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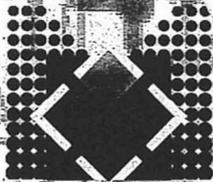


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CRUSTAL EVOLUTION OF THE SOUTH AMERICAN PLATFORM, BASED ON Sr AND Nd SYSTEMATICS ON GRANITOID ROCKS

Umberto G. Cordani and Kei Sato

Instituto de Geociências - Universidade de São Paulo. Rua do Lago 562 CEP05508-900, São Paulo - Brasil
e-mail: ucordani@usp.br

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INTRODUCTION

The isotopic composition of radiogenic isotopes formed by radioactive parents with very long half-lives, such as Sr, Nd, Pb, Hf, and Os, are largely used to constrain the crustal evolution of geotectonic units. This work will deal with the so called South American Platform, the tectonically stable continental mass which acted as the cratonic area for the tectonomagmatic episodes which occurred in the Phanerozoic within the Andean belt.

Cordani et al. (1988) have already produced a synthesis on this subject, employing the Sr isotopic composition of granitoid rocks, obtained from more than 10000 individual measurements on samples collected all over the continental area, and performed mainly at the Geochronology Research Center of the University of São Paulo (CPGeo-USP). In recent years, a comprehensive Sm-Nd study was carried out by Sato (1998), at the same laboratory, permitting a direct comparison of the results by two independent methods, which has led to an important improvement in the knowledge of the crustal evolution of South America.

It is known that both parent-daughter pairs Rb-Sr and Sm-Nd are strongly fractionated during the complex processes which forms "juvenile" continental crust from primary mantle sources. However, in a clear contrast to the Rb-Sr system, the subsequent crustal processes normally produce only minor or even negligible changes in the Sm/Nd ratio, a property that has made the Nd isotopic studies a very powerful tool in characterising continental crustal provinces.

Granitoid rocks, in the broader sense, are the main constituents of the continental crust. They may be formed through many different petrogenetic processes, and measurements of their isotopic systematics can be employed as tracers for their origin and for the character of their source materials. For this synthesis, magmatic suites ranging from granodiorites

and tonalites to true granites were employed, as well as granitoid rocks from medium to high-grade regional metamorphic terrains, which are the prevalent units of the gneissic-migmatitic-granulitic complexes so common in shield areas.

CRUSTAL EVOLUTION OF THE SOUTH AMERICAN PLATFORM

If we accept that some sort of plate tectonic regime acted during Proterozoic times, when different parts of South America were involved in the formation and disruption of supercontinents such as Rodinia and Gondwana, and also that magmatism associated with mantle-continental crust differentiation processes was common during the Archean, at least two main petrogenetic processes can be envisaged in order to originate very large volumes of granitoid rocks.

1 - Formation of juvenile granitoids within magmatic arcs, in association with subduction of oceanic lithosphere. They may derive from different types of magma sources, including the heated mantle wedge above the subduction zone.

2 - Formation of granitoids from pre-existing crustal protoliths, by partial melting within the continental crust. They may occur in association with both orogenic belts and intraplate magmatism, by melting of the lower crust when heated by underplated primary basaltic liquids.

Figure 1 shows the main geotectonic provinces of South America, with the indication of the Andean belt, and the approximate extent of the influence of the Phanerozoic orogenic events. In this figure, the Late Proterozoic geotectonic situation of the Platform is shown, with the large Amazonian and São Francisco cratons, the small Rio de La Plata, São Luis and Luiz Alves cratonic fragments, and the mobile belts associated to the Brasiliano-Pan African orogenic Cycle, in northeastern, central, southeastern and southern Brazil and eastern Uruguay.

The South American Platform was subsequently divided into crustal domains with internally coherent structural evolution and geochronological pattern. The resulting figure 2 keeps the main boundaries of figure 1, and the Amazonian craton was further subdivided according to its internal tectonic provinces. Where the Precambrian basement is concealed beneath the sedimentary rocks of the Amazonian, Parnaíba and Paraná basins, the crustal domains were extrapolated with the help of some drill core informations. The extension of the South American Platform beneath the Andean foredeep basins (Llanos, Beni, Chaco, Pampas) was not considered, because of complete lack of information. The area included in figure 2 includes Brazil, French Guiana, Guyana, Surinam, Uruguay, and parts of Bolivia, Venezuela, Paraguay and Argentina, comprising $9.3 \times 10^6 \text{ Km}^2$.

RESULTS AND DISCUSSION

In the case of strontium, the initial $^{87}\text{Sr}/^{86}\text{Sr}$ ratio for a suite of cogenetic granitoid rocks is the main indicator for source material. In the cited work by Cordani et al. (1988), this indicator was used together with some other geological criteria in order to estimate the relative amount of juvenile continental crust accreted during each time interval of geological time, for the area of the Brazilian Shield. The curve 1 on figure 3 represents the fraction of continental growth (or survival) with time, according to Cordani et al. (1988)

In Sato's (1998) study, Nd isotopic composition and Sm-Nd model ages were obtained for several hundred granitoid rocks, many of which had already been analysed for Sr isotopes at the CPGeo-USP. The association of the Sm-Nd measurements with the already available geochronological data, obtained by other methods, permitted an improved interpretation for the origin of the granitoid rocks under examination. Juvenile material would be indicated by concordant Rb-Sr and Sm-Nd apparent age values, by positive or slightly negative $\epsilon_{\text{Nd}(T)}$ values and by low $^{87}\text{Sr}/^{86}\text{Sr}$ initial ratios.

For the Archean rocks of the South American Platform, the isotopic systematics indicates essentially juvenile material, as in other parts of the world. The oldest rocks found so far come from central-southern Bahia State, within the São Francisco craton. They yielded Rb-Sr and U-Pb zircon SHRIMP ages of

about 3.4 Ga., and Sm-Nd T_{DM} model ages up to 3.7 Ga.

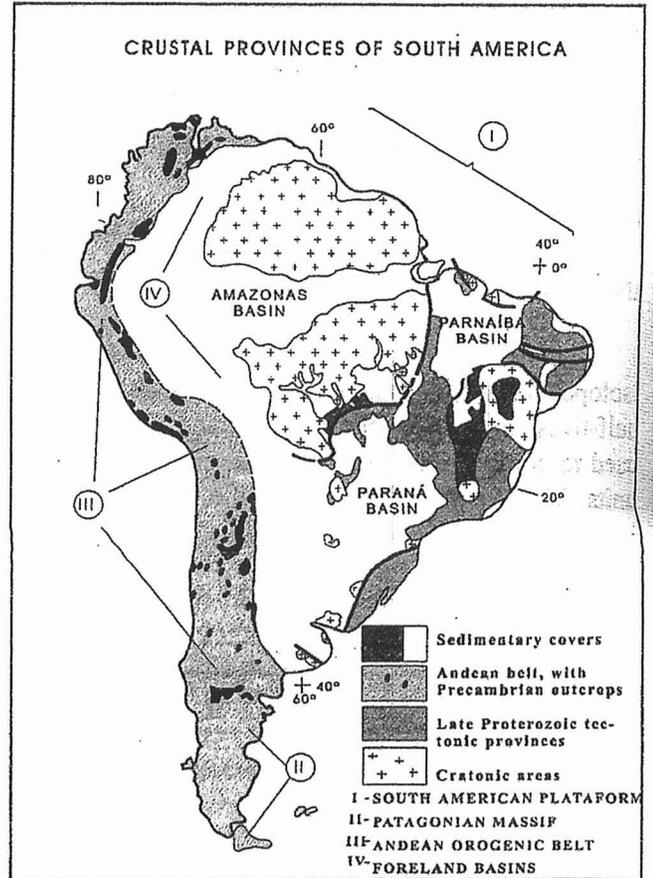
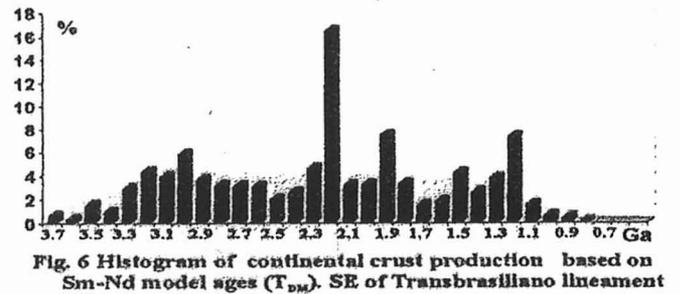
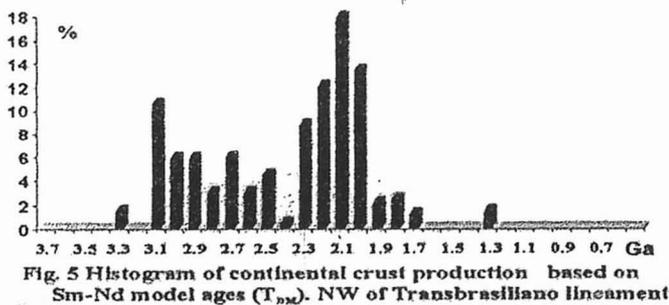
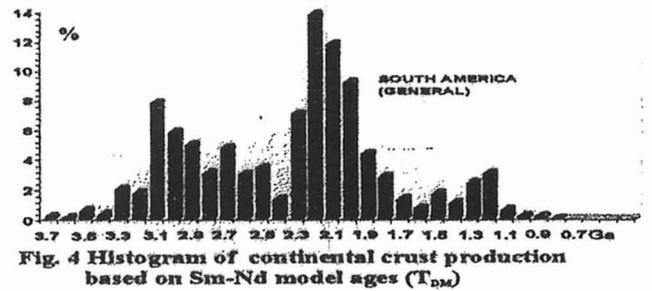
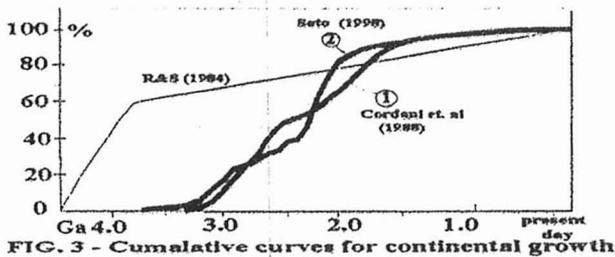
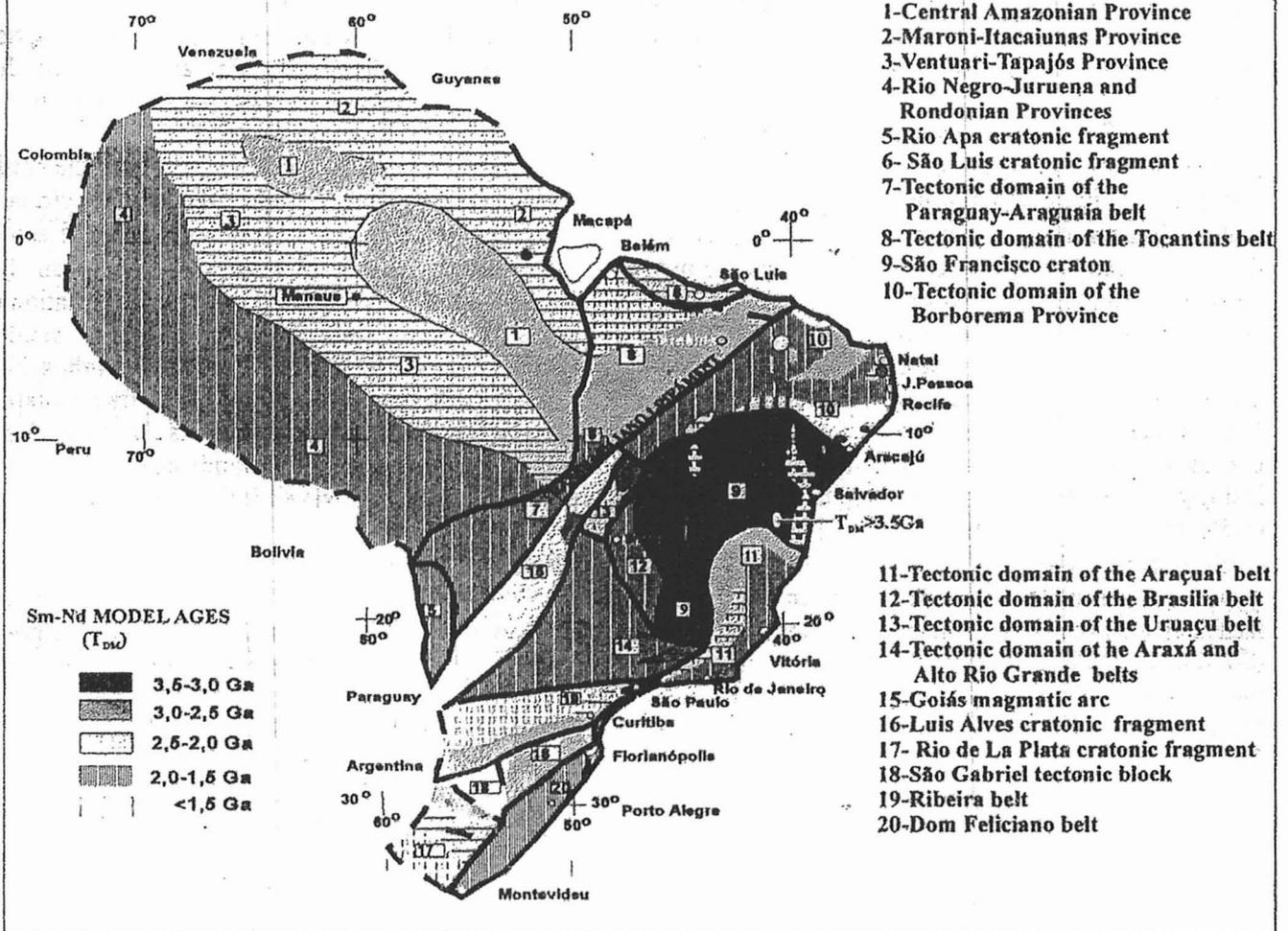


FIG. 1 - Main geotectonic provinces of South America, modified after Cordani and Brito Neves (1982).

For Early to Middle Proterozoic rocks, both juvenile and reworked granitoid rocks are found. In the eastern part of the platform, corresponding to the São Francisco craton and to the basement of the younger mobile belts which surround it, reworked material predominates. However, for the western part, and especially within the Ventuari-Tapajós and the Rio Negro-Juruena tectonic provinces, juvenile material is widespread. The geotectonic model for this region of the Amazonian craton envisages the evolution of a very large oceanic lithospheric plate undergoing continuing subduction, with the formation of successive magmatic arcs, later accreted to the adjacent continental masses.

In Middle to Late Proterozoic times, the granitoid rocks formed within the mobile belts of this age, as well as the granitoids formed by intraplate processes over the cratonic areas, seem to have been formed by reworking of previous crustal material.

FIGURE 2 - CRUSTAL DOMAINS OF THE SOUTH AMERICAN PLATFORM



Exceptions are to be made for the region of southern Goiás State, where a Neoproterozoic magmatic arc of juvenile character was identified by Pimentel & Fuck (1992) and the São Gabriel tectonic block in Southern Brazil.

The Sm-Nd T_{DM} values from all the crustal provinces were employed for the construction of the histogram of figure 4. From this figure, it is apparent that small amounts of continental crust older than 3.3 Ga. survived within Archean fragments formed between 3.1 and 2.6 Ga. However, the main period of continental crust formation was between 2.2 and 2.0 Ga., in early Proterozoic times, corresponding to the Transamazonian orogenic Cycle. Accretion of juvenile material continued until the Neoproterozoic, but at much slower rates. A small peak on the histogram corresponds to the Espinhaço/Rondonian Cycle (1.2 - 1.3 Ga.) but the Brasiliano orogenic Cycle is barely visible in the figure. The continental growth (or survival) curve derived from the Sm-Nd measurements (curve 2 in figure 3) is not very much different from the one based in the Rb-Sr results. It indicates that about 34% of the present crust was formed in the Archean, 80% by the end of the Transamazonian Cycle, and about 98% at the onset of the Brasiliano Cycle, in Neoproterozoic times.

The Transbrasiliano lineament is a megafault zone and a probable megasuture, active in the Neoproterozoic, which separates a large north-western continental mass, including the Amazonian craton, from a south-eastern continental mass, formed by a collage of cratonic fragments of different sizes, of which the São Francisco craton is the largest. When the crustal evolution of these two large continental masses is considered individually (see figures 5 and 6), a few conclusions can be made:

1 - Old Archean rocks (older than 3.3 Ga.) can be

found at present only within the south-eastern part of the South American Platform.

2 - On both continental masses, crustal evolution between 3.0 and 1.7 is quite similar, suggesting that they were possibly contiguous within a Paleoproterozoic supercontinent.

3 - During Meso and Neoproterozoic times, the north-western continental mass remained virtually unaffected by tecto-orogenic events, while the south-eastern mass underwent disruption into smaller cratonic fragments, with the concomitant formation of regions of oceanic floor. These smaller microcontinents and pieces of oceanic lithosphere took part in the agglutination and later fragmentation of at least two large supercontinents, Rodinia in the Mesoproterozoic and Gondwana in the Neoproterozoic (Brito Neves & Cordani, 1991).

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