SOUTHERN BRASILIA BELT (SE BRAZIL): TECTONIC DISCONTINUITIES, K-AR DATA AND EVOLUTION DURING THE NEOPROTEROZOIC BRASILIANO OROGENY

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ABSTRACT This paper focuses the tectonic evolution of the southern Brasilia belt, with emphasis on the Furnas segment, along the 21'S parallel. The uppermost structural unit (Passos Nappe - PN) comprises a highly deformed metasedimentary succession interpreted as a fragment of the Neoproterozoic passive margin of the São Francisco craton. An inverted metamorphic passive margin range from greenschist to lower granulite facies of medium to high-pressure regime characterizes the PN as a subduction zone. The External Domain displays a complex imbrication of basement rocks (Archean Prumhia greenstones, a turbiditic graywacke succession and a calc-alkaline granitoid suite) with undated siliciclastic low-grade metasedimentary rocks. The São Francisco Craton (SFC) comprises pre-1.8 Ga basement rocks covered by an accretionary Neoproterozoic carbonate shallow marine platform deposits of the Bambui group. The Brasiliano thrust stacking generated a coarse clastic influx of molassic character on the foreland zone of São Francisco Craton, coeval with the exhumation of the External Domain thrust sheets. New K-Ar determinations on mineral separates are presented and interpreted among previous data. The SFC basement rocks display Paleozoic Neoproterozoic cooling ages. The allochthonous units, in contrast, display K-Ar ages within the 560-675 Ma range. Brasiliano thrust stacking is therefore interpreted to have taken place onto a "cold" São Francisco craton foreland, in a thin-skinned style, as basement rocks were not heated enough to have their K-Ar systems reset during the allochthony.

Keywords: Brasilia Belt, K-Ar, Neoproterozoic, thrust tectonics, Brasiliano orogeny

INTRODUCTION The Brasilia belt is an important tectonic element of the Tocantins orogenic Province, developed during the Neoproterozoic passive margin sedimentation. A transitional contact with the Upper Unit, with paragneisses and feldspathic schists, probably marks reactivation of extensional stresses, which led to the erosion of granite-gneissic basement sources. Frequent intercalations of continental tholeiitic metabasalts are also characteristic. To the top of this transition, predominant metapelites with thin beds of paragneiss, calc-silicate rocks and spessartite-quartz metachert indicate deep marine environments. The geochemistry of intercalated metamorphic rocks is indicative of progressive lithospheric extension, starting with the predominance of continental metabasalts, tending towards the top to a predominance of E-MORB type metabasalts (Valeriano & Simões 1997).

The PN displays a sole thrust always below the main quartzite level of the Lower Unit. Lithologic contacts (enveloping surfaces of the relic bedding planes) at map scale are subparallel to the basal thrust surface, regardless of pervasive tight intrafolial recumbent main phase folding. This feature played important role during the tectonic transport, in which the basal metapelites, over lain by relatively competent quartzite beds, acted as a crustal detachment zone. The internal deformation comprises early sin-metamorphic low angle shear processes, which originated tight to isoclinal folds with gently W to NW dipping axes and penetrative axial plane foliations related to progressive refolding of early foliation. Associated stretching lineation is always subparallel to fold axes. Abundant shear sense indicators show unequivocal tectonic transport towards between E and SE directions. This main deformation is interpreted as the initial stage of crustal shortening related to a Neoproterozoic subduction zone, followed by the formation of the basal detachment zone and final thrust-emplacement onto the External Domain (Simões 1995). The thrust-driven ascension of the Passos nappe must have been relatively fast, indicated by the preservation of an inverted medium to high-pressure metamorphic gradient (Simões 1995), ranging from upper greenschist to lower granulite facies, with metamorphic zonation nearly parallel to bedding and basal thrust. The post-metamorphic peak deformations of the PN include two sets of gentle to open folds with steep axial planes, one with NW trending axes and a later phase with N-S axes.

External Domain This tectonic domain is a foreland thrust-fold belt with four imbricated main lithologic associations (Valeriano et al. 1995), all displaying greenschist facies metamorphism (chlorite zone), that is:

i) the Serra da Boa Esperança unit, a siliciclastic succession of still undefined age. Typical lithology includes coarse orthoquartzites, sericite phyllites and quartz-metaconglomerates with subordinated iron formation and carbonaceous metasahales;
Figure 1: Main structural elements of southern Brasilia belt and adjacent geotectonic units. Compiled from Schrank et al. (1990), Morales et al. (1993), Ribeiro et al. (1995), Valeriano et al. (1995), Seer (1999) and Simões (1995).
ii) an Archean granite-greenstone association, with metakomatiites containing relict pillows and spinifex texture, in association with mafic to felsic metavolcanic and metasedimentary rocks (Schrank 1982). U-Pb zircon dating of a gabbro sill within the volcanic sequence yielded an upper intercept at 3116±10 Ma (Machado & Schrank 1989). At the Piumhi town area, granitoid rocks are clearly intrusive in the volcanic rocks. South of Piumhi, granitoid rocks predominate over the greenstones. South of Santo Hilario, an expanded deformed calc-alkaline granitoid suite predominates, ranging from gabbro to granite (Valeriano 1992);

iii) a thin-bedded turbidite sequence of low metamorphic grade, and

iv) minor thrust slices of the Bambuí Group slates.

In addition to the main continuous exposures under the Passos nappe, eleven small klippen were also mapped overlying the Cratonic Domain. The structural evolution of the External Domain contrasts with that of the other tectonic domains. Individual thrust sheets display a deformational fabric due to an intense N-verging low-angle shear tectonic transport marked by a stretching lineation and associated shear sense indicators. Valeriano et al. (1995) suggest that this fabric could be a relict of a pre-Brasiliano crustal shortening event. These previously deformed rock were involved in the Brasiliano east-vergent thrust stacking, at shallow crustal levels, on top of the Cratonic Domain. The Brasiliano deformation produced upright chevron folds.

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Table 1 - Analytical data of new K-Ar determinations from the Furnas segment of the Brasilia belt, performed at the CPGeo-USP (Valeriano 1992).

<table>
<thead>
<tr>
<th>Age (Ma)</th>
<th>Mineral</th>
<th>Rock type</th>
<th>Sample number</th>
<th>UTM coordinates</th>
<th>% K</th>
<th>rad.40Ar x 10^-6 (ccSTP/g)</th>
<th>% atm. Ar40</th>
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<tr>
<td>595 ± 7</td>
<td>White mica</td>
<td>Quartzite</td>
<td>FU-3-C</td>
<td>363.20–7713.25</td>
<td>8.4555</td>
<td>231.72</td>
<td>5.98</td>
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<td>600 ± 13</td>
<td>White mica</td>
<td>Quartzite</td>
<td>CRC-1-16</td>
<td>386.95–7694.70</td>
<td>8.2755</td>
<td>228.65</td>
<td>3.10</td>
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<tr>
<td>637 ± 17</td>
<td>White mica</td>
<td>Quartz-phyllite</td>
<td>CRC-2-33</td>
<td>383.30–7691.15</td>
<td>7.7239</td>
<td>228.84</td>
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<tr>
<td>673 ± 27</td>
<td>White mica</td>
<td>Quartz-mica schist</td>
<td>ALP-1</td>
<td>354.80–7693.60</td>
<td>7.3508</td>
<td>232.30</td>
<td>2.92</td>
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<td>567 ± 7</td>
<td>White mica</td>
<td>Quartzite</td>
<td>BE-5-131</td>
<td>427.10–7680.80</td>
<td>7.9269</td>
<td>205.05</td>
<td>6.03</td>
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<td>575 ± 11</td>
<td>White mica</td>
<td>Quartzite</td>
<td>CRI-C-62</td>
<td>426.40–7684.60</td>
<td>7.0482</td>
<td>185.18</td>
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<td>588 ± 15</td>
<td>White mica</td>
<td>Quartz-phyllite</td>
<td>CRI-CL-4a</td>
<td>431.90–7679.60</td>
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<td>659 ± 8</td>
<td>White mica</td>
<td>Granitic phyllonite</td>
<td>BE-2-85</td>
<td>433.20–7682.10</td>
<td>7.0409</td>
<td>217.43</td>
<td>17.32</td>
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<tr>
<td>2251 ± 26</td>
<td>Hornblende</td>
<td>Dioritic gneiss</td>
<td>CRI-1090</td>
<td>419.80–7684.85</td>
<td>0.4973</td>
<td>86.50</td>
<td>4.16</td>
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<tr>
<td>1727 ± 100</td>
<td>Biotite</td>
<td>Granite</td>
<td>CRI-CWM-a</td>
<td>445.00–7680.30</td>
<td>0.6821</td>
<td>76.33</td>
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</table>
overprinting the previous subhorizontal foliation containing the N-S lineation. These folds are typically associated with brittle-ductile deformation, such as inverse and vertical faults, kink-bands, and intense jointing along axial surfaces. Overprinting of these N-S folds, by late and E-W to NW-SE folds, resulted in dome-and-basin interference patterns.

Cratonic Domain  The autochthonous basement rocks, covered by the Bambuí group, extend continuously from the SW border of the SFC, along the southern limb of the PN (Fig. 2). This sector comprises an association of Archean to Paleoproterozoic migmatite-granite complexes with greenstone-belt remnants. South of the PN, moderate to high angle ductile and brittle shear zones overprint and obliterate previous structures, defining a major NW-SE sinistral strike-slip crustal discontinuity, referred to as the Campo do Meio Shear Belt by Morales (1993). The Bambuí group displays a deformational gradient from undisturbed subhorizontal beds on the craton, to highly sheared tectonites underneath the External Domain (Alkmin et al. 1989). As in the overlying domains, the overprinting of two sets of late open folds and kinks, on the slaty cleavage, is also registered. A Brasiliano sincompressional foreland basin is represented by the Samburá Formation, which overlies discordantly the Bambuí Group and is tectonically covered by the external allochthons. The most representative lithotype is a polimict metaconglomerate that occurs along the basal portion of repetitive erosive upward-fining sedimentation meter thick cycles, interpreted as sub-aqueous fan deposits related to the erosion of the advancing thrust front of the Brasília belt (Valeriano 1992, Castro & Dardenne 1996). Clast compositions show clear provenance from the External Domain and Bambuí group rocks.

K-Ar DATA AND TECTONIC IMPLICATIONS  New K-Ar determinations (Table 1) in addition to pre-existing data indicate that the regional cooling pattern constrains the timing of exhumation of the allochthonous domains, with implications regarding the thermal state of the foreland during orogeny.

In the External Domain, white mica from three samples of Serra da Boa Esperança quartzites (Table 1) yield a relatively narrow range of 588 ± 15 to 567 ± 17 Ma apparent ages, related to the Brasiliano tectonic imbrication. A significantly older white mica age of 659 ± 8 Ma from a basement granitoid-phylolinite thrust sheet (sample BE-2-85, Table 1), is interpreted as a mixed age, due to the presence of non recrystallized coarse primary mica. Hornblende from an orthogneiss sample (CRI-1090) within the granite-greenstone thrust slice yielded a 2251 ± 26 Ma age. Although isolated, this value is compatible with the chlorite zone metamorphism in the External Domain, which was not high enough to reset older K-Ar hornblende systems.

In the Passos Nappe, available K-Ar age determinations (Correia et al. 1982, Machado Filho et al. 1983, Valeriano 1992) constrain its regional cooling within the 674-640 Ma age intervals obtained from hornblende/biotite and white mica, respectively. It is noteworthy that the youngest white mica ages from the NP are closely coincident with those of the External Domain (ca 570 Ma). This may be interpreted as the cooling age of the allochthons under 350 ± 50°C, which is the estimated closing temperatures of argon in white mica (Hanes 1991).

Teixeira (1982, 1985) has studied the K-Ar cooling pattern of basement rocks from the Cratonic Domain of the southern SFC area in detail. The widespread apparent ages at ca. 1.8 Ga led the author to interpret them as the result of a conspicuous uplift and cooling event at the end of the Transamazonian collage (2.2-1.9 Ga). In the gneisses south of the Passos nappe, Teixeira et al. (1989) detected Mesoproterozoic isotopic Rb-Sr rehomogenization (1404 ± 54 Ma) and K-Ar hornblende ages related to the Transamazonian event (2254 ± 39 and 1988 ± 29 Ma), possibly related to thermal influence of the hot allochthons of the Varginha-Guaxupé nappe (Figure 1). However, relatively old K-Ar ages indicate that, during the Neoproterozoic orogenic stage, the Cratonic Domain basement rocks were not heated enough to have their K-Ar systems reset, yielding pre-Brasiliano ages. Allochthony is therefore interpreted to have taken place onto a “cold” São Francisco craton foreland, resulting from thin-skinned nappe emplacement.

Figure 3 - Evolution of thrust-stacking events along the Furnas segment of southern Brasilia belt.
CONCLUDING REMARKS  As recorded by the main deformation/metamorphism in the Internal Domain of the Passos nappe, crustal shortening took place first at medium to lower crustal levels. Through correlation with the adjacent Araxá nappe, where Seer (1999) obtained Sm-Nd whole mineral isochrons, this metamorphic event took place at ca 630 Ma. With initiation of thrust stacking and exposure of the External Domain thrust sheets (Fig. 3a), coarse clastic influx of molassic character (Samburá Formation) took place in the exposure of the External Domain thrust sheets (Fig. 3a). The late “out-of-sequence” character of thrusting and emplacement of the Passos Nappe caused the truncation of the contacts between the External and Cratonic domains (e.g., north of Carmo do Rio Claro, Figs. 2 and 3b) and between the Bambuí Group and basement rocks (west of Carmo do Rio Claro). The timing of emplacement of the Passos nappe and of the External Domain, onto the Cratonic Domain, is loosely constrained by the K-Ar data on white mica ranging 673-566 Ma and 588-567 Ma, respectively.

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References


