Tectonophysics 603 (2013) 68–78

Contents lists available at ScienceDirect

Tectonophysics

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

Seismic activity offshore Martinique and Dominica islands (Central Lesser Antilles subduction zone) from temporary onshore and offshore seismic networks

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ARTICLE INFO

Article history:
Received 28 February 2011
Received in revised form 1 August 2011
Accepted 5 August 2011
Available online 16 August 2011

Keywords:
Lesser Antilles Arc
Subduction zone
Seismicity
Ocean bottom seismometer

ABSTRACT

This work focuses on the analysis of a unique set of seismological data recorded by two temporary networks of seismometers deployed onshore and offshore in the Central Lesser Antilles Island Arc from Martinique to Guadeloupe islands. During the whole recording period, extending from January to the end of August 2007, more than 1300 local seismic events were detected in this area. A subset of 769 earthquakes was located precisely by using HypoEllipse. We also computed focal mechanisms using P-wave polarities of the best azimuthally constrained earthquakes.

We detected earthquakes beneath the Caribbean forearc and in the Atlantic oceanic plate as well. At depth seismicity delineates the Wadati–Benioff Zone down to 170 km depth.

The main seismic activity is concentrated in the lower crust and in the mantle wedge, close to the island arc beneath an inner forearc domain in comparison to an outer forearc domain where little seismicity is observed. We propose that the difference of the seismicity beneath the inner and the outer forearc is related to a difference of crustal structure between the inner forearc interpreted as a dense, thick and rigid crustal block and the lighter and more flexible outer forearc. Seismicity is enhanced beneath the inner forearc because it likely increases the vertical stress applied to the subducting plate.

1. Introduction

The Lesser Antilles subduction zone is known to be moderately seismically active. Few events having M>7 are known to be interplate thrusts events, which do not preclude the occurrence of a future great subduction earthquake (e.g. Dorel, 1981). French volcanological and seismological observatories of Guadeloupe and Martinique continuously record seismicity since a long time and the general seismic pattern is well known (Bengoubou-Valérius et al., 2008). However locations of small magnitude earthquake east of the volcanic arc, over the potential seismogenic zone, are poorly constrained by the permanent seismic network deployed on the islands.

In the framework of the European project "Thales was Right", three seismic surveys (TRAIL, Sismantilles II and OBSAntilles) were carried out to better constrain the lithospheric structure of the Central Lesser Antilles subduction zone (Fig. 1), its seismic activity and associated seismic hazards. It is the first time that an onshore–offshore seismic network of this extent is deployed in the region. The Sismantilles II experiment was conducted in January 2007 on-board R/V *Atalante* (IFREMER, France). A total of 80 ocean bottom seismometers (OBS) from Géoazur, Nice, INSU/IPG, Paris, IFM-GEOMAR, Kiel and AWI, Bremerhaven were deployed on a regular grid on the Caribbean margin, offshore Antigua, Guadeloupe, Dominica and Martinique islands. During the active part of the survey, more than 2500 km of multi-channel seismic profiles were shot along the grid lines. Then the OBS remained on the seafloor for approximately four months until April 2007 to record the local seismic activity. In April 2007, the OBS were recovered during the OBSAntilles experiment, carried out on-board R/V *Antéa* (IRD, France) and 28 instruments were

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0040-1951/$ – see front matter © 2011 Elsevier B.V. All rights reserved.
doi:10.1016/j.tecto.2011.08.006

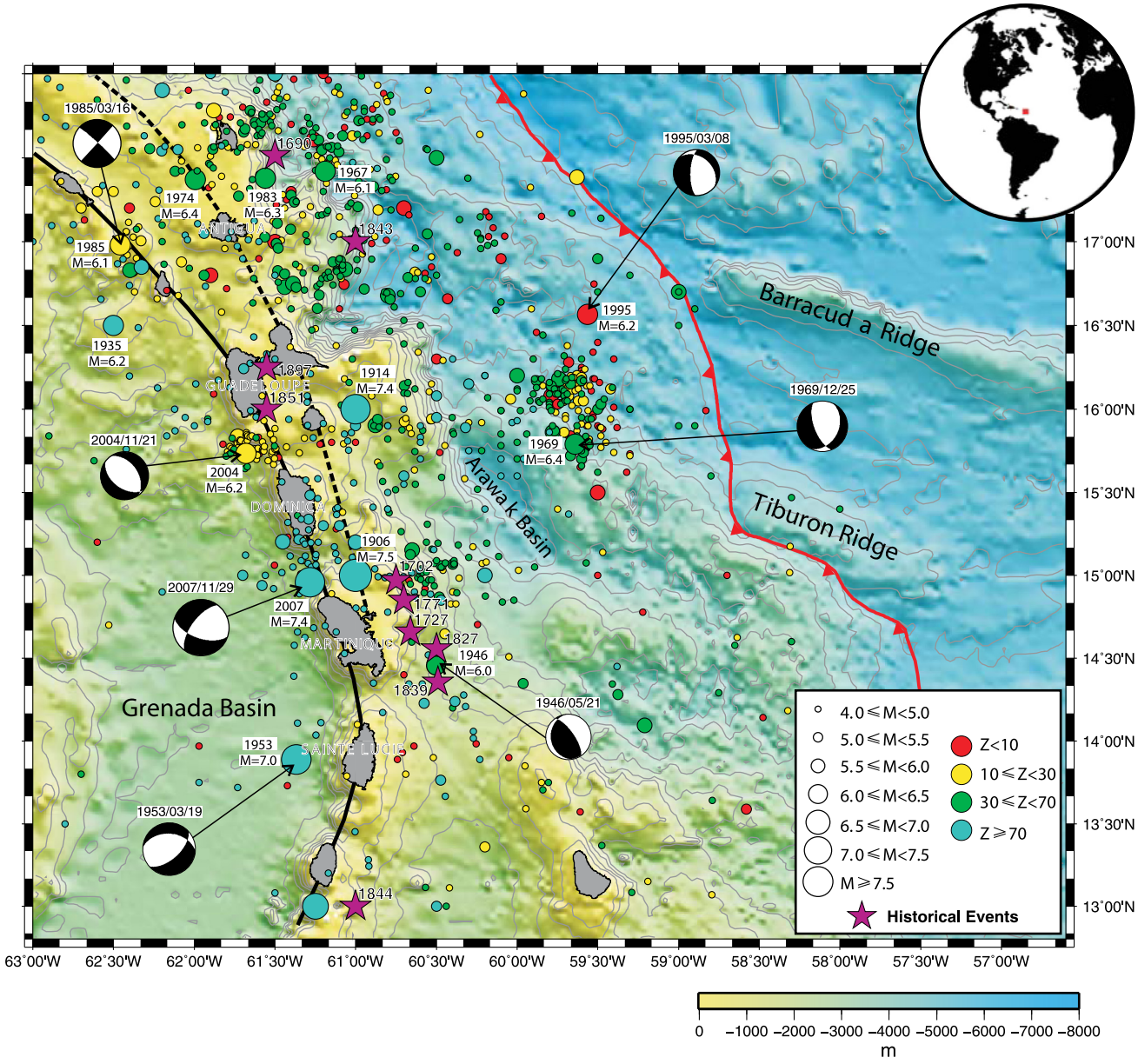

Fig. 1. Map of the Central Lesser Antilles subduction zone and its seismic activity from 1906 to 2008 (ISC Catalog, 2001). Only epicentres with magnitude equal or greater than 4 are shown. Red stars represent the most important historical events which have occurred in this region (Bernard and Lambert, 1988; Dorel, 1981; Dorel et al., 1971; Feuillet et al., 2002; Robson, 1964). Continuous and dashed black lines are respectively representing the active and ancient volcanic arcs. Focal mechanisms of major events are shown (after the Global CMT Project; http://www.globalcmt.org/; Bazin et al., 2010; Russo et al., 1992; Stein et al., 1982).

redeployed offshore Martinique and Dominica during four additional months of continuous recording of the local seismicity. In addition, up to 30 seismic stations from IPG Paris, CSIC, Barcelona, INSU/Lithoscope and ETH, Zurich were deployed on land, on the islands, from Antigua to Martinique (Fig. 2). This work focuses on the analysis of the seismological data recorded offshore Martinique and Dominica.

2. Seismotectonic setting

The Lesser Antilles Arc is an approximately 850-km long and north–south trending island arc formed by the subduction of the ~90 My Atlantic lithosphere (from ~84 My at the latitude of Barbuda to 140 My at the latitude of Barbados) underneath the Caribbean lithosphere. This subduction accommodates the convergence, at ~2 cm/yr and roughly in a N67° direction, between the North American and the Caribbean plates (DeMets et al., 2000; Deng and Sykes, 1995; Dixon et al., 1998). The deformation front is clearly observed along the entire Lesser Antilles arc. To the south, it is the eastern limit of the huge Barbados accretionary prism, formed by the sedimentary contribution of Orinoco and Amazon rivers (Bouysse and Westercamp, 1990; Westbrook, 1982). The Lesser Antilles Arc is the place of intense volcanic and seismic activity. From Martinique northwards, two volcanic arcs exist (Fig. 1). Volcanism along the eastern one ceased during several millions years and resumed at early Burdigalian (~20 Ma) along the western volcanic arc, 50 km to the west, that is still nowadays active (Bouysse et al., 1990). This first-order event has been related to the collision of a buoyant Atlantic volcanic ridge (Bouysse et al., 1990). East of the deformation