6th International Symposium on Andean Geodynamics (ISAG 2005, Barcelona), Extended Abstracts: 596-599

An AMS and paleomagnetic study across the Andes in Tierra del Fuego

Augusto E. Rapalini *, Horacio Lippai *, Alejandro Tassone *, & María E. Cerredo **

* INGEODAV, Dept. Cs. Geológicas, FCEyN, Universidad de Buenos Aires, Argentina; rapalini@gl.fcen.uba.ar
** Dept. Cs. Geológicas, FCEyN, Universidad de Buenos Aires, Argentina

Introduction

The tectonic evolution of the Southern Andes in Tierra del Fuego has been the subject of numerous studies in recent years (e.g. Klepeis, 1994, Cunningham, 1995, Mukasa and Dalziel, 1996, Diraison et al., 2000, Lodolo et al., 2003, etc.), but several topics still remain controversial, i.e: the timing and magnitude of an hypothetical oroclinal bending, the competing importance of thrust versus strike-slip tectonics, the role and mechanisms of a back-arc basin inversion, etc. As part of a multidisciplinary study, a reconaissance anisotropy of magnetic susceptibility (AMS) and paleomagnetic survey across the Fuegian Andes in the Argentine sector of the Isla Grande de Tierra del Fuego was carried out. First results from this study are reported here.

Geology and Sampling

The Andes of Tierra del Fuego in the Argentine sector are composed of several WNW-ESE thrust complexes that involved in its central sector the Late Jurassic Lemaire and Early Cretaceous Yahgan formations. These rocks have been folded and thrusted in the Late Cretaceous, presenting a very low-grade metamorphism and a pervasive slaty cleavage that in many places is parallel or sub parallel to bedding planes.

Location of sampling sites across the Fuegian Andes is shown in Figure 1. They were located along road cuts, quarries or natural exposures. Ninety-six oriented samples were collected at 12 sites. Except for seven block samples at site Y12, all others were drilled in the field with a portable drilling machine, and oriented both with sun and magnetic compasses whenever weather permitted. Sites comprised basic metavolcanic sills and lavas (Y1-Y5, Y8, Y9), a rhyolitic intrusive (Y6), metapelites as an enclave of the metabasalts (Y7), a gabbroic sill (Y10) and a dacitic porphyry (Y11, Y12). At some sites few samples from the encassing metasediments were also collected. In all cases measurements of the cleavage and bedding planes were obtained at each site along the margins of the magmatic bodies. Thickness of the sampled bodies varied from 2 m (Y1) to several tens of meters (Y2, Y10, Y11). These bodies are either intercalated in the Late Jurassic Lemaire Fm. or intrude this or the Early Cretaceous Yahgan Fm. Basic rocks are porphyric with clinopyroxene and plagioclase phenocrysts immersed in a subophitic groundmass. Primary magmatic associations display variable overprinting by static sea-floor metamorphic assemblages (clinoamphibole-zoisite), later affected by oriented deformation-related paragenesis (chlorite-prehnite±pyrite).

Radimetric dating of these magmatic bodies is scarce or absent. The Lapataia gabbro (Y10) have yielded whole-rock K/Ar age of 88±3 Ma (Acevedo et al., 2002), while the dacitic porphyry (Y11,Y12) has yielded ages of 77±3 Ma (Ramos et a., 1986) and 100±6 Ma (Acevedo et al., 2002), with the same methodology.

AMS results

AMS results are illustrated in fig.1. No AMS data is available from sites Y1 and Y12. Most sites showed low bulk susceptibility values, consistent with a magnetic fabric governed by paramagnetic minerals. A tectonic

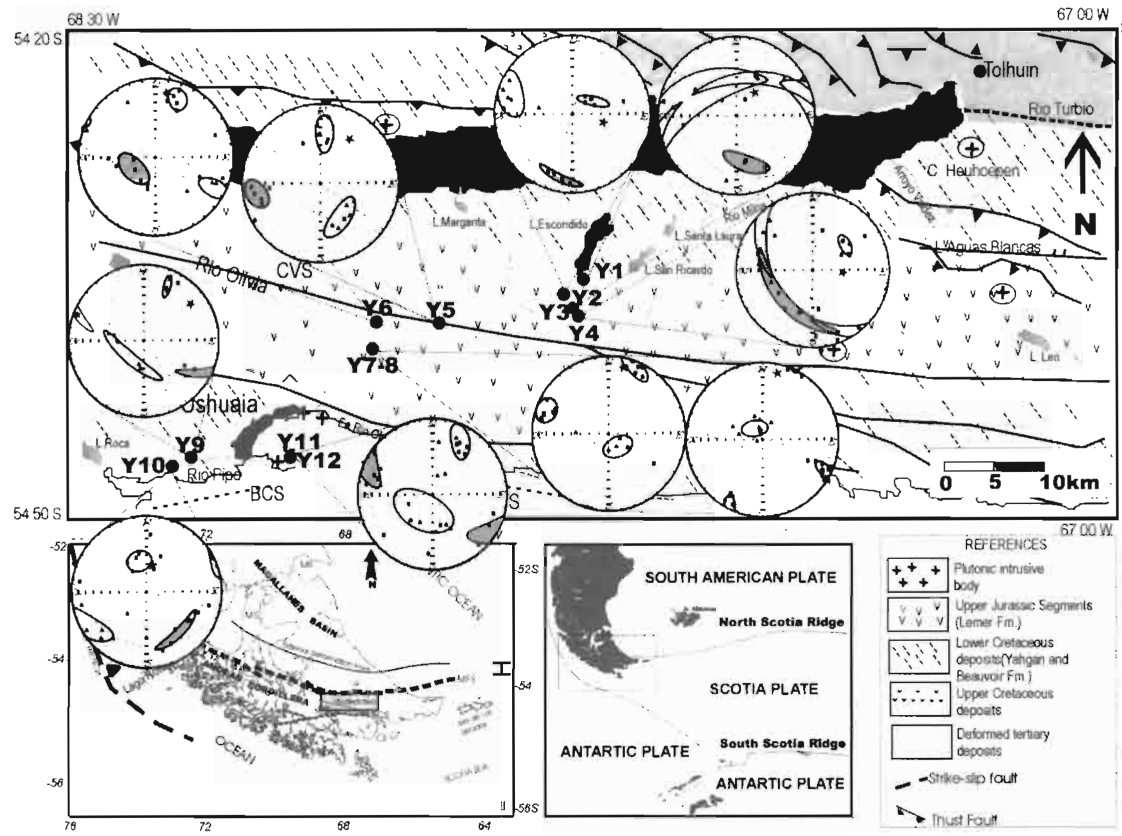

Fig.1. Geologic map of the Andes of Tierra del Fuego and location ofsampling sites with their respective AMS lower hemisphere estereograms. K1 (magnetic lineation) ellipse is shaded. Dashed lines: bedding/cleavage planes. CVS: Carbajal lineament; MFS: Magallanes-Fagnano fault zone, BCS: Beagle Channel fault zone.

fabric is inferred in all sites with the only exception of site Y11. As shown in Fig. 2, anisotropy degree is highly variable with P' ranging from 1.03 (dacitic porphyry, Y11) to 1.45 (metapelitic enclave, Y7). The ellipsoid shape is also variable with a slight tendency towards oblate shapes. Fig. 1 shows the distribution of AMS axes. In all cases (except Y11) a correlation between these axes and the bedding/cleavage plane of the encassing metasediments is observed, confirming the tectonic origin of the fabric. There is clear correlation between the anisotropy degree and the deformation intensity, as observed under the microscope. The increase in P' values from Y3-Y4 to Y2 is parallelized by the progressive development of a mylonitic fabric which is fairly defined in Y2 and characterized by clinopyroxene porphyroclasts enveloped by a matrix composed of oriented prehnite-chlorite. Similarly, no deformation fabric was observed in the dacitic porphyry of Y11. K3 (pole to the magnetic foliation) falls always close to the pole to bedding/cleavage although in several cases it is rotated about 30° ccw. K1 (magnetic lineation) is subhorizontal or gently plunging in all but one case (Y6). K1 may represent the stretching lineation and trends N-S to NE-SW in the northern sector of the transect (Y2-4) and E-W to ESE-WNW in the south. This change in direction may mean that deformation is governed by N to NE directed thrusts in the northern sector (near Paso Garibaldi), while E-W to ESE-WNW strike-slip faulting (E-W lineation) has pervasively affected the fabric to the south. It is interesting that the higher degrees of anisotropy which should reflect higher internal deformation are observed on sites close to the Carbajal lineament, which is consistent with this being a significant strike-slip mega-fault. Moreover, samples from sites located along the Carbajal valley often display extensional microstructures (e.g. pyrite-strain fringes complexes in deformed rhyolites and in black shales, large chlorite crystallized in micro-pull-apart zones in metabasic rocks) parallel to K1.

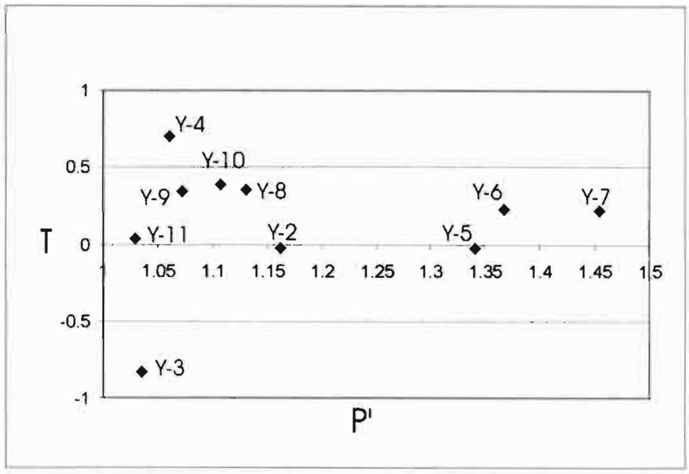

Fig.2: P´ vs T diagram (Jelinek, 1981) for the studied sites. T values over (under) zero indicate oblate (prolate) shapes for the ellipsoid.

Paleomagnetism

Paleomagnetic samples were submitted to alternating field (AF) and thermal demagnetization procedures. Most sites showed an unstable magnetization with very low to low coercivities and unblocking temperatures indicating that rocks from these sites were not useful for paleomagnetic analysis. Other sites (Y1, Y2, Y4, Y7, Y11, Y12), however, permitted the isolation of a characteristic remanence, being the AF generally more efficient than thermal treatments. Preliminary analysis points to (titano?) magnetite as the main magnetic carrier. However, acceptable within site consistency of directions ($\alpha 95 < 15°$) was only obtained at three sites (Y2, Y11 and Y12). Their mean directions are presented in Fig.3. While Y2 corresponds to a thick (> 100 m) metabasaltic sill possibly coetaneous with the Lemaire formation, and affected by internal deformation (see magnetic fabric in Fig.2), the other two sites correspond to the post-tectonic dacitic porphyry of Ushuaia Peninsula. Figure 3 shows the in situ direction of these three sites and the Late Cretaceous reference direction for the study area (Somoza, 2002). Sites Y2 and Y11 show a similar direction which suggests significant ccw rotation (near 60°) of both sites since the acquisiiton of magnetization. This would imply a post-tectonic magnetization for Y2 which is to be expected considering the internal deformation observed. Y12 direction is anomalous and suggests an undetected tilting of the site. This preliminary and tentative interpretation of the paleomagnetic data would support the oroclinal bending models for development of the Fuegian Andes. The sense and magnitude of ccw rotations of sites Y2 and Y11 is in accordance with the 90° ccw rotation determined for the Hardy Fm (Cunningham et al., 1991) and the 30° ccw rotation interpreted for the Hewhoepen intrusion (Baraldo et al., 2002). However, if a primary magnetization for Y2 is considered and the mean magnetization restored to paleohorizontal it becomes coincident within error with the expected direction. In this case, no significant rotation could be postulated for the Fuegian fold and thrust belt, ruling out any significant oroclinal bending. In such case, other rotations found in the region should be assigned to local tectonics associated to the several sinistral transcurrent and transform faults of the region. Further paleomagnetic studies on the region and determination of the origin of magnetization at site Y2 may help elucidating between these two alternatives.

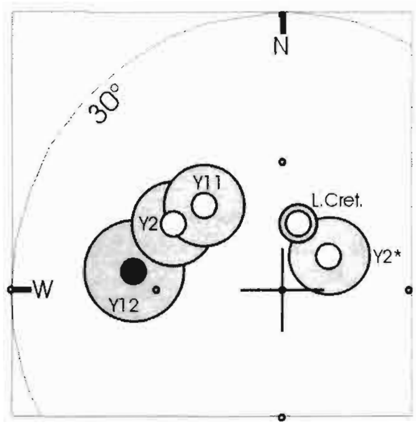

Fig.3: Mean site in situ paleomagnetic directons and their α95 (shaded circles) for sites Y2, Y11 and Y12. L Cret is the expected direction according to the Late Cretacous pole for South America (Somoza, 2002). Y2* is the direction for this site after bedding correction. Open (solid) symbols mean upward (downward) directions.

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