Journal of South American Earth Sciences 71 (2016) 309–319

Contents lists available at ScienceDirect

Journal of South American Earth Sciences

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

Present-day stress tensors along the southern Caribbean plate boundary zone from inversion of focal mechanism solutions: A successful trial

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ARTICLE INFO

Article history:
Received 18 September 2015
Received in revised form
7 June 2016
Accepted 11 June 2016
Available online 14 June 2016

Keywords:
Stress tensor
Fault-slip data
Quaternary tectonics
Focal mechanism solution (FMS)
Caribbean
Venezuela

ABSTRACT

This paper presents a compilation of 16 present-day stress tensors along the southern Caribbean plate boundary zone (PBZ), and particularly in western and along northern Venezuela. As a trial, these new stress tensors along PBZ have been calculated from inversion of 125 focal mechanism solutions (FMS) by applying the Angelier & Mechler's dihedral method, which were originally gathered by the first author and published in 2005. These new tensors are compared to those 59 tensors inverted from fault-slip data measured only in Plio-Quaternary sedimentary rocks, compiled in Audemard et al. (2005), which were originally calculated by several researchers through the inversion methods developed by Angelier and Mechler or Etchecopar et al.

The two sets of stress tensors, one derived from geological data and the other one from seismological data, compare very well throughout the PBZ in terms of both stress orientation and shape of the stress tensor. This region is characterized by a compressive strike-slip (transpressional *senso lato*), occasionally compressional, regime from the southern Mérida Andes on the southwest to the gulf of Paria in the east. Significant changes in direction of the maximum horizontal stress ($\sigma_H = \sigma_1$) can be established along it though. The σ_1 direction varies progressively from nearly east-west in the southern Andes (SW Venezuela) to between NW-SE and NNW-SSE in northwestern Venezuela; this direction remaining constant across northern Venezuela, from Colombia to Trinidad. In addition, the σ_V defined by inversion of focal mechanisms or by the shape of the stress ellipsoid derived from the Etchecopar et al.'s method better characterize whether the stress regime is transpressional or compressional, or even very rarely trantensional at local scale.

The orientation and space variation of this regional stress field in western Venezuela results from the addition of the two major neighbouring interplate maximum horizontal stress orientations (σ_H): roughly east-west trending stress across the Nazca-South America type-B subduction along the pacific coast of Colombia and NNW-SSE oriented one across the southern Caribbean PBZ. Meanwhile, northern Venezuela, although dextral strike-slip (SS) is the dominant process, NW-SE to NNW-SSE compression is also taking place, which are both also supported by recent GPS results.

1. Introduction

Following the integration of stress tensors derived from fault-slip data and compilation of focal mechanism solutions (FMS) published by Audemard et al. (2005) for the southern Caribbean plate boundary zone (PBZ), this paper presents 16 new regionally-consistent stress tensors obtained from inversion of the 125 FMS compiled in that work from all over northern and western Venezuela. The Dihedral method developed by Angelier and Mechler (1977) was applied to invert FMS into present-day stress tensors. After being compared to the 59 tensors derived from fault data of Audemard et al. (2005), these tensors are discussed in terms of their significance with respect to the interactions among the Caribbean, South America and Nazca plates and other involved minor continental blocks of north-western South America, as well

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http://dx.doi.org/10.1016/j.jsames.2016.06.005
0895-9811/

as to the Quaternary or active tectonics of the southern Caribbean PBZ.

2. Geodynamic setting

The present-day tectonics of northern South America is complex because several plates and blocks interact: the Caribbean, South America and Nazca plates, Panamá microplate and other minor blocks (Chocó, North Andean, Bonaire, and Maracaibo Blocks; Fig. 1), which are squeezed by above mentioned larger plates. Northern Venezuela essentially lies in the direct interaction zone between the Caribbean and South America plates, whereas western Venezuela and northern Colombia show a more complex geodynamic setting involving a number of tectonic blocks or microplates (Fig. 1). A wide consensus establishes that the Caribbean plate moves eastward relatively to South America (Bell, 1972; Malfait and Dinkelman, 1972; Jordan, 1975; Pindell and Dewey, 1982; Sykes et al., 1982; Wadge and Burke, 1983; Audemard et al., 2005; Audemard, 2014; among others), this being confirmed by over twenty years of GPS results (Freymueller et al., 1993; Kaniuth et al., 1999; Weber et al., 2001; Pérez et al., 2001a, b; Trenkamp et al., 2002; Jouanne et al., 2011; Pérez et al., 2011; Reinoza, 2014; Reinoza et al., 2014, 2015). However, this Caribbean-South America plate boundary —which drives and defines active tectonics along northern Venezuela (from Colombia to Trinidad)- is not of the simple dextral type (Soulas, 1986; Beltrán, 1994) since it is an over 100 km wide active transpressional PBZ (Audemard, 1993; Singer and Audemard, 1997; Audemard, 1998; Ysaccis et al., 2000; Audemard et al., 2005; Audemard, 2009, 2014), partly occurring offshore and onshore northern Venezuela. Very important positive reliefs within the onshore portion of the PBZ, such as the Coastal and Interior ranges, are along the north-central and northeastern Venezuelan coast (shown in Fig. 2). This wide transpressional boundary (in its widest definition, meaning coexistence of strike-slip and compression but not necessarily accommodated jointly on one single structure) extends southwestward into the Mérida Andes. The southern Caribbean PBZ in western Venezuela is eventually up to 600 km wide and comprises a set of discrete tectonic blocks or microplates (Fig. 1), independently moving among the surrounding larger plates (Caribbean —CA-, South America —SA- and Nazca —NZ-), among which the Maracaibo block stands out for its perfect triangular shape (TMB in Fig. 1). This independent block is bounded by the left-lateral strike-slip Santa Marta-Bucaramanga fault (SMBF) in Colombia and right-lateral strike-slip (RLSS) Boconó fault (BF) in Venezuela and separated on the north from the Bonaire block —BB- by the RLSS Oca-Ancón fault (OAF). Besides, both Maracaibo and Bonaire blocks are roughly being extruded northward —while the Bonaire block also moves

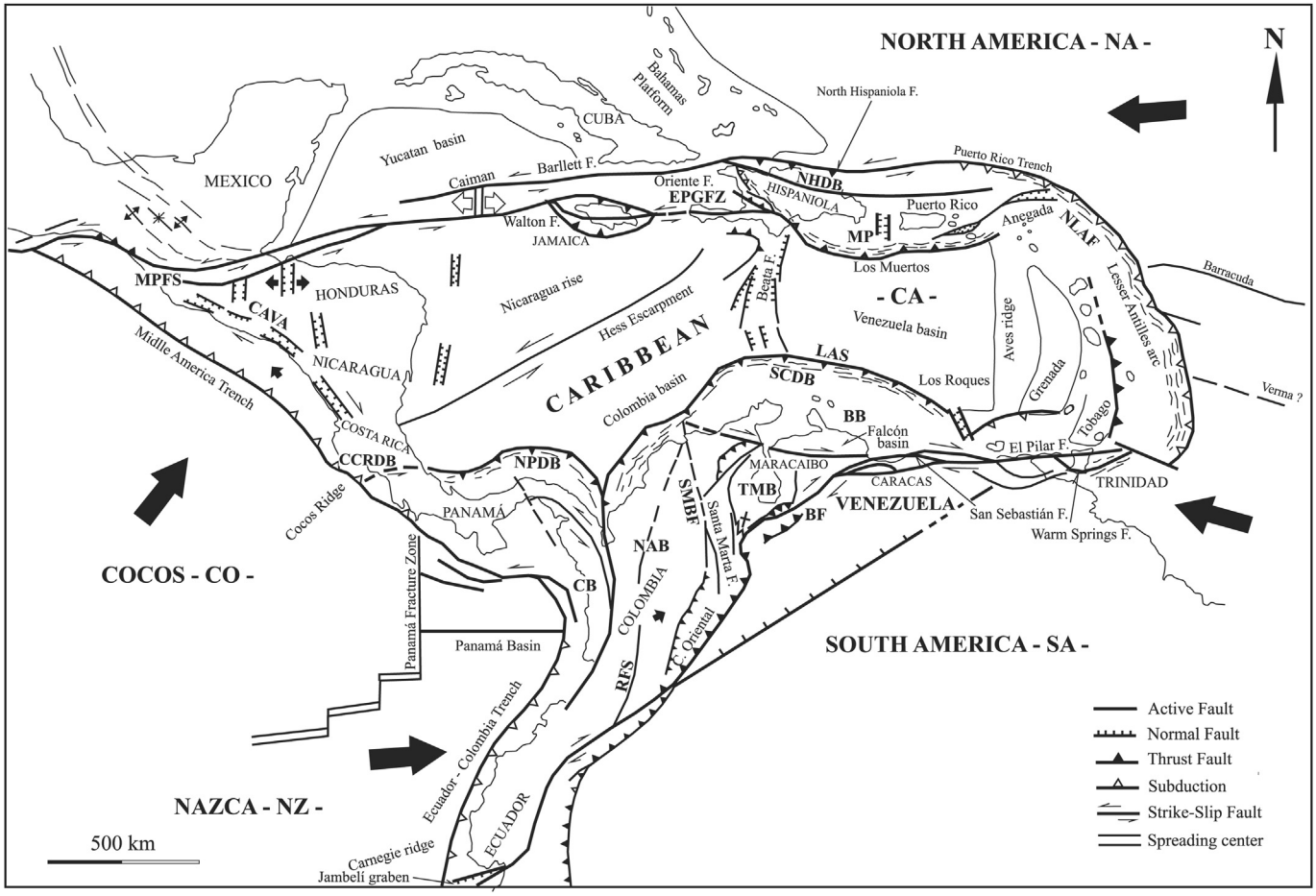

Fig. 1. Major tectonic features of the Caribbean region (Audemard, 2014; modified from Stephan, 1982). Abbreviations (same as in text): BB Bonaire block; BF Boconó fault; CAVA Central America volcanic arc; CB Chocó block; CCRDB Central Costa Rica deformed belt; EPGFZ Enriquillo-Plantain Garden fault zone; LAS Leeward Antilles subduction; MPFS Motagua-Polochic fault system; NAB North Andes block; NHDB North Hispaniola deformed belt; NLAF Northern Lesser Antilles forearc; NPDB North Panamá deformed belt; SCDB Southern Caribbean deformed belt; SMBF Santa Marta-Bucaramanga fault; TMB Triangular Maracaibo block. Large solid black arrows are plate vectors relative to the Caribbean plate. The discontinuous NE-SW fault extending across the Colombian and Venezuelan Llanos is thought as a potential future major simplification of the NW South America PBZ, by connecting the NZ-SA and CA-SA subductions from Guayaquil gulf to southern Trinidad.