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# WORKSHOP
# Geology of the SW Amazonian Craton: State-of-the-Art

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## Extended Abstracts

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# From Rodinia to Gondwana : a review of the available evidence from South America*

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## Introduction

Rodinia was conceived by Hoffman (1991). It has Laurentia in its central part, and the other cratonic units are surrounding it. It was formed by the successive collisions of cratonic masses, some of them of continental size, such as Nena and Atlantica (Rogers, 1996), during a series of orogenies contemporary to the "Grenville orogenic cycle", between 1350 and 950 Ma. It seems that there are now enough correlation indicators to constrain the relative position of Laurentia, Baltica and perhaps Australia and Eastern Antarctica (Karlstrom et al., 1999). However, the position of the other cratonic nuclei, now included in South America and Africa, is far from being resolved.

In this work, we will examine the available evidence for the position of the cratonic masses that eventually formed West Gondwana in the Neoproterozoic, such as Amazonia, West Africa, São Francisco-Congo, Rio de La Plata and Kalahari. We will give some emphasis to the South American evidence, especially that related to the smaller cratonic fragments and microcontinents that are usually forgotten in the exercises of global reconstruction.

We will also focus to the time of disruption up of Rodinia, a supercontinent that is considered in most papers to have been stable at least between 950 and 750 Ma. (Meert et al., 1995). To our knowledge, the younger orogen that could still be considered as a member of the Grenvillian family is the Cariris Velhos mobile belt, with ages between 960 and 1000 Ma., occurring within the Borborema Province in Northeast Brazil. (Brito-Neves et al., 2000). Hoffman (1991) argues for the stability of Rodinia until about 700 Ma., when break-up would have occurred. From our data it appears that many rifting phases, corresponding to the onset of Wilson Cycle episodes, started as early as the final collisional events of the Grenville Cycle and Rodinia build-up. Moreover, we think that simultaneously to various episodes of rifting and fracturing of Rodinia, continental collisional events, related to the accretion of Gondwana were already occurring.

## The paleomagnetic evidence

A survey of the paleomagnetic evidence available for West Gondwana (South America and Africa) for the age interval of interest (1200 to 450 Ma.) was made. However, great part of such data does not exhibit the reliability that would be necessary for an adequate and unequivocal assessment. Moreover, there are large time intervals and also large geotectonic units for which paleomagnetic poles are simply non-existent. This fact is mainly observed for the time interval between 600 and 1000 Ma., where reliable paleomagnetic poles are rare. Because of the position of the dated units within areas affected by the Brasiliano/Pan-African orogeny, two main points are critical. The first one is linked to the difficulties of the dating methods, and the second is due to the possibility of remagnetization during events younger than the age of the geologic unit.

Anyway, for the oldest time-interval, around 1000 Ma., the available evidence is compatible with a configuration of Rodinia close to that given by Weil et al. (1998), or D'Agrella-Filho et al. (1998). Such paleogeographic reconstructions are based on poles from large dike swarms, indicating already a tendency for continental distension, at least over the São Francisco-Congo Craton.

Apparent polar wander (APW) paths, or at least parts of them, can be traced for the São Francisco-Congo and Rio de La Plata continental masses. These APW paths suggest that they collided and joined around 600-650 Ma., the main tectonomagmatic pulse for the Brasiliano/Pan-African orogenic Cycle. The APW path of Australia, however, indicates that this continent joined West Gondwana a little later, around 550-530 Ma., time of the Kuunga orogeny (Meert et al. 1995). The positioning of Amazonia can only be assessed if we consider it as linked to Laurentia, when the APW path of the latter indicated an approximation with São Francisco-Congo at about 580 Ma. For West Africa and Kalahari there are no reliable paleomagnetic evidence (e.g. Meert et al., 1995), but the collisional belts within the Borborema and Damara provinces suggest that these large continental masses joined West Gondwana during the 650-550 time interval. Moreover, geochronological and paleomagnetic data indicate that Kalahari was always close to Congo-São Francisco, at least since about 800 Ma., after the Zambesi orogeny (Hanson et al.,1998; D'Agrella-Filho et al., 1998). As a consequence of the above reasoning, West Gondwana was already formed at around 550 Ma.

**The geochronological evidence**

The initial break-up of Rodinia occurred, in our view, not longer after its final formation, at the time of the Grenville orogenies. However, the disruption of that supercontinent into smaller masses, down to microcontinents and continental fragments, took a long time, and was more or less synchronous with the formation of Gondwana (and Pannotia) during the entire Neoproterozoic. The dispersion of the Rodinia fragments, and their later reassembling into another supercontinent, induced a series of successive collisions of allochtonous terrains of all sizes, which are comprised into the large areas affected by the so called Brasiliano/Pan-African orogenic Cycle. These orogenies are related to the disappearances of several oceanic branches, and were formed in association with a coherent geodynamic mantle/crust pattern, active during a few hundred million years, and quite different from that responsible for the activation of the Grenville orogenic Cycle.

We will attempt to identify below the major fragments originated from the disruption of Rodinia, that were involved in the agglutination of West Gondwana, as well as those oceanic domains that were destroyed when they collided during successive orogenies.

A relatively extensive ocean was formed in central Brazil, at about 800-900 Ma. Its disappearance is well marked by the existence of juvenile material, the Goiás magmatic arc, that was added to the continental crust between 800 and 650 Ma. (Pimentel et al., 2000). This was the only large episode of continental accretion, in South America, in the Neoproterozoic. As it can be seen, the growth of continental crust for that part of Gondwana was minimal in the Neoproterozoic, basically restricted to the mentioned area of the Goiás magmatic arc and the small São Gabriel block in southern Brazil (Cordani and Sato, 1999). Although juvenile oceanic crust must have been produced by the disruption of Rodinia, only small volumes of it survived as ophiolitic fragments, added as tectonic slices within the Brasiliano/Pan-African orogens.

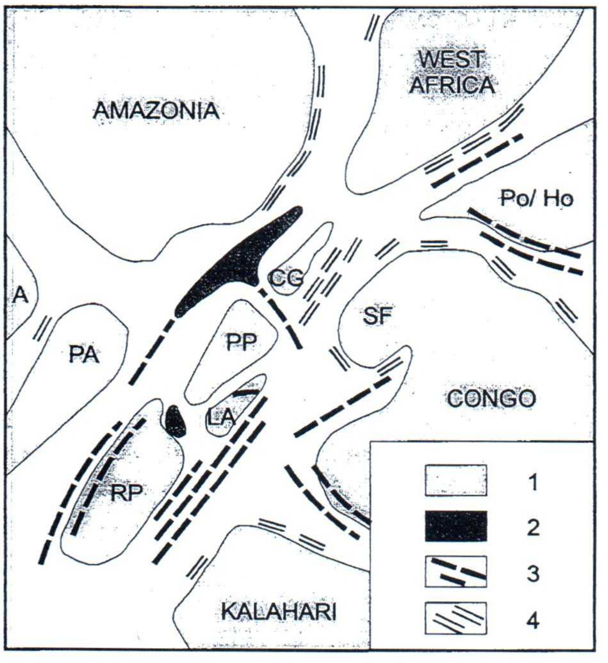


Figure 1, Modified after Brito Neves and Cordani (1991), and Brito-Neves et al.(1999), shows a very large “collage” of cratonic masses and fragments, which makes up a branched system of orogenic belts of Neoproterozoic age. The main cratonic areas were outlined: Amazonia, West Africa, São Francisco-Congo, Kalahari, and Rio de La Plata. They exhibit marginal basins that were transformed into Neoproterozoic mobile belts, however, in all them, the extension of the respective cratonic area can be traced as reworked basement. The Arequipa-Antofalla, Pampia, Paranapanema and Luiz Alves terranes are supposed to be cratonic fragments, not greatly disturbed by the Brasiliano/Pan-African tectonomagmatic events, although the first two were tectonically affected by the Phanerozoic events connected with the evolution of the Andes. In contrast, the Central Goiás massif is formed by old crustal material, with Archean to Mesoproterozoic ages, but reworked by the Neoproterozoic orogenies. The same is true for the Borborema terrane, which is the extension, in South America, of the very large Hoggar massif in Africa.

Legend for Figure 1: Idealised reconstruction of the branched system of orogenic belts related to the assembly of West Gondwana at about 600 Ma.

(1)- main cratonic areas or fragments. A = Arequipa/Antofalla; PA = Pampia; RP = Rio de La Plata; PP = Paranapanema; LA = Luiz Alves; CG = Central Goiás; SF = São Francisco; Po = Potiguar; Ho = Hoggar.

(1) - main cratonic areas or fragments. A = Arequipa/Antofalla; PA = Pampia; RP = Rio de La Plata; PP = Paranapanema; LA = Luiz Alves; CG = Central Goiás; SF = São Francisco; Po = Potiguar; Ho = Hoggar.

(2) – early Neoproterozoic (750-900 Ma.) juvenile magmatic arcs.

(3) – late Neoproterozoic (550-700 Ma.) magmatic arcs, formed by reworked crust.

(4) – mafic to ultramafic rocks, probable fragments of Neoproterozoic oceanic lithosphere.

The very large amount of granitoid material with ages between 650 and 530 Ma., and intrusive into all Neoproterozoic mobile belts, was formed by reworking of older crust, with some contribution of mantle material, suggesting ensialic settings for the magmatic arcs.

The limited amount of accrecionary juvenile material within the Brasiliano/Pan-African mobile belts seems to indicate that only small oceans were formed between the fragments resulting from Rodinia disruption. This suggests the action of a series of Wilson Cycle episodes, with minor formation of oceanic lithosphere that left only traces within the mobile belts formed later. As a corollary, the continental fragments displayed in figure 1 should bear more or less the same relative position as in the Rodinia framework. This is not incompatible with the reconstructions of Weil et al.(1998) or D'Agrella-Filho et al. (1998). The more important change that we may suggest is that West Africa shall be placed closer to the São Francisco craton

In our view, time and duration for the Rodinia break-up shall be re-examined, because within the Brasiliano/Pan-African mobile belts there are ample evidence of collisional events that occurred prior to the final assembly of Gondwana at about 550 Ma. Such events are already driven by the geodynamic pattern that is related to the formation of the Neoproterozoic supercontinent. In many cases, such earlier collisional events, in the general time frame between 850 and 650 Ma., are difficult to identify, because of the usually stronger imprint by the tectonomagmatic events and associated granitoid magmatism which are typical of the Brasiliano/Pan-African belts.

The main geochronological evidence in this respect are:

1 – The ca.800 Ma. age of the Zambezi orogeny (Hanson et al., 1998), which indicates a link between the São Francisco-Congo and the Kalahari cratons since that time.

2 – The ca. 800 Ma. age of the Embu Complex, within the Ribeira belt (Cordani et al, 2001), and the 750 to 900 Ma. ages for granitoids related to the Passinho and São Gabriel orogenies in southern Brazil (Hartmann et al., 2000), which are constraints for the junction of the Rio de La Plata and the Kalahari cratons.

3 – The ca. 760 Ma. metamorphic age of the high grade gneisses of the Central Goiás Complex (Pimentel et al., 2000), indicating a collisional episode between a microcontinent and the Amazonian craton. This metamorphic age also affects the granitoid rocks of the Goiás magmatic arc, formed earlier in a large oceanic environment.

There are other evidence for events occurring in the 650-850 Ma. age interval, related to rocks from the Neoproterozoic belts. They are less documented, some of them indicate collisional and others indicate distensive episodes. This corroborates the diachronism already mentioned, when contemporaneity is observed between compressional and tensional events occurring in different parts of the same supercontinent.

**Conclusions**

From the previous items, a few main conclusions can be drawn:

1 – When the reconstruction of Rodinia is taken into account, it is necessary to include into the picture the smaller continental masses, microcontinents and the like, such as the Central Goiás terrain, the Borborema-Hoggar, the Luiz Alves, the Pampia, etc. The same is true for the

marginal zones of the major cratonic masses, where basement inliers are present as tectonic slices.

2 – For the break-up of Rodinia, it is necessary to consider a large time interval of disruption. Signals of distension are as old as 1000 Ma., when basic dike swarms are observed in the São Francisco-Congo craton. The formation of the large Goiás ocean occurred at about 900 Ma., and other fragmentation episodes were recorded successively until about 630 - 640 Ma.

3 – For the agglutination of Gondwana (and Pannotia), the first continental collisions are reported at about 800 Ma. However, the most important episodes are those associated to the Brasiliano/Pan-African orogenic cycle, between 650 and 500 Ma. It is apparent that the fragmentation of Rodinia is more or less synchronous with the accretion of Pannotia and Gondwana.

4 – If Laurentia is central for the Rodinia supercontinent, the São Francisco-Congo is central for Gondwana, because most of the Brasiliano/Pan-African mobile belts are disposed all around it. Its APW path, between 750 and 500 Ma., seems to indicate a rotational movement which could be explained by its accomodation to the successive collisional events that affected it. The last one may well have been the accretion of East Gondwana, by the collisional episodes recorded in the Mozambique belt, and related to the Kuunga orogeny

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