NEW PALEOMAGNETIC DATA FROM THE LATE EDIACARAN SEDIMENTARY COVER OF THE TANDILIA SYSTEM: PALEOGEOGRAPHIC IMPLICATIONS FOR THE RIO DE LA PLATA CRATON

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ABSTRACT

Paleomagnetic studies were performed on samples from two bore cores from the Avellaneda Formation at the Alicia quarry, located in the Olavarría area of the Tandilia System, in the Río de la Plata craton. High temperature demagnetization yielded a mean characteristic remanence direction of Dec: 14.6°, Inc: 67.4°, k: 31.3, α95: 8.3° N:11 after bedding correction. This direction in combination with those obtained by Franceschinis *et al.* (2022) for the same unit in the La Cabañita quarry, permitted the calculation of a refined paleomagnetic pole for the ca. 570 Ma Avellaneda Formation at: 0.9° S, 312.5° E, A95: 5.2°. The apparent polar wander path (APWP) for the Rio de la Plata Craton during the Late Ediacaran was analyzed and a new alternative path is presented considering an opposite polarity for poles older than *ca.* 580 Ma. This path resembles the recently proposed APWP of West Africa craton, whose large oscillations were attributed to two events of inertial interchange true polar wander (IITPW).

Keywords: Ediacaran, Rio de la Plata craton, Tandilia System, Avellaneda Formation.

RESUMEN

Se realizaron estudios paleomagnéticos en muestras de dos núcleos de sondeo de la Formación Avellaneda en la cantera Alicia, ubicada en el área de Olavarría del Sistema Tandilia, en el cratón del Río de la Plata. La desmagnetización a alta temperatura arrojó una dirección de remanencia característica media de Dec: 14,6°, Inc: 67,4°, k: 31,3, α95: 8,3° N:11 después de la corrección de estratificación. Esta dirección en combinación con las obtenidas por Franceschinis et al. (2022) para la misma unidad en la cantera La Cabañita, permitió el cálculo de un polo paleomagnético refinado para la Formación Avellaneda de ca. 570 Ma a: 0,9° S, 312,5° E, A95: 5,2°. Se analizó la trayectoria de desplazamiento polar aparente (APWP) del Cratón del Río de la Plata durante el Ediacárico tardío y se presenta una nueva trayectoria alternativa considerando una polaridad opuesta para polos con una antigüedad mayor a ca. 580 Ma. Esta trayectoria se asemeja a la APWP recientemente propuesta para el cratón de África Occidental, cuyas grandes oscilaciones se atribuyeron a dos eventos de desplazamiento polar verdadero por intercambio inercial (IITPW).

Palabras clave: Ediacárico, Cratón del Río de la Plata, Sistema Tandilia, Formación Avellaneda

1. Geological setting

The Tandilia System is a 350 km long NW trending orogenic belt located in the Buenos Aires province, Argentina. It presents the best exposures of the Rio de la Plata craton (RPC) in Argentina. It is composed of a Paleoproterozoic basement covered by a Neoproterozoic sedimentary succession which generally lies in a sub-horizontal position (Cingolani, 2011). The sedimentary cover is subdivided into the Sierras Bayas and La Providencia groups (Arrouy *et al.,* 2015). The latter is made up by the Avellaneda, Alicia and Cerro Negro formations. The Avellaneda formation is the main objective of this work. It lies above an erosional unconformity (Barker surface) showing a variable thickness between 4 and 25 m. It comprises laminated and massive marls at the bottom, which grade upward into red massive mudstones. The age of the Avellaneda Formation is constrained stratigraphically between the Barker surface (ca.580 Ma) and the Cerro Negro Formation (ca. 560-550 Ma).

2. Methodology

This study was carried out on samples from the Avellaneda Formation collected from two vertical bore cores (A-23 and A-33) drilled by Cementos Avellaneda S. A. in the Alicia quarry, near the city of Olavarría. Nine block samples were collected from bore core A-33 and eleven from A-23 from which 39 and 42 specimens were obtained from the Avellaneda Formation, respectively. They were fragments of the cores of 10 to 30 cm long. All paleomagnetic specimens were drilled centered on a fiduciary mark along the vertical axis of the bore core and in coincidence with the down-dip direction of the lamination. This permitted a preliminary azimuthal orientation of the samples, assuming that the lamination in the sampled cores followed the regional bedding attitude (NE strike, SE dip). This was later refined using the low-coercivity component of the natural remanent magnetization (NRM, see Franceschinis et al. 2022 for a similar procedure).

All the laboratory work was carried out at the Laboratorio de Paleomagnetismo Daniel A. Valencio from IGEBA (University of Buenos Aires). Magnetic remanence of each specimen was measured with a JR6 spinner magnetometer (AGICO). Based on previous results on this formation by Franceschinis *et al*. (2022) at La Cabañita quarry, high temperature demagnetization was assessed as the most likely method to efficiently isolate the different magnetic components. To confirm this pattern, one specimen per sample from A-23 bore core was demagnetized by AF method using an LDA-3A demagnetizer (AGICO), finding that the original assumption was correct. Therefore, all remaining specimens were subject to high-temperature demagnetization using a single chamber ASC48-TD furnace. The steps utilized were 100, 200, 250, 300, 350, 400, 450, 500, 530, 560, 580, 600, 620, 650 and 670°C.

3. Results

In the A-23 bore core the base of the Avellaneda Formation is at 119.3 meters below surface (mbs), being its stratigraphic thickness of 14.4 m. It presents a mean dip of 26°. The lower section is made up of laminated marls with light and dark reddish and greenish levels. The upper section is composed of massive mudstones with reddish, greenish and greyish tones. Thirty-six specimens showed a low-temperature magnetic component labelled “a”. This was identified as an upward trending component with a maximum unblocking temperature of 350-400°C. Following Franceschinis *et al*. (2022), this component was used for refining the azimuthal orientation of the cores. Component “a” was compared with the low temperature/ low coercive force component obtained by Franceschinis *et al*. (2022) for the Avellaneda Formation in the La Cabañita quarry and found to be very similar in unblocking temperature, polarity and inclination. This low-T component shows directional consistency and allowed to azimuthally orient the bore cores at the La Cabañita quarry. Its presence in the bore cores from Alicia quarry permitted us to carry out the same procedure. *In situ* component “a” obtained in each bore core sample was rotated azimuthally around a vertical axis until its mean declination matched that of the soft component obtained by Franceschinis *et al.* (2022). A second component “b” was defined at higher unblocking temperatures (350 - 650°C) and was interpreted as the characteristic remanent magnetization (ChRM). This component presents an in situ direction of Dec: 322.6°, Inc: 58.5°, k: 18.8, $\alpha95$: 9.8°, n:13 (specimens), and after the bedding correction: Dec: 15.2 °, Inc: 71.0°, k: 18.8, $\alpha95$: 9.8°.

In the A-33 bore core the Avellaneda Formation presents sub horizontal lamination and a vertical thickness of 11.1 m. It is composed by laminated marls that alternate light and dark reddish bands in different proportions. In thirty-eight specimens the low temperature component "a" was identified, allowing to apply the same procedure as in bore core A-23 to refine the azimuthal orientation of the bore core samples. The high unblocking temperature component "b" was also determined between 400 and 670 °C, yielding an *in situ* average direction of Dec: 13.2°, Inc: 64.8°, k: 21.4, α95: 5.5°, n: 33 and after correction to the paleohorizontal, Dec: 12.5°, Inc: 66.7°, k: 21.4, α95: 5.5°.

An average component "b" of the Avellaneda Formation was obtained considering a mean direction per each sample from both A-23 and A-33 bore cores. Only those samples with three or more specimens were considered. The mean direction obtained in geographic coordinates is: Dec: 359.6°, Inc: 64.7°, k:20.2, α95: 10.4°, N: 11, and when the bedding correction is applied: Dec: 14.6°, Inc: 67.4°, k: 31.3, α95: 8.3°. The DC fold test of Enkin (2003) was applied to this component yielding a positive result.

A directional analysis was performed combining the directions obtained for the Avellaneda Formation in the Alicia quarry and those obtained by Franceschinis *et al.* (2022) in La Cabañita quarry. The mean component "b" obtained *in situ* is Dec: 5.8°, Inc: 61.6°, k: 18.7, α95: 4.3°, N: 62 and after applying the bedding correction: Dec: 19.9°, Inc: 66.8°, k: 24.7, α95: 3.7°. These results demonstrate that there is not a significant difference between the mean ChRM directions obtained in both quarries.

4. APWP of the Rio de la Plata craton

A new paleomagnetic pole for the Avellaneda formation at 0.9° S, 312.5° E, A95: 5.2°, N:62 was obtained from the combination of the VGPs computed in our study and those reported by Franceschinis *et al.* (2022). Those authors assigned an age of *ca.* 570 Ma for the Avellaneda pole (AV) and proposed a modified APWP for the RPC during the Late Edicaran (Fig. 1A). This pole, together with the Cerro Negro pole (CN) implies

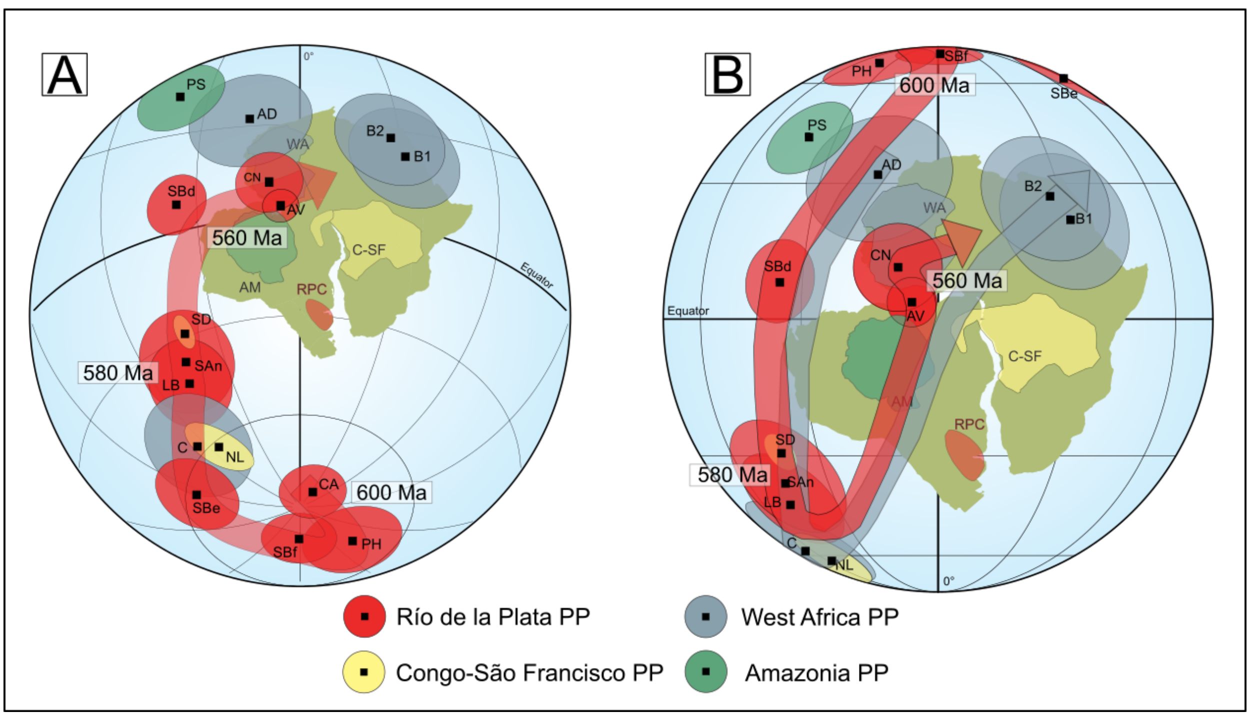

Figure 1. A) APWP of the RPC in the ca. 600-560 Ma interval taken from Franceschinis *et al*. (2022) with the new recalculated pole for the Avellaneda Formation (AV). B) The new APWP proposed for the RPC in this work.

a fast polar drift of the RPC and a path that turns into northern central Africa, different from previous models (Rapalini *et al*., 2013). The Ediacaran APWP for the RPC is mainly based on four key paleomagnetic poles (Franceschinis *et al*., 2022). Apart from the AV pole, they are the Sierra de las Animas (SAn) and Los Barrientos (LB) poles (*ca.* 580-575 Ma) and the Playa Hermosa Formation pole (PH, *ca*. 600-590 Ma). The other poles: Campo Alegre (CA), Villa Mónica (SBf), Cerro Largo (SBe) and Olavarría (SBd) are VGPs due to low number of samples and sites. Traditionally, the poles older than ca. 580 Ma have been assumed as south poles resulting an APWP for the RPC that presents a long swing from higher southern latitudes (in a Western Gondwana reconstruction in present-day African coordinates, Fig.1) to equatorial latitudes in central-western Africa in the Late Ediacaran. The pole positions at *ca*. 580 Ma (SAn and LB) have been supported by the Nola dykes (ND) pole from Congo craton and Adrar-n-Takoucht Volcanics pole (C) from West Africa cratons. However, the older poles of the RPC do not coincide with others Gondwana poles and have been generally interpreted as a likely independent kinematic evolution of RPC in Early Ediacaran. We propose an alternative APWP for the RPC during the Late Ediacaran in which the polarity of the poles prior to 580 Ma were inverted (CA, PH, SBf and SBe poles, Fig 1B). With this change, the APWP becomes somewhat longer but the early Ediacaran poles from RPC fall much closer to the *ca.* 615 Ma Planalto da Serra pole (PS) from Amazonia and *ca*. 616 Ma Adma Diorite pole (AD) from West Africa craton (Fig. 1B). In addition, this alternative APWP is like that recently proposed for West Africa by Robert *et al*. (2017). These authors proposed the existence of two Inertial Interchange True Polar Wonder events during the Ediacaran based on this APWP. The first event would have occurred between ca. 615 and 590-575 Ma and the second one between 575 and 565 Ma.

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