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NEW EDIACARAN PALEOMAGNETIC POLE FOR THE RIO DE LA PLATA CRATON: PALEOGEOGRAPHIC RESTRICTIONS IN THE ASSEMBLY OF WESTERN GONDWANA

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ABSTRACT

Preliminary paleomagnetic data obtained in marls of the Avellaneda Formation (La Providencia Group) of Ediacarian age outcropping in the Río de la Plata craton (RPC) are presented. Sampling was carried out in quarry and in a bore-core. Standard stepwise demagnetization showed a directional consistency among both sets of samples yielding a preliminary paleomagnetic pole located at 0.8° N, 308.4° E, (A95: 5.7°, n: 68) for the Avellaneda Formation. This indicates very high latitudes for the craton and suggests that the most accepted Ediacarian apparent polar wander path (APWP) for the 600-500 Ma period for RPC must be reconsidered.

Keywords: Avellaneda Formation, Rio de la Plata craton, Ediacarian

RESUMEN

Se presentan datos paleomagnéticos preliminares obtenidos en margas de la Formación Avellaneda (Grupo La Providencia) de edad ediacariana, en el cratón del Río de la Plata (RPC). El muestreo se realizó en una cantera y testigo de perforación. La desmagnetización mostró una dirección consistente entre ambos conjuntos de muestras que produjeron un polo paleomagnético preliminar ubicado a 0.8 ° N, 308.4 ° E, (A95: 5.7 °, n: 68) para la Formación Avellaneda. Esto indica latitudes muy altas para el craton y sugiere que, para el RPC, se debe reconsiderar la ruta de desplazamiento polar aparente (APWP) más aceptada para el período 600-500 Ma.

Palabras clave: Formación Avellaneda, Craton del Rio de la Plata, Ediacárico

1. Introduction

An APWP has been defined for the Río de la Plata craton (RPC) with nine poles (Rapalini *et al*., 2013, 2015) between around 600 and 500 Ma. These data suggest that the RPC was at intermediate latitudes towards 575 Ma, possibly already attached or very close to the Congo-São Francisco craton. Although some consensus seems to have been reached in tracing the Ediacaran-Cambrian apparent polar wander path for the RPC (Rapalini, 2018), it is still rudimentary and based on very few high quality paleomagnetic poles. These deficiencies indicate the need of systematic paleomagnetic studies on rocks of that age in order to confirm, refine or modify the APWP accepted so far and its paleogeographic implications. With this aim, preliminary paleomagnetic studies are presented in Ediacaran sedimentary units of the Tandilia System, in the province of Buenos Aires, Argentina.

2. Geological background

In the Tandilia System, the Neoproterozoic units of the Sierras Bayas and La Providencia Groups overlie the Paleoproterozoic basement of the Buenos Aires Complex (Arrouy *et al*., 2015). These authors proposed a new stratigraphic scheme for the Neoproterozoic cover of the Tandilia system based mainly on findings from numerous exploratory bore-holes for the mining industry in the Olavarría area. The new scheme generated the La Providencia Group and renaming the Cerro Negro formation. La Providencia Group is integrated from base to top by the Avellaneda, Alicia and Cerro Negro Formations. The Avellaneda Formation (Arrouy *et al*., 2015) is deposited on top of the "Barker" carstic erosive surface developed on the limestones of the Loma Negra Formation. It consists of an association of facies, starting from the base with a mixed composition of massive and laminated marls, gradually increasing the content of siliciclastic material reaching massive red clays at the top. The paleoenvironment proposed for this formation is shallow marine, with evidence of episodic subareal exposure. Arrouy *et al*. (2016) reported the finding of an Ediacaran fossil biota including the gender *Aspidella* sp. in the upper levels of the Cerro Negro Formation that has been correlated with the "White Sea" fauna dated to between 550 and 560 Ma. Based on this, and the assigned age of ca. 580 Ma for the Loma Negra Formation (Gómez Peral *et al*., 2019) an age of 560 to 570 Ma is considered the most likely for the Avellaneda Formation.

3. Methodology and results

Sampling of the Avellaneda Formation was carried out in an outcrop in the "La Cabañita" quarry, by means of the extraction of four cores and five oriented hand samples (Site AV1: 36.9887° S, 60.2208° W) covering a stratigraphic thickness barely exceeding 6 m. The outcrop consists of a fairly monotonous succession of purple marls with intercalations of lighter levels.

Cementos Avellaneda S.A. gave us access to sample bore-cores. The bore-core studied and presented here (TSE-34) was located less than 100 meters from the aforementioned AV1 sampling site. The measured vertical thickness of the Avellaneda Formation in this core is 9.86 m, ranging from 91 m below the surface to almost 81 meters. Twelve samples were selected, approximately 10 to 30 cm in length. Three to seven cylindrical cores measuring 2.54 cm in diameter and approximately 3 cm in height were extracted from each sample, from which a 2.2 cm high specimen was obtained.

Processing of the Avellaneda formation sampled at AV1 was carried out with a first stage of demagnetization by stepwise alternating magnetic fields (AF) up to 90 mT, followed by high temperatures of 100, 150, 300, 400, 500, 530, 560, 590 and 620 °C. These procedures allowed to define, by means of principal component analysis (PCA, Kirschvink, 1980), the presence of a magnetic component of low to medium coercivities defined by AF lower than 40 mT (component "a"). A second component "b" was determined between 50 and 90 mT. Finally, a third component ("c") could be defined through demagnetization at high temperatures with a tendency towards the origin of coordinates. Unblocking temperatures close to or greater than 600 °C were observed. A directional coherence was observed for the "a" component isolated in the different samples, the mean direction in geographical coordinates being: Dec: 13.7°, Inc: -62.2°, α_{95}: 4.3°, k: 25.3, n: 46 (specimens). This direction is very close to that expected for the recent dipolar field in the sampling location (Dec: 0°, Inc: -56.4°), suggesting a probable recent origin for this component. Component "b" did not show directional consistency while component "c" presented a consistent direction: Dec: 10.0°, Inc: 56.9°, α_{95}: 4.4°, k: 48.1, n: 23 (specimens). After applying the paleohorizontal correction, the characteristic mean direction of this component for the site is: Dec: 11.8°, Inc: 65.3°, α_{95}: 4.4°, k: 48.1.

Paleomagnetic cores collected from bore-core TSE-34 showed magnetic behavior similar to that of outcrop samples from the AV1 site. All paleomagnetic cores (n: 48) were subjected to thermal demagnetization according to the following steps: 90, 120, 150, 200, 250, 300, 350, 400, 450, 500, 525, 550, 575, 600, 620 and 640 °C. Components were defined using the principal component analysis (PCA, Kirschvink, 1980). Up to approximately 250-350 °C, a low temperature magnetic component (component "a") of moderate negative inclination pointing to NE was defined. This component is very similar to the "a" component isolated in the samples obtained in the quarry outcrops (AV1). Between 350 and 575 °C, a high temperature component (component "b") was generally isolated tending towards the origin of coordinates. The mean direction of the "a" component *in situ*: Dec: 5.0°, Inc: -53.0°, α95: 5.6°, k: 14.5, n: 48, coincides with the dipolar field expected at the drilling site (Dec: 0°, Inc: -56.4°). On the other hand, the mean direction of component "b" is *in situ*: Dec: 11.3°, Inc: 53.5°, α95: 5.4°, k: 16.6, n: 45 and after the paleohorizontal correction: Dec: 13.3°, Inc: 68.5°, α95: 5.1°, k: 18.1.

We combined the directions of the "a" components of the bore-core and the outcrop (Fig. 1) yielding a mean *in situ* direction of Dec: 8.8°, Inc: -57.7°, α95: 3.6°, k: 17.3 (n: 94) and after bedding correction of Dec: 8.4°, Inc: -44.9°, α95: 3.8°, k: 15.7. The same procedure was applied for the characteristic components determined in outcrop and bore-core (Fig. 1) obtaining the following mean directions *in situ*, Dec: 10.9°, Inc: 54.7°, α95: 3.8°, k: 21.3, n: 68 and after bedding correction, Dec: 12.8°, Inc: 67.4°, α95: 3.7°, k: 23.0. This component showed a dominant reverse polarity with only few specimens presenting antipodal directions.

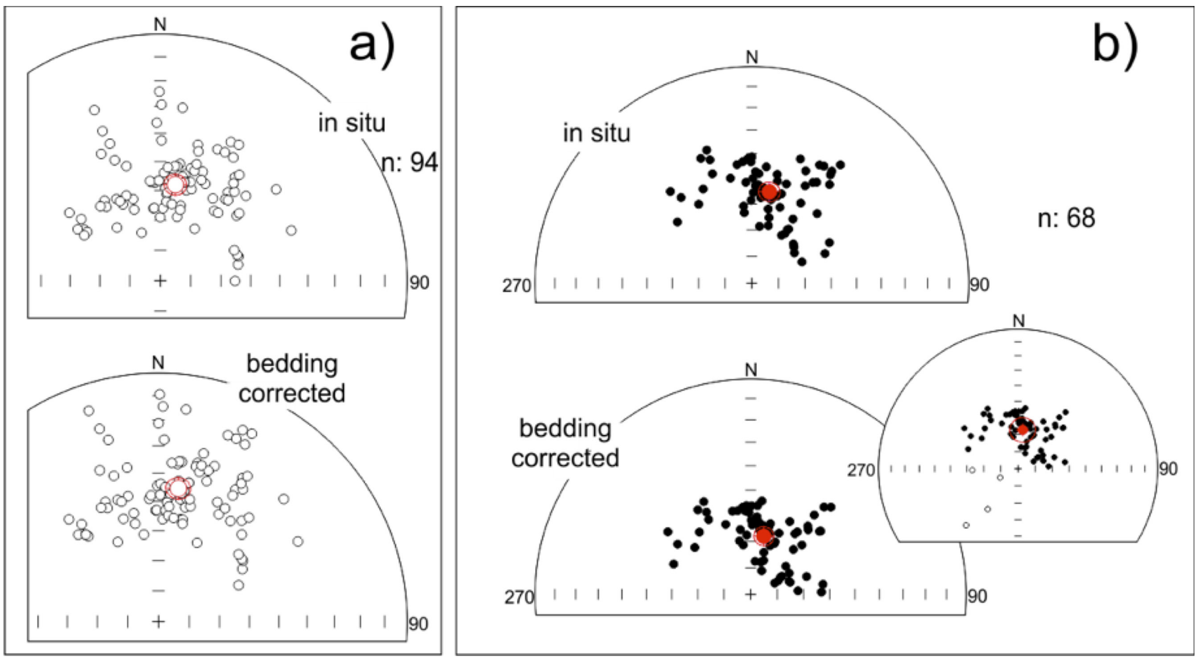

Figure 1. a) Directions of the magnetic component "a" of the Avellaneda Formation in situ (above) and after bedding correction (below); **b)** characteristic remanence of the Avellaneda Formation specimens *In situ* and after bedding correction. All directions have been plotted in the lower hemisphere. Small inset shows distribution of bedding corrected directions with the proper polarity for each sample.

4. Paleogeography and conclusions

The apparent polar wander path of the Rio de la Plata craton in the Neoproterozoic during the 600-500 Ma interval (Rapalini *et al.*, 2015, Rapalini, 2018) proposed in the last decade shows a very long track from positions close to the current south pole (when a Gondwana configuration is reconstructed in African coordinates) around 600 Ma to positions in North Africa in the Cambrian.

The paleomagnetic pole of the Avellaneda Formation computed from the characteristic remanence falls very far from poles of only slightly older ages such as SAn (Sierra de las Animas Complex, 579 Ma, Rapalini et al., 2015) or the Los Barrientos clays (Cerro Largo Formation, Sierras Bayas Group, Rapalini, 2006). If the isolated remanence in the Avellaneda Formation is primary, this position implies a rapid polar displacement between approximately 580 Ma (SAn and LB) and 560 Ma (AV), modifying the previosuly proposed path into a much shorter one and suggesting that the RPC experienced high paleolatitudes during the early Late Ediacaran. This would be consistent with the demise of the carbonatic platform represented by the Loma Negra Formation.

References

Arrouy, M.J., Poiré, D., Gómez Peral, L.E., Canalicchio, J.M., 2015. Sedimentología y estratigrafía del grupo La Providencia (nom. nov.): cubierta superior neoproterozoica, Sistema de Tandilia, Argentina. *Latin American Journal of Sedimentology and Basin Analysis. 22,* 2, 171–189.

Arrouy, M.J., Warren, L. V., Quaglio, F., Poiré, D.G., Simões, M.G., Rosa, M.B., Peral, L.E.G., 2016. Ediacaran discs from South America: Probable soft-bodied macrofossils unlock the paleogeography of the Clymene Ocean. *Scientific Reports. 6,* 1–10.

Gómez Peral, L.E., Julia, M., Poiré, D.G., Cavarozzi, C.E., 2019. Redox-sensitive trace element distribution in the Loma Negra Formation in Argentina: The record of an Ediacaran oxygenation event. *Precambrian Research. 332, 105384.*

Kirschvink, J., 1980. The least-squares line and plane and the analysis of paleomagnetic data. *Geophysical Journal International. 62, 3,* 699–718.

Rapalini, A.E., 2006. New Late Proterozoic paleomagnetic pole for the Rio de la Platacraton: implications for Gondwana. *Precambrian Research*. *147,* 3-4, 223–233.

Rapalini, A.E., Trindade, R.I.F., Poiré, D.G., 2013. The La Tinta pole revisited: Paleomagnetism of the Neoproterozoic Sierras Bayas Group (Argentina) and its implications for Gondwana and Rodinia. *Precambrian Research. 224,* 51–70.

Rapalini, A.E., Tohver, E., Sánchez, L., Lossada, A.C., Barcelona, H., Pérez, C., 2015. The late Neoproterozoic Sierra de las Ánimas Magmatic Complex and Playa Hermosa Formation , southern Uruguay , revisited : Paleogeographic implications of new paleomagnetic and precise geochronologic data. *Precambrian Research. 259,* 143–155.

Rapalini, A.E., 2018. The Assembly of Western Gondwana: Reconstruction Based on Paleomagnetic Data. In: Siegesmund, S., Basei, M.A.S., Oyhantçabal, P., Oriolo, Sebastián (eds.), Geology of Southwest Gondwana. Regional Geology Reviews, Springer International Publishing, Cham, 3-18.