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The northern Caribbean plate boundary in the Jamaica Passage: Structure and seismic stratigraphy

J. Corbeau [a,*], F. Rolandone [a], S. Leroy [a], B. Mercier de Lépinay [b], B. Meyer [a], N. Ellouz-Zimmermann [c], R. Momplaisir [d]

[a] Sorbonne Universités, UPMC Univ Paris 06, CNRS, Institut des Sciences de la Terre de Paris (iSTeP), 4 place Jussieu, 75005 Paris, France
[b] Géoazur, CNRS, Univ. Sophia-Antipolis, Valbonne, France
[c] IFPEnergies Nouvelles, Rueil-Malmaison, France
[d] Université d'Etat d'Haiti, Port au Prince, Haiti

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ABSTRACT

Multibeam bathymetry data and multichannel seismic reflection profiles have been collected at the end of 2012 along the Enriquillo-Plantain-Garden Fault Zone (EPGFZ) in the Jamaica Passage, between Jamaica and Hispaniola. Analysis of the data set reveals the tectonic evolution and the stratigraphic complexity of the northern Caribbean boundary. Stratigraphic correlations with previous marine and on land studies are proposed to place the identified seismic sequences in their regional tectonic history. Two distinct crustal domains are interpreted. Typical stratigraphic sequences for the rifted blocks of the Eastern Cayman Trough margin are identified in five basins of the Jamaica Passage, highlighting the eastward limit of the Cayman Trough margin. These inherited basins are deformed and folded during a first phase of compression that could correspond to the regional tectonic rearrangement recorded in the early Miocene (about 20 Ma). A distinct crustal domain that we propose to relate to the Carib Beds (Caribbean typical reflectors A″, B″ and V) is identified in the southern part of the Jamaica Passage, indicating that the Caribbean Large Igneous Province could extend up to the extreme northeast part of the Lower Nicaragua Rise. The left-lateral EPGFZ currently cuts across two pre-existing basins, the Morant and Matley basins. During the activity of the EPGFZ, these basins are deformed and folded indicating a second phase of compression. In contrast, the Navassa basin, located in the middle of the Jamaica Passage, results from the strike-slip motion of the EPGFZ and is interpreted as an asymmetrical basin bordered by the EPGFZ only on its northern side.

1. Introduction

The deadly Mw 7.0 Haiti earthquake of 2010 reminded us of the necessity to characterize the structures and improve understanding of the tectonic processes acting along the northern Caribbean plate boundary. This plate boundary extends from Central America to Puerto Rico and is defined mainly by offshore strike-slip faults, including the Swan Fault, the Septentrional-Oriente Fault Zone (SOFZ), the Walton Fault and the Enriquillo-Plantain-Garden Fault Zone (EPGFZ; Fig. 1). Although previous seismic reflection data acquisition has led to a description of the seismic stratigraphy of the eastern Cayman Trough and the northeastern Lower Nicaraguan Rise (Fig. 1; Leroy et al., 1996; Mauffret and Leroy, 1997; Mauffret and Leroy, 1999), our knowledge of the tectonics remains sparse along several segments of the Northern Caribbean plate boundary. For example, our knowledge of the Jamaica Passage between Jamaica and Hispaniola, which is crossed by the EPGFZ, was formerly based on widely-spaced and low resolution seismic reflection profiles and bathymetry (Robinson and Cambray, 1971; Horsfield and Robinson, 1974; Case and Holcombe, 1980; Mann et al., 1995). During November–December 2012, a marine geophysical survey (HAITI-SIS) was carried out aboard the Research Vessel *L'Atalante* around the northern Caribbean plate boundary to unravel the detailed geometry of the active fault system (Leroy et al., 2015).

Our study focuses on the Jamaica Passage, with the aim of deciphering and characterizing its structure and stratigraphy (Fig. 1). We use high-resolution multibeam bathymetry and 60 multi-channel seismic reflection profiles to image the EPGFZ and the crustal domains between Jamaica and Hispaniola. The bathymetric map highlights the recent fault trace of the EPGFZ as well as distinct morphological features. The seismic reflection profiles acquired during the HAITI-SIS cruise are compared with former reflection seismic studies in the Caribbean area in order to define the main stratigraphic sequences in the Jamaica Passage. Based on morphological, structural and sedimentological criteria derived from the combined interpretation of the bathymetry and seismic data, we identify two distinct crustal domains and two distinct

* Corresponding author.
E-mail address: jordane.corbeau@upmc.fr (J. Corbeau).

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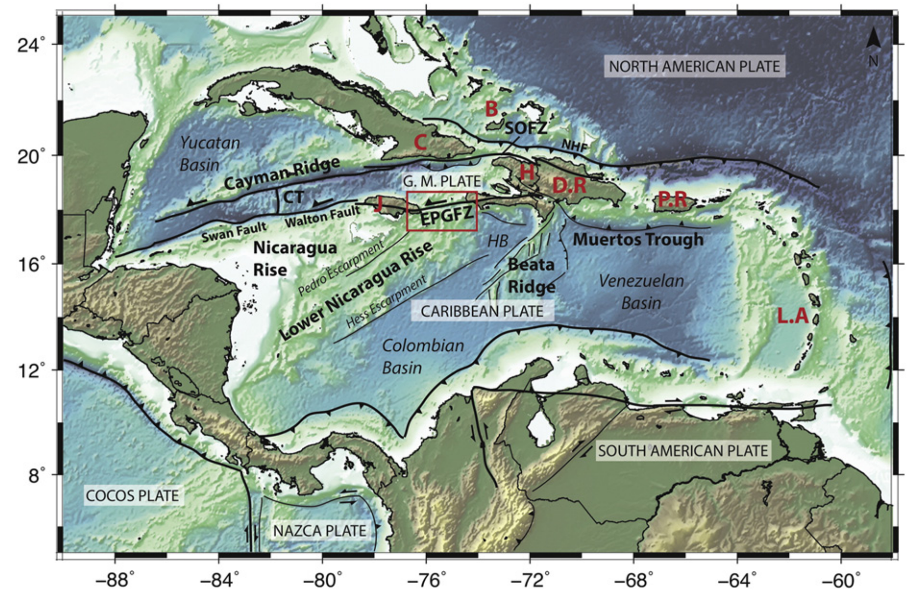

Fig. 1. Tectonic map of the Caribbean. CT: Cayman Trough, EPGFZ: Enriquillo-Plantain-Garden Fault Zone, SOFZ: Septentrional-Oriente Fault Zone, NHF: North Hispaniola Fault, C: Cuba, J: Jamaica, B: Bahamas, H: Haiti, D.R: Dominican Republic, P.R: Puerto Rico, L.A: Lesser Antilles, G. M. PLATE: Gonâve micro-plate, HB: Haitian sub-basin. The red rectangle indicates the study area. Topography and bathymetry are from the 2 arc-minute global relief of Earth's surface ETOPO.

basin structures in the vicinity of the EPGFZ. The new HAITI-SIS data set is then used to propose a structural sketch of the Jamaica Passage and highlights its main tectonic features.

2. Geological setting

The Caribbean plate's interior is mainly formed by a Cretaceous Oceanic Plateau, known as the Caribbean Large Igneous Province (CLIP). This province is covered by extended lava flows of varying thickness that cover an igneous basement. Seismic stratigraphy studies of the Caribbean crust have described several seismic units typical of oceanic material in the Colombian Basin (Lu and McMillen, 1982; Bowland, 1993) and in the Venezuelan Basin (Ladd and Watkins, 1980; Ladd et al., 1990; Diebold and Driscoll, 1999; Driscoll and Diebold, 1999) with thickness of the crust around 5 km. Moreover, the interpretation of seismic reflection data has led to identification of the Carib Beds (Caribbean typical prominent reflection horizons A″ and B″), which have been drilled and widely mapped in the Venezuelan Basin (Fig. 1; Ladd and Watkins, 1980; Diebold et al. 1981; Diebold and Driscoll, 1999; Driscoll and Diebold, 1999; Granja Bruña et al., 2009; Kroehler et al., 2011), in the southwest and west of the Colombian Basin (Fig. 1; Bowland, 1993; Bowland and Rosencrantz, 1988), south of the Beata Ridge (Fig. 1; Hopkins, 1973; Stoffa et al., 1981) and in the Lower Nicaraguan Rise (Fig. 1; Mauffret and Leroy, 1997).

The CLIP was formed during the Cretaceous on the Pacific Farallon plate, over the Galapagos hotspot (Duncan and Hargraves, 1984), while the Greater Antilles volcanic arc (i.e., Cuba, Hispaniola and Puerto Rico) was initiated by an eastward dipping subduction in Central America (Pindell et al., 2012; Van der Lelij, 2013; Hastie et al., 2013). The volcanic arc and the plateau subsequently moved north- and eastwards to their current position between the North and South American plates, thus individualizing the current Caribbean plate. The eastern Greater Antilles arc (i.e., Hispaniola and Puerto Rico) became an inactive intra-oceanic arc during the northeastward motion of the Caribbean plate. The northeastward motion of the newly formed Caribbean plate lasted until the beginning of the collision between the

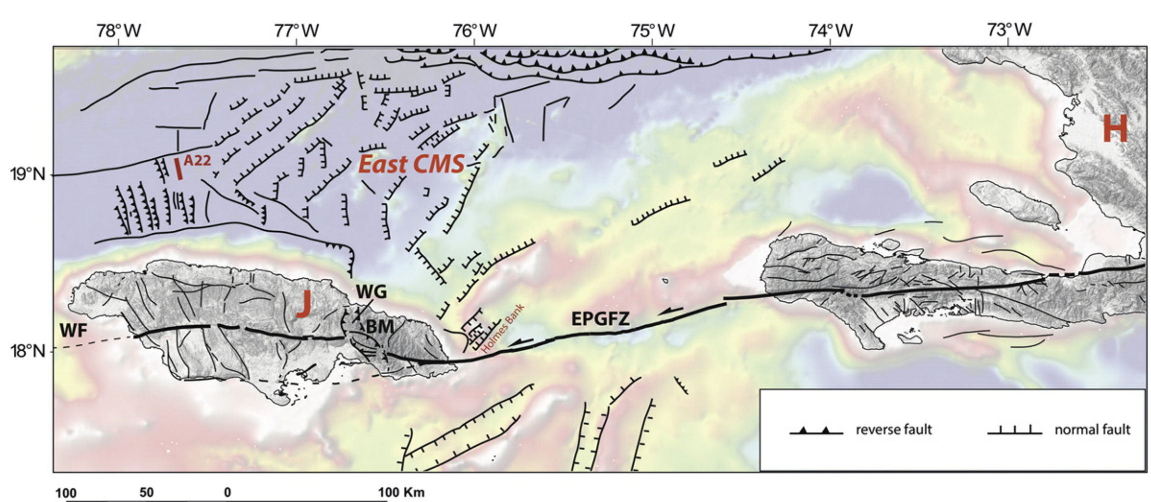

Fig. 2. Synthetic structural map of the study area. Faults are from Bien-Aimé Momplaisir (1986), Calais and Mercier de Lépinay (1991), Leroy et al. (1996 and 2000), Granja Bruña et al. (2011) and Benford et al. (2012a). J: Jamaica, H: Hispaniola, East CMS: Eastern Cayman Margin System. WF: Walton Fault, WG: Wagwater Graben, BM: Blue Mountains, HB: Holmes Bank, EPGFZ: Enriquillo-Plantain-Garden Fault Zone. A22: magnetic anomaly 22 (~49 Ma, Leroy et al., 2000).