

PALEOMAGNETIC STUDY OF THE LATE MIOCENE LAS ARCAS FORMATION, PAMPEAN RANGES, NORTHWESTERN ARGENTINA.

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ABSTRACT

A paleomagnetic study was carried out in the Late Miocene Las Arcas Formation of northwestern Pampean Ranges (26° 45.757' S, 66° 2.189' W) in order to contribute with paleomagnetic information to the knowledge of the deformation of the area. The sampled formation is composed of fluvial red sandstones and pelites that were recently dated, near the top, in 6.88 My (Georgieff *et al.* 2013). It was sampled a stratigraphic section of 340 m thick from bottom to top of the unit. Of 17 sites analyzed, 14 carried a primary magnetization that was used to calculate a paleomagnetic pole (D = 176.2°, I = 34.0°, A₉₅ = 6.9°) that indicates a rotation of 0.3° \pm 5.8°. This result suggests that the area did not undergo rotation since Late Miocene.

Keywords: Cenozoic, Santa María valley, block rotation

Introduction

The Pampean Ranges consists of uplifted basement ranges bounded by high-angle thrusts and alternating Cenozoic basins (Ramos, 1999). One of these basins is the Santa María Valley, an elongated SSE-NNW tectonic depression, more than 100 Km long and about 30-20 Km wide, located in the provinces of Catamarca, Tucumán and Salta (Bossi *et al*, 2001) (fig. 1A). The sedimentary succession of this valley lies on a peneplain surface of crystalline basement rocks; it begins whit Paleogen continental sedimentites overlain in discordance by the Mio-Pliocene Santa María Group (Ruiz Huidobro, 1960; Galván, Ruiz Huidobro, 1965). A paleomagnetic study was carried out in the Jujuil Creek (26° 45.757' S, 66° 2.189' W) over the fluvial red sandstones and pelites of the Santa María Group, known as Las Arcas Formation. The top of this unit was recently dated in 6.88 Ma (Georgieff *et al.* 2013).

The rotations observed in the Central Andes were explained by two different models, one involves Late Cenozoic oroclinal bending (Bolivian Orocline) and the other explains deformation by small-block rotations (Somoza *et al.* 1996). The study succession is located in the Transition Segment (26°- 30° S) (Ramos, 1999), a zone of contact between the Puna and the Pampean Ranges that is of interest for the understanding of the kinematics of the Andean Ranges. In this transition zone the angle of the subducted slab of the Nazca plate shallows, the continental lithosphere slims and the amount of horizontal shortening decreases. There are also important lineaments perpendicular to the range, like the Tucumán Transfer Zone, a right-lateral transpressional zone that form the southern bound of the Puna (de Urreiztieta *et al.* 1996). This work intends to contribute whit paleomagnetic information to the knowledge of the history of deformation of the area.

Methodology

The sampled interval encompasses Las Arcas Formation; 31 sites were determinate along a 340 m thick stratigraphic section. The sampled rocks vary between very fine sandstones to siltstones. Three to four hand samples were collected at most of the sites. In sites 27 and 30 the cores were obtained with a portable electric



powered drill. All the samples were orientated whit a magnetic and a solar compass (whenever possible). The bedding plane was measured at each site (fig. 1b)



Figure 1. A. Map and satellite image of the Santa María Valley whit indication of the sampling location (red point), Jujuil Creek; B- Image of the Jujuil Creek whit the paleomagnetic sites (red points).

The processing of the specimens was carried out at the Paleomagnetic Laboratory (INGEODAV) of the Department of Geological Sciences of the Universidad de Buenos Aires, Argentina. Intensity and direction of the natural remanent magnetization were measured with a spinner magnetometer (AGICO JR6). Thermal demagnetization was carried out with a single chamber oven with internal magnetic fields below 10 nT (ASC Scientific TD-485C). Alternating fields (AF) demagnetization was achieved with a rotative demagnetizer (AGICO LDA-3A).

Specimens from 17 sites were processed. One specimen per site was demagnetizated by AF in 16 steps (3, 6, 9, 12, 15, 20, 25, 30, 35, 40, 50, 60, 70, 85 and 100 mT). Most part of the specimens were demagnetizaded by high temperatures in 18 steps (100, 200, 250, 300, 350, 400, 450, 480, 500, 520, 540, 560, 580, 600, 620, 640, 660 and 680°C). Magnetic components were obtained by principal component analysis (Kirschvink, 1980), with a maximum angular deviation (MAD) under 15°, only two remanence directions have greater MAD (15.6° and 17.6°). The Remasoft 3.0 software was used to analyze data (Chadima, Hrouda, 2006).



To better constrain the magnetic mineralogy, acquisition of isothermal remanent magnetization (IRM) tests were performed in 15 specimens. This was achieved with a pulse magnetizer (ASC Scientific IM-10-30) by applying increasing direct magnetic fields in 14 steps (17, 29, 44, 61, 90, 150, 250, 350, 450, 600, 1000, 1310, 1640 and 2300 mT), and back field in 2 steps (29 and 61 mT).

Results and Analysis

IRM curves indicate that magnetite is the principal magnetic mineral, with a small presence of hematite. The saturation curve of all the specimens shows a steep slope in the beginning of the acquisition curve (magnetite), but still continues to rise at 2000 mT because of the presence of hematite. The low remanence coercivity $(31 \le B_{rr} \le 45 \text{mT})$ is another indicator of this magnetic mineral composition (fig. 2).



Demagnetization curves present unblocking temperatures in the range of 500-580°C and 660- 680°C. Three components were obtained: a low-temperature (A), an intermediate one (B) and a high-temperature (C). The A component have similar direction that the recent normal field, it was interpreted as a viscous overprint. The B and C components have the same orientation. Although strata at most sites show very similar attitude, after the application of the bedding correction over B and C components the statistical parameters slightly improve, kappa increase from 27.91 to 33.76 and A₉₅ diminishes from 7.7° to 6.9° (Table 1). These results suggest that these components represent a primary magnetization (fig. 3).



Figure 3. A- Tilt corrected site remanence directions for Las Arcas Formation; B-After inverting all negative directions to the lower hemisphere. Equal-area projection, open (close) symbols mean negative (positive) inclinations.



A virtual geomagnetic pole (VPG) was calculated from B and C components. Mean direction after bedding correction is D 176.2°, I 34.0° with $A_{95} = 6.9^{\circ}$. This direction was compared with the expected direction for the sampled locality to calculate the vertical axis rotation. Using the 10 Ma reference paleomagnetic pole for South America (Besse, Courtillot, 2002) the found rotation is of $0.3^{\circ} \pm 5.8^{\circ}$. These results expose that this sector of the basin have not experiment significant rotation since Late Miocene. The comparison also denoted a flattening of $-10.1^{\circ} \pm 5.5^{\circ}$, which may be due to compaction of the beds or the sedimentary nature of the unit.

Site	n	Dec (°)	Inc (°)	α_{95}	<i>Dec</i> *(°)	Inc*(°)	$\alpha_{_{95}}$
1	2	193.9	30.1	47.7	177.8	32,8	47.5
3	1	197.3	22.8	0.0	185.0	28.0	0.0
4	2	354.2	-37.2	28.9	336.9	-30.5	29.0
8	1	345.2	-45.1	0.0	326.1	-29.2	0.0
11	2	214.6	37.5	135.6	189.9	42.3	135.8
19	2	19.4	-36.1	21.4	357.9	-37.5	21.3
22	3	18.9	-25.8	7.7	359.9	-29.9	7.7
23	1	31.4	-11.4	0.0	19.1	-32.3	0.0
25	3	18.7	-40.1	34.1	347.6	-42.7	34.1
27	3	19.3	-18.1	30.4	1.7	-27.4	30.4
28	3	2.2	-40.8	10.6	330.9	-32.0	10.6
29	2	28.4	-15.4	24.1	11.1	-31.4	24.3
30	3	18.1	-26.3	22.3	354.0	-32.5	22.4
Mean <i>in situ</i>		Dec: 197.2° Inc: $30.7^{\circ} A_{95} = 7.7^{\circ} K = 27.91$					
Mean after structural bedding correction		Dec: 176.2° Inc: $34.0^{\circ}A_{gs} = 6.9^{\circ}$ K = 33.76					

 Table 1. Mean site paleomagnetic data for Las Arcas Formation. Dec Inc: declination and inclination in situ.

 Dec* Inc*: declination and inclination after bedding correction.

Conclusions

The mean remanence direction obtained for Las Arcas Formation in the Jujuil Creek evidence that this area have not experiment significant rotation since Late Miocene, in concordance with previous works in the region (Taylor *et al.* 1998; Aubry *et al.* 1996; de Urreiztieta *et al.* 1996). This result reinforces the hypothesis that the transversals displacements along the large lineaments (for example the Tucumán Transfer Zone) had take place before latest episodes of Andean deformation (Mon, 1979).

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