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ARE VARANGIAN OR STURTIAN THE GLACIAL DEPOSITS ON THE SÃO FRANCISCO CRATON? EVIDENCE FROM AGE DETERMINATION OF SEDIMENTARY ROCKS AND MINERALS OF THE NEOPROTEROZOIC UNA GROUP

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INTRODUCTION

The Neoproterozoic time is marked by extensive epicontinental carbonatic sequences and by glacial events. Due to the lack of fossil record on these sequences, radiometric dating on sedimentary rocks and minerals is extremely necessary for understanding their geologic evolution.

The Neoproterozoic Una Group, Irecê basin (Bahia State) is correlative with the better known Bambuí Group of the São Francisco Basin (Minas Gerais State). Both basins are remnants of widespread carbonate platform that covers more than 300,000 km^2 deposited on the São Francisco Craton in Brazil. The Una Group strata comprise a basal siliciclastic sequence, mostly composed of glacial diamictites (Bebedouro Formation), followed by a several hundred meter thick carbonate succession (Salitre Formation). The ages of these formations are still not well defined. The main problem to obtain reliable ages on the sediments is due to tectonic processes that partially affected most of the sedimentary sequence during the Brasiliano - Pan African orogeny (ca. 500-600 Ma).

For this study we have collected phosphate-bearing columnar stromatolite and different dolomitic and/or massive black limestones from the eastern Irecê Basin. These rocks belong to the middle to upper part of the Salitre Formation which is stratigraphically correlated to the Unit B1 of Misi and Veizer (1998). The aim of this preliminary study is to present radiometric ages which could be compared to previously obtained chemostratigraphic results (Misi and Veizer, 1998) of this formation. Additionally, with our results we could define if the glacial event (underlying Salitre Formation) is Varanger or Sturtian in age.

RESULTS AND DISCUSSION

We collected carbonate rocks at three different outcrops in eastern Irecê basin. One outcrop (BR-2; BA98-15) contains stromatolitic carbonates; twenty whole-rock chips, free of visible seconday veins, were analyzed for Pb isotopes. The determined Pb isotopic compositions are very radiogenic and show a large spread (^{206}Pb-^{204}Pb = 30 to 100) in the Pb diagram (Fig. 1). The data plot along a linear array corresponding to an age of 467 ± 68 Ma (MSWD = 42.3). Pb isotopic compositions determined from samples from the other two outcrops (BR13; BA98-23 and BR19; BA98-28) are much less radiogenic (^{206}Pb-^{204}Pb = 18-21) and did not provide enough spread for age determination. However, their Pb isotopic compositions fall on the lower end of the isochron defined by stomatolitic carbonates (Fig. 1).

A new approach was applied in this study where clay minerals were separated from the two carbonate samples and dated by K-Ar and Rb-Sr methods. For this purpose clay minerals (< 2.0 μm) were subdivided by ultracentrifugation in several grain-size fractions. The main objective of this

procedure was to obtain authigenic clays which could yield the depositional age of these samples.

Clay minerals (< 2.0 μm) were recovered from one carbonate sample (BR-19) and were divided in three different grain-size fractions and were dated by K-Ar method. The proportion of the different clay minerals, chlorite, smectite and illite, does not vary with grain size. The age obtained for the coarse fraction (0.8-2.0 μm) was 515 ± 13 Ma; the middle-sized fraction (0.4-0.8 μm) showed an age of 502 ± 12 Ma; and the finest fraction (0.0-0.4 μm) yielded an age of 512 ± 12 Ma. These K-Ar ages are similar within the experimental error indicating that all the clays, despite their grain-size, where formed at the same time.

Different K-Ar results were obtained for the same sized clay mineral fractions from the other carbonate sample (BR-13). The coarsest grain-size fraction contains predominantly chlorite and some illite. Toward the finest fraction the amount of chlorite decreases, illite increases and illite/smectite become more common. The determined K-Ar ages are 539±14 for the coarse (0.8-2.0 μm), 498±12 Ma for the middle-size (0.4-0.8 μm) and 484±12 Ma for the finest fraction (0.0-0.4 μm). Since the rocks are not mesoscopically deformed, the older age could reflect the time when illite was formed, probably during a fluid percolation event that took place at ca. 520 Ma (Babinski *et al.*, 1999a, b). The younger age could be interpreted as another event during which illite/smetite was crystallized or even the late stages of the same fluid percolation event.

In order to obtain results which may could be less affected by the post-depositional events, a leaching technique was applied to clay minerals of sample BR13. This procedure allows Rb-Sr dating on single clay fractions. The clay fractions were first leached with 1N HCl for 15 min at room temperature to differentiate the elements that either were adsorbed on the surface of the particles or trapped in acid-soluble minerals associated with the clay particles, from those trapped in the silicates, following a technique used in Toulkeridis *et al.* (1994). The leachates which amounted between 2.1 and 8.1% in weight of the untreated aliquots, were recovered separately from residues by centrifugation. Each residue was then rinsed in distilled water and both the leachates and the residues were analyzed separately. The data of the leached and residual fractions increase the spread of the isotopic ratios compared to that obtained for the untreated clay fraction. This is because the leachate is usually less radiogenic and the residue is more radiogenic related to the untreated clay fraction in the Rb-Sr isotopic system (Toulkeridis *et al.*, 1998). This technique was applied to five different grain fractions below 2 μm (0.0-0.2 μm, 0.2-0.4 μm, 0.4-0.8 μm, 0.8-1.0 μm and 1.0-2.0 μm) which have been separated out of limestone BR13.

The Rb-Sr ages obtained increases with the increasing size fraction (Fig. 2). The age is 516 Ma for the finest fraction, 565 Ma for the middle-size fractions, and the coarse-grained fractions have ages of 649 Ma and 701 Ma (Fig. 2). The youngest age was determined on the finest fraction which is composed by authigenic illite/smectite and illite, and it represents the time of crystallization of these minerals; this age is coincident with the time of the fluid percolation event (Babinski et al., 1999a, b). The older age (701 Ma), which was determined on the coarser fraction which is made up almost exclusively by authigenic chlorite, is interpreted as the crystallization age of this clay mineral. The other ages are probably mixing ages which reflect the varying proportions of the different clays minerals present in these fractions.

Although Pb-Pb, K-Ar, and Rb-Sr ages of ca. 500 Ma were determined on the samples and they represent the time of post-depositional events that took place in the basin, the Rb-Sr age of 700 Ma determined on authigenic chlorites from the carbonate rock of the Salitre Formation provides its minimum depositional age. Based on this age we can suggest that the glacial event recorded by the diamicitites underlying the Salitre Formation is Sturtian (*ca.* 780 Ma). Additionally, Pb-Pb evaporation ages determined on zircons recovered from a diamictite from the Macaúbas Group (Minas Gerais State) show values of ca. 900 Ma (Buchwaldt *et al*, 1999) reinforcing the above hypothesis.

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REFERENCES

Babinski, M., Van Schmus W.R., Chemale Jr., F., 1999a. Pb-Pb dating and Pb isotope geochemistry of Neoproterozoic carbonate rocks from the São Francisco basin, Brazil: Implications for the mobility of Pb isotopes during tectonism and metamorphism. Chemical Geology (in press).

Babinski, M., Van Schmus, W.R., D'Agrella, M., Trindade, R.I.F., Ernesto, M., 1999b. Cambrian U-Pb isotope resseting and remagnetization of the Neoproterozoic Bambuí carbonates, Brazil. II South American Symposium on Isotope Geology, Cordoba, Argentina. Extended Abstracts (this volume).

Buchwaldt, R.,Toulkeridis, T.,Babinski, M., Noce, C.M., Martins Neto, M. and Hercos, C.M., 1999. Age determination and age-related provenance analysis of the Proterozoic Glaciation event in central eastern Brazil. II South American Symposium on Isotope Geology, Cordoba, Argentina. Extended Abstracts (this volume).

Misi, A. and Veizer, J., 1998. Neoproterozoic carbonate sequences of the Una Group, Irêce Basin, Brazil: chemostratigraphy, age and correlations. Precambrian Research. 89: 87-100.

Toulkeridis, T., Goldstein, S.L., Clauer, N., Kröner, A. and Lowe, D.R., 1994. Sm-Nd dating of Fig Tree clay minerals of the Barberton Greenstone Belt, South Africa. Geology. 22: 199-202.

Toulkeridis, T., Clauer, N., Chaudhuri, S. and Goldstein, S.L., 1998. Multi-method (K-Ar, Rb-Sr, Sm-Nd) dating of bentonite minerals from eastern United States. Basin Res. 10: 261-270.

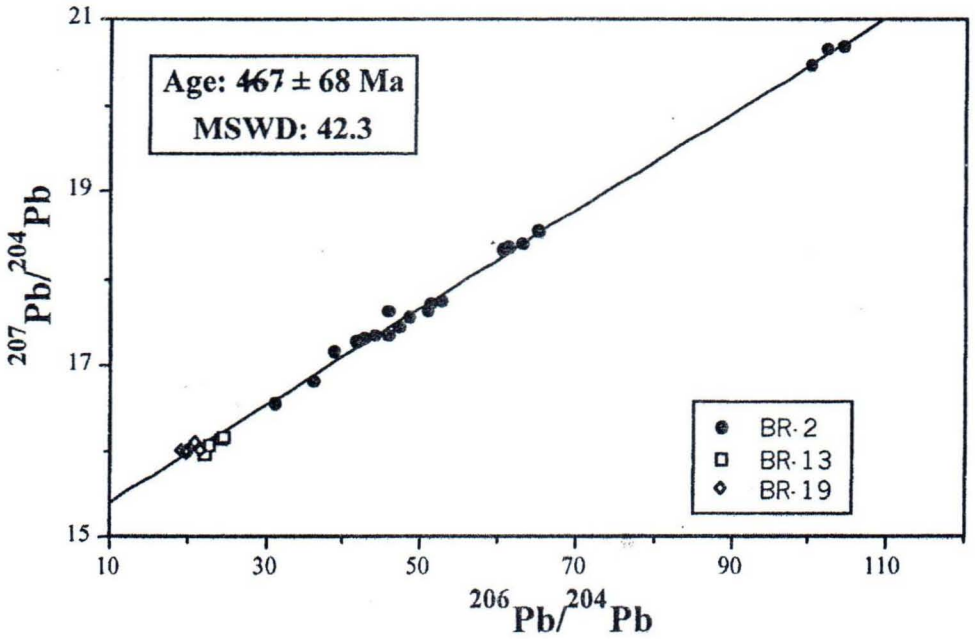

Fig. 1: Pb-Pb dating of limestone sample BR-2. Samples BR-13 and BR-19 are also plotted.

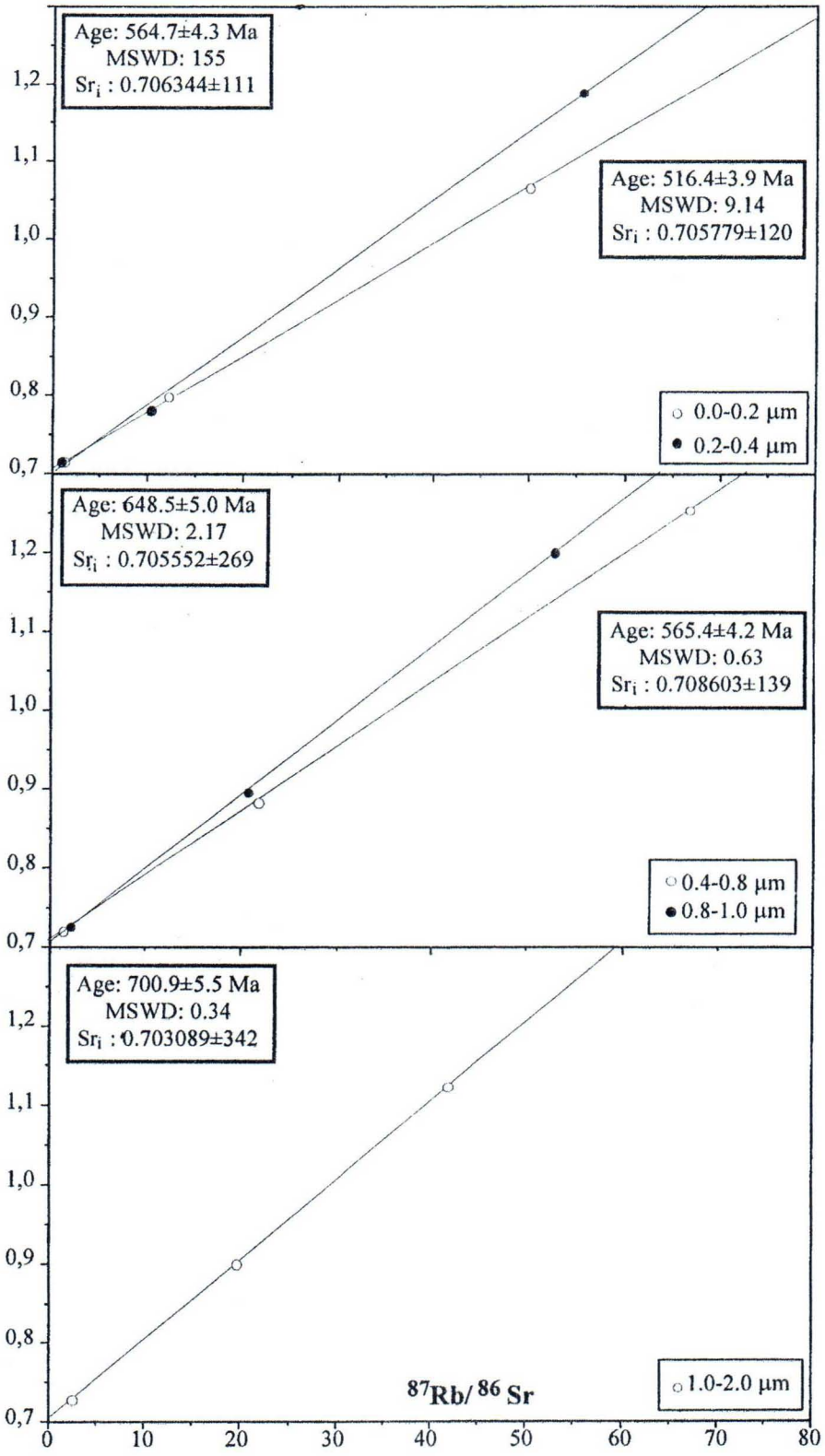

Fig. 2: Rb-Sr dating of separated clay-mineral fractions of sample BR-13.