PETROGRAPHIC AND GEOCHEMICAL STUDIES OF THE SOUTHWESTERN COLOMBIAN VOLCANOES

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RESUME:
Les volcans actifs plio-quaternaires du sud-ouest de la Colombie sont situés dans la Zone Volcanique Nord (NVZ) des Andes. Ils appartiennent tous à la série calcoalcaline moyennement potassique typique des marges continentales actives. Les laves sont principalement des andésites et des dacites avec des teneurs en silice variant de 53% à 70%. Les analyses pétrographiques et géochimiques montrent que les phénomènes de cristallisation fractionnée, de mélange de magma et de contamination crustale sont impliqués à divers degrés dans la génèse des laves des volcans colombiens.

KEY WORDS: Volcanology, geochemistry, geochronology, Neogene, Colombia.

INTRODUCTION:

This publication is a comparative of petrographical, geochemical and geochronological analysis of six quaternary volcanoes of the Northern Volcanic Zone of southwestern Colombia (0-3°N): Puracé, Doña Juana, Galeras, Azufral, Cumbal and Chiles. The Colombian volcanic arc is the less studied volcanic zone of the Andes despite the fact that some of the volcanoes, which lie in it, are ones of the most actives in the Andes, i.e. Nevado del Ruiz, Puracé and Galeras.

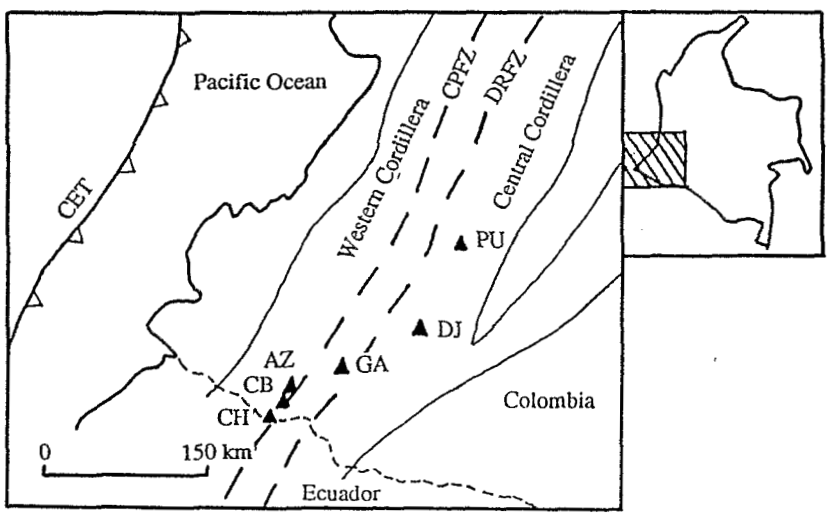

Figure 1: Location map of the studied area. Solid triangles indicate the active volcanoes. PU: Puracé; DJ: Doña Juana; GA: Galeras; AZ :Azufral; CB: Cumbal; CH: Chiles; CPFZ: Cauca-Patía Fault Zone; DRFZ: Dolores-Romeral Fault Zone; CET: Colombia-Ecuador Trench.

GEOLOGICAL SETTING:

The main line of active volcanoes of Colombia strike NNE. It lies about 300 Km east of the Colombia-Ecuador Trench, the underthrusting of the Nazca plate beneath South America. The recent volcanoes are located 150 Km above a Benioff Zone which dips eastward at 25°-30°, as defined by the work of Barazangi and Isacks (1976). The crust is 40 Km in thickness and is younger than Mesozoic in age and it includes a large oceanic component (ocean floor) west of the Dolores-Romeral mega-shear zone in the Western Cordillera of Colombia (Marriner and Millward; 1984). East of this fault zone, in the Central and Eastern cordilleras, the crust is predominantly of pre-Cretaceous igneous and metamorphic rocks type. The Late Pliocene-Holocene volcanoes from the Central and Western cordilleras are situated either on the Cauca-Patía or on the Dolores-Romeral fault systems which represent the main active fault zones of the area. Both systems are sub-parallel, oriented NE-SW, and run over more than 800 Km through Ecuador and Colombia. The volcanoes belong to the medium-potassic calcalkaline serie typical of active continental margins. The lavas are predominantly andesites to dacites with lesser amount of basalts and rhyolites, and range from 53% to 70% SiO2. The andesitic lavas are highly porphyritic with phenocrysts content as high as 25-30%. The groundmass texture is microlitic-intergranular to hyalopilitic in the more siliceous rocks. Phenocrysts include plagioclase, clinopyroxene and orthopyroxene found as groundmass as well. The basalts and basaltic andesites are less porphyritic than the acidic andesites and usually show a well preserved flow structure. The olivine is rare and partially to completely altered or replaced by iddingsite/serpentinite.

CONCLUSIONS:

The nature and the age of the downgoing oceanic plate, the geometry of subduction and the thickness of the continental crust remain nearly constant in the segment studied (Cauca Segment; Pennington, 1981). In contrast, the chemical composition of the continental crust vary greatly from west to east reflecting the chemical variation of the lavas along the same direction.

The petrographic desequilibrium assemblages and the coexistence of normal and reverse zoning in the phenocrysts of plagioclases and pyroxenes, within a single sample, suggest that fractional crystallization surimposed by various stages of magma mixing has occured in the magmatic sequences of each volcano with important differences among them. For the Puracé, the northernmost studied volcano, the K-group elements (K, Ba, Rb, Sr) silica-normallized values are higher than those for the southernmost volcanoes. Rb content decrease twofold from the Puracé (north) to the Cumbal (south), instead the distance to the Trench and the Benioff zone top remain constant. It is important to note that the Puracé shows the lowest K/Rb normallized ratio (near the bulk crust value) and the highest K (fig. 2) and Rb content which is undoubtly due to a high sialic crustal contribution (Hildreth and Moorbath, 1988). Although, the high variability of alkalies and Ba content within nearby southern volcanoes (20-30 Km interval) could also reflect heterogeneous continental crust composition related to the wide zone affected by the tectonic mélange due to both the Cauca-Patía and the Dolores-Romeral fault zones. The Puracé, located 30 Km east of the latter, lie above a quiet homogeneous metamorphic crust.

This northward increase of K-group elements of the calcalkaline lavas is therefore attributed to the High contribution of the siliceous "old crust" (pre-Mesozoic) in the north of the studied area, compared to the younger oceanic basement of the southernmost volcanoes.

The REE patterns show strong relative enrichment in the LREE (fig. 3) and have a high normallized Ce/Yb ratio for the Puracé and Doña Juana volcanoes which are located on the "siliceous" metamorphic crust of the Central Cordillera. The HREE content of mafic to intermediate lavas is nearly constant for all volcanoes, what is expected for calcalkaline suites in active continental margin environment (Gill, 1981).

According to the geochemical data, it can be concluded that the contribution of crustal material is more important in the magmatic processes on the volcanoes located above the sialic crust of the Central Cordillera than those situated above the oceanic crust of the Western Cordillera, west of the Dolores-Romeral fault zone.

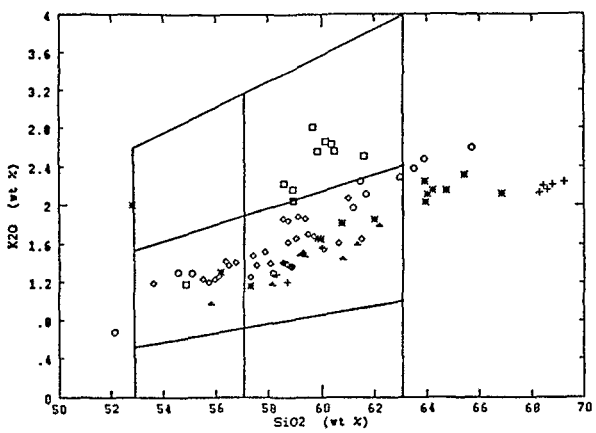

Figure 2: K2O content vs SiO2 of the active southwestern Colombian volcanoes (modified from Gill, 1981).

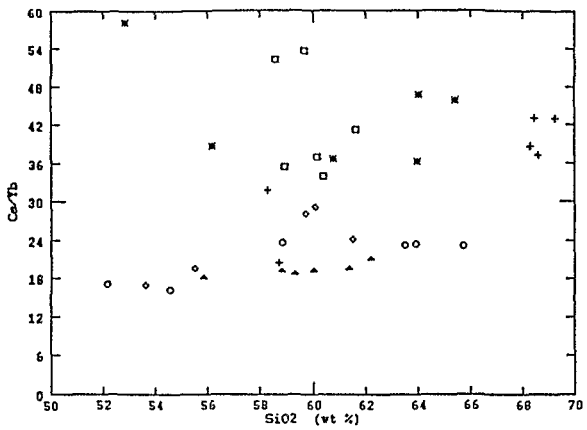

Figure 3: Ce/Yb ratio vs SiO2.

Symbols:
square: Puracé; star: Doña Juana; diamond: Galeras; cross: Azufral; triangle: Cumbal; circle: Chiles.

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