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CHEMOSTRATIGRAPHIC CORRELATION OF THE NEOPROTEROZOIC SEQUENCES FROM SOUTH AMERICA

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GEOTECTONIC SETTING

The deposition of the Neoproterozoic sedimentary sequences in South America, some of which are hosting base metal deposits, took place as a consequence of extensional events that occurred during the fragmentation of the Rodinia supercontinent between 900 and 600 Ma. Although associated with the closure of the Pan-African-Brasiliano rift system (~900 to 500 Ma, Porada, 1989), the Neoproterozoic basins were essentially formed by extensional processes. In this sense, Condie (2002) suggested that the overall processes that led to the Rodinia formation and breakup, along with the subsequent assembly of Gondwana may be considered a unique cycle, although overlaps between each stage did occur. The diachronic history of the Pan African-Brazilian orogeny in South America was pointed out by Brito Neves et al. (1999).

The Neoproterozoic sedimentary basins are shown in Figure 1. The sequences are distributed in the following geotectonic settings:

1. Carbonatic and siliciclastic sequences deposited on tectonically stable terranes (cratonic areas): (a) on the São Francisco Craton (Brazil): Bambuí and Una groups (São Francisco, Irecê and Una-Utinga Basins) and Rio Pardo Group (Rio Pardo Basin); (b) on the Amazonas Craton: Alto Paraguay, Corumbá, Murciélago, Itapucumi, Tucuvaca, Jacadigo, Boqui groups and Araras and Puga Formations, in the marginal basins of the Paraguay Belt; (c) on the Rio de La Plata cratonic area: Arroyo del Soldado, Puncoviscana and La Tinta or Sierras Bayas groups.
2. Intensely deformed siliciclastic and carbonatic sequences in passive margin basins surrounding the cratonic areas: Cuiabá Group (Paraguay Belt), Ibiá and Vazante groups (Brasília Fold Belt), Miaba, Canudos and Vasa Barris groups (Sergipe Fold Belt), Açungui Group (Ribeira Fold Belt), Macaúbas Group (Araçuaí Fold Belt), and Porongos Group (Dom Feliciano Belt).
3. Siliciclastic + volcanic-volcanoclastic infills in basins associated with fold belts in tectonically active settings: Bom Jardim, Camaquã, Fuente del Pluma groups (Dom Feliciano Belt).

AGE CONSTRAINTS

The most significant age constraints available for the Neoproterozoic sediments are the following:

- U-Pb SHRIMP age of 950 Ma obtained in detrital zircons extracted from basal diamictite of glacio-marine origin within the Araçuaí fold belt may be considered the upper age limit of the glaciation. Pedrosa Soares et al. (2000) attributed this value to a magmatic episode during a rifting event.
- Based on Rb-Sr age determination Macedo (1982) and Macedo and Bonhomme (1984) suggested a time interval of 667 ± 30 to 932 ± 30 Ma for the glaciogenic basal sediments of the Una Group (Bebedouro Fm.).
- From the Rb-Sr isotopic dating of pelitic sediments the same authors suggested a time interval of 560 to 770 Ma for the sedimentation of the carbonate sequence above the glaciogenic units of the Una Group.
- Babinski et al. (2002) obtained a Pb-Pb isochron age from well-preserved carbonates of the Bambuí Group of 740 ± 22 Ma. (MSDW = 0.66), and interpreted it as the depositional age.
- The lower age limits are represented by Vendian fossils of the genus *Cloudina* and *Corumbella* (580 to 543 Ma.) reported in the Corumbá and Arroyo del Soldado groups by Zaine (1991), Boggiani (1998) and Gaucher et al. (2003), among others.

CHEMOSTRATIGRAPHIC CORRELATION

High resolution isotope stratigraphy may be a powerful tool for solving important controversies of the Neoproterozoic successions, specially related to regional and global stratigraphic correlations, and to the age of sedimentation. Adequate use of chemostratigraphic data depends on the existence of high quality stratigraphic sections and of detailed petrographic and geochemical investigation, allowing for accurate interpretation of diagenetic processes and extent of sample alteration. In this study we have used samples with clear indication of good preservation, on the basis of trace element determination. Only samples retaining the lowest Mn/Sr ratios (<1) and/or the highest Sr concentration (>500ppm) were selected, specially in consideration of their $^{87}Sr/^{86}Sr$ ratios. The preservation of the carbon isotope signal is possible, even in conditions not favorable for $^{87}Sr/^{86}Sr$ preservation. On the other side, for the oxygen isotopes, the signal is reseted during recrystallization.

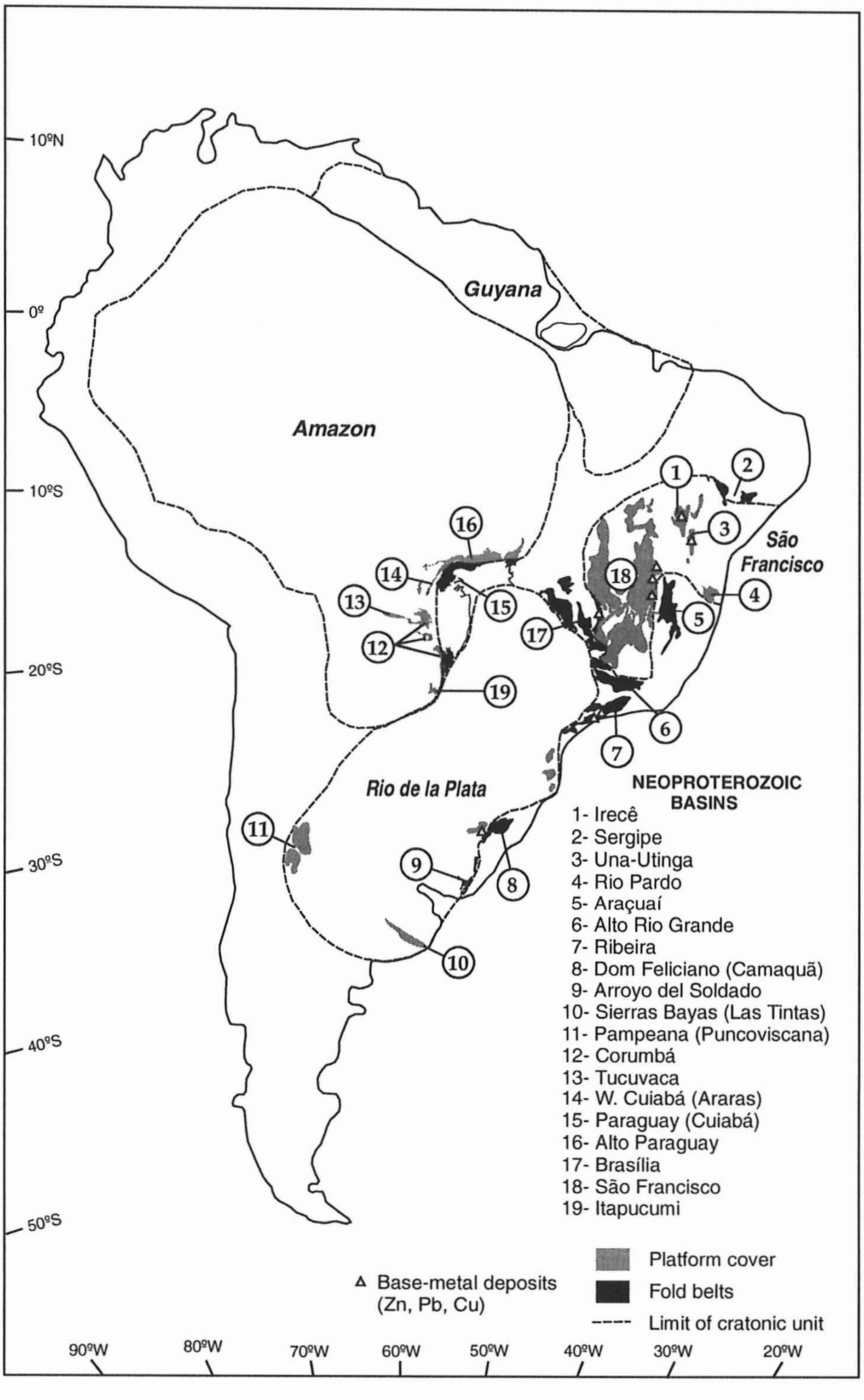

Figure 1. The Neoproterozoic Basins of South America.

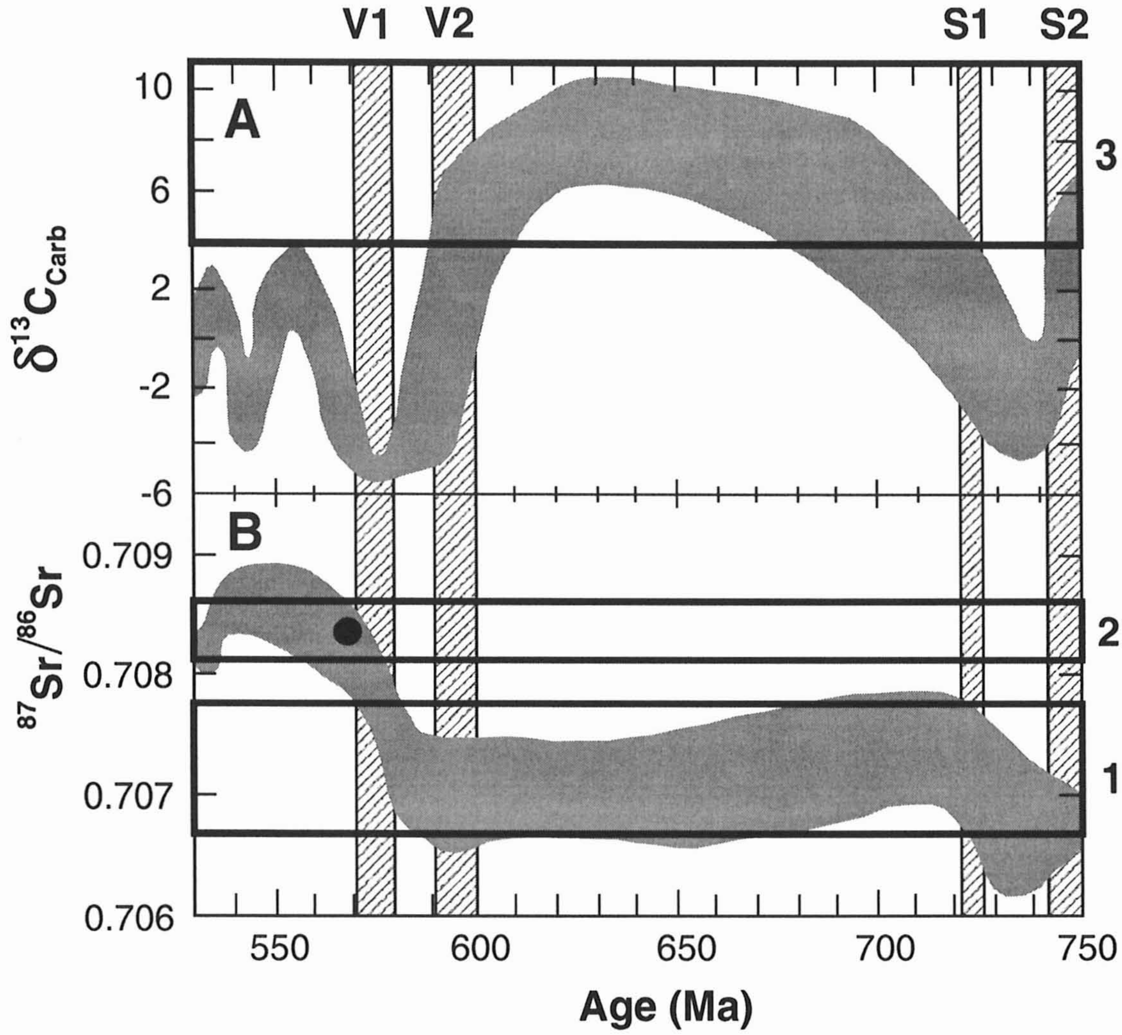

Figure 2. $\delta^{13}C$ and $^{87}Sr/^{86}Sr$ evolution of Neoproterozoic seawater according to Jacobsen and Kaufman (1999). V1, V2: upper and lower Vendian glaciations; S1, S2: upper and lower Sturtian glaciations. **1** – Range of $^{87}Sr/^{86}Sr$ least radiogenic values in the following groups: Arroyo del Soldado (Yerbal Fm.), Cuiabá (Araras Fm.), Vazante, Bambuí and Una. **2** – Least radiogenic values of $^{87}Sr/^{86}Sr$ in the Corumbá Group. **3** – Range of $\delta^{13}C$ positive excursions in the Groups: Vazante (Upper Pamplona Fm.), Bambuí (Lagoa do Jacaré Fm.) and Una (A1 Unit). The black dot, indicates the only samples with unequivocal geochronological markers (Vendian fossils) from the Corumbá Group.

Three mega-stratigraphic sequences are represented in the cratonic as well as in the passive margin basins (1 and 2 above) by the following respective mega-sequences: The Glaciogenic Sequence, the Carbonate/Siliciclastic Sequence and the Molassic-Type Sequence. They are separated by unconformities, and within each mega-unit there are other secondary boundaries that may be useful for regional correlation purposes (Misi, 2001).

At least two transgressive-regressive marine cycles appear to have occurred during the evolution of the Carbonate/Siliciclastic Sequence above a glaciogenic diamictite (Sturtian glaciation?). They are represented by two shallowing-upward sub-sequences. The first sub-unit initiated with cap dolomites and laminated limestone and terminated by an extensive sub-aerial exposure with the occurrence of dolostone with tepee structures. The zinc-lead deposits of the Vazante, Bambuí and Una groups are associated to the end of this first cycle (Misi et al., 1999). The second sub-sequence is represented by marl and shale followed by black oolitic and pisolitic limestone. A glaciogenic diamictite is present in the Corumbá Group at a stratigraphic position probably situated at the end of the first sub-sequence, but there is no direct evidence of this second glaciation (Varengerian?) in the other sections, except for the negative $\delta^{13}C$ values in the Upper Pamplona Fm. (Vazante Gr.) and in the B1 Unit of the Una Group.

$^{87}Sr/^{86}Sr$ determinations of well preserved carbonate samples permit a better correlation. Excepting for the Corumbá Basin, the $^{87}Sr/^{86}Sr$ least radiogenic set of data range from 0.70684 to 0.70780 suggesting that the age of sedimentation are between the Sturtian (~750 Ma) and the Varanger ice age of *ca.* 600 Ma ago, or have been deposited immediately after the first Varanger glaciation (Jacobsen and Kaufman, 1999) (Fig. 2 B). In the Corumbá Basin, the best preserved carbonates of the Polanco and Tamengo Formations (Corumbá Group) show ratios around 0.70850 (Boggiani, 1998), suggesting that the sequences are younger (Fig. 2 B). This is confirmed by the presence of Vendian fossils (Boggiani, 1998; Gaucher et al., 2003).

$\delta^{13}C$ and $\delta^{18}O$ studies in the same sequences revealed some remarkable excursions that may also be used for stratigraphic correlation:

a. $\delta^{13}C$ negative excursion with values ranging from -2 to -6‰ PDB in different sections, present in the cap carbonates at the base of the Vazante, Bambuí and Una groups. These negative excursions are normally observed in post-glacial Neoproterozoic carbonates worldwide. Another negative carbon isotope excursion appear to occur in dolostone at the top of the first sub-sequence, suggesting the existence of a second glaciation at the end of the first transgressive-regressive cycle. This could be represented by the diamictites of the Puga Formation (Corumbá), but the only possible indication in the other sequences are the negative $\delta^{13}C$ excursions in the Vazante and Una groups.

b. $\delta^{13}C$ positive excursion ranging from +4 to +14‰ PDB in different sections, immediately above dolostone with teepee structures in the second cycle, present in the Vazante, Bambuí and Una groups (Fig. 2 A).

c. Increase in the $\delta^{18}O$ positive values observed in the shallow water dolomite at the top of the first sub-sequence, confirming the evaporative nature of the sedimentary environment due to sub-aerial exposure.

The $\delta^{34}S$ data obtained from sulfate minerals and trace sulfates of carbonate samples from most of the sequences – varying from +15 to + 46‰ CDT – are consistent with known Neoproterozoic changes.

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