GEOCHEMISTRY AND TECTONICS AT THE SOUTHERN TERMINATION OF THE NORTHERN VOLCANIC ZONE (RIOBAMBA VOLCANOES, ECUADOR); PRELIMINARY RESULTS

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INTRODUCTION:

The Riobamba volcanoes constitute the southern termination of the NVZ. To the south, active volcanism is absent along a 1600 km long segment of the Andes (Fig. 1A-B). This work presents preliminary geochemical data for these volcanoes and relates them to an unusual underlying slab and the complex seismo-tectonics of the continental crust in the area.

SEISMOTECTONICS:

In the Riobamba area, the main Ecuadorian arc becomes frontal and Sangay volcano lies unusually eastward (Fig. 1C). Contrary to southern Colombia and Ecuador, beneath which intermediate depth seismicity is almost absent, a strongly seismogenic slablet dipping • 35° towards N58°E is present under the Sangay area at • 130 km beneath the volcano (Fig. 1D). The N58°E boundary between this slablet to the south and the weakly seismogenic slab to the north reflects a sharp change in the thermal characteristics of the subducted oceanic crust, and corresponds to a tear running from the Grijalva Fracture Zone (GFZ; Fig. 1B), that separates the young (<24 My) crust subducted under Colombia and Ecuador, from older crust (>32 My) beneath southern Ecuador and northern Peru (Monzier et al., 1999). To the south, another N58°E boundary probably separates this slablet from the shallow dipping slab which is typical of southern Ecuador and northern Peru. Due to the convergence motion between the Nazca and South America plates (• 8.0 cm/y in a direction • N80°E; De Mets et al., 1990), the N58°E tear in the slab slowly sweeps the area. Calculations show that this tear was under the Chimborazo-Puñalica area • 1.35 My BP and under the Calpi-Tungurahua area • 0.7 My BP; it is presently under Tulabug-El Altar volcanoes and will be under Sangay in • 1.16 My (Fig. 1D). These calculations neglect, among other factors, the dextral strike-slip motion between the North Andean Block and the rest of South America. The southern termination of the NVZ -which is oriented • N148°E in contrast with the usual N30°E orientation of the Ecuadorian arc- is exactly perpendicular to the N58°E dipping Sangay slablet. Thus, to a large extent, the volcanic history of the termination has been controlled by the southeastward migration of this narrow piece of old oceanic crust, bounded to the North by the GFZ but also cut by numerous secondary fracture zones parallel to the GFZ.

RIOBAMBA VOLCANOES:

Plio-Quaternary volcanoes are located on the edges or in the middle of the Riobamba pull-apart basin (a segment of the Interandean Valley), with the exception of El Altar and Sangay, which are clearly located in the Eastern Cordillera of Ecuador (Fig. 2A-B). In addition to the old and eroded Igualata and Huisla edifices, four major Pleistocene volcanoes developed in the area, as well as several smaller volcanic cones. The Chimborazo complex formed first by effusive eruptions (acid andesites), then by explosive activity (dacite-rhyolite); some 35,000 y BP, this volcano experienced cone collapse and a large-scale debris avalanche. Post-collapse activity ended with eruptions of basic andesites before 11,000 y BP (Clapperton, 1990; Kilian et al., 1995). The Tungurahua complex is composed of three successive volcanic edifices, the first two of which were partially destroyed by sector collapse. The last collapse event occurred • 3,000 years ago, preceding the construction of the present cone, which is dominated by basic andesites (Hall et al., 1999). Over the past 500,000 y, the Sangay volcanic complex also has had three successive andesitic edifices. The two former cones have been largely destroyed by sector collapses. The present edifice is active at least since 14,000 y BP (Monzier et al., 1999). Finally, El Altar volcano consists of subglacial andesite breccias, with the remnants of a shallow (< 3 km) magma chamber, including a large rhyolitic body and a subordinate diorite body. Its development ended with the cataclysmic evisceration of this chamber (probably accompanied by sector collapse) that resulted in caldera formation; subsequent glacial erosion has deeply eroded the edifice (Monzier et al., in prep.). Other volcanic centers of the Riobamba area include the small cones of Calpi and Tulabug. For all the Riobamba edifices, extensive geochemical sampling is currently done or in progress.

CHARACTERISTICS OF RIOBAMBA VOLCANICS AND DISCUSSION:

A striking feature of the Riobamba volcanics is that basic rocks are more abundant here than in the rest of the NVZ (Fig. 2C). This may be explained by the fact that most of the these volcanoes are associated with a large pull-apart basin, bounded by major N22°E strike-slip faults oblique to the regional N-S orientation of the Cordillera, and profusely cut by transverse faults. Such a faulted crustal structure provides pathways for rising magmas and thus limits the effect of upper crustal fractionation processes. Except for this feature, Riobamba volcanics are not significantly different from other NVZ arc rocks, showing the usual enrichment in incompatible elements as the distance to the trench increases. All share similarly low Y and HREE contents (Fig. 2D). However, Riobamba volcanics dont show the marked decrease in Y and Zr (Fig. 2E) frequently observed for differentiated rocks from the rest of the arc, and certainly caused by upper crustal amphibole fractionation. By contrast, and except for the most evolved compositions, Y contents remain almost constant and Zr clearly acts as an incompatible element in Riobamba volcanics. For the Sangay suite, the low concentration in Y, as well as the presence of Sr-rich andesites, can be explained by AFC processes occuring at the base of a 50 km-thick crust, where basaltic melts pond and assimilate remelts of previously underplated, compositionally similar basaltic material (Monzier et al., 1999). Similar AFC processes probably affect other magmas of the southern termination, as indicated, for example, by samples from Tulabug, that comprise basalts (53% SiO_2 & 725 ppm Sr) associated with Sr-rich andesites (58% SiO_2 & 1000 ppm Sr, but not plagioclase cumulative). Furthermore, partial melting of altered Cretaceous MORB, tectonically accreted to the lower crust, was proposed by Kilian et al. (1995) to explain the genesis of some Sr-rich andesites from the Chimborazo complex. Thus, AFC processes seem to be active at the base of the crust beneath most Riobamba volcanoes. Work is currently being done to constrain these processes and better understand the magmatic evolution of the whole area.

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