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# U-Pb AGES IN ZIRCONS FROM ROCKS OF ALKALINE AFFINITY FROM THE CARDOSO ISLAND, SOUTHEAST OF SÃO PAULO STATE

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## INTRODUCTION

The data in this paper result from a geological and geochronological study of the terrains outcropping in the Cardoso Island, located in the southeastern littoral of São Paulo State, at the Paraná State border. The island, of approximately 151 km$^2$ (Fig. 1), is an environment protection area (APA), managed by the Instituto Florestal of the Secretaria do Meio Ambiente of São Paulo State. It is hilly, the maximum altitude reaching 814 m, and covered by the Mata Atlântica dense vegetation.

Geologically, an igneous complex (Weber 1998), represented by light-gray, leucocratic, inequigranular, medium- to coarse-grained syenitic rocks (aegirine/augite-hornblende-alkali feldspar syenite) mainly forms the Cardoso Island. These rocks, named Três Irmãos Syenite (TIS) show magmatic flow orientation given by the alignment of potassic feldspar and amphibole phenocrysts and are crosscut by gray-rosy, inequigranular, medium-grained leucocratic hornblende/biotite- alkali feldspar granites, related to the Cambriú Granite (CG). In the southern portion of the island, a belt of medium- to high-metamorphic grade metasedimentary rocks occurs (low-pressure amphibolite facies, ~ 4 kb), structured along an E-W general trend. Quartz schists, mica-quartz schists and quartz-mica schists, usually with andalusite and cordietite, predominate. These metasedimentary rocks continue in the continent, extending to the south in narrow belts. Equivalent metasedimentary belts were recognized within the Paranaguá Batholith granitoids (Basei *et al.*, 1990, Siga Jr. 1995).

## GEOCHEMISTRY

The chemical analyses for TIS and CG yield a metaluminous series, alkaline affiliation with characteristics of anorogenic to late-orogenic granites.

The REE diagram (Fig. 2a) enhances the geochemical behavior of these rocks, which shows strong fractionation and gain in HREE, except for two samples that present HREE depletion, probably due to the participation of residual amphibole during its formation. The jigsaw pattern suggests that these bodies originated from crustal melting, typical of anorogenic to late-orogenic granites and that the fractionation in these elements can be related to hornblende crystallization. The hypothesis of analytical problems is not ruled out. A variation concerning Eu is observed, some samples showing greater negative anomaly than in others, suggesting that feldspar had an important rule during partial melting, followed by crystal fractionation.

For the metasedimentary rocks, only the data relative to REE (Fig. 2b) were considered, which show a strong fractionation between LREE and HREE. The strong Ce depletion is relative to the rocks that may have lost Ce during weathering. The other two samples are from more psammitic terms, which do not show such anomaly. The slight Eu depletion and LREE enrichment indicate that andesitic rocks developed in continental island arcs or arcs formed close to continental margins as sediment sources (Bathia and Crook, 1986). The LREE enrichment also implies that 80% of the original material has as source felsic igneous rocks (Ericksson and Soegaard, 1985).

## GEOCHRONOLOGY

U-Pb analyses in zircons from the Cardoso Island gray syenitic terms (TIS) were performed for two outcrops, one located in the Fole Beach (sample WW-46), and the other in the Sambaqui Mirim River (sample WW-75). For the former, two zircon fractions M(-4) and NM(-5) were concentrated, which intercept the Concordia curve at 618 ± 7 Ma, (Fig 2c).

Prismatic, idiomorphic, translucent zircons with rare fluid inclusions predominate in all fractions observed and were therefore chosen for dating. Three zircon fractions from sample WW-75 (alkali feldspar syenite) were analyzed, from which M(-5) and M(-4) plotted relatively close to the Concordia curve in the U-Pb diagram, presenting the age of 619 ± 29 Ma for the upper intercept (Fig. 2d). The third fraction NM(-5) was not considered in the calculations for it plots above the Concordia curve, indicating probable Pb and/or U mobility. Additionally, the Discordia curve was drawn including the diagram origin (forced as zero), due to the proximity of these points. The dated zircons show a typology very similar to that observed in the zircons of the syenitic rock outcropping in WW-46. The ages obtained for both samples are interpreted as related to the time of zircon crystallization, thus indicating the time of emplacement of the syenitic rocks. The K-Ar analysis done in amphiboles, concentrated from a sample of the same outcrop (WW-46), yielded the age of 597 ± 14 Ma, indicating quick cooling.

ROSY GRANITOIDS OF CAMBRIÚ TYPE (CG)

The geochronological pattern observed in the Cambriú-type granitoids that crosscut the TIS syenitic terms is distinct from that presented by those syenites. The name "Cambriú type" is applied due to the excellent expositions of these rocks in the homonymous locality, where enclaves of the syenitic terms with varied shapes and sized are observed within the rosy granitoids.

U-Pb analyses were performed in zircon fractions M(-1), M(-2), M(-3) and M(-4), extracted from the syenogranitic rock numbered WW-79. The data obtained are well distributed and relatively aligned in the U-Pb diagram, indicating for the upper intercept an age of 583 ± 45 Ma (Fig. 2e). Such zircons did not undergo abrasion, which could cause strong clustering of points (mainly the M-4 fraction) on the Concordia curve, resulting in a higher precision of the age obtained. These zircons are long prisms, biterminated, with well-developed edges and faces, and in general containing fluid inclusions. They are distinct from those concentrated from TIS because they are fractured and light gray. These characteristics could explain part of the high discord yield by these zircons. K-Ar analysis done in amphiboles concentrated from a sample of the same outcrop (WW-79) indicated the age of 531 ± 5 Ma, relative to the cooling of these rocks.

## FINAL CONSIDERATIONS

The geochronological pattern for the Cardoso Island igneous rocks sets two distinct magmatic episodes, the older being TIS, with ages around 619 Ma, which defines as a probable age of formation of these rocks, with cooling around 597 Ma. The second episode regards CG with age of formation around 580 Ma and cooling around 531 Ma.

The geological relation between the terrains of the island and the continent suggests a possible continuity of the metasediments of the island with similar rocks that, from the Pariquera-Açu region, extend southwards throughout the coastal portion up to Guaraqueçaba and Paranaguá, and are thought to be correlated to the Rio das Cobras Formation. These metasediments crop out as narrow and elongated belts, suggesting a distribution conditioned to long NE-SW-trending lineaments.

The igneous and metamorphic rocks from the Cardoso Island, despite their particularities, possibly integrate the Paranaguá Domain Terrains (Basei *et al.*, 1990; Basei *et al.*, 1992 e Siga Jr, 1995) being significantly different from those observed in the other tectonic blocks known in the region.

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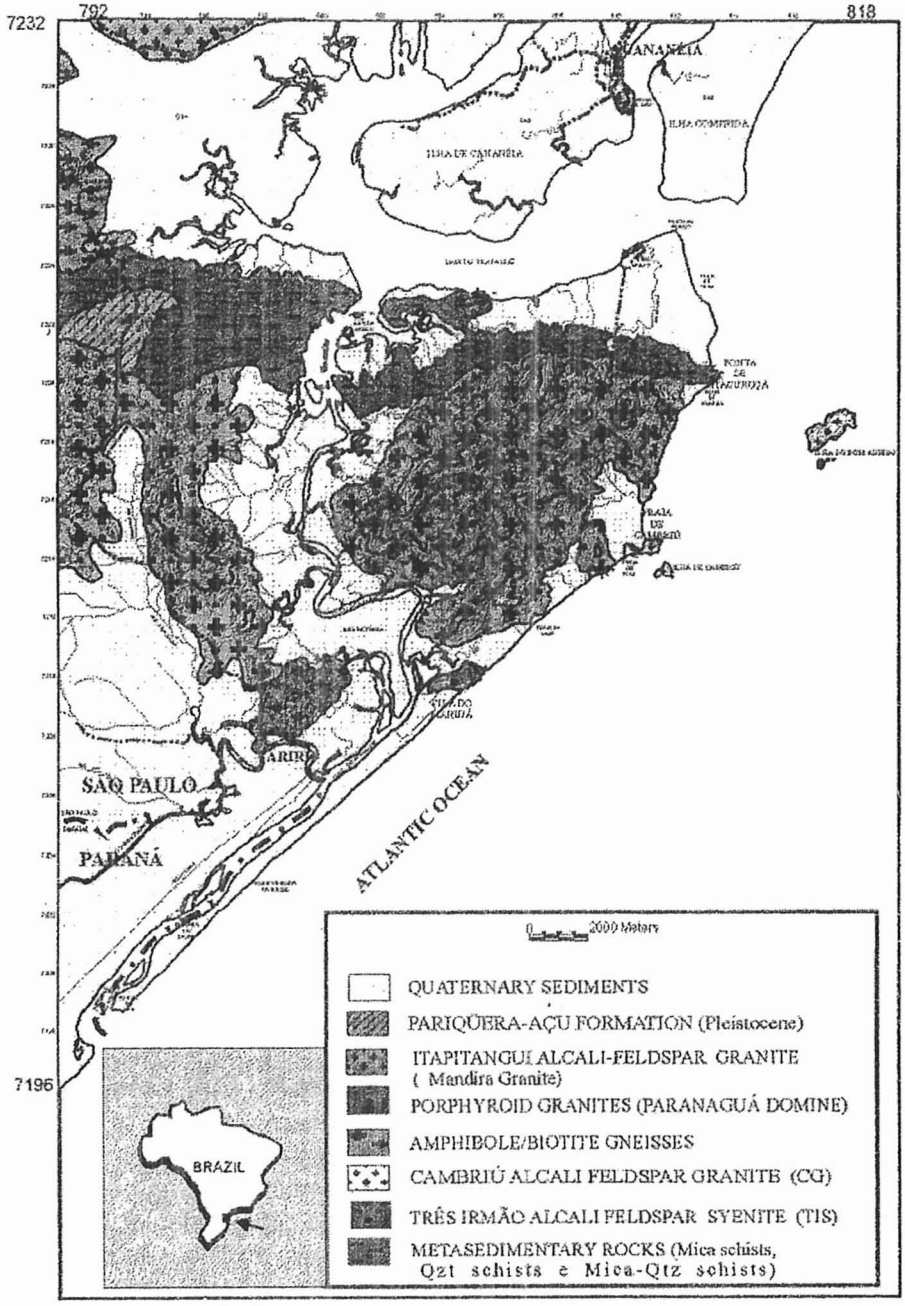
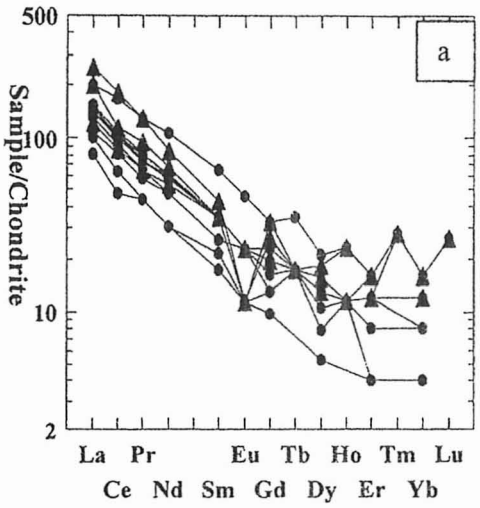
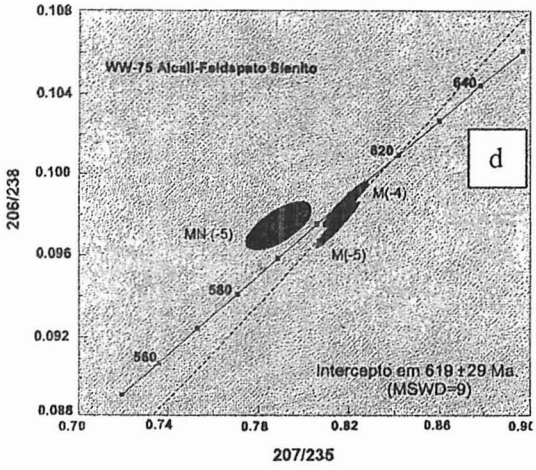
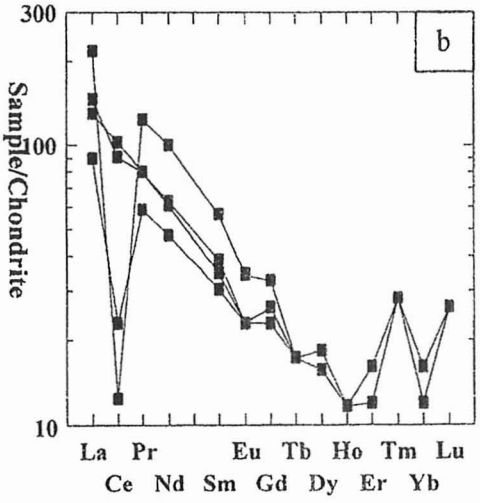
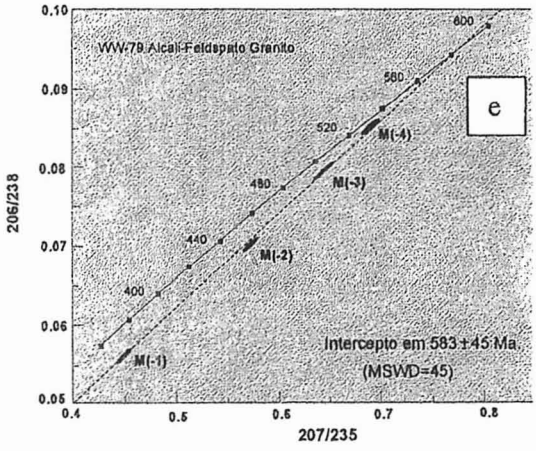



FIGURE 1: Simplified geological map



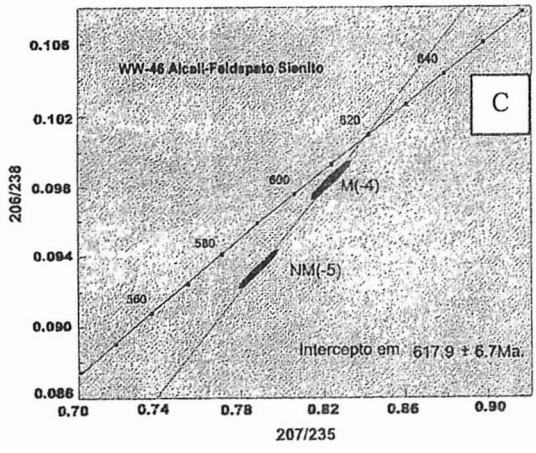




**Figure 2:** a) REE Diagrams. Triangles-GC; circles-TIS. b) REE diagram for the metasedimentary rocks. c and d) U-Pb diagrams for TIS. e) U-Pb diagram for GC.