PRESENT KNOWLEDGE OF THE JURASSIC VOLCANOGENIC FORMATIONS OF THE SOUTHERN COASTAL PERU.

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RESUMEN: Se propone una nueva cronología de las formaciones jurásicas de la costa del Sur del Perú, basada sobre argumentos paleontológicos y geocronológicos, y se presentan observaciones mineralogicas y geoquímicas.

KEY WORDS : Lias, Dogger, low grade metamorphism, calc-alkaline, active continental margin-type setting, Southern Peru.

INTRODUCTION

Jurassic volcano-sedimentary rocks have been recognized in various places of the coastal region of Southern Peru (figure 1A). They have been generally assigned to three main formations. A thick sequence (>3000 m) of volcanic breccias with intercalated rhyolitic to andesitic flows are correlated with the Chocolate Fm defined in the Arequipa area (Jaén & al., 1963; Olchauski, 1980). In this area, an early Sinemurian fauna is present at the top of the Formation (Vargas, 1970, Vicente, 1981). The Chocolate Fm is unconformably overlain by the Bajocian to Oxfordian marine series of Guaneros Fm in the southernmost part of the coastal region (Jaén & al., 1963). Finally, in the northern segment of the area described here, Aalenian to Tithonian marine sediments associated with volcanic material have been regrouped into the Rio Grande Fm (Ruegg, 1956, 1961; Olchauski, 1980).

New stratigraphical, paleontological, and geochronological data from near Nazca, Chala, Ilo and Tacna (figure 1A) have led to a necessary partial or complet redefinition of the jurassic formations exposed in the coastal area of Southern Peru. Moreover, the presence of a low-grade non-deformational metamorphism in all these three formations has been put in evidence. Its characteristics and their consequences on the primary chemistry of the volcanic rocks are also discussed.

THE JURASSIC FORMATIONS OF THE COASTAL AREA OF SOUTHERN PERU

Near Ilo (figure 1B-A), a sequence of conglomerates, volcanic breccias and dacitic to andesitic flows that uncomformably overlain the precambrian basement are intruded by gabbro and diorite rocks dated at 190 Ma and 150 Ma (Mc Bride, 1977; Sánchez, 1983; Mukasa, 1986; Clark & al., 1990) and by granodiorites with a K/Ar, hornblende, age of 205 ± 11 Ma cropping out near Punta de Bombón. This sequence probably represents the lower part of the Chocolate Fm and may be correlated with the lower part of the La Negra Fm of Northern Chile (Muños & al., 1988). Near La Yarada (figure 1B-B), volcanic breccias with intercalated ignimbritic flows of the Chocolate Fm. are unconformably overlain by shales, sandstones

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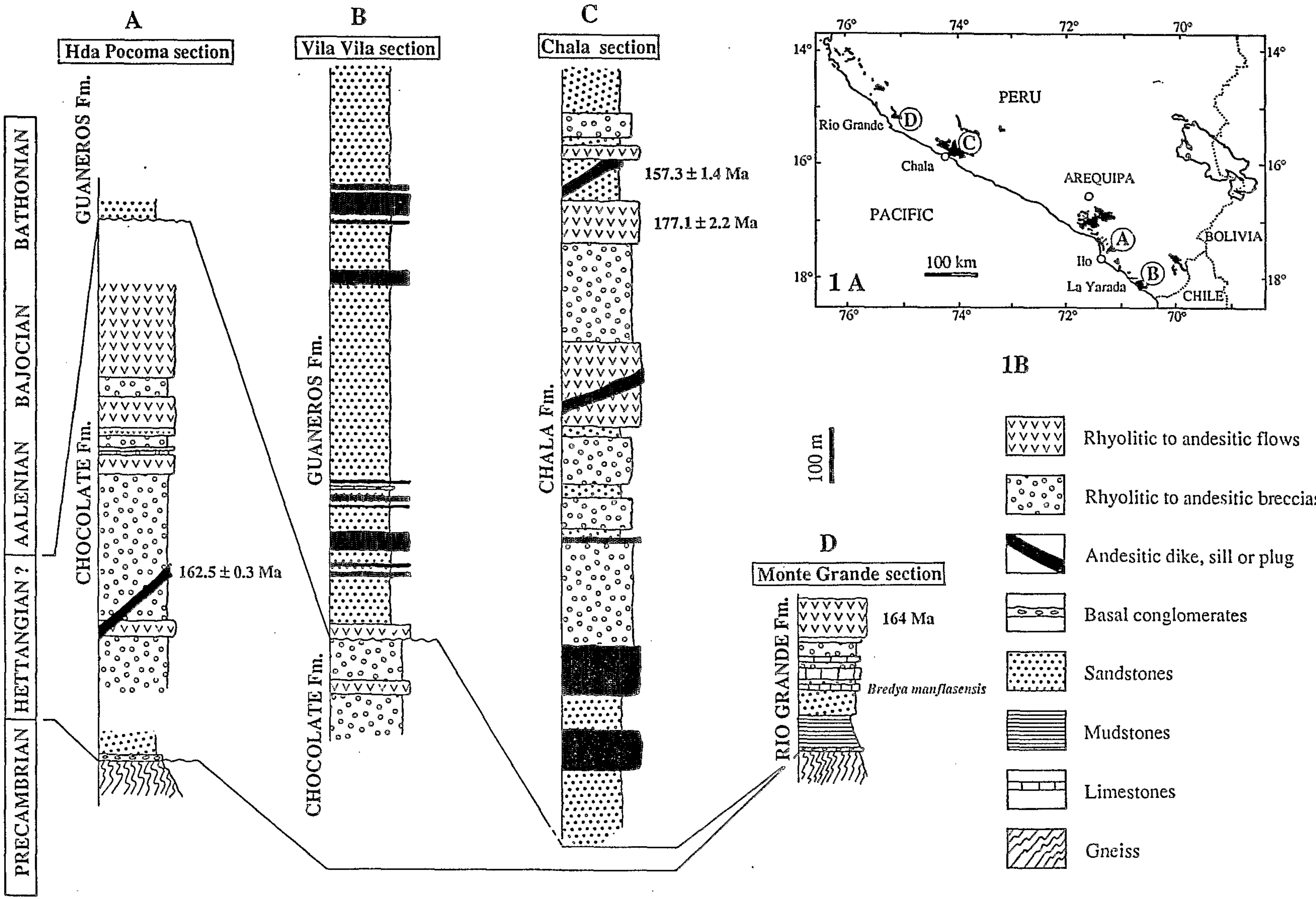

FIGURE 1 : AGE AND PROPOSED CORRELATIONS OF SOUTH PERUVIAN JURASSIC FORMATIONS.

with rare limestone intercalations of the Guaneros Fm. *Leptosphinctidae, Spiroceras sp.* (La Yarada) and *Lilloetia cf. Steinmani Spath* (Ilo) indicate that the base of the Guaneros Fm. is older (upper Bajocian to the upper Bathonian) than previously postulated (Callovian). In the Chala area, a thick sequence of basaltic to ignimbritic flows and dacitic breccias with intercalated red beds (figure 1B-C) was previously assigned to the Chala Fm and correlated with the Chocolate Fm (Olchauski, 1980). Nevertheless, an $^{39\text{-}40}Ar$ age of 177 Ma obtained on a basaltic flow from the base of the formation indicate that the Chala Fm should be correlated with the Guaneros Fm and the Rio Grande Fm (figure 1B-D) where occurrence of the Aalenian *Bredya manflasensis* assemblage zone has been reported (Roperch & Carlier, 1992). Various generations of andesitic stocks, sills and dikes crosscut all the Jurassic formations of the coastal range. An $^{39\text{-}40}Ar$ age determination performed on dikes from the Ilo and Chala areas (Roperch & Carlier, 1992) indicates magmatic activity contemporaneous with the Middle Jurassic sedimentation. A similar age from an andesitic flow of the Rio Grande area has been reported (Aguirre & Offler, 1985; Aguirre, 1988). Nevertheless, a K/Ar on hornblende of 91.3 ± 9.2 Ma from a dike of Chala area indicates that some of these subvolcanic intrusions can represent the feeding channels of younger volcanic series as the Albian Matalaque Fm or Paleogene Toquepala Fm.

METAMORPHISM

The regional low-grade metamorphism that affects all the volcanogenic formations is marked by the lack of deformation. In the basaltic to rhyolitic flows and basaltic to andesitic subvolcanic intrusions, this metamorphism is characterized (1) by replacement of primary olivine, plagioclase, hornblende, titanomagnetite and groundmass, and (2) by secondary amygdule filling. The metamorphic assemblages consists of various associations of the following minerals : chlorite/smectite, celadonite, albite, K-feldspar, K-rich zeolite ?, sericite, albite, quartz, calcite, epidote, hematite, titanite and rare pumpellyite, prehnite, analcite and actinolite. These assemblages suggest sub-greenschist facies conditions, *i. e.* zeolite to prehnite-pumpellyite facies (T = 150-275° C, P < 3 kbars).

In the other hand, the replacement of primary plagioclase by albite, K-feldspar and K-rich zeolite ?, the secondary filling of amygdules by calcite, quartz, chlorite/smectite and celadonite documente the relatively high mobility of Na, K, Ca, Si, Fe and Mg during the metamorphism.

GEOCHEMISTRY

The Na, K and Si mobility precludes their use to characterize the primary chemistry of the flows and subvolcanic intrusions. Particularly, in some rocks, the very high K_2O content (up to 7.1 wt%) associated with abnormally high Ba (2520 ppm) and Rb (250 ppm) contents results from a secondary enrichment.

The jurassic flows and subvolcanic intrusions show high LILE and LREE contents and characteristically low content of Ti and other HFSE of volcanic rocks associated with convergent plate margins (figures 2 and 3).

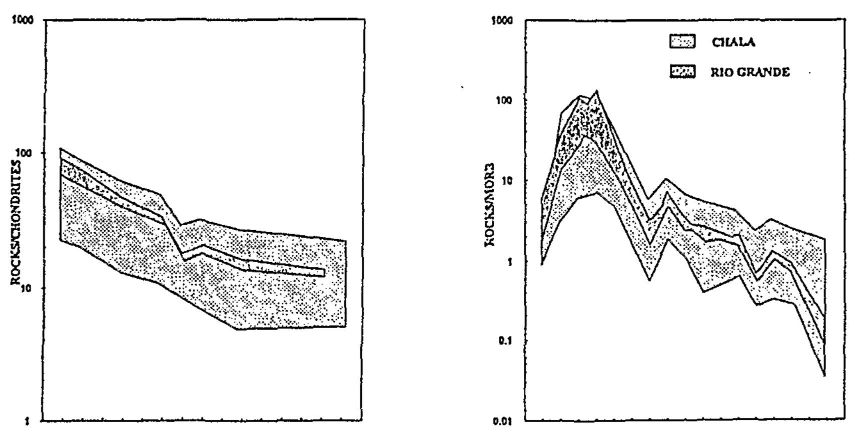

FIGURE 2 : Chondrite-normalized rare earth element diagram (A) and MORB-normalized element abundance diagram (B) of southern peruvian volcanic rocks showing LREE enrichment and typical Ti, Nb, Zr negative anomalies of volcanic rocks associated with convergent plate margins.

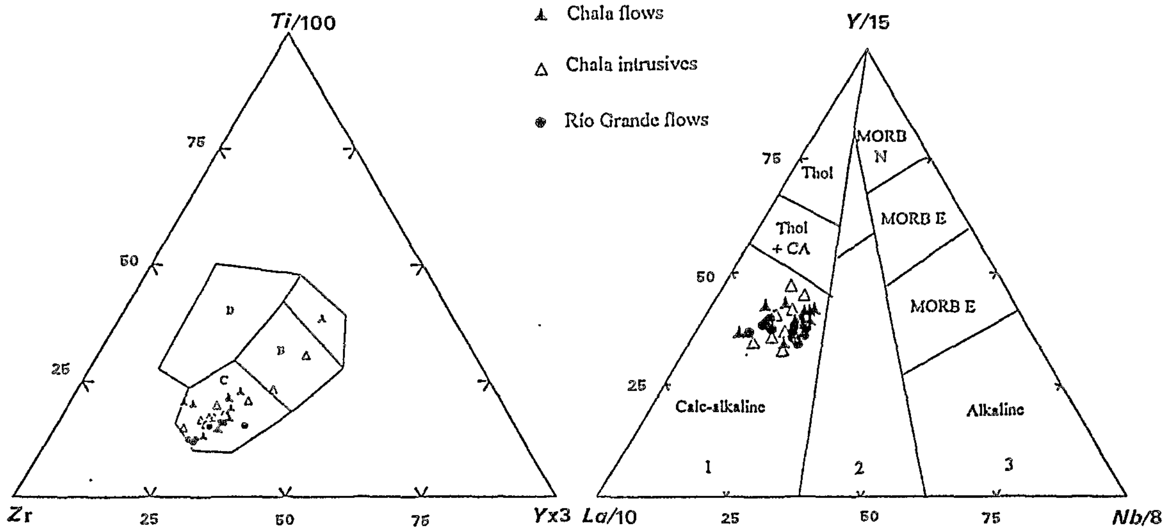

FIGURE 3 : Ti - Zr - Y and Y - La - Nb Plots of southern peruvian volcanic rocks. A is field of low-K tholeiite; B, ocean floor basalt; C, calc-alkali basalt; D, within plate basalt; 1, orogenic domains; 2, late to post orogenic intracontinental domains and 3, anorogenic domains.

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