Investigation of Lithospheric Deep Structure of the Caribbean Region

James, K. H., Lead Scientist, N. Amelin, CEO, and L. Miles, Interpretation Manager, Geology Without Limits,

Caribbean geology remains enigmatic. Most literature describes an oceanic origin of the area in the Jurassic Pacific, followed by Late Cretaceous oceanic plateau thickening above a hot spot/mantle plume, collision with an intra-oceanic volcanic arc and subduction polarity reversal, then Late Cretaceous to Recent engulfment by the westward-migrating Americas.

In this complex history, continental fragments of southern Mexico and northwestern S America, carrying ancient zircons, were subducted and metamorphosed, later to resurface during arc-parallel extension. Arc activity ceased during Middle Eocene collision along the northern and southern plate boundaries and rocks were accreted to the Greater and Leeward Antilles. The Yucatan and Grenada back-arc basins opened as plate boundaries jumped from Cuba to the Cayman Trough and from the Aves Ridge to the Lesser Antilles. Subduction continues below northwestern S America, the Greater Antilles (to the north and south) and the Lesser Antilles (the remaining active part of the arc). Crust as thick as 20 km in the Venezuela and Colombia basins represents the oceanic plateau, which is capped by upper Cretaceous basalts.

An alternative view is that the Caribbean formed, along with the Yucatan and Grenada basins and the Gulf of Mexico, simply by intra-continental extension between N and S America. Cuba, Hispaniola and Puerto Rico formed by Middle Eocene northward thrusting of volcanic and "oceanic" rocks onto the continental basement of the Bahamas. Mirror image thrusting occurred along northern S America. Since then, west to east strike-slip has dominated these boundaries, with eastward-migrating stress producing extensional subsidence followed by transpression, uplift and overthrusting. No subduction occurred here; ancient zircons indicate in-place continental basement.

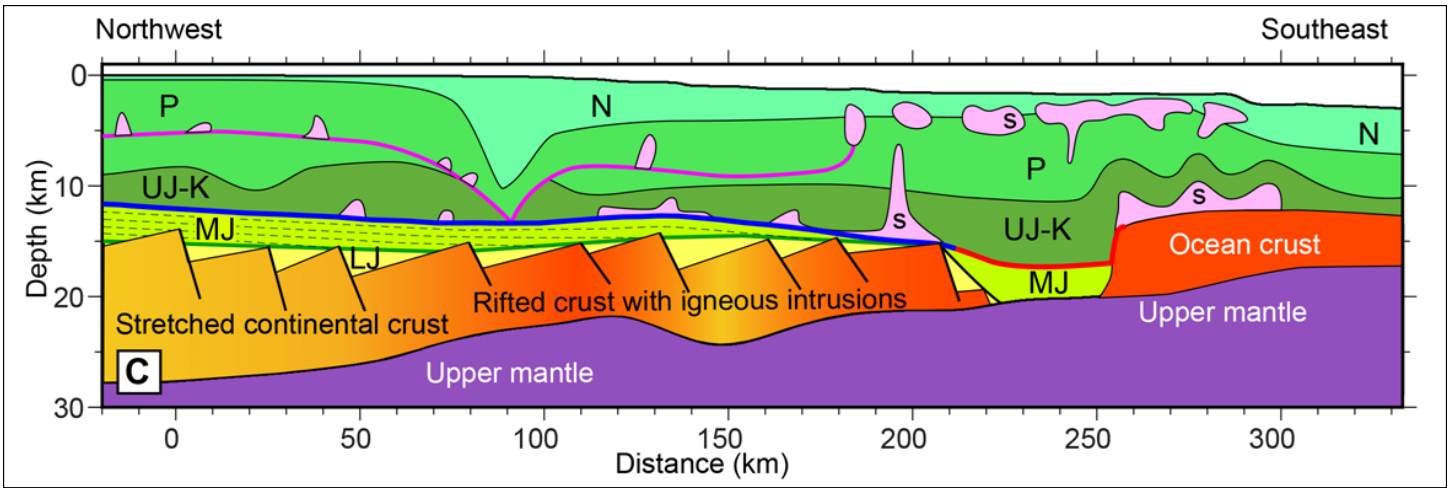

Figure 1. Section over the northeastern Gulf of Mexico, constructed by Van Avendonk et al., 2015.

It is anomalous that today, 50 years after the Pacific model surfaced along with Plate Tectonic theory, the origin of the Caribbean, Yucatán and Grenada basins remains unknown, despite their lying between the well-explored Gulf of Mexico and northern S America. This results in part from dominance of the Pacific paradigm, which focuses studies and interpretations. Geographically dispersed geology, including poorly mapped areas (access, weathering), and lack of regional data over the area's interior are further problems.

Even in the Gulf of Mexico, deeper geological history is only now coming to light, as latest seismic techniques reveal sub-salt architecture. A recently published section (Fig. 1[1]) shows basinward evolution from rifted continent, with salt, to extended continent and then oceanic crust. Seismic line ew9501/1293 (Fig. 2[2]), recorded by Lamont Doherty in 1995, shows similar architecture in the Caribbean interior. DSDP-drilled, upper Cretaceous basalt (seismic Horizon B") overlies underlying extended geology, which is not a 20 km thick oceanic plateau.

Salt diapirs are present, protected by cap rocks where they pierce the sea floor and locally rafting fragments of the basalt layer. Similar geology is seen along N and S Atlantic margins. Comparison of line ew9501/1293 with seismic offshore Brazil suggests interesting similarities.

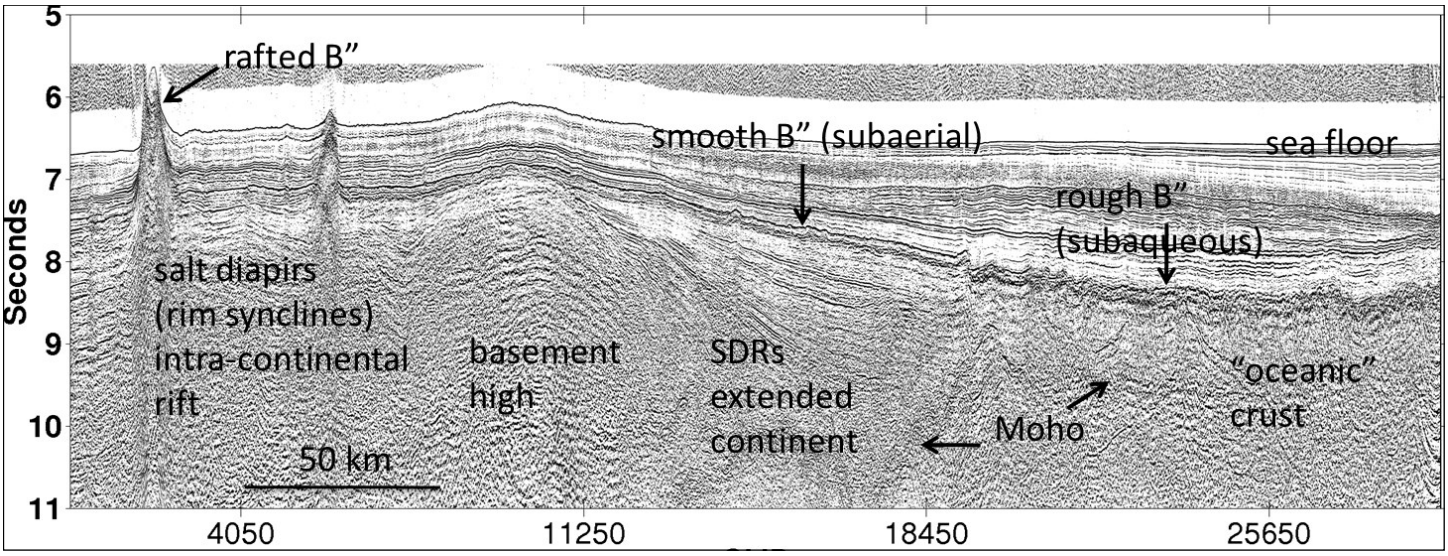

Figure 2. Seismic line ew9501.1293, recorded by Lamont Doherty, Diebold et al., 1999; interpreted James, 2015.

This alternative suggests that the Yucatán, Colombia, Venezuela and Grenada basins share history with the Gulf of Mexico. A simple and coherent model for Middle American evolution emerges.

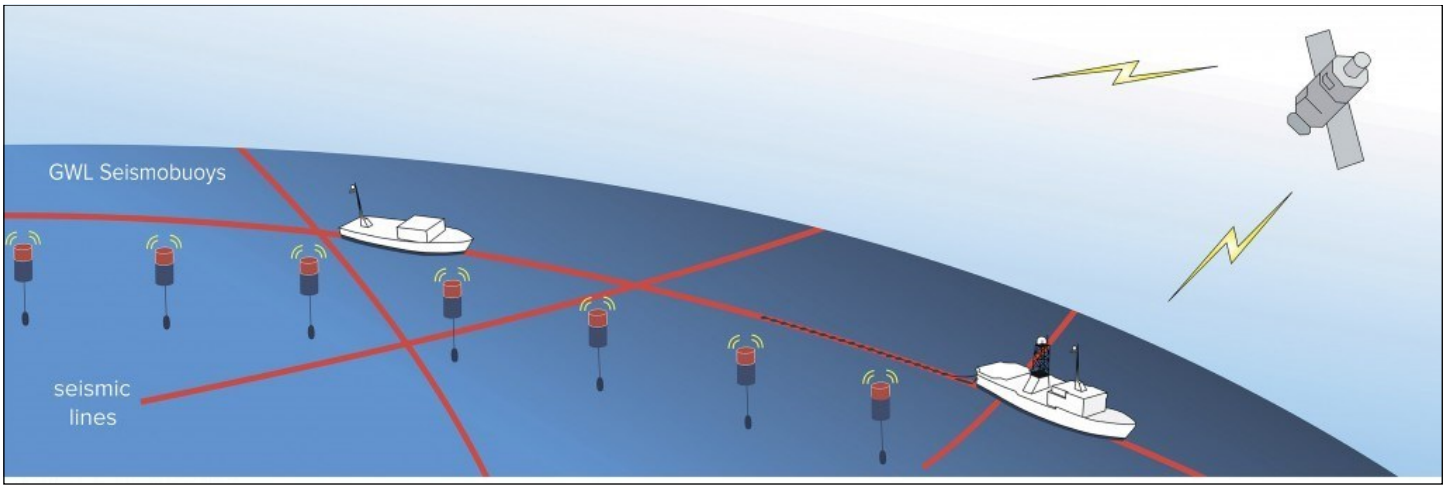

Figure 3. Schematic illustrating use of free-floating seismobuoys.

Jurassic- and Cretaceous-sourced oils could be expected, along with Tertiary-sourced gas. Prospectiveness would be much more positive (important for Caribbean nations) than that suggested by the Pacific model. Indeed, Jurassic oil similar to Gulf of Mexico oil occurs on Jamaica. Cretaceous oil similar to Venezuelan crude is produced on Barbados and has been sampled on Antigua and Saba.

It is important to note that the Caribbean interior (2,750,000 km^2) is as well known today as the North Sea (750,000 km^2) was in 1965. The seismic investigation to be launched in Q4 2015, conducted with the cutting-edge technology GWL Seismobuoy® (Fig3), which extends seismic data offsets up to 150 km and builds reliable velocity models for depths up to 40-45 km, will cover 46,000 km (Fig.4) and should resolve the long-standing debate on Caribbean plate origins. Velocity and structural architecture should show whether the area is entirely oceanic or if it formed during continental extension.

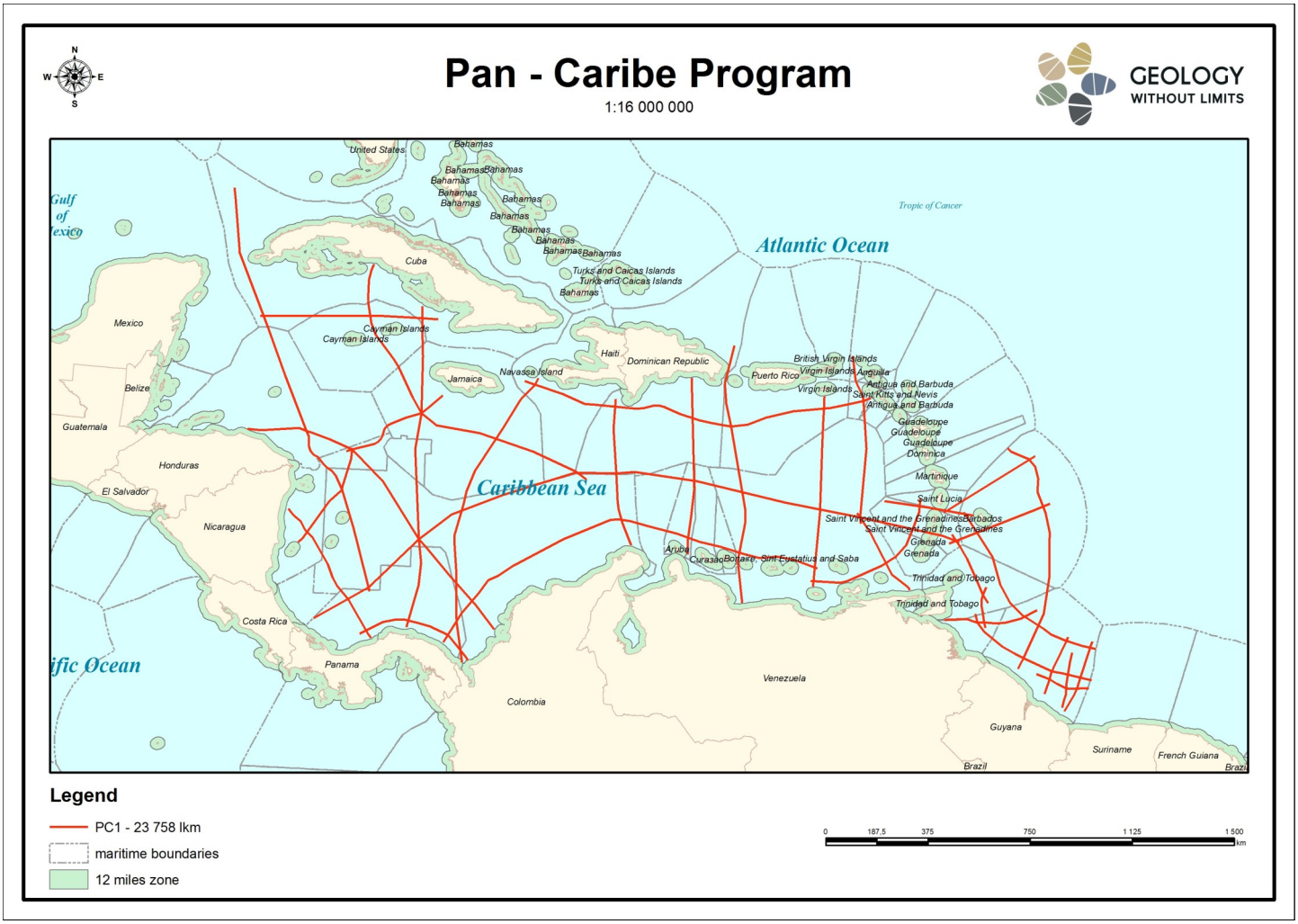

Figure 4. The GWL Seismic program; commencing Q4, 2015.

Readers with questions are invited to address them to:

Keith James khj@aber.ac.uk.

Further articles available at kjgeology.com

References:

[1]Van Avendonk, H. J. A., G. L. Christeson, I. O. Norton and D. R. Eddy, 2015, Continental rifting and sediment infill in the northwestern Gulf of Mexico: Geology, v. 43, no. 7, p. 631-634.

[2]Diebold, J., N. Driscoll and the EW-9501 Science Team, 1999, New insights on the formation of the Caribbean basalt province revealed by multichannel seismic images of volcanic structures in the Venezuelan Basin: IN: Mann, P. (ed.), Caribbean Sedimentary Basins, Sedimentary Basins of