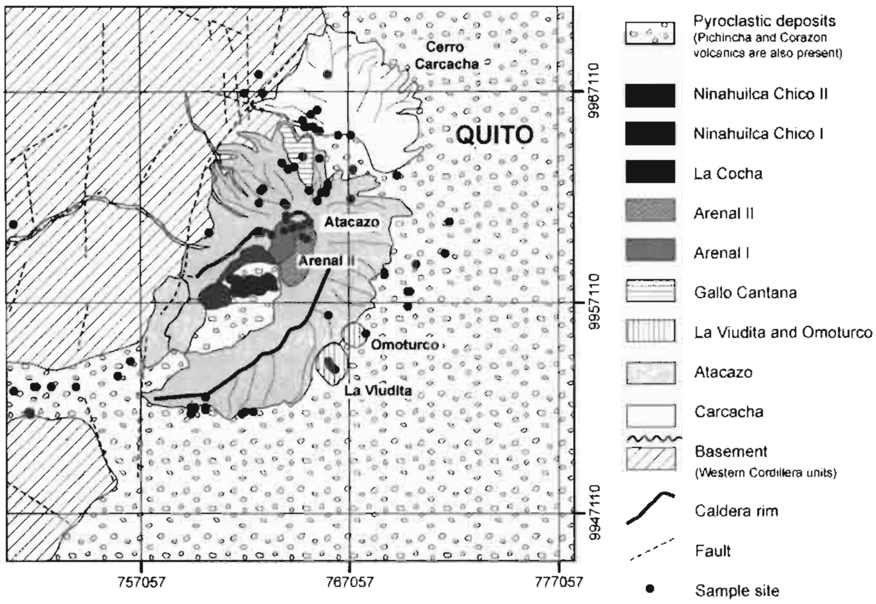

Fig.1 Schematic map of the geology of the Atacazo-Ninahuilca Volcanic Complex. UTM zone 17.

The older part of the complex (Carcacha and Atacazo) consists into two pyroxenes andesites, with subordinated amphibole. SiO_2 ranges between 57.28 and 62.30 wt% it is positively correlated with Na_2O and K_2O and negatively correlated with MgO, CaO, TiO_2 and FeO (Fig. 2). All data plot on a single differentiation trend. By contrast, La Viudita and Gallo Cantana domes consist in very homogeneous high - SiO_2 dacites (66.18 to 67.04 SiO_2 wt%) such that they do not draw any differentiation trend (Fig. 2). They are made up of pl+amph+opx+mag.

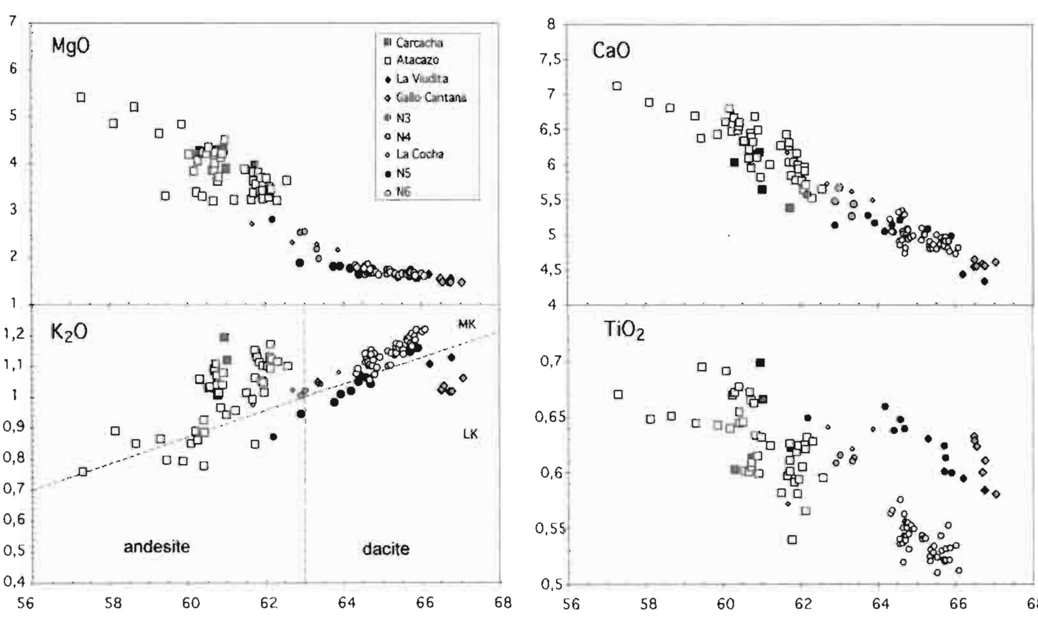

Fig. 2 Harker diagrams for Atacazo-Ninahuilca complex rocks. Classification after Peccerillo and Taylor (1976) is shown in K2O vs SiO2 diagram. LK= low postassium, HK= high potassium.

The N5 (62.88 – 65.88 SiO_2 wt%) and N6 (64.30 – 66.07 SiO_2 wt%) levels consist in pl+amph+opx+mag±bio dacites (N5 can also contain ilmenite) (Fig.2). N5 and N6 events are easily discriminated by their trace element contents, N5 being strongly TiO_2- Eu-, Nd- and Ce-richer than N6. In Harker diagrams, in both series, only Al_2O_3 and TiO_2 are negatively and K_2O positively correlated with SiO_2 (Fig. 2).

N1 to N4 levels have chemical characteristics intermediate between the Carcacha-Atacazo and the N5 and N6 products. They are pl+amph+opx+mag bearing andesites and dacites (61.97 – 63.87 SiO_2 wt%).

Transition elements, such as Sc, V, Cr and Ni present a negative correlation with SiO_2 for Carcacha-Atacazo rocks, while they do not display any change in the domes. Incompatible elements such as Rb and Ba show positive correlations whereas Sr remains constant (>400 ppm) in N5, N6 and in the external domes. Nb, La, Ce, Nd and Sm behave similarly except a small dispersion for Carcacha-Atacazo rocks (diagrams are not shown). The N-MORB normalized (Sun and McDonough, 1989) multi-element diagrams show that patterns are identical for all elements except for HREE where two groups are clearly discriminated: the old lavas are HREE-rich whereas the younger ones (external domes, N5 and N6) are HREE-poor (Fig.3).

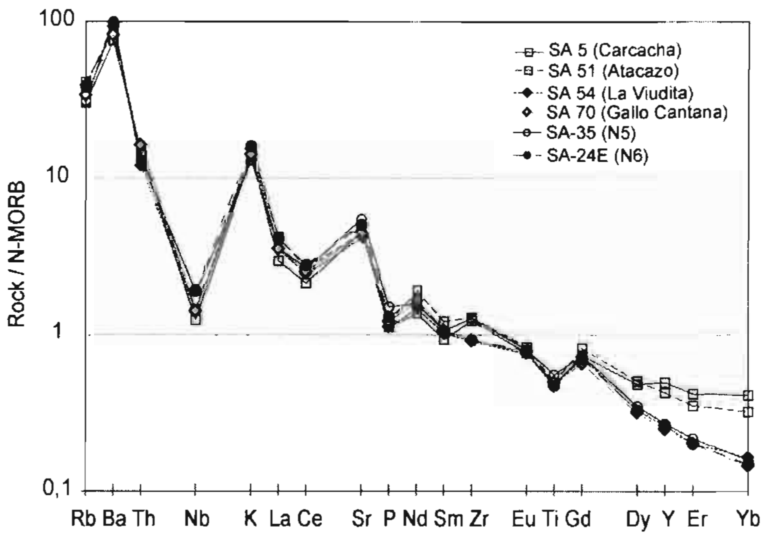

Fig. 3 Spider diagram for selected samples from different series of the Atacazo-Ninahuilca volcanic complex. Normalization to N-MORB from Sun and McDonough (1989).

Conclusions

The Carcacha -Atacazo rocks show almost classic calk-alcaline geochemical characteristics, while the external domes and N5 and N6 products well reproduce the high-SiO_2 adakites (HAS) characteristics (Martin et al., 2005) (ie. high Na_2O, Sr and low HREE and Y; Fig. 3). This temporal change in magmas chemistry (from classical calc alkaline to adakitic) has already been reported for several other volcanoes in the Ecuadorian arc (Cayambe: Samaniego et al., 2002; Iliniza: Hidalgo, 2002, see also Andrade et al., this volume). Following these authors, we propose that this recurrent change may be linked to important geodynamic modification of the thermal state and geometry of the subducted slab. This change could be related to the entry of the Carnegie ridge into subduction and to its presence today below the volcanic arc (Gustcher et al., 2000; Samaniego et al., 2002). ANVC geochronological data, associated with other detailed studies in Pichincha, Cayambe and other volcanic complexes will allow us to constraint the time of such a transition in each part of the arc.

Further studies are carried out in order to better constrain the sources of the Atacazo-Ninahuilca magmas and their evolution.

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