

Out of many one – the story of Jamaica’s geology

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Jamaica has a complex geological history. This short paper explains the geology of Jamaica and where the island came from.

INTRODUCTION

Jamaica, the third largest island in the Greater Antilles, has a rock record extending back to the early Cretaceous some 140 million years ago, although older (Jurassic) rocks must exist at depth. If we were to go back to the Triassic and look down on the World, it would have been a very different place; there was no Atlantic Ocean (thin oceanic crust) and Africa, North America and South America (thick continental crust) were locked together to form the supercontinent Pangea. At this point there was no Gulf of Mexico (with some oceanic crust), no Caribbean Sea (oceanic crust) and no Jamaica. So where did Jamaica form and how do we know?

Over the last 25 years extensive work on the geology of Jamaica has demonstrated how Jamaica must have formed. This is based on understanding the igneous, metamorphic and sedimentary rocks found in Jamaica and also from the analysis of oil samples taken from some of the sedimentary rocks. This demonstrates that parts of Jamaica formed in very different settings which must have been many hundreds to thousands of kilometres apart and that these different fragments finally came together about 50 million years ago to form Proto-Jamaica. I will explain some of the evidence here and outline what this tells us about Jamaica.

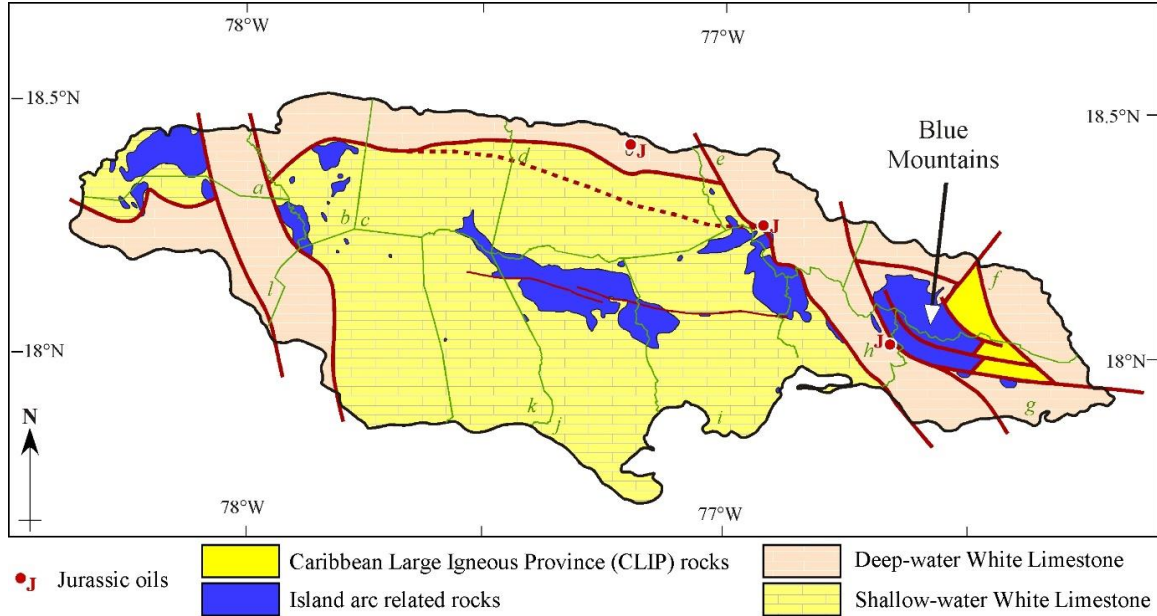


Figure 1. Simplified geology of Jamaica showing likely shallow-water and deep-water White Limestone rocks in Jamaica (prior to erosion) and the locations of selected Cretaceous inliers (older rocks surrounded by younger rocks). The Cretaceous rocks can be attributed to either the Caribbean Large Igneous Province (CLIP) or island arc rocks. Parishes (green): a, Hanover; b, St James; c, Trelawny; d, St Ann; e, St Mary; f, Portland; g, St Thomas; h, Kingston and St Andrew; i, St Catherine; j, Clarendon; k, St Elizabeth; l, Westmoreland. The loactions of Jurassic oil samples (J) are also shown.

OIL SAMPLES

Oil samples occur in Jamaica in a range of sedimentary rocks and these can be analysed chemically to tell us about the age of the rocks that the oils were formed in. This is because the organic matter from which the oils formed changed over time, so we can distinguish Jurassic (201–145 million years ago), Cretaceous (145–66 million years ago) and Cenozoic (66–0 million years ago) oils.

It turns out that three sets of oil samples from Jamaica found in the parishes of St Ann, St Mary and St Thomas are Jurassic oils and match similar oils from Belize and the Gulf of Mexico (**Figure 1**). We know that these kinds of oils formed on continental crust, so that there must be a fragment of continental crust under at least these parts of Jamaica, with the oils leaking up along major fault lines (**Figure 1**). It is likely that this piece of continental crust was acquired from the Yucatan block (Belize and parts of Mexico) in the late Cretaceous to early Cenozoic.

If we look at the eastern part of the Blue Mountains (extending from Bath in the south to Port Antonio in the north) we find a suite of characteristic igneous rocks of Cretaceous (88-92 million years old) age. These rocks have chemical signatures that indicate they were formed by a mantle plume. Mantle plumes come from deep in the Earth and originate at the core-mantle boundary, they rise through the mantle and produce Large Igneous Provinces or LIPs over hot spots such as Hawaii and the Galapagos Islands. In fact, these LIP rocks also form the central part of the Caribbean Sea as well as the south-west peninsula of Haiti (**Figure 2**) and parts of Costa Rica and are known as the Caribbean LIP or CLIP. We can trace the CLIP back in time, and it had an origin over the Galapagos hot spot, which was situated in the heart of the Pacific Ocean with South America situated much closer to Africa with only a small Atlantic Ocean. Subsequently, these rocks had to be emplaced between the Americas to form the Caribbean we see today.

Across the rest of Jamaica (**Figure 1**), the Cretaceous rocks carry volcanic and plutonic igneous rocks that were formed in an oceanic island arc much as exists at the present time in the Lesser Antilles. Metamorphic rocks are associated with the igneous rocks in the south-western Blue Mountains and include blueschists that were formed at depths of some 20 km within a subduction zone (where oceanic crust sinks into the mantle beneath an island arc). In fact the chemistry of some of these metamorphic rocks indicates that they came from

the CLIP and this indicates that the CLIP was subducted (underthrust) beneath this part of Jamaica and this can only be explained if the subduction zone dipped towards the east. This contrasts with the Cretaceous rocks found in Cuba (which was mostly part of the Caribbean Plate at this time), Hispaniola (**Figure 2**) and Puerto Rico which had a westwards dipping subduction zone. So the island arc rocks of Jamaica were not linked to the island arc rocks of the other islands of the Greater Antilles, with the Jamaican subduction zone having a similar orientation to subduction zones along western Guatemala and extending up through western Mexico. It is notable that some of the fossil clams (rudists) found in Jamaica are the same as forms found in western Mexico, whereas they are absent from the other islands of the Greater Antilles.

We can put this together into what is now a complex model, but we can simplify here to the following stages:

Stage 1. In the early Jurassic, North America broke away from Africa and South America (which remained joined) and new oceanic started form in the central Atlantic Ocean, the Proto-Caribbean Seaway and the Gulf of Mexico. The Gulf of Mexico stopped spreading in the late Jurassic and the Proto-Caribbean seaway grew larger as North America drew further away from South America. By the late Jurassic, organic-rich sedimentary rocks were forming on the Yucatan and this would eventually become part of Jamaica.

Stage 2. In the early Cretaceous South America started separating from Africa and the southern Atlantic Ocean began opening. At this time a subduction zone dipping to the east extended from Jamaica up the western side of North America (Fig. 3: Hauterivian); it was here that the oceanic island arc rocks of Jamaica were formed. At the same time, a new subduction zone developed to the south-west which dipped towards the west; it would be in this arc that the Cretaceous igneous and metamorphic rocks of Cuba, Hispaniola and Puerto Rico would form.

Stage 3. In the early late Cretaceous (88-92 million years ago) the CLIP was produced above the Galapagos Hot Spot. The CLIP would become the centre of the Caribbean Plate and this is the where the CLIP rocks of the eastern Blue Mountains were formed (**Figure 3**: Campanian).

Stage 4. As the Atlantic Ocean grew in size the subduction zones along the western margins of

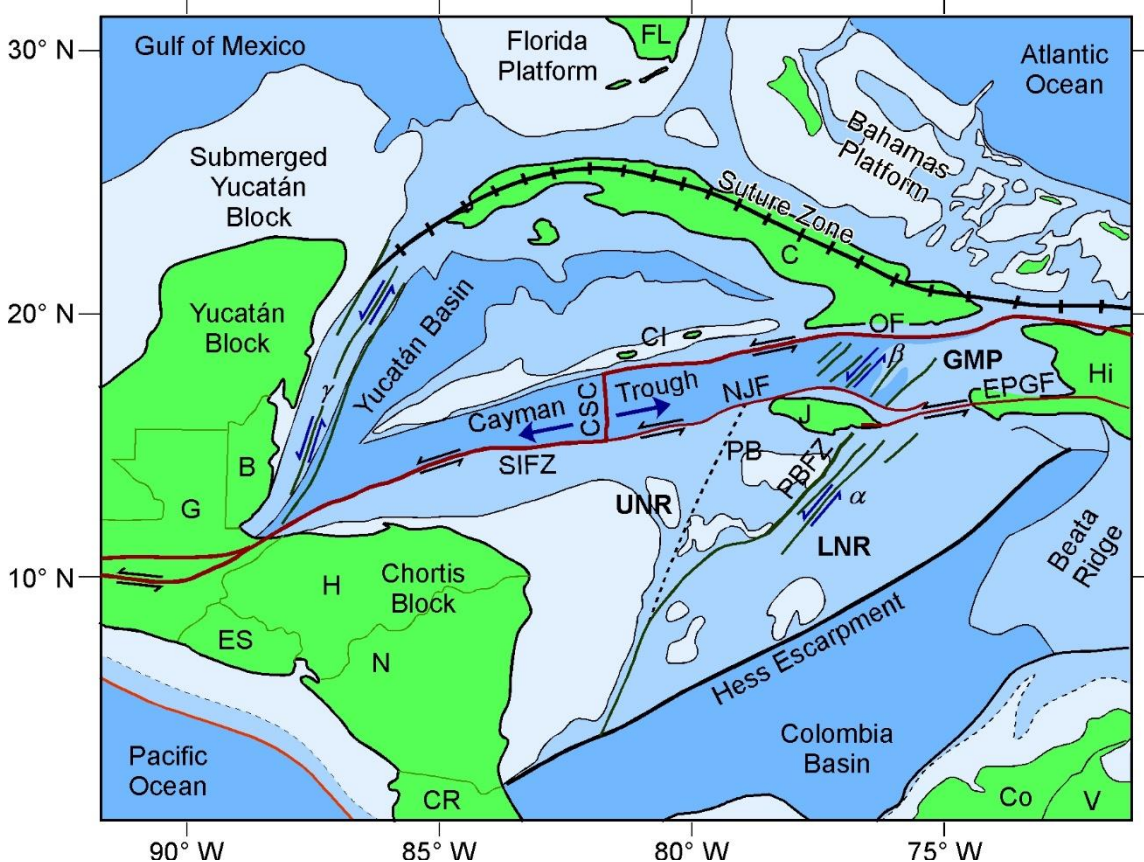


Figure 2. Geological features of the Central American. UNR, Upper Nicaragua Rise; LNR, Lower Nicaragua Rise. B, Belize; C, Cuba; Co, Colombia; CI, Cayman Islands; CR, Costa Rica; ES, El Salvador; FL, Florida; G, Guatemala; H, Honduras; Hi, Hispaniola; J, Jamaica; N, Nicaragua; V, Venezuela. Faults shown: EPGF, Enriquillo-Plantain Garden Fault; NJF, Northern Jamaica Fault; SIFZ, Swan Island Fault Zone; OF, Orient Fault; PBFZ, Pedro Bank Fault Zone, Hess Escarpment. NE-SW lineaments are shown by α , β and γ and show the faults that assembled Proto-Jamaica.

North America and South America subducted Pacific oceanic crust. In contrast the Greater Antilles Arc was subducting Proto-Caribbean oceanic crust. This resulted in tectonic interactions between the arcs and the CLIP rocks situated behind the Greater Antilles Arc. The associated strike-slip (side-by-side movement) faults now brought the various different parts of Jamaica closer together (Figure 3: Paleocene).

Stage 5. By the early Eocene (50 million years ago) the Cuban segment of the Greater Antilles Arc collided with the North American Plate and a change in plate movements meant that the assembly of Proto-Jamaica was complete (Figure 3: Middle Eocene). Cuba was transferred to the North American Plate, and Proto-Jamaica became part of the northern margin of the Caribbean Plate.

Subsequently, Jamaica would move to the east relative to the North American plate to the position that it occupies today (Figure 3: Present Day). Jamaica’s motto “Out of many one” not only fits its population, but also its geological history.

For more information (and additional references) see:

Mitchell, S. F. 2020. Cretaceous geology and tectonic assembly of Jamaica. In I. Davison, J.N.F. Hull and J. Pindell (eds.), *Geological Society of London, SP504 The basins, orogens and evolution of the southern Gulf of Mexico and northern Caribbean*, <https://doi.org/10.1144/SP504-2019-210>.

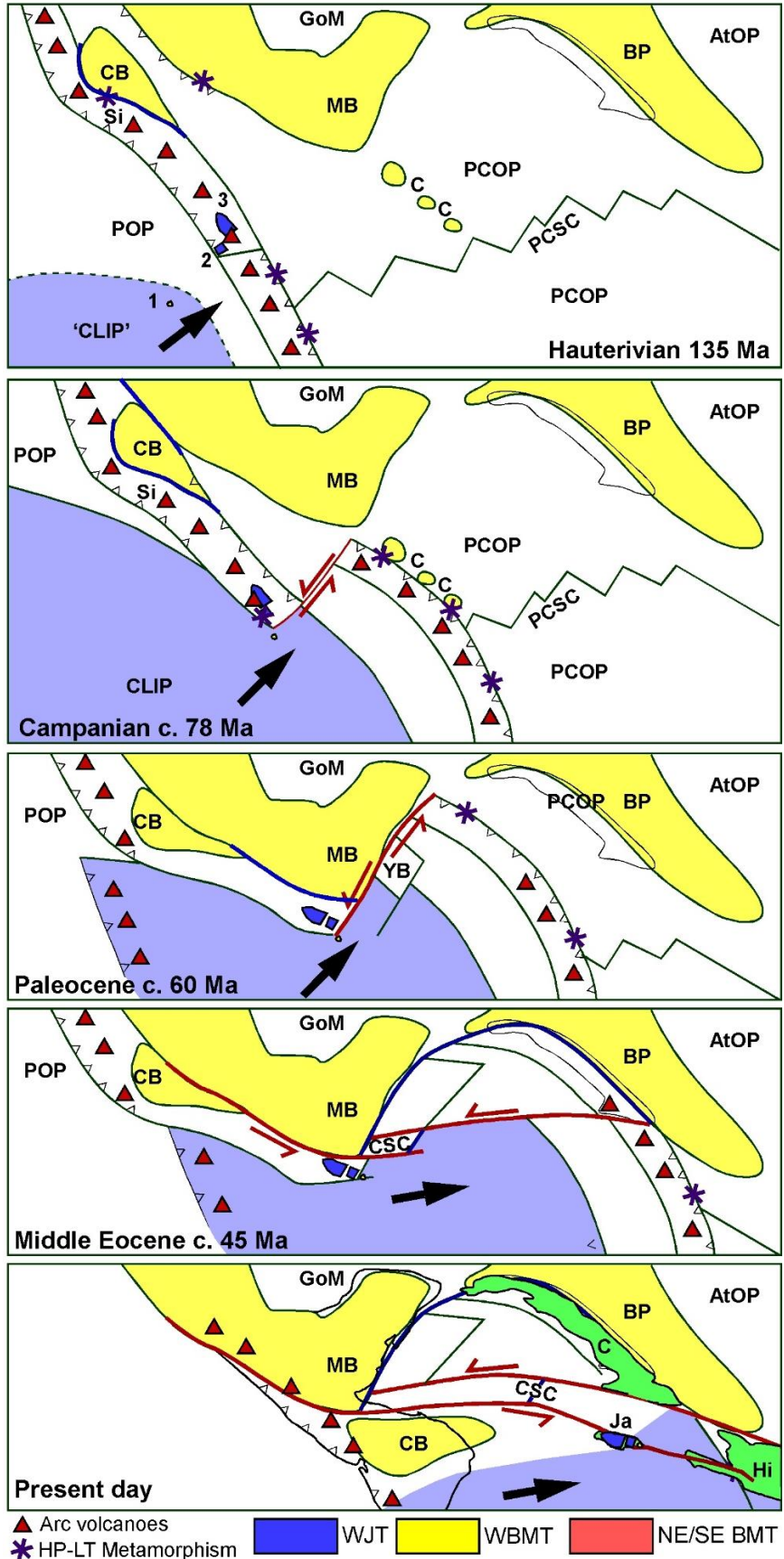


Figure 3. Simplified model showing evolution of Jamaica within a Plate Tectonic framework. CB, Chortis Block; GoF, Gulf of Mexico; MB, Maya Block; BP, Bahamas Platform; PCOP, Proto-Caribbean Oceanic Plate; PCSC, Proto-Caribbean Spreading Centre; AtOP, Atlantic Oceanic Plate; POP, Pacific Oceanic Plate; ‘CLIP’, future position of CLIP; CLIP, Caribbean Large Igneous Province; C, Caribeana continental fragments. Large black arrow, relative motion of the Caribbean Plate. Red arrows, strike-slip faults. Open black triangles on hanging wall of subduction zones. 1, CLIP related rocks; 2-3, arc-related rocks. Central American arc omitted for simplicity. (Modified from: Mitchell, S. F. 2020. Cretaceous geology and tectonic assembly of Jamaica. In I. Davison, J.N.F. Hull and J. Pindell (eds.), Geological Society of London, SP504 The basins, orogens and evolution of the southern Gulf of Mexico and northern Caribbean, <https://doi.org/10.1144/SP504-2019-210>).