GEOCHEMISTRY OF MESOZOIC K-ALKALINE COMPLEXES FROM CENTRAL-EASTERN PARAGUAY

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The Mesozoic alkaline activity in Central-Eastern Paraguay consists of a group of complexes, plugs and associated dikes which were emplaced 120 Ma ago (Capaldi, unpublished data) into the central area of the Asunciòn-Sapucai graben (Fig. 1).

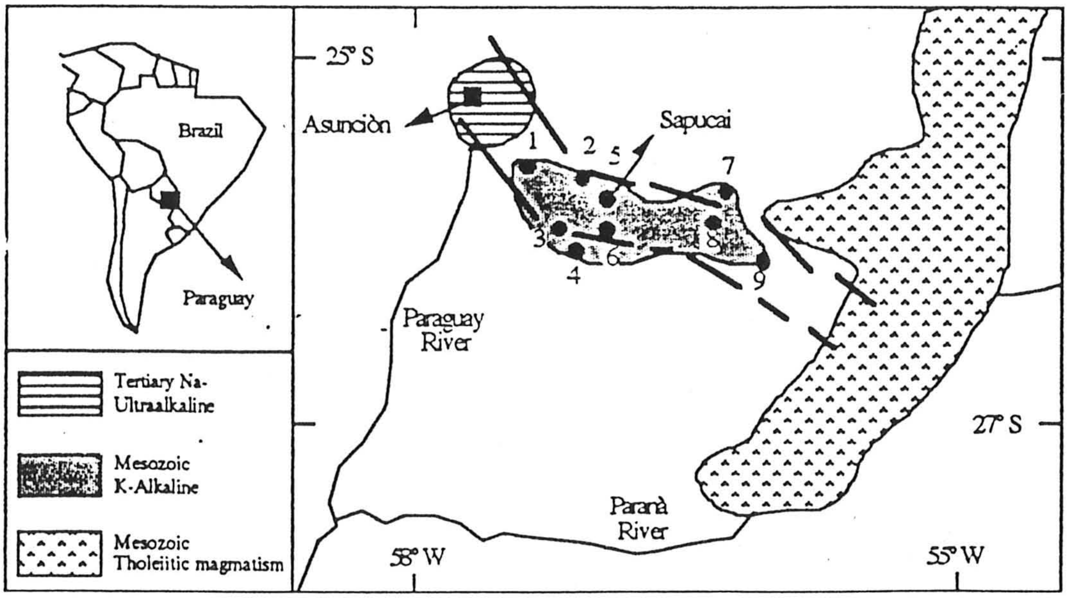

Fig. 1 - Sketch map showing the Asunciòn-Sapucai graben and the main occurrences of magmatic rock-types. Number of K-complexes and plugs, as in Table 1.

The alkaline rock-types, intruded into the continental Silurian sandstones of the Caacupé Formation (Bellieni et al., 1986 and therein references), vary from trachybasalts and basanites to phonolites and peralkaline phonolites and their intrusive equivalents, i.e. alkaline gabbros and theralites to nephelin syenites.

The emphasis of this study will be on the geochemistry of basic-intermediate rock-types sampled in nine complexes and plugs of Asunciòn-Sapucai graben

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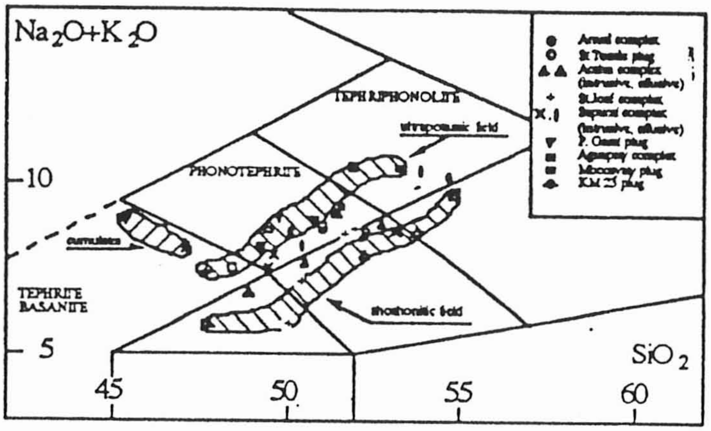
(ASU) and systematically showing metaaluminous tendency (i.e. $(Na_2O+K_2O)/Al_2O_3$ molar ratio < 1).

Fig. 2 - Total alkali - SiO_2 diagram with sub-divisions from Le Maitre (1989). The dashed fields as inferred from Peccerillo & Taylor (1976) and Foley (1987). Source of data: this work and Comin-Chiaramonti & De Min (unpublished averaged analyses)



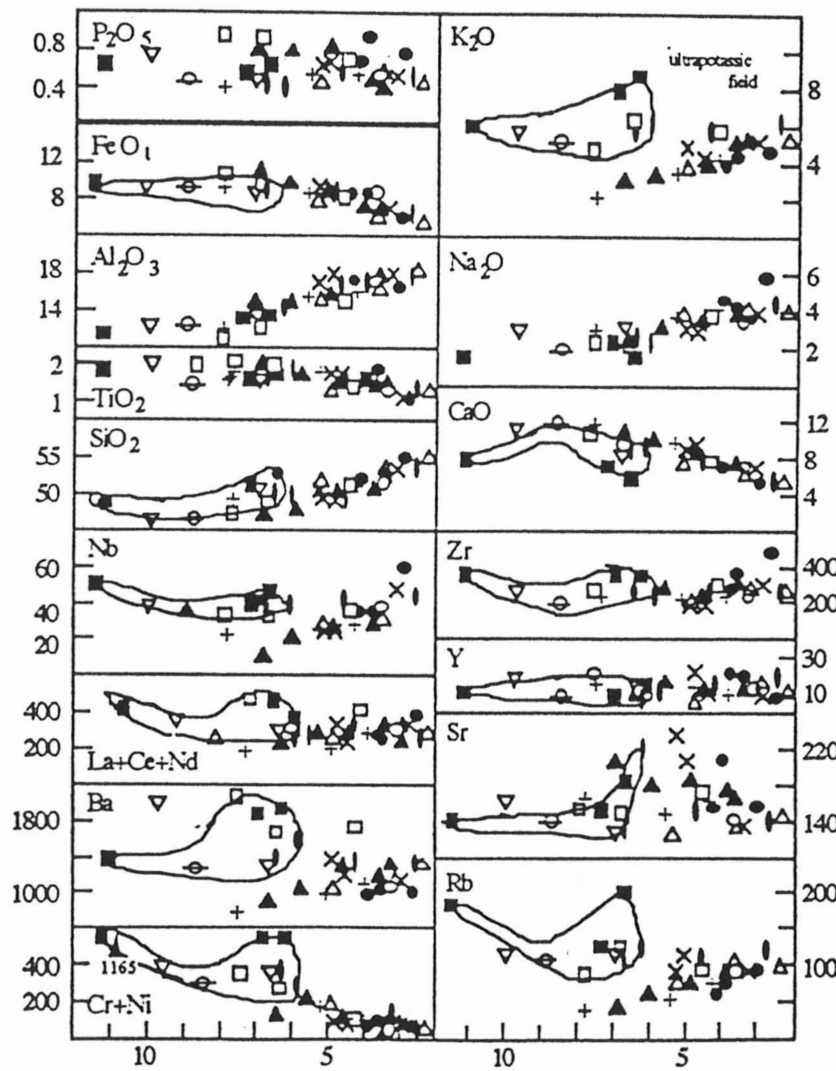
Representative and averaged analyses are plotted in TAS and variation diagrams (Figs. 2 and 3, respectively) and selected analyses are reported in Table 1.

Table 1

	1 Arrua-I	2 St Tomas	3 Acahay		4 St José		5 Sapucai		6 Garay	7 Aguapety	8 Mbocayaty	9 CerroKm23
	PS 204	3090	3341	3344	PS 233	PS 237	PS 30	PS 31	PS 245	PS 264	PS 263	25(a)
SiO_2	54.97	52.17	47.41	52.32	51.55	49.85	49.35	53.90	45.11	49.35	53.26	47.03
TiO_2	1.21	1.34	2.02	1.52	1.61	1.85	1.78	1.43	2.06	1.95	1.81	1.60
Al_2O_3	17.27	17.71	15.00	16.23	17.02	13.02	18.12	18.29	13.11	13.19	14.32	12.98
Fe_2O_3	1.02	1.27	1.65	1.30	1.24	1.44	1.30	0.99	1.42	1.47	1.11	1.49
FeO	5.84	7.24	9.41	7.43	7.06	8.23	7.42	5.67	8.10	8.42	6.32	8.50
MnO	0.15	0.18	0.18	0.16	0.15	0.18	0.16	0.14	0.19	0.17	0.11	0.18
MgO	3.12	3.71	6.89	5.24	4.29	7.68	4.87	2.84	9.75	6.76	6.57	8.70
CaO	5.24	7.34	11.06	7.66	8.01	11.80	8.94	5.64	10.55	9.28	5.41	11.71
Na_2O	6.09	3.91	2.78	3.99	4.53	3.36	3.15	4.63	3.41	2.60	2.10	2.43
K_2O	4.36	4.62	2.80	3.69	3.97	2.20	4.22	5.95	5.53	5.93	8.38	4.90
P_2O_5	0.73	0.51	0.80	0.46	0.56	0.38	0.68	0.51	0.77	0.88	0.61	0.47
Fe_2O_3	4.13	3.02	3.47	4.99	2.48	3.03	3.02	3.22	4.45	2.56	3.30	3.76
FeO	2.82	5.47	7.50	4.00	5.78	6.62	5.67	3.55	5.15	7.24	4.11	6.27
LOI	2.51	1.71	1.03	1.04	1.20	0.99	0.83	0.88	1.23	1.25	2.17	0.99
Σ	99.47	99.69	99.17	100.17	99.31	99.27	98.90	99.22	99.31	99.29	99.38	99.28
mg#	0.488	0.477	0.566	0.557	0.520	0.629	0.539	0.472	0.682	0.589	0.649	0.646
A.I.	0.85	0.65	0.51	0.65	0.69	0.61	0.54	0.77	0.88	0.81	0.87	0.72
K_2O/Na_2O	0.72	1.18	1.01	0.93	0.88	0.66	1.34	1.29	1.62	2.28	3.99	2.02
Cr	42	22	115	155	57	153	37	25	288	241	429	250
Ni	25	13	44	50	22	47	15	9	109	56	131	60
Sc	10.9	-	36.5	23.9	25.8	39.4	26	9.9	36.8	32.4	56.3	-
Rb	103	100	53	92	81	41	116	128	114	136	203	115
Sr	1562	1409	1856	1224	1555	1597	1853	514	1624	1507	1811	1385
Zr	498	267	224	225	277	282	213	291	279	252	382	207
Nb	62	41	16	31	34	28	26	48	41	38	48	39
Ta	8.4	5.1	1.8	2.3	2.6	1.5	1.4	1.8	3.1	2.8	3.2	-
Ba	1094	1186	1003	1117	1142	729	1268	1425	1958	1741	1995	1331
Th	24.5	11.9	15.6	4.8	9.1	8	8.5	12.7	6.6	6.2	9.8	9
U	6	-	4.5	1.3	2.4	1.8	1.9	2.9	1.7	1.9	3.1	-
Y	15.9	19	15.6	11.4	15.2	23	15	26.3	22	18.4	19	15
La	106.4	79	58.7	68	81.1	52	66.2	98.9	106.3	83	108	71
Ce	209.6	146	144.9	147	154.7	106	129.1	151.4	177.5	163.5	197	146
Pr	20.3	-	14.7	12.9	15	-	12	19.3	27	-	-	-
Nd	68.7	60	59.4	44.1	54.2	50	45.3	60.3	78.4	66.3	65	59
Sm	16.6	9.4	11.8	12.1	13	10	13.7	14.9	21.3	11.1	12.9	9.6
Eu	2.7	1.9	3.1	2.4	2.6	1.9	2.5	2.6	2.5	3	2.5	2.6
Gd	3.1	3.9	4.7	6.4	4.1	5	7.3	5.5	5.5	5.8	4.3	5.4
Tb	0.53	-	0.77	0.71	0.6	0.8	0.9	0.67	-0.93	0.7	0.79	0.61
Dy	3.2	3.6	4.1	3.09	3.21	-	3.25	3.29	3.7	3.78	3.5	3.7
Ho	0.8	-	0.84	0.65	0.72	-	0.79	0.72	1.13	-	-	-
Er	2.11	1.81	1.62	2.01	1.77	-	2.27	2.01	2.2	1.47	1.2	1.3
Tm	0.29	-	0.26	0.27	0.28	-	0.28	0.35	0.34	-	-	-
Yb	1.6	1.48	1.4	1.41	1.62	1.6	1.3	1.53	1.3	1.16	1	1.1
Lu	0.23	0.21	0.225	0.247	0.268	0.25	0.222	0.257	0.249	0.112	0.12	0.14
$^{87}Sr/^{86}Sr$	0.70718(6)	0.70800(6)			0.70720(32)				0.70777(?)	0.70745(2)	0.70773(2)	0.70737(3)
R_0 (120Ma)	0.70685	0.70694			0.70694				0.70742	0.70700	0.70718	0.70696

Three main groups are apparent (Fig. 2): i) "Shoshonitic" (SHO) rock-types, common in the western complexes and plugs; ii) "ultrapotassic" (UK) rock-types (association III of Foley et al., 1987), dominant in the eastern complexes; iii) rock-types (K) intermediate between the above groups, widespread in the whole region.

Fig. 3 - Variations of major and selected trace elements in ASU alkaline rock-types with MgO as index of differentia-tion. Symbols as in Fig. 2.



In general, mg-values as well as Ni and Cr contents are relatively low and the rock-types with mg-values which might be appropiate for primary mantle melts show cumulus textures. Notably, the major and trace element variations in a single complex or plug are controlled by removal or accumulation of clinopyroxene ± olivine ± biotite ± Ti-magnetite ± plagioclase ± foids. However fractional crystallization does not explain the chemical differences between SHO+K and UK groups (Fig. 3). Note that in SHO+K rock types Rb, Ba and Nb have high positive correlations with K_2O and MgO, whereas Zr and Y display similar contents, 300 (±100) and 18 (±8) ppm, respectively, in both SHO+K and UK groups. In general, the scattered elemental variations suggest distinct magma reservoirs at shallow levels. The chemical differences may be due to different

H_2O and O_2 (F,P) activities responsible for the crystallization of biotite+apatite ± amphibole (cf. Comin-Chiaramonti et al., 1991).

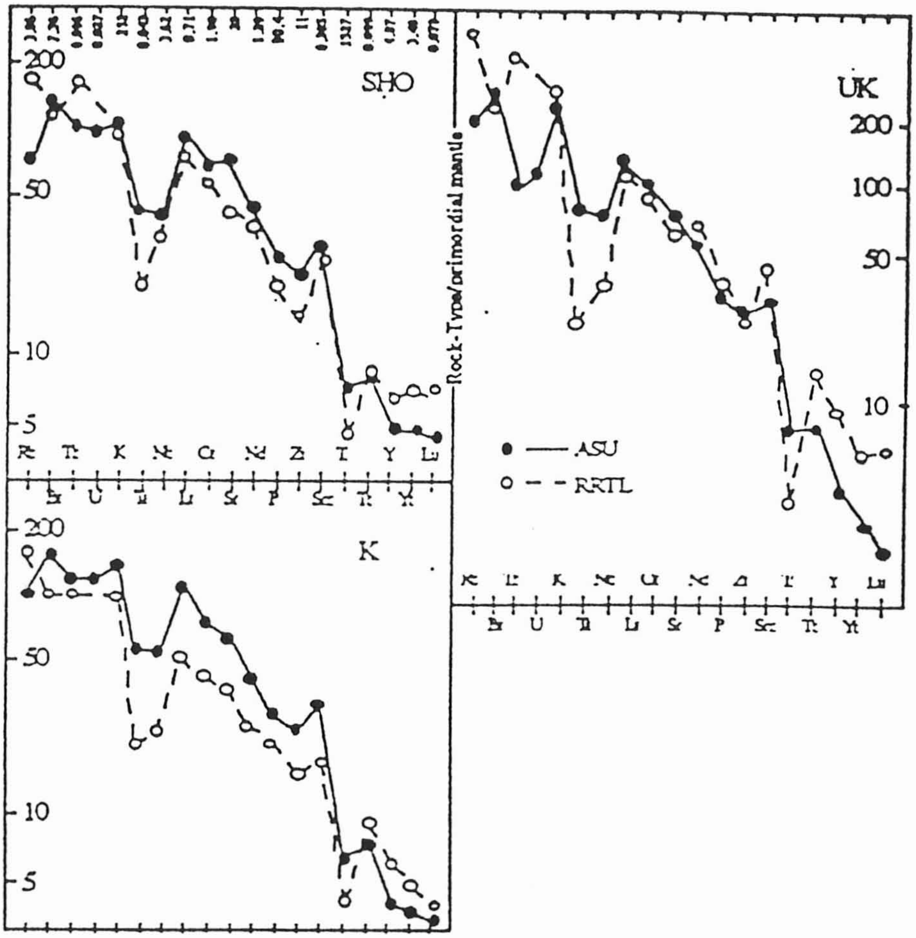


Fig. 4 - Primordial mantle normalized diagrams for ASU (Asunciòn-Sapucai) and RRTL (Roman Region) averaged analyses (SHO, K, UK; shoshonitic, K-alkaline and ultrapotassic rock-types). RRTL source data: Civetta et al. (1987); Beccaluva et al. (1991).

The observed geochemical trends for K-magmatism in Eastern Paraguay are quite similar to those of "Roman Region Type Lavas" (RRTL, Barton, 1979; Civetta et al., 1987; Beccaluva et al., 1991), where SHO, K and UK rock-types are believed to be originated from mantle peridotites variably contaminated by subducted crustal materials.

The spidergrams of Figure 4 show, for similar rock-types, similar negative spikes for Ta-Nb, Zr, Ti and positive spikes for Sm and Tb. The major differences regard the contrasting ratios relative to Rb/Ba, a negative anomaly for Th (U) in Paraguay rock-types which also have higher LREE/HREE (Y) ratios. Ba/Nb vs. La/Nb plot (Fig. 5) shows that ASU, RRTL, primordial mantle and E-MORB define an array which does not include the bulk continental crust.

In the Nb/Zr vs Th/Zr (Fig. 5) the K-magmatism of Paraguay (ASU) plots in the "subduction setting" of Beccaluva et al. (1991) even if it is related to extensional rifting. This suggests that the ASU chemical characteristics can be due to "metasomatized" mantle peridotites with Nb-bearing residual phase(s). This can explain the relatively high and constant $^{87}Sr/^{86}Sr$ initial ratios (av. 0.7071 ± 0.00003) of ASU magmatims, without the intervention of substantial crustal contamination.

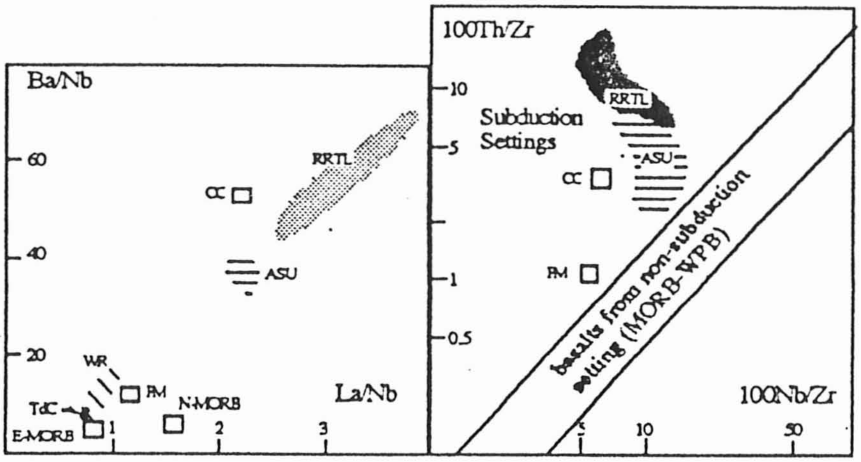


Fig. 5 - Ba/Nb vs La/Nb and 100Th/Zr vs 100Nb/Zr diagrams for averaged fields for ASU and RRTL (cf. Fig. 4). Source of data: this work (ASU, cf Table 1) and Civetta et al. (1987) + Beccaluva et al. (1991) for RRTL and MORB+WPB. CC: continental crust (cf Weaver, 1991); WR: Walvis Ridge (Humpheris & Thomson, 1983); TdC: Tristan da Cunha (Le Roex et al., 1990); PM: Primordial Mantle (Wood et al., 1979); N-MORB and E-MORB, from South Atlantic (Sun et al., 1979).

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