MAGNETIC FABRICS OF LATE TO POST-TECTONIC PALEOPROTEROZOIC INTRUSIVE BODIES OF THE PIEDRA ALTA TERRANE, RÍO DE LA PLATA CRATON, URUGUAY

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ABSTRACT

Nine Paleoproterozoic intrusive bodies of the Piedra Alta terrane, in western Uruguay, with ages between 2.2 and 2.0 Ga, were sampled in order to obtain information on emplacement kinematics and regional stress regime during intrusion by means of studies of anisotropy of magnetic susceptibility (AMS). Petrographic thin sections were analyzed in order to obtain information about the degree of deformation and its potential influence in the AMS results. Most plutons show *K1* subvertical axes and E-W subvertical foliations planes suggesting an extensional N-S regional stress field controlling the magma ascent. This is consistent with the E-W structural grain of the Piedra Alta terrane and the geographic distribution of the plutons in the San José metamorphic belt.

Keywords: Piedra Alta terrane, Paleoproterozoic, anisotropy of magnetic susceptibility (AMS)

Geological setting: The Piedra Alta terrane

The San José belt is an E-W metamorphic belt, exposed along the central to southern areas of the Piedra Alta terrane of the Río de la Plata craton (Sanchez Bettucci *et al*., 2010) is represented by the San José and Paso Severino formations (Fig. 1). The San José Formation consists of metavolcanic rocks and a metasedimentary succession. The Paso Severino formation consists of rhyolites, basalts, metapelites, carbonates and banded iron levels. The San José belt is affected by the Cufré Shear Zone (CSZ), of possible Paleoproterozoic age, it shows an approximate E-W orientation and sinistral behavior. It also presents a series of post-orogenic intrusive granites and gabbros of around 2.10-2.05 Ga (Hartmann *et al*., 2008; Peel and Preciozzi, 2006), many of which were the focus of our study.

Geochemical and isotopical studies by Preciozzi (1993) and Oyhantçabal *et al*. (1998, 2011) determined that most of these plutons are calc-alkaline with medium to high K content. However, the A-type rapakivi Soca Granite presents a metaluminous or slightly peraluminous composition and a shoshonitic character (A2- type or postcollisional, Eby 1992).

The intrusion of the studied plutons is interpreted as the final stages of post-collisional crustal stabilization of the newly formed Río de la Plata craton.

1. Sampling and methodogy

Nine intrusions, located in the San José belt in the Piedra Alta terrane, were sampled. Twenty-two sites (C1

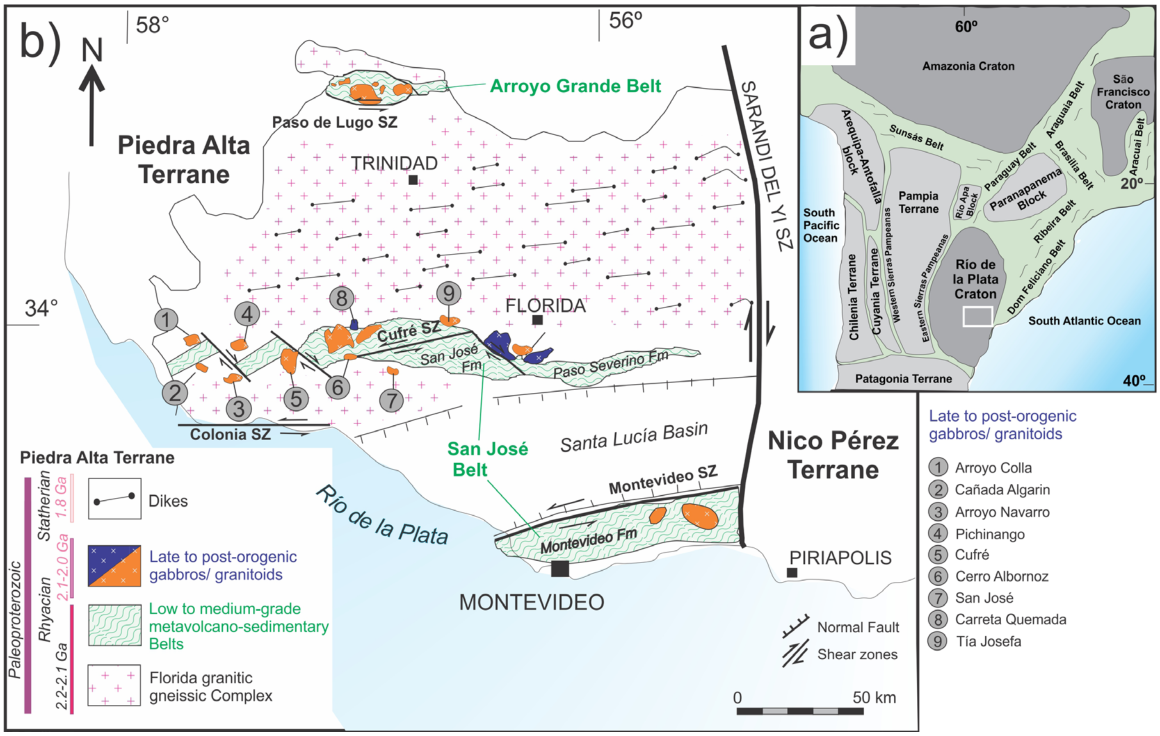

Fig.1. a) Location of Río de la Plata craton and its relationship with other South American Proterozoic terranes and cratons; b) Intrusives studied in this resume. Modified from Sánchez Bettucci *et al.* (2010); Rapalini *et al.* (2015) and Franceschinis et al. (2016). SZ: Shear Zone.

to C22) were collected for a magnetofabric studied, with 204 independently oriented cores (295 specimens). We generally sampled 9 cores at each site, covering several square meters of areal extension in order to obtain representative results at a local level. The distance between sites within the same body was in the order of hundreds of meters to a few kilometers.

2. AMS study

Almost all bodies show bulk susceptibilities that fall well into the “paramagnetic” range with the exception of the Pichinango Granite and the Carreta Quemada Gabbro that have values corresponding to the “ferromagnetic domain” (Tarling, Hrouda 1993). The values of the three principal axes of anisotropy are shown in Table 1. Most *K1* axes are grouped around the subvertical direction while *K2* and *K3* axes are distributed along the subhorizontal plane defining a subvertical foliation plane with dominant E-W direction.

3. Petrographic observations

With the only exceptions of the Cufré, Cerro Albornoz, Tía Josefa and Arroyo Navarro intrusives, that show evidence of some low temperature deformation, the remaining intrusive bodies show no signs of significant internal deformation (Carreta Quemada Gabbro and Pichinango and Arroyo Colla Granites) or only show evidence of some high temperature, syn to submagmatic deformation (San José and Cañada Algarín intrusives).

4. Rock magnetism

Thermomagnetic curves (k *vs.* T) were performed for sites C2, C3, C6, C9, C10, C14, C15, C18, C19, C20 and C22. Low temperature curves show a typical paramagnetic decay consistent with bulk susceptibility

Intrusive	**Site**	**Kmean (SI)**	**Pj**	**T**	**K1**	**K2**	**K3**
Cufré	**C1**	1.19E-04	1.032	0.003	126.4/71.0 (*9.0/3.7*)	232.6/5.5 (*8.6/4.8*)	324.4/18.1 (*5.9/4.5*)
	C2	1.96E-04	1.044	-0.038	190.8/83.5 (*12.7/7.4*)	74.7/2.9 (*14.0/10.8*)	344.4/5.8 (*13.1/5.9*)
	C3	1.63E-04	1.041	-0.05	52.0/18.1 (*6.3/3.1*)	291.4/57.3 (*10.3/5.2*)	151.3/26.3 (*10.1/3.9*)
	C4	1.78E-04	1.032	-0.233	113.7/75.1(*16.1/10.2*)	285.2/14.8 (*29.3/11.4*)	15.7/2.1 (*29.2/14.3*)
	C5	3.66E-05	1.035	-0.492	11.4/82.7 (*8.6/5.1*)	234.4/5.4 (*43.8/7.3*)	143.9/4.9 (*43.8/4.9*)
Cerro Albornoz	**C6**	4.14E-05	1.029	-0.131	223.0/80.2 (*18.5/14.1*)	44.4/9.8 (*25.7/11.1*)	314.4/0.2 (*23.9/15.8*)
	C7	3.28E-05	1.067	0.315	335.2/76.7 (*13.3/4.2*)	133.4/12.4 (*14.9/6.0*)	224.5/4.8 (*9.5/3.3*)
Carreta Quemada	**C8**	6.08E-03	1.123	0.667	107.5/58.6 (*38.3/7.2*)	13.3/2.5 (*38.3/16.8*)	281.8/31.3 (*17.1/7.0*)
	C9	6.46E-04	1.036	0.063	158.8/62.4 (*33.1/10.8*)	61.5/3.8 (*35.1/27.1*)	329.6/27.3 (*30.4/12.6*)
San José	**C10**	1.78E-05	1.022	0.547	86.4/20.3 (*40.4/9.1*)	230.6/65.5 (*40.5/13.5*)	351.5/13.1 (*14.0/9.1*)
	C11	1.88E-05	1.022	-0.075	85.1/13.7 (*19.6/14.0*)	212.0/68.0 (*24.6/18.7*)	350.8/17.0 (*25.5/10.1*)
	C12	1.23E-05	1.031	-0.526	73.0/0.7 (*9.8/7.2*)	163.4/34.6 (*46.7/8.6*)	341.9/55.4 (*46.7/8.4*)
Tía Josefa	**C13**	5.36E-04	1.029	-0.44	23.0/53.0 (*23.9/8.3*)	182.8/35.3 (*31.0/21.0*)	279.8/9.8 (*30.8/13.4*)
	C14	4.49E-04	1.028	0.034	16.8/65.0 (*9.7/7.0*)	177.6/23.8 (*14.5/9.0*)	270.9/7.3 (*14.3/7.5*)
Arroyo Navarro	**C15**	6.08E-05	1.045	0.156	110.7/52.3 (*4.8/3.2*)	339.3/27.1 (*7.9/4.5*)	236.1/24.2 (*7.8/3.0*)
	C16	6.24E-05	1.058	0.674	139.7/53.9 (*29.2/8.5*)	335.2/35.1 (*29.4/10.9*)	240.0/7.4 (*13.2/6.9*)
Pichinango	**C17**	4.80E-03	1.251	0.227	310.3/70.8 (*5.4/3.3*)	180.2/12.7 (*7.1/4.5*)	86.9/14.2 (*7.6/3.4*)
	C18	3.79E-03	1.104	0.075	184.3/56.9 (*12.3/3.8*)	1.7/33.0 (*13.0/9.0*)	92.4/1.2 (*10.0/4.0*)
Arroyo Colla	**C19**	8.54E-05	1.146	0.629	235.2/13.1 (*9.7/6.1*)	141.4/15.9 (*11.3/7.7*)	2.8/69.1 (*10.1/6.2*)
	C20	1.47E-04	1.017	-0.328	252.7/44.3 (*34.8/11.4*)	8.7/24.2 (*34.3/26.4*)	117.7/35.9 (*26.8/14.3*)
	C21	7.71E-05	1.100	0.686	33.1/44.8 (*9.9/4.4*)	285.3/17.1 (*12.4/8.5*)	180.2/40.2 (*11.4/4.3*)
Cañada Algarín	**C22**	1.94E-05	1.044	0.342	191.6/0.4 (*46.9/9.6*)	101.5/17.9 (*46.9/15.1*)	282.7/72.1 (*16.3/9.2*)

Table 1. AMS parameters: *K1*, *K2* and *K3* correspond to the maximum, intermediate and minimum axes of the ellipsoid, respectively. Their directions (declination/inclination) are presented with the respective 95% confidence ovals (maximum and minimum semiaxes are quoted in italics between brackets). Kmean stands for the mean site bulk susceptibility in SI units. Pj is the corrected anisotropy factor (Jelinek, 1978). T is Jelinek's (1981) shape parameter.

values in the paramagnetic domain (Tarling and Hrouda, 1993). The Pichinango Granite shows bulk susceptibility values in the ferromagnetic domain and a well-developed Verwey transition at -155° C. High-temperature curves are irreversible. Only the Pichinango Granite shows a Hopkinson peak between 540° and 560° C suggesting the existence of SD magnetite. In the remaining sites, Curie temperatures between 550° C and 580° C are observed, indicative of (Ti poor) magnetite.

To analyze the influence of the ferromagnetic fraction in the overall AMS pattern, anisotropy of anhysteretic remanent magnetization (AARM) measurements were made on five samples from site C3 in the Cufré Granite and another five from site C18 in the Pichinango Granite. Comparison of AMS and AARM main axes directions indicates similar magnetic fabrics ruling out, inverse AMS fabrics.

5. Conclusions

The magnetic fabric of nine late to post-tectonic Paleoproterozoic intrusive bodies that affect the San José Belt of the Piedra Alta terrane permitted to determine that most of these bodies present subvertical disposition of the *K1* axes and a subvertical E-W foliation plane. This is interpreted as mainly determined by final magma displacement and emplacement kinematics in most bodies. The low to null deformation observed in petrographic thin sections allows to suggest a roughly N-S extensional regional field controlling the magma ascent, consistent with the main structural grain of the Piedra Alta terrane and the geographic distribution of the plutons in the volcano-sedimentary metamorphic belts. This is consistent with the model that suggest that these plutons were intruded during post-collisional relaxation following the accretion of the Río de la Plata craton.

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