MAGNETOSTRATIGRAPHY AND PALEOMAGNETIC ROTATION OF THE NORTH-CENTRAL BOLIVIAN ALTIPLANO BASIN

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INTRODUCTION

Magnetostratigraphic dating can be a very powerful tool in the study of continental basins. In the Andes, for example, magnetostratigraphic studies have brought important constrains in the understanding of the development of the foreland basins of the Sierras Pampeanas [Johnson et al., 1986].In this study, we report an attempt to use paleomagnetism to determine sedimentation rates in one of the thickest Andean Tertiary sedimentary basins located in the north-central Bolivian Altiplano [Kennan et al., 1995; Rochat et al., this volume].

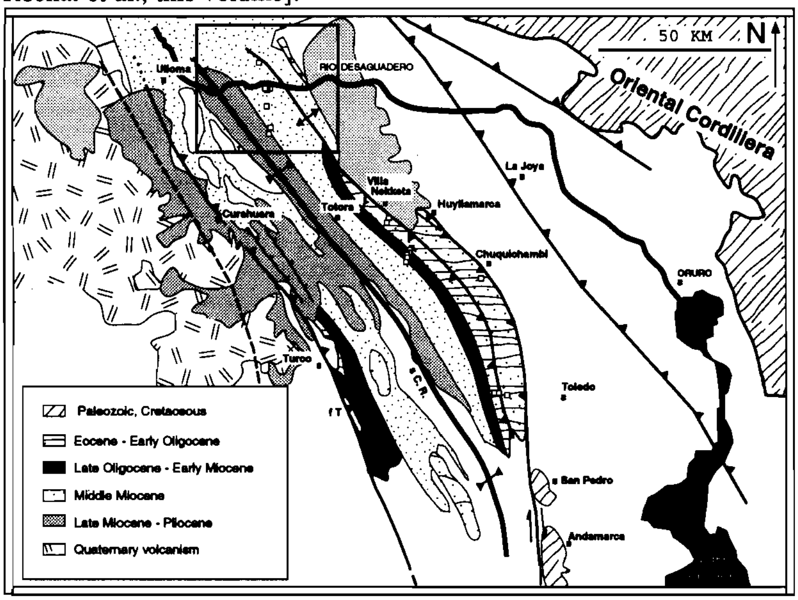

Figure 1: Simplified geologic map of the Central Bolivian Altiplano (modified from Rochat et al., in press). Squares correspond to the paleomagnetic sampling.

The sequence of Tertiary continental deposits is well exposed within the Corque syncline (Fig. 1). This structure is oriented N150 and its axis can be traced for more than 100 km. The lowest sedimentary sequence is the Eocene-Oligocene Tihuanaku formation which is well exposed on the eastern border of the basin. The age of this formation is poorly constrained because of the lack of fossils or interbedded volcanic units. This sequence is followed by the more conglomerate Coniri formation of Late Oligocene- Early Miocene age. The middle Miocene Totora formation overlay conformably the Coniri formation. Most of the deformation took place in late Miocene and the main tectonic structure is the curved Chuquichambi thrusts system.

We first did a paleomagnetic survey to determine the stability of the magnetization and evidence of a reliable magnetostratigraphic record.. Most of the successful studies in the Neogene basins of NW

Argentina deal with sediments rich in volcanoclastic and the remanent magnetization carried by magnetite. In contrast, the central Altiplano basin is mostly filled by red beds deposits.

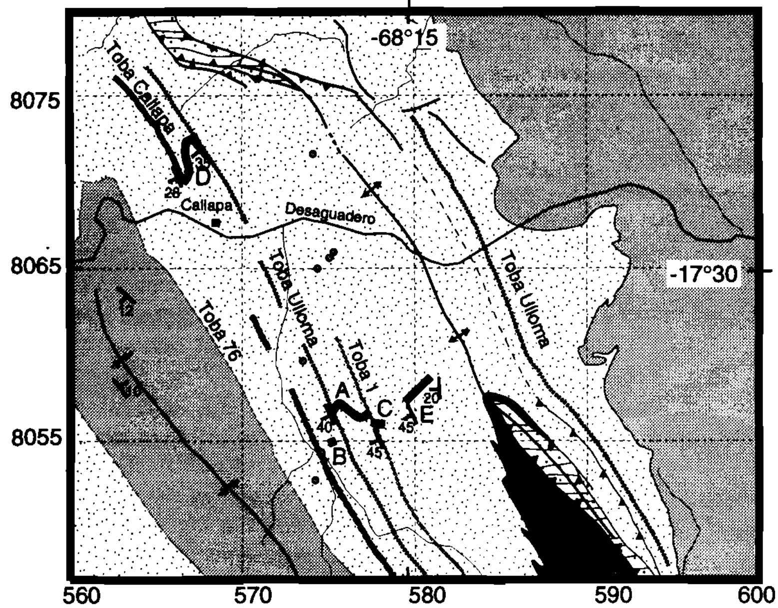

Figure 2: Map showing the locations of the magnetostratigraphic sections

The Tihuanaku formation (also named Huayllamarca) is mainly composed of consolidated fine red sandstones with interbedded red claystones. The sandstones do not record a stable magnetization and only the claystones have a stable remanence carried by hematite. The red claystones record in sequence normal or reverse polarity and this observation indicates a detrital or early diagenetic origin for the hematite. However, the lack of fresh exposure of a sufficiently continuous sequence has so far prevented the acquisition of a magnetostratigraphic record in the Tihuanaku formation. The Totora formation is mainly composed of poorly consolidated sandstones with interbedded claystones. After removal of 10 to 20 cm of weathered clays, instead of taking oriented blocks, we choose to drill the soft sediments with air-cooling; a technique which enables to collect a large number of samples (997 cores in this study).

MAGNETOSTRATIGRAPHY OF THE TOTORA FORMATION:

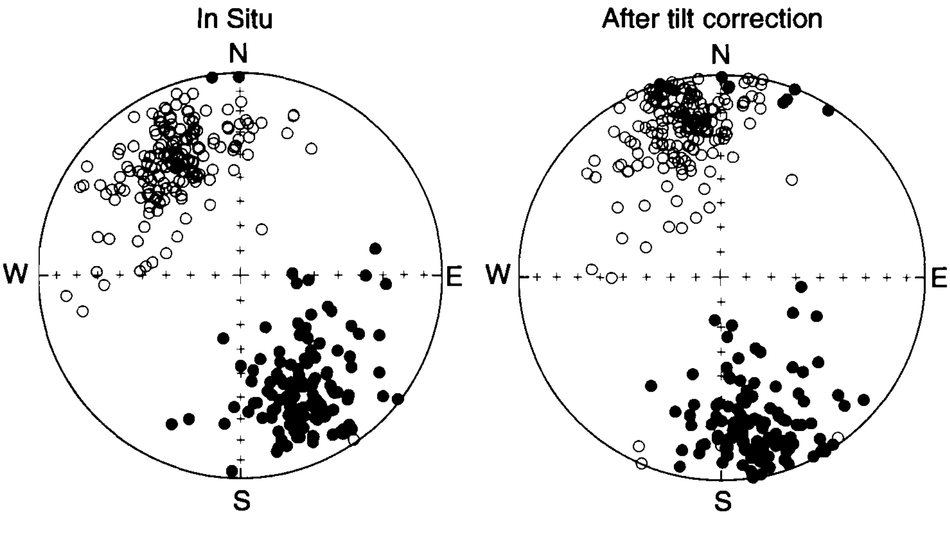

Figure 3: Equal-area projections of the characteristic magnetizations for section D in in situ and after tilt correction. Open (filled) symbols correspond to negative (positive) inclinations. In in situ coordinates the observed magnetizations are significantly different from the present day field. Normal and reverse polarity magnetizations are also antiparallel..

The Totora formation is a thick formation which outcrops largely on the eastern limb of the Corque Syncline with layers dipping to the west from about 45° to 30° (Figure 2). An other important feature of the Totora formation is the existence of numerous tuff layers and two of them have been previously dated by K-Ar and Ar^{39-40} radiometric dating. The Callapa and Ulloma tuffs are also well recognized in the field and they provide straightforward stratigraphic markers. We sampled four main sections (A, C, D and E). It was almost impossible to perform an E-W traverse perpendicular to the strike of the sedimentary sequence. The positions of the sampling sites were obtained by GPS positioning and the complete thickness of our magnetostratigraphic sequence was calculated according to the strike and dip of the structure. We arbitrarily put the base of our sequence at the base of section E. Sampling between the Ulloma and Callapa tuffs was performed north of the Callapa village. From the base of section E to the top of section D (Tuff Callapa), the sequence is about 4600m thick. The large sampling gap between sections E and C and the absence of radiometric control in the lower part of the section do not permit magnetostratigraphic dating of the lower part. We will only report the interpretation of the composite section (C+A+D). Normal and reverse polarities are observed. The magnetization is carried by magnetite and hematite. There is a slight increase in magnetic susceptibility toward the top of the sequence (from 2-3 10^{-4} to 10^{-3} SI) indicating the volcanism input in the sediments. The tilt toward the west of the sedimentary strata provides a good control on the age of the magnetization and we can discard the effect of viscous overprints in the present day field (Figure 3). The numerous radiometric datings of the Callapa and Ulloma tuffs indicate that this part of the magnetostratigraphic record should be correlated to the geomagnetic reversal polarity timescale [4] (GRPTS) in the time interval 8-11 Ma. The correlation of the observed magnetic record with the GRPTS shows that sediments were deposited from about 11.7 Ma to 9 Ma with an almost constant sedimentation rate of 0.97Km/Ma. Using this mean rate of sedimentation, the Ulloma tuff is dated at 10.23 Ma and the Callapa tuff at 9.17Ma. These estimates are in excellent agreement with the best ages given by Marshall et al. (1992) of 10.35±0.06 and 9.03±0.07Ma.

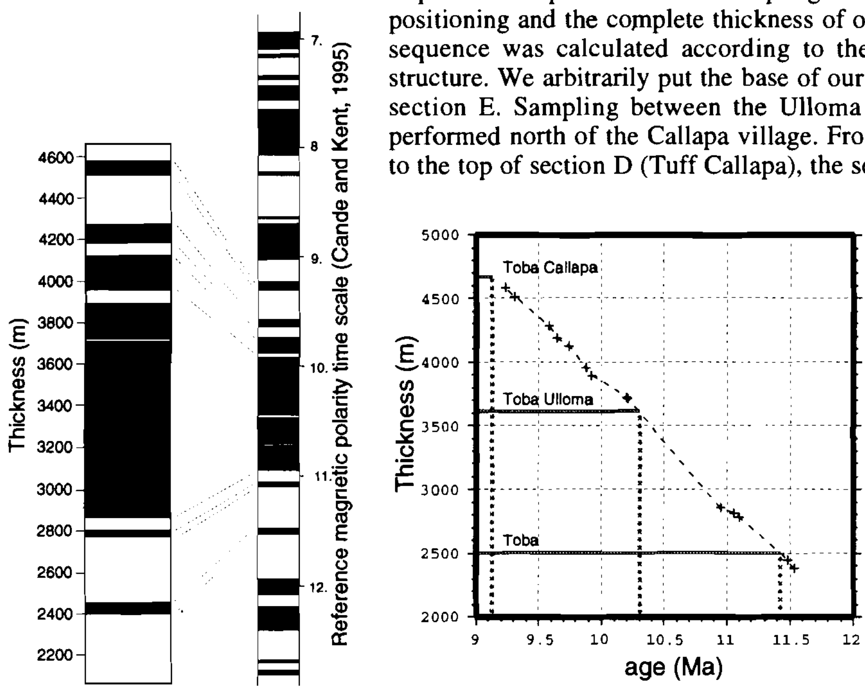

Figure 4: Correlation of the observed record with the GRPTS

TECTONIC ROTATION OF THE CENTRAL ALTIPLANO BASIN.

The Chuquichambi thrust system is characterized by its curved structure. This curved shape is possibly inherited or was enhanced during deformation. Nine paleomagnetic sites (129 cores) were drilled where the structures are NW oriented and 5 sites (71 cores) further south in the north trending structures. The mean declination for the northern sites is deflected from the expected direction by about 30° while the southern sites give 20° suggesting that most of the Chuquichambi curvature is possibly due a paleogeographic feature (Fig. 5). The two populations are however not statistically different. An additional sampling is needed to ensure the 10° difference between the two branches of the Chuquichambi structure. Nevertheless, our paleomagnetic study indicates that the whole Chuquichambi struture is rotated counterclockwise by about 20°

The paleomagnetic results from the dispersed sampling within the Totora formation as well as those from sections A,B and C and D (Fig.6) also confirm the existence of a counterclockwise rotation greater than 10° after 9 Ma. The consistency of the paleomagnetic results over several tens of kilometers demonstrates that the Central Altiplano basin rotated about 10° since the late Miocene. The respectively 20° and 10°

rotations are likely related to the shortening observed across the eastern cordillera and subsequently in the subandes.

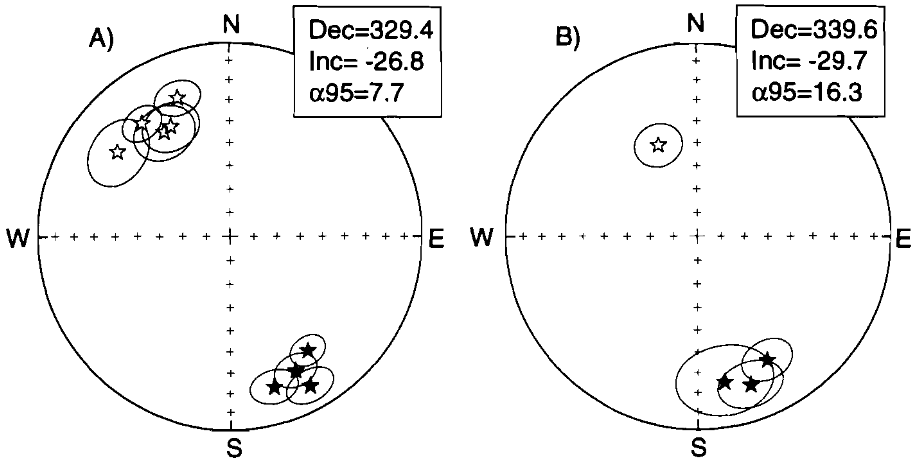

Figure 5: Paleomagnetic results from the Chuquichambi structure. A) northern branch, B) southern sites

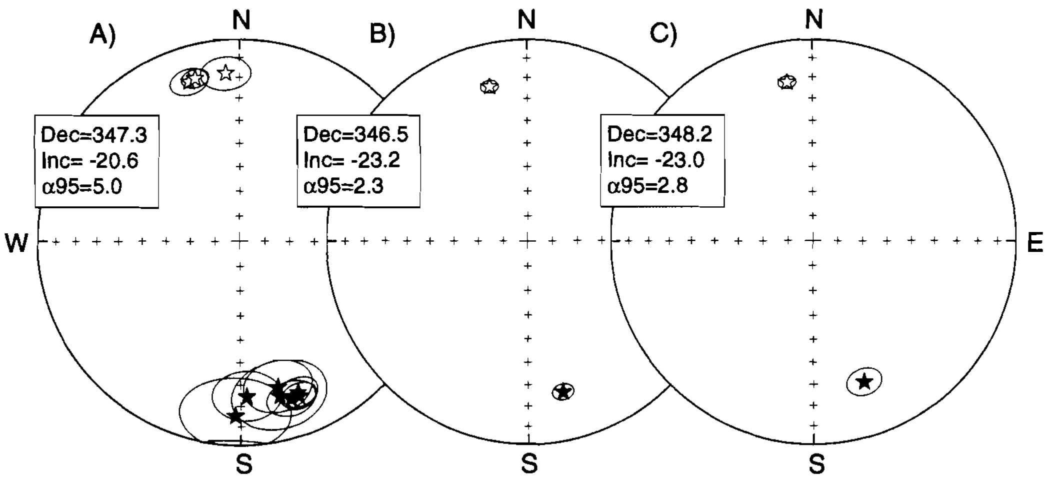

Figure 6: Paleomagnetic results from the Totora formation. A: dispersed sampling; B: section D mean 298 samples ; C: sections A+B+C mean 272 samples

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