WITHIN-PLATE VOLCANISM IN UPPER TRIASSIC TO LOWER JURASSIC PUCARÁ GROUP CARBONATES (CENTRAL PERU)

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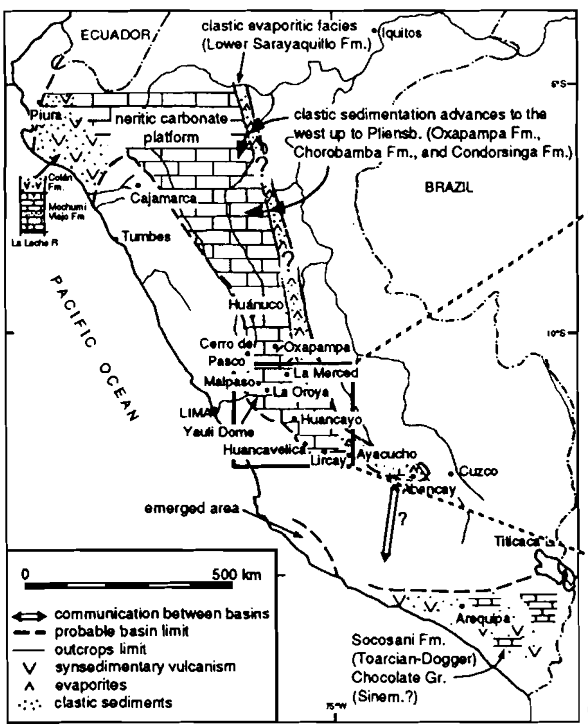
INTRODUCTION

The Pucará Group platform carbonates (Upper Triassic - Lower Jurassic) were laid down in northern and central Peru in a NNW-SSE elongated basin (Fig. 1). They represent the first sediments of the Andean cycle, the beginning of which is marked by a Norian transgression (Mégard, 1978). The sedimentary evolution of the Pucará Group can be explained in terms of a large transgressive/regressive second order sequence which consists of predominantly shallow water carbonates including a maximum flooding period represented by ammonite-bearing bituminous calcareous shales.

Detailed investigations in the southern part of the basin show that the Pucará Group thickens progressively from west to east in the form of a half-graben (Fig. 2). This can be explained by asymmetrical subsidence during sedimentation such being assisted by contemporaneous faulting along the eastern margin of the basin (permitting rapid subsidence) and a stable hinge zone to the west. Synsedimentary tectonics at the eastern edge led to the formation of discrete structural blocks with extreme variations in thickness and facies. It has been suggested that, during burial diagenesis, these faults served as channelways for the basinal brines responsible for MVT-mineralization (Fontboté et al., 1995, Spangenberg, 1995, and Moritz et al., 1996).



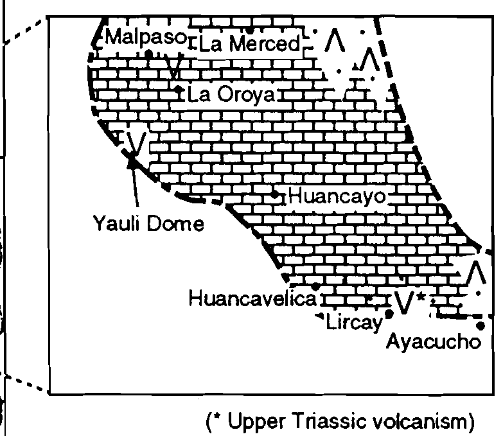


Fig. 1. Paleogeographic scheme for the Liassic. Modified from Audebaud et al. (1973), Mégard (1978), Fontboté (1990), and Rosas (1994).

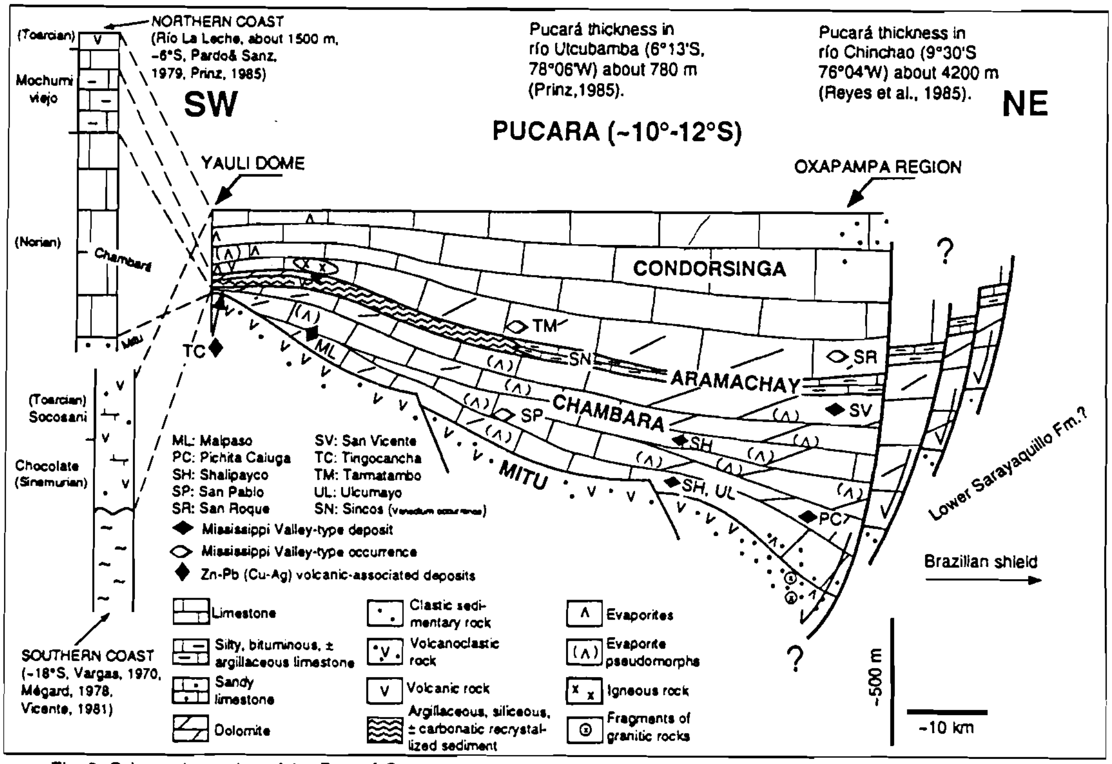


Fig. 2. Schematic section of the Pucará Group and its western equivalents. The location of some MVT and volcanic-associated deposits is shown (from Rosas & Fontboté, 1995)

Table 1. XRF-analyses of magmatic rocks intercalated in the Pucará Group.

Unit	Montero volcanic rocks in Condorsinga Fm. (Liassic)					Tuffs in Aramachay Fm. (Liassic)			Volcanic rocks in Chambará Fm. (Triassic)		
Section	Yauli Dome					Yauli D.	Malpaso		Lircay		
Sample	PB-51	PB-53	PB-54	PB-55	PB-56	PB-22	PA-103	PA-107	HU-17	HU-21	HU-23
height (m)	127.7	126.0	129.5	135.0	149.5	33.3	350.2	366.0	(2 analyses)		
					%						
SiO2	53.55	53.71	51.55	53.47	41.78	56.93	72.28	72.02	46.36	44.25	47.01
TiO2	2.23	1.76	2.26	2.30	2.16	0.89	0.51	0.26	2.64	1.71	2.19
Al2O3	13.94	10.60	13.81	14.10	13.71	22.11	14.25	10.82	14.76	15.32	15.16
Fe2O3	11.78	8.37	15.54	11.68	10.36	1.04	0.83	0.41	10.88	9.43	10.21
MnO	0.14	0.06	0.18	0.18	0.16	0.01	bdl	bdl	0.21	0.46	0.15
MgO	4.12	0.14	3.55	4.10	2.04	0.77	0.88	0.58	6.43	5.27	6.62
CaO	6.54	10.26	5.35	6.33	11.37	5.44	2.13	6.20	7.90	7.86	9.30
Na2O	3.00	5.02	4.04	3.76	4.41	0.06	bdl	0.39	4.05	4.66	3.02
K2O	2.21	1.63	2.53	1.78	1.79	1.53	1.99	1.99	2.06	1.82	1.73
P2O5	0.57	0.40	0.51	0.37	0.31	0.18	0.12	0.16	no data	0.29	0.93
LOI	2.42	8.11	1.20	1.50	10.64	10.96	6.87	7.03	4.50	8.64	2.73
					ppm						
Ba	427	194	427	381	302	151	38	84	384	399	732
La	20	13	15	10	30	34	18	17	no data	31	32
Ce	56	44	39	41	51	75	55	60	no data	37	91
Cr	20	13	19	19	24	<5	6	<5	no data	322	294
Ni	11	<5	12	17	<2	7	<5	<5	no data	250	419
Rb	67	29	54	46	30	51	53	55	22	40	34
Sr	200	96	352	333	114	467	224	250	157	284	963
Y	59	47	47	54	36	31	57	26	no data	21	27
Zr	301	244	193	212	198	447	323	152	186	124	217
Nb	14	13	8	9	<5	19	14	6	no data	23	50
V	376	312	420	435	422	67	15	10	no data	215	188
Co	56	24	65	59	31	bdl	bdl	bdl	no data	50	40.00
Cu	49	70	12	17	<4	18	20	16	no data	13	49
Pb	7	22	6	4	<2	18	2	33	no data	41	118
Zn	95	105	70	78	64	no data	bdl	bdl	no data	198	113.00
TOTAL (%)	100.68	100.18	100.69	99.74	100.51	100.06	99.94	99.93	99.83	99.91	99.39

bdl= below detection limit, LOI=lost on ignition

A sequence analysis of the western margin of the southern part of the basin, together with the westward thinning of the sequence, point to the existence of a structural high at the western margin of the basin and to a connection between the Pucará basin and open ocean in the north-western part of Peru (see also discussion in Rosas, 1994 and Rosas & Fontboté, 1995). This contrasts with previous interpretations (Loughman & Hallam, 1982) which on the basis of the relatively large amounts of phosphate in the middle part of the Pucará Group, suggested that the Pucará basin was a carbonate shelf unrestrictedly open to the paleo-Pacific to the west. As an explanation for this phosphate formation, they proposed an upwelling of phosphate-rich waters from deep ocean. However, according to Calvert & Price (1971), upwelling of water from great ocean depths is not strictly necessary for phosphate formation, and according to Bentor (1980), Pevear (1966), and Föllmi (1993) the origin of phosphates of this type is in any case not necessarily related to upwelling. This makes Loughman & Hallam's assumption unnecessary.

Intercalated in Pucará sediments are known a number of volcanic occurrences (Rosas, 1994, Kobe, 1995). The purpose of this contribution is to present geochemical data of selected volcanic rocks in order to determine the possible geotectonic setting(s) during deposition.

VOLCANIC INTERCALATIONS IN THE PUCARA GROUP

Upper Triassic volcanic intercalations are unknown in the occidental series. However, evidence of Upper Triassic volcanic activity has been reported in central regions of the basin. They are basic and quartz-dacitic altered lava flows and tuffaceous layers in Atacocha (Hirdes & Amstutz, 1978, Hirdes, 1990) and alkaline olivine basalts in Lircay (Rangel, 1978, Mégard et al., 1983, Morche et al., 1996). The geochemistry of these rocks (Table 1) is not indicative of volcanic arc activity but of within-plate volcanism (Fig. 4). Tuffaceous layers have been described at the lower part of the Pucará succession in the Yauli Dome by Dalheimer (1990), but they can not unequivocally be ascribed to the Upper Triassic.

Younger intercalations of lava have been observed in a few places. One of these is in the Yauli Dome where several dark-brown lava flows are intercalated with Liassic carbonates over a thickness of 40 m. These lavas are known as the "Montero Basalt" and show an aphanitic texture with vesicles and amygdales filled with calcite, chlorite, and zeolites. Incipient flow-banding has also been recognized. Geochemical studies, including trace element analyses (Table 1), indicate an andesite basalt composition (Fig. 2) and a clear within-plate signature for these rocks (Fig. 4).

Relatively thin (<3 m) intercalations of acid tuffs have been studied in the lower Liassic series of the Yauli Dome and in the Malpaso region. They consist of greenish altered fine-grained rocks, which trace elements indicate to be of rhyodacitic, dacitic, or trachyandesitic composition (Fig. 3).

In the north-western part of Peru, Pardo & Sanz (1979) and Prinz (1985) describe Upper Liassic volcanic rocks in a succession of tuffaceous graywackes, red beds and bedded cherts. They are known as the Colán Formation. The volcanic components of this unit have been studied geochemically by Romeuf (1994), from which she concludes a calc-alkaline basaltic composition and a volcanic arc setting.

In the southern coastal area of Peru volcanic rocks occur in the middle Liassic (Benavides 1962, James, et al., 1975, Vicente et al., 1982, Boily et al., 1984). They are known as the Chocolate Formation and consist of between 900 and 3000 m of andesites, subordinate dacites, volcanic agglomerates and breccias which could represent early stages of volcanic-arc activity.

DISCUSSION AND CONCLUSIONS

Audebaud et al. (1973) proposed the existence of a western volcanic arc contemporaneous with Pucará sedimentation. However, the above data suggest that within-plate volcanism characterized the Pucará basin during Upper Triassic times as well as up into middle Liassic times. The volcanic arc started its activity in the northwest and south of Peru during Liassic times, as it did also in northern Chile where Hillebrandt et al. (1986) dated Hettangian and Sinemurian marine carbonates below the calc-alkaline basalts and basaltic andesites of the La Negra Formation. The influence of the volcanic arc elsewhere in the Pucará Basin is not revealed in the lithofacies described in Rosas (1994) and Rosas & Fontboté (1995).

In conclusion, the Pucará Basin possibly formed mainly as a result of aborted rifting at the western margin of the Brazilian shield. Some within-plate volcanism accompanied this stage. The western volcanic arc developed only coetaneously with the uppermost part of the Pucará Group and had little if any influence in the sedimentary record of the central part of the basin.

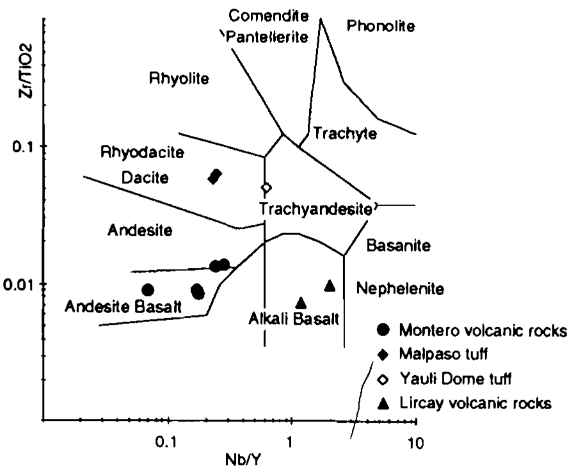


Fig. 3. Nb/Y vs Zr/TiO diagram (after WINCHESTER & FLOYD, 1977) for classification of magmatic rocks.

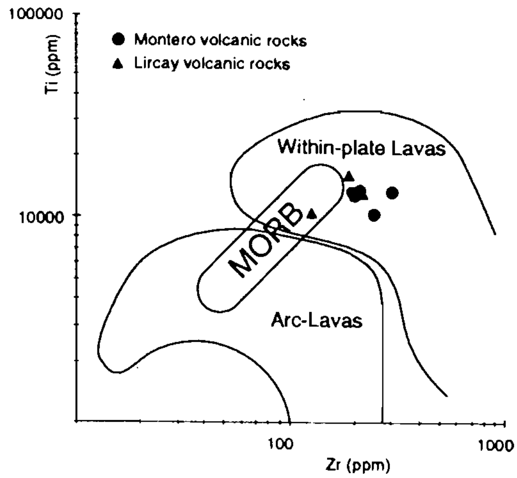


Fig. 4. Ti vs Zr diagram (after PEARCE, 1982) for interpretation of the origin of magmatic rocks.

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