ANISOTROPY OF MAGNETIC SUSCEPTIBILITY AND KINEMATIC ANALYSIS IN DEFORMED NEOGENE SEQUENCES, NW SIERRAS PAMPEANAS (27° 30' S): PRELIMINARY RESULTS

R. Quiroga[1]*, M. Peña[2,3,4], L. Giambiagi[1], J. Suriano[1], J. Mescua S, S. Perroud[2]

[1] Grupo de Tectónica, IANIGLA, CCT Mendoza, CONICET, Argentina.
[2] Departamento de Geología, Universidad de Chile, Plaza Ercilla 803, Santiago, Chile.
[3] Laboratorio de Tectónica y Paleomagnetismo, Departamento de Geología, Universidad de Chile.
[4] Escuela de Geología, Universidad Mayor, Santiago, Chile.

*e-mail: rquiroga@mendoza-conicet.gob.ar

ABSTRACT

We present preliminary results of AMS and kinematic analysis of Neogene deformed sequences exposed in Precordillera and northwest Sierras Pampeanas (27° 30' S). The AMS analysis from 30 sites show a wide range of foliation degree, between sedimentary to tectonic. The kinematic analysis, in more than 500 mesoscopic-scale faults shows a contractional and a strike slip event. The magnetic lineation and foliation is well developed near to the meso and large-scale structures and K_1 orientation is parallel to the main fold axes and inverse faults that affected the Neogene sequences. In the Precordillera (Fiambala Basin), the kinematic analysis shows, a contractional event with E-W major direction from ~9-8 Ma. NW and NE strike-slip faults affect all the Neogene sequences, suggesting a later (after 3 Ma) strike-slip event in the basin. Meanwhile in NW Sierras Pampeanas, the deformation is predominantly contractional since ~15 Ma. By comparing the AMS and kinematic analysis results, we obtain a timing for syn-lithification and post-lithification strain field. In this way, we compare both broken foreland intermontane and foreland basins to understand spatio-temporal strain variations.

Key Words: AMS, Broken foreland, Fiambalá basin, Strain, West Sierras Pampeanas.

RESUMEN

Presentamos resultados preliminares de AMS y análisis cinemático de secuencias neógenas deformadas expuestas en Precordillera y en el sector noroeste de Sierras Pampeanas (27° 30' S). El análisis de AMS de 30 sitios muestra un amplio rango de grado de foliación, entre sedimentario y tectónico. El análisis cinemático, en más de 500 fallas de escala mesoscópica, muestra un evento de contracción y deslizamiento lateral. La lineación y foliación magnética están bien desarrolladas cerca de las estructuras meso y a gran escala y la orientación de K_1 es paralela a los ejes del plegamiento principal y las fallas inversas que afectaron las secuencias neógenas. En la Precordillera (Cuenca de Fiambala), el análisis cinemático muestra un evento de contracción con dirección principal E-W de ~ 9-8 Ma. Las fallas de deslizamiento lateral de rumbo NW y NE afectan a todas las secuencias neógenas, lo que sugiere un posterior evento de deslizamiento lateral en la cuenca (después de 3 Ma). En tanto, en el noroeste de las Sierras Pampeanas, la deformación es predominantemente contraccional desde ~ 15 Ma. Al comparar los resultados del análisis cinemático y de la AMS, identificamos el momento del campo de estrés correspondiendo con el del tiempo de la litificación y post-litificación. De esta manera, comparamos ambas cuencas intermontanas rotas y de antepais para comprender las variaciones espacio-temporales del estrés.

Palabras Claves: AMS, Antepais roto, Cuenca Fiambalá, Esfuerzo, Sierras Pampeanas Occidentales

1. Introduction

The Precordillera and NW Sierras Pampeanas, are located in the northern transition between the normal and flat subduction zones (27°30' S), and constitute the major morpho-structural features of the southern Central Andes, mostly exposed in Argentine territory (Fig. 1). Although there are several studies focused on

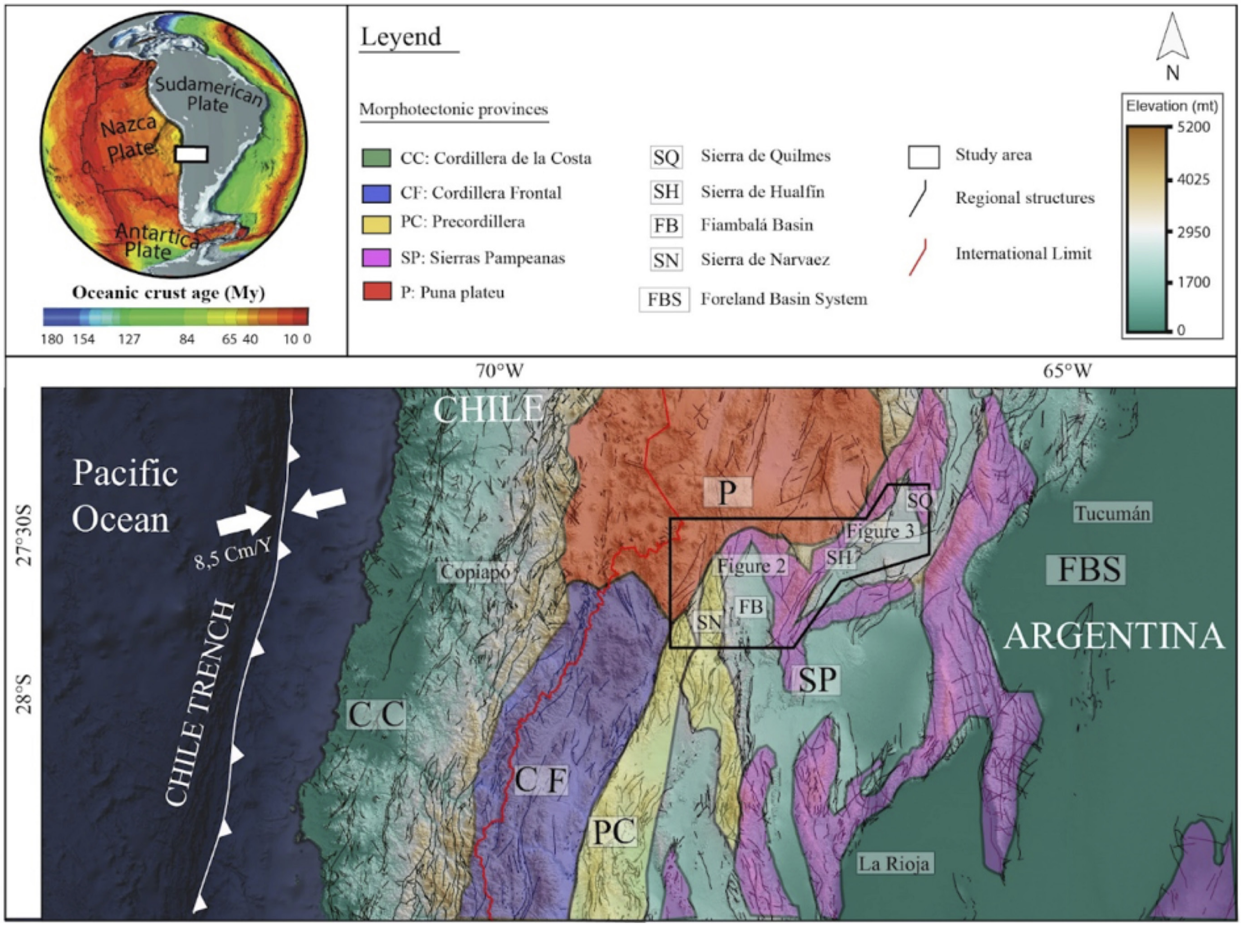

Figure 1. Simplified map showing the morphostructural units, location of the study area and the location of Figure 2 and 3.

Neogene deformation are insufficient to understand how the strain and stress fields change during the latest orogenic stage, and how the synorogenic sequences are deformed. In this work, we use two methodologies to analyze the Neogene deformation: anisotropy of magnetic susceptibility (AMS) analysis in Miocene to Pliocene volcanic and sedimentary rocks and in pre-Miocene sedimentary-crystalline substrate; and kinematic analysis of fragile deformation from fault-slip data.

2. Geological settings

The study area is located between the northern segment of Precordillera and NW Sierras Pampeanas, to the SE part of the southern segment of Puna plateau (Fig. 1). The Precordillera at this latitude is a double-vergent thick-skinned fold-and-thrust belt formed by volcano-sedimentary continental to marine Ordovician, Permian and Mesozoic sequences. These rocks are locally covered by volcanic, epiclastic, and clastic Miocene sequences (Rubiolo *et al*., 2001). Fiambalá basin is located between the Precordillera and Sierras Pampeanas and its fluvio-alluvial Neogene sequences record the evolution from an integral, continuous and more extensive foreland-basin system, to a subsequent intermontane basin, as a result of east propagation of the orogenic front from Precordillera to Sierras Pampeanas area at ~ 6 Ma (Carrapa *et al*., 2008, 2011; DeCelles *et al*., 2011, and others). Finally, the NW Sierras Pampeanas is a region composed by basement blocks bounded by high-angle reverse-faults and composed of metasedimentary to high-grade metamorphic Precambrian rocks (Cristallini, *et al*., 2004; Ramos *et al*., 2002, among others). Intermontane basins between Sierras Pampeanas are represented by Neogene continental lacustrine, fluvial-alluvial and volcanic sequences that record a progressive change in the provenance, associated to the onset of fragmentation of the foreland with the uplift of basement blocks after 6 Ma (Mortimer *et al*., 2005 and references therein). Figure 1 shows the field area and principal location of these morphotectonic units.

3. Methodology

In order to understand the deformation we present: (1) A structural map of Precordillera and Sierras Pampeanas (Fig. 2 and 3), based on published data (Rubiolo *et al*., 2001, Carrapa *et al*., 2008; Bossi *et al*., 2009, among others) and new observations (2) Anisotropy of magnetic susceptibility (AMS) analysis carried out in the Tectonics and Paleomagnetism Laboratory of the Department of Geology of Universidad de Chile using a Kappabridge KLY-3S (Agico), in Neogene rock samples grouped in 30 sites (N~4-8), to determine the type of magnetic fabrics, magnetic mineralogy and degree of anisotropy; and (3) Kinematic analysis in more than 500 mesoscopic-scale faults, using Faultkin 8 software (Allmendinger, 2018). These new data are used to compare possible changes in the strain registered in the rocks, to recognize possible magnetic fabrics developed during tectonic activity following the criteria exposed in Robion *et al*. (2007). In this way, a magnetic fabric affected by tectonic activity provides a correlation of maximum susceptibility (K_1) directions with LPS directions in weakly deformed rocks (Weil and Yonkee, 2009). The kinematic analysis of mesoscale structures allows us determinate contraction and extension directions developed during the late fragile deformation stage.

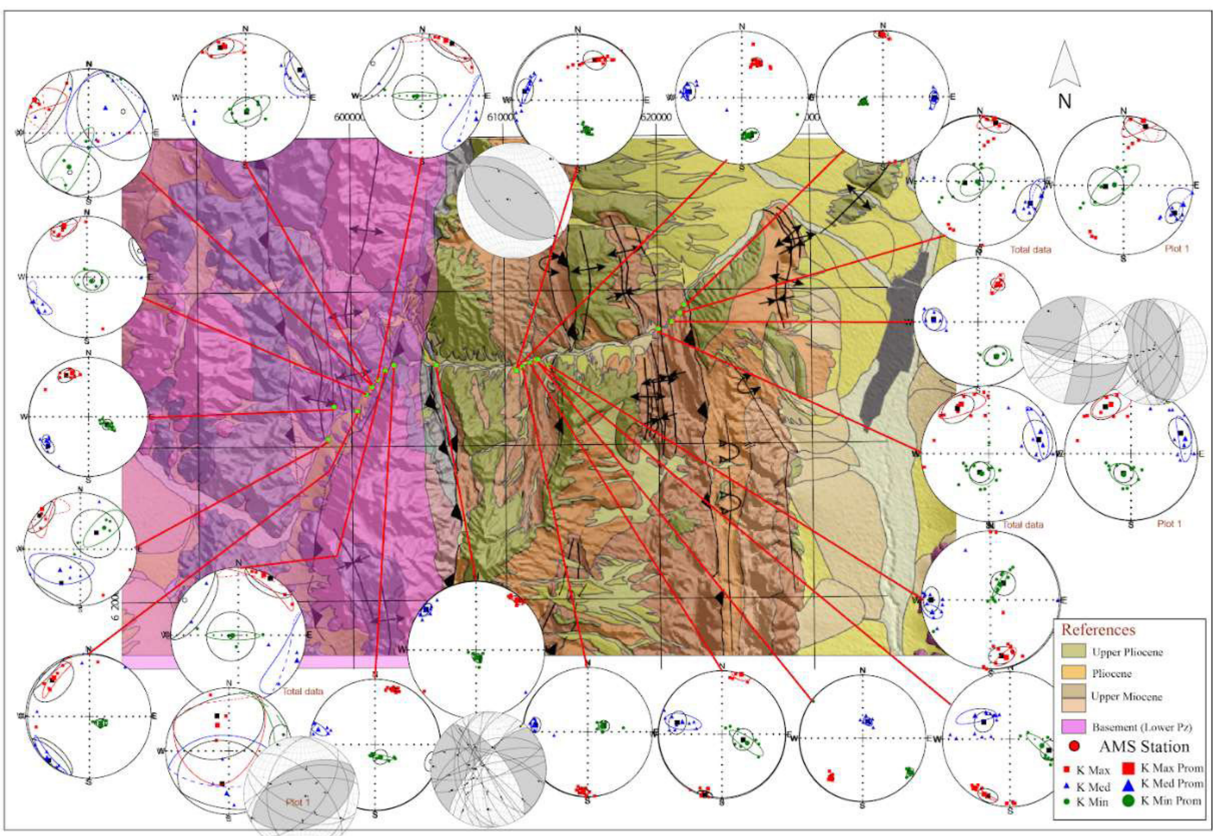

Figure 2. Geological map of the Fiambala basin in Precordillera showing the AMS and kinematic stations.

4. Preliminary results

The AMS analysis from 30 sites shows a wide range of foliation degree, between sedimentary to tectonic foliation. In the Fiambalá basin, particularly, the foliation close to faults affecting Neogene rocks from Tamberia Formation (9 to ~8Ma, Carrapa *et al*., 2008), is similar to III and IV foliation type, with oblate to prolate variation in ellipsoid shape, suggesting a transitional magnetic fabric between sedimentary to tectonic (Fig. 2). In the basement block in the western side of the basin, there is a progradation of the anisotropy that increases closer to the main faults (Fig. 2). On the other hand, the sites in the Sierras Pampeanas (Fig. 3) show a similar pattern, where the foliation is near to IV-III type in folds and faults that affected these rocks. The lineation (K_1) is, in general, well developed near major faults to the West in Fiambalá area and less well developed to the east (Fig. 4). The K_1 direction is N-S to NNE, and is consistent with the orientation of major fold axes (and local structural variation) and fault orientations (Fig. 3). On the one hand, kinematic analysis from meso-scale faults that affect Neogene sequences (between 10 to 3 Ma) shows, a contractional event with E-W major direction in sequences dated between 8-5 Ma in the Precordillera (Sierra de Narvaez and Fiambalá basin). NW and NE strike-slip faults affect all the Neogene sequences, suggesting a later strike-slip event in the basin (after 3 Ma). On the other hand, Quaternary activity evidenced by field observed morphological features, suggest E-W to ENE-WSW contraction in Pleistocene-Holocene times. Moreover, towards the East, in NW Sierras Pampeanas, the deformation is predominantly contractional, and kinematic analysis shows EW contraction associated to the anisotropy of metamorphic foliation that shows a consistent relation with the orientation of regional Neogene faults.

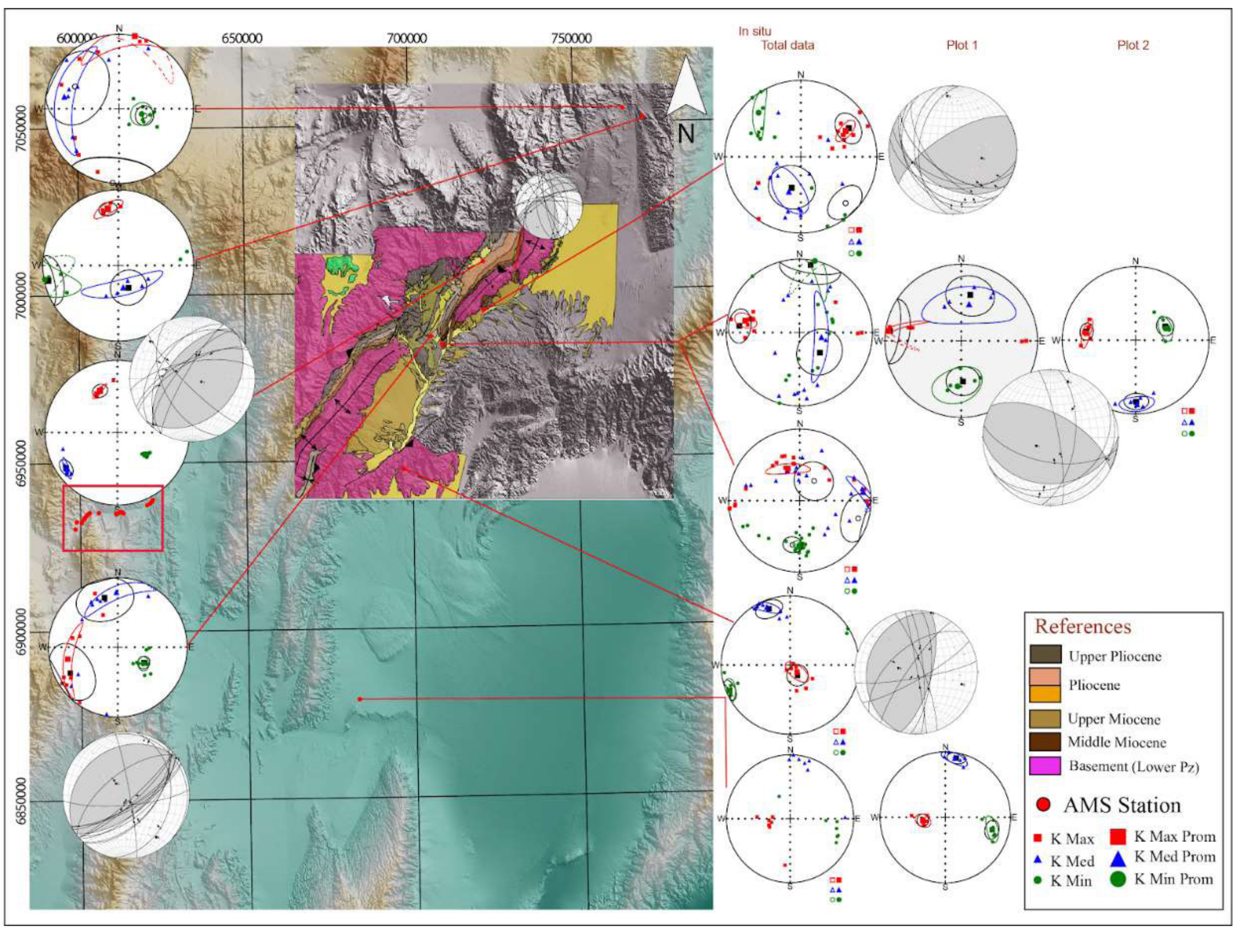

Figure 3. Geological map of North-West Sierras Pampeanas showing the AMS and kinematic stations (See the references therein).

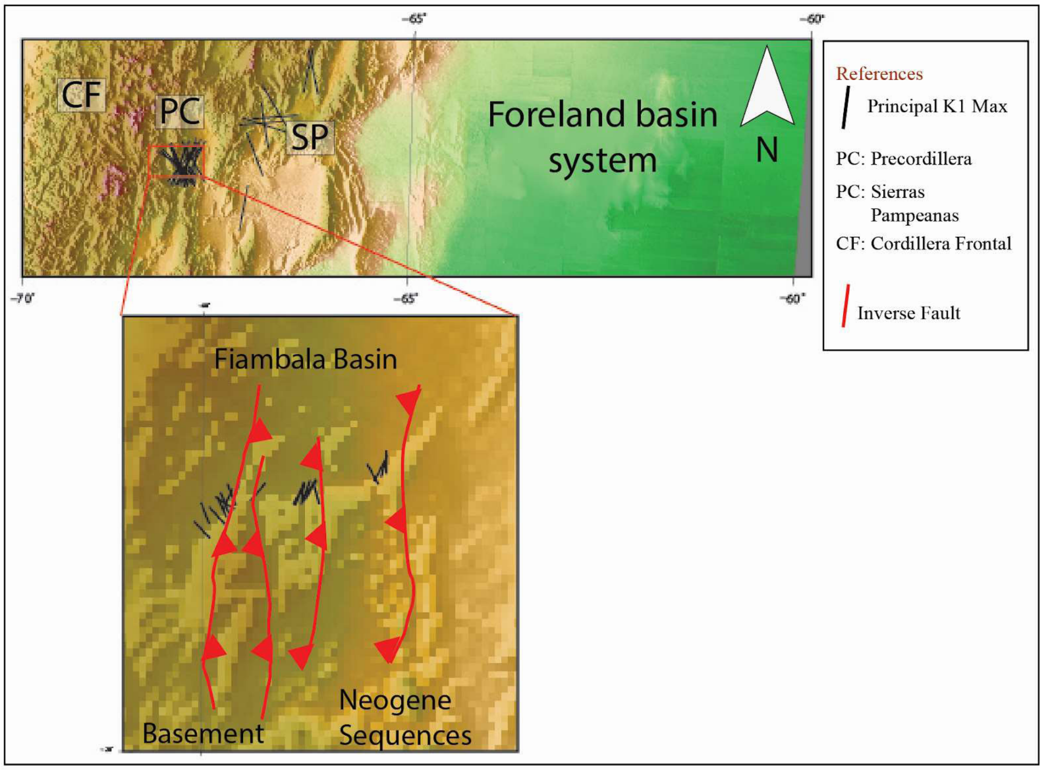

Figure 4. Plot of Principal K1 Max from analysis of Stereographic plot shown in Fig. 2 and 3 (See the references therein).

5. Conclusion

The magnetic lineation and foliation are well developed near to the meso and large-scale structures. We propose that the magnetic fabric have a tectonic origin closer to the main faults, in the western sector of the Fiambala basin, where the Miocene synorogenic units of 9-8 Ma are in contact with basement blocks. The intensity of the anisotropy decreases eastward far away from these major structures and in local areas with low degree of meso-scale deformation within deformation zones in Neogene sequences. In the Sierras Pampeanas, the pattern is similar. The kinematic analysis shows a Late Miocene E-W contractional event followed by a strike-slip deformational event after 3 Ma. Subsequently, contraction prevails in Pleistocene-Holocene times. In the Sierras Pampeanas, contraction directions have an important variation controlled by the orientation of metamorphic foliation of basement rocks.

Comparing the AMS analysis with the kinematic analysis results, the E-W contractional direction suggested by the K_1 lineation and the increase of the grade of anisotropy toward major contractional faults, indicate a similar E-W contractional direction both during and after deposition. These K_1 lineation and degree of anisotropy, in general, diminish towards the east, close to the Sierras de Quilmes, where the AMS stations indicate a sedimentary fabric instead of tectonic. On the other hand, the strike-slip obtained with kinematic analysis is not recorded in magnetic fabrics obtained by AMS analysis.

These preliminary conclusions suggest that, when the AMS has a tectonic origin, it could be used to quantify the strain variation from a proximal deformation front to distal areas. By comparing the AMS and kinematic results, we obtain a timing for syn-lithification and post-lithification strain field. In this way, we compare both broken foreland intermontane and foreland basins to understand spacio-temporal strain variations.

Acknowledgments

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