Sediment Accretion and Orogenesis in the Southeastern Caribbean: One Prism or Two?

Jim Pindell[1], Rod Graham[2,] and Kyle Reuber[3]

[1]*Tectonic Analysis Ltd. and ION Advisors; Ltd., Chestnut House, Sussex, UK*
[2]*Independent Consultant and ION Advisors*
[3]*ION Geophysical*

Abstract

The long-accepted model of Caribbean Plate migration along and between the passive margins of North and South America implies a single accretionary prism ahead of the Caribbean's Lesser Antilles arc, assumed to be the Barbados Subduction Accretion Complex. However, the fact remains that several hundred km of N-S convergence occurred between the North and South American plates prior to and during the Caribbean's eastward migration (Pindell et al., 1988; 1991; 1998; 2007; 2009), and thus we should expect the existence of a convergent plate boundary somewhere in the Proto-Caribbean basin (east of the migrating Caribbean Plate) that has been merged progressively with the Lesser Antilles/Caribbean prism.

The first seismic tomographic cross sections of the Caribbean clearly show a severing of the original continent-ocean transition along northern South America, beneath the overlying allochthonous Caribbean lithosphere. Later work employed this evidence to suggest that the pre-existing convergence zone between the Americas, or "Proto-Caribbean thrustbelt", lay along northern South America, and that the dextral oblique progressive Caribbean-South America transpressional collision was not of the arc-continent type, but rather a collision between two pre-existing convergent margins. This concept remained fairly dormant for several years due to the complex nature of both the southern Caribbean's actual geology and the predictions made by the concept, but yet later work considered that Cenozoic paleo-deposition and erosion history along northern South America and the southern Caribbean terranes such as Tobago were best viewed in terms of the trench-trench collision model, upon which they elaborated.

Concurrently, the seismic tomographic results of the BOLIVAR research program (Rice University) have refined the early tomographic views. We now know that a swath of the Atlantic slab extends steeply beneath NE Venezuela to a depth of many hundreds of km, and that the Caribbean slab entering the NW Colombian Trench extends several hundred km into the mantle as far east as the Merida Andes (several papers by Alan Levander and colleagues). These observations confirm large allochthoneity of the Caribbean Plate, of course, but of greatest interest here is that the severing of the original Jurassic South American margin was also observed by BOLIVAR, and that the sinking Proto-Caribbean lithosphere has been forced south of its original tear line at the paleo-surface, thus recording the convergence between North and South America, which is independent of the Caribbean Plate's motions. This strongly implies the existence of shortened sedimentary section along northern South America that is unrelated to Caribbean migration, but distinguishing such terrane from Caribbean-driven shortening is not straightforward.

It has been suggested that the cooling histories of the meta-sediments of Venezuela's Caracas Group, the autochthonous parts of Araya, and the Paria-Northern Range fit a model in which progressive metamorphism in these belts was driven by Proto-Caribbean, rather than Caribbean, convergence, and that uplift and cooling of the belts were driven by Caribbean arrival. New cooling ages on some of these rocks continue to suggest this two-fold history. But more importantly, newly processed deep penetration seismic lines across the greater Barbados accretionary complex show only a relatively small amount of shortening (<200 km) ahead of the Barbados Ridge, on which Barbados Island lies. Although subduction accretion belts rarely record much of their shortening due to telescoping of the detachment surface to the paleo-seafloor at the deformation front, this low shortening value is also attributable to the two-prism model, in which we envision the Barbados Ridge as having formed by NW-vergent shortening between North and South America, and not to the migration of the Caribbean along South America. We believe the Barbados Ridge is a Proto-Caribbean accretionary prism with a Cretaceous section beneath the Paleocene-Middle Eocene Scotland beds, that formerly continued westward from Barbados into Trinidad's Northern Range, and onward into the Araya-Paria belt, and then the Caracas Group, prior to collision with the leading edge of the Caribbean Plate. This Proto-Caribbean prism was subsequently uplifted diachronously eastward as Caribbean collision progressed (in the Early Miocene north of Trinidad), providing a northward source of largely non-volcanogenic clastic sediments to the Central Range by Early Miocene (i.e., "Northern" Nariva, Cunapo and Brasso Fms). Farther offshore, the leading edge of the Caribbean Plate wedged into (underthrust) the west side of the Barbados Ridge prism, but overthrust the South American crustal hanging wall of the Proto-Caribbean subduction zone, such that the Ridge was accreted to the Caribbean Plate/prism and has been pushed farther eastward across the South American oceanic crust during Miocene-Recent Caribbean relative motion. All subsequent shortening east of Barbados Ridge is less than 200 km and the trace of the Proto-Caribbean Trench has been subducted beneath the southern Lesser Antilles arc system, except where it appears to exit from beneath the Caribbean Plate today along the ENE trending gravity low (Tiburón Trough) to the northeast of Barbados. In summary, the newly processed seismic dataset over Barbados further clarifies the tectonics of the SE Caribbean and hence the Pacific origin of the Caribbean Plate.