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Collisional zones in Puerto Rico and the northern Caribbean

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A R T I C L E I N F O

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A B S T R A C T

Puerto Rico is an amalgamation of island arc terranes that has recorded the deformational and tectonic history of the North American-Caribbean Plate boundary. Four collisional zones indicate the contractional events that have occurred at the plate boundary. Metamorphism and deformation of Middle Jurassic to Early Cretaceous oceanic lithosphere during the Early Cretaceous indicate the earliest collisional event. Then, an ophiolitic mélange, mostly comprised of blocks of the metamorphosed oceanic lithosphere, was formed and emplaced in the backarc region during the Turonian-Coniacian deformational event. A possible collision with a buoyant block in the North American Plate caused late Maastrichtian-early Paleocene contraction that created fold-and-thrust belts and the remobilization and uplift of serpentinite bodies in the Southwest Block. Late Eocene-early Oligocene transpression was localized along the Southern and Northern Puerto Rico fault zones, which occur north and south of large granodiorite intrusions in the strong Central Block. The deformation was accommodated in pure shear domains of fold-and-thrust belts and conjugate strike-slip faults, and simple shear domains of large mostly left-lateral faults. In addition, it reactivated faults in the weak Southwest Block. This island-wide transpression is the result of a Greater Antilles arc and continental North American collision. The kinematic model of the structures described in Puerto Rico correlate with some structures in Hispaniola and Cuba, and shows how the northern boundary of the Caribbean Plate was shortened by collisions with continental lithosphere of the North American Plate throughout its history. The tectonic evolution of the Greater Antilles shows a history of collisions, in which the latest collision accretes Cuba to the North American Plate, reorganizes the plate boundary, and deforms with transpression Hispaniola and Puerto Rico. The latest collision in Puerto Rico shows the case in which an arc collides obliquely with buoyant crust producing left-lateral transpression and converges obliquely with dense oceanic lithosphere.

1. Introduction

Island arc-continent collision is a fundamental geological process that accretes terranes into continents, creates mountain belts, and concentrates mineral deposits into the continental crust. Collisions are defined as the arrival of a continental margin to a subduction zone that may cause the subduction to stop, reverse the polarity of subduction or migrate to a new location (Brown and Ryan, 2011). Studies of ongoing collisions in the southwest Pacific Plate show how the resulting deformation depends on the nature of the continental crust and the island arc, and the dynamics of the subduction zone (e.g. Stern, 2002; Byrne et al., 2011; Harris, 2011; Boutelier and Chemenda, 2011; Gerya, 2011; Brown et al., 2011). Factors such as across- and along-strike changes in thickness, shape, width, structure and composition, rheology, and obliqueness of collision, convergence angle, and convergence rate influence the outcome of arc-continent collision (Brown et al., 2011).

The Caribbean-North American plate boundary is an example of an island arc-continent collisional boundary that experienced along-strike changes in the nature of the colliding margins and obliqueness of the collision that created profound changes through out its tectonic history (Fig. 1A; Pindell et al., 1988, 2012). The island arc collided with buoyant terranes during the Cretaceous that uplifted metamorphic and igneous rocks (Draper et al., 1996; Kerr et al., 1999; García-Casco et al., 2006, 2008). During the Paleocene to the Eocene, the island arc collided with the Bahamas continental margin (Bralower and Iturralde, 1997; Mann et al., 2002; Saura et al., 2008; Iturralde et al., 2008; García-Casco et al., 2008; van Hinsbergen et al., 2009; Cruz-Orosa et al., 2011). However, the continental margin shows variability as it has continental crust in the Florida Straits, thin continental crust in western Bahamas, and

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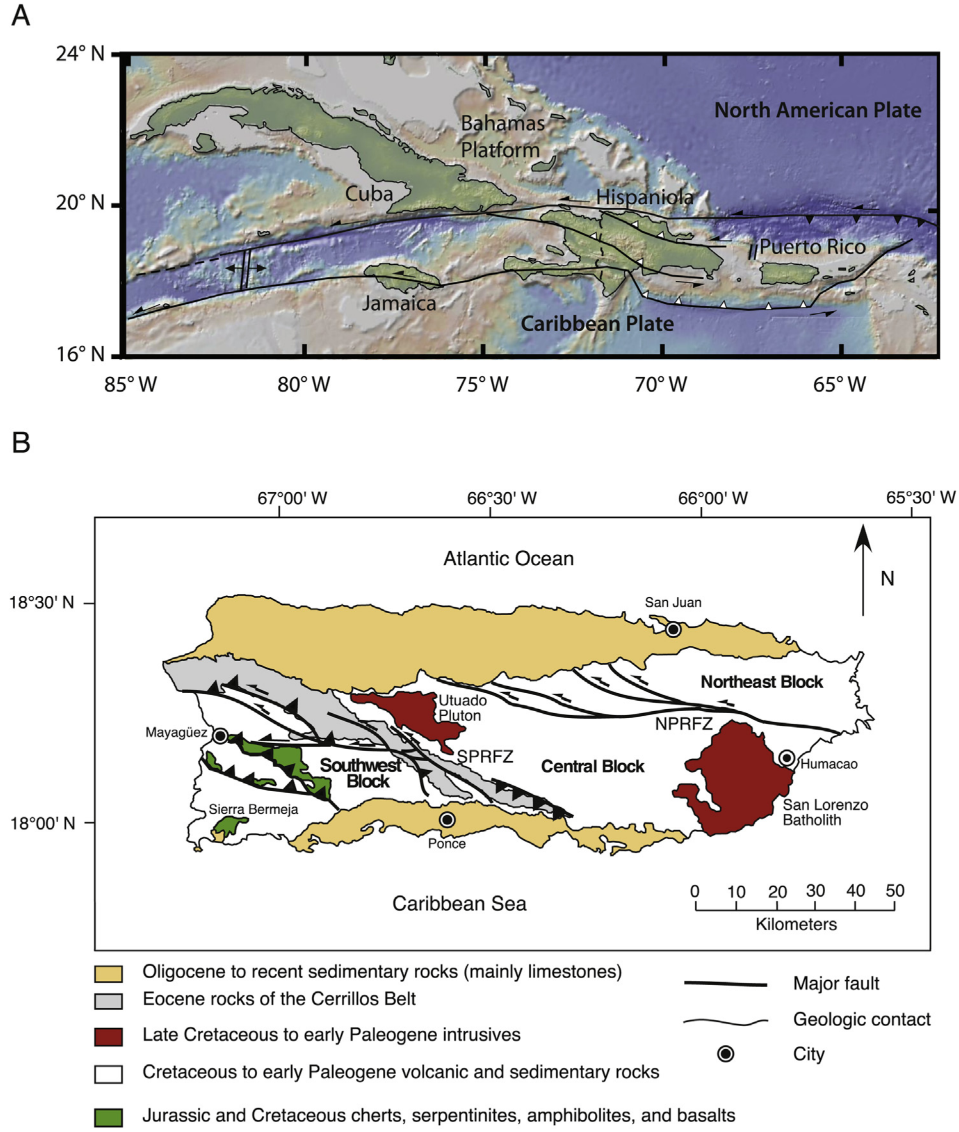

Fig. 1. A. Tectonic map of the Northeastern Caribbean (modified from Wadge et al., 1984; GeoMapApp, http://www.geomapapp.org; Ryan et al., 2009). B. Geologic map of Puerto Rico (modified from Monroe, 1980).

thick oceanic crust in southeast Bahamas (Uchupi et al., 1971; Ladd and Sheridan, 1987; Pindell et al., 2006). During this collision, Cuba was accreted to the North American Plate and deformation associated with the collision stopped by the Oligocene (e.g. Iturralde et al., 2008). The collision reorganized the plate boundary into an oblique left-lateral transform boundary south of Cuba and north of Hispaniola and Puerto Rico. In Hispaniola, this deformation began later than in Cuba in the Paleocene and continues today (Mann et al., 1991; Escuder-Viruete and Pérez-Estaún, 2013). Puerto Rico also collided at an oblique angle with the Bahamas platform (Glover, 1971; Erikson et al., 1990). However, transpression stopped in early Oligocene as the Puerto Rican arc crust started to converge obliquely with the dense oceanic crust of the North American Plate. The Caribbean-North American Plate boundary shows a variety of temporal and spatial scales of its latest collision.

Thus, the plate boundary shows the case in which an island arc collides, at a low angle, the continental side of a rifted margin, and progressive deformation brings part of the island arc over the continent-ocean transition to converge obliquely with dense oceanic crust. The oblique collision of the north-east moving island arc with the edge of the north-south trending eastern North American rifted margin shows along-strike collisional variations in which parts of the island arc were accreted to the continental plate (Cuba), parts continue to collide obliquely with the thick oceanic crust of the Bahamas platform (Hispaniola), and parts have collided with the thick oceanic crust of the Bahamas platform, and now converge obliquely with dense oceanic crust (Puerto Rico). The exceptional collisional processes recorded in rocks of Puerto Rico are important to be studied as it may help to understand how collisional mountain belts and continental crust evolve where similar collisions have occurred. Although oblique collisions of island arcs with continents are common (e.g. Harris, 2011; Byrne et al., 2011) few island arc-continent collisions show the transition of collision of an island arc with a continent to convergence with oceanic crust over a rifted margin.

The objective of this paper is to review the timing and deformation styles of the collisional zones in Puerto Rico and compare to the deformation styles with other islands of the Greater Antilles island arc to produce a model of the oblique collision between an island arc and buoyant crust. Moreover, this paper aims to improve