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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

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ABSTRACT

A new paleomagnetic study was carried out on 15 sites of the Sierra de las Ánimas complex, exposed in SE Uruguay. A paleomagnetic remanence was isolated at six sites, and this direction is likely to be pretectonic and primary. Mean directions from five of these sites are consistent with the SA2 paleomagnetic pole, which is based on a previous paleomagnetic study of the complex. A new paleomagnetic pole was computed for compiled results from the Sierra de las Ánimas complex (SAn, 12.2° S, 258.9° E, A95: 14.9°). A geochronological study based on U/Pb (SHRIMP) dating of magmatic zircons was also carried out on three samples of the Sierra de las Animas Complex, yielding a grand mean age of 578 ± 4 Ma. The new SAn paleomagnetic pole anchors the Early Ediacaran segment of the Apparent Polar Wander Path for the Río de la Plata craton. Consistency of the new pole with other Ediacaran poles from the Congo-São Francisco craton suggests a coherent Central Gondwana by this time. These data also support a wide Clymene Ocean between the conjoined Río de la Plata–Congo-São Francisco blocks and Western Gondwana, i.e., Amazonia–West Africa. Additional sampling (sixteen samples) was carried out on the basal levels of the glaciogenic Playa Hermosa Formation, exposed in the same area. These samples retain a paleomagnetic component consistent with the previously reported data, confirming the original pole position. U–Pb (SHRIMP) dating of detrital zircons reveal a bimodal distribution of Paleoproterozoic (around 2.1 Ga) and late Neoproterozoic ages. The youngest zircons are interpreted as pre-dating to penecontemporaneous with deposition and points to a ≤594 Ma age for deposition of the older levels of the Playa Hermosa Formation. A minimum age of deposition is set by the 578 ± 4 Ma age of the Sierra de las Ánimas magmatism. The low inclination of magnetization indicates that low-latitude (13.0° +9.5°/−5.5°), Gaskiers-aged glacial deposits are preserved atop the Rio de la Plata craton.

1. Introduction

The late Proterozoic chronology of the fragmentation of Rodinia and the assembly of Gondwana is poorly constrained (e.g. Li et al., 2008; Murphy et al., 2013). Reliable paleomagnetic data on accurately dated rocks are essential to reconstruct the paleogeographic evolution of the different cratonic blocks. The relevant time period should encompass the entire period over which Rodinia disintegrated and Gondwana formed, from around 800 up to 500 Ma. The Río de la Plata craton (RP, Fig. 1) is a relatively small crustal block with Paleoproterozoic (and very minor Archean) basement, that forms the southernmost cratonic unit of South America (Dalla Salda et al., 1988; Cingolani and Dalla Salda, 2000; Cordani et al., 2000; Rapela et al., 2007, 2011; Bossi and Cingolani, 2009). The paleogeographic position of the Rio de la Plata craton over the 800–500 Ma interval is poorly known. Some workers favor a close proximity of

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Fig. 1. Main geotectonic units of the Río de la Plata craton and location of the study area in southern Uruguay. SYSZ: Sarandí del Yi shear zone. Modified from Rapalini et al. (2013).

the Rio de la Plata craton to Amazonia, and therefore to Eastern Laurentia (e.g. Weil et al., 1998; Meert, 2001; Collins and Pisarevsky, 2005; Li et al., 2008; Gaucher et al., 2011), though no conclusive geologic evidence supports that reconstruction. In contrast, several geological studies (e.g. Campos Neto, 2000; Tohver et al., 2012) have shown that the Rio de la Plata was surrounded by several Neoproterozoic oceanic domains that were closed by the end of that era, and might have never been part of Rodinia (Kröner and Cordani, 2003; Tohver et al., 2006; Rapela et al., 2007).

A review of the available Neoproterozoic paleomagnetic data from the Rio de la Plata craton suggests that this block was not connected to Eastern Laurentia in the Ediacaran (Rapalini et al., 2013). These authors defined an apparent polar wander path (APWP) for the Río de la Plata craton from around 600 to 500 Ma based on eleven paleomagnetic poles. This APWP is marred by known uncertainties: some of these poles should be regarded as mean virtual geomagnetic poles due to low number of sites or samples, and some of the poles are based on remagnetizations, the age of which is inferred from the pole position, while other poles show poor confidence ovals and/or age uncertainties. Despite the progress made in the last decade, a more robust APWP for the Rio de la Plata craton is clearly needed.

The Sierra de las Ánimas Magmatic Complex, exposed in SE Uruguay, provided the first late Neoproterozoic to early Paleozoic paleomagnetic results for the Río de La Plata craton (Sánchez Bettucci and Rapalini, 2002). Two paleomagnetic poles (SA1 and SA2) were calculated from this complex with assigned ages to these poles of ca. 520 and 550 Ma, respectively. This interpretation indicates either long-lived magmatism (over 30 Ma) or two discrete magmatic events, one in the Ediacaran (SA2) and one in the Cambrian (SA1). However, in the absence of precise geochronological determinations for these rocks, these age assignments are weakly constrained and inferential. More recently, Oyhantçabal et al. (2007) reported a well-behaved, $^{40}Ar/^{39}Ar$ plateau age of 579 ± 2 Ma for hornblende from the Pan de Azúcar syenite, which would imply a significant revision to the age of the SA2 pole, assuming that the hornblende does not record protracted cooling of the body. This geochronological uncertainty aside, it must be stated that both the SA1 and SA2 poles are based on a relatively small number of sites and consequently show large uncertainties in their positions. A third mean virtual geomagnetic pole reported by Sánchez Bettucci and Rapalini (2002) derived from study of the glaciogenic sedimentary rocks of the Playa Hermosa Formation. This pole, computed from only 6 samples, was interpreted as primary in origin and dating from the inferred ca. 600 Ma age of sedimentation.

In order to construct a more robust apparent polar wander path for the Río de la Plata craton, we conducted a new paleomagnetic study on the Sierra de las Animas complex and the Playa Hermosa Formation. This paleomagnetic study was complemented by geochronologic determinations by U–Pb (SHRIMP)