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NEW LATE PROTEROZOIC PALEOMAGNETIC DATA FROM THE RIO DE LA PLATA CRATON: IMPLICATIONS FOR PANNOTIA AND GONDWANA

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CONICET

INTRODUCTION

The Late Proterozoic global paleogeographic evolution is loosely bracketed between the dispersal of Rodinia (e.g. Hoffman, 1991) and the assembly of Gondwana (e.g. Rogers et al., 1995). Despite dramatic progress in the last decade, the tectonic and paleogeographic evolution in the Late Proterozoic is very far from being accurately known. One of the main reasons for this is the lack of a robust paleomagnetic database for the large continental blocks that were involved in Rodinia dispersal and Gondwana assembly (e.g. Meert, 2001).

The Rio de la Plata craton (RP, Fig.1) is one of the major blocks that integrated Western Gondwana. Its paleogeographic evolution and its relationship to neighbouring blocks during Gondwana assembly is controversial and very poorly known (for a recent review of geologic evidence see Cordani et al., 2000). Its disputed relations with the Kalahari, Congo-Sao Francisco, Amazonia and Pampia blocks turn RP a likely key player in unraveling the processes that led to the formation of the Gondwana supercontinent.

Recent paleomagnetic results presented by Sanchez Bettucci and Rapalini (2002) has started to fill a vacuum of data for RP in the Late Proterozoic. These results gave further support to a latest Proterozoic (ca. 550 Ma) age for amalgamation of major cratonic blocks of Gondwana. The available paleomagnetic poles from some of these blocks were interpreted by Sanchez Bettucci and Rapalini (2002) in terms of a model of assembly of Gondwana that involved the collision of three major blocks (Western, Central and Eastern Gondwana) by the end of the Proterozoic. However, several other models have also been postulated that disagree with each other (see for instance Meert, 2001, Powell and Pisarevsky, 2002). Among these models, is a proposal of a short-lived supercontinent located in the southern hemisphere that involved most land masses in the latest Proterozoic (Pannotia, Powell, 1995)

In order to reduce the uncertainties concerning the dispersal of Rodinia and assembly of Gondwana, a project to obtain reliable paleomagnetic poles for RP in the Late Proterozoic is under way by several institutions led by the Instituto de Geofísica Daniel Valencio of the Universidad de Buenos Aires. As part of these studies, a paleomagnetic study was completed on

a succession of red claystones exposed in a quarry at the Sierra de los Barrientos (province of Buenos Aires, Argentina) of a likely Vendian age. Preliminary results have been presented previously (Rapalini and Rapela, 1999). Results of this study as well as its implications for current models of Pannotia and Gondwana are presented.

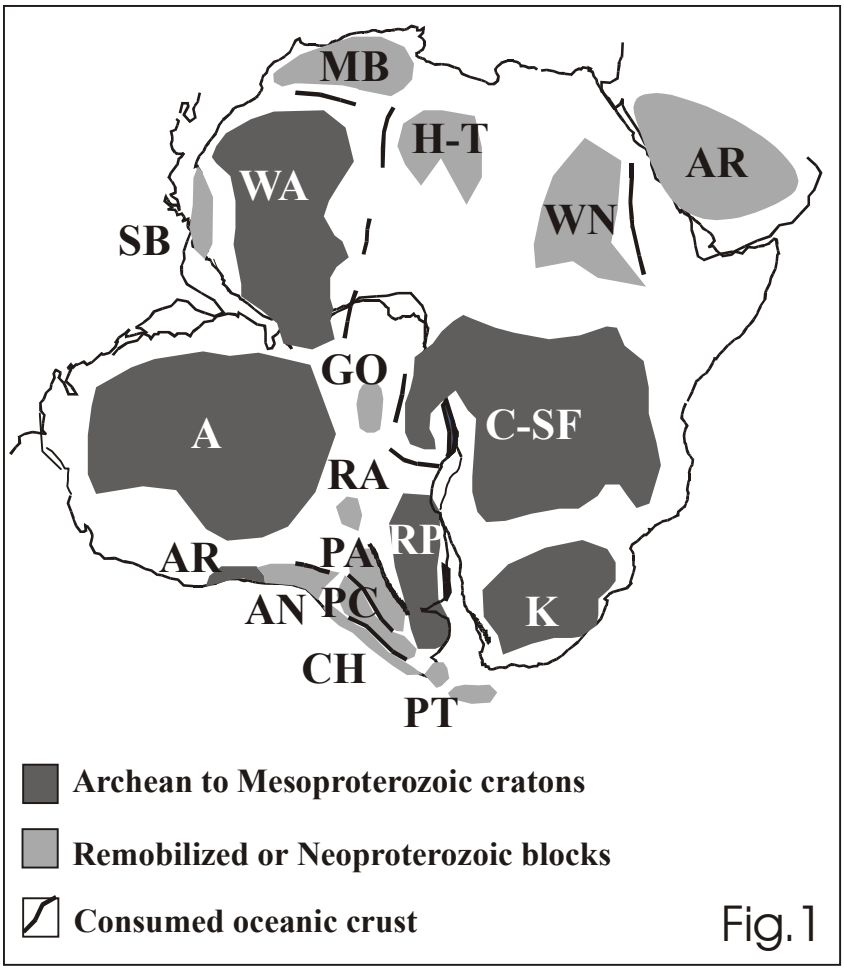

Fig.1. Main tectonic domains of Western Gondwana in the Neoproterozoic. A: Amazonia, AB: Central Arabia, AN: Antofalla, AR: Arequipa, CH: Chilenia, C-SF: Congo-Sao Francisco, GO: Goias, H-T: Hoggar-Tibesti, K: Kalahari , MB: Moroccan block, PA: Pampia, PC: Precordillera, PT: Patagonian – Malvinas block, RA: Rio Apa, RP: Rio de la Plata , SB: Senegalese block, WA: West Africa, WN: West Nile. Taken from Sanchez Bettucci and Rapalini (2002).

PALEOMAGNETIC STUDY

The study section is exposed at a quarry in Sierra de los Barrientos, (37.8°S, 59.0°W), in the province of Buenos Aires, Argentina. It consists of nearly 20 meters of homogeneous, mainly subhorizontal red claystones. This succession lay under several meters of greenish to brownish siltstones and sandstones that mark a transition to the thick beds of coarse quartzite of the Cambrian – Ordovician Balcarce Formation. Few hundred meters from the sampled section crops out the diabasic sill that intrudes the Balcarce Formation and that has been dated as Ordovician (Rapela et al., 1974). The age of the red calystones at Sierra de los Barrientos has not yet been

determined. However, on the basis of lithologic and stratigraphic considerations it is likely that they are correlative to the Vendian Cerro Negro Formation (Poiré et al., 2000) exposed in the Sierras Bayas area or Las Aguilas Fm (Zalba, 1978) in the Barker region. Bonhomme and Cingolani (1980) proposed a maximum age of 600 Ma for claystones exposed in the nearby San Manuel region which they correlated to the Las Aguilas Fm. X ray analysis indicate that illite is the dominant clay fraction in the Sierras de los Barrientos succession, which is similar to the Cerro Negro clays. Considering all this it is most likely that the study succession is of Vendian age.

Sixty-two oriented samples were collected from the succession of red claystones distributed into 13 sites (4 to 7 samples per site). Sites were distributed along most of the succession (Fig.1). Sites 18, 19 and 21 were collected from an area tectonically disturbed by an open and local fold. Samples were submitted to standard stepwise demagnetization procedures. AF demagnetization was unsuccessful to demagnetize the samples. Therefore all information was obtained from thermal treatment. All samples presented high stability of magnetization, and the remanence directions were determined by principal component analysis (Kirschvink, 1980). Unblocking temperatures generally over 650°C indicate that hematite is the single magnetic carrier. This is also supported by rock magnetic experiments and X-ray mineralogical determinations.

Within site consistency of characteristic remanence directions is high for all sites. Significantly different site mean directions even when sites are stratigraphically separated by less than 0.5 m suggest an early acquisition of remanence, probably during first stages of diagenesis. This is strongly supported by recording of a reversal of the magnetic field between sites 19, 20A and 20B (Fig.2). It is interpreted that remanence at site 20A is recording a transitional magnetic field. An improvement of clustering of directions after application of bedding correction also argue in favor of a primary origin for the remanence. A mean of bedding corrected site remanence directions (excluding site 20A) yields an average direction at Dec: 103.5° Inc: -49.0° N: 12 sites a95: 12°. On the basis of the mean remanence direction a paleomagnetic pole was computed for the red claystones of Sierra de los Barrientos (SB) which falls on Lat: 8.4°S, Long: 242.6°E, dp: 10.5°, dm: 15.9°.

The obtained paleomagnetic data indicate that the sediments of the Sierra de los Barrientos were deposited at a paleolatitude of around 30°S.

INTERPRETATION AND CONCLUSIONS

Figure 3 shows the latest Proterozoic paleomagnetic poles for the Gondwana cratonic blocks. SB is consistent with the SA2 pole recently obtained from the Sierra de Animas complex (Sanchez Bettucci and Rapalini, 2002) and the Sinyai dolerite pole (SI, Meert and Van der Voo, 1996). SA2 is approximately dated in 550 Ma and SI is more accurately determined as 547 Ma. A similar age for SB can be inferred, although a slightly older age cannot be ruled on the basis of the available paleomagnetic data. In any case an age younger than 600 Ma is implied from the far located paleomagnetic poles of that age from RP, and from geologic considerations. SB position confirms the conclusions obtained by Meert and Van der Voo (1996) and Sanchez Bettucci and Rapalini (2002) that Gondwana was likely already assembled or about to be so by 550 Ma.

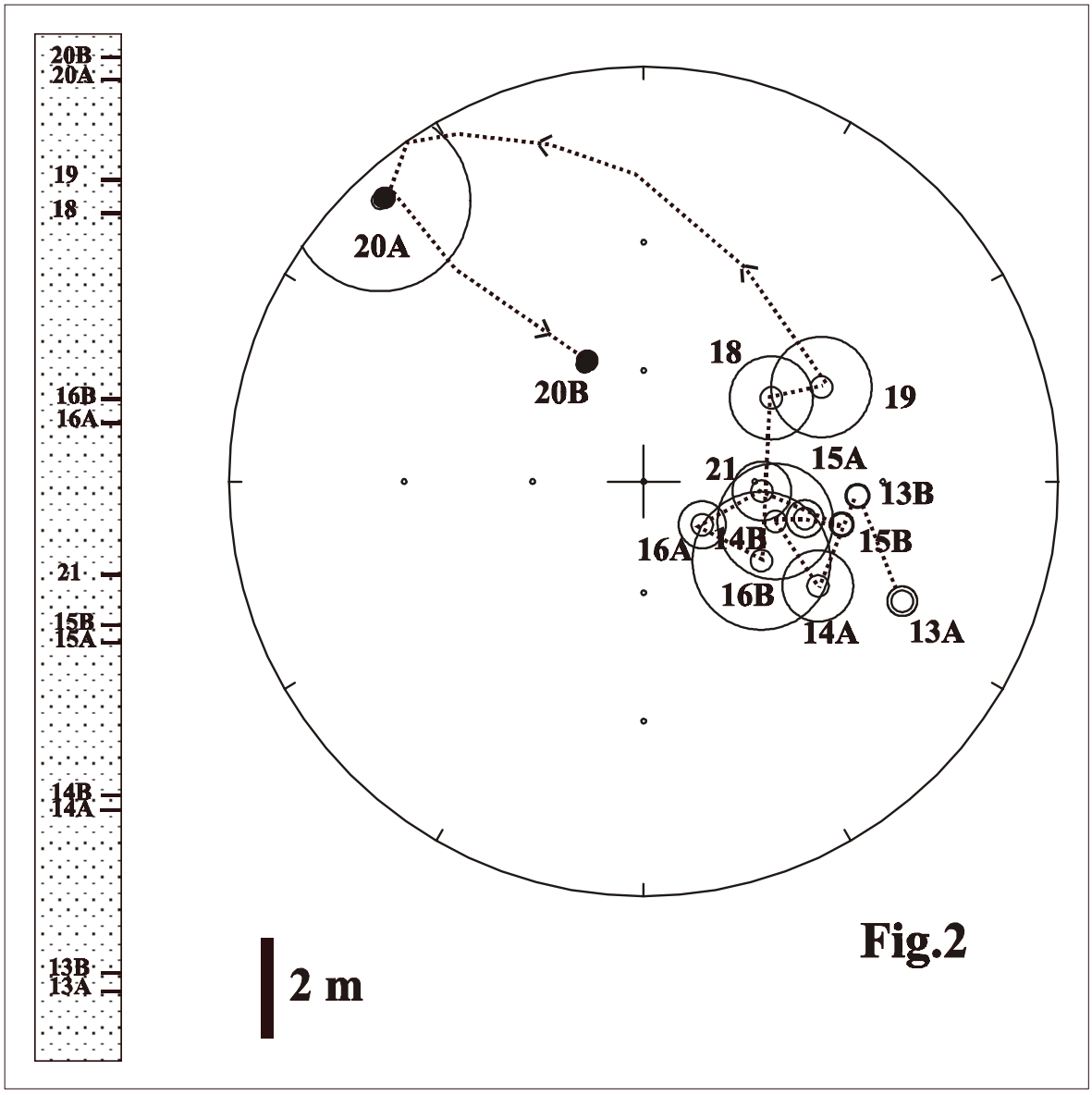

Fig.2. Distribution of bedding corrected site mean directions of characteristic remanence from the Sierra de los Barrientos red claystones. Note the progression of directions and recording of a reversal of the Earth magnetic field. Stratigraphic position of each site is shown on the left.

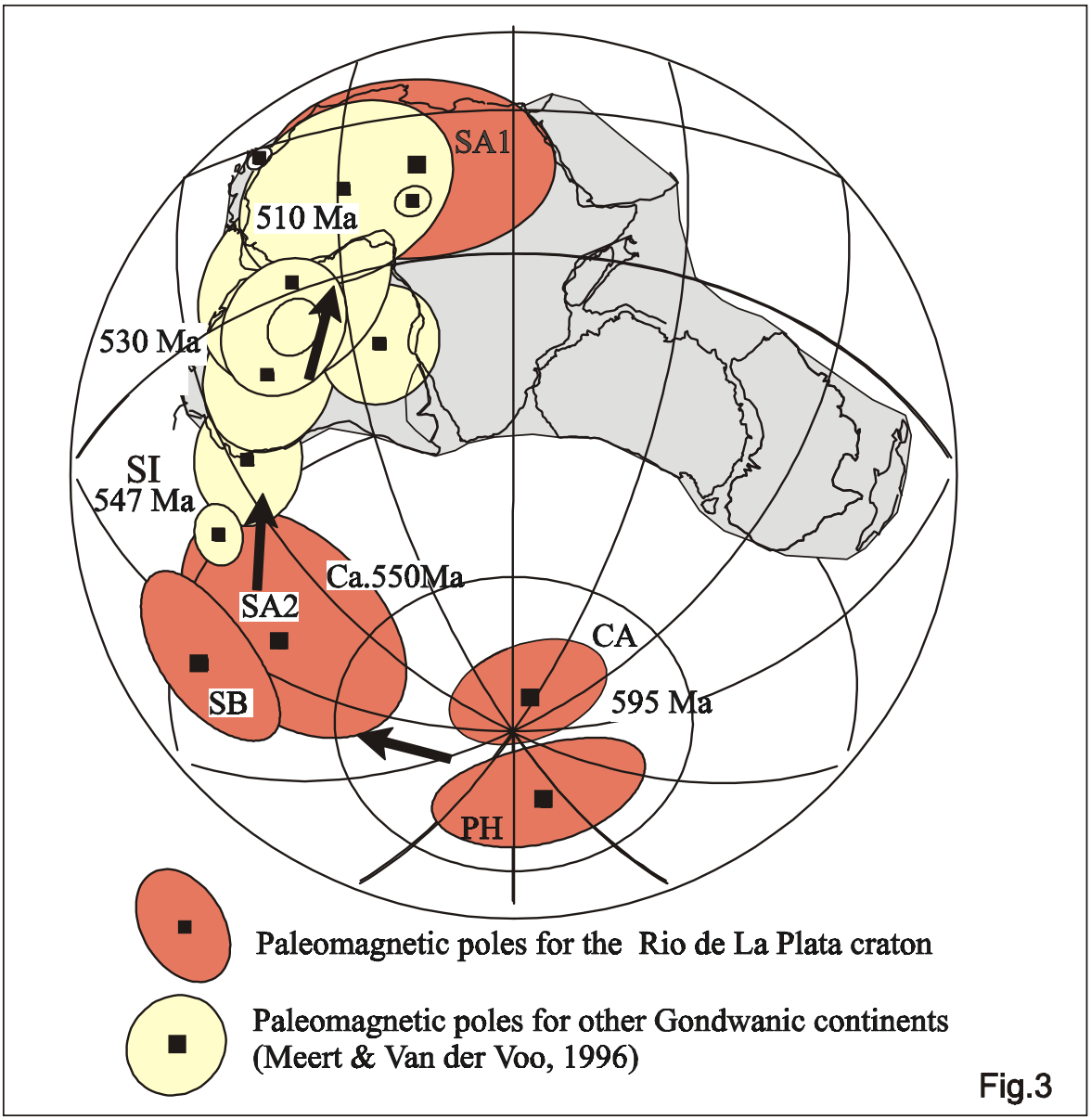

Fig.3. Paleomagnetic pole for Sierra de los Barrientos claystones (SB) and other poles for the Rio de la Plata craton and other Gondwanic continents. Note that since 550 Ma all poles tend to form a single apparent polar wander path. For references see Sanchez Bettucci and Rapalini (2002).

Powell (1995) proposed the existence of a short-lived supercontinent named Pannotia in Vendian times. Briefly, this proposal suggests that Gondwana was formed before Western Gondwana (mainly Amazonia and RP) drifted apart from Eastern Laurentia. Available paleomagnetic data suggest that RP, Congo-Sao Franciso and West Nile blocks formed a single continent by ca. 600 Ma, separate from Amazonia and West Africa that were still attached to Eastern Laurentia by that time (Sanchez Bettucci and Rapalini, 2002). This implies that a supercontinent like the hypothetical Pannotia did not exist by 600 Ma.

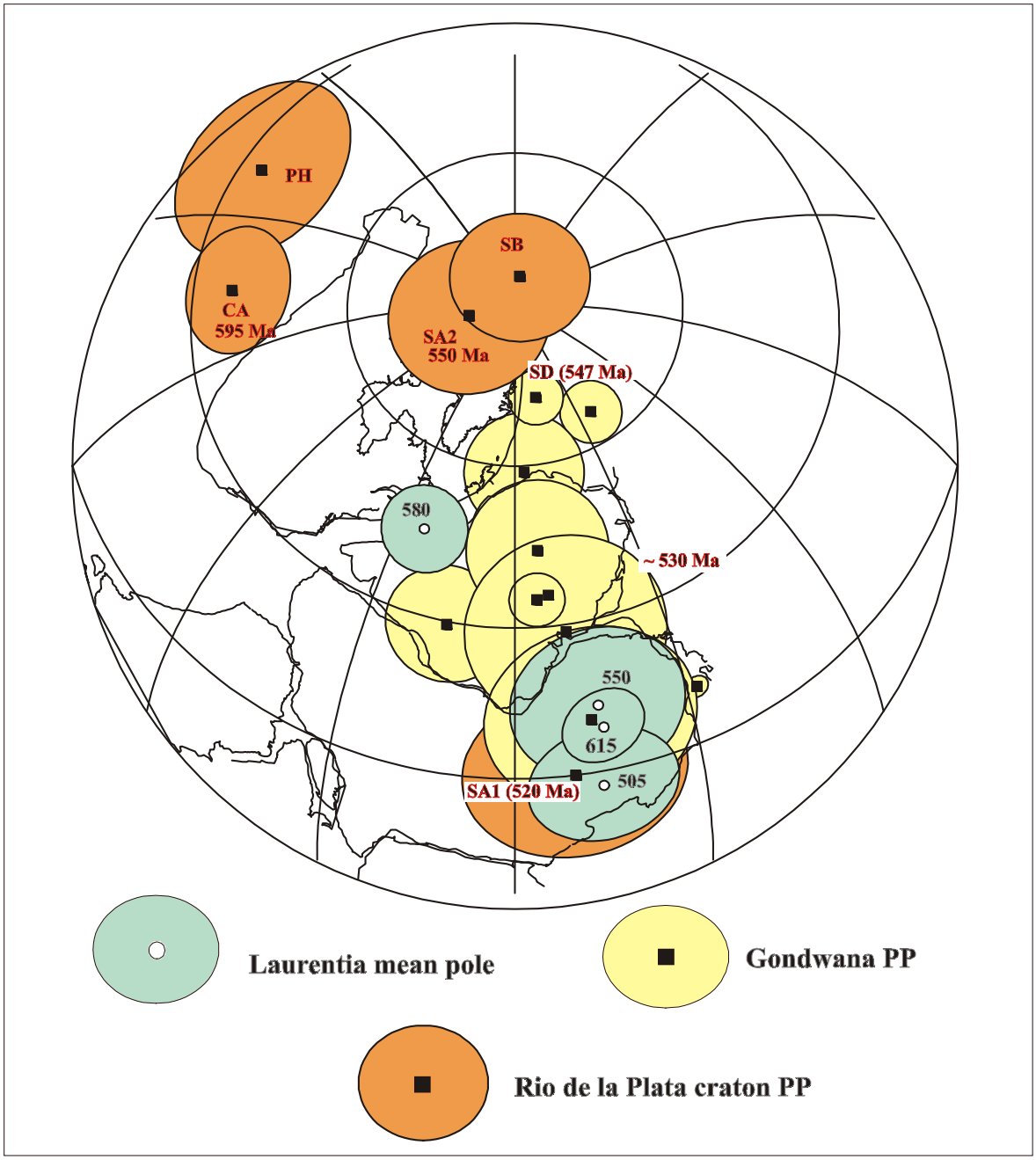

Fig.4. Comparison of Vendian to Cambrian paleomagnetic poles from RP and other Gondwanan blocks with the reference poles for Laurentia after rotation of Gondwana into a Pannotia configuration. Note that poles of similar ages do not match, turning unlikely the existence of Pannotia in the Late Proterozoic

The paleomagnetic data of ca. 550 Ma from RP, Congo and Australia presented in Fig.3 is incompatible also with the idea of Pannotia. However, a Pannotia-like configuration might have existed between 600 and 550 Ma since no reliable paleomagnetic data from the Western Gondwana continents is available for that gap. This possibility is explored in figure 4 which presents the available paleomagnetic poles from Laurentia and Gondwana forming blocks since

600 Ma in a Pannotia-like configuration (western South America juxtaposed with eastern Laurentia). Comparison of pole positions show no superposition of poles of equal age. SB does not superpose with any Laurentian pole older than 550 Ma, which indicates that even if SB is older than 550 Ma no paleomagnetic hints for the existence of Pannotia can be invoked with the available data.

ACKNOWLEDGEMENTS

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