Tectonophysics 623 (2014) 1–13

Contents lists available at ScienceDirect

Tectonophysics

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

Constraints for the recent tectonics of the El Salvador Fault Zone, Central America Volcanic Arc, from morphotectonic analysis

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ARTICLE INFO

Article history:
Received 18 April 2013
Received in revised form 16 October 2013
Accepted 12 March 2014
Available online 20 March 2014

Keywords:
Active tectonics
Hypsometry
Tectonic geomorphology
Transtension
El Salvador Fault Zone
Strike-slip fault

ABSTRACT

We have used hypsometric analysis to improve our understanding of the current tectonic deformation and structure of El Salvador Fault Zone; a N90°E oriented strike-slip fault zone that extends 150 km through El Salvador, Central America. Our results indicate an important amount of transtensive strain along this fault zone, providing new data to understand the tectonic evolution of the Salvadorian volcanic arc. We have defined kilometric scale tectonic blocks and its relative vertical movements, length of segments with homogeneous vertical motions and lateral relay of active structures. We have identified and quantified slip-rate variations along-strike of the El Triunfo fault within El Salvador Fault Zone, ranging from 4.6 mm/year in its central parts to 1 mm/year towards the tips of the fault. This study supports the hypothesis of a recent rotation in the maximum shortening direction, and the accommodation of the current deformation through the reactivation of pre-existing structures inherited from a previous tectonic regime.

1. Introduction

El Salvador is located in northern Central America, in the western margin of the Caribbean plate. Crossing El Salvador with a N90°E direction, there is a 150 km long right lateral strike-slip fault zone first described by Martínez-Díaz et al. (2004) and named as El Salvador Fault Zone. The southern area of the country is part of the forearc sliver of the Caribbean plate, while the northern part of this country belongs to the Chortís Block (Fig. 1A), a continental block composed by a Paleozoic basement, mesozoic marine sediments and volcanic material associated to the Cocos plate subduction beneath this block (Rogers et al., 2002).

The neotectonic evolution of the Chortís Block region has been studied by many authors at different scales and using several tools. At a regional scale, it has been studied using GPS data, numerical modeling and through seismotectonics and seismologic analysis (i.e. Álvarez-Gómez et al., 2008; Cáceres et al., 2005; Correa-Mora et al., 2009; DeMets et al., 2007; Franco et al., 2012; Guzmán-Speziale, 2001). At a local scale, faulting and tectonics in the Central America Volcanic Arc have been studied through paleoseismology and tectonic geomorphology (Canora et al., 2012; Corti et al., 2005; Ruano et al., 2008). All of these authors conclude the existence of a transtensive regime in the western boundary of the Chortís Block. The transtensive regime along the volcanic arc is driven by the relative eastward drift of the Caribbean plate relative to the North America plate, being the forearc sliver pinned to the North American plate (Álvarez-Gómez et al., 2008). Also, it is important to highlight that there is an important change in scale between the studies done on the Chortís Block at a regional scale and the detailed studies carried out in different segments of the ESFZ. This makes it difficult to compare local observations with the regional morphotectonic features in the area.

For these reasons we consider it necessary to tackle this problem developing an intermediate scale study in order to improve our understanding of the ESFZ, its tectonic behavior and hazard implications. The transtensive regime may be reflected in local tectonic and geomorphological evidences and in the structural and geomorphological characteristics of the ESFZ (Fig. 1B). The analysis of the recent morphotectonics along this fault zone using geomorphological indexes can be useful to address these aspects.

The study of the recent topographic development and the use of geomorphological indexes are adequate tools for the quantification of the active tectonics (Burbank and Anderson, 2001; Keller and Pinter, 2002). At Central America the studies developed using geomorphological indexes are scarce (i.e. Álvarez-Gómez, 2009; Hare and Gardner, 1985; Morell et al., 2012). Previous studies describe a transtensive tectonic regime at the Central America Volcanic Arc in El Salvador (Fig. 1A), which induces relative vertical motions on the faults within El Salvador Fault Zone (i.e. Álvarez-Gómez et al., 2008; Cáceres et al., 2005; Canora et al., in press). We have mainly utilize hypsometry

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http://dx.doi.org/10.1016/j.tecto.2014.03.012
0040-1951/

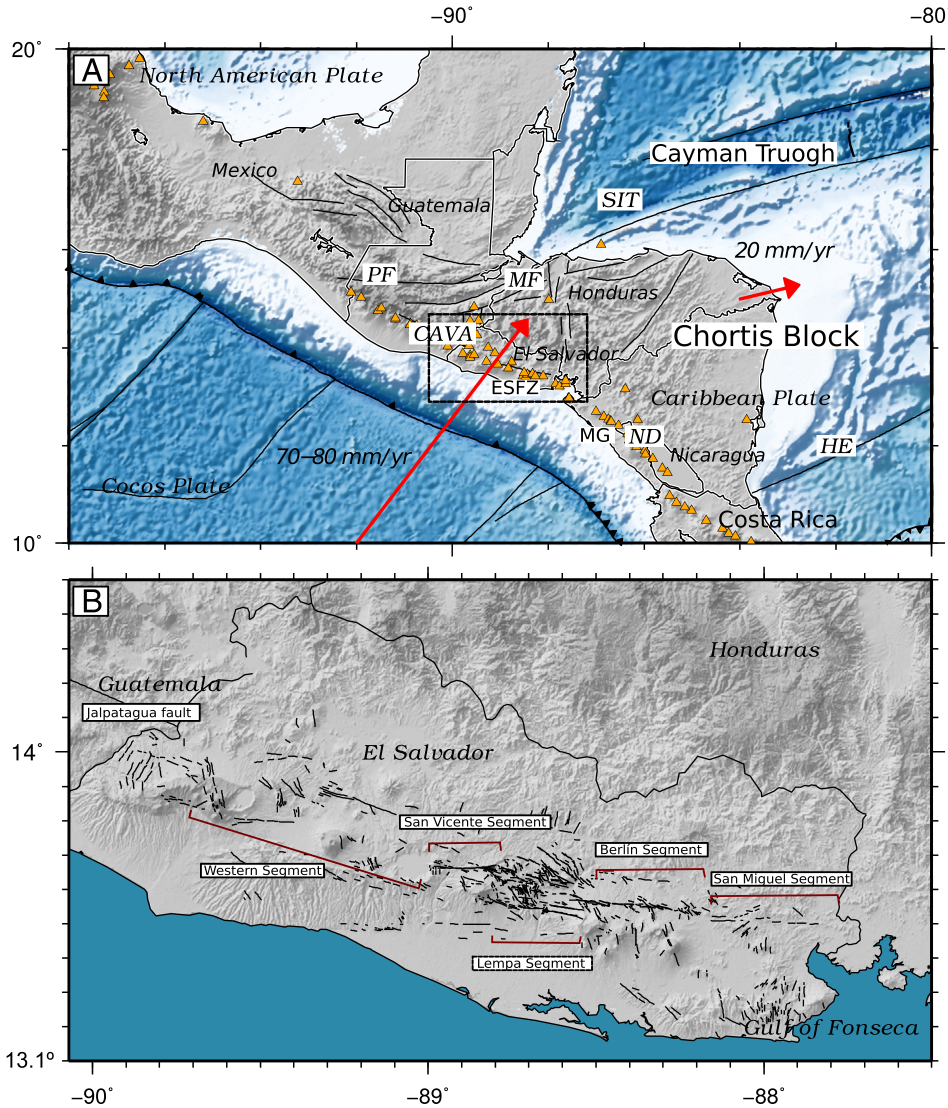

Fig. 1. A: Tectonic setting of northern Central America. Red arrows show relative displacements and its magnitude. Orange triangles show volcanoes from Central America Volcanic Arc. Area enclosed in rectangle is Fig. 1B. Abbreviations are: SIT: Swan Island Transform; MF: Motagua Fault; PF: Polochic Fault; ND: Nicaraguan Depression; HE: Hess scarp; CAVA: Central America Volcanic Arc. B: SRTM image of El Salvador. Black lines are main and secondary active faults, after Canora et al. (2012).

(Strahler, 1952), because the possible dip-slip component in the faults forming ESFZ should be reflected on this index. The relative vertical movements associated to these faults may create differences in the evolution of the adjacent basins. The measuring of the area–altitude relationships of the basins could reflect the relative motions of the hanging and foot walls of the faults (Keller and Pinter, 2002). Up to know, studies in active tectonics in El Salvador have been focused on the strike-slip motion of the ESFZ (i.e. Corti et al., 2005; Martinez-Díaz et al., 2004), but there are no studies focused on the relative vertical motion related to these faults.

In this work we define kilometric scale tectonic blocks and its relative movements to constrain the recent strain distribution along the ESFZ, the length of segments with homogeneous vertical movements and the lateral relay of active structures. The results of this study support the hypothesis of a recent rotation in the maximum shortening direction, and the accommodation of the current deformation along structures formed in a previous tectonic frame. A similar tectonic evolution in Nicaragua as described by Weinberg (1992) is interpreted from the results of this work of El Salvador.

2. Tectonic setting

El Salvador is located in the western margin of the Chortís Block, where a volcanic arc is present (Central America Volcanic Arc), extending from northern Costa Rica to Guatemala. The Central America Volcanic Arc (CAVA) ends abruptly at the Polochic Fault in Guatemala (Fig. 1A). The volcanic arc has been divided into three main zones according to its orientation, the style of its structures and geomorphology (Álvarez-Gómez, 2009). From south to north the main structures within the Central America Volcanic Arc are: The Nicaraguan Depression, from Northern Costa Rica to the eastern Gulf of Fonseca (McBirney and Williams, 1965; van Wik de Vries, 1993), the El Salvador Fault Zone, from western Gulf of Fonseca to approximately El Salvador–Guatemala border (Martínez-Díaz et al., 2004) and the Jalpatagua Fault in Guatemala (Carr, 1976).

The northern boundary of the Chortís block is the Motagua–Polochic–Swan Island transform fault (North boundary of the Caribbean plate), a fault zone with pure left lateral strike-slip motion. The interaction between the Caribbean, North America and Cocos plates results in a