

ACTAS

II SIMPOSIO SUDAMERICANO DE GEOLOGIA ISOTOPICA

II SOUTH AMERICAN SYMPOSIUM ON ISOTOPE GEOLOGY

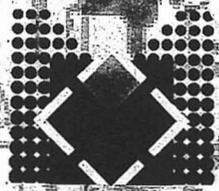


Argentina 1999

DEDALUS - Acervo - IGC



30900011202



**SUBSECRETARÍA
DE MINERÍA
DE LA NACIÓN**

ISSN 0328-2325

CORDOBA 1999



**INSTITUTO
DE GEOLOGÍA
Y RECURSOS
MINERALES**

SEGEMAR

SERVICIO GEOLÓGICO
MINERO ARGENTINO

ANALES XXXIV

SINGLE ZIRCON SHRIMP DETERMINATIONS FROM ARCHEAN TONALITIC ROCKS NEAR UAUÁ, BAHIA, BRAZIL

Umberto G. Cordani¹, Kei Sato¹ and Allen Nutman²

1 - Institute of Geosciences, University of São Paulo. São Paulo, Brazil. ucordani@usp.br

2 - Research School of Earth Sciences, Australian National University.

Key words: SHRIMP, zircon, concordia, Sm-Nd model age

INTRODUCTION

Several nuclei with Archean rocks have been identified in the State of Bahia, eastern Brazil, during an extensive reconnaissance work, carried out at the Geochronological Research Center of the University of São Paulo, in association with the State Secretariat of Mines and Energy of Bahia (Mascarenhas and Garcia 1989), and they are very important for the understanding of the geological evolution of the São Francisco craton.

One of these nuclei occurs in relation with the Rio Capim greenstone belt, an important geotectonic unit located about 20 kms east of the city of Uauá. From rocks believed to represent the basement to the Rio Capim supracrustals, Rb-Sr work had already indicated an old apparent age, in excess of 3000 MA, when two separated Sm-Nd model ages (T_{DM}), yielded extremely old results, of more than 3600 MA.

These geochronological data, among the oldest in the South American continent, stimulated further research, and the same samples analysed by the Sm-Nd method were selected to be submitted to zircon separation in order to obtain a series of U-Pb measurements by ion microprobe at the Australian National University.

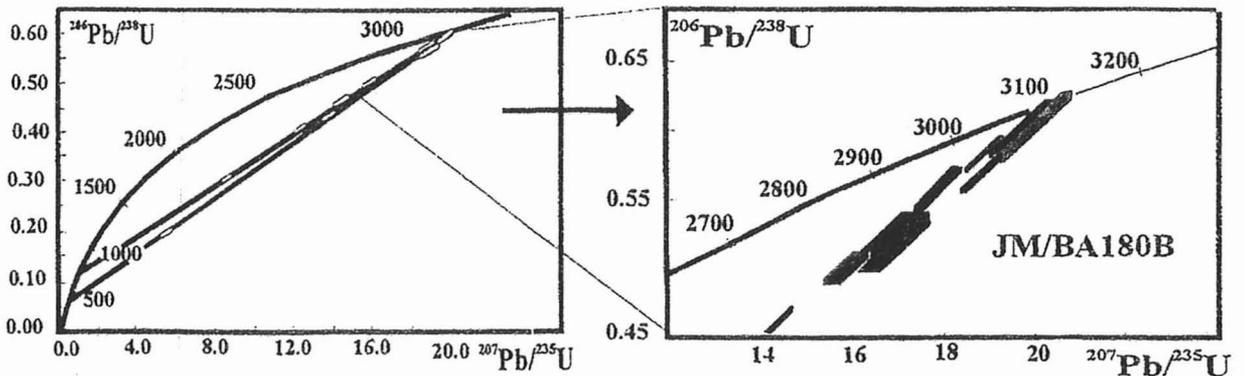
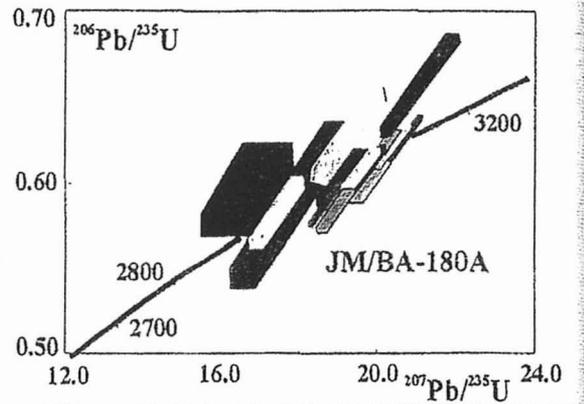
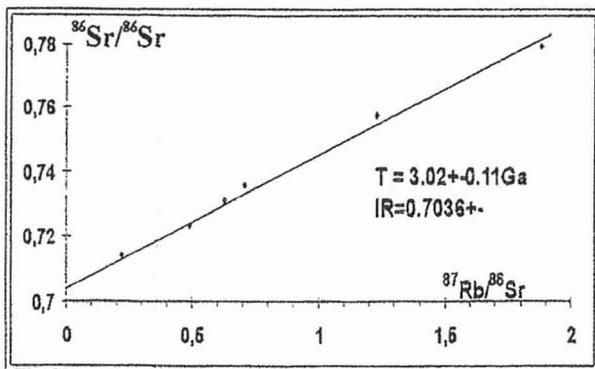
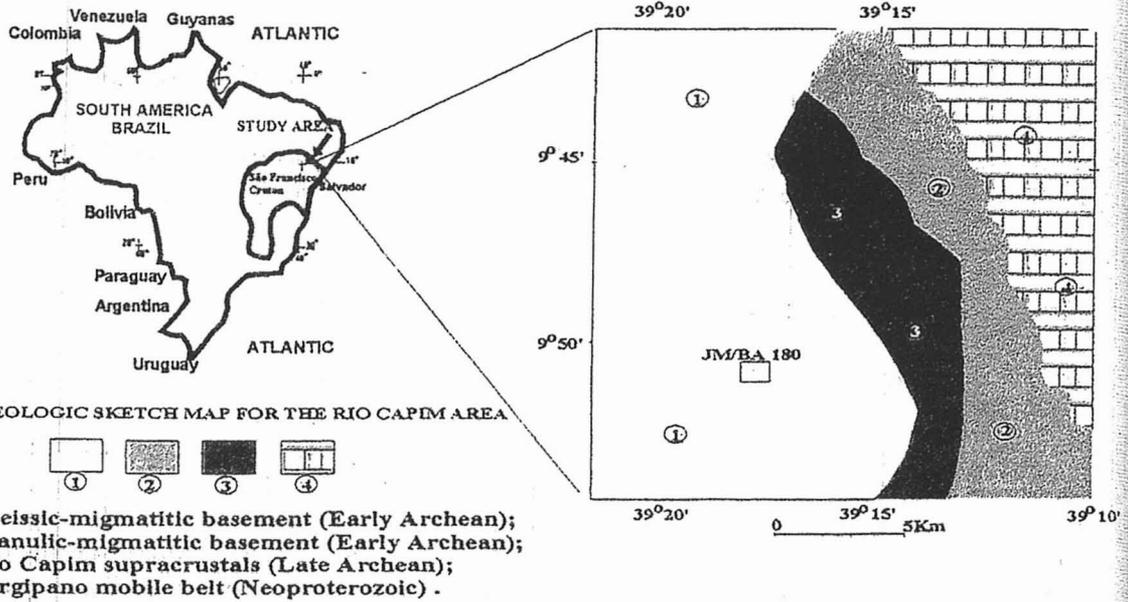
Single grain zircon U-Pb analyses are especially suited for the determination of very old ages in granitoid / gneissic rocks, since the mineral zircon is an excellent chronometer of geological events, indicating generally the time of its crystallisation from a magmatic source. Its atomic network is known to be highly resistant to later transformations, by weathering, hydrothermal alteration, or metamorphism, and thus zircon is able in many cases to keep its original age, regardless of the evolution of the rock

system in which it is included. For tonalitic orthogneisses, such as in the present case, the SHRIMP U-Pb results could be of great value to establish the age of crystallisation of the protoliths, and perhaps also of the ages of possible previous crustal sources. Moreover, the use of different dating methods may also disclose other aspects of the evolution of these rocks, and especially the times of possible later metamorphic events which affected them.

GEOLOGIC SETTING

In the region of Rio Capim, north-northeast of Bahia State, a sequence of supracrustal rocks is described, including basic, intermediate and acid metavolcanics, banded iron formations, calc-silicate rocks, quartzites, schists and marbles (Winge, 1984). This sequence is considered as a remain of a greenstone belt, lying over a basement consisting of a gneissic-migmatitic complex, and is highly tectonized and metamorphosed to the amphibolite facies. In its western side, the supracrustals present a tectonic contact with tonalitic gneisses considered to be their basement (Fig. 1). Both units, supracrustals and gneisses, exhibit similar structural styles, in response to at least three deformational phases.

The tonalitic gneisses are considered to be older than the supracrustals because of a sequence of mafic dikes which cuts through the gneisses but does not affect the Rio Capim sequence. Such dike swarm is truncated by the contact fault zone, which is considered to be of transcurrent character. The basement rocks are occasionally cut by small quartz-feldspathic veins, which have locally produced a metasomatic addition of potassium.



Petrographically, the tonalitic gneisses are homogeneous medium grained rocks with antiperthitic oligoclase, quartz and biotite, with some microcline, hornblende and secondary muscovite. Both analysed samples, JM-BA-180A and 180B, exhibit some milonitization, which is more intense in sample JM-BA-180A. Some hydrothermal alteration is shown by the presence of epidote, chlorite and calcite, and saussuritization of the plagioclase. Accessory minerals include zircon, apatite, sphene and pyrite.

Sample JM-BA-180A is fine grained, sub-millimetric, and presents a blastomylonitic texture, with abundant plagioclase "microaugens". It is highly foliated, with major amount of green biotite. Sample JM-BA-180B exhibits a granoblastic texture, where small augens (0.5 to 3 mm) of quartz and plagioclase occur together with patches of very fine aggregate formed by the same minerals plus biotite and opaques.

EXPERIMENTAL METHODS

The Rb-Sr and Sm-Nd analyses were carried out at the Geochronological Research Center of the University of São Paulo. Analytical procedures were reported by Cordani *et al.* (1985) and Sato *et al.* (1995).

The U-Th-Pb isotopic ratios were obtained in the ion microprobe SHRIMP I of the Research School of Earth Sciences at the Australian National University, following the procedures described by Compston *et al.* (1984). Repeated analyses of the SL13 standard ($^{206}\text{Pb} / ^{238}\text{U} = 0.0928$) during each analytical session were used to determine the uncertainty in the inter-element isotopic ratios of unknowns. The individual zircon ages quoted in this paper are weighted means with 2 sigma uncertainties, derived from the measured sets of $^{207}\text{Pb} / ^{206}\text{Pb}$ ratios. These isotopic ratios were corrected for small amounts of common Pb.

ZIRCON POPULATIONS

More than 80% of the zircon grains in sample JM-BA-180A are prismatic in habit, up to 300 μm long, and their U contents, based on the analysed sites, range between 100 and 300 ppm. Of this population, at least two subgroups can be identified. For one of them, most of the crystals are subhedral, exhibiting a pale-yellow to light brown colour, and only a slight rounding on their bipyramidal

terminations. They also display weakly developed euhedral zoning, throughout the entire grains. For the other subgroup, the crystals are somewhat smaller, lighter and brighter in colour, with less pronounced internal zoning, and with evidence of some rounding in their terminations. Between 15 and 20 % of the grains of the same sample belong to a different population. Here the crystals are larger, up to 400 μm long, oval shaped, well rounded, unzoned, and with a pinkish tonality. For this population, U content is lower, between 40 and 70 ppm.

Overgrowth of neoformed material was not observed in the zircon crystals of sample JM-BA-180A, but a few of the grains exhibit a kernel of what appears to be unzoned zircon. In this sample, perhaps 50% of the grains are darkened to some extent by metamictization. Some of them exhibit fracturing, and some others contain a few sparse mineral inclusions. None of the grains presenting such features were selected for the SHRIMP analyses.

Similar zircon typologies were found in sample JM-BA-180B. In this sample, more than 90% of the grains are prismatic, subhedral, up to 300 μm long, pale-yellow to light brown in colour, and corresponding to both subgroups already described for sample JM-BA-180A. However, they usually exhibit much higher U content, up to more than 700 ppm. About 8% of the crystals in this sample seem to belong to the same population already observed in sample JM-BA-180A, of large, oval shaped, rounded and unzoned crystals. Also in this case, U content resulted much higher, up to more than 400 ppm.

Very probably because of the generally higher U content, in sample JM-BA-180B the proportion of metamict crystals is about 75-80 %. Some of the grains are completely blackened by metamictization. Overgrowth of neoformed zircon was observed in one case, and its uranium content was distinctly lower, around 100 ppm. Only clearly non-metamict crystals, and the supposed least disturbed sites in the grains, were selected for the SHRIMP analyses.

RESULTS AND DISCUSSION

The Rb-Sr results were already interpreted by Mascarenhas *et al.* (1989). The two whole rock samples from outcrop JM-BA-180, plus three other samples of similar rocks from outcrop JM-BA-182, which occurs nearby, produced the isochron diagram

of Fig. 2, where the best fit line indicated an age of 3016 ± 110 MA (2 sigma), with initial $^{87}\text{Sr}/^{86}\text{Sr}$ of 0.7036 ± 0.0011 . In this diagram, the analytical points are reasonably aligned, and the calculated MSWD resulted close to 1.00, indicating a possible geological significance for the age value.

Single grain U-Pb determinations were carried out on separated zircon crystals from samples JM-BA-180A and 180B. Fourteen individual analyses were performed on selected grains from each of the two samples.

Figure 3 shows how the single zircon analyses of sample JM-BA-180A are closely related to the concordia curve, with a high degree of concordance. The age values resulted between 3050 and 3130 MA, with different experimental errors, in the order of 50MA. The only zircon grain that yielded a discordant result, does not appear in the figure. This sample exhibits the highest U content (356 ppm) of all analysed zircon grains, and its discordant pattern may be referred to some degree of metamictization.

Figure 4 includes the results for sample JM-BA-180B. Most of the zircon grains of this sample are discordant, with different degrees of discordance. Only 1 of the grains are reasonably concordant, indicating an age close to 3120 MA, very similar to the one reported for sample JM-BA-180A. The other points in this figure locate along a straight line connecting the upper intercept at 3120 MA with a lower intercept at about 700 MA. We consider this age value as representing an episode of lead loss associated with a main tectonomagmatic event affecting the nearby Sergipano mobile belt, one of

the Neoproterozoic tectonic provinces of the Brasiliano orogenic Cycle.

From outcrop JM-BA-180 two samples were analysed by the Sm-Nd method, and yielded T_{DM} model ages related to the early Archean. The ϵ_{Nd} values related to the age of the rocks are slightly negative, indicating some crustal component for the material which formed the tonalitic magma, a fact which is further enhanced by the relatively high $^{87}\text{Sr}/^{86}\text{Sr}$ initial ratio for an early Archean rock unit, as indicated by the Rb-Sr whole rock isochron age value.

REFERENCES:

- Compston, W., Willians, I. and Meyer, C. - 1984 - U-Pb geochronology of zircons from lunar breccia 73217 using a sensitive high mass-resolution ion microprobe. *J. Geophys. Res.*, 89 supplement B:525-534.
- Cordani, U.G; Sato, K. and Marinho, M.M. - 1985 - The geologic evolution of the ancient granite-greenstone terrane of central-southern Bahia, Brazil. *Precambrian Research*, 27 p187-213.
- Mascarenhas, J.F. e Garcia, T.W., (1989), Mapa Geocronológico do Estado da Bahia, 1/1.000.000. Texto explicativo, S.G.M-SME, Salvador - Bahia.
- Sato, K; Tassinari, C.C.G., Kawashita, K. e Petronilho - 1995 - O método geocronológico Sm-Nd no IG-USP e suas aplicações. *An. Acad. Bras. Ci* v67(3) p313-336.
- Winge, M. - 1984 - A sequência vulcanosedimentar do Grupo Capim - Bahia. *Geologia e recursos minerais do Estado da Bahia. Textos básicos*, 5o. volume. CPM - SME - Bahia.