SECOND PARTIAL MELTING STAGE OF A SLAB-MELT METASOMATIZED MANTLE AT SUMACO VOLCANO (NORTHERN VOLCANIC ZONE, ECUADOR)

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INTRODUCTION

Sumaco is one of the less known volcanoes of Ecuador, partially because of its remoteness as it is the only recent volcano located in the amazonian forest of the NVZ. However, it has been known for a while that most of its products are understaturated alkaline lavas, with frequently more then 15% of normative nepheline and normative apatite (Colony & Sinclair, 1928). The aim of this contribution is to present the first results obtained on this isolated and peculiar volcano after a recent survey (january 2001) in order better to constrain the petrogenetic process active in the geodynamic setting of Ecuador.

LOCATION AND MORPHOLOGY OF SUMACO VOLCANO

Located some 90 km ESE of Quito, Sumaco volcano rises above the rain forest of the Amazonian province of Ecuador on the eastern foothills of the andean chain. It is the volcano situated the farest from the trench of all the NVZ, in rear-arc position (Fig. 1). It is at the latitude of Sumaco the the width of the NVZ arc reachs its maximum, with more then 100 km. Sumaco exibits a regular cone well preserved morphology, suggesting that it may have experienced recent volcanic activity. At least one major avalanche event disected its northeast flank and its semi-circular scar is still visible in the topography. The summit cone build inside the avalanche scar, is mainly constituted by scorias intercalated with massive lava flows.

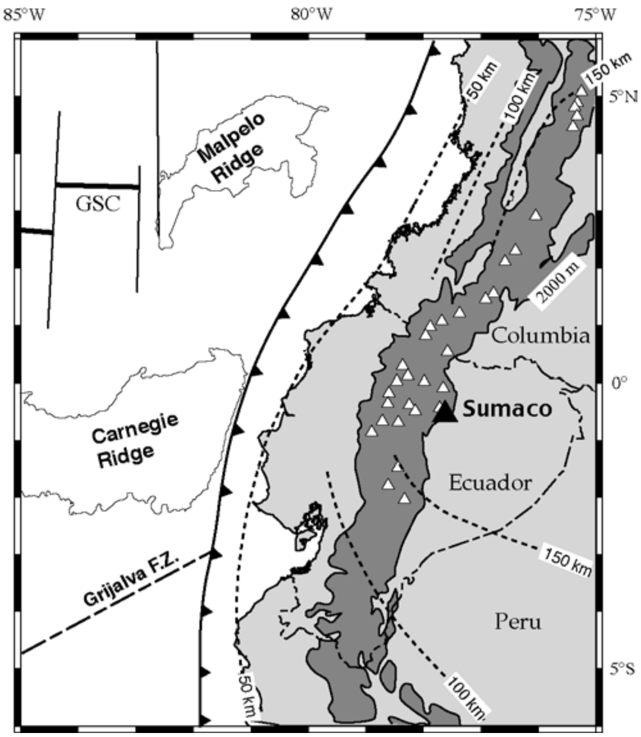

Figure 1 :
Map of the northwestern part of South America including main oceanic features, as well as the inferred position of the subducted slab beneath Colombia and Ecuador.
Depth contours to the Wadati-Benioff zone indicated as dotted lines (from Gutscher et al., 1999).
Andes Cordillera defined by 2000 m contour.
Trench is defined by toothed line.
Active volcanoes are designed by open triangles.
GSC: Galápagos Spreading Center.

PETROLOGY AND GEOCHEMISTRY OF SUMACO LAVAS

The mineralogical composition of the rocks of Sumaco volcano includes clinopyroxene, abundant hauyne and apatite, Fe-Ti oxides, ± amphibole, ± plagioclase, ± olivine in accordance with a first studies (Colony & Sinclair, 1928; Barragan *et al.,* 1998; Bourdon, 1999). Some lavas exibit a high countain of felsdpathoid in absence of plagioclase, corresponding to the initial definition of absarokite (Iddings, 1895).

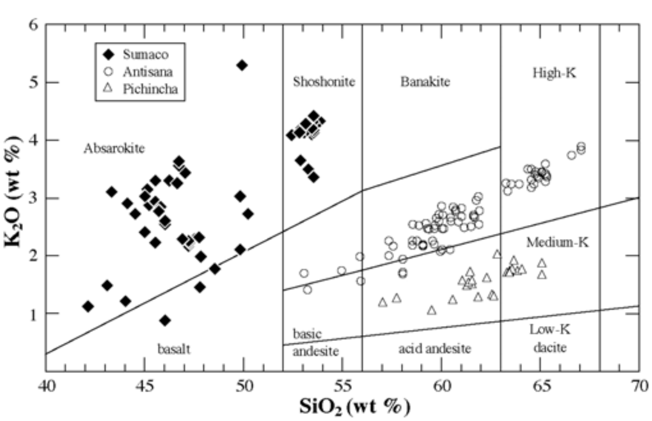

Figure 2 : K_2O versus SiO_2 classification diagram for orogenic magmas, modified from Peccerillo & Taylor (1976) showing Pichincha (triangles), Antisana (circles) and Sumaco (diamonds) lavas.

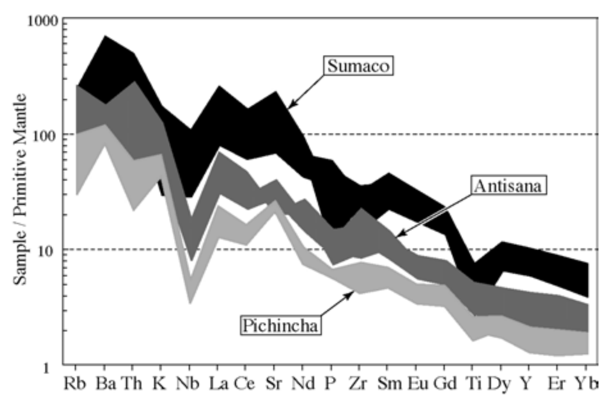

Figure 3 : Extended trace elements patterns of rocks from Pichincha, Antisana and Sumaco volcanoes. Normalization to the primitive mantle (normalization values from Sun & McDonough, 1989).

Geochemically, they are constituted by K-rich ($0.9 < K_2O\% < 5.3$) undersaturated lavas ranging in composition from basic absarokite to shoshonite ($44 < SiO_2\% <5\ 4$; Fig. 2) with high concentrations in all incompatible elements (Fig. 3). They also present a strong enrichment of LREE over HREE (La/Yb = 28-50), unless these later are significantly enriched (*e.g.* Yb = 2.02-3.9 ppm) compared to other rocks from the NVZ in Ecuador. On primitive mantle-normalized trace element patterns, a significant positive anomaly in Sr is observed (Fig. 3). But the most remarkable feature of these lavas is their strong enrichment in Nb (21-79 ppm): therefore, these lavas can be designated as high-niobium basalts (HNB ; Defand *et al.*, 1992). Isotopicaly, these lavas show unradiogenic characteristics with Sr ($^{87}Sr/^{86}Sr \approx 0.7042$), Nd ($^{143}Nd/^{144}Nd > 0.512880$) and Pb isotope data that are virtually the same than those from the adakites from the Western Cordillera (Bourdon, 1999; Bourdon *et al.*, 2002).

DISCUSSION : GEODYNAMIC IMPLICATIONS

The geochemical characteristics of Sumaco absarokites are close to those of HNB found in others arc settings in association with adakites (Saunders *et al.*, 1987; Defand *et al.*, 1992). The close association HNB-adakites has suggested to many authors that HNB could be the partial melting product of a mantle metasomatised by slab melts (Defand *et al.*, 1992). Indeed, slab melts are likely to transport Nb in the mantle, unlike hydrous fluids (Kesson & Ringwood, 1989).

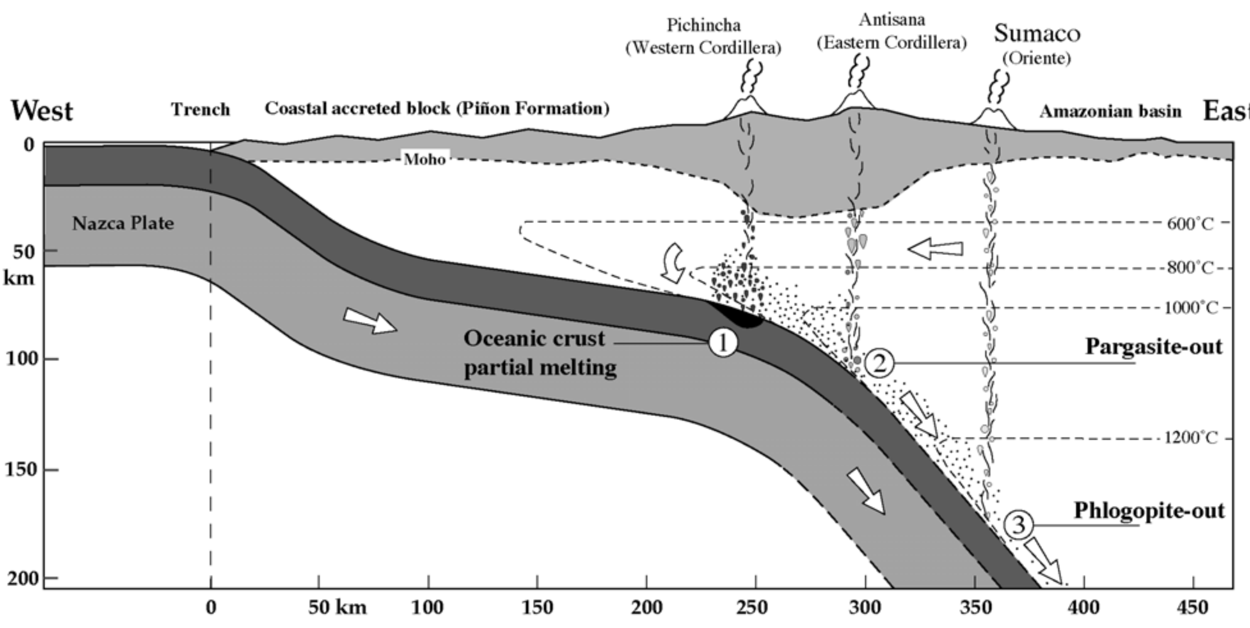

Figure 4: Schematic petrogenetic model in three steps for the NVZ in Ecuador, see the last paragraph (from Bourdon *et al.*, 2002).

Furthermore, Tatsumi & Koyaguchi (1989) experimentally showed that an absarokite with geochemical characteristics close to the most basic basalts of Sumaco was in equilibrium with a phlogopite-rich peridotitic mantle, suggesting that the source of this type of magma is likely to be a metasomatised mantle with significant amounts of phlogopite. Other studies on HNB related to adakites have shown that their low HREE concentrations could be related to a genesis in a garnet-rich mantle, resulting of a metasomatism by slab melts (Defand *et al.*, 1992). But unlike most HNB, Sumaco basalts display no strong HREE depletions, suggesting that garnet is no longer present in the source. They could, however, be produced by the destabilization of phlogopite (Tatsumi & Koyaguchi, 1989).

But could Sumaco lavas be related to an intracontinental hotspot or an old enriched mantle and not to subduction processes ? In the absence of extensional structures in the eastern Andean foothills, the lavas from the Sumaco cannot be related to the partial melting of an adiabatically uplifted mantle. Moreover, the Nb anomalies of the Sumaco lavas are a clear imprint of a "subduction component". Lastly, the exact "match" between the isotopic signature of magma types from the arc front and the Sumaco is an irrefutable proof that their genesis are closely related to one another and thus to the subduction processes (Bourdon *et al.,* 2002).

In our schematic petrogenetic model in three steps (Fig. 4), the magmas of the fore-arc ([1] *e.g.* Pichicnha volcano) are mainly alimented today by adakitic magmas resulting from the direct partial fudion of the oceanic slab, but the adakitic melts are also metasomatising the mantle wedge. Therefore, below the Eastern Cordillera ([2] *e.g.* Antisana volcano), the melts are mainly pseudo-adakites producted by the partial fusion of these metasomatised peridotites. And finally in rear-arc positon, ([3] *e.g.* Sumaco volcano), the melts result a deeper, second partial fusion stage at a much lower fusion rate.

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