U-Pb SHRIMP AGES OF THE SERTÂNIA COMPLEX: IMPLICATIONS ON TECTONIC FRAMEWORK OF THE TRANSVERSAL SUBPROVINCE, NORTHEAST BRAZIL

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INTRODUCTION

Concepts recently developed in the Borborema Province, Northeast Brazil, has envisaged a complex evolution in which terranes of different ages were amalgamated by several events culminating in two successive orogenies in the Late Precambrian. Around three major subprovinces are recognized (Van Schmus et al. 1995; Brito Neves et al. 2000), each one of them comprising terranes of different tectonic patterns and ages (Santos 1996). The Northern subprovince is greatly an wide basement composite terrane involving Archean and Paleoproterozoic blocks and Neoproterozoic linear belts. The Transversal subprovince is made up mainly by Stenian to Tonian terranes placed tectonically side by side to Brasiliano belts, which surround Paleoproterozoic inliers. The Southern subprovince corresponds to the external marginal domain relative to the São Francisco cratonic area in the south, including foreland and hinterland monocyclic belts. The Transversal subprovince includes several supracrustal belts mainly of Cariris Velhos (around 1,0 Ga) and Brasiliano (ca. 0,6 Ga) ages (Brito Neves et al., 1995) but high grade terranes contains also a sedimentary component of unknown age. One of these paragneisses is referred as Sertânia Complex, described originally in the region of the Rio Moxotó valley, state of Pernambuco (Santos, 1977). The Sertânia Complex is formed essentially by high grade migmatitic supacrustals that are typical of the Alto Moxotó terrane (figure 1), although some questions about the relationships with the São Caetano Complex of the Cariris Velhos age yet remain in some areas. This paper presents the first geochronologic data of the Sertânia Complex, in order to aid the tectonostratigraphic comprehension of this important lithotectonic domain of the Borborema Province.

LITHOSTRATIGRAPHIC PATTERNS

The Sertânia Complex is a sedimentary sequence including a subordinate volcanic component, metamorphosed in upper amphibolite conditions, occurring in the Alto Moxotó terrane, Transversal Subprovince of the Borborema Province (figure 3). In the type area environs of the Sertânia town, the complex is formed essentially by migmatites of metapelitic protholith, including sillimanite-in or sillimanite-out garnet-biotite schists, in places carrying a volcanoclastic component, interlayered with marble, minor quartzite, calc-silicate rock and amphibolite (figure 1). In the Sumé (PB) region, the garnet-biotite schists contain abundant lenses of marble and they are lesser migmatized. In the westernmost the supracrustals grade to quartzite-rich facies, and includes also BIF´s and mafic metavolcanics. According to Santos et al (2002), the Sertânia Complex was intruded by tonalitic and trondhjemitic sheets, in places described as Camalaú suite. One sample of alkali-feldspar granitic orthogneiss and two ones of migmatitic metagraywacke and schist of were collected at the region of Aroeiras (PB) (figure 3) for geochronologic purposes. The sample of the São Luís farm (SPP-GN-FSL) is a garnet-biotite-plagioclase schist with disperse quartz porphyroblasts, besides titanite, apatite, zircon and opaque minerals. The zircon of this sample shows well crystallized crystals largely with an oscillatory zoning parallel to margin of crystals (figure 2) suggesting a magmatic or volcanoclastic origin (probably dacitic to quartz andesitic tuffs). Another sample of the same region (SPP-GN-BXS) is a plagioclase-rich gneiss, including also quartz and Ti-rich biotite and occasional sillimanite with a similar composition. The sample SPP-GN-PER is a microcline-rich migmatite with a dominant leucosome matrix and relict of a garnet-plagioclase-quartz schist mesosome, typically of sedimentary origin.

ANALYTICAL PROCEDURES

SHRIMP operating calibrations of data, analytical errors and calculation of dates Zircon U-Pb isotopic data were obtained from the Australian National University (ANU) SHRIMP I instrument using a ca. 25 μm spot with a mass-filtered 02-primary íon beam. A mass resolution of 5,500 to 6,000 (at 1% peak height) was used for analysis. Details of the analytical procedure are presented by Stern (1998) and Williams (1998). Due to effects such as the differential yield of metal and oxide species between elements during sputtering, inter-elements ratios are calibrated with a standard, where the ratios are known by isotope dilution thermal ionisation mass spectrometry (IDITMS). This calibration method is explained fully by Stern (1998) and Williams (1998). Thus $^{206}Pb/^{238}U$ ratios have an error component (typically 1.5 to 2.0%) from calibration of the measurements using the standard zircons. U abundance was calibrated against 238 ppm U (<±10%) fragments of the single crystal SL13 standard and Pb/U was calibrated against the multicrystal standard AS57 of 1,100 Ma; Paces and Miller 1993). All errors take into account non-linear fluctuations in ion counting rates beyond that expected from counting statistics (e.g.

Stern 1998). The decay constants and present-day $^{238}U/^{235}U$ value given by Steiger & Jäger (1977) were used to calculate dates. For suites Neoproterozoic zircons of lower U (≤1,500 ppm), the most reliable dates considered to be those derived from $^{206}Pb/^{238}U$ ratios, following correction for common Pb by the ^{207}Pb method (Compston et al 1984) and use of the Cummings & Richards (1975) model Pb composition for the likely age of the zircons. For Neoproterozoic higher U zircons suites, where matrix contrasts with the standard zircons can make the calibration of U/Pb unreliable, most confidence is placed in $^{207}Pb/^{206}Pb$ dates, following correction for common Pb based on measured ^{204}Pb. For assessment of dates on older zircons, most reliance is placed on $^{207}Pb/^{206}Pb$ dates on sites with close to concordant dates, following correction for common Pb based on measured ^{204}Pb. Pooled dates calculated in this paper are weighted means (analysis inverse-variance weighted, 95% confidence and rounded to the nearest million year), basing on grouping of sites interpreted from CL (cathodoluminescence) images to belong to one generation of zircon. The dates were calculated using the program Isoplot/Ex of Ludwig (1998). U abundances and Th/U of analyzed sites are only discussed when considered important for interpretation of isotopic data. Data are presented as $^{238}U/^{206}Pb$ versus $^{207}Pb/^{206}Pb$ "Tera-Wasserburg" plots.

GEOCHRONOLOGIC DATA

It were analyzed zircon populations of the SPP-GN-FSL and SPP-GN-PER. The SPP-GN-FSL sample yielded mostly prismatic zircons, up to 200μm long. In CL images many of these display oscillatory zoning subconcordant to the exterior of the grains (figure 2). They commonly have thin partial overgrowths, which appear bright and homogeneous in CL images. A minority of the grains show oscillatory zoning strongly truncated at grain boundaries. Nine analyses are undertaken on 9 grains. All 6 analyses of oscillatory zoned zircons yielded a $^{207}Pb/^{206}Pb$ weighted mean date of 2,126±26 Ma (95% confidence, MSWD=0.14) (figure 3). One analysis of a bright homogeneous rim yielded dates within error of this, whilst analyses of two other grains also of bright rims yielded younger discordant dates. The sample is clearly dominated by Paleoproterozoic zircons of igneous origin and restricted age, which were affected by subsequent metamorphism and disturbance, probably in the Neoproterozoic. The sample SPP-GN-PER contained oval to somewhat rounded prismatic zircons, up to ~250μm long (figure 2). In CL images many grains display oscillatory zoning. This is generally subconcordant with the exterior of the grains, but in some cases it has been truncated. Some grains have overgrowths, which appear homogeneous to weakly oscillatory-zoned in CL images. Sixteen analyses were undertaken on 15 grains. Most sites on oscillatory zoned zircon yielded close to concordant dates, with $^{207}Pb/^{206}Pb$ dates between ~2,200 and 1,950 Ma (figure 3). These grains are interpreted as derived from a Paleoproterozoic terrane dominated by rocks formed in a short period. Given the apparent lack of abrasion of these grains, they were probably not transported far in a sedimentary system. Two analyses of overgrowths yielded much younger dates. Although these not define a precise date, they clearly indicate zircon overgrowth during metamorphism in the Neoproterozoic. The SSP-GN-BJL sample (orthogneiss) data (8 analyses) all produce a model 1 regression of 2,016±27 Ma, 393±150 Ma intercepts, MSWD=0.6 (figure 3). Alternatively, the 4 closest to concordant analyses give a weighted mean $^{207}Pb/^{206}Pb$ date of 2,008±21 Ma, 95% confidence, MSWD=0.8. The ca. 2,000 Ma dates are alternative calculations on the age of igneous zircons in this sample. The 393±150 Ma lower intercept in the regression is an indication of early Palaeozoic to Late Neoproterozoic disturbance. The behavior of Nd isotopic data of both orthogneisses and supracrustals of the Alto Moxotó terrane is also similar. The Aroeira and Sertânia samples show model ages Nd T_{DM} of 2,4 Ga, however samples of other localities exhibit ages around 2,6 Ga, all with negative εNd parameter, clearly indicating an Archean source yet not known in this terrane. The most of Rb-Sr data of the Alto Moxotó rocks plots on reference isochron of 2,190 Ma (Brito Neves et al 2001), supporting the influence of the Transamazonian event in this terrane.

DISCUSSION AND CONCLUSIONS

The ages obtained for orthogneisses and supracrustals of the Alto Moxotó terrane confirm this tectonic segment represent a distinct domain within the Transversal subprovince framework, which is dominated by Cariris Velhos and Brasiliano belts. However recent chemostratigraphic and Pb-Pb ages obtained in marbles of the Alto Pajeú and Alto Moxotó terranes have suggested a Cariris Velhos age for sedimentation and metamorphism of the supracrustals of both terranes (V.H. Santos et al 2002). We believe these more new ages resulted of metamorphic disturbances operating in O and C systems under influence of the Cariris Velhos and/or Brasiliano events acting on both domains.

REFERENCES

Brito Neves, B.B.; Van Schmus, W.R.; Santos, E.J.; Campos Neto, M.C.; Kozuch, M. 1995. O evento Cariris Velhos na Província Borborema. Rev. Bras. Geoc. 25:279-296.

Brito Neves, B.B.; Santos, E.J.; Van Schmus, W.R. 2000 Tectonic history of the Borborema Province. In: Cordani, U.G. et al (Eds.) 2000 Tectonic evolution of the South American Platform. 31st Internat. Geol. Congress, p.151-182.

Brito Neves, B.B.; Campos Neto, M.C.; Van Schmus, W.R.; Fernandes, T.M.G.; Souza, S.L. 2001. O terreno Alto Moxotó no leste da Paraíba ("Maciço Caldas Brandão"). Rev. Bras. Geoc. 31(2):185-194.

Compston, W.; Williams, I.S.; Myer, C. 1984. U-Pb geochronology of zircons from lunar breccia 73217 using a sensitive high mass-resolution ion microprobe. Journ. Geophys. Research 89B:525-534.

Cumming, G.L.; Richards, J.R. 1975. Ore lead ratios in a continuously changing Earth. Earth Planetary Science Letters 28:155-171.

Ludwig, K.R. 1998. Isoplot/Ex. Berkeley Geochronology Center Special Publication 1.

Paces, J.B.; Miller, J.D.Jr. 1993. Precise U-Pb ages of Duluth Complex and related mafic intrusions, northeastern Minnesota: Geochronological insights to physical, petrogenetic, paleomagnetic, and tectonomagmatic processes associated with the 1.1 Ga midcontinent rift system. Journal Geophysical Research 98:13997-14013.

Santos, E.J. 1977 Síntese da geologia precambriana da folha Arcoverde, Pernambuco. Simp. Geol. Nordeste 8, Atas p.225-245.

Santos, E.J. 1996. Ensaio preliminar sobre terrenos e tectônica acrescionária na Província Borborema. Cong. Bras. Geol. 39, Anais 6:47-50.

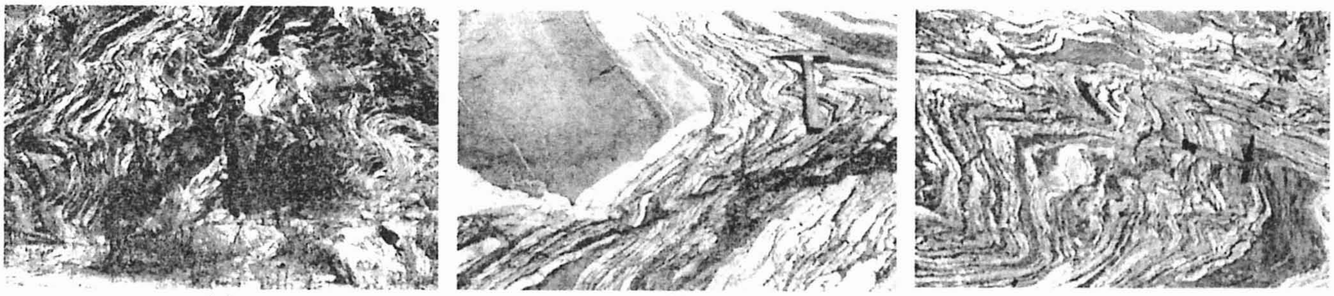
Santos, E.J.; Ferreira, C.A.; Silva Jr., J.M. 2002. Geologia e recursos minerais do estado da Paraíba. Secretaria de Minas e Metalurgia/PB & CPRM-Serviço Geológico do Brasil, Prog. Levant. Geol. Básicos do Brasil, 142p.

Santos, V.H.; Ferreira, V.P.; Sial, A.N.; Babinski, M.; Pimentel, M.M. 2002 C, Pb and Sr isotopic chemostratigraphy in Proterozoic carbonate sequences in the eastern Transversal domain of the Borborema Province, Northeast Brazil. Congresso Brasileiro de Geologia 41, Anais, p. 509.

Steiger, R.H.; Jäger, E. 1993. Subcommission on geochronology: Convention on the use of decay constants in geo- and chosmochronology. Earth Planet Science Letters 36:359-362.

Stern, R.A. 1998. High resolution SIMS determination of radiogenic trace isotope ratios in minerals. In: L.J. Cabri and D.J. Vaughan (editors). Modern approaches to ore and environmental mineralogy. Mineralogical Association of Canada Short Course Series 27:241-268.

Van Schmus, W.R.; Brito Neves, B.B.; Hackspacher, P.; Babinski, M. 1995 U/Pb and Sm/Nd geochronological studies of eastern Borborema Province, northeastern Brazil: initial conclusions. J. S. Am. Earth Sci., 8:267-288.



(a) (b) (c)

Figure 1. Stromatic and folded migmatites of the Sertânia Complex from the type area: (a) general view of the folded migmatite; (b) preserved piece of metavolcanoclastics in migmatized garnet-biotite schist developing a pegmatitic leucosome along the contact between both two lithologies; (c) amphibolite relict in folded mimatite with metapelitic mesosome.

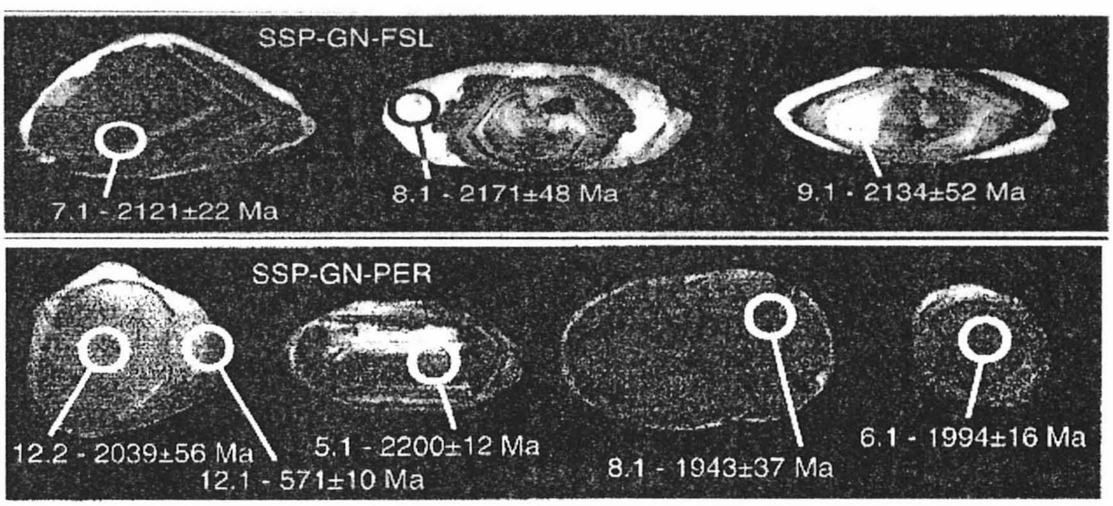


Figure 2. Cathodoluminescence images of zircons of the supracrustals of the Sertânia Complex. Sample SPP-GN-FSL volcanoclastic schist of the São Luís farm; SPP-GN-PER garnet-biotite schist of the Pereiro farm.

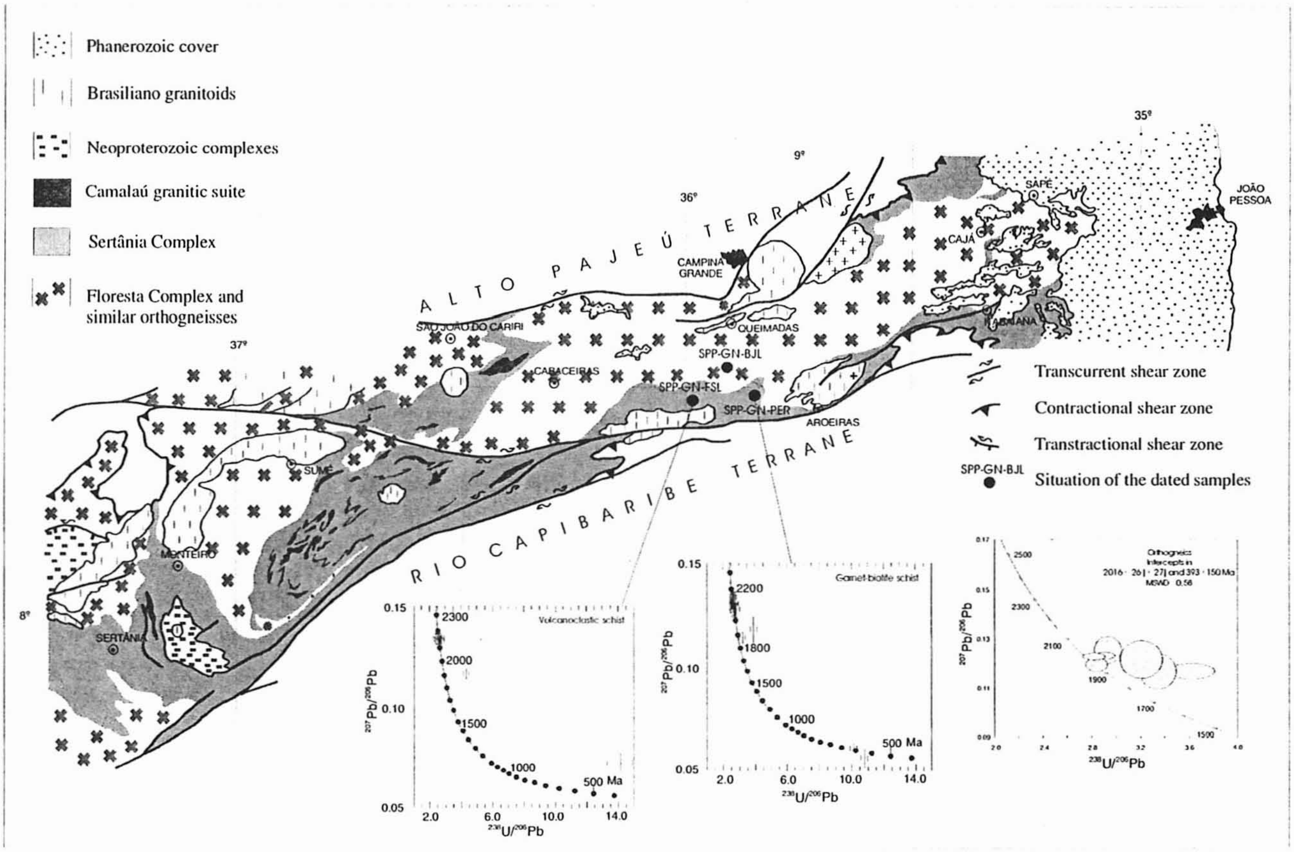


Figure 3. Simplified geological map of the Alto Moxotó terrane, showing the distribution of the Sertânia Complex and the situation of the dated samples (geology according Santos et al., 2002).