MESOZOIC DYKE SWARM IN THE SAPUCAI GRABEN (CENTRAL-EASTERN PARAGUAY)

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The western side of the central Paraná Basin, corresponding to eastern Paraguay, was the site of repeated and widespread magmatic activity since the Lower Cretaceous. Landsat, aeromagnetic and gravity data are consistent in indicating that the Eastern Paraguay region was subjected to NE-SW trending extension during Late Mesozoic times (Comin-Chiaramonti et al., 1991a, and therein references). The resulting normal faulting formed a complex rift-graben structure 25-45 km wide in the Asunción-Sapucai region, where alkaline rocks forming dykes, lava flows and shallow-level intrusive complexes, are particularly abundant (Fig. 1). This province, widely characterized by potassic rocks (90-120 Ma), abuts Mesozoic (128-130 Ma) tholeiitic volcanics of the Serra Geral Formation (Bellieni et al., 1986) on the eastern side, and Tertiary (60-38 Ma) ultraalkaline (sodic) rocks on the western side (Comin-Chiaramonti et al., 1991a). Generally, the alkaline rocks of the Sapucai area intruded Silurian sandstones of the Caacupè Formation and are intersected by mainly NW-SE trending dyke swarm of at least 200 dykes, 0.5-20 m thick. These dykes are formed by K-alkaline assemblages and rock-types span from tephrites to phonolites and from trachybasalts to latites (Fig. 2).

The diversity in types of mineral assemblages and the heterogenous distribution of megacrysts vs microlites, dictate that one or a few large magma chambers underlying the Sapucai system would not have been sufficient to produce the diversities that exist solely through fractional crystallization. The crystallochemical data are in favour of the existence of a large number of small magma-filled reservoirs that reflect differences in H2O and O2 activities and repeated mixing among batches of metaaluminous precursors with variably fractionated and degassed magmas (Comin-Chiaramonti et al., 1991b).

However, almost two "end-member" trends are apparent among all the possible arrangements (Fig. 2, Table 1), characterized by relatively low and high K_2O, TiO_2, P_2O_5, Nb, Sr, Rb and Zr and by high and low SiO_2 contents, respectively, fitting the trachybasalt to latite (TB-L) and

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tephrite to phonolite (T-P) lineages.

Hygromagmatophile element patterns (primordial mantle normalized, Fig. 3) show strong LILE/HFSE fractionations and negative anomalies for Ta, Nb, P, Zr and Ti. These behaviour, according to various authors (e.g. Edgar, 1980; Pearce, 1983); Thompson et al., 1984; Beccaluva et al., 1991) would support a subduction-driven activity. In particular, the geochemical features such as those observed in the magmas from Asunción-Sapucai rift, T-P and TB-L respectively, are similar to "high-K" and to "low-K" series from Roman Region type lavas (RRTL: cf. Civetta et al., 1987). Notably, the RRTL are interpreted (Beccaluva et al., 1991) as generated from mantle sources modified by components from subducted crustal materials "at a destructive, post collisional plate margin".

In the Th/Zr vs. Nb/Zr diagram (Beccaluva et al., 1991) the Asunción-Sapucai dyke swarm overlaps to some extent the RRTL, plotting away from the narrow band relative to mid-ocean ridge and intraplate sources (Fig. 4). Also on the Th/Yb vs. Ta/Yb tectonic discrimination diagram (Pearce, 1982), T-P and TB-L tend to be distinct from within-plate field (Fig. 5).

Thus strong mineral-chemical (Comin-Chiaramonti et al., 1991a) and geochemical affinities have emerged between Sapucai dykes and the Roman Region type lavas. It is clear that in Paraguay this RRTL occurs in a rifted continental setting devoid of orogenic and/or subduction-driven activity. Therefore, a causal relationship of the latter activity with RRTL is not supported and remains questionable.

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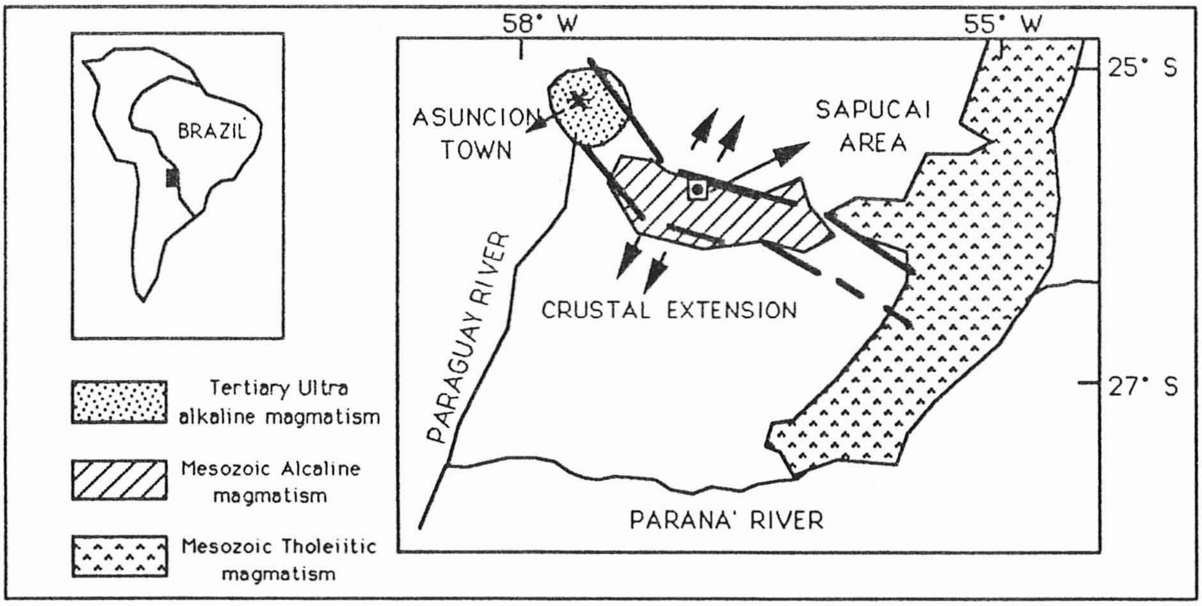

Figure 1 - South-Eastern Paraguay sketch map showing Asunción-Sapucai and the main occurrences of magmatic rocks. The square outlines the area with the highest concentration of outcropping dykes (more than 70%).

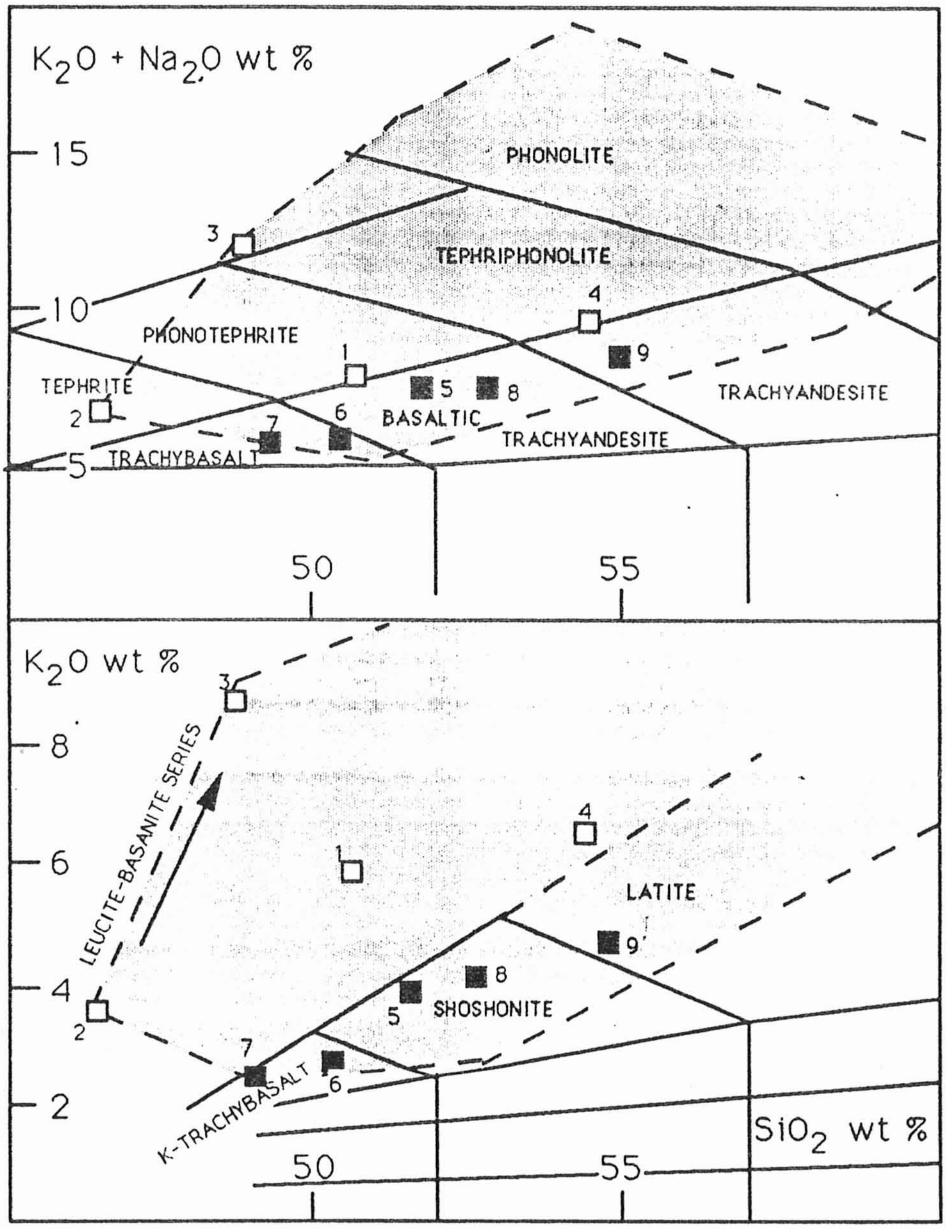

Figure 2 - Field of K-alkaline dykes from Sapucai area in the TAS (Le Bas et al., 1986) and K_2O-SiO_2 (after Beccaluva et al., 1991) diagrams. Representative single analyses: open and solid squares, high and low K_2O rock-types, respectively (numbers as in Table 1).

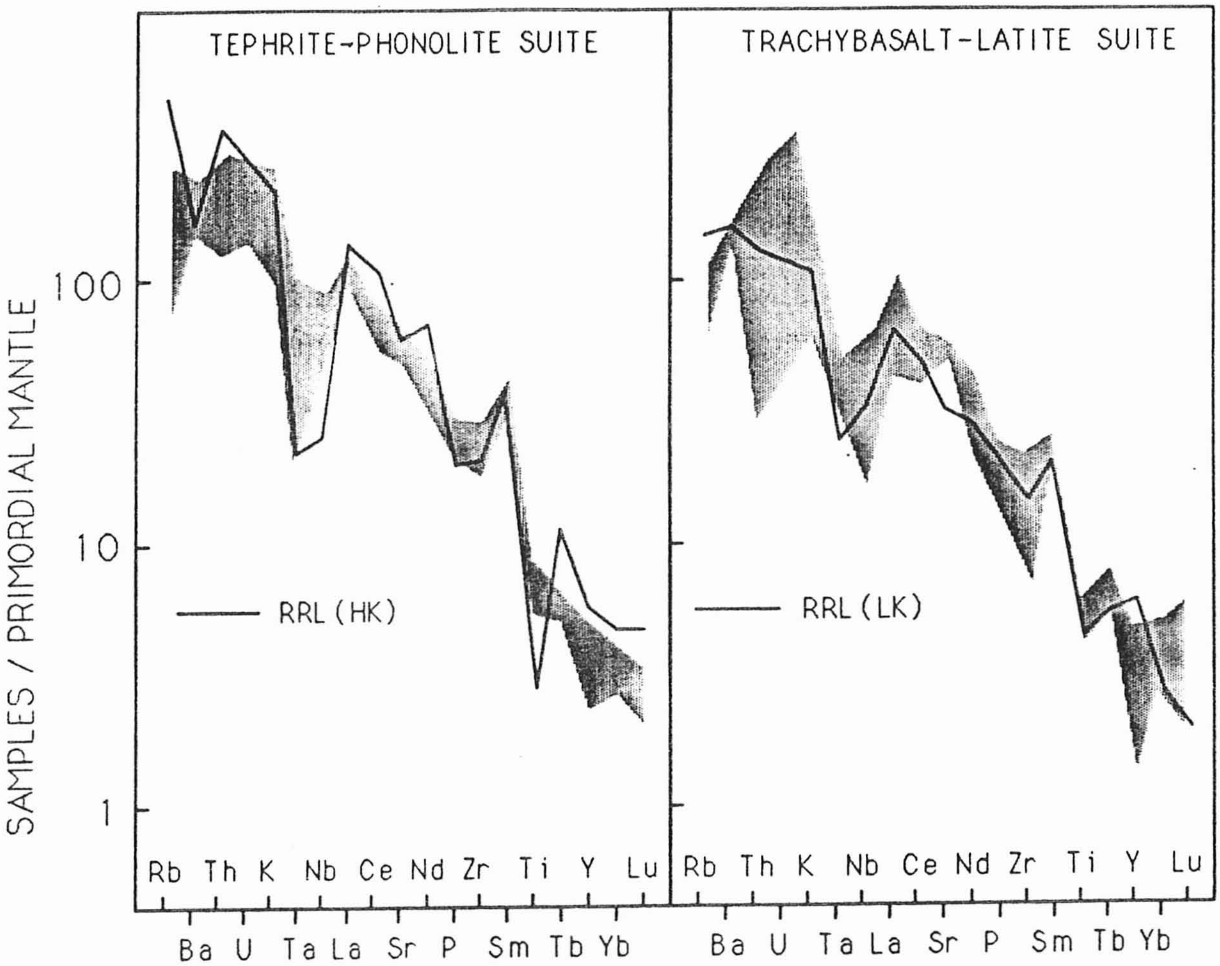

Figure 3 - Primordial mantle normalized diagram depecting the variation in composition of the Sapucai dykes. For comparison the averaged compositions ("high potassium": HK, and "low potassium": LK) of Roman Region Lavas (Civetta et al., 1987) are also reported.

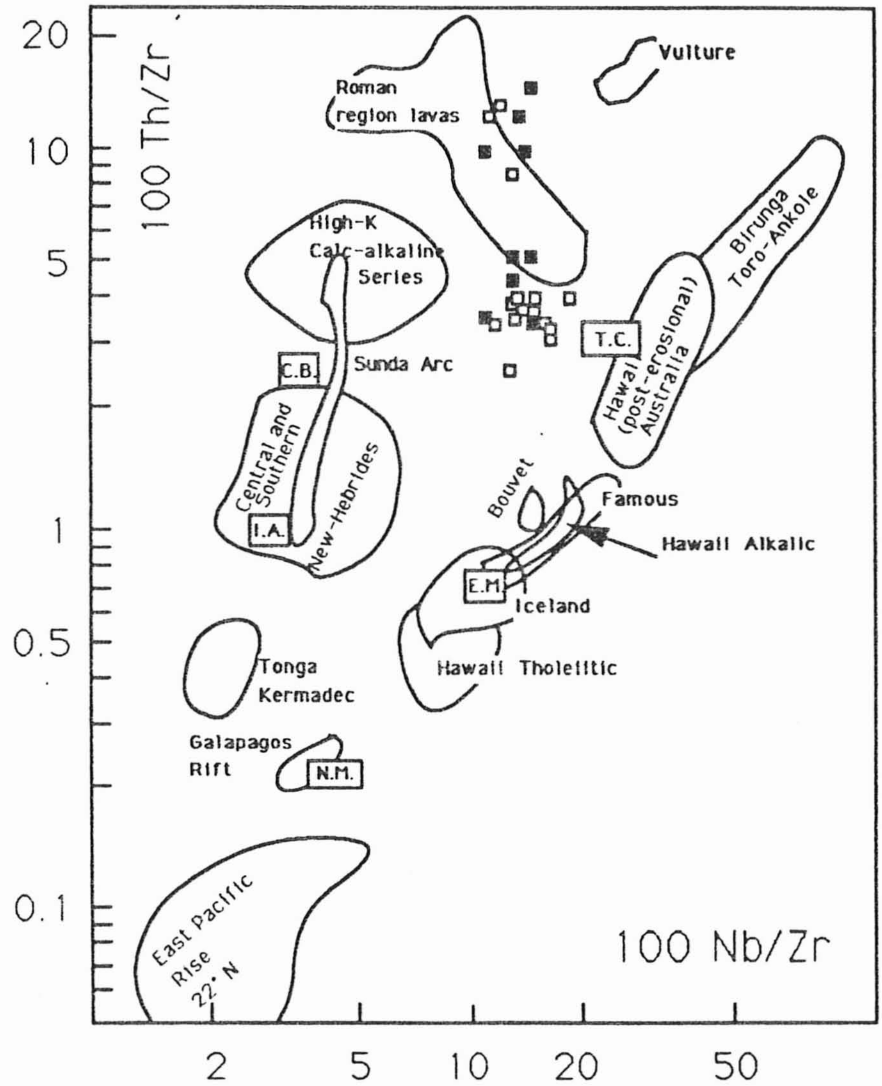

Figure 4 - Thx100/Zr vs. Nbx100/Zr (Beccaluva et al., 1991: Fig. 8) showing the fitting of Sapucai dykes (symbols as in Fig. 2; source of data: Table 1, Bitschene, 1987, and Censi, Comin-Chiaramonti & De Min, unpublished data). TC, NM, EM, IA and CB are representative of Tristan da Cunha trachybasalt, N- and E-MORB, island arc tholeiitic and calc-alkaline basalts (Sun, 1980; Thompson et al., 1984), respectively.

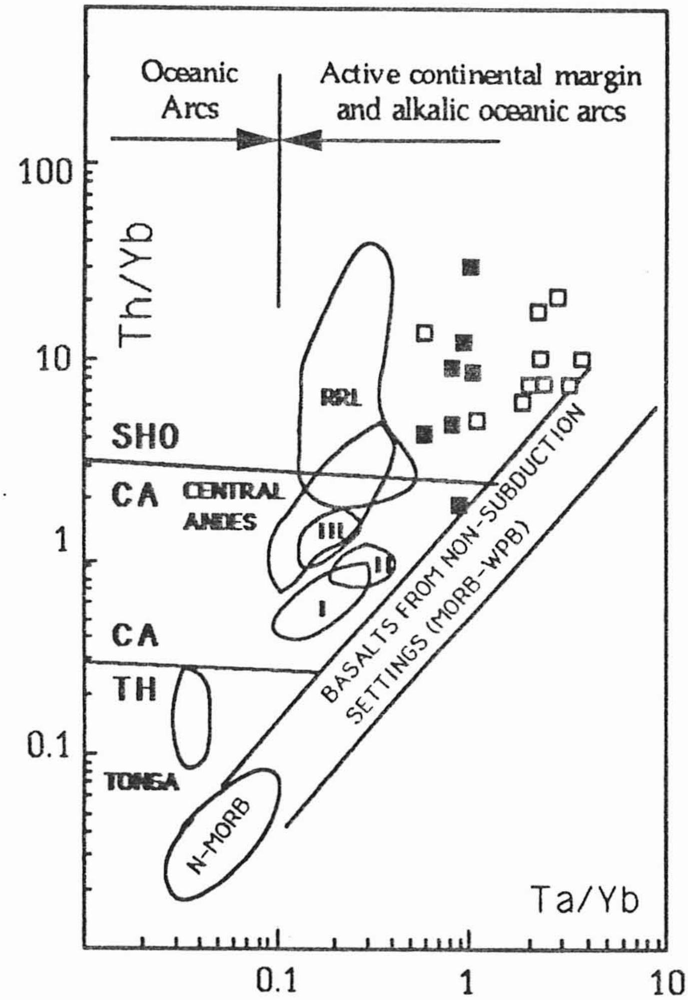

Figure 5 - Th/Yb vs. Ta/Yb diagram showing the composition of Sapucai dykes (symbols an in Fig. 2; source of data: Table 1 and Censi, unpublished data). The mantle array, tholeiitic (TH), calc-alkaline (CA and Central Andes) and shoshonitic (SHO) boundaries for arc basalts are taken from Pearce (1982). Source of RRL ("Roman Region lava" field) from Civet87, and therein references). The fields relative to tholeiitic basalts from Paraguay regions are also shown (source of data: Cordani et al., 1988; Marques et al., 1989): I, L-Ti (TiO_2<2%, ($^{87}Sr/^{86}Sr$)i<0.706); II, H-Ti (TiO2>2%, (87Sr/86Sr)i<0.706); III, L-Ti (TiO_2<2%, ($^{87}Sr/^{86}Sr$)i>0.707).

Table 1 - Selected analyses from Sapucai dykes. Major elements normalized to 100% on volatile-(LOI) free basis, assuming $Fe_2O_3/FeO = 0.175$.

	1	2	3	4	5	6	7	8	9
	PS111	PS34	PS102	PS164	3318	PS127	PS130	PS166	PS136B
SiO_2	50.64	46.40	48.82	54.39	51.54	50.21	49.06	52.59	54.82
TiO_2	1.69	2.41	1.97	1.61	1.39	1.47	1.15	1.14	1.07
Al_2O_3	14.71	13.43	16.47	17.23	14.50	14.14	16.10	17.18	18.23
Fe_2O_3	1.30	1.80	1.29	1.09	1.23	1.49	1.55	1.25	1.03
FeO	7.41	10.27	7.32	6.24	7.03	8.52	8.90	7.07	5.91
MnO	0.16	0.19	0.15	0.12	0.13	0.15	0.19	0.18	0.14
MgO	7.80	7.31	3.87	2.95	8.09	8.29	6.42	4.06	3.00
CaO	7.73	10.71	6.98	5.98	7.91	9.45	10.68	8.38	6.51
Na_2O	2.35	3.47	3.80	3.38	3.90	3.36	3.43	3.79	4.17
K_2O	5.86	3.43	8.62	6.47	3.75	2.58	2.22	3.90	4.58
P_2O_5	0.35	0.59	0.70	0.53	0.53	0.35	0.30	0.46	0.53
Fe_2O_3	3.81	7.05	4.15	2.70	2.78	3.65	4.66	4.02	1.30
FeO	4.94	4.96	4.43	4.60	5.35	6.17	5.62	4.35	5.54
LOI	1.07	3.14	2.39	2.07	2.81	2.84	3.23	1.81	1.02
Σ	98.83	98.84	99.03	99.28	99.42	98.04	98.81	99.35	99.22
Cr	289	190	53	46	456	429	160	43	12
Ni	65	85	22	29	162	172	36	29	7
Rb	71	69	260	132	89	98	66	56	88
Ba	1292	1626	1935	1550	1330	1284	1368	1085	1145
Th	31.3	13.8	12.7	27.9	13.3	9.0	2.8	19.8	31.7
U	7.4	2.7	3.5	8.6	3.5	1.7	1.4	4.9	9.5
Ta	1.1	3.4	5.1	3.2	1.3	1.5	1.4	1.7	2.1
Nb	29	52	62	43	33	26	11	23	37
La	77	106	98	98	76	78	33	59	76
Ce	127	162	186	164	137	128	79	104	135
Sr	1353	1913	1626	1680	1309	1398	1336	1439	1412
Nd	51	73	63	62	61	58	31	49	56
Zr	225	358	365	316	236	167	73	191	260
Sm	13.6	20.0	15.9	16.1	10.4	7.7	9.2	9.8	11.2
Tb	0.75	0.67	0.59	0.60	0.63	0.88	0.63	0.79	0.91
Y	19	29	13	20	25.2	10.5	6	20	20
Yb	2.01	1.97	1.59	1.39	1.3	1.8	1.51	2.0	2.3
Lu	0.17	0.29	0.23	0.25	-	0.37	0.17	0.48	0.43
mg	0.65	0.56	0.49	0.46	0.67	0.63	0.56	0.51	0.48
K_2O/Na_2O	2.49	0.99	2.27	1.91	0.96	0.77	0.65	1.03	1.10