Tectonophysics 637 (2014) 289–304

Contents lists available at ScienceDirect

Tectonophysics

journal homepage: www.elsevier.com/locate/tecto

# Counterclockwise rotations in the Late Eocene–Oligocene volcanic fields of San Luis Potosí and Sierra de Guanajuato (eastern Mesa Central, Mexico)

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ARTICLE INFO

*Article history:*
Received 23 January 2014
Received in revised form 14 October 2014
Accepted 18 October 2014
Available online 25 October 2014

*Keywords:*
Central Mexico
Paleomagnetism
Counterclockwise rotations
Tepehuanes-San Luis fault system
Sierra de Guanajuato
Oligocene

ABSTRACT

We used paleomagnetic and structural data to investigate the late Eocene–Oligocene tectonic evolution of the Mesa Central area in Mexico. The Mesa Central was affected by NW-trending faults (Tepehuanes-San Luis fault system) coeval with a Late Eocene–Oligocene ignimbrite flare-up and by post-27 Ma NNE-trending grabens related to the Basin and Range. We obtained reliable paleomagnetic directions from 61 sites within the Late Eocene–Oligocene volcanic series (~30 to ~27 Ma) of the San Luis Potosí volcanic field and Sierra de Guanajuato. For each site we also measured the anisotropy of magnetic susceptibility (AMS). Tilt corrections were made using AMS data for 33 sites where in situ bedding measurements were not available. Paleomagnetic directions indicate counterclockwise rotations of about 10° with respect to stable North America after 30–25 Ma. Structural data suggest that the volcanic succession was mainly affected by normal faults. However, we also found evidences for oblique or horizontal striae showing a left-lateral component along NW-trending faults and a right lateral component along NE-trending faults. Both motions are consistent with a N–S extension oblique to the Tepehuanes-San Luis fault system. Previous paleomagnetic studies in northern and southern Mexico show the prevalence of minor left-lateral shear components along regional-scale transpressional and transtensional lineaments. Our paleomagnetic data may reflect thus small vertical-axis rotations related to a minor shear component coeval with the Oligocene intra-arc extension in central Mexico.



## 1. Introduction

The central part of Mexico (the so-called "Mesa Central") is well known for its Late Eocene to Miocene volcanic succession. This region is particular since it has recorded the transition from the NW-trending Late Eocene–Oligocene ignimbritic and rhyolitic volcanic arc (Sierra Madre Occidental, Ferrari et al., 2005) related to the subduction of the Farallon plate (Atwater, 1970) to the Late Miocene–Pliocene early stages of the E-trending Trans-Mexican Volcanic Belt resulting from the subduction of the Cocos plate (Ferrari et al., 1999, 2000). The Mesa Central is also well known from a structural point of view. This region forms a complex extensional domain resulting from two major events. The first one (~32 to 27 Ma) is synchronous with the so-called ignimbrite flare-up (Aranda-Gómez et al., 2007; Labarthe-Hernández et al., 1982; McDowell and Clabaugh, 1979) and resulted in a regional (~600 km long) array of NW-trending faults commonly referred as the Tepehuanes-San Luis fault system (Fig. 1, Nieto-Samaniego et al., 2005). The second event (post 27 Ma) is usually related to the "Basin and Range" (Ferrari et al., 2000; Henry and Aranda-Gómez, 1992; Nieto-Samaniego et al., 1999) and produced large-scale N- to NNE-trending grabens, which form the most significant morphological features in central Mexico (Fig. 1).

The Late Eocene–Oligocene volcanic sequence of the Mesa Central consists mainly of ignimbritic flows and rhyolitic domes. The stratigraphy and ages of these units are remarkably well constrained in the eastern part of the Mesa Central (Gross, 1975; Labarthe-Hernández et al., 1982; Nieto-Samaniego et al., 1996). The bulk of the volcanic deposits was emplaced in a short period of time between 30 and 27 Ma. Pyroclastic sequences form large tabular surfaces which are well suited for paleomagnetic studies (e.g., Alva-Valdivia et al., 2005; Gattacceca et al., 2007; Molina-Garza et al., 2012). Paleomagnetic studies have focused on younger volcanism in this region (e.g., Conte-Fasano et al., 2006; Maciel-Peña et al., 2011; Uribe-Cifuentes and Urrutia-Fucugauchi, 1999) whereas the Eocene-Oligocene volcanism of this region has received little attention. However, the few existing studies show that reliable paleomagnetic directions can be retrieved from these units (e.g., Aranda-Gómez et al., 2007).

Previous paleomagnetic studies in Mexico were mainly carried along the present day Trans- Mexican Volcanic Belt. This volcanic arc is affected

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http://dx.doi.org/10.1016/j.tecto.2014.10.015
0040-1951/

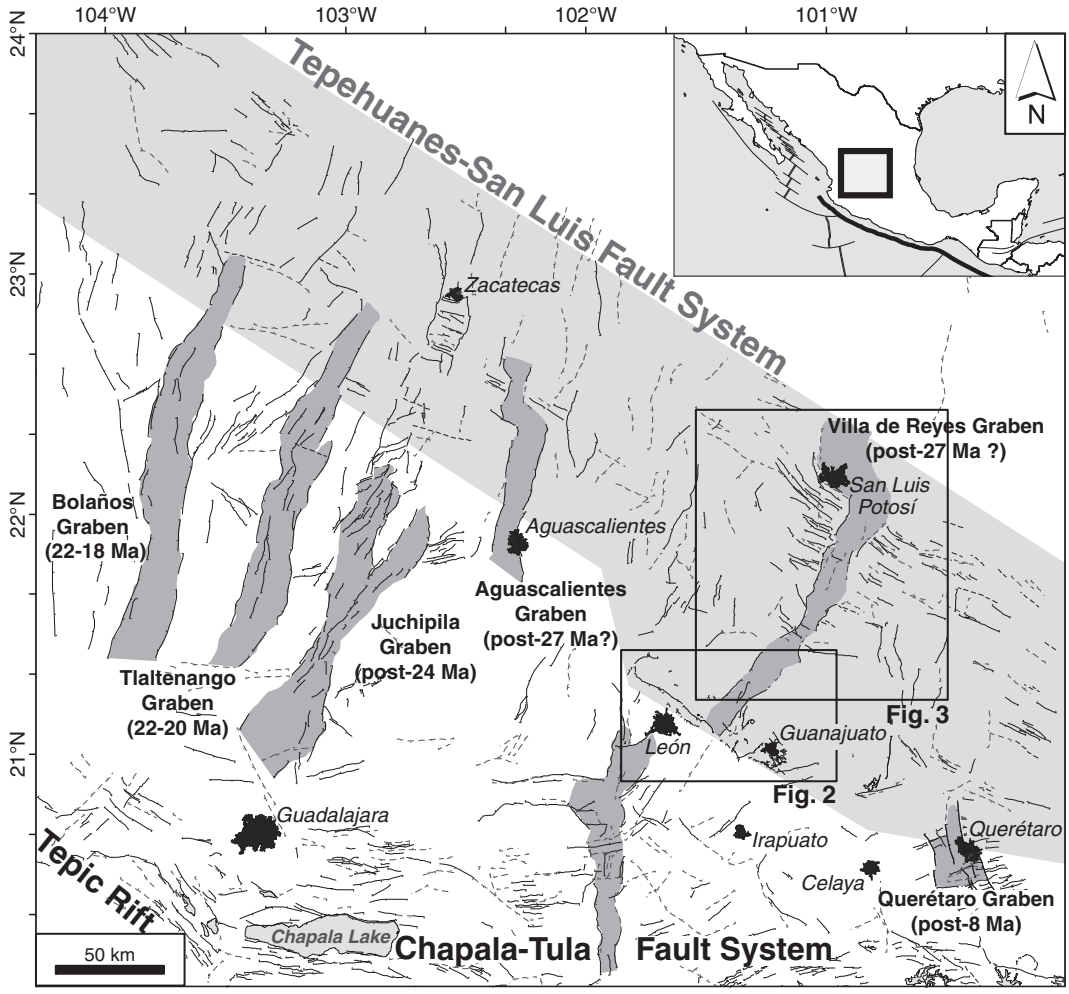


**Fig. 1.** Structural map of the extensional domain in central Mexico. Lines represent faults. Dashed lines represent lineaments interpreted from DEM. Light grey area represents the extend of NW-trending normal faults synchronous of the Late Eocene-Oligocene volcanic pulse (Tepehuanes-San Luis and El Bajío fault systems). Dark grey areas represent the depressions associated to the structures related to the southern Basin and Range domain.

by the E- to NE-trending faults of the Chapala-Tula Fault System (Fig. 1, Johnson and Harrison, 1990; Langridge et al., 2000; Suter et al., 2001; Szynkaruk et al., 2004), which accommodate a left-lateral transtension related to the motion of the fore-arc sliver (Andreani et al., 2008; Ego and Ansan, 2002; Johnson and Harrison, 1990). Paleomagnetic results show counterclockwise rotations ranging between 8.9° ± 6.4° and 12.4° ± 5.4° (e.g., Ruiz-Martínez et al., 2000; Soler-Arechalde and Urrutia-Fucugauchi, 2000). Other studies in northern Mexico show counterclockwise rotations of about 15° (Goguitchaichvili et al., 2001; Nowicki et al., 1993; Urrutia-Fucugauchi, 1981). These rotations took place along several NW-trending lineaments resulting from the reactivation of the Sonora-Mojave Megashear during the Paleogene (e.g., Aranda-Gómez et al., 2005; Flotte et al., 2008; Gray et al., 2008).

The aim of this work was to extend paleomagnetic and structural investigations in the central part of Mexico in order to determine if measurable block rotations were produced along the NW-trending Tepehuanes-San Luis fault system or the NNE-trending grabens. We present paleomagnetic results and structural data from sites located within the San Luis Potosí volcanic field and Sierra de Guanajuato (easternmost part of the Mesa Central). Our data cover the complete Late Eocene-Oligocene volcanic succession. For each site we extracted paleomagnetic directions and tilt corrections were based on both in situ and anisotropy of magnetic susceptibility (AMS) data. We also provide structural data based on striated fault planes from sampled areas. Finally, we discuss the computed mean paleomagnetic rotations and their structural implications.

## 2. Geological setting

### 2.1. Regional stratigraphy

The oldest rocks outcropping in the Mesa Central are Mesozoic and belong to three paleogeographical domains. The first one is the Lower Cretaceous volcano-plutonic succession of the Guerrero block (Centeno-Garcia et al., 1993). This sequence outcrops mainly in the Sierra de Guanajuato (Fig. 2) and is interpreted as the remnants of an intra-oceanic island arc (Monod et al., 1990; Martínez-Reyes et al., 2004). Towards the NNE this arc sequence overlaps a second Upper Jurassic/Lower Cretaceous volcano-sedimentary sequence, the so-called Arperos Formation (Monod et al., 1990; Ortiz-Hernández and Martínez-Reyes, 1993). The Arperos Formation is interpreted as an oceanic basin that was subducted at the end of the Lower Cretaceous, when the Guerrero block was accreted to the North American craton (Freydier et al., 1996). The last domain extends northwest of the previous ones and is part of the so-called Sierra Madre Oriental fold-and-thrust belt. It consists in Tethyan carbonate platforms and epicontinental basins folded and thrusted during the Laramide orogeny (late Cretaceous to early Paleocene).

Paleocene and Eocene continental deposits consist of sands and conglomerates derived from the dismantling of the Sierra Madre Oriental fold-and-thrust belt. They are locally outcropping in the Sierra de Guanajuato (Aranda-Gómez and McDowell, 1998; Edwards, 1955) and San Luis Potosí areas (the so-called Cenicera Formation;