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Kinematic reconstruction of the Caribbean region since the Early Jurassic

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ABSTRACT

The Caribbean oceanic crust was formed west of the North and South American continents, probably from Late Jurassic through Early Cretaceous time. Its subsequent evolution has resulted from a complex tectonic history governed by the interplay of the North American, South American and (Paleo-)Pacific plates. During its entire tectonic evolution, the Caribbean plate was largely surrounded by subduction and transform boundaries, and the oceanic crust has been overlain by the Caribbean Large Igneous Province (CLIP) since ~90 Ma. The consequent absence of passive margins and measurable marine magnetic anomalies hampers a quantitative integration into the global circuit of plate motions. Here, we present an updated, quantitatively described kinematic reconstruction of the Caribbean region back to 200 Ma, integrated into the global plate circuit, and implemented with GPlates free software. Our reconstruction includes description of the tectonic units in terms of Euler poles and finite rotation angles. Our analysis of Caribbean tectonic evolution incorporates an extensive literature review. To constrain the Caribbean plate motion between the American continents, we use a novel approach that takes structural geological observations rather than marine magnetic anomalies as prime input, and uses regionally extensive metamorphic and magmatic phenomena such as the Great Arc of the Caribbean, the CLIP and the Caribbean high-pressure belt as correlation markers. The resulting model restores the Caribbean plate back along the Cayman Trough and major strike-slip faults in Guatemala, offshore Nicaragua, offshore Belize and along the Northern Andes towards its position of origin, west of the North and South American continents in Early Cretaceous time. We provide the paleomagnetic reference frame for the Caribbean region by rotating the Global Apparent Polar Wander Path into coordinates of the Caribbean plate interior, Cuba, and the Chortis Block. We conclude that formation of the Caribbean plate, west of the North and South Americas, as a result of Panthalassa/Pacific spreading leads to a much simpler plate kinematic scenario than Proto-Caribbean/Atlantic spreading. Placing our reconstruction in the most recent mantle reference frames shows that the CLIP originated 2000–3000 km east of the modern Galápagos hotspot, and may not have been derived from the corresponding mantle plume. Finally, our reconstruction suggests that most if not all modern subduction zones surrounding the Caribbean plate initiated at transform faults, two of these (along the southern Mexican and NW South American margins) evolved diachronously as a result of migrating trench–trench–transform triple junctions.

Contents

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1. Introduction

Kinematic reconstruction of regional tectonic evolution comprises translation of qualitative geological data into a quantitative model, describing the relative motions of plates and regional tectonic units. Ideally, the reconstruction is quantified by sets of Euler poles and corresponding finite rotation angles. This has become normal practice in the global reconstruction of continents and continental fragments through geological time (e.g. Besse and Courtillot, 2002; Müller et al., 2008; Torsvik et al., 2008, 2012; Doubrovine et al., 2012; Seton et al., 2012), but regional examples are still few (e.g. van Hinsbergen et al., 2011, 2012, 2014). Generally, regional tectonic reconstructions compile relative motions through time, but when being linked to the global plate circuit of plate motions using a mantle reference frame, they become key input for the assessment of how lithospheric evolution is coupled to underlying mantle processes and mantle structure (Spakman and Hall, 2010).

In the present paper, we aim to develop this kind of kinematically quantified tectonic evolution model of the Caribbean region since ~200 Ma, tied to the North and South American plates. This model can be incorporated in a current or future global plate circuit of choice of either relative of absolute motion. There is currently no generally accepted global plate circuit, but through time the differences in relative plate motions among the models proposed have become gradually smaller (e.g., Gordon and Jurdy, 1986; Müller et al., 2008; Torsvik et al., 2008, 2012; Doubrovine et al., 2012; Seton et al., 2012). In this study, we incorporate our plate model into the South America–Africa and North America–Africa frame of the global plate circuit of Torsvik et al. (2012).

The Caribbean plate is a largely oceanic tectonic plate (3500 km E–W by 1000 km N–S), bounded by convergent margins in the east (Lesser Antilles subduction zone), west (Central American subduction zone), and along the northeastern margin of South America (South Caribbean Deformed Belt), and strike-slip-dominated boundaries in the north