THE GEOCHRONOLOGY OF THE SETUVA NUCLEUS: POLYCYCLIC TERRAINS EXPOSED TO UPPER CRUSTAL LEVELS DURING THE NEOPROTEROZOIC

Siga Jr., O.[1]; Kaulfuss, G.A.[1]; Sato, K.[1]; Basei, M.A.S.[1]; Vasconcelos, P.M.[2]; Harara, O.M.[1] and Cury, L.F.[1]

1. Instituto de Geociências-USP. Rua do Lago 562. Cid. Universitária-SP, 05508-080. osigajr@usp.br
2. University of Queensland. Steele Building. Brisbane Qld 4072 - Australia

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INTRODUCTION

The Precambrian terrains of the eastern Paraná and southern São Paulo States are largely represented by an expressive sequence of metasedimentary/metavolcano-sedimentary rocks (the Apiaí Fold Belt), limited to the south-southeast by gneissic-migmatitic rocks from the Atuba Complex. Conspicuous granitic magmatism stands out in the Apiaí Fold Belt context, as well as terrains considered as basement rocks, represented by the Tigre, Betara and Setuva nuclei, the latter object of this study (Fig. 1).

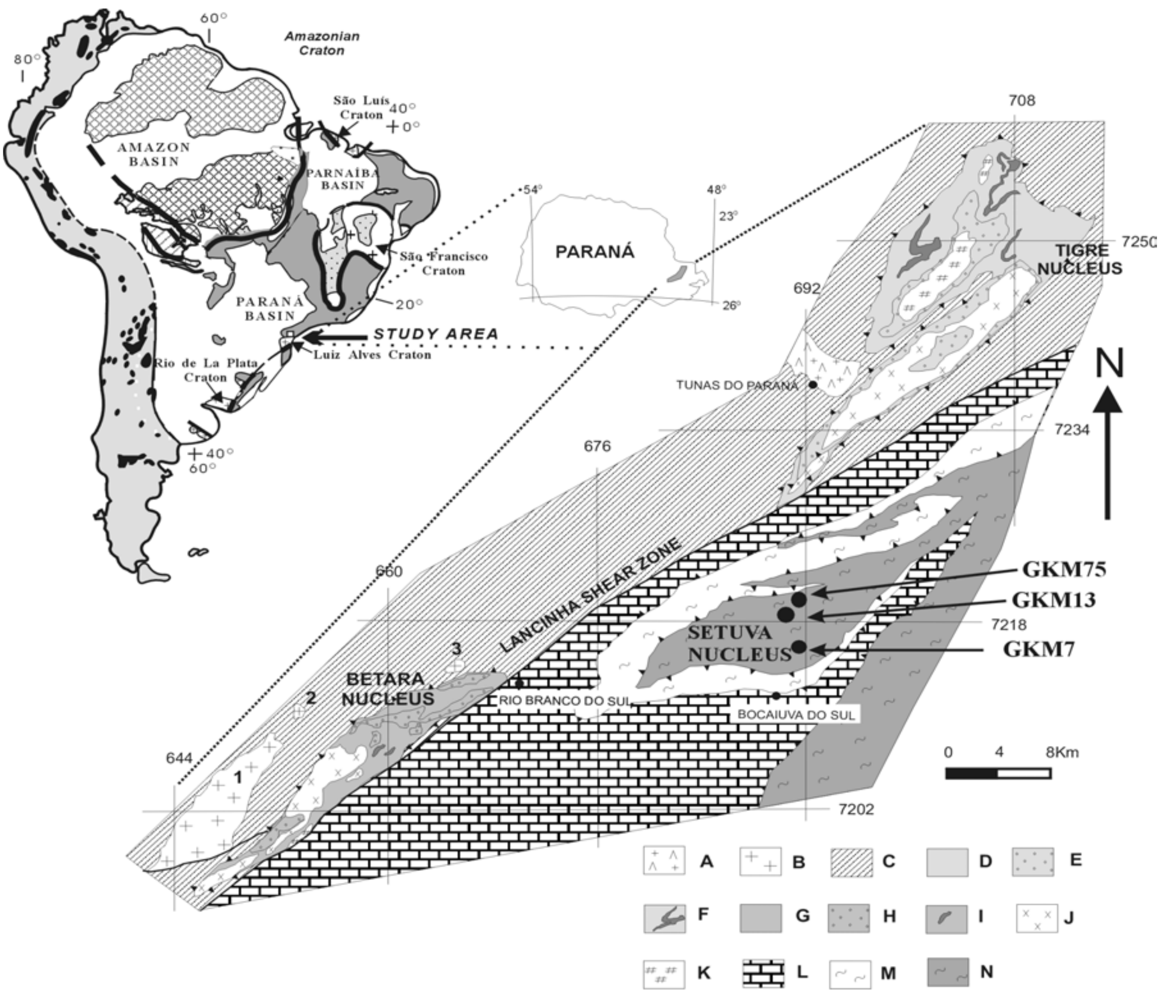

Figure 1. Geologic sketch map (after Kaulfuss, 2001) and sample location.

[Mesozoic]: Tunas alkaline Complex - (A) syenite, alkali syenite and volcanic breccia; [Neoproterzoic]: Late tectonic granitoids - (B) 1 Cerne granite, 2 Cerne syenite, 3 Rio Abaixo granite; [Mesoproterozoic]: Açungui Group - (C) Metavolcano-sedimentary sequences; [Mesoproterozoic / Paleoproterozoic]: Perau Complex - (D) schists and dolomite marble, (E) quartzites, (F) metabasic rocks; Betara Formation - (G) mica schist and phyllites, (H) quartzites, (I) metabasic rocks; [Upper Paleoproterozoic]: Folded granitoids - (J) syenogranite; [Paleoproterozoic / Archean]: (K) monzonites, granodiorites, quartz-monzonites, quartz-granodiortes; [Neoproterozoic]: Capiru Formation - (L) meta-calc-dolomite, metaritimite, phyllites and quartzites, (M) schists, phyllites and quartzites; [Neoproterozoic / Paleoproterozoic \ Archean]: Atuba Complex - (N) gneisses and migmatites, folded granitoids and amphibolites.

The main objective of this paper is to present an isotopic study (zircon U-Pb, whole-rock Sm-Nd, and biotite K-Ar and Ar-Ar methods) of the Setuva Nucleus, aiming at the correlation with other similar segments in Paraná and São Paulo, and to better understand the tectonic scenario of south-southeastern Brazil.

GEOLOGIC CHARACTERISTICS

The Setuva Nucleus is represented by allochthonous terrains, exposed within metasedimentary sequences (dolomitic marbles, phyllites, quartzites and schists) of the Capirú Formation. It occurs south of the Lancinha Shear Zone, and is elongated, sigmoidal, predominantly trending NE-SW. It is represented by protomylonitic to mylonitic rocks, predominating gneissic-migmatitic lithotypes in its southern portion and syeno- to monzogranites in its central-northern portion.

The gneissic-migmatitic lithotypes are strongly weathered and are characterized by centimeter- to millimeter-sized banding, formed by alternating quartz-feldspatic and reddish to ochre levels, the latter containing quartz, feldspar, micas and possibly amphiboles. Quartz-feldspatic injections of various dimensions and forms occur both concordant and discordant with the gneissic-migmatitic banding.

In Setuva's central-northern sector, proto- to mylonitic, rosy-gray syenogranitic rocks predominate, with abundant sub-millimeter to centimeter-sized, oval-shaped K-feldspar porphyroclasts. They contain K-feldspar, quartz, plagioclase and biotite, and additional chlorite and sericite/muscovite.

Proto- to mylonitic rocks of granodioritic to monzogranitic composition were also individualized in Setuva's western and northern sectors. In general, they are fine-grained and are composed of millimeter- to centimeter-sized K-feldspar porphyroclasts, quartz, plagioclase and biotite.

The structural pattern observed in the Setuva Nucleus is similar to the described for the Apiaí Belt, which is related to a low-angle tectonics, with kinematic indicators suggesting transport from NW to SE (in the direction of the Atuba Complex). These surfaces were affected by important transcurrent shear systems (such as the Lancinha Shear Zone) and wide associated folds, responsible for structuring and compartimentation of these terrains (Fiori, 1992; Silva et al., 1998; Yamato, 1999).

GEOCHRONOLOGIC STUDY

The geochronologic studies (U-Pb, Sm-Nd, and K-Ar/Ar-Ar) refer to three outcrops that represent proto- to mylonitic gneissic-migmatitic rocks (southern sector), protomylonitic syenogranites (central sector), and mylonitic syenogranites (northern sector).

The protomylonitic syenogranites (Setuva's central sector) contain elongated, prismatic zircon crystals, translucent to the transmitted light, presenting a few inclusions (Fig. 2). U-Pb analytical data, when plotted in the concordia diagram, cluster close to the upper intercept, yielding 2140 +/- 8 Ma (Fig. 3). Such value, related to the Transamazonian cycle, is interpreted as the time of zircon crystallization and consequently formation of the syenogranitic rocks. Sm-Nd analyses (T_{DM}) carried out for these lithotypes yielded an Archean model age of 2948 ± 16 Ma, interpreted as the time of mantle derivation of the syenogranite crustal protoliths. Additionally, K-Ar and Ar-Ar analyses carried out in biotites developped along low-angle Sc planes indicated ages of 586 ± 15 Ma and 585 ± 1 Ma respectively (Fig. 4). Such values indicate emplacement according to isotherms of temperatures lower than 300°C during the Neoproterozoic.

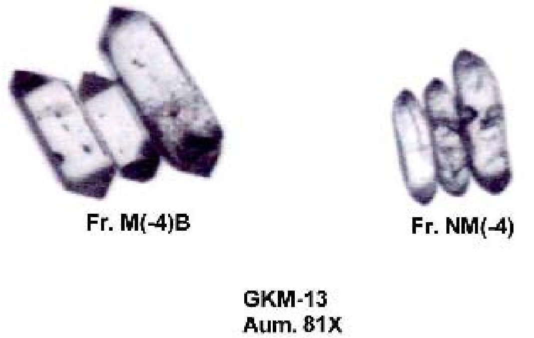

Figure 2. Transmitted light image from GKM-13 sample.

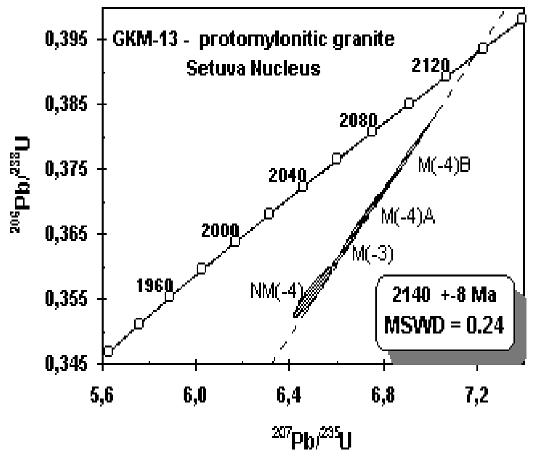

Figure 3. U-Pb Concordia diagram for GKM-13 zircon sample.

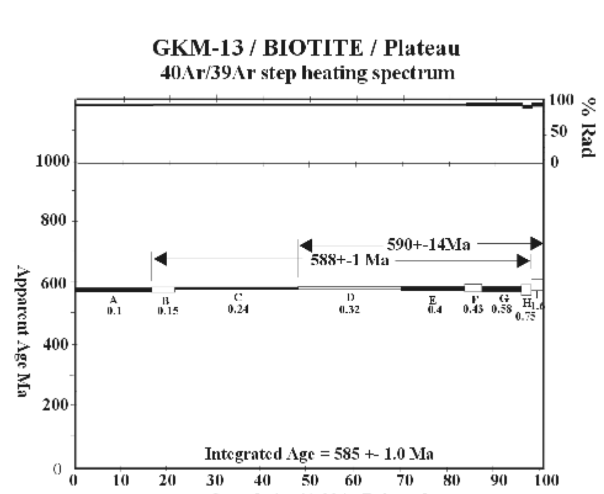

Figure 4. Ar-Ar diagram.

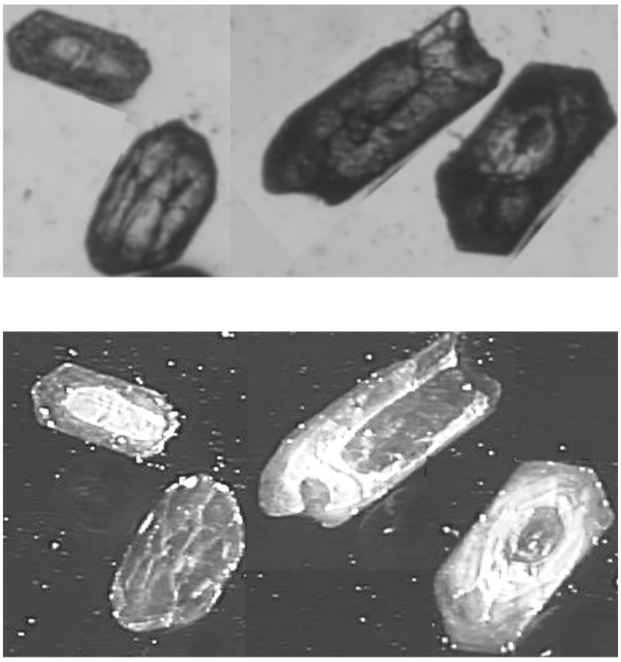

Figure 5. a -Tramsmitted light image (above) and b - cathodeluminescence image (below) from GKM 75 sample.

The zircon crystal that occur in mylonitic syenogranites of Setuva's northern portion are rosy, turbid, inclusion-rich, and fractured (Fig. 5a). Cathodeluminescence reveals bright nuclei surrounded by darker overgrowths (Fig. 5b). Possibly due to Pb losses, the analytical data, when plotted in the concordia diagram, yield ages devoid of geological meaning, both at the upper and lower intercepts (2400Ma and 480 Ma, Fig. 6).

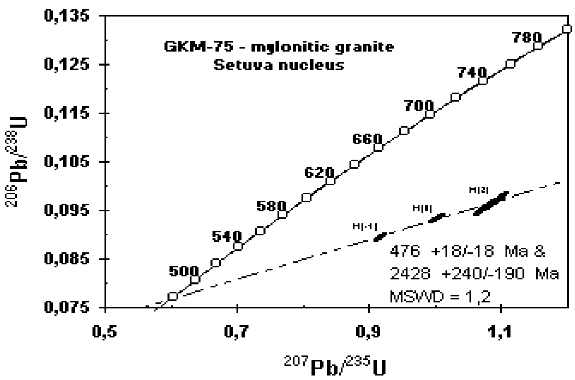

Figure 6. U-Pb Concordia diagram for GKM 75 sample.

These zircons, when analyzed with the single zircon Pb evaporation technique, show great isotopic complexity, with nuclei and overgrowth zones yielding Archean (3000 Ma and 2640 Ma) and Paleoproterozoic (2100 Ma) ages (Figs. 7a, b).

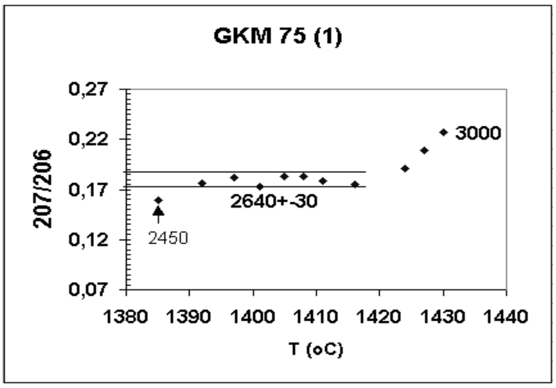

Figure 7a. Lead evaporation by step heating.

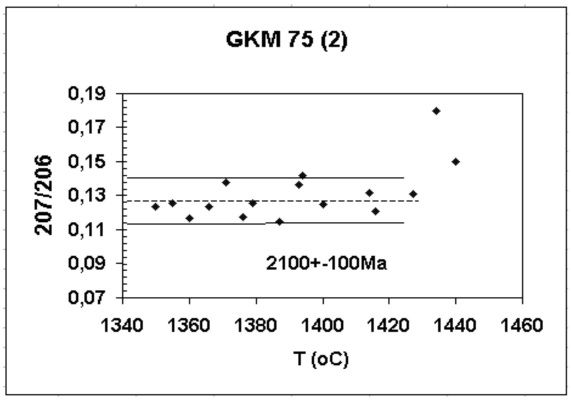

Figure 7b. Lead evaporation by step heating.

Regarding the gneissic-migmatitic rocks of Setuva's southern portion, U-Pb studies were carried out in zircons from thin-banded lithotypes (mesosome), from leucocratic levels intercalated concordant with banding (leucosome), and aplitic veins that are sometimes concordant, sometimes discordant with the general structuring. The zircons of the three lithotypes are very similar under the stereoscope, characterized by turbid elongated, biterminated prismatic crystals, showing aspect, usually containing fractures and inclusions (Fig. 8). In cathodeluminescence images, a central portion surrounded by dark, concentric overgrowths stand is better defined at the crystal terminations.

Figure 8. Transmitted light image from GKM 7 sample.

The analytical data, when plotted in the concordia diagram, reveal different isotopic heritages. The analytical results for the mesosome plot relatively close to the upper intercept, whereas those for leucosome and aplitic veins cluster closer to the lower intercept of the concordia curve. These data, when plotted together in the concordia diagram, are well aligned and distributed, indicating the age of 3175 ± 24 Ma for the upper intercept and a relatively young age of 513 ± 35 Ma for the lower intercept (Fig. 9).

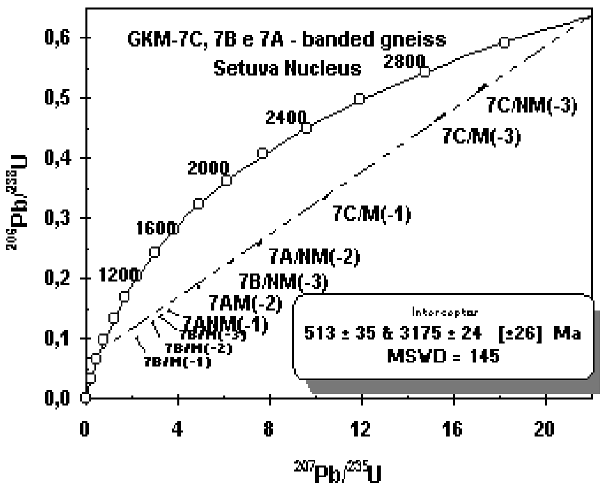

Figure 9. U-Pb concordia diagram for GKM7 sample.

Additional analyses were carried out for the mesosome, using the single zircon Pb evaporation technique, yielding steps of 3100 ± 50 Ma and 3150 ± 50 Ma (Figs. 10a, b), similar to the concordia diagram upper intercept. Sm-Nd model ages (T_{DM}) obtained for mesosome and aplitic veins, respectively 2866 ± 100 Ma and 2811 ± 100 Ma, are a little lower than the ones obtained for the zircons. Because the rocks are intensely weathered, these values may lack geological meaning, due to possible modifications in Sm/Nd ratios.

FINAL CONSIDERATIONS

The geological-geochronological study of gneissic-migmatitic, syenogranitic and monzo- to granodioritic terrains belonging to the Setuva Nucleus reveal a complex, polycyclic tectonic scenario. The U-Pb isotopic pattern in zircons characterizes the formation of gneissic-migmatitic rocks during the Archean (3175 ± 24 Ma), and the proto- to mylonitic syenogranitic lithotypes (central and northern portions) during the Archean (~2600 Ma) and Paleoproterozoic (2140 ± 8 Ma). In general, the analyzed zircons show overgrowths of doubtful Neoproterozoic ages, obtained by the application of the K–Ar and Ar–Ar methods in biotites (585 ± 1 Ma). Such isotopic pattern is very similar to the observed for the Atuba Complex gneissic-migmatitic terrains located south of Setuva. The Betara and Tigre Nuclei are relatively distinct from Setuva, once these are predominantly constituted by proto- to mylonitic granitoids (granodiorites, quartz monzonites and quartz monzodiorites) formed in the Archean (2600 Ma) and Paleoproterozoic (2200 Ma), intensely tectonized during the Neoproterozoic. In these terrains proto- to mylonitic syenogranites also stand out, associated with the Statherian Taphrogenesis (1750 Ma).

The geochronological pattern allied with the structural pattern suggests that the emplacement, largely controlled by shearing, at upper crustal levels occurred during the Neoproterozoic. The initial, low-angle tectonics, with kinematic indicators suggesting transport from NW to SE, in direction to the Atuba Complex, associated with transcurrent shear systems and later folding, should be responsible for the allochthony of these terrains and consequent emplacement at upper crustal levels.

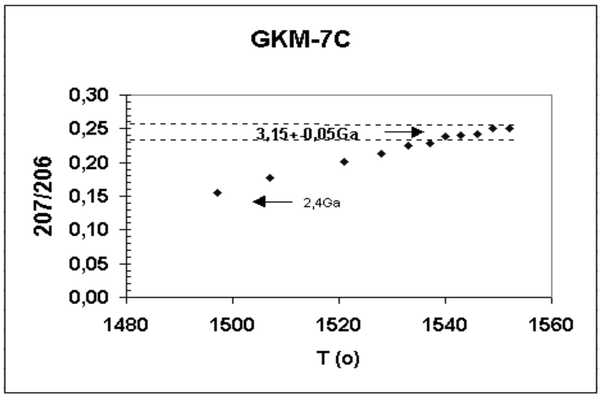

Figure 10a. Lead evaporation using step heating technique.

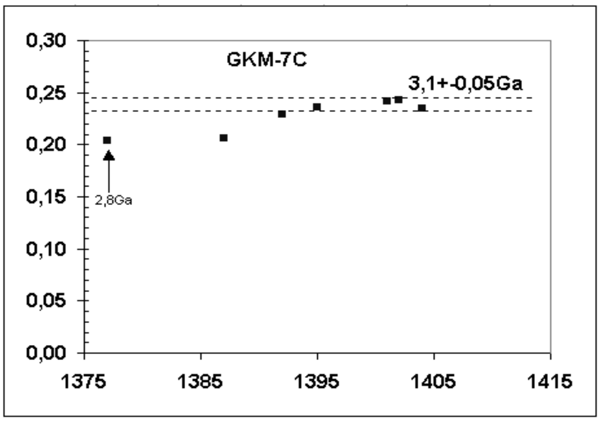

Figure 10b. Lead evaporation using step heating method.

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