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The Puente Piedra group in the Lima area and the demise of Jurassic arc volcanism along the Gondwana margin of Peru: The Conundrum of the Oyotun Formation and its bewilldering correlation with the Misahualli formation

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INTRODUCTION

The lower part of the Puente Piedra Group consists of thick bedded porphyritic to aphanitic basalts and basaltic andesite lava flows interbedded with medium bedded lithic to crystal lapilli tuffs known as the Tambo Inga Formation. The middle unit consists of varycolor tuffaceous shales interbedded with ash tuffs and thinly bedded fine grained lapilli tuffs that contain a rich Berriasian to Tithonian age fauna known as the Puente Inga Formation. The uppermost unit consists thick bedded massive porphyritic to aphanitic interbedded with coarse grained lapilli tuffs with rests of plants and well stratified pyroclastic breccias that toward the top contain abundant calcareous lapilli tuffs and recurrent varycolor tuffaceous shales that resemble the Middle unit and it is known as the Ventanilla Formation. Northward, between Piedras Gordas and Playa Ancon this unit is more than 1523 meters and it is dominated by porphyritic massive lava flows with abundant hyaloclastic breccias.

The Puente Piedra Group and the correlative Oyotun and Guaneros formation documents the last stages of the Jurassic arc. Indeed, the Mesozoic arc initiated in Central Chile Margin during the Early Triassic continued throughout the Cretaceous along the Chilean margin. However; near the Peru-Chile border, this volcanic arc suddenly fade away during the Neocomian approach and subduction of an oceanic plateau. As a result the subduction shallowed and was accompanied by extensional uplift of the Maranon and Paracas terranes and concomitant quartz-rich provenance change nourished by these terranes. Although, the Puente Piedra Group and the Guaneros and Oyotun formations have very similar normalized chondrite patterns that fluctuate from E-MORB and OIB caused by hyper-extension that boudinage the crust and brought up deeper fertile mantle during adiabatic decompression melting. However, while the Puente Piedra and Upper Guaneros have a gentle LREE slope and almost concave HREE with subtle negative Eu anomaly, the samples from the Oyoutun Formation have a spiky pattern with a distinctive signature branded by Tb-enrichment that it is difficult to explain (Fig. 1). Because of the pervasive intraplate extension coeval with enriched mantle upwelling, the Misahualli has similar chondrite pattern which perhaps was correlated with this unusual arc sequences. Indeed, while the Misahualli Formation was associated to a regional intraplate volcanism and extension prior to the opening of the South Atlantic, the Late Jurassic units along the coast of Peru were linked to a volcanic arc that underwent hyper-extension during oblique convergence. Finally, it is difficult to conceive a geotectonic correlation between the Misahualli Formation and the Jurassic Oyotun-Colan-Traposa formations. While the first unit has only been mapped east of the accreted Paleozoic terranes in Ecuador and it was developed during intraplate extension; the coastal units occurred only east of the Maranon Block and was part of a continental arc characterized by important E-MORB and OIB signatures. The broad variation in high in this diagram is related to removal of olivine, plagioclases and pyroxenes

during fractionation and the relatively flat HREE perhaps reflects the absence of deep garnet.

The normalized N-MORB diagram depicts a strong correlation between the Upper Guaneros and Oyotun formations with the Puente Piedra. The diagram shows a strong enrichment in LIL that is less pronounced in the Oyotun samples, however there is a slight depletion in the more HFS with higher enrichment in Pb and Sr and strong depletion in Nb typical of subduction related volcanic arcs (Fig. 2)

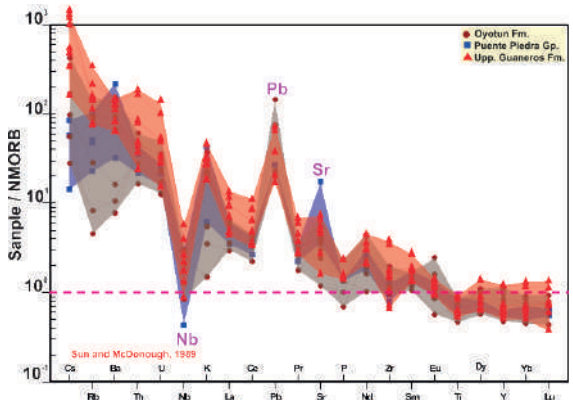

Fig. 1. Normalized chondrite for the Upper Guaneros and Oyotun Formation compared with the Puente Piedra Group

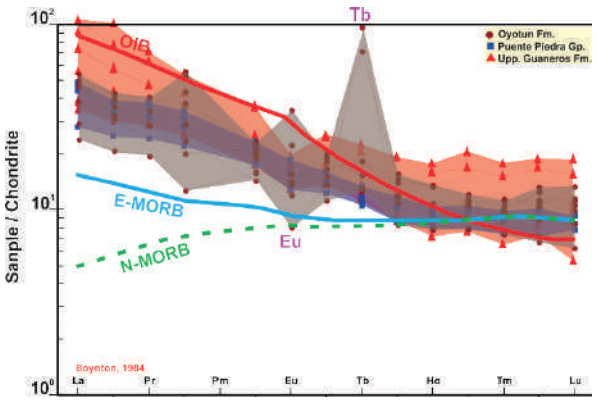

Fig. 2. Normalized NMORB for the Upper Guaneros and Oyotun Formation compared with the Puente Piedra Group

THE PUENTE PIEDRA GROUP STRATIGRAPHIC CORRELATIONS AND TECTONIC INTERPRETATIONS ISSUES

Perhaps an old concern in the tectonic interpretation of the Lima area was related to the interpretation of the Lima Anticlinal, which today has been reinterpreted as related to block rotation during Mesozoic deposition (Lisson, 1908; Aleman et al, 2004). However, there has been an effort to sub-divide this group (Puente Piedra Formation) in seven member of questionable worthwhileness (Rivera et al, 1975). Moreover, we must have caution when we mapped the Puente Inga Formation, since this facies often has a documented recurrence in the uppermost Ventanilla Formation. The stratigraphic problem was also magnified when trying to correlate this group with the type locality of the Pucusana Formation which has been authenticated to be overlying and underlying by the Morro Solar Group and Lurin Formation respectively (Rivera et al, 1975, Aleman et al., 2004). This miscorrelation has caused erroneous geochemical and tectonic interpretations (Atherton et al, 1985). The tectonic interpretation has become even more shocking when May and Butler (1985), in their quest to identify allochthonous terranes in South America, no only proposed the "Cangrejo Terrane" that must have docked by a least mid-Albian without latitudinal translation of the Puente Piedra Group but also suggested that this group was folded prior to magnetization associate to the emplacement of the Santa Rosa Super Unit of Coastal Batholith. In our opinion, this counter-clockwise rotation is due to independent block rotations associated with the Mesozoic hyper-transtension set by a shear couple developed during oblique convergence, rather than being associated with the Arica Oroclinal as suggested by larger declinations in Mesozoic rocks than those related with oroclinal bending (Beck, 1988. Roperch and Carlier, 1992).

THE OYOTUM CONUNDRUM

This unit was initially described informally as the "Calabozo Volcanics" by Fisher (1956). Later, Pardo and Sanz (1979), termed Colan Formation to describe designated this volcaniclastic sequence outcropping along the La Leche River. However, Wilson (1984) used the informal term "Oyotun Volcanics" that was later formalized as a stratigraphic unit. This formation consist of medium to tick bedded pyroclastic breccias interbedded with dacites and andesite lava flows and medium to thin bedded ash and lapilli tuffs and thin bedded silicified limestones outcropping in the Oyotun village along the Zaña Valley. Most of the samples used in this study are located near the termination of a collisional suture formed during the accretion of the Amotape-Olmos Terrane. It is also important to point out that the southern offshore termination of this accreted terrane is

against an oceanic crust which was involved in the collision, either as a mid ocean ridge or an oceanic fracture.

CONCLUSIONS

The Jurassic arc documented from Central Chile is documented by the Guaneros Formation in southern Peru, the Puente Piedra in Central Peru until northern Peru where has been documented by the Oyotun and its associated intrusives. The proposed correlation with the Misahualli in eastern Ecuador is questionable from the geodynamic evolution of this arc, although some geochemical parameters might suggest similitude because of the significant extensional process during their emplacement (Fig. 3 and 4). In our opinion, the Misahualli Formation was related to an intraplate extension that is well documented from Central Eastern Peru, Ecuador, Colombia and Western Venezuela. This is in contrast with the long lived arc-trench system developed along the western margin of Gondwana from northern Peru to Central Chile.

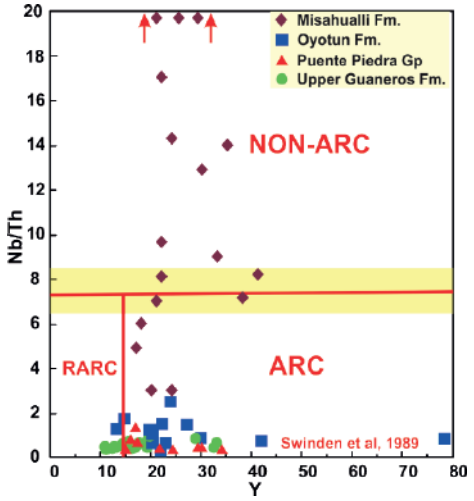

Fig. 3. Diagram showing some samples of the Misahualli Formation with a more dominant MORB-OIB trend.

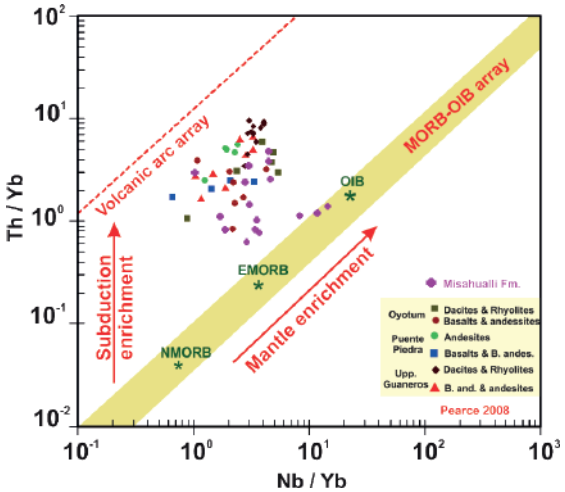

Fig. 4. Diagram Y vs Nb/Th to illustrate the dominant non-arc nature of the Misahualli Formation) the three samples from the top of the graph have higher Nb/Th values.

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