

syms = 078554J

HTiB and are usually characterized by R_o values lower than 0.7060. This also applies to the LTiB from southern Paraná which have R_o below 0.7060. Thus only the basalts with $R_o < 0.7060$ may be considered slightly contaminated or "uncontaminated".

Palmas acid volcanics (PAV) are anomalously enriched in Rb, U and Th relative to the Chapecó analogues (CAV). Notably, PAV have high R_o values (0.714-0.728), while CAV have comparatively low R_o values (0.706-0.708).

Notable differences (up to 4 times) in incompatible element ratios between "uncontaminated" HTiB and LTiB may be generated by the same type of mantle (garnet peridotite) source material by different degrees of melting (e.g. HTiB = 5%, and LTiB = 20%). In addition, Sr- and Nd-isotope data and other chemical differences indicate existence of a large-scale mantle heterogeneity between the mantle source materials of the NPP and SPP basalts. The preferred model for explaining the Paraná basalt variations combines different melting degrees and a heterogeneous mantle source. Small-scale mantle heterogeneity is responsible for the detailed individual sample variation within NPP and SPP.

The generation of Palmas and Chapecó acid volcanics is in part consistent with fractional crystallization starting from the associated LTiB and HTiB, respectively. However, the virtual absence of intermediate rock-types and the confinement of the acid volcanics towards the Brazilian continental margin, suggest that a melting model involving NPP and SPP basic materials with different composition from the lower crust is a more plausible alternative. The basic parental materials might be represented by mafic granulites or, more probably, by basalts trapped at the crust mantle discontinuity (crustal underplating), corresponding in composition to the contrasting low- (SPP) and high- TiO_2 (NPP) basalts that flooded the Paraná basin in Lower Cretaceous times.

PETROLOGICAL AND GEOCHEMICAL STUDIES OF ALKALINE ROCKS FROM CONTINENTAL BRAZIL.

4. THE JUQUIÁ INTRUSIVE ALKALINE-CARBONATITE COMPLEX, STATE OF SAO PAULO

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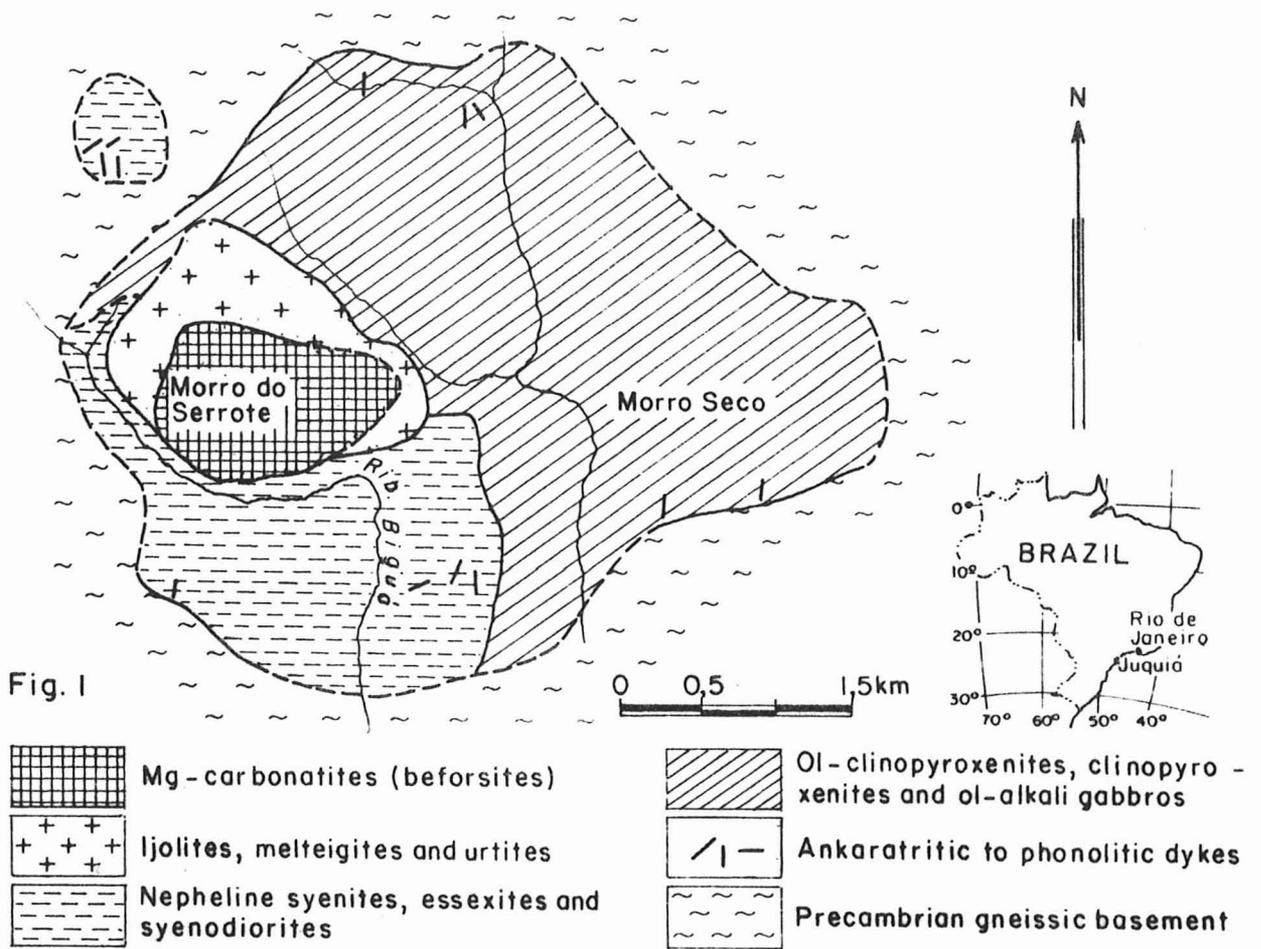
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The Juquiá intrusive complex outcrops over an area of about 15 km² in the Precambrian gneissic basement, about 150 km SW of the city of São Paulo. K/Ar data indicate an age of 127 Ma (Amaral et al., 1967).

The circular intrusion, about 5 km wide, is dominated in the northeastern sector by cumulitic olivine-clinopyroxenites and clinopyroxenites, whereas to the SW the predominant nepheline syenites, ijolites (with minor amount of melteigites and urtites) and carbonatites outline a subannular concentric pattern. Olivine alkali gabbros and essexites/syenodiorites are also found associated with clinopyroxenites and nepheline syenites, respectively, in the northern and southern parts of the complex. Ankaratritic and phonolitic dykes are also present. A preliminary, modified version of Born's (1971) geologic map, mainly based on field and petrographic evidences, is showed in Figure 1.

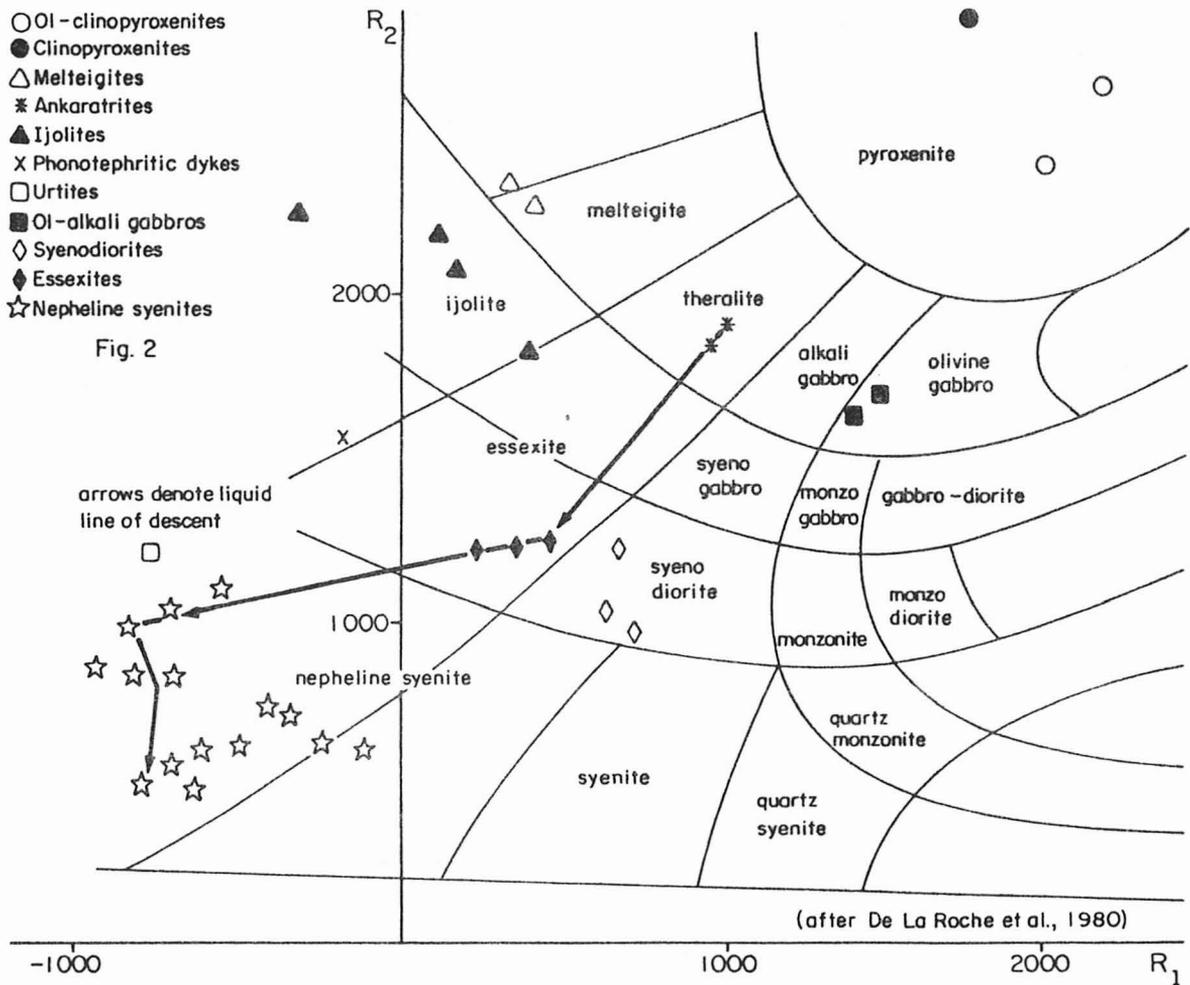
Petrographically, olivine-clinopyroxenites are mesocumulates consisting of cumulus Mg-olivine and salitic clinopyroxene, intercumulus magnetite, ilmenite plagioclase and poikilitic phlogopite. Orthocumulitic olivine alkali gabbros have the same mineralogy except for a higher content of plagioclase. Essexites and nepheline syenites show hypidiomorphic textures characterized by the disappearance of oligoclase, from the former to the latter, and by the gradual modal increase of nepheline and orthoclase, coupled with variation of clinopyroxene from salite to Fe-salite up to acmite concomitantly with the transition to the peralkaline field. The accessory phases (apatite, sphene and calcite) show the highest modal content for nepheline syenites with agpaitic index of 0.96-1.05 and differentiation index (D.I.) 65-73. Melteigites, ijolites



and urtites are mesocumulates characterized by increasing nepheline/salite (zoned to Fe-salite) ratio and highly variable content of Ti-magnetite, biotite, alkali feldspar, sphene, apatite, calcite and \pm perovskite. Classification of the rocks on chemical basis (De La Roche et al., 1980) is showed in Figure 2.

Magnesio-carbonatites (beforsites) are essentially composed of dolomite, apatite, calcite, magnetite and phlogopite.

Petrographical characteristics and chemical evolutionary trend suggest an origin of the complex by dominant shallow fractional crystallization processes which proceeded inward from the periphery, starting from an ankaratritic parental magma. From ankaratrites through essexites (and phonolitic tephrites) to nepheline syenites (and phonolites), Ca, Mg, Fe, Ti, Ni and Cr decrease, being enriched in the corresponding cumulates, whereas Si, Al, Na, K, Rb and Nb increase. Sr and Ba increase up to the least differentiated nepheline syenites, then decrease in the most fractionated nepheline syenites due to predominant



removal of alkali feldspar in the extremely residual liquids. Continuous removal of minor phases such as apatite and sphene starting from essexitic magmas appears to be responsible for the bulk REE depletion and modification of intermediate REE pattern from positively fractionated to flat in the most fractionated nepheline syenites (Fig. 3).

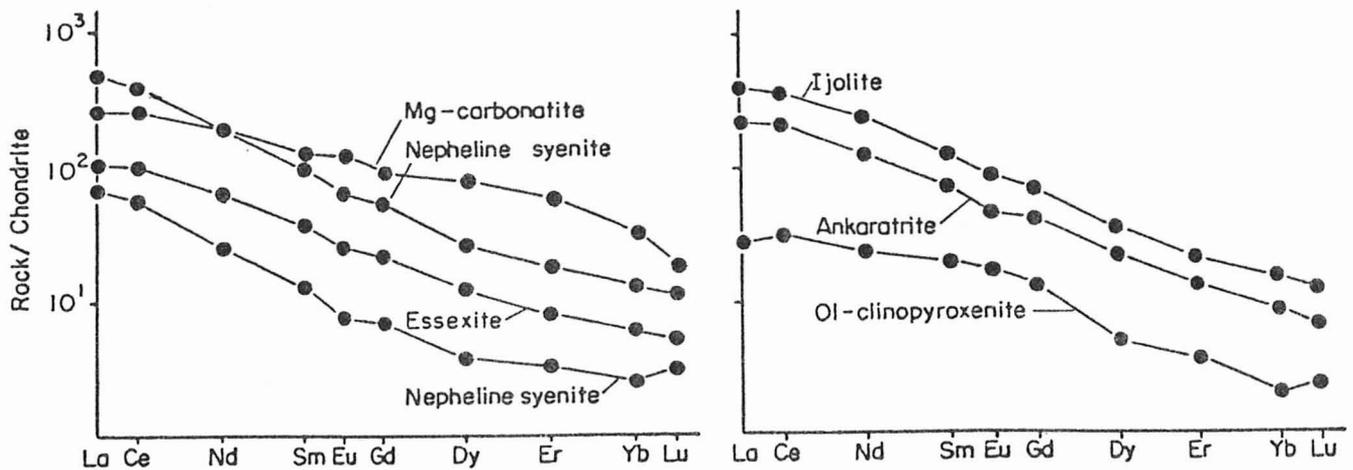


Fig.3

Least square mass balance calculations between whole rock and constituent minerals indicate that essexites (D.I. 60) could be produced from an ankaratritic magma (D.I. 30) by about 66% fractionation of salitic clinopyroxene (36%), olivine (8%), phlogopite (8%), plagioclase (6%), Ti-magnetite (5%), and ilmenite (3%) resulting in the formation of the olivine-clinopyroxenite and olivine gabbro cumulates. Moderately fractionated nepheline syenites (D.I. 65-72) could in turn be derived from essexitic magmas by about 82% removal of solid phases involving alkali feldspar (30%), oligoclase (21%), salitic clinopyroxene (21%), Ti-magnetite (5%), ilmenite (4%), and apatite (1%), whose bulk chemistry perfectly corresponds to syenodiorites outcropping in the southern part of the complex. The successive fractionation step requires formation of immiscible carbonate and nepheline syenite magmas coupled with continuous fractional crystallization processes: computations suggest that 2-4% carbonatitic liquid could exsolve from nepheline syenitic magma (D.I. 65-72) whose composition closely approaches the miscibility gap in the $\text{Na}_2\text{O}+\text{K}_2\text{O}-\text{SiO}_2+\text{Al}_2\text{O}_3-\text{CaO}$ experimental system. Immiscibility appears to have occurred in the most SiO_2 -undersaturated, CO_2 -enriched peralkaline nepheline syenite magmas which, in addition to exsolving carbonatites, would also continue to fractionate biotite (8%), nepheline (5%), salite (5%), Ti-magnetite (3%), sphene (2%), and apatite (1%) giving rise to cumulitic ijolites and melteigites at the interface between nepheline syenites and the internal carbonatite nucleus. Elemental partitioning between carbonatite and silicate melts indicates that heavy-REE, Y, P and Sr are strongly enriched in the carbonatite fraction with K_d varying in the range 3-25. In order to fit the chemical constraints posed by both experimental and mass balance modelling a higher original content of Na, K (and related elements) should be admitted for the immiscible carbonatite liquid and, by implication, the possibility that a large quantity of alkalis has been lost in aqueous fluids possibly producing fenitization phenomena in the country rock.

Results from mass balance calculations are in good agreement with the volume estimates for the main lithotypes of the complex (olivine-clinopyroxenites +

olivine gabbros, 74%; nepheline syenites + essexites + syenodiorites, 20%; ijolites + melteigites + urtites, 4.2%; carbonatites, 1.8%) suggesting that the parental ankaratritic magma body fractionated essentially under closed system conditions.

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PETROLOGICAL AND GEOCHEMICAL STUDIES OF ALKALINE ROCKS FROM CONTINENTAL BRAZIL.

5. THE MORRO REDONDO ALKALINE COMPLEX, STATE OF RIO DE JANEIRO

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The Morro Redondo alkaline complex is located about 160 km west of Rio de Janeiro and east of the larger alkaline complexes of Itatiaia and Passa Quatro. It crops out over an area of 8 km² within the gneissic Precambrian basement. K/Ar dating give an age around 66 Ma (Ribeiro Filho & Cordani, 1966).

The complex is composed of dominant medium- to coarse-grained nepheline syenites in the eastern sector and by mainly altered phonolitic breccias in the central-west (Valença et al., 1983). Some micro-essexitic rocks have also been found at the contact with the Precambrian basement to the east, most probably representing a border facies of the intrusion. Phono-tephritic to peralkaline