A CRETACEOUS HOT SPOT IN THE ECUADORIAN ORIENTE BASIN: GEOCHEMICAL, GEOCHRONOLOGICAL, AND TECTONIC INDICATORS

R. BARRAGAN (1) and P. BABY (2)

(1) Kerr-McGee Corporation, 16666 Nothchase, Houston, TX 77060, USA; *rbarragan@kmg.com*
(2) Convenio IRD-Petroproduccion, P.O.Box, 17 11 6596, Quito, Ecuador; *pbaby@pi.pro.ec*

KEY WORDS: hot spot, Oriente Basin, HPT series, LIL/HFS ratios, Cretaceous

INTRODUCTION

A paleo intra-continental plume has been identified along the Ecuadorian "Oriente" Basin (Fig. 1) in the Cretaceous sediments of the Napo and Hollin Formations. Analysis of well log data, seismic sections, core and outcrop descriptions reveal two major facies of magmatism: i) Extrusive facies, mostly characterized by basaltic volcanoclastic deposits (altered tuffs and palagonitized hyaloclatites), reflecting shallow marine environment of emplacement and characteristic Surtseyan eruptive style, producing typically ring and tuff cones as is reflected in several seismic lines (Fig. 2). ii) Intrusive facies, characterized by major gabbroic sill complexes and diabasic dikes emplaced anywhere within the Cretaceous sedimentary series. Petrographic features suggest an alkaline type composition, fine-coarse grained phaneritic texture, and an intergrown phenocryst assemblage enriched in labradorite + olivine + clinopyroxene.

GEOCHEMISTRY AND GEOCHRONOLOGY

The geochemistry of representative Cretaceous igneous samples from different locations along the basin shows a restricted range of compositional variation). They lie within the alkaline basaltic field, show high contents in TiO2 (≥ 3 wt%), K2O (1-2 wt%), P2O5 (>0.6 wt %) (Fig. 3) and incompatible elements similar to the HPT series (high Ti and P) observed in several basaltic flood provinces (FBP) such as the northern portion of the Paraná-Etendenka and Karoo basalt provinces (Cox, 1988, Hawkesworth et al., 1988). Comparing the compositional range observed for other basalt tectonic settings, such as mid-ocean ridge basalts (MORB), intra-plate volcanism (OIB), and subduction-related basalts (Table 1; modified form Shinjo, 1998), the

Oriente Basin Basaltic magmas (OBB) are enriched in the whole spectrum of incompatible elements relative to normal MORB and subducted-related back arc basalts. On the other hand, they are characterized by LIL/HFS element ratios (i. e., K/Zr ≅ 36-68, Rb/Zr ≅ 0.06-0.15, Ba/Zr ≅1.8-2.8, Zr/Y ≅ 7.8-9.5, Ba/Nb ≅ 6.3-8.6, Ba/Ce ≅ 4.9-7.9, La/Nb ≅ 0.6, and Zr/Nb ≅ 3) and general trace element patterns (Fig. 4) similar to those compositional signatures observed in oceanic intraplate lavas (OIB). The Triangular Tb-Th-Ta discrimination diagram (after Cabanis and Thiéblemont, 1988) confirms the above conclusions and suggests that the OBB samples are associated with alkaline basaltic magmas of anorogenic series erupted within continental-plate (Fig 5).

Radiometric ages from several well locations ($^{40}Ar/^{39}K$ and $^{40}Ar/^{39}Ar$ data) and the distribution of igneous bodies suggest an Albian to Campanian age for the magmatism in the Ecuadorian Oriente Basin (OBB). Stratigraphic correlation supports the absolute age dating. The oldest evidences of igneous activity are contemporary to the Upper Hollin Formation (Albian) and identified along the north-central part of the Basin (106±5 My) (Fig. 1). Younger evidence of igneous activity are found contemporary to Lower Napo and Napo T in the Central part of the basin (92±3.9 Ma), and synsedimentary to the Campanian lower M1 Unit (Upper Napo Fm) in the west south-central part of the Oriente Basin (84±2 My; and 82±0.5 My). No evidence of basaltic volcanism has been found in younger sediments.

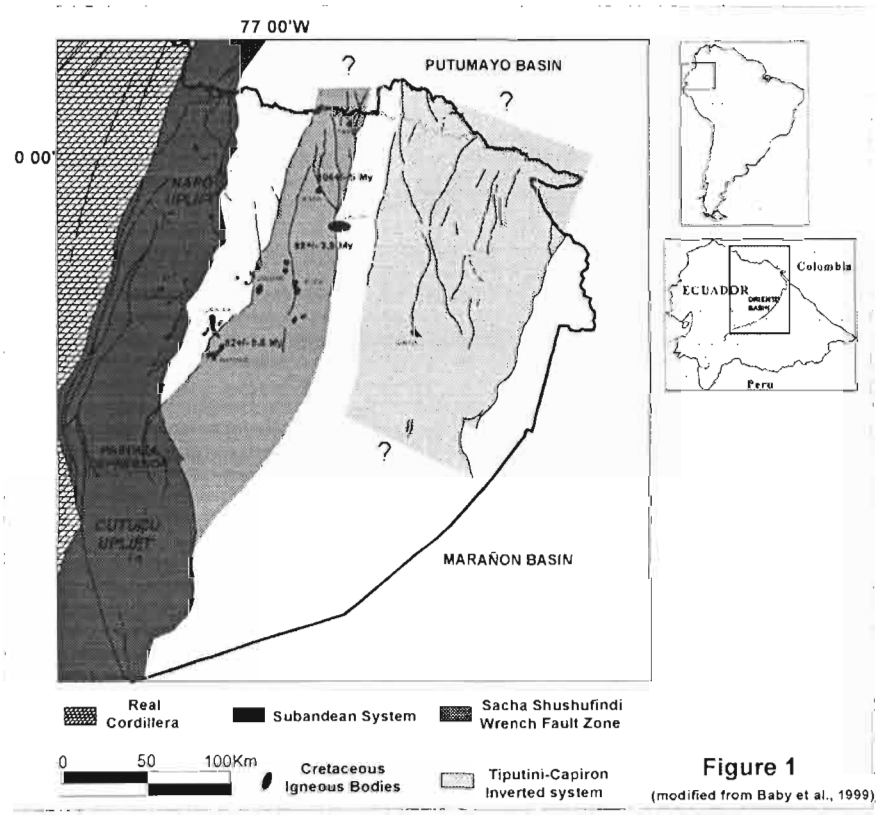
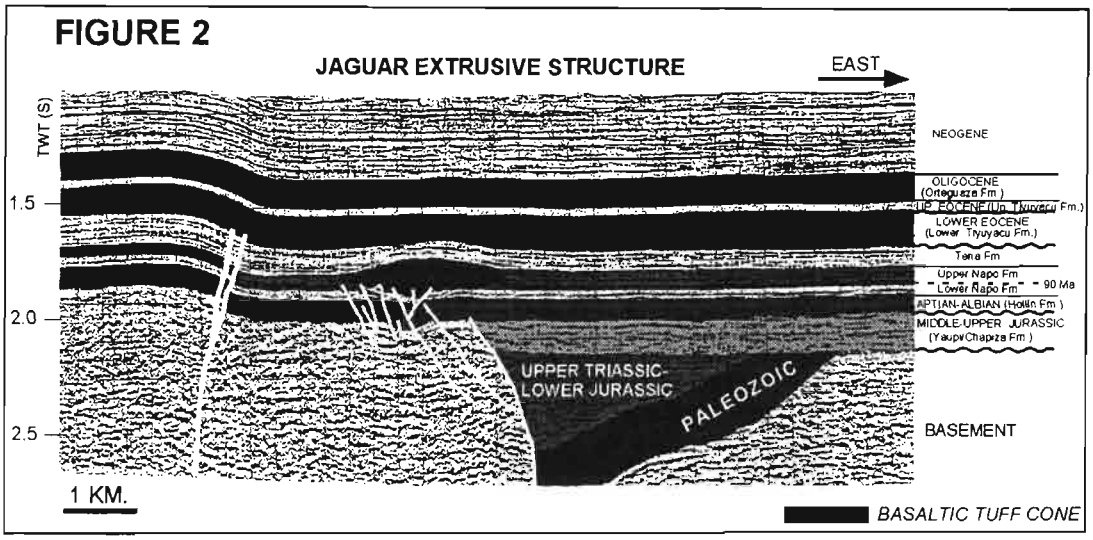


Figure 1
(modified from Baby et al., 1999)

TECTONIC CONTROL

It is also evident from reflection seismic data that the locations of major eruptive sites, are controlled by pre-existing basement structures in the Ecuadorian Oriente Basin reactived during the Cretaceous (Fig. 2). These represent major wrench-fault systems originated within Triassic and Jurassic basins that then acted as deep lithospheric shear zones and magma pathways to the surface during Cretaceous times. This is reflected in the regional geographic distribution of the Cretaceous magmatic bodies in the Ecuadorian Oriente Basin (Fig. 3). Either extrusive or intrusive facies, the igneous rock bodies are aligned in a very specific NNE-SSW trend vector along right-lateral convergent wrench-fault zones (Fig. 1), mainly in the center of the basin, where the Shushufindi-Sacha wrench-fault-zone results from the inversion of a NNE-SSW trend of Upper Triassic to Lower Jurassic half-grabens, in a transpressive stage during Coniacian-Maastrichtian times (Baby et al; 1999).



CONCLUSIONS

All the intrusive and extrusive facies recognized within the Cretaceous sedimentary series of the Ecuadorian Oriente Basin show similar geological and geochemical features, even though they were developed at different ages and at different geographic locations. Also, they are related to the main pre-Cretaceous extensional features, so their emplacements are associated to the regional field stresses that reactivate regional structures during Cretaceous times.

Geochemical signatures suggest that the different igneous facies recognized at the Oriente basin are genetically associated with magmas originated in an ancient "intra-continental plate hot spot" paleotectonic

setting. Geographic and chronological controls in the distribution of all the magmatic bodies in the Oriente Basin are evident. They are aligned in a very specific NNE-SSW trend direction, with the oldest facies placed since Lower Albian (≈105-110 My) and developed to the NNE and the youngest, Campanian (≈85 My) to the SSW. This observations suggest that magmatism has migrated to the SSW, and strongly support confirm the presence of an "intra-continental hot-spot" under the Oriente Basin.

REFERENCES

Baby P., Rivadenera M., Christophoul F., and Barragan R. 1999. Style and timing of deformation in the Ecuadorian Oriente Basin: ISAG 99, *this issue.*

Cabanis B., and Thieblemont D. 1988. La discrimination des tholéiites continentales et des basaltes arriére-arc: proposition d'un nouveau diagramme: le triangle Th-3xTb-2xTa. Bull: Soc. Géol. France, 8, 927-935.

Cox K. G. 1988. The Karoo Province, *in* MacDougall, J. D., ed., Continental Flood Basalts: Dordretcht , Kluger Academic Publishers, 239-271.

Hawkesworth C. J., Mantovani M., and Peate D. 1988. Lithosphere remobilization during Parana CFB magmatism: Journal of Petrology, Special Lithosphere Issue, 205-223.

Shinjo R. 1998. Petrochemistry and tectonic significance of the emerged late Cenozoic basalts behind the Okinawa Troughs Ryukyu arc system: Journal of Vulcanolgy and Geothermal Research, 80, 39-53.

Wilson M. 1993. Magmatism and the geodynamics of basin formation: Sedimetary Geology, 86, 5-29.

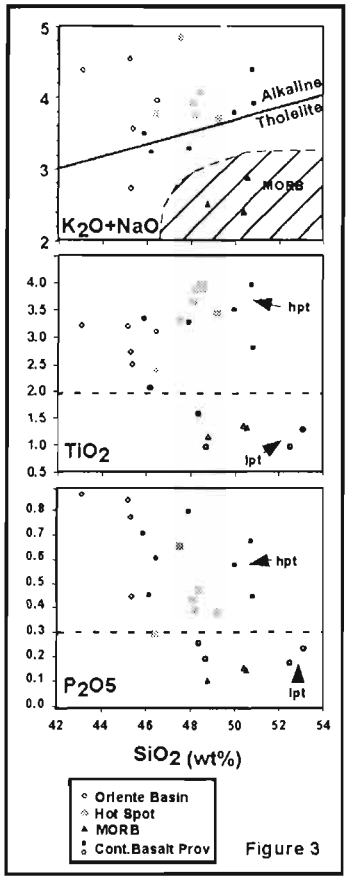


Figure 3

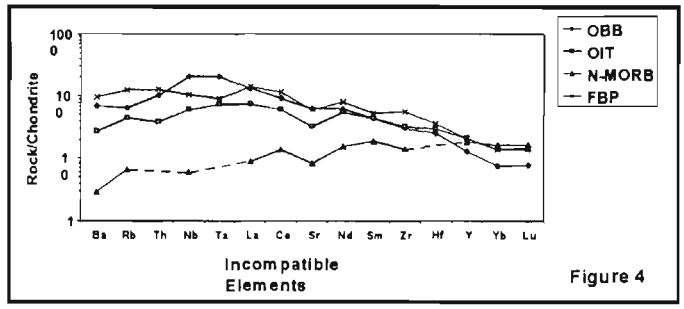


Figure 4

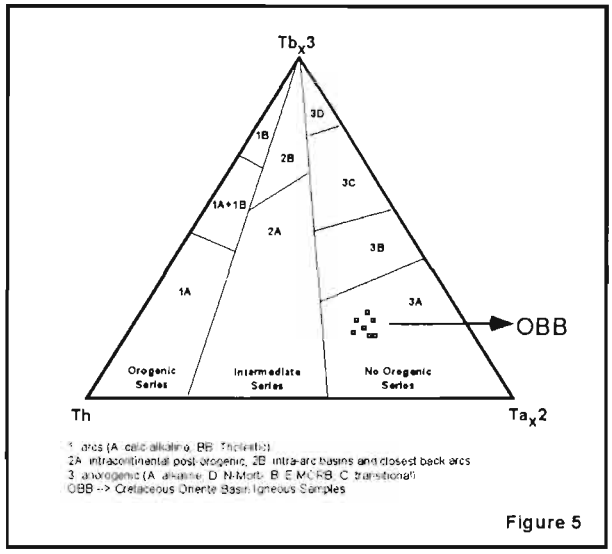


Figure 5

	OBB	Subduction-related basalts		MORB		OIB
		IAT	HAB and CA	N-MORB	E-MORB	
K/Zr	35.5-67.8	147	216	12	26	44
Rb/Zr	0.06-0.15	0.21	0.35	0.01	0.05	0.1
Ba/Zr	1.79-2.83	5	7.5	0.1	0.9	1.7
Ba/Nb	6.33-8.56	157	214	4	8	7
Ba/Ce	4.93-7.85	30	13	1	5	5
La/Nb	0.57-0.67	1.86	7.14	0.97	0.78	0.66
Zr/Nb	2.88-3.89	31	29	27	9	4
Zr/Y	7.79-9.46	1.8	2.7	2.9	3.4	7.3

TABLE 1 Selected incompatible ratios for the Cretaceous Oriente Basin Igneous Rocks and various tectonic settings. IAT = Island-arc tholeiitic; HAB = high-alumina basalt; CA = calc-alkaline basalt; OIB = ocean island basalt. Data source: (Sun, 1980; in Shinjo, 1998).