The Origin and Evolution of the Caribbean Plate

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The Origin and Evolution of the Caribbean Plate

EDITED BY

K. H. JAMES
Aberystwyth University, Wales, UK

M. A. LORENTE
Central University of Venezuela, Venezuela

and

J. L. PINDELL
Tectonic Analysis Ltd, West Sussex, UK
Rice University, Texas, USA

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Preface

This book records the proceedings of a conference, held in Spain, 2006, that addressed aspects of the geology of the area between North and South America, with focus upon the origin of the Caribbean Plate. Additional papers provide new data. The book follows the structure of the conference, beginning with papers that describe different understandings of the plate origins, continuing with a geological tour of the Caribbean and ending in the plate interior.

The papers express a wide variety of understanding of Caribbean geology. They cannot all be correct. We, and the Geological Society, hope that a book that brings them together will facilitate debate and help readers to make their own analyses. The first four papers in particular describe considerably different visions of Caribbean Plate origins and make-up.

Caribbean geology is complicated by wide dispersal over many geographic elements, some with poor accessibility, tropical weathering and/or young volcanic cover and some just poorly studied. Much of the plate interior lies below deep water and is directly sampled only by a few cores. Literature is spread over many sources, some international but many local, in English, French, German and Spanish. Given its location between the Gulf Mexico and northern South America, both well-explored places where surprises continue to surface, it is obvious that a lot remains to be learned about the Caribbean.

Prevailing understanding is that the Caribbean Plate formed in the Pacific Ocean and migrated between the Americas. It is built, therefore, of oceanic and intra-oceanic volcanic arc rocks. Alternatively, it could have formed in place by extension between separating North and South America. It could include continental crust. Some models are hybrids of these possibilities.

Pindell & Kennan provide an update on Caribbean evolution in which the Americas engulf a swath of Pacific-origin oceanic lithosphere during their westward drift from Africa, from Early Cretaceous to Present, after a period of Jurassic passive margin formation around the Gulf of Mexico and Proto-Caribbean Sea. References, frames, origins of arcs, arc-continent interactions, mantle plume exrusion, back arc spreading events and neotectonic settings are integrated to form an intrinsically consistent evolutionary model. **Giunta & Oliveri** also suggest oceanic spreading and formation of an oceanic plateau but between the Americas. **James** synthesizes data that indicate an *in situ* origin of the plate by extreme continental extension and serpentinization. **James** describes a plate evolution interpretation of these in a separate paper, along with implications and outstanding problems. Existing data/samples could provide many answers if revisited by studies designed to distinguish between different ideas.

Milsom compares the Caribbean with basin/orocline pairs in the Mediterranean area and the Banda Sea. **Giner-Robles *et al.*** describe the structure of the Atlantic Plate as it descends below the Scotia Plate, using earthquake focal mechanism solutions. This offers an analogue for the Lesser Antilles subduction zone of the eastern Caribbean.

Keppie *et al.* discuss Oligocene–Miocene events in southwestern Mexico. Instead of being influenced by movements of the Chortís Block, the geology results from forearc subduction resulting from collision of an oceanic plateau with the trench and change of plate relative motion associated with the breakup of the Farallon Plate. **Cerca *et al.*** describe analogue models that reproduce the tectonic evolution of SW Mexico and the Xolapa complex related to oblique sinistral transpressional movement of the Chortís Block. **Guzmán-Speziale** uses earthquake data to suggest that the Chortís Block is extruding to the SE in response to interaction with the North American and Cocos Plates and **Valls Alvarez** details geological history recorded in Guatemala in similar terms. **Ratschbacher *et al.*** provide new data relevant to plate history in Guatemala and Honduras, while **Solari *et al.*** focus upon zircon data to unravel the Palaeozoic history of the area.

Cobiella-Reguera details the record of volcanic arc activity and Late Cretaceous–Middle Eocene emplacement of ophiolites in Cuba. Volcanic activity ceased from the Late Campanian to the Danian when a new arc with north-dipping subduction formed. This is not consistent with the concept of a coeval and continuous north-facing Great Arc of the Caribbean. In western and central Cuba, the Northern Ophiolite Belt and Cretaceous volcanic arc rocks were thrust several tens of kilometres to the north by the Middle Eocene. In contrast, **Stanek *et al.*** suggest that volcanic activity moved southwards to the Cayman Ridge with south-dipping subduction. This, plus history of HP metamorphic rocks on Cuba, derived from the southern Yucatán, supports the development of the Caribbean Great Arc in the Pacific.

Hastie *et al.* describe the geochemistry and significance of Cretaceous island arc tholeiites and calc-alkaline rocks on Jamaica. Both occur before and after the Aptian/Albian, thus commonly seen

volcanic arc subduction polarity reversal at this time is not supported. In a separate paper, **Hastie** shows that Caribbean primitive island arc (PIA) rocks are chemically indistinguishable from modern island arc tholeiites (IAT) and recommends abandonment of PIA usage.

Buchs *et al.* report on detailed field studies of the Osa and Burica Peninsulas (Costa Rica) that recorded a long-term history of accretion alternating with subduction erosion. An igneous complex includes a Coniacian–Santonian oceanic plateau and Coniacian–Santonian to Middle Eocene seamounts that accreted along the Caribbean Plate between the Paleocene and the Late Eocene. A mélange formed along the Igneous Complex in the Late Eocene by accretion of mass wasting deposits reworked from the igneous complex and the Central American Arc. The study suggests that some sequences of Late Cretaceous oceanic plateau(s) in Central America are unrelated to the Caribbean Large Igneous Province (CLIP) and formed in the Pacific before being accreted along the Caribbean Plate.

Montgomery & Kerr reinterpret red cherts on La Désirade, Lesser Antilles, relating them to hydrothermal sedimentation at an Upper Jurassic, Pacific spreading ridge.

Jaillard *et al.* relate upper Cretaceous ocean plateau rocks of western Ecuador to the Caribbean Oceanic Plateau by their similar evolutions. If correct, the latter formed on the Farallon Plate and not above the Galapagos hot spot. Similarly, **Kennan & Pindell** relate the history of western rocks from northern Peru to Colombia to migration of the Caribbean Plate and arcs at its leading and trailing margins.

Grande & Urbani report the first findings of Grenvillian basement or derived rocks in northwestern Venezuela. Their data will help to complete ancient palaeogeography of Pangaea. **Weber *et al.*** describe new data on serpentinites, gabbros and andesites from the Guajira Peninsula, relating these to a surfacing supra-subduction zone. This paper also supports migration of the Caribbean Plate.

Audemard details the progressive collision of a migrating Caribbean volcanic arc along northern Venezuela and proposes that the Falcón, Bonaire, Blanquilla and Grenada Basins of northern Venezuela and the eastern Caribbean began life as a single, back-arc basin. **Baquero *et al.*** describe Late Cretaceous–Middle Eocene nappe emplacement in the Falcón area of Venezuela, followed by Late Eocene–Early Miocene graben formation and then Middle Miocene inversion. The classic Upper Cretaceous petroleum source overmatured during graben formation and oils of this region are sourced by Cenozoic rocks.

Higgs proposes a radical change of timing of Caribbean evolution, with rifting ending in the Coniacian instead of the Jurassic, and with Santonian–Campanian spreading lasting only 10–15 Ma instead of 140 Ma, followed by subduction of the Caribbean below northern South America. Entry of the Caribbean arc occurred in the Oligocene, not in the Palaeocene, and Caribbean relative motion became eastward in the Pliocene, not in the Middle Miocene. **Higgs** also presents indirect evidence of a former Berriasian–Valanginian Carib Halite Formation, formed in a graben extending from Colombia to Trinidad and seen today only in Colombia. Indications include solution subsidence, saline springs, heat-flow and gravity anomalies, and thrust belt structural style.

Cooney & Lorente present data that show an unrecognized Campanian structural event and resultant unconformity in the Maracaibo Basin that could be related to changes in Caribbean Plate tectonics.

Maresch *et al.* discuss HP/LT metamorphic rocks of Margarita, overlain by greenschists. HP/LT protoliths were both oceanic and continental (Palaeozoic and Mesozoic) and metamorphism is seen to have occurred to the west, in accord with Pacific models for the Caribbean.

Pindell *et al.* discuss heavy mineral content of rocks from eastern Venezuela, Trinidad and Barbados, and outline a history of Cretaceous passive margin, Palaeogene subduction below South America, Eocene–Miocene foredeep development related to passage of the Caribbean Plate and Miocene–Recent sedimentation of the Orinoco River.

Diebold presents seismic data over the Caribbean Plateau of the western Venezuela Basin. Two separate sequences, possibly coeval lower intrusions and upper extrusions, were folded during emplacement of the upper sequence, prior to uplift of the Beata Ridge. This could have occurred as the Caribbean Plate was entering the Caribbean area in the Late Cretaceous. **Kerr *et al.*** discuss chemistry of basalts drilled at DSDP Site 1001 and conclude that they are most likely derived from depleted mantle plume, possibly mixed with depleted upper mantle source.

Drs A. W. Bally, M. A. Lorente and D. Roberts chaired the 2006 meeting. The conference convenors, Keith James and Maria Antonieta Lorente, gratefully acknowledge financial support for the meeting from BP, Repsol, SEPM, Shell and Statoil and the support of the Spanish Asociación de Geólogos y Geofísicos Españoles del Petróleo, especially President Wenceslao Martínez, Vice-President Susanna Torrescusa Villaverde and Secretary Aurelio Jiménez Fernández. We also wish to thank

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K. H. JAMES
M. A. LORENTE
J. L. PINDELL