THE SIERRA DE LAS ANIMAS MAGMATIC COMPLEX, SOUTHERN URUGUAY, REVISITED: 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 Animas Complex, exposed in SE Uruguay. Preliminary results show that six sites carry a likely pre-tectonic characteristic remanence. Mean directions from five of these sites are consistent with those six published previously that led to the SA2 paleomagnetic pole. On the basis of 11 virtual geomagnetic poles a new preliminary paleomagnetic pole was computed for the Sierra de Animas Complex (SAn, 12.2°S, 258.9°E, A95: 14.9°). This falls slightly displaced respect to the original SA2 pole, but is consistent with the Los Barrientos pole from the Rio de la Plata craton and poles of ca. 550 Ma from Arabia and Congo. A geochronologic study based on U/Pb (SHRIMP) dating in zircons was also carried out. Two samples, obtained in a microsyenite and a rhyolite provided well defined ages of 573±2 and 585±4 Ma, respectively, confirming the Early Ediacaran age of the complex and precisely dating the new paleopole and this segment of the APWP for the Rio de la Plata craton. These ages also cast serious doubts on the extension of this magmatic event into the Cambrian.

Resumen

Se llevó a cabo un nuevo estudio paleomagnético en 15 sitios de muestreo del Complejo Sierra de Las Ánimas, aflorante en el SE de Uruguay. Resultados preliminares permiten determinar que seis sitios portan una remanencia magnética característica de probable origen pre-tectónico. Las direcciones medias de cinco de estos sitios son consistentes con las de seis sitios previamente publicados y que conformaron el polo paleomagnético SA2. En base a 11 polos geomagnéticos virtuales se calculó el nuevo polo paleomagnético preliminar para el Complejo Sierra de Las Ánimas (SAn, 12.2°S, 258.9°E, A95: 14.9°). Este se encuentra ligeramente desplazado del primitivo SA2, siendo consistente con el polo paleomangético de Los Barrientos en el mismo cratón del Río de La Plata, y polos de ca. 550 Ma de Arabia y Congo. Se llevó asimismo un estudio de datación geocronológica mediante el método U/Pb (SHRIMP) en circones. Dos muestras obtenidas, en una microsienita y una riolita, aportaron edades cristalización bien definidas de de 573±2 y 585±4 Ma, respectivamente, confirmando la edad Ediacarana temprana para el complejo y permitiendo datar con precisión el nuevo polo paleomagnético y este tramo de la CDPA del cratón del Río de La Plata. Estas edades ponen en duda la extensión del magmatismo hasta el Cámbrico.

Introduction

The assembly of Gondwana in the late Proterozoic – Cambrian was apparently a very complex and diachronic process. New paleomagnetic data precisely constrained by up-to-date radiometric dating

is essential to unravel the kinematic evolution of the different cratonic nucleii and terranes that amalgamated to form Gondwana. The Sierra de las Animas magmatic complex, exposed in SE Uruguay, provided the first Ediacaran to Cambrian paleomagnetic results for the Río de La Plata Craton (Sánchez Bettucci and Rapalini, 2002) that permitted to propose an apparent polar wander path of that craton for such period. Two paleomagnetic poles (SA1 and SA2) were originally calculated from this complex with poorly constrained ages, from very old and unreliable datings, of ca. 520 and 550 Ma, respectively. This interpretation assumed either a very long magmatic event (over 30 Ma long) or a magmatic event with two pulses, one in the Ediacaran (SA2) and one in the Cambrian (SA1). Both poles were also of low quality due to low number of sites and large uncertainties in their positions. More recently Oyhantçabal et al. (2007) provided an Ar/Ar cooling age of 579±2 Ma for the Pan de Azúcar syenite (considered as part of the Sierra de Las Animas Complex), which permitted a better definition of the age of pole SA2.
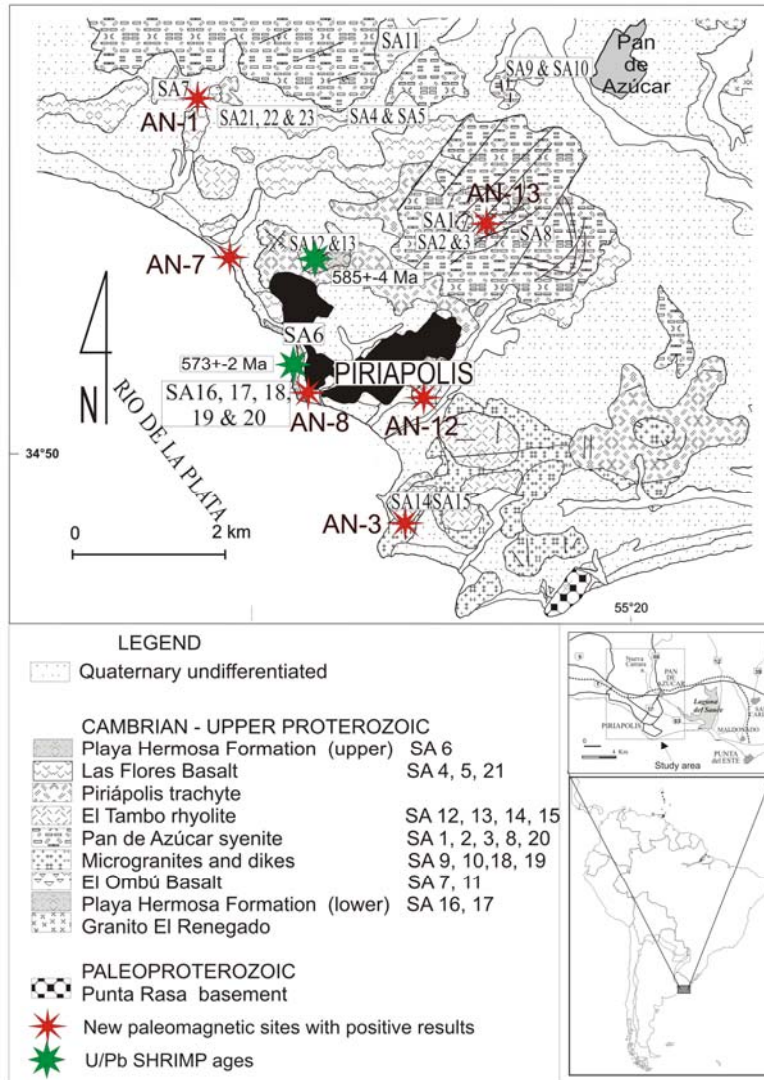

Fig.1

Fig.1: Simplified geologic map of the Sierra de Las Ánimas Complex, near Piriápolis, Uruguay, taken from Sánchez Bettucci and Rapalini (2002) and their original distribution of sites. New sites with positive paleomagnetic results are shown as red stars, and sites that provided precise crystallization ages as green stars

In order to provide better quality pole positions for the Ediacaran and Cambrian of the Rio de la Plata Craton a new paleomagnetic study was carried out on different lithologic units of the Sierra de Animas Complex. This study was complemented with a geochronologic study based on U/Pb (SHRIMP) datings on magmatic zircons from the complex. Preliminary results of this study are presented below.

Geology, Sampling, Laboratory Procedures and Results

The Sierra de Las Ánimas Complex constitutes an association of intrusive, volcanic and sedimentary rocks generated during an extensional stage within the evolution of the Neoproterozoic Brasiliano-Pan African orogeny (Sánchez Bettucci and Rapalini, 2002). The studied area is situated in southeastern Uruguay (Fig. 1), and presents a complex stratigraphic sequence. It is composed by an igneous association of bimodal character represented by intrusive bodies, subvolcanic, volcanic and pyroclastic rocks. The trachyte constitutes the more abundant and widespread distributed terms. The extrusive units are rhyolites, basalts and pyroclastic flows, while shallow intrusive bodies like the Pan de Azúcar syenite (Oyhantçabal et al., 2007) and microsyenitic dykes associated to it are also integrated into the complex.

The age of the complex has not been accurately determined. On the basis of old and poorly constrained radimetric data, Sánchez Bettucci and Rapalini (2002) proposed that the complex magmatic activity may have extended for at least 30 m.y. between ca. 550 and 520 Ma. Oyhantçabal et al. (2007) recently provided the first accurate determination of the age of at least part of the complex, the Pan de Azúcar syenite, for which an Ar/Ar cooling age in hornblende yielded an age of 579±2 Ma.

One hundred and fifteen oriented samples were collected with a portable drill at fifteen sites distributed in different magmatic lithologies as basalt, trachyte and micro-syenite. Samples for geochronologic studies were taken from sites of the previous sampling by Sánchez Bettucci and Rapalini (2002), specifically at sites SA8 (syenite), SA12 (rhyolite) and SA20 (micro-syenite). While the first and third contributed to the original SA2 pole (ca.550Ma), the second provided paleomagnetic directions used to compute pole SA1 (ca.520 Ma).

Paleomagnetic samples were submitted to standard stepwise demagnetization techniques. Alternating field demagnetization permitted the isolation of a within-site consistent characteristic magnetic component in six sites (shown in Fig.1). Definition of remanence directions was attained by vectorial principal component analysis and fisherian statistics. In just one site combination of isolated vectorial components and remagnetization circles (McFadden and McElhinny, 1988) was employed. Five of these sites (AN-1, 3, 7, 8 and 13) presented mean directions consistent with those corresponding to the six sites from which pole SA2 was originally calculated. Virtual geomagnetic poles were computed from the eleven mean site directions and a new paleomagnetic pole for the Sierra de Las Animas Complex was obtained from its mean: SAn, 12.2°S, 258.9°E, n: 11, A95: 14.9°.

U/Pb dating of separated zircons from samples from the already mentioned sites was carried out at the Geochronologic Laboratory of the Western Australia University, by the Sensitive High Resolution Ion Microprobe technique (SHRIMP). While sample corresponding to the Pan de Azúcar syenite provided an ill-defined age of ca. 583 Ma, high quality results were obtained from samples corresponding to site SA12 (El Tambo rhyolite): 585 ± 4 Ma and SA20 (microsyenite intruding upper levels of Playa Hermosa Formation): 573 ±2 Ma.

Discussion and Interpretation

Since site SA20 contributes to the newly defined SAn pole, the most likely age for it is set at 573 Ma. This is over 20 Ma older than previously proposed by Sánchez Bettucci and Rapalini (2002) and is consistent with cooling age of 579 Ma for the Pan de Azúcar syenite.

The 585 Ma age for the El Tambo rhyolite however conflicts with the interpretation of the previous paleomagnetic study since SA-12 contributes to the SA1 pole that was considered Cambrian (ca. 520 Ma). The newly obtained age strongly suggests that the Sierra de Las Ánimas magmatic complex was extruded in a much shorter time during the Early Ediacaran and that pole SA1 is a likely remagnetization of Cambrian age.

Figure 2 illustrates the position of the newly obtained preliminary paleomagnetic pole for the Sierra de Las Ánimas complex, to which a 573 Ma age is assigned, after rotation into a tight Gondwana reconstruction (Trindade et al., 2006). The new pole and its well defined age can become a key pole for the Río de La Plata craton and broadly confirms previous inferences in the shape of the APWP for this block. The position of SAn is slightly displaced from the original SA2, becoming more consistent with the Los Barrientos pole (LB) from the Río de La Plata craton, the Sinyai dolerite pole (Meert and Van der Voo, 1996) from Congo and Mirbat Sandstones pole (Kempf et al., 2000) from Arabia; while it moves away from the coetaneous pole from the Nola dykes (Moloto-A-Kenguemba et al., 2008). The implications of the new pole position and age respect to the time of final assembly between the Congo and Río de La Plata cratons may probably need further well dated paleomagnetic studies on both regions.
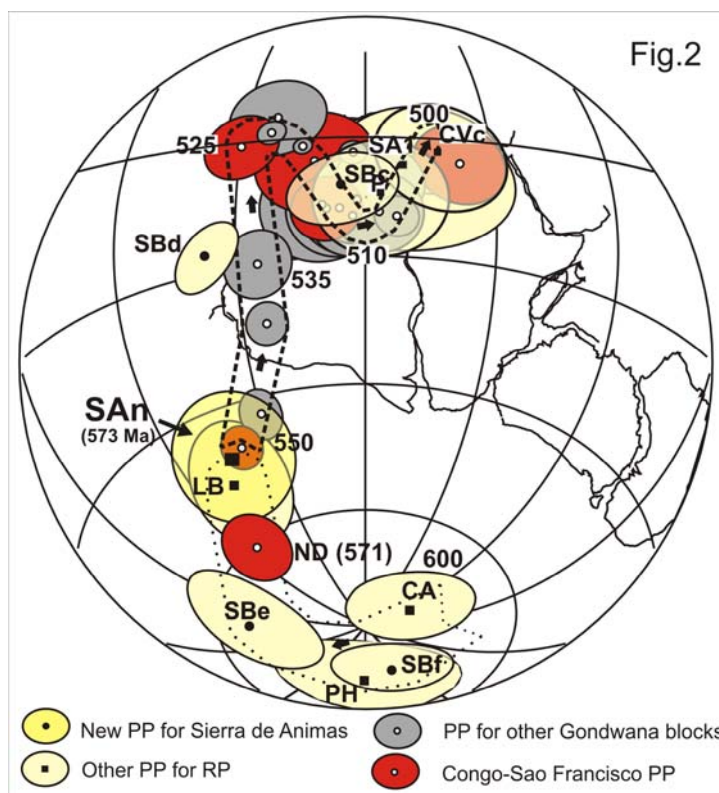

Fig.2: Distribution of main paleomagnetic poles for the Río de La Plata and other Gondwana cratons for the Ediacaran-Cambrian and the position of the newly calculated Sierra de Las Animas pole (SAn). Modified from Rapalini et al. (2011)

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