Post-Grenvillian (ca. 930 Ma) S-type granites in SW Amazonian Craton: Crustal extensional magmatism resulted from gravitational collapse?

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Introduction and Geological Setting

Westward growth (present-day configuration) of the SW Amazonian craton sector during the Paleo- and Mesoproterozoic occurred as juvenile crustal domains were progressively amalgamated to the evolving continental margin. The accretionary events reported in this region are: the Alto Jauru (1.79 to 1.74 Ga), Cachoeirinha (1.56 to 1.54 Ga), Santa Helena (1.45 Ma to 1.42 Ga), Rio Alegre (1.52 to 1.47 Ga), San Ignácio (ca. 1360 Ma) and finally the Sunsás (1.10-1.00 Ga) (Tassinari et al., 2000). Continental bimodal intraplate magmatisms comprise also important accretionary crustal events in the region and these intermittent intraplate complexes could be regarded as distal manifestations inboard of extentional environment related to the development of the evolving continental margin (Geraldes et al., 2001).

Several S-type granites, volumetrically less important than the I- and A-type granites, are reported in the SW Amazonia craton. This work deals with isotope constrains (U/Pb, Sm/Nd and Pb/Pb) of one of the S-type granite (the São Domingos suite) and its bearing on the evolution of the continental crust at the Meso- Neoproterozoic boundary.

The São Domingos Suite

The São Domingos Suite (SDS) is a S-type granite comprised roughly of circular bodies intruded in the 1.45-1.42 Ga Santa Helena batolith. The main lithology is a white, isotropic and fine-grained granite. Pegmatitic facies also may be observed near to the borders, presenting higher contents of biotite and muscovite. Locally magmatic layering may be observed formed by higher amounts of biotites and garnets. K-feldspar, quartz, plagioclase, biotite, muscovite and garnet are the major minerals; zircon, apatite and oxides occur as the accessory minerals. Two U-Pb (single grain) zircon ages indicated an upper intercept age (four points) of 930 ± 12 Ma for a muscovite biotite-pegmatite and 936 ± 26 Ma for a garnet-bearing granite.

Pb isotope ratios obtained on leaches of garnets yielded an imprecise Pb/Pb isochron age of 891 ±110 Ma (MSDW=0.59). A two-point Sm/Nd mineral (K-feldspar and garnet) isochron for the garnet-bearing granite yielded an age of 927 ± 5 Ma. Both isochron ages are in agreement (within errors) with the U/Pb zircon ages. The above geochronologic data strongly indicate that SDS crystallized at ca. 930 Ma, and that it

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is younger than the Aguapeí Thrust Belt, which have been dated at ca. 980 Ma (K/Ar ages). Recent $^{40}Ar/^{39}Ar$ data (plateau age) for the Aguapeí deformation (Tohver et al., 2000) indicate hornblende age of 970 ± 6 Ma. All these ages indicate that the SDS rocks were originated 40-50 Ma after the Aguapeí Thrust Belt metamorphic peak.

The Nd evidence (ε_{Nd} values for two SDS samples are –14 and –2) indicates an origin from crustal protoliths. In addition, O stable isotopes analysis ($\delta^{18}O$ values of + 8.6‰ and + 9.0‰), and the whole rock chemical analysis (4 samples) indicate slightly peraluminous character, suggesting a pelitic metasedimentary protolith for the SDS rocks granite genesis.

Pb initial isotopic composition was also determined from K-feldspars of the more important regional units (the 1.79-1.74 Ga Alto Jauru, 1.58-1.52 Ga Cachoeirinha and 1.45-1.42 Ga Santa Helena rocks). These results when plotted in a $^{207}Pb/^{204}Pb$ *versus* $^{206}Pb/^{204}Pb$ diagram indicate that the Santa Helena rocks evolved along a growth curve with μ_1 value of 9.50 while Alto Jauru and Cachoeirinha rocks and the SDS rocks evolved along a growth curve with μ value of 9.85. These results allow to suggest that the SDS rocks were originated by the melting of the Alto Jauru and Cachoeirinha rocks, although SDS rocks are hosted by the Santa Helena batolith.

Tectonic Implications

At the end of the Mesoproterozoic (see Figure 1) an important continental distension (rifting) took place in the SW Amazonian Craton represented by the deposition of the sedimentary rocks of the Sunsás and Vibosi groups in Bolivia and the Aguapeí and Nova Brasilândia groups in Brazil. Furthermore, these basins were closed during the development of shortening and uplift processes resulted of plate collision probably related to the Rodinia assembly. Up to now two metamorphic pulses linked to such processes were identified: a regional metamorphism at ca. 1100-1080 Ma in the Arequipa-Antofala terrane (Tostal, 1996), and Garzon-Santa Marta massif (Restrepo-Pace et al., 1997), within the Andean Chain; and Nova Brasilândia terrane (Rizzoto et al., 1999), located in Rondonia. A second metamorphic episode occurred at ca. 1000-970 Ma in Bolivia (Sunsás event) and Brazil (Aguapeí Thrust Belt).

The granitic activities in the Nova Brasilândia region took place into two distinct pulses at 1098 ± 10 Ma (U/Pb; Rio Branco granite) and 995 ± 15 Ma (U/Pb; Rio Pardo granitic suite) (Rizzoto, 1999). Metamorphism age of the Nova Brasilândia rocks is indicated by an anatetic granitic dated at 1100 ± 08 Ma (U/Pb SHRIMP ages; Rizzoto, 1999) and $^{40}Ar/^{39}Ar$ data, reported by Tohver et al., (2000) at 1104 ± 3 Ma and 1091 ± 2 Ma (plateau ages) in biotites of metamorphic rocks, constrain the regional cooling of the crust.

The Sunsás Cycle magmatic activity in Bolivia occurred between 1005 to 993 Ma (Rb/Sr ages) and is represented by the Rincon del Tigre Igneous Complex (Rb/Sr age of 992 ± 86 Ma) and syn to late-kinematics granitoids (Rb/Sr age of 1005 ± 12 Ma). K/Ar ages in micas of Sunsás metasedimentary rocks suggest a metamorphic peak at 1005-972 Ma. According to Teixeira and Tassinari (1984) these ages are in agreement with those already observed for the Younger

Granites of Rondônia. The effects of the Sunsás Orogen in northern Rondônia and adjacent areas occurred between 1.15 and 0.97 Ga. It includes mainly rapakivi granites, mafic dikes and granitic plutons between 1080 and 970 Ma emplaced into the older Rio Negro/Juruena and Rondonian/San Ignacio rocks. These effects are partially coeval with the Sunsás Orogen in Bolivia as well as the evolution of the Aguapeí Thrust Belt and the Nova Brasilândia Terrane.

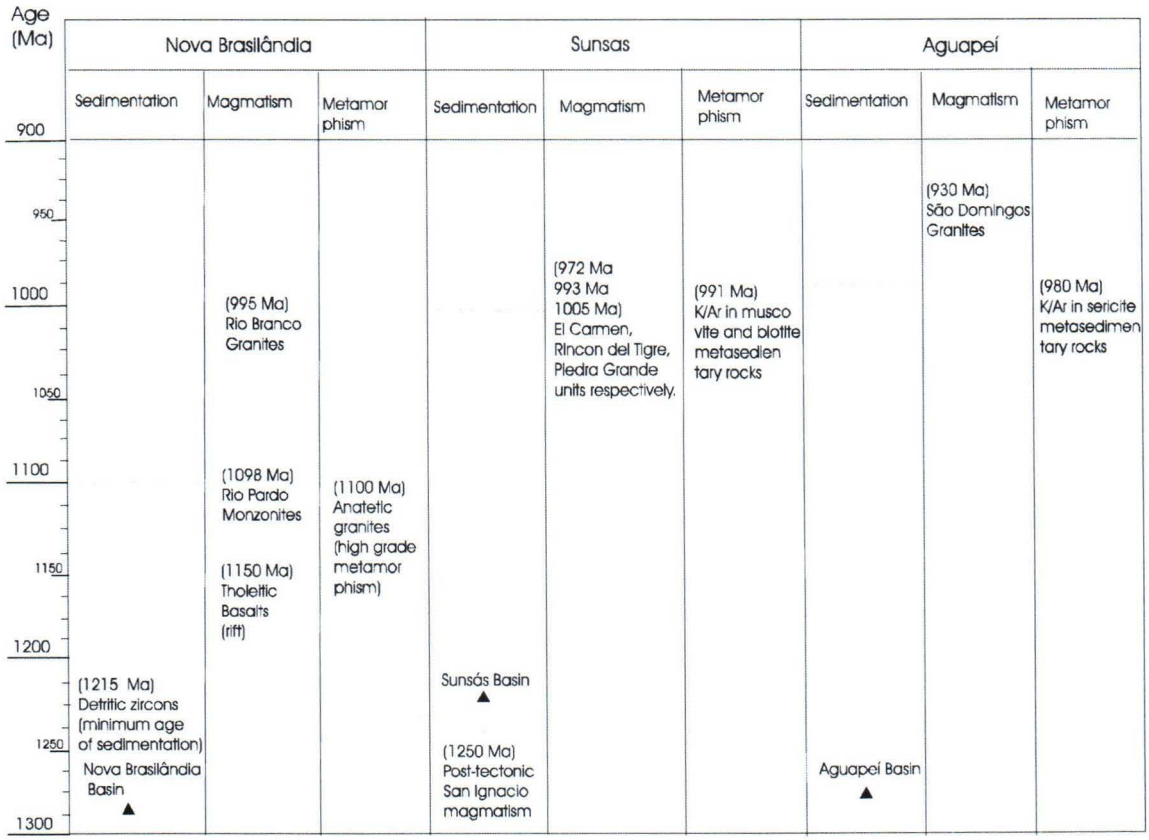

Figure 1. SW Amazonian Craton geologic events from 1.3 Ga to 0.9 Ga.

Global Correlations and Concluding Remarks

The western part of the Amazonian craton, like the Grenville Province, is a multi-orogen region formed between 1.8 and 1.0 Ga, during which successive magmatism, metamorphism and deformation took place. The ca. 1100 Ma metamorphism of the Nova Brasilândia and the Arequipa-Antofala rocks allow a correlation with the first stage of the Laurentia-Amazonia collision (Grenville Cycle), represented in Canada by the Sawinigan (1190-1140 Ma) pulse. The Sunsás and Aguapeí deformational events may be correlated to the Rigolet (1000-980 Ma) pulse (of the Canadian Shield), and may have occurred in the final stage of the agglutination of Rodinia.

Meso- Neoproterozoic post-collisional correlatable igneous episodes with SW Amazonia in the Greenville

Province are represented by granitoid plutons and aplite dykes dated between ca. 966-956 Ma (Tucker and Gower, 1994, Gower, 1996, Wasteneys, 1996). In the Sveconorwegian orogen (1.1-0.9 Ga) of SW Sweden and S-SW Norway, post-collisional bimodal rift-related AMCG intrusions and dolerites are recorded at ca. 966 Ma and 956 Ma interval. Examples of S-type leucogranites of ca. 930 Ma similarly to the SDS granites here reported have been described in east Greenland (Kalsbeek et al., 2000). The S-type granite rocks of Greenland were interpreted as formed in high-grade metamorphism not related to the Grenvillian event, but to an younger episode of extension and crustal thinning.

Arc-related granitoids of Grenvillian age (1190-980 Ma) have been recognized only in Bolivia, suggesting that the evolving continental margin was westward (actual) from the studied area. In such a framework, the S-type granites of the SDS, dated at 930 ± 12 Ma and 936 ± 26 Ma, may be related to extensional tectonics like the post-Greenvilian S-type granites reported in Greenland. From the above, SDS rocks probably result from melting of the Alto Jauru and Cachoeirinha country rocks, and are related to gravitational collapse following crustal overthickening achieved during the preceding Grenvillian collisional event, represented in the studied area by the Aguapeí Thrust Belt rocks.

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