GEOCHEMICAL CHARACTERISTICS OF THE CRETACEOUS BASEMENT OF WESTERN ECUADOR

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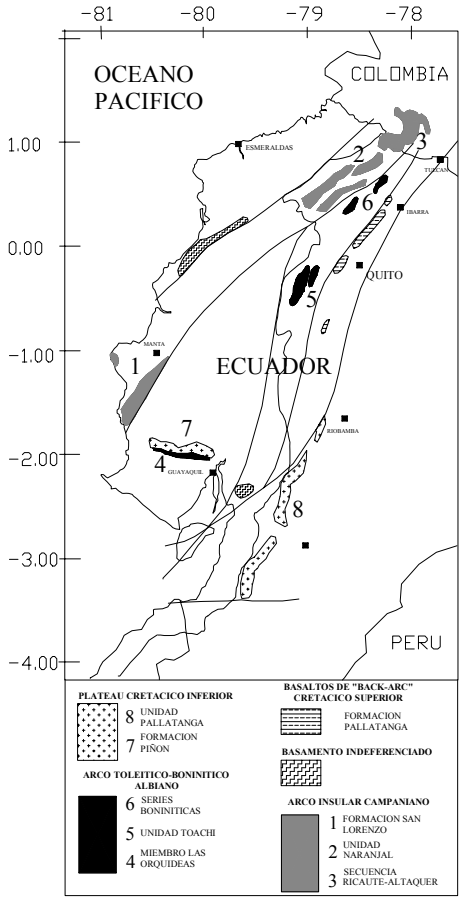


Fig. 1 *Location map of ambient in the basement of Western Ecuador*

INTRODUCTION

The basement of the Western Cordillera and the Coastal plain from the Gulf of Guayaquil toward the north are considered constituted by terrains originated in different oceanic scenarios and accreted to the continent. This work considers the studies and chemical analysis made on rocks of the Cretaceous basement, referred in different publications since 1987, and interpreted in a new geodynamic context based on the new published cartography of those regions of the Ecuador (10). We conclude with the existence of an old plateau of the Lower Cretaceous, an Albian boninitic-toleithic arc, a pre-Campanian back-arc basin and a Campanian mature insular arc (Fig. 1).

GEOLOGICAL SETTING

The simplest interpretation of the Cretaceous basement considered the Piñón Formation on the Coastal plain with its equivalent one within the Western Cordillera (8).

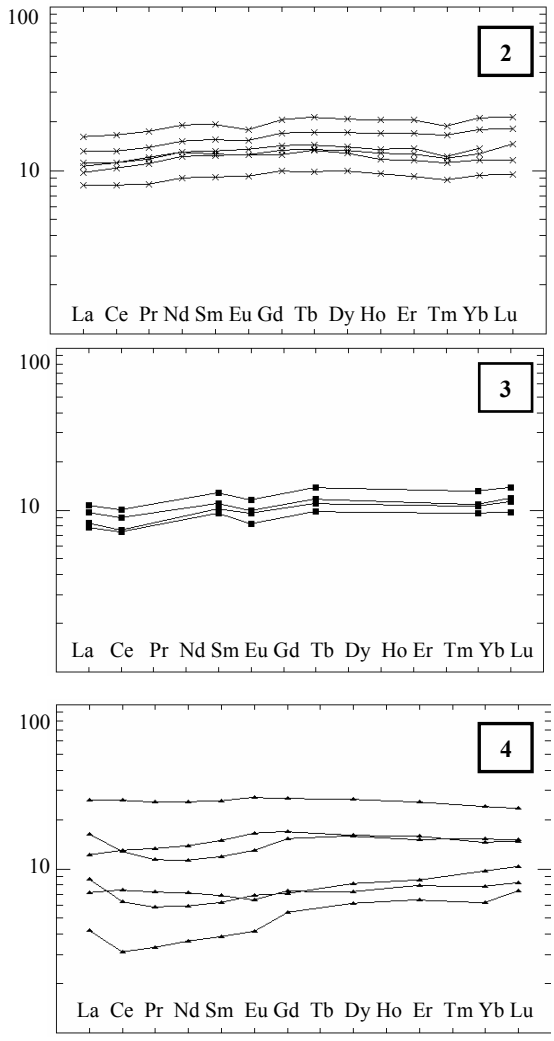
The present knowledge indicates that the coastal basement is constituted by the Piñón Formation (FP) of the Lower Cretaceous showing characteristics of oceanic plateau (11), by the Las Orquídeas Member (MLO) (11), corresponding to an Upper Albian to pre-Turonian Island Arc, and by the San Lorenzo Formation (FSL) dated 85-65 Ma (7) with the same affinities. The Cretaceous basement of the Western Cordillera (COE) is considered formed by the Pallatanga Unit (UP) (2) generated in a probable oceanic plateau environment and correlated with the Diabasic Group from Colombia (GDC), by the Toachi Unit attributed to an pre-Turonian insular arc (3) and by the Naranjal Unit (UN) of the Late Campanian (2). Thick volcano-sedimentary turbiditic sequences of the Campanian-Turonian age are known in the Western Cordillera and the Central Northern Coast (2). The accretion age for those oceanic terrains remains uncertain, however two events

have been accepted, a former Santonian to Later Campanian accretion of the UP, and a late Eocene to Oligocene event, involving the FP and the Macuchi Unit. Nevertheless, another important tectonic event is suggested during the Late Paleocene to Early Eocene, correlated with the FP and MLO collision (6).

The process under similar criteria of the geochemical data included in the published works, allows a new characterization and a coherent structural distribution for the recognized oceanic terrains during Cretaceous times.

OCEANIC PLATEAU PIÑÓN (FP) AND PALLATANGA SOUTH (UPS) (Lower Cretaceous)

The rocks of the UP are considered similar in age and geological environment to those of the FP (2, 7). The age of FP is Lower Cretaceous (11), while the age of the UP is not clearly defined, because toward the north a Santonian- Early Campanian age is reported (2) whereas in the southern part an age range from Middle Jurassic? to Early Cretaceous is suggested (9). Also, the geochemical data show differences between the UP outcropping in the Northern Western Cordillera in front of the southern portion of this.



Chondrite- normalized REE abundances for::
***Fig. 2** Piñón Formation (Data from Reynaud et al., 1996)*
***Fig. 3 P**allatanga Unit, south part (Data from Lebrat, 1987)*
***Fig. 4** Pallatanga Unit, north part*
(Data from Boland et al., 2000)

The rocks of the UPS, FP and GDC are similar in the following features: all samples are plotted in the field of sub-alkaline basalt using the discriminatory diagram of Zr/TiO_2 vs. Nb/Y; models of REE sub parallel ($0.8 < (La/Yb)N < 1.4$) (Figs. 2, 3); models of REE show intermediate characteristics between N-MORB and OIB; samples show abnormal Eu, reflecting plagioclase removal or accumulation; and high Nb values, comparable to those of GDC ($4 < Nb < 9$), differentiating them of rocks originated by subduction. In the diagram La-Nb, most of samples belong to the E-MORB (OIB) field, with some of them in the limit of N-MORB (Fig. 5).

Thus, it is possible that FP and UPS have been originated in a "Hot Spot" older than the plateau involving GDC within the Caribbean domain.

BACK-ARC BASIN PALLATANGA NORTH (UPN) (Pre-Campanian)

The UP of north central Ecuador shows geochemical characteristics different than the previous rocks. The samples plot in the field of basaltic andesites. The values of Nb ($1 < Nb < 8$) show a larger range than the FP, the UPS and the GDC, the values of some samples being similar to rocks of an arc. An uncommon Ce anomaly, is similar to that found in rocks of the "back-arc" of the northern Mariana Trough of the Western Pacific Ocean, where the expansion area is close to the volcanic arc (4).

The UPN also present a wide range of geochemical signatures, showing characteristic of rocks N-MORB in their majority, with two samples with characteristics of T- MORB and orogenic lavas (Figs. 4, 5). In the graphic La/Nb it is observed that the rocks of UP of the part center north form a different group, having bigger affinite with rocks N-MORB (Fig. 5).

Associated to these rocks are thick volcano-sedimentary turbiditic sequences of the Pilatón Unit (COE), the Cayo Formation (Coast) and the Natividad Unit (COE), of Turoniano-Maastrichtiano age (2) and that they could represent the filling of a " back-arc " basin.

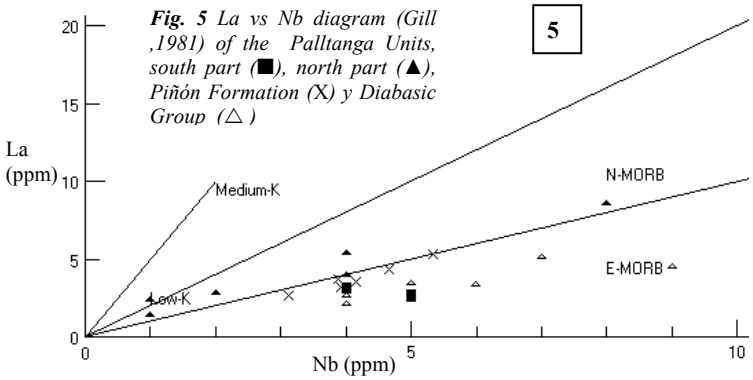
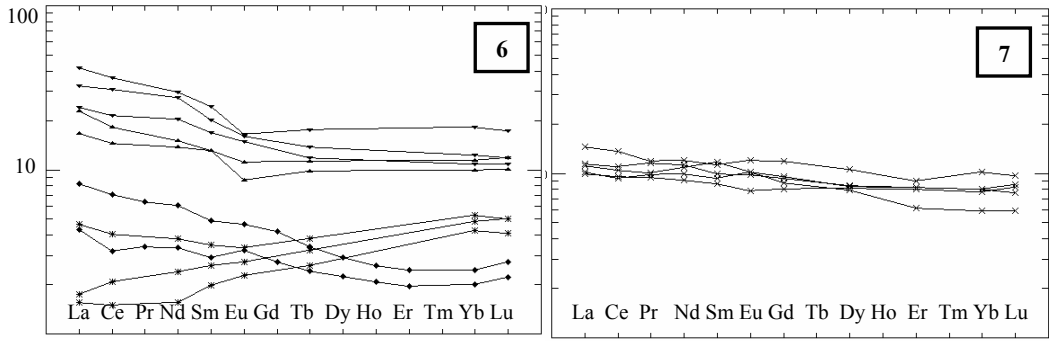


Fig. 5 *La vs Nb diagram (Gill ,1981) of the Palltanga Units, south part (■), north part (▲), Piñón Formation (X) y Diabasic Group (△)*

BONINITIC-TOLEITIC ARC: LAS ORQUÍDEAS (MLO)– TOACHI (UT) (Albian)

The MLO of Upper Albian-Cenomanian and the UT of pre-Coniacian (3,5) exhibit geochemical caracteristics of sub-alc-alcaline basalts, basic andesites and andesites, with an orogenic arc affinity.

The REE diagrams of MLO show low concentrations and an enrichment in LREE (Fig. 6), whereas UT rocks have a flat profile (Fig. 7). In respect to N-MORB, they present low concentration in Nb, a sign related to subduction magmatism. They present high content in MgO, Ni, Cr and low content in Al_2O_3, TiO_2, Y and Zr, abnormal to rocks of a typical arc, suggesting the presence of a source of primary magma. The $^{87}Sr/^{86}Sr$ ratio show the involment of some subducted sediments in the source or fluids recycled from the hydrothermalised subducted slab. Following these geochemical caracteristics, the MLO group could be assimilated to boninites (1), in relashioship with the generation of the primitive UT arc. Furthermore, north of the COE, in the Pilatón Unit, some rocks presenting boninitic geochemical caracteristics have been described (13) (Fig. 6), a unit that could have genetical relationships with the MLO and the UT.



Chondrite-normalized REE abundances for:
Fig. 6 *MLO (◆) (Data from Reynaud et al.. 1996), Boninite series (✳) and island-arc normal (▽) (Data from Van Thournout et al., 1991).*
Fig. 7 *Toachi Unit (cf. Macuchi Unit of Hughes and Bermúdez 1997)*

OCEANIC ISLAND ARC NARANJAL-SAN LORENZO-RICAURTE (Campanian)

The FSL of Campanian (6), the UN of Late Campanian (2) and the Ricaute-Altaquer sequence of Campanian (12) are geochemicaly basaltic andesites with affinity toleitic and/or calco-alkaline, they have REE models rich in LREE. With respect to MORB show depletion in Nb (Figs. 8, 9, 10), typical to subduction. The low values of Cr, Ni y Mg suggests that they didn't generate of primitive magmas, different than Albian arc. The values of TiO_2, Al_2O_3, Y and Zr, are normal to arc basaltic andesites, in conclution this suite have affinity with normal

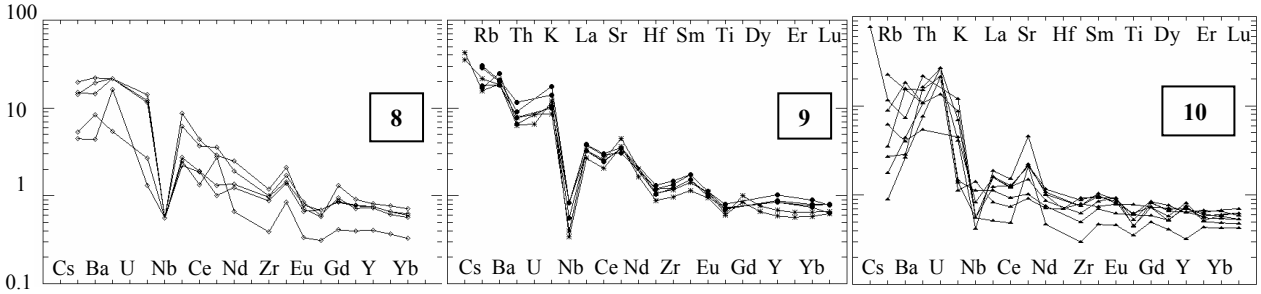
island arc which evolved from toleitic to calco-alkaline. Inside of group of rocks of UN are mapping rocks with geochemistry of N-MORB, these rocks possibility represents the floor over the Campanian arc development.

UNDIFFERENT BASAMENT

In the Northwest Coast zone and next to Gulf of Guayaquil (Fig. 1), there are rocks mapped like the FP and UPS, but their age and geochemistry are not know; nevertheless, given their structural position the rocks in the north-west zone of the Coast should be related to the Caribbean-Colombian Oceanic Plateau of Late Cretaceous.

CONCLUSIONS

The following geodynamic domains can be recognized during the Cretaceous evolution of the Western Cordillera and Coastal plain of Ecuador: 1. An Early-Cretaceous oceanic plateau involving the FP and UPS; 2. An Albian to pre-Turonian toleitic-boninitic arc former to the extensive basin in the Late Cretaceous; 3. A Santonian-Campanian back-arc basin involving the UP North and a thick sedimentary sequence; and, 4. A Campanian-Maastrichtian normal island arc showing evolution from toleitic to calc-alkaline composition, overlying an oceanic floor of N-MORB. The recognized structural features define a right-lateral to transpression pattern where thrusting could be expected in spite of no field evidences.



MORB-normalized trace element pattern for: ***Fig 8*** *Ricaute-Altaquer Sequence (Data from Spadea y Espinoza, 1996),* ***Fig 9*** *San Lorenzo Formation (Data from Reynaud et al,1999, Lebrat 1987),* ***Fig 10*** *Naranjal Unit (Data from Boland et al., 2000)*

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