GEOLOGY, GEOCHEMISTRY AND GEOCHRONOLOGY (Rb-Sr, U-Pb, Sm-Nd AND Ar-Ar) OF THE ORTHOGNEISSES FROM THE ALTO PAJEÚ TERRANE

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GENERAL GEOLOGICAL FEATURES

In the central domain of the Borborema Province, from the Pernambuco/Piauí boundary (to the SSW) up to the coastal area, north of João Pessoa (to the ENE, Mari municipality) occurs a fold belt of ca. 700 km long (over 100 km wide, at some places), with a WSW-ENE general trend, Early Neoproterozoic in age. This fold belt/terrane called Alto Pajeú is mostly composed of volcanic-sedimentary and immature sedimentary supracrustal assemblages ("Complexo São Caetano do Navio") which are pierced by dozens sheets and small bodies of orthogneisses (so-called "Cariris Velhos Orthogneisses").

This orogenic system was developed in the early beginnings of the Neoproterozoic time (990-930 Ma), which includes all their evolutionary stages, since the complex system of paleogeographic realms (small ocean basins??) up to the main deformational events (contracional deformation was rather important). Later on, during the Neoproterozoic III and Cambrian times, this belt was submitted to important overprint of the Brasiliano collage and their related extrusional events (Brito Neves et al., 2000).

There are some recent signs of occurrences of additional branches of the Alto Pajeú belt to the south of the central domain ("Zona Transversal") of the Borborema, in the Pernambuco-Alagoas massif as well as in the northern part of the Sergipano Belt ("Southern Domain"). These possibilities are being matter of geological investigations in the present moment by researchers of the UNICAMP. To the north of the Zona Transversal ("Rio Grande do Norte Terrane"or "Northern Domain" of the Borborema Province), no indication for these orogenic development has up to now been noticed.

The main area of occurrence of this orogenic system is bounded by important shear zones, as Serra do Caboclo and Patos (to the northwest and north) and Afogados do Ingazeira (partially) and Congo shear zones (to the south and southeast).

Even though the structures of this orogenic systme are diagonally reaching the shore line and the continental shelf, the continuity of this development (to the Cameroon?) in the African territory has not been recorded. Actually, it is necessary to state that geologic analogues for the Alto Pajeú Belt (ages and composition) were not pointed out in the South America continent, so far.

The supracrustal assemblages ("São Caetano do Navio") are mostly banded rocks, with biotite and muscovite (+ garnet) schists and metagraywackes predominating, with intercalations of metadacites (some metabasalts), metarhyolites (metafelsites) and some local metacarbonates, under amphibolite facies of metamorphism. Migmatites have broadly been generated in many places (like Guarabira and north Floresta areas), so increasing the banded features of these rocks. Many small bodies, sheet-like bodies of othogneisses occur somehow crosscutting these supracrustal assemblages. These are (usually) rocks with high SiO_2 and K_2O contents and high Rb/Sr ratios, with biotite and muscovite (+ sillimanite) as common minerals for orthogneisses (so-called "Ambó", "Recanto" etc. leuco-orthogneisses), which use to present modal composition of syenogranites, granites, monzogranites and (minor) granodiorites. In spite of the few amounts of supracrustals xenoliths in these gneisses, in many places their structural relationships as younger intrusive bodies seem to be clear.

From the point of view of the regional structural geology, these rock assemblages were involved in a very important contractional event (what is confirmed by the geochemical data of the orthogneisses), probably as result of a collisional event. Such event (D_{n+1}) and the predominating foliation (S_{n+1}) then generated were clearly produced by a second (superposed) generation of tectonic movements. Such tangential deformation, with kinematics indicators towards NW and NNW is pervasive along important part of the "Transversal Zone", particularly to the southeastern and central-eastern part of the Paraíba State, and to the central-north and southwest part of Pernambuco State (Brito Neves et al., 2001). This tangential framework occurs affecting both the Paleoproterozoic basement rocks and the Early Neoproterozoic assemblages, and it was later or involved in the Brasiliano phases of deformation

A preliminary interpretation for this framework sugestes an outstanding collisional process, between the Alto Moxotó terrane (Paleoproterozoic, to the south) and the Rio Grande do Norte terrane (to the north) in the aftermaths of a period of B subduction ("Pedras Pretas magmatism"/ ophiolitic remnants?, accretionary calc-alkaline volcanism of "Lagoa das Contendas" etc., described by Santos, 1995). Part of the the Cariris Velhos orthogneisses are probalble to be generated by fusion of the supracrustal assemblages during that collisional process, what is a conclusion placed in advance, but that will partially be reiterated by the lithogeochemical data.

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The structural patterns obtained by the collisional events were widely affected by the tectogenic (taphrogeneses and orogeneses, magmatism) processes of the superposed Brasiliano Cycle. Several ways of Brasiliano overprint (two up to three phases of deformation) may be observed, from discontinuous or local processes of folding up to huge events of shearing and strucutural transposition. The Brasiliano heating processes used to be widespread, as it will be later on discussed, therefore making difficult to point out absolutely unaffected Cariris Velhos domains. Many Brasiliano processes of lateral and vertical accretion are well known (many references available, see Brito Neves et al., 2000) for the Borborema Province as a whole, being specially relevant the events associated to the final extrusional phases (shearing and granitogenesis s.l.) that gave the final geometric-geologic outlines of the Province as a whole. Brasiliano tectonic-magmatic episodes have been recorded the beginnings of the Cryogenian period (taphrogeneses and magmatism) up to the early-Ordovician (extrusional shearing and cooling processes).

Thus, the (Early Neoproterozoic) Alto Pajeú terrane is actually only part of a fold belt that could be discriminated in the complex basement of the Brasiliano Borborema Province (Middle Neoproterozoic - Early Ordovician development)

The compositions of the Cariris Velhos orthogneisses varies - most of all - from syenogranites, monzogranites and granodiorites. Muscovite and muscovite-biotite (+ garnet) are common. Garnet, apatite, turmaline and zircon occur as accessory minerals (monazite is particularly rare as accessory). These orthogneisses use to crop aout as small bodies (stocks) and sheet-like bodies, these latter positioned in structural concordance with the contractional tectonic that characterize most of the Cariris Velhos terrane. Mostly in the southeast of Pernambuco (Floresta area) and northeast of Paraíba (Guarabira area) there are widespread occurrences of migmatized facies of these rocks. Banding from compositional features as well as due to some migmatizations processes are rather usual for these rock assemblages.

PRELIMINARY GEOCHEMICAL DATA

The geochemical analyses of the orthogneisses display high contents of SiO_2 (> 7%), Al_2O_3 (> 13%) and Na_2O (5,3%), and the Ba contents are variables (from 100 up to 1100 ppm). These and other characteristics may point out these rocks either for the group II of Harris et al. (1986) or the MPG group (between MPG and the CPG group) of Barbarin (1999). In both cases, the small amounts of monazite (as above mentioned) and the frequency of sphene were not expected, but they are understandable when the large possibilities/variety of sources are took into account.

These rocks are positioned in the metaluminous (most of them) to peraluminous and sub-alkalines fields. In the spidergrams normalized for primitive mantle, the final results obtained for these leuco-orthogneisses is coherent with those of Santos (1995, in Floresta-PE area), i. e., exhibiting typical depletions in Ba, Nb, Sr and Ti, and so presenting general geochemical data and characteristics of collisional granites, according to Thompson et al (1984), so reiterating the previous petrographic assumptions according to Barbarin (1999, MPG group). Even some sheet-like bodies of orthogneisses (that use to occur circumscribing the main batholiths, resembling ring complexes) keep these same general pattern of geochemical data.

The use of discrimination diagrams present some controvertial features. The distribution of points falls in different fields (Pearce et al., 1984), from volcanic arc (+ syn- Colg) up to anorogenic granites, with major concentration of points in the "within plate" field. The use of the diagram of Pearce et al. (1986), most of the granites fall in the "post-Colg" field. In recent thesis, Kozuch (2003, unpublished) made analyses of many Cariris Velhos orthogneisses (different samples) and she got geochemical results very similar to these granites of Andean and Japan arcs, using the same discrimination diagram. So, without discarding the problem existence, it is necessary to consider that there are many aspects to be faced: the nature and paradigms of the diagrams, the present (still small) critical mass of data, the overprint of metamorphism (Cariris Velhos and Brasiliano), and of other still unsuspected processes.

GEOCHRONOLOGICAL DATA

The orthogneisses of the Alto Pajeú display coherent set of Rb-Sr isochronic diagrams. Different parts of the terrane have been sampled and presented ages values 915 Ma, 954 Ma and 966 Ma. Particularly the isochrons with age values over 950 Ma are more frequent and with better analytical quality (high Rb/Sr ratios). Even regarding the general nature and characteristics of this method, these values are significant because of their consistency (and the correspondence with U-Pb data), and because they were preserved in spite of the widespread overprint of the Brasiliano processes

The results obtained with U-Pb method in the Alto Pajeu terrane- both from conventional method and from SHRIMP analyzes are still deserving a refining in their knowledge and interpretation. Age values have been obtained since from 920 Ma (large errors involved) up to 995 Ma (small amount of errors), with the most important set of ages around 950 Ma (sheets of othogneisses enclosed by metagraywackes). So doing, these age values are repeating those obtained by Rb-Sr methodology. It is necessary to emphasize the importance of these data which support the existence of an Early Neoproterozoic orogenic event in the Borborema Province, but the origin, number and sucession of events still remain as open questions.

Sm-Nd data for both the Cariris Velhos orthogneisses and for their enclosing metagraywackes and schists ("S. Caetano do Navio Complex") display similar behavior. For the cases of metragraywackes de $T_{(DM)}$ values varies from 1300 up to 2500 Ma, but in the majority of the cases this upper limit is below 2000 Ma. The εNd values use to be positive between (+1) and (+2) for the cases with the lowest values of $T_{(DM)}$, and they are moderately negative,

between (-7) and (-10), for the cases with highest values of $T_{(DM)}$. So, the admittance of some cases of juvenile sources for the formation of theses rocks seems to be reasonable. Otherwise, there are some few particular cases of very high values of $T_{(DM)}$ (between 2500 and 3600 Ma), and negative values of εNd indicating sparse contribution of older source rocks, even from far Archean domains.

For the orthgneisses themselves the range of values for $T_{(DM)}$ is mostly between 1300 and 1900 Ma, with some rare cases of values over 2000 Ma. The values for εNd use to show remarkable regularity, with the lowest values between (-0.12) up to (+2.0), i.e. near zero, for the cases of lowest values of $T_{(DM)}$, and the negative values around (-3.0) and (-5.0) for the case of high $T_{(DM)}$ values, over 1700 Ma. According to these data it is possible to assume important juvenile contribution in the formation of part of the Cariris Velhos orthogneisses.

Just some few Ar-Ar data were run in samples of these rock assemblages, in order to evaluate the behavior of the Alto Pajeu Terrane (Fold Belt Pajeú-Paraíba) during the subsequent events of the Brasiliano Collage. The choosen samples were collected from areas where (apparently) the events of the Brasiliano were of lesser importance, far from Neoproterozoic intrusives and shearing domains. The results from amphibole (S. José do Egito, amphibolite), 623 ± 15 Ma; muscovites (S. José do Egito, metagraywacke and Lagoa do Meio metadacite), 512 ± 3 Ma; and rhyolite, whole rock (Serra do Machado rhyolite, intrusive in Cariris Velhos orthogneiss) give an idea of widespread occurrence of the Brasiliano events and different times of cooling, as well as they are clearly showing the difficulty to state some unaffected areas, preserved of the thermal events of the superposed Brasiliano Cycle.

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