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Paleomagnetism of Permo-Triassic and Cretaceous rocks from the Antofagasta region, northern Chile

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ABSTRACT

New paleomagnetic data from Permo-Triassic and Late Cretaceous rocks yield a consistent trend of vertical-axis-tectonic-rotations which are consistent with the Central Andean Rotation Pattern (CARP). However, three sites in the Tuina Formation and one site in the Purilactis Group record large rotations (80°). These mayor rotations are probably due to dextral-transpressive deformation occurring in close relation with the Incaic tectonic phase. Consequently, it is possible to infer that previous tectonic phases Peruvian and K-T would not have produced significant tectonic rotations in the area.

1. Introduction

The central Andes, a noncollisional orogeny, are a prime example of oroclinal bending (Isacks, 1988), the idea that mountain ranges form initially in a linear geometry and then are bent into their more highly curved configuration (Carey, 1955). The "Bolivian Orocline" is the change in trend of the Andes from NW to N near 18°S. The origin of the Bolivian Orocline has traditionally been studied with paleomagnetic data (e.g., Arriagada et al., 2003, 2006a, 2008; Beck, 1987; Coutand et al., 1999; Lamb, 2001; McFadden, 1990; Roperch and Carlier, 1992; Scanlan and Turner, 1992; Somoza and Tomlinson, 2002). Counterclockwise rotations with respect to stable South America are found along the Peruvian margin (Heki et al., 1984, 1985; May and Butler, 1985; Roperch and Carlier, 1992; Roperch et al., 2011) while clockwise rotations characterize the Chilean margin (Forsythe et al., 1987; Hartley et al., 1992a; Riley et al., 1993; Roperch et al., 1997). This pattern of tectonic rotations is usually called Central Andean Rotation Pattern (CARP) (Beck, 2004; Taylor et al., 2005; Roperch et al., 2006; Arriagada et al., 2008).

Mountain building in the Central Andes occurred mainly during the Cenozoic and this is the reason why paleomagnetic studies along the margin of northern Chile and Peru have been focused on essentially Jurassic, Cretaceous and Tertiary units (Fig. 1). While there are numerous paleomagnetic studies in Paleozoic rocks of the Argentinan Andes (Geuna and Ecosteguy, 2004), few studies have been reported for the Paleozoic-Triassic basement in the Andes of Northern Chile (Jesinkey et al., 1987). However, in the study of Jesinkey et al. (1987) there is no paleomagnetic data on Tertiary rocks to test the rotation history of this area.

In the present contribution, we will present paleomagnetic results from the Permo-Triassic Tuina Formation in an area where Cretaceous and Tertiary red beds have already been studied (Hartley et al., 1992a; Arriagada et al., 2000; Somoza and Tomlinson, 2002; Arriagada et al., 2003).

2. Tectonic setting

The oldest rocks found here correspond to a succession of andesitic lavas, tuffs and sandstones (Tuina Formation) deposited in a continental, volcanic environment (Mundaca, 1982). Continental sedimentary rocks of Albian to Maastrichtian-Danian age (Tonel,

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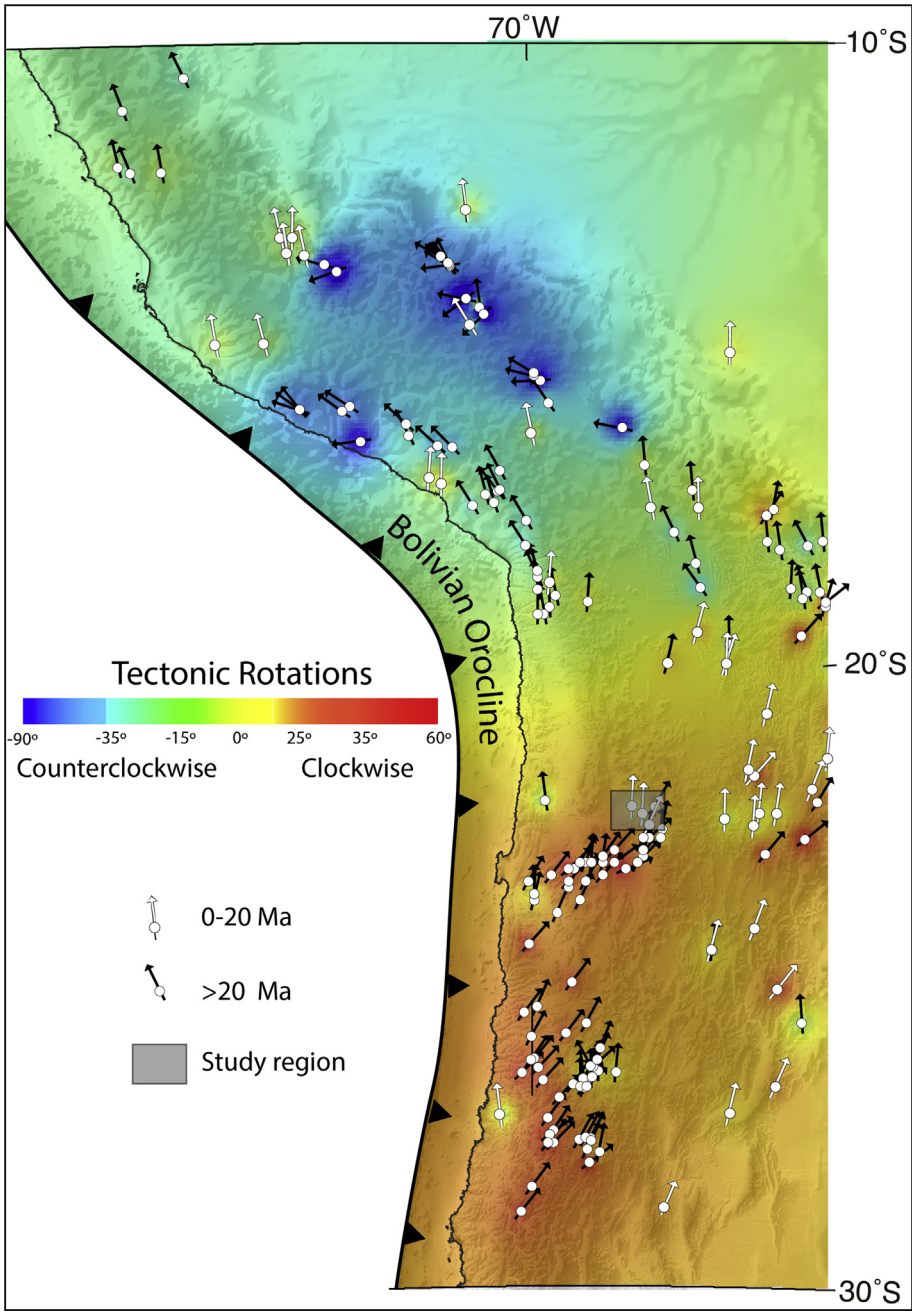

Fig. 1. Tectonic rotations in the central Andes. A raster surface based on the magnitude of rotations has been created by using the inverse distance weighting interpolation method. Paleomagnetically determined block rotations about vertical axes are shown as white arrows for rocks younger than 20 Ma and black arrows for rocks older than 20 Ma. Clockwise (counterclockwise) rotations are shown in warm colors (cool colors). The paleomagnetic database of the central Andes was obtained from Roperch et al. (2006) (see auxiliary material, available at ftp://ftp.agu.org/apend/tc/2005tc001882) and the database of the southern central Andes from Arriagada et al. (2006) (see auxiliary material, available at ftp://ftp.agu.org/apend/tc/2005tc001923).

Purilactis and Barros Arana Formations) lie on top of the former, in slight angular unconformity. A proximal, alluvial sedimentary environment is registered from the Late Oligocene onwards (Tambores Formation), which was deposited in angular unconformity over the Cretaceous and Paleogene units. The paleomagnetic sampling made for this study was performed on two first order morphostructural units: the Cordillera de Domeyko (Fig. 2), in the Cerros de Tuina Area, and the Barros Arana Syncline (Fig. 2), at the western border of the Salar de Atacama Basin.

The Cordillera de Domeyko of northern Chile, is a narrow, N–S oriented mountain chain situated in the Andean forearc. It is located between the Preandean Depression, which borders the Salar de Atacama to the east and the Central Depression to the west (Fig. 2). It has an average height of 3.000 m above sea level, and comprises successions of Paleozoic to Triassic volcano-sedimentary rocks, intruded by Carboniferous to Permian granitoids (Ramírez and Gardeweg, 1982). The volcano-sedimentary units found, whose bases are not exposed, are the Tuina Formation (Late Permian-Middle Triassic) (Raczynnski, 1963; Marinovic and Lahsen, 1984; Mundaca, 2002), the El Bordo Beds (Permian–Triassic) (Ramírez and Gardeweg, 1982), the Peine Group (Bahlburg and Breitkreuz, 1991), and the Cas Formation and its equivalents