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Plio–Pleistocene palaeogeography of the Llanura Costera del Caribe in eastern Hispaniola (Dominican Republic): Interplay of geomorphic evolution and sedimentation

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ABSTRACT

This paper aims to reconstruct the palaeogeographic evolution of the Llanura Costera del Caribe (LCC) in eastern Hispaniola (Dominican Republic) during the Pleistocene, adding new insights to published information on Pliocene–Early Pleistocene deposits. The LCC is a generally flat region comprising the unfolded sedimentary cover of the Cordilleras Central and Oriental. Within this cover, the Pliocene–Early Pleistocene Yanigua Formation,mainly consisting of marl, changes seawards to the mainly limestone Los Haitises Formation. Both units formed in a shallow-water platform rimmed by a reef barrier at least in the latest depositional stages. The overlying Pleistocene La Isabela Formation consists of two major offlapping reef terraces, in which a reef core enclosed a lagoon, and prograded over forereef bioclastic debris. Two belts in LCC's morphostructure directly reflect its sedimentary evolution. The Inner Belt extends over the marly substrate of the Yanigua Formation and the Coastal Belt comprises three major surfaces corresponding to the depositional top of the Los Haitises Formation (Upper Surface), and to the Upper and Lower terraces of the La Isabela Formation (Intermediate and Lower Surfaces, respectively). The MIS 5e age of the 10–20 m high Lower Terrace implies a low uplift rate of 0.033–0.068 mm/yr for the Lower Surface. The Pliocene–Early Pleistocene platform was emergent in the Early–Middle Pleistocene. The Early Pleistocene reef barrier separated endorheic watersheds extending over the former shelf lagoon from the open ocean. Reefs built the Upper Terrace of the La Isabela Formation during one or several Middle Pleistocene highstands and the Lower Terrace during MIS 5e and previous highstands. Siliciclastic deposits in this terrace record the opening to the Caribbean Sea of watersheds in the eastern LCC. The Lower Terrace emersion and opening of the large drainage systems of the western and central LCC took place after MIS 5e. Relative sea level fall and emersion of a large area did not imply increased terrigenous sedimentation in the adjacent marine basin. Development of endorheic watersheds over most of the emergent surface delayed the diachronic arrival of siliciclastics into the marine basin for hundreds of thousands of years.

1. Introduction

The eastern Dominican Republic in Hispaniola is part of the Hispaniola–Puerto Rico microplate (Byrne et al., 1985) within the North America–Caribbean plate boundary zone. Continuous uplift during the Neogene and Quaternary resulted in increased surface of this part of the island, largely due to emersion of upper Neogene and Pleistocene shallow marine sedimentary rocks. This is the origin of the Llanura Costera del Caribe (LCC), a generally flat region extending from the southeast end of the Cordillera Central to the east of the Cordillera Oriental (Fig. 1) and composed of unfolded Pliocene and Pleistocene shallow-marine mixed carbonates and siliciclastics (Fig. 2) (Díaz de Neira et al., 2007; Díaz de Neira, 2011; Braga et al., 2012). The sedimentary record and geomorphic traits of this virtually undeformed region allow a detailed reconstruction of its palaeogeographical evolution since the Pliocene and an assessment of the major factors controlling the processes leading to the present-day landforms.

Geological studies on the LCC are very scarce. The pioneering survey of Hispaniola by Vaughan et al. (1921) included references to the Neogene stratigraphy of the northeastern part of the region, which was

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redefined by Brouwer and Brouwer (1982). These latter authors established two of the major lithostratigraphic units of the LCC, the Yanigua and Los Haitises Formations, in the first detailed paper on the sedimentology of the Neogene cover of the Cordillera Oriental. The Pleistocene reef terraces fringing the southern coast of the LCC were described by Barrett (1962) and Geister (1982), and partially dated for the first time by Schubert and Cowart (1982). Mann et al. (1991) presented a synthetic map of southeastern Hispaniola at 1:150,000 scale in their comprehensive work on the island's tectonic evolution. A general map of the geology of the Dominican Republic 1:250,000 scale was published in the same year by the Dirección General de Minería and the Bundesanstalt fur Geowissenschaften und Rohstoffe (Germany) (Toloczy and Ramírez, 1991). Mann et al. (1995) analysed the uplift rate of Pleistocene reef terraces in eastern Hispaniola in order to compare the relative tectonic stability and low tectonic uplift of the Hispaniola–Puerto Rico microplate with the actively evolving Gonave microplate (Rosencrantz and Mann, 1991) to the west. During the last two decades, a geological survey funded by the European Union (Sysmin I and II Programs) has fostered geological and geomorphological research in the Dominican Republic, and provided new and valuable information reflected in maps and their reports, and in a number of publications, some of which deal with the geomorphological evolution (Díaz de Neira et al., 2007), the structure (García-Senz et al., 2007) and the sedimentology of the Neogene and Quaternary deposits (Braga et al., 2012) of eastern Hispaniola. This paper is a further result of the Sysmin I and II Programs and its aims are to: (a) reconstruct the palaeogeographic and geomorphic evolution of the Llanura Costera del Caribe based upon information from geological and geomorphological mapping together with sedimentological analysis and biostratigraphic and radiometric dating of Pliocene to Pleistocene deposits; (b) show that this evolution and the present-day landscape are markedly controlled by the sedimentary history of the area, with a limited influence of tectonic processes other than moderate uplift and local faulting; and (c) demonstrate the effects of geomorphic evolution in coeval sedimentation: relative sea-level fall and emersion of large areas does not necessarily imply increased terrigenous sedimentation in adjacent marine depositional settings.

2. Methods

The information on the spatial distribution of sedimentary rocks and tectonic structures is based upon geological mapping at 1:50,000 scale of the region while the geomorphic features were mapped at 1:100,000 scale. Analyses of digital elevation models and geomorphological profiles have been used to complement the maps. The sedimentary evolution of Pliocene–Lower Pleistocene mixed siliciclastic–carbonate deposits has been addressed in a recent paper by Braga et al. (2012). Facies distribution and depositional geometries of Pleistocene reef-related carbonates have been studied by a combination of lithological mapping, logging of 6 selected sections, additional observations at 14 sites (Fig. 2), and analysis of digital elevation models. Facies analysis and interpretation have been based on field observations and the examination of 30 thin sections under the optical microscope. Radiometric dating by U–Th series on coral skeletons has been attempted in all Pleistocene terraces distinguished by mapping but only corals from the youngest terrace preserve enough original aragonite to allow reliable results. Coral samples were selected for U–Th dating based on XRD analysis of their aragonite content (Table 1) and visual inspection for the absence of secondary mineralisation. Approximately 0.3 g subsamples were dissolved in nitric acid, a mixed ^{229}Th:^{236}U tracer added and then refluxed in aqua regia overnight to remove organic material and allow sample-tracer isotope equilibrium to be achieved. Uranium and thorium were separated from each other and the sample matrix by anion chromatography using AG1-X8 resin following the procedure of Negre et al. (2009). Measurement of U and Th isotope ratios was by a Nu Instruments MC-ICP-MS at the University of Oxford. Both U and Th were measured with the minor isotopes (^{234}U, and ^{229}Th and ^{230}Th) in ion counters, U was measured statically while Th was measured in peak hopping mode so masses 229 and 230 could be measured in the same collector.

Fig. 1. Location of the study area and main physiographic domains.