



NEW PALEOMAGNETIC POLE FOR THE NORTHERN PARANA IGNEOUS PROVINCE

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ABSTRACT

The Parana Igneous Province (PIP) preceded the opening of the South Atlantic Ocean during Early Cretaceous times. Presently, it occupies a large extend in southern Brazil, and neighbour countries, and, in a lesser extent, in Namibia (Africa). In this paper we present new paleomagnetic data from 54 sampling sites from the northern area of the PIP. A paleomagnetic pole based only on data from extrusive rocks differs slightly from the pole calculated for the sills intruding the paleozoic sedimentary sequence on the eastern border of the area. The new pole has confidence circle that intercepts the one for the southern PIP which is compatible with the ages differences reported so far for the two areas. However, the paleomagnetic pole for the sills in the northern area seems to represent a younger phase of the magmatic activity, similar to the dyke swarms bordering the Parana basin.

Keywords: Parana Igneous Province, Early Cretaceous, paleomagnetic poles.

RESUMO

A Província Ignea do Paraná (PIP) precedeu a abertura do Atlântico Sul durante o período Cretáceo Inferior. Atualmente ocupa uma grande área do sul do Brasil e dos países vizinhos e, em menor proporção, também da Namíbia (África). Neste trabalho apresentamos novos dados paleomagnéticos de 54 sítios de amostragem da parte norte da PIP. Um polo paleomagnético, baseado somente em dados de rochas extrusivas, difere daquele calculado com base nas soleiras de diabásio que intrudem os sedimentos Paleozóicos da borda leste da região. O novo polo tem círculo de confiança que intercepta aquele calculado para a região sul da PIP e é compatível com as pequenas diferenças de idade até agora publicadas para as duas áreas. Entretanto, o polo paleomagnético das soleiras parece representar uma fase mais jovem do magmatismo, similar àquela dos enxames de diques que bordejam a Bacia do Paraná.

Palavras chave: Província Ignea do Paraná, Cretáceo Inferior, polos paleomagnéticos.

The Parana Igneous Province (PIP) preceded the opening of the South Atlantic Ocean during Early Cretaceous times. Presently, it occupies a large extend in southern Brazil, and neighbor countries, and, in a lesser extent, in Namibia (Africa). The volcanic rocks are mainly represented by basaltic flows and subordinated acid rocks, with few intermediate rocks (*e.g.* Marques and Ernesto, 2004). In literature, two regions are normally recognized based on the chemical composition. The south region (south of the Rio Uruguay) is dominated by basalts with relatively low contents of titanium ($\text{TiO}_2 \leq 2$ wt %) and incompatible elements, which are associated with Palmas volcanic rocks also depleted in these elements. The north region (north of the Rio Piquiri lineament), is characterized by basalts with relatively high concentrations of titanium ($\text{TiO}_2 > 2$ wt %), and incompatible elements; along with Chapecó acid rocks, which are also relatively enriched in incompatible elements. The north area also exhibits a large amount of intrusive rocks (mostly high-titanium basic rocks), as the Ponta Grossa and Serra do Mar dyke swarms, and the sills outcropping mainly in the eastern edge of the PIP. Between these two areas, a central area exhibits both high- and low- TiO_2 rocks, and



the two acid rock types (*e.g.* Marques and Ernesto, 2004). The major, minor and trace element behavior of each group of basic to intermediate rocks is compatible with fractional crystallization processes, associated with different degrees of crustal assimilation, whereas the acid rock genesis was probably related to melting of low- and high-titanium basaltic material, trapped in the base of the crust (underplating), giving rise to Palmas and Chapecó types, respectively.

The PIP has long been subject to $^{40}\text{Ar}/^{39}\text{Ar}$ geochronologic dating and paleomagnetic approaches which led to place its rapid formation at the Hauterivian stage (~ 133 Ma) with onward progression to Barremian (Renne *et al.*, 1992; Ernesto *et al.*, 1999). Recently, some of the available results were recalculated (Thiede, Vasconcelos, 2010) to the new ^{40}K decay constant. This new calibration provided a systematic increasing of the absolute ages to values older than about 2 m.y., the inception age of the volcanism now estimated within the Valanginian at 135 ± 1 Ma. A precise U-Pb baddeleyite/zircon dating on a Chapecó-type dacite (Janasi *et al.*, 2011) indicated an age ~ 134 Ma consistent to northward migration of the volcanism within a very brief time span.

In spite of the several polarity intervals recorded by the lava piles (Ernesto *et al.*, 1990) in the southern (latitudes $< \sim 27^\circ\text{S}$) and central (latitudes of ~ 24 - 27°S) Paraná Province the paleomagnetic data show small dispersion in agreement with the short time intervals indicated by the $^{40}\text{Ar}/^{39}\text{Ar}$ ages. The paleomagnetic database for the Paraná Magmatic Province (PMP) has been enlarged in recent years (Alva-Valdivia, 2003; Mena *et al.*, 2006; Solano *et al.*, 2010; Goguitchaichvili *et al.*, 2013), however, the northern area which corresponds to the major area of the PMP, is still poorly known in terms of chemical composition, paleomagnetism and geochronology. Exception is made for the intrusive rocks on the eastern border (Ernesto *et al.*, 1999). One limiting factor is the sedimentary cover by the Late Cretaceous Bauru Group, and the flatter relief preventing good exposures as those found in the other areas.

This paper presents new paleomagnetic results from the northern PIP, mainly from the western side of the Rio Paraná. The new data allowed the calculation of a paleomagnetic pole for the lavas based on 54 sites independent from the paleomagnetic pole from the intrusive rocks. The Figure 1 shows the location of the already studied sites in the northern PIP. Normal and reversed polarity were found all over the area, however, there is a clear concentration of reversed polarities on the extreme NE region, already stressed by Ernesto *et al.* (1999) and reinforced here, indicating time differences in the emplacement of the magma in the area. A comparison of the paleomagnetic poles for the three regions shows that the circles of confidence for the southern and northern areas intercept, reinforcing the proposition of a brief time interval for the onset of all the PIP. The paleomagnetic pole for the sills suggests a slightly younger age, in accordance to the data from the dyke swarms bordering the PIP (Ernesto *et al.*, 1999).

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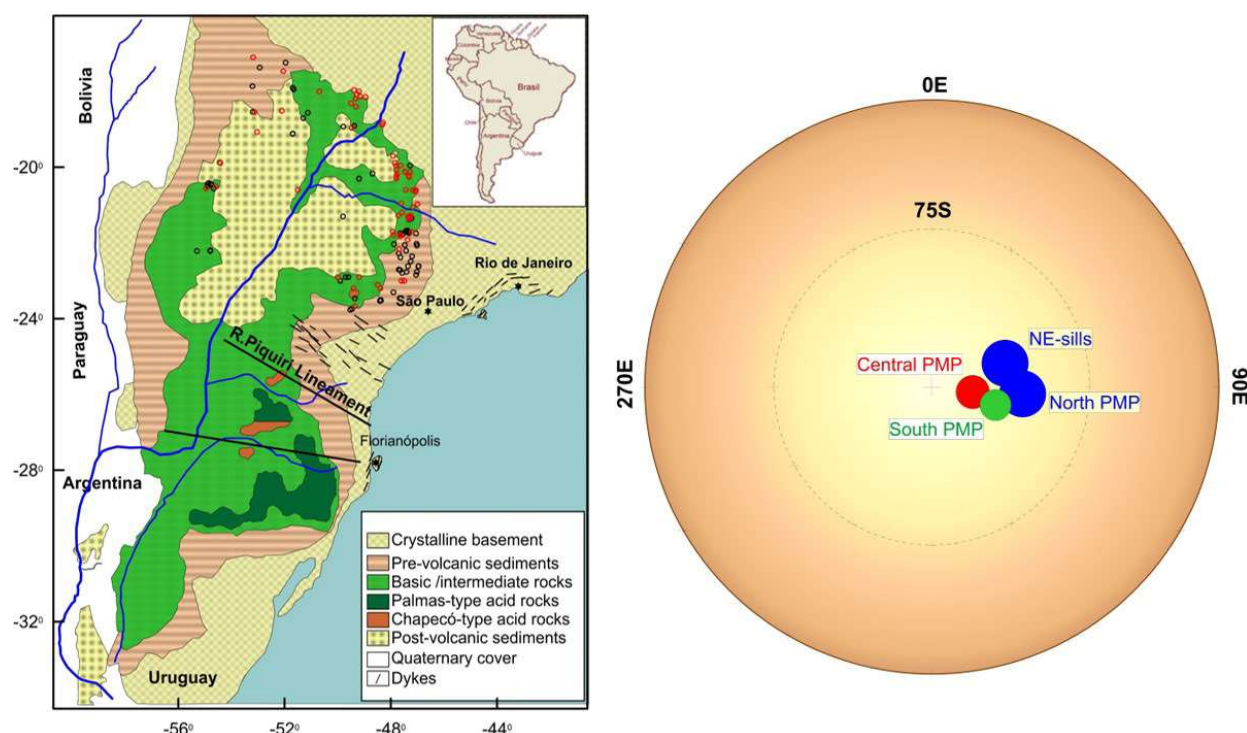


Figure 1. Simplified map of the Paraná basin (left) showing the sampling sites discriminated according to their magnetization: normal (black) and reversed (red) polarity. Paleomagnetic poles from the south, central, and north regions of the Paraná Magmatic Province (PMP). Poles for flows and sills from the north area were computed independently.

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