ANISOTROPY OF MAGNETIC SUSCEPTIBILITY ANALYSIS IN CORES OF TUNAS FORMATION (PERMIAN), CLAROMECÓ BASIN, BUENOS AIRES, ARGENTINA: IT RELATION WITH DEPOSITIONAL CONDITIONS

M. B. Febbo[1,2,3*], R. N. Tomezzoli[4,5], N. Cesaretti[2,3], J. M. Calvagno[4,5], G. Arzadún[4,6], L. Gallo[4,5],

[1] Comisión de Investigaciones Científicas de la Provincia de Buenos Aires (CIC), Argentina.
[2] Departamento de Geología, Universidad Nacional del Sur (UNS), Bahía Blanca, Argentina.
[3] CGAMA Centro de Geología Aplicada y Medio Ambiente (CIC- UNS), Bahía Blanca, Argentina.
[4] Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Argentina.
[5] Instituto de Geociencias Básicas y Aplicadas de Buenos Aires (IGEBA), Laboratorio de Paleomagnetismo D.A. Valencio, Departamento de Geología, FCEyN, Universidad de Buenos Aires, CABA, Argentina.
[6] Laboratorio de Termocronología (La.Te Andes), CONICET, Salta, Argentina.
[*] belenfebbo@gmail.com

ABSTRACT

Claromecó Basin (Buenos Aires Province, Argentina) is composed by carboniferous-permian rocks that lie on a Paleozoic basement. The PANG 0003 well, located in the center of the basin, contains rocks belong to Tunas Formation. The succession is composed by sandstones, mudrocks, carbonaceous mudrocks, coals and tuffs. The aim of this work is to analyze the internal structure of cores through anisotropy of magnetic susceptibility (AMS) studies and to relate these parameters with depositional and post-depositional conditions. Additionally, the aim is to compare the results with previous outcrop data of the Tunas Formation. Standard AMS study was carried out from the base to the top of the well. AMS parameters vary with depth. Magnetic susceptibility (K_{mean}) present an average of 209 x10^{-6} SI, consistent with the presence of paramagnetic minerals. Anisotropy degree (P_j) increase with depth due to overburden. The shape parameter (T) mainly range from $0 < T < 1$ indicating oblate fabric. As the cores are not oriented, K_{max} axis lie distributed in the Equatorial plane, near the horizontal, while K_{min} axis position are near the vertical, perpendicular to the bedding plane, with horizontal attitude indicating a triaxial to sedimentary fabric. These results are consistent with those obtained from the outcrops that indicate efforts attenuating upwards of the sequence and toward the foreland basin located to the east. This kind of study allows increasing the knowledge about the basins as Claromecó, currently considered as frontier basin.

Keywords: AMS parameters, frontier basin, Tunas Formation, Claromecó Basin, Gondwana, Paleozoic.

INTRODUCTION

Claromecó Basin (Carboniferous-Permian), placed at the south of Buenos Aires province, Argentina, belonged to the southwest part of Gondwana supercontinent during Late Paleozoic. It is composed by carboniferous-permian rocks that lie horizontal on a Paleozoic basement. According to Ramos (1984) and Rosello and Lopez Gamundi (1992) is considerate a foreland basin. It has economic potential based on coal beds and associated methane gas, recorded underground (Lesta and Sylwan 2005; Arzadún 2015; Arzadún *et al.,* 2017; Febbo *et al.,* 2018). The PANG 0003 well (S37° 34.0' 44.24', W61° 22.0' 12.56'') is located in the basin center, at the northeast of Sierras Australes, Buenos Aires, Argentina (Fig. 1). Based on its lithological and fossiliferous content, these rocks are assigned to Tunas Formation (Harrington 1947).

Sequences are represent by medium to fine sandstones, mudrocks, carbonaceous mudrocks, coal seams and tuffs (Arzadún *et al.,* 2016, 2018). Tunas Formation outcrops, at the east portion of the Sierras Australes, from the north of Sierras de las Tunas to the south of Sierra de Pillahuincó, with small outcrops near Gonzalez Chavez and Mariano Roldán (Monteverde 1937; Furque 1965; Llambías, Prozzi 1975; Tomezzoli y Vilas, 1997, Febbo *et al.,* 2018). In surface is integrated by medium to fine sandstones, of green color, interbedded with siltstones and claystones, and thin pyroclastic levels (Harrington 1947, Andreis *et al.,* 1979, López Gamundi 1996). Presence of *Glossopteris* flora (Archangelsky, Cúneo 1984) and radiometric isotopic dating suggest a Permian age (Alessandreti *et al.,* 2013; López Gamundi *et al.,* 2013, Arzadún *et al.,* 2018). Regarding deformation in the Sierras Australes, the south-west sector involves higher deformation sequences belts than the northeastern ones, which belong to the center of the basin with low grade of deformation. AMS and compaction studies on Tunas Formation shows a decrease in the magnitude of deformation during the Permian toward the foreland (Arzadún *et al.,* 2016). Based on AMS and paleomagnetic studies, some authors assume that tectonism began during the Late Devonian - Carboniferous and continue until Late Permian product of collision of microplates with Gondwana (Tomezzoli 2012, Arzadún *et al.,* 2016; Tomezzoli *et al.,* 2018).

The aim of this work is to analyze the internal structure in cores through anisotropy of magnetic susceptibility (AMS) studies and to relate these parameters with depositional and post-depositional (diagenesis) conditions. Additionally, to compare these results with previous outcrop data of Tunas Formation from the Sierras Australes area.

SAMPLES AND METHODS

AMS is a useful tool to study rock petrofabric from preferred orientation of magnetic minerals into a rock or unconsolidated sediments (Hrouda 1982; Tarling, Hrouda 1993). Rocks typically reflects the preferred crystallographic orientation, and the shape and distribution of magnetic minerals, hence AMS results depend on mineralogy, lithology and grain size, compaction and tectonic efforts acting during overburden. Standard AMS study was carried out from the base to the top of the PANG 0003 well (901 meters below wellhead, mbw) with 432 specimens measured. Samples were not oriented. Measurements of AMS were accomplished using a MFK1-FA Kappabridge at "Daniel Valencio" Paleomagnetic laboratory at the Universidad de Buenos Aires, IGEBA-CONICET. The obtained parameters were mean susceptibility (K_{mean}), corrected anisotropy degree (P_j; Jelínek, 1978), shape parameter (T), foliation (F) and lineation (L). Shape parameter describes the shape of the ellipsoid; positive/negative values of T indicate oblate/prolate fabrics respectively (Jelínek, 1978).

AMS RESULTS

Stratigraphic column of PANG 0003 well is composed by sedimentary rocks belonging to Tunas Formation (Fig. 2). Sedimentary sequence is integrated by carbonaceous mudrocks and coal beds interbedded with medium to fine sandstones at the base and fine sandstones interbedded with green mudrocks, thin tuffs levels and coal seams to the top. Measured AMS parameters are variable with depth. Mean magnetic susceptibility (K_{mean}) ranges from 20 x 10^{-6} SI to 540 x10^{-6} SI with an average of 209 x10^{-6} SI. Sandy facies exhibit a weak susceptibility due to the presence of diamagnetic minerals as inherited particles (clasts) or authigenic minerals precipitated during diagenesis (carbonate cement and clay minerals). Fine facies (mudrocks, coals and tuffs) show higher magnetic susceptibility due to presence of paramagnetic minerals (iron phyllosilicates as biotite, muscovite, chlorite and illite). Low values of susceptibility into the mudrocks are related to high content of organic matter in carbonaceous mudrocks and coals, in which Total Organic Content (TOC%) reach values range 1-51%. Present Ferromagnetic minerals are magnetite and pyrrhotite, which is frequent in anoxic sedimentary environments.

Anisotropy degree (P_j) ranges from 1.00 to 1.20 with an average of 1.057 (Fig. 3a). This parameter increases with depth, consistent with the increment of burial. Thereby, the higher values are located at the base (P_j: 1.10 – 1.30) and correspond to mudrocks and coals. The shape parameter (T) is variable from −1.0 to +1.0 with an average of 0.55 (Fig. 3a) with predominate values from $0 < T < 1$ indicating oblate fabric. From 500 mbw to the top of the sequence values show variation between $-0.5 < T < 0.8$ that represent prolate to oblate fabrics. Directional AMS data show that K_{max} axis lie near the horizontal while K_{min} axis are near the vertical, perpendicular to the bedding plane with horizontal attitude, indicating a triaxial to sedimentary fabric. However, at the base of the sequence from 900 to 800 mbw, there are small intervals that show the K_{min} axis moving to horizontal positions (Fig. 3b). The foliation (F) variates from 1 to 1.15 with an average of 1.042.

PETROFABRIC ANALYSIS AND CORRELATION

Sedimentary fabrics are characterized by oblate ellipsoids ($0 < T < 1$) with vertical K_{min} axes (Borradaile, Henry, 1997; Tarling, Hrouda 1993). Analyzed AMS parameters are consisting with sedimentary magnetic fabric with oblate ellipsoids (T values mainly positives) and shortening direction (K_{min}) in the vertical, perpendicular to bedding planes. Samples belong to cores were not orientated, hence correlation with azimuthal values of K_{max} and K_{min} previously obtained in Tunas Formation from outcrops of Claromecó Basin (Arzadún *et. al.,* 2016) cannot be possible. Nevertheless, based on scalar parameters, sedimentary magnetic fabric is similar subsurface and in outcrops in the basin center.

CONCLUSIONS

Variations of magnetic susceptibility observed from cores of Tunas Formation would belong to changes in sedimentary and chemical conditions during deposition; then, low susceptibility values indicate absence or minor quantity of magnetic minerals under anoxic conditions and high susceptibility reflect presence of magnetic minerals under sub-oxic/oxic conditions. In addition, these variations would reflect changes in environment energy (sand or mud grain size) and the influence of diagenesis (precipitation of authigenic minerals) during deeping.

Tunas Formation predominantly show a sedimentary magnetic fabric with K_{min} in the vertical, perpendicular to bedding plane. There are two main intervals at the base of the well that show a fabric with more clearly tectonic influence ($-0.5 < T < 0$), K_{min} axis moving to horizontal positions and high foliation values (increasing in the Pj values). At these depths, bedding planes could be not disposed horizontal. These differences may correspond to the diagenetic degree and overburden conditions.

Magnetic sedimentary fabric of Tunas Formation in subsurface is consistent with outcrops observations of Tunas Formation in Claromecó Basin, confirming that tectonic deformation had been attenuated to the east toward the foreland basin. Study of rock petrofabric in cores is an important tool to increase knowledge about Claromecó Basin, currently considered as a frontier basin.

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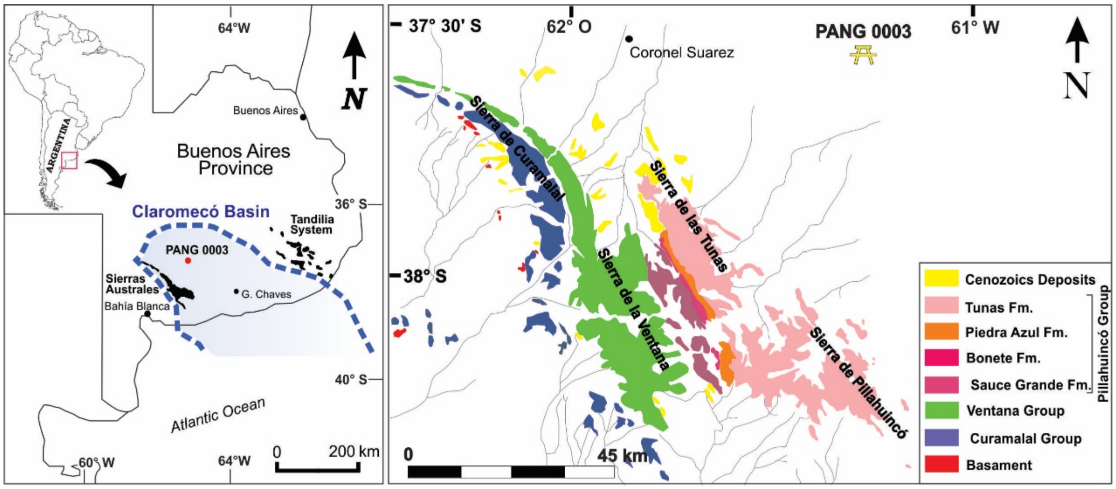

Figure 1. Location of Claromecó Basin and PANG 0003 well.

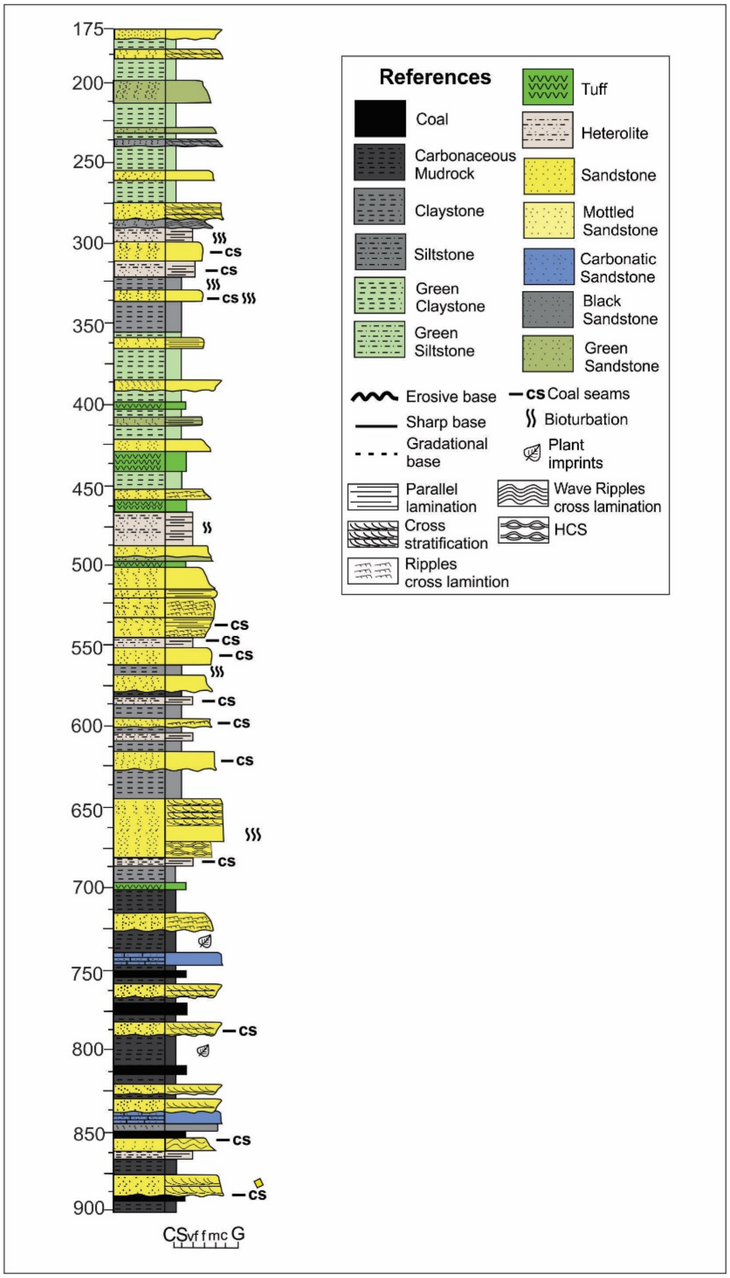

Figure 2. Sedimentological profile of PANG 0003 well.

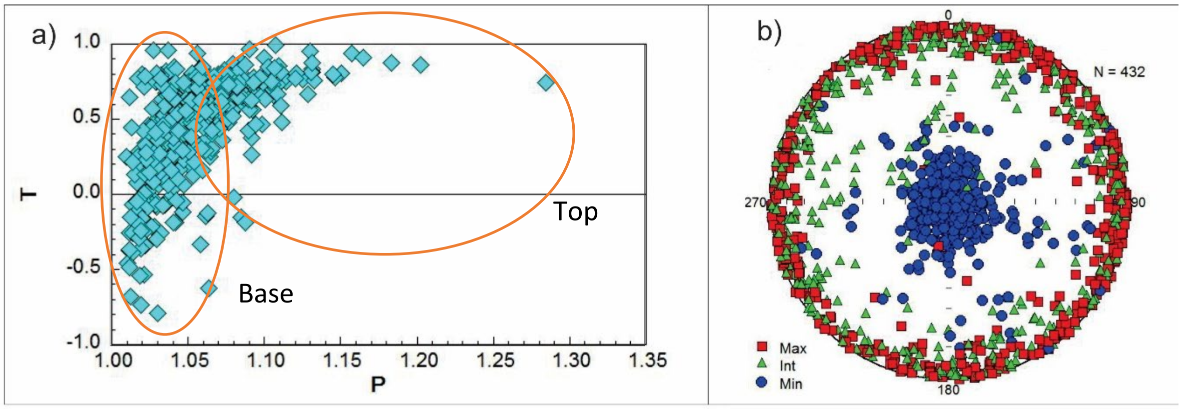

Figure 3. a) Anisotropy degree (P) vs. shape parameter (T). b) Stereographic projections of the principal susceptibility axes (K*max*, K*int*, K*min*).