A WITHIN-PLATE GEOCHEMICAL SIGNATURE AND CONTINENTAL MARGIN SETTING FOR THE MESOZOIC – CENOZOIC LAVAS OF CENTRAL CHILE

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RESUMEN: A pesar de sus diferencias de edad, ubicación geográfica y condiciones tectónicas inferidas, las lavas Jurásicas a Terciarias de Chile central (210 muestras) presentan patrones químicos similares y característicos para rangos dados de SiO_2–K_2O y tienen una componente común 'within plate'. Las composiciones químicas de estas lavas son consistentes con magmas derivados de la litósfera sub–continental en un margen continental activo.

KEY WORDS: Chile, Andes, Mesozoic-Tertiary, geochemistry, within-plate, continental margin

INTRODUCTION

A predominant part of the stratified sequences in the Chilean Andes is composed of Jurassic to Tertiary volcanic rocks, but relatively little has been published about their geochemistry compared to the much better known Quaternary lavas. In addition, most of the papers on pre–Quaternary volcanic rocks in the Andes treat altered and unaltered samples together or do not mention the problem of alteration. Since the Mesozoic and Tertiary rocks without exception are incipiently to pervasively altered and many elements are mobile during alteration processes, it is important to restrict the sampling to veinlet– and amygdule–free parts of flows with a minimum of alteration (checked with XRD), here referred to as 'unaltered'. Such screening was done in a study of Mesozoic and Tertiary lavas from central Chile (25°30' to 35°S) which showed that shoshonitic and high–K calc–alkaline lavas were common rock types during the Jurassic to Early Cretaceous, and suggested a north–south and east–west pattern of crustal thickness reverse to the present one during that time (Levi et al., 1988).

The purpose of the present study was to determine the chemical variation for the same given rock type (defined by its SiO_2 – K_2O contents according to the diagram of Peccerillo & Taylor, 1976) erupted at different times (Jurassic to Tertiary) in different parts of the ca. 1000 km long segment of central Chile treated by Levi et al. (1988). The samples of these authors were complemented with material from additional profiles, giving a total of 210 analyzed 'unaltered' basalts, basaltic andesites and andesites for this study.

GEOLOGICAL SETTING

The studied segment of the Chilean Andes is characterized by two parallel longitudinal belts of Mesozoic volcanics of successively younger ages towards a central axis that is occupied by a Late Cretaceous to Tertiary volcanic belt. Up to the 'middle' Cretaceous the lavas are intercalated with alternately continental and marine sedimentary rocks, whereas the Late Cretaceous and Tertiary lavas formed in a continental caldera/graben environment (Thiele et al., 1991). The presence of symmetric volcanic belts combined with a lack of geochemical trends expected at an active continental margin (e.g. an increase of K towards the interior of the continent) was interpreted as the result of ensialic spreading-subsidence during volcanism (Levi and Aguirre, 1981; Levi et al., 1988), enhanced by spreading caused by intrusion of granitoids (Drake et al., 1982).

RESULTS

The various populations of lavas at given $SiO_2 - K_2O$ contents (cf. Peccerillo & Taylor, 1976) each have rather uniform chemical compositions, the main exception being the few lavas belonging to the low-K series. The standard deviations for the average compositions are quite small considering that each population is composed of lavas of quite different age and geographic location (see example in Table 1). All the lavas have a common within-plate geochemical signature (i.e. they are enriched in incompatible elements that are

Table 1. Average compositions and standard deviations for 36 samples of calc-alkaline basaltic andesites from six E-W profiles in central Chile (Jurassic: 7 west, 6 east; Early Cretaceous: 1 west, 6 east; Late Cretaceous: 4 west, 4 east; Tertiary: 8). See Levi et al. (1988) for analytical methods.

	Jurassic		Early Cretaceous		Late Cretaceous		Tertiary	
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
SiO_2	52.8	1.3	52.8	1.2	52.6	1.3	53.1	1.4
TiO_2	1.60	0.66	1.47	0.49	1.26	0.32	1.21	0.34
Al_2O_3	16.6	2.3	16.4	2.2	17.7	1.5	17.6	1.7
FeO*	9.86	3.15	9.34	2.28	9.30	1.38	8.77	1.21
MnO	0.16	0.04	0.17	0.04	0.22	0.08	0.18	0.04
MgO	3.83	0.69	3.95	1.29	3.39	0.62	3.89	0.96
CaO	8.56	0.75	8.34	0.56	8.01	0.82	7.96	0.83
Na_2O	3.01	0.34	3.59	0.65	3.66	0.38	3.66	0.48
K_2O	1.10	0.37	1.14	0.29	1.26	0.32	1.18	0.21
P_2O_5	0.32	0.15	0.34	0.18	0.28	0.11	0.20	0.12
H_2O^+	1.53	0.56	1.56	0.58	1.65	0.53	1.53	0.52
CO_2	0.16	0.15	0.36	0.29	0.23	0.21	0.30	0.23
Ba	188	59	275	155	366	79	338	69
Ce	42	17	59	19	32	9	37	10
Co	56	28	31	24	36	14	58	26
Cr	31	15	74	102	26	12	52	46
Nb	17	10	12	3	8	3	10	3
Ni	61	83	42	26	18	8	39	23
Rb	21	8	27	11	21	10	21	7
Sm	7.0	3.0	8.3	3.2	4.9	0.9	5.3	1.8
Sr	334	115	473	186	471	77	423	124
V	257	72	264	61	246	49	203	75
Y	43	19	39	20	29	7	26	10
Yb	3.6	1.8	3.5	2.2	2.3	0.5	2.5	1.2
Zr	182	99	210	74	107	26	113	40

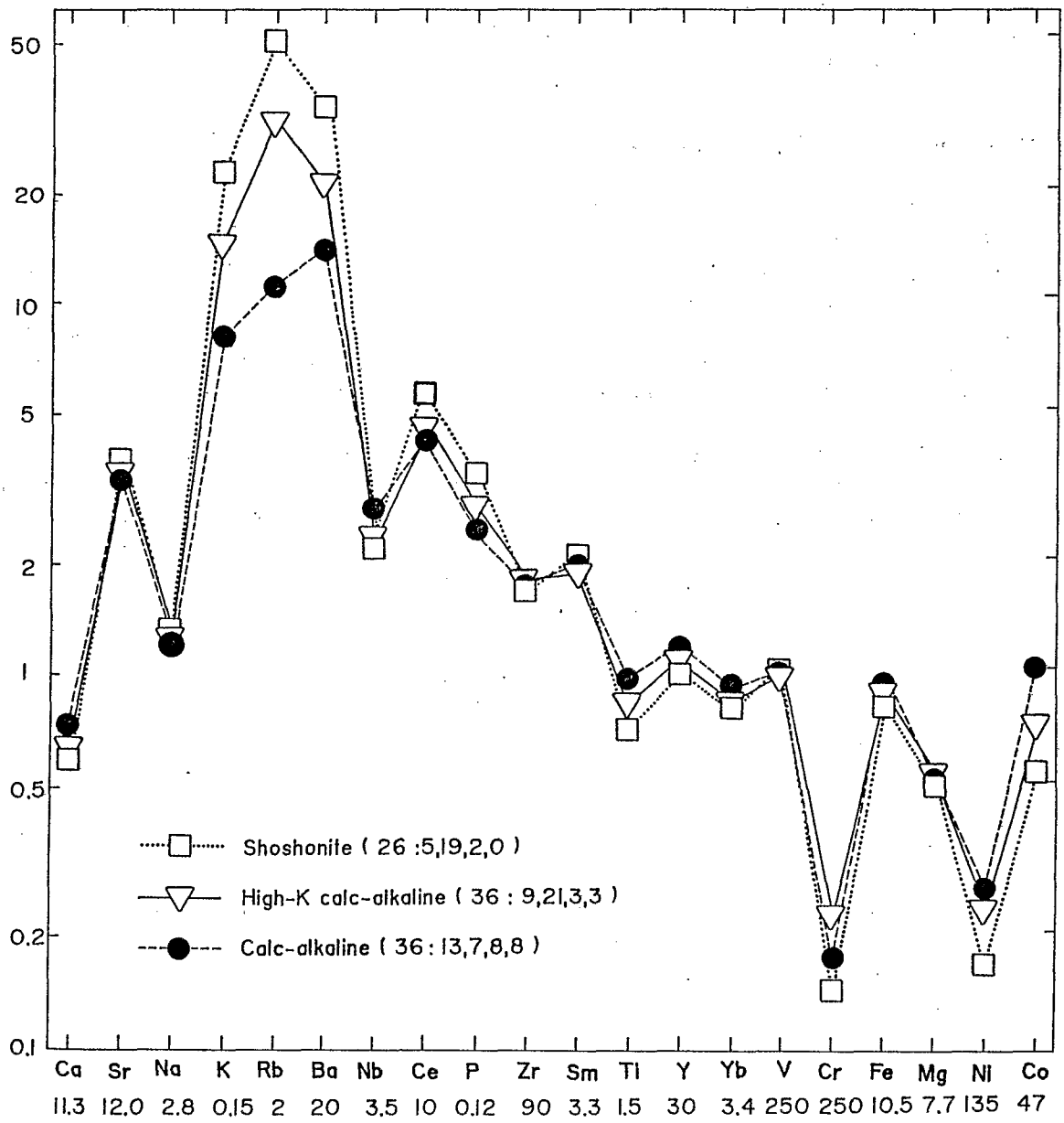

Fig. 1. MORB–normalized multielement diagram for the average compositions of Jurassic to Tertiary basaltic andesites of different K content from central Chile (total number of samples averaged in parenthesis, followed by number of samples within each age group: Jurassic, Early Cretaceous, Late Cretaceous, Tertiary). MORB values from Pearce (1983) except Ca, Na, V, Cr, Fe, Mg, Ni and Co (after Taylor & McLennan, 1985).

known not to be accomodated in the subduction component, with high concentrations of Nb relative to Zr, and of Zr relative to Y and Yb; Pearce, 1983), showing only variations in K, Rb and Ba at constant SiO_2 values and SiO_2–related differences in Cr, Mg and Ni. This signature is illustrated for basaltic andesites of different K–series in Fig. 1.

Discussion and Conclusions

The relatively uniform chemical compositions of each SiO_2–K_2O population of lavas erupted during a time–span of ca. 200 million years in central Chile is remarkable. However, there are some differences related to geographic position and age (e.g. a decrease in Ti with time, and a slight difference between Jurassic to Early Cretaceous and Late Cretaceous to Tertiary lavas; Table 1). Changes in tectonic regime with time in the studied area are reflected in the relative abundance of different rock types rather than their geochemical signature. Shoshonitic rocks, scarce during the Late Cretaceous, appear to be absent during the Tertiary, and high–K calc–alkaline types also become less abundant with time.

A within–plate component, indicating a contribution from incompatible element–enriched upper mantle, has earlier been indicated for some Jurassic to Tertiary lavas in the Chilean Andes (Pearce, 1983). Such component is also seen in the published analyses of Quaternary lavas from the Central and South Volcanic Zones occurring in the investigated area (25°30' to 35°S). This persistent geochemical feature despite considerable differences in age, location, Sr–Nd isotope composition (see Nyström et al., this volume) and inferred tectonic regime is consistent with a simple process of magma generation operating on a similar source material. The within–plate component suggests that the lithospheric plate was a major source for the magma. A geochemical similarity between the lavas studied by us and corresponding SiO_2–K_2O populations of Quaternary lavas in the same segment of the Chilean Andes indicates that this part of the Andean Belt has been an active continental margin since the Jurassic.

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