COUNTERCLOCKWISE ROTATION OF THE SOUTH PERUVIAN FOREARC AND IMPLICATIONS FOR THE FORMATION OF THE BOLIVIAN OROCLINE

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INTRODUCTION

Paleomagnetic studies undertaken in the Central Andes demonstrate that tectonic rotations are a key feature of the deformation. Paleomagnetic results obtained in Mesozoic rocks (Roperch and Carlier, 1992; Macedo Sanchez, 1993) and Paleocene rocks (Macedo Sanchez, 1993) demonstrate counterclockwise rotations of Southern Peru larger than 30 degrees supporting the hypothesis of oroclinal bending of the Central Andes. However, the timing of the rotations remains poorly determined. In this study we present new paleomagnetic evidence for a late Paleogene counterclockwise rotation of Southern Peru.

PALEOMAGNETIC SAMPLING

In Southern Peru, the Moquegua Formation, which corresponds to a thick continental sedimentary sequence deposited during the Paleogene, is an especially good paleomagnetic target to further constrain the timing of oroclinal bending. The Lower Moquegua formation corresponds to fine claystones and siltsones deposited unconformably on a well-developed paleosurface postdating the Paleocene Toquepala volcanics. The Upper Moquegua Formation consists of more than 500 m of upward coarsening siltstones and conglomerates with interbedded late Oligocene and Early Miocene tuffs and ignimbrites.
In southern Peru, we sampled 15 sites in claystones and silstones of the Lowwer Moquegua formation and 15 sites in the overlying ignimbrites. In northern Chile to the south of the Arica bend, we sampled the Azapa Formation (equivalent to the Lower Moquegua Fm) and the lower Miocene Oxaya ignimbrites.

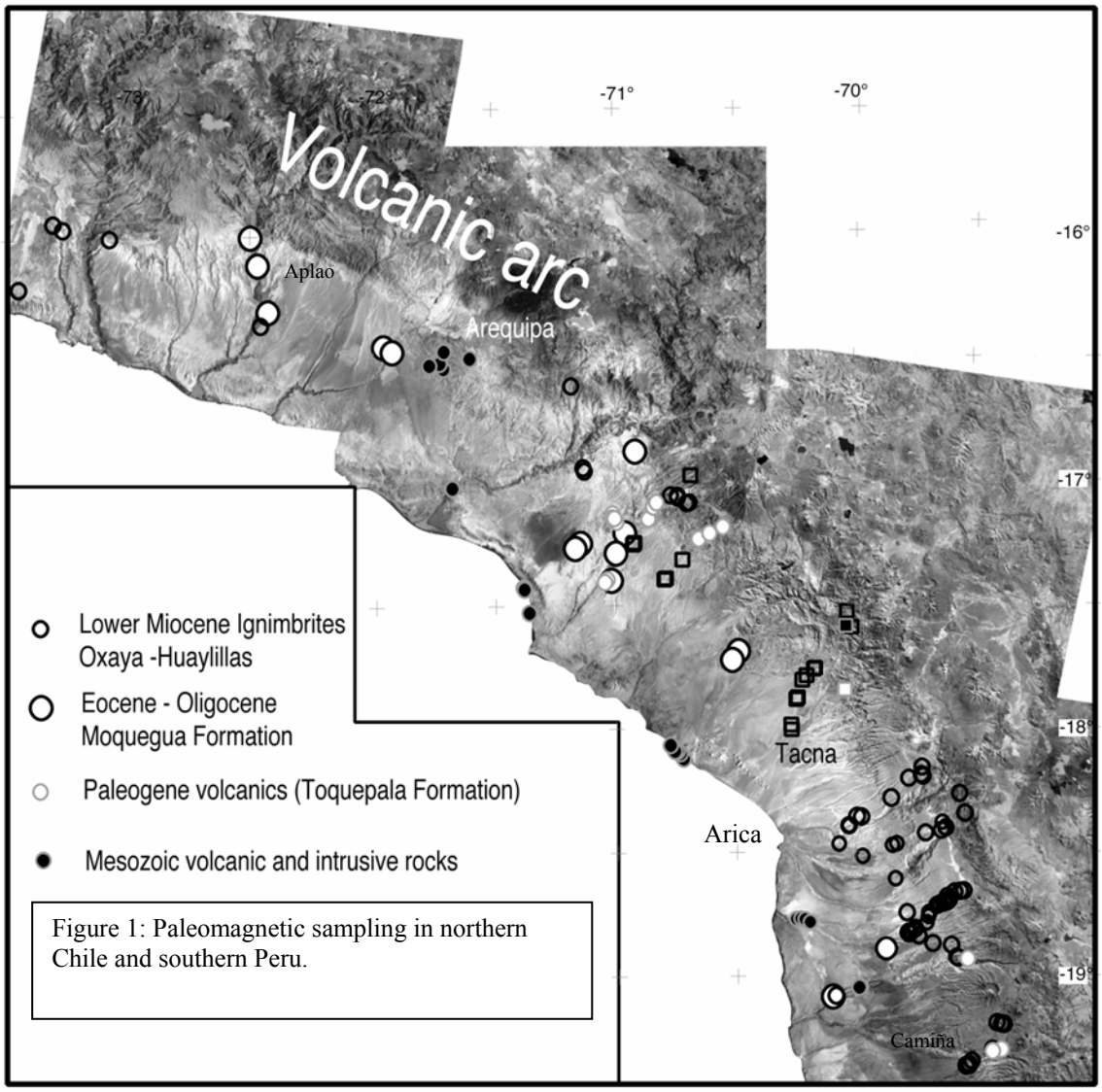


Figure 1: Paleomagnetic sampling in northern Chile and southern Peru.

Ten to twenty cores were drilled at each site. At most sites in the Moquegua Formation, cores were drilled in several claystones and siltstones beds in stratigraphic succession.

PALEOMAGNETIC RESULTS

Moquegua Formation in Southern Peru:

Magnetization is very stable and a characteristic direction was determined in 12 sites out of the 15 sites sampled in the Moquegua formation (figure 2b). Normal and reverse polarity magnetizations are found. At some sites, changes in polarity are observed within the thickest sampled sections.

The average direction calculated for the Aplao and Arequipa area is : (Declination=138.7° Inclination 29.0° α95=17.0° N=4 sites). Near Moquegua, the average paleomagnetic direction is :(Declination=146.0° Inclination 33.3° α95=4.8° N=8 sites).

Paaleogene rocks in northern Chile:

Two sites, drilled in the Azapa Formation underlying the Lower Miocene Oxaya Formation, provide a characteristic magnetization with normal polarity.

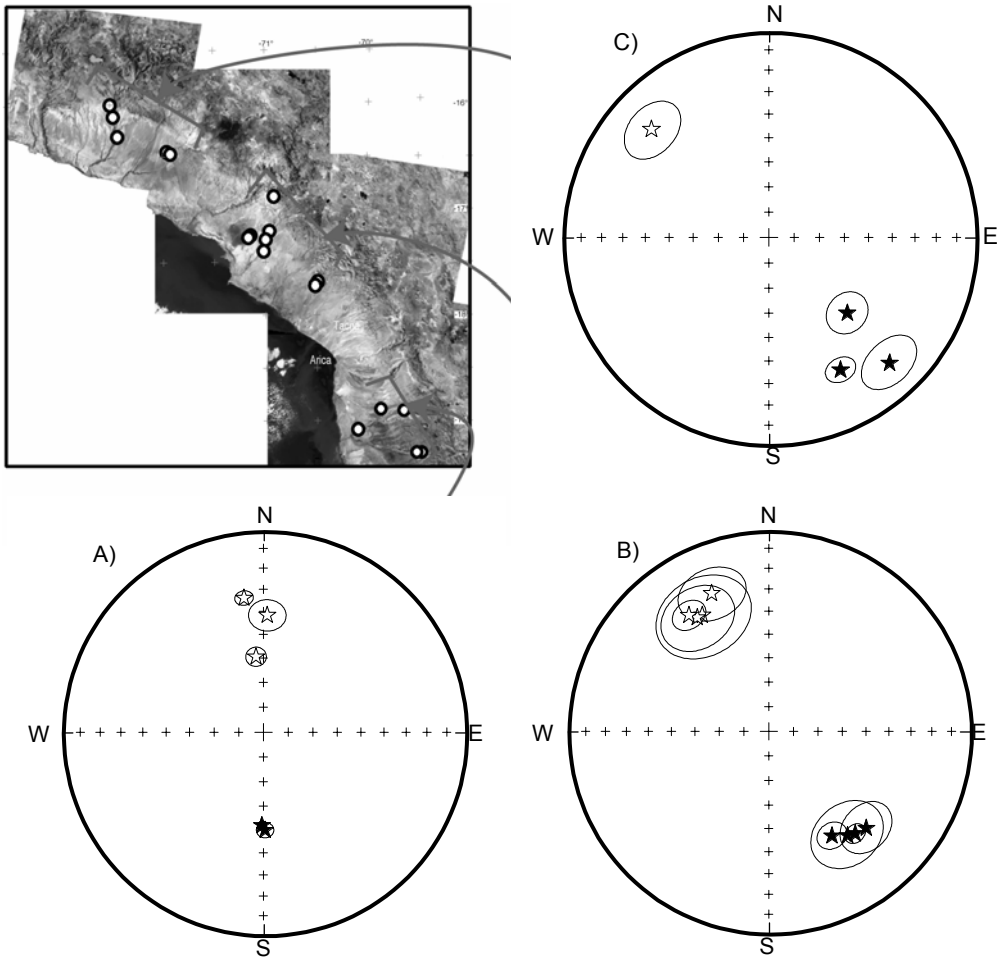
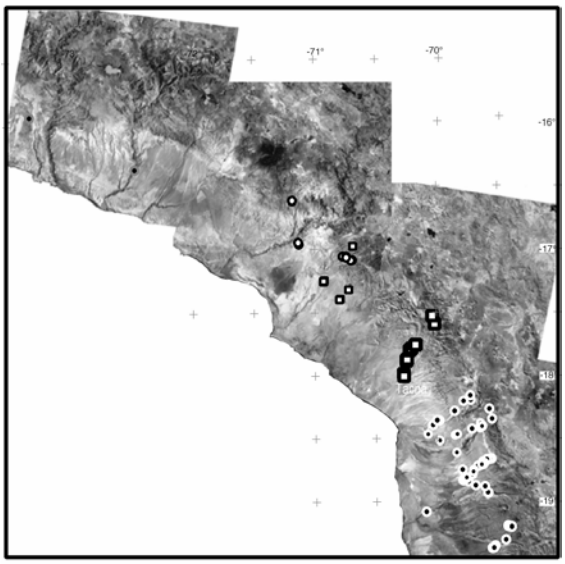


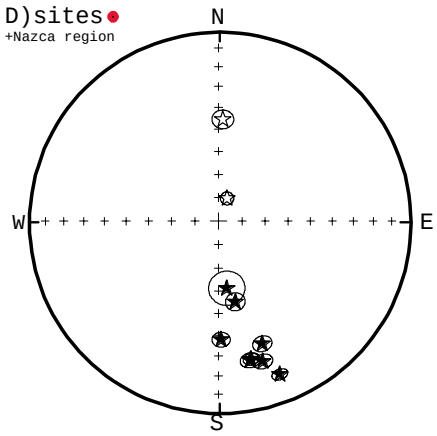
Figure 2: Eocene-Oligocene characteristic magnetizations south (A) and north (B&C) of the Arica bend. Equal area projections of site-mean directions with 95% confidence angle.
Open (filled) stars are characteristic directions of normal (reverse) polarity. Data set (A) corresponds to sites located in Chile, (B) corresponds to the Moquegua region and (C) to the Arequipa and Aplao region.

Near Camiña, a remagnetization of reverse polarity was found in Cretaceous-lower Tertiary sediments underlying the lower Miocene ignimbrites. The remagnetization, not observed in the overlying ignimbrites, is interpreted as a magnetization acquired during the Paleogene. A paleomagnetic result was also obtained in a lower Tertiary intrusive. The average direction calculated from these 5 sites is: (Declination=177.5° Inclination 47.2° α95=17.0° N=4 sites).

Lower Miocene Ignimbrites:

In northern Chile (A) and southern Peru (B) there is no evidence for significant relative rotations. This observation is in good agreement with the apparent continuity in the distribution of flat-lying thick ignimbrites. Near Moquegua (C), several sites were drilled in two large ignimbrites recording intermediate paleomagnetic directions with steep inclinations. These results cannot constrain tectonic rotations. North of Arequipa (D), evidence for significant counterclockwise rotations is also lacking.





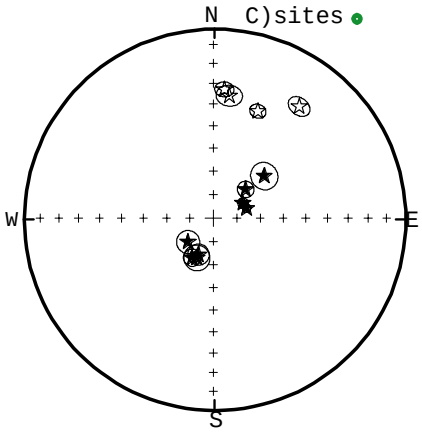
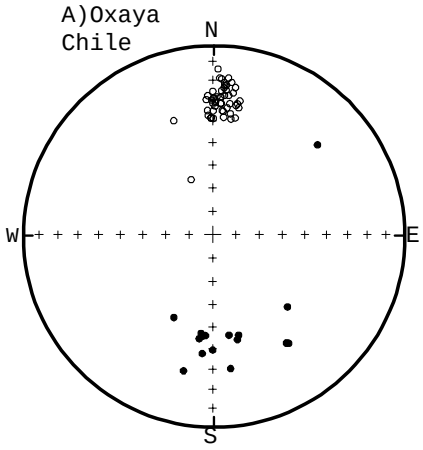
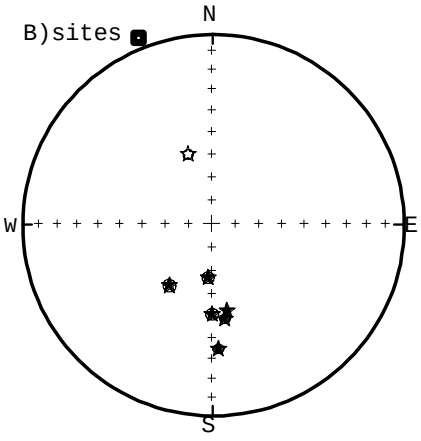


Figure 3: Paleomagnetic sampling in Lower Miocene ignimbrites and equal-are projections of characteristic directions. Angle of confidence at 95% have been omitted for results from northern Chile (A). Results from the Tacna region (squares) are shown in B. Results from the Nazca tuff are shown in D but the sampling sites are located further to the west and not shown on the satellite image.





CONCLUSION

The new paleomagnetic results demonstrate that sediments from the lowermost part of the Moquegua Formation record the same large (>30°) counterclockwise tectonic rotation previously observed in Cretaceous and Paleocene rocks in southern Peru. The lack of rotation shown by the paleomagnetic results in lower Miocene ignimbrites support the hypothesis that oroclinal bending in the forearc occurred mostly during Oligocene time. We will discuss the implications of these results for our understanding of the early stages of deformation in the Central Andes.