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MIDDLE TO LATE EDIACARAN MAGNETOSTRATIGRAPHY OF THE AVELLANEDA FORMATION, RIO DE LA PLATA CRATON

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ABSTRACT

The Avellaneda Formation represents an opportunity to access magnetic field information of the middle to late Ediacaran world, a critical period for the Earth. We performed a preliminary magnetostratigraphy study from data obtained in marls of the Avellaneda Formation (La Providencia Group) exposed in the Río de la Plata craton. Two drill cores were sampled (TSE-34 and TSE-7). Paleomagnetic analyses by standard stepwise thermal demagnetization revealed a high-temperature and dual polarity components persistent in both drill core analysed. As result, the presence of one normal and reversed polarity zone has potential for providing a timescale that could be applied to constrain sediment accumulation rates, estimate the duration of geological events, and construct a high-resolution chronostratigraphy that may be a useful marker for global correlation.

Keywords: Ediacaran, magnetostratigraphy, Rio de La Plata craton

RESUMEN

La Formación Avellaneda representa una oportunidad para acceder a la información del campo magnético del mundo Ediacárico medio a tardío, un período crítico para la Tierra. Realizamos un estudio preliminar de magnetoestratigrafía a partir de datos obtenidos en margas de la Formación Avellaneda (Grupo La Providencia) expuestas en el cratón del Río de la Plata. Se tomaron muestras de dos testigos de perforación (TSE-34 y TSE-7). Los análisis paleomagnéticos por demagnetización térmica revelaron componentes de alta temperatura y polaridades normal e inversa en ambos testigos de perforación analizados. Como resultado, la presencia de una zona de polaridad normal e inversa tiene el potencial de proporcionar una escala de tiempo que podría aplicarse para restringir las tasas de acumulación de sedimentos, estimar la duración de los eventos geológicos y construir una cronoestratigrafía de alta resolución que puedan servir como un marcador para correlaciones global.

Palabras claves: Ediacara, magnetoestratigrafía, Craton del Rio de La Plata

1. Introducción

The Ediacaran Period (~ 635–541 Ma) encompasses a dynamic interval of Earth history (Knoll *et al*. 2006). It is characterized by drastic climatic change from Snowball Earth glaciation (Hoffman and Li, 2009) and an active tectonic of continental break-up and collision (Li *et al.,* 2008). These events were accompanied by unusual biogeochemical events recognized globally in both carbonate rocks and sedimentary organic matter associated to large variations in seawater chemistry which indicates significant disturbance in oceanic and atmospheric redox conditions (Li *et al.,* 2010). The end of Ediacaran Period is marked by the beginning of a biologically distinct world, characterized by diverse calcified skeletal macroscopic animals (Grotzinger *et al.,* 2000).

Among other paleocontinents, Rio de La Plata craton plays an important role in documenting Earth's critical changes in terminal Ediacaran Period (Rapalini *et al.,* 2013; 2015). The Ediacaran strata from Rio de La Plata craton have exceptional preservation of oldest metazoan fossils (Arrouy *et al.,* 2016), acritarchs and multicellular algae (Arrouy *et al.,* 2015), as well as large variations in seawater chemistry, which indicate significant transitions in oceanic and atmospheric redox conditions (Gomez Peral *et al.,* 2019).

Due to the limitation of biostratigraphy techniques to correlate globally sedimentary rock, prior to the widespread appearance of cosmopolitan biotic assemblages, magnetostratigraphy provides one of a few reliable methods to build a chronostratigraphic framework for the Ediacaran strata. Nevertheless, paleomagnetic data from Rio de La Plata is a key challenge. First, Ediacaran rocks in the Rio de La Plata comprise mainly carbonate rocks, which are prone to thermal and chemical alteration. Second, there is a possible influence of multiple episodes of tectonic activities, during Phanerozoic Era. Third, it has been suggested that the geomagnetic field in Ediacaran time was not stable and had transient non-geocentric-axial-dipole (GAD) behaviour intermittently (Abrajevitch and Van der Voo, 2010), increasing the difficulty of a straightforward interpretation and application of paleomagnetic data, especially without reliable age constraints. Here, we present a preliminary magnetostratigraphy study of the Ediacaran Avellaneda Formation combining paleomagnetic and rock-magnetic analysis to evaluate the potential build of chronostratigraphic framework.

2. Geological setting

Ancient sedimentary cover of the Rio de La Plata craton is exposed in the Tandilia System in eastern Argentina. Sedimentary cover encompasses rocks from Cryogenian to Ediacaran age grouped into the Sierras Bayas Group (Poiré, 1993) and La Providencia Group (Arrouy *et al*., 2015). The Sierras Bayas Group includes Villa Mónica, Colombo, Cerro Largo, Olavarría and Loma Negra Formations, while La Providencia Group comprises Avellaneda, Alicia and Cerro Negro Formations (Arrouy *et al*., 2015). Both groups are documented in the Olavarría region and are about ~ 400 m thick. The basal section of the La Providencia Group comprises a mixed siliciclastic-carbontate succession inserted in the Avellaneda Formation. This unit lay on top of the "Barker surface", a karstic erosive boundary that separates it from the underlying Sierras Bayas Group. The Avellaneda Formation is mostly composed of red to purple laminated and massive marls at the base, which grade vertically into red massive mudstone. Depositional setting interpreted for the Avellaneda Formation includes shallow-marine environments under tidal effects (Arrouy *et al*., 2015). Until now, there is no available geochronological data for the Avellaneda Formation, but the fossil index *Aspidella sp*., correlated to the White Sea assemblage found in the Cerro Negro Formation, provided an age between 550 and 560 Ma (Arrouy et al., 2016). Meanwhile, $\delta^{13}C$ and $^{87}Sr/^{86}Sr$ isotope data of the Loma Negra Formation suggest an age around 600-580 Ma. For this reason, a constrained age of 570 to 560 Ma is considered the most likely for the Avellaneda Formation.

3. Methods and results

The samples were collected from two vertical drill cores (TSE-34 and TSE-7) from La Cabañita quarry, near the town of Olavarria. Samples for paleomagnetic analysis were selected at 0.3–0.5 m resolution, spanning the entire Avellaneda Formation interval. At least two 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. Summed, the two drill holes provided 100 cylindrical cores. Individual specimens from each sample were subjected to stepwise thermal demagnetization up to 700 °C with an internal field <10 nT. The thermal demagnetization steps were 90, 120, 150, 200, 250, 300, 350, 400, 450, 500, 525, 550, 575, 600, 620, 640, 660, 680, 700 °C. Measurements of the natural remanent magnetization (NRM) were made using a three-axis 2G cryogenic magnetometer, housed in a magnetically shielded room at the palaeomagnetic laboratory of the University of São Paulo (USPmag). During each thermal treatment, bulk susceptibility was controlled to identify possible chemical or mineralogical changes due to experimental heating. Magnetic components were identified individually and computed by means of principal component analysis (PCA, Kirschvink, 1980). Magnetic components were defined with at least three steps (generally five or more) and arbitrary a MAD ≤ 15° was accepted (over 75% of components were defined with MAD < 10°). All measurements were processed using the Remasoft software.

The data acquired is briefly presented here. Both drill cores show a closely magnetic behaviour. The paleomagnetic data measurements revealed the presence of two magnetic components (Figure 1). A low-

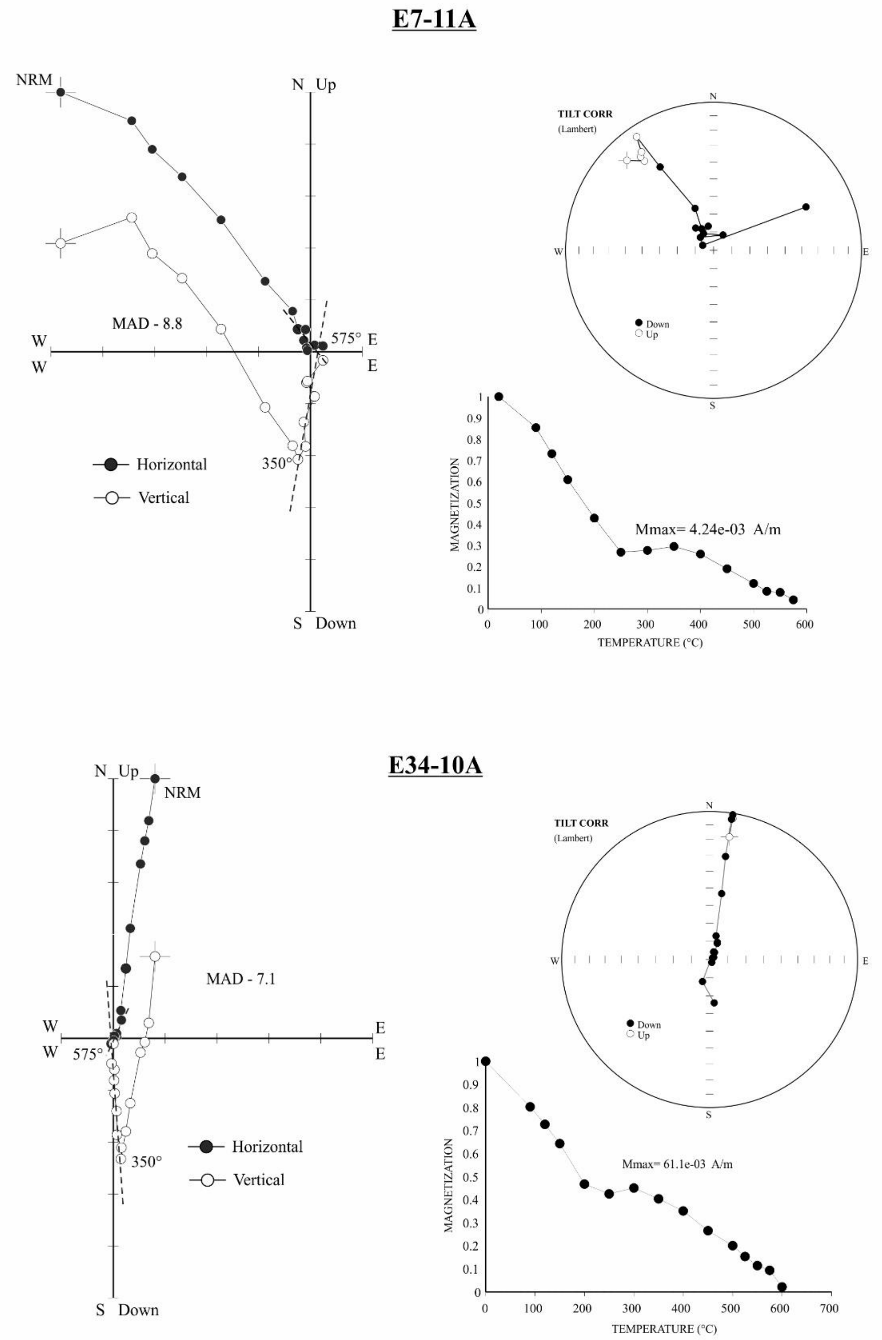

Figure 1. Representative thermal demagnetization data. Data are in stratigraphic coordinates and are plotted in vector-endpoint diagrams (Zijderveld, 1967), equal-area stereographic projection and magnetization intensity versus temperature curves. The characteristic remanent magnetizations were determined by principal component analysis (Kirschvink, 1980).

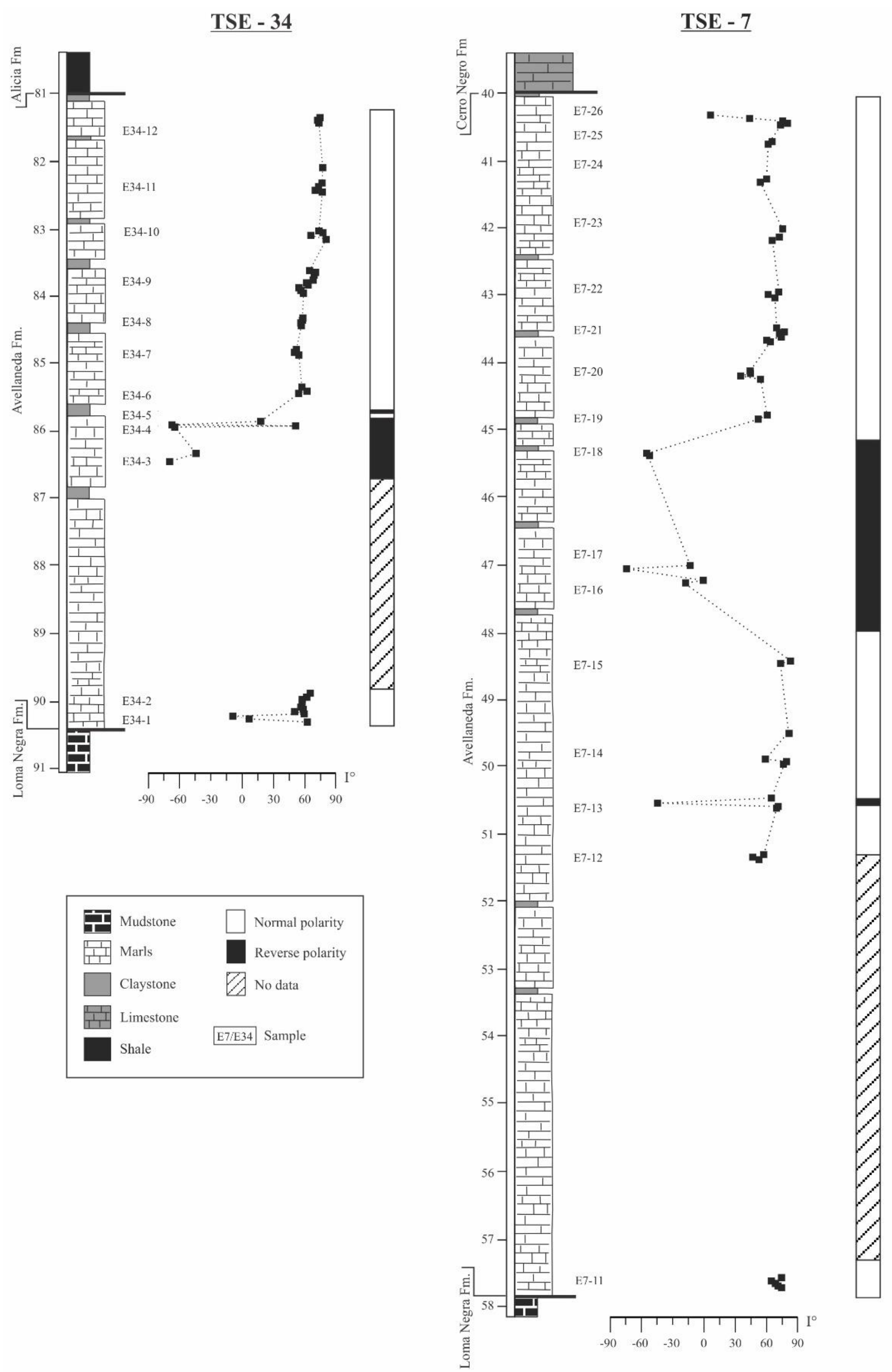

Figure 2. Plot of inclination (I°) versus thickness (meters) for drill cores TSE-34 and TSE-7 and the corresponding polarity logs.

temperature component (LTC) is isolated up to ~300 °C. It is composed of only normal polarity directions close to the present Earth's magnetic field at the site. A high-temperature component (HTC) is observed above ~350-575°C or 620°C depending on samples. This range of unblocking temperatures suggests that the carrier of this component is titanomagnetite with low-titanium content or titano-hematite. Most analysed samples show a positive inclination and orientation to NE/NW. Two samples from drill core TSE-34 (E34-3 and E34-4) exhibit negative inclination and direction pointing to SW (Figure 2). The mean directions HTC observed in the TSE-34 core after the paleohorizontal correction (N=12 and n=45) is Dec: 13.3°, Inc: 68.5°, α95: 5.1°, k: 18.1. The sampled drill core TSE-7 preserves a dual polarity magnetization characterized by negative (E7-16 and E17) and positive inclinations (Figure 2). The mean directions HTC observed in the TSE-7 after the paleohorizontal correction (N=15 and n=51) is Dec: 10.6°, Inc: 67.8°, α95: 9.2°, k: 5.9.

4. Conclusion

The magnetostratigraphy study on Late Ediacaran sedimentary rock from Avellaneda Formation showed that a high-temperature component has a dual polarity. In the future, we hope available a paleomagnetic results from Ediacaran Avellaneda Formation robust enough to provide a detailed and reliable magnetostratigraphy coupled with stable isotopes that may serve as a marker for global correlation.

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