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PERMO-TRIASSIC COLLISION OF PATAGONIA? PALEOMAGNETIC EVIDENCE

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ABSTRACT

Two paleomagnetic poles from magmatic rocks of the Permo-Triassic La Esperanza Plutono-Volcanic Complex in northern Patagonia show significantly different positions. A paleomagnetic study on the Collinao Dacite, dated as 253 Ma, yielded a pole that is anomalous with respect to the Gondwana Late Paleozoic apparent polar wander path, falling within the Late Carboniferous (340-300 Ma) reference poles. On the other hand, a pole computed for acidic dykes of 244 Ma is consistent with Early Triassic (250-240 Ma) reference poles for Gondwana. A model proposing a *ca*. 30° counterclockwise (ccw) rotation of the North Patagonian Massif in such lapse as final stages of collision of Patagonia against the Gondwana margin, closing a small V-shaped oceanic (?) basin, may explain the paleomagnetic evidence and is consistent with different geological evidence.

Keywords: Paleomagnetism, Patagonia, Gondwana, Permian, Triassic

RESUMEN

Dos polos paleomagnéticos de rocas magmáticas del Complejo Plutono-Volcánico La Esperanza de la Patagonia septentrional muestran posiciones significativamente diferentes. El estudio paleomagnético de la Dacita Collinao, datada en 253 Ma, produjo un polo que es anómalo respecto a la curva de deriva polar aparente de Gondwana para el Paleozoico tardío, ubicándose junto a los polos de referencia del Carbonífero tardío (340-300 Ma). Por otra parte, un polo calculado para diques ácidos de 244 Ma es consistente con los de referencia de Gondwana para el Triásico temprano (250-240 Ma). La evidencia paleomagnética puede explicarse mediante un modelo que propone una rotación antihoraria de ca. 30° para el Macizo Norpatagónico, cerrando una pequeña cuenca oceánica (¿?) en forma de V en el lapso entre ambas unidades, como parte de las etapas finales de colisión de la Patagonia contra el margen de Gondwana. Este modelo es consistente a su vez con evidencia geológica diversa.

Palabras clave: Paleomagnetismo, Patagonia, Gondwana, Pérmico, Triásico

One reason for debate over the last three decades has been whether Patagonia has been an authochtonous Gondwanan block since its assembly in Cambrian times (Dalla Salda *et al*., 1990, Rapalini *et al*., 2013, Pankhurst *et al*., 2014), or an allochthonous terrane accreted to SW Gondwana through a frontal collision in Late Paleozoic times (Ramos, 1984, 2008, Ramos, Naipauer, 2014). Paleozoic paleomagnetic data from the North Patagonian Massif (NPM, Rapalini, 2005, Tomezzoli *et al*., 2012) is broadly consistent with the Devonian to Permian apparent polar wander path for Gondwana, supporting models of an authochtonous or para-authochtonous origin for Patagonia (Rapalini *et al*., 2010). However, these data are scarce and magnetization ages not accurately determined, which make comparison with the reference Gondwana poles ambiguous and having low paleogeographic resolution.

In order to reduce these uncertainties, a systematic paleomagnetic and geochronologic study on Permian to Triassic magmatic rocks exposed in the NPM is under way. First results shed unexpected new light on the paleotectonic evolution of Patagonia and its relation to the SW Gondwana margin.

Thirty-five paleomagnetic sites were sampled in different units of the La Esperanza Plutono-Volcanic Complex (LEPVC, Martínez Dopico *et al*., 2017), exposed in the province of Río Negro, central NPM. Four sites were located in a Rhyolite Dome dated as 264±2 Ma (U-Pb, Pankhurst *et al*., 2006). Nine sites corresponded to the Collinao Dacite or correlative units, which we dated as 253±2 Ma (U-Pb, Luppo *et al*., 2017). Seven sites were drilled in subvertical basic dykes, the age of which is bracketed between 255 and 244 Ma from cross-cutting relations with other well-dated magmatic units in the area. Finally, fifteen acidic dykes intruding the previously mentioned units were sampled (one site per dyke) and dated by U-Pb on zircons as 244±2 Ma (Luppo *et al*., 2017), which is consistent with a previous dating of 246±2 Ma (Pankhurst *et al*., 2006) on these rocks. The rhyolitic and dacitic units are observed as sub-horizontal in the field and the dykes (both acidic and basic) are subvertical, suggesting negligible tilting since these rocks were erupted or intruded.

Paleomagnetic studies were done following standard demagnetization techniques in the Daniel Valencio Paleomagnetic Laboratory of Buenos Aires (IGEBA), using a cryogenic 2G 755R magnetometer, a dual-chamber TD48 ASC thermal demagnetizer and a static three-axes degausser. Rock magnetic properties were explored via isothermal remanent magnetization (IRM) acquisition and back-field curves (ASC pulse magnetizer) and K-T low and high temperature thermomagnetic curves (Agico MFK1-A susceptometer).

Both AF and thermal demagnetization were efficient to isolate the characteristic remanence (ChRM) at one site from the Rhyolite Dome, seven sites at the Collinao Dacite and four basic dykes. While twelve out of fifteen acidic dykes provided consistent paleomagnetic directions only after AF demagnetization. High unblocking temperatures (≤ 580° C) indicating magnetite as the main magnetic carrier and a positive inverse contact-test in a site of the Collinao Dacite suggest that the ChRM is likely a primary magnetization in the study units.

Virtual geomagnetic poles (VGPs) were computed from the mean ChRM at each site (Fig.1). Systematic different locations are observed in VGPs from the Rhyolite Dome (264 Ma) and the Collinao Dacite (253 Ma) with respect to those of the acidic dykes (244 Ma), meanwhile two VGPs from the basic dykes fall with the first group and two with the second.

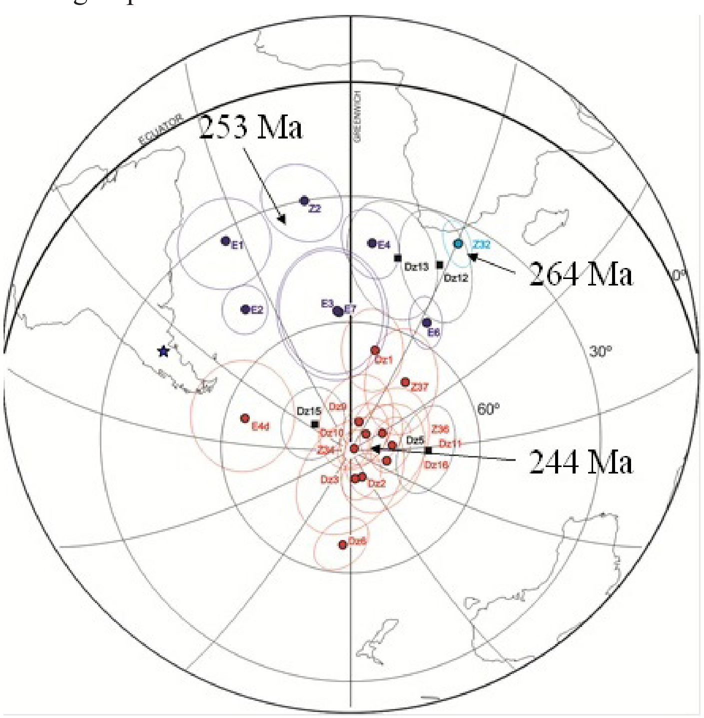

Figure 1. Virtual geomagnetic poles from different magmatic units, in the La Esperanza Pluton-Volcanic Complex, northern Patagonia. Light blue: Rhyolite Domo (264 Ma), dark blue: Collinao Dacite (253 Ma), black: basic dykes (255-244 Ma), red: acidic dykes (244 Ma). Each VGP is represented with its corresponding 95% confidence ellipse. Star: study locality.

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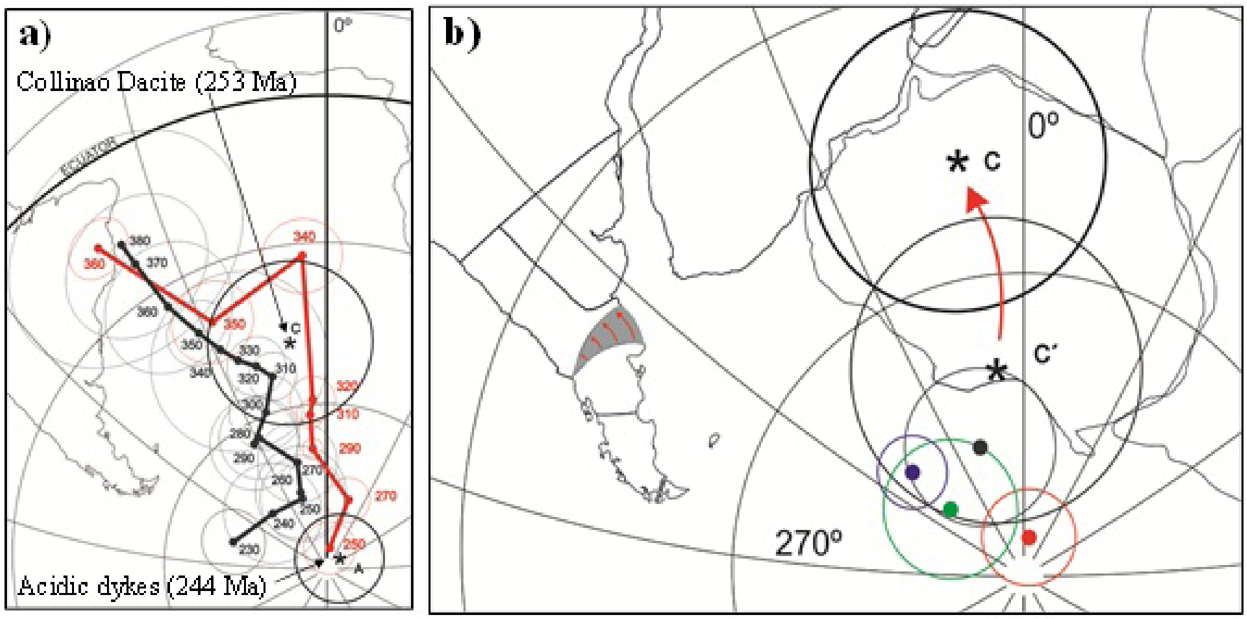

Figure 2. a) Carboniferous – Triassic reference apparent polar wander paths for Gondwana in South American coordinates according to Torsvik *et al* (2012) in black and Geuna and Escosteguy (2014) in red. Numbers indicate the age in Ma for each reference pole. Paleomagnetic poles from the acidic dykes and the Collinao Dacite are indicated as A and C, respectively and represented with their corresponding 95% confidence ellipses. **b)** Tectonic sketch of a V-shaped basin closed by counterclockwise rotation of Patagonia during collision with Gondwana in the Early Triassic and corresponding displacement of the C pole from a position consistent with 250 Ma reference poles for Gondwana (C´) to that observed (C). 250 Ma reference poles are from Torsvik *et al* (2012) in black and Geuna and Escosteguy (2015) in red, alternative reference poles as the Middle Permian-Early Triassic mean pole for Gondwana by Gallo *et al* (2017) in blue and the Late Permian-Early Triassic mean pole for South America (Brandt *et al*., 2009) are presented too.

Corresponding paleomagnetic poles were computed for the Collinao Dacite (C, 48.3° S, 349.9° W, N = 7, A95 = 15.1°, Fig.2a) and the acidic dykes (A, 87° S, 51.5° E**,** N = 12, A95 = 8.1°; Fig. 2a). Figure 2a illustrates the positions of the C and A poles with respect to Late Paleozoic reference apparent polar wander paths for Gondwana in South American coordinates (Torsvik *et al*., 2012, that while the A pole (244 Ma acidic dykes) is consistent with the expected position, the C pole Geuna and Escosteguy, 2015). Despite some differences between both reference curves, it is evident (253 Ma Collinao Dacite) is significantly anomalous, falling on Late Carboniferous section of the curves (340-300 Ma).

Wide distribution of sites from both units and structural considerations strongly argue for a major ccw rotation (*ca*. 30°) of the NPM (or the whole Patagonia) in short lapse of *ca*. 10 Ma across the Permian-Triassic boundary as viable hypothesis to explain these paleomagnetic results. A simplified sketch of a possible tectonic scenario in the late Permian is presented in Figure 2b. In this model a V-shaped small oceanic (or quasi-oceanic?) basin closed between northeastern Patagonia and SW Gondwana in the earliest Triassic, probably as the last stages of a collision between both blocks.

The strong deformation in Late Permian to Early Triassic granitoids of the Yaminué Complex in northern Patagonia (López de Luchi *et al*., 2010, Chernicoff *et al*., 2013, Pankhurst *et al*., 2014, Martinez Dopico *et al*., 2016), the Early Triassic maximum northward advancement of the orogenic front in the Hesperides Basin (Pángaro *et al*., 2015), and the Early Triassic major transpressional deformation in the Cape Fold Belt (Tankard *et al*., 2009), are all consistent with this simple model. Compression due to closure of the basin in central and eastern areas was coeval with extension on the western areas like the San Rafael Block (Kleiman, Japas, 2009). This model is also consistent with the loosely defined age of the previous Late Proterozoic paleomagnetic poles of Patagonia.

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