CHAPTER 4

Latest Eocene to Middle Miocene Tectonic Evolution of the Caribbean: Some Principles and their Implications for Plate Tectonic Modelling

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ABSTRACT: The tectonic model presented here for the latest Eocene through middle Miocene interval for the Caribbean Region may be controversial in the sense that it introduces several new perspectives into Caribbean Plate tectonic reconstructions. However, the issue is not the model itself, but the series of geologic facts on which it is based. These facts, properly taken into consideration, will lead to a better understanding of the geologic structure and tectonic evolution of the Caribbean. One of these facts is that many different episodes of orogeny have affected the Caribbean Region and surrounding areas during the past 170 Ma. The most significant of these took place in the late Aptian (120 Ma to 110 Ma), late Campanian–early Maastrichtian (75 Ma to 70 Ma), and middle-late Eocene (45 Ma to 38 Ma), and had worldwide effects. In the Caribbean, these effects included: (1) modification of the rates of plate movement, (2) rotation of major stress axes, (3) modification of the orientation and extension of volcanic arcs, (4) alteration of magmatic geochemistry, and (5) formation of fold belts. Another fact is that clockwise stress field rotation in the Caribbean has been affecting the movement of tectonic plates as well as other related geological processes. For example, arc magmatism took place as regionally discrete magmatic stages punctuated by nonvolcanic intervals. Each of these stages is separated by structural unconformities due to tectonic deformation and uplift, by hiatus related to erosion and non-deposition, and by deposition of coarse clastic and carbonate sedimentary rocks. This concept of regionally-discrete magmatic stages contradicts the widely-held view of a single “Great Arc” continuously developing on the leading edge of the Caribbean Plate from the Jurassic onward. As a result of the combined effects of stress rotation and orogenesis, the evolution of the Caribbean can be subdivided into three main periods: (1) Jurassic to Late Cretaceous (200 Ma to 70 Ma); (2) Late Cretaceous to middle-late Eocene (70 Ma to 38 Ma); and (3) late Eocene to Recent (38 Ma to 0 Ma). Different sets of geologic units have been active for each time period, and only through accurate palinspastic reconstructions can the evolution of the Caribbean Region be understood.
INTRODUCTION

PLATE TECTONIC MODELS for the Caribbean (e.g., Malfait and Dinkelmann 1972; Duncan and Hargraves 1984; Leclere and Stephan 1985; Ross and Scotese 1988; Donnelly 1985, 1989; Pindell and Barrett 1990; Mann et al. 1995; Hay and Wold 1996; Iturralde-Vincent 1994a, b, 1996) vary widely in their comprehensiveness and testability (Rull and Schubert 1989). For example, agreement is still lacking regarding the number and fit of plates and microplates in the Caribbean Region, and many other details (Donnelly 1985; Ross and Scotese 1988; Pindell 1994; Hay and Wold 1996). Major discrepancies among models often concern the principles by which they are designed, a subject that is discussed here in the example of the late Eocene through middle Miocene plate tectonic evolution of the Caribbean.

PLATE TECTONIC MODELLING IN THE CARIBBEAN

Basic assumptions underlying plate tectonic reconstructions of the Caribbean and their bearing in major discrepancies among available models are presented in the following paragraphs.

OROCOGENIC EVENTS

Many different episodes of orogeny, from regional to global, have affected the Caribbean region and surrounding areas during the past 170 Ma. The most significant of these took place in the late Aptian (120 Ma to 110 Ma), late Campanian–early Maastrichtian (75 Ma to 70 Ma), and middle-late Eocene (45 Ma to 38 Ma) and had worldwide effects. In the Caribbean, these effects included: (1) modification of the rates of plate movement, (2) rotation of major stress axes, (3) modification of the orientation and extension of volcanic arcs, (4) alteration of arc magmatic geochemistry, and (5) formation of fold belts (Schwan 1980; Mattson 1984; Pszonkowsk and Flores 1986; Iturralde-Vincent 1994c; Iturralde-Vincent et al. 1996; Bealower and Iturralde-Vincent 1997).

The orogeny which occurred in the middle-late Eocene is especially noteworthy. Associated with this orogeny were (1) reduction in the relative motion of the North and South American Plates (Pindell 1994, Figure 2.3), (2) reorientation of the Caribbean Plate....

Figure 4.1. A Caribbean tectonic frameworks: current position of geological units active from latest Eocene through late Miocene.
stress field from mainly NE–SW to dominantly E–W, and (3) formation of numerous microplates, blocks, and terranes along plate margins (Case et al. 1984). Figure 4.1 (A and B) illustrates the tectonic framework of the Caribbean from Late Cretaceous to late Miocene.

In the Greater Antilles, the middle-late Eocene orogeny was associated with cessation of magmatic activity and the uplift of volcanic structures formed in the Paleocene through early-middle Eocene. The cessation of magmatism in the Greater Antilles (and probably on the Cayman Ridge and Aves Ridge) led to a permanent shift to the Lesser Antilles arc. This orogeny additionally led to deactivation of the Yucatan Basin spreading centre and the shifting of ocean crust production to the Cayman Trench (Rosencrantz 1990) and the Grenada Basin (Bird et al. 1993). Owing to these movements, a fold belt was formed which is now present in the Greater Antilles, Aves Ridge, Aruba-Tobago Belt, Caribbean mountains, Colombian-Venezuelan Andes, and Central America (Fig. 4.1A). Consequently, the tectonic activity and plate movements ought to differ before (Fig. 4.1B) and after (Fig. 4.1A) the middle-late Eocene, as geodynamic forces operate on different sets of tectonic entities.

**Evolution of Island Arc Magmatism**

The most important magmatic events in the history of the Caribbean area were: (1) continental margin magmatism in association with the break up of Pangaea (170 Ma to 110 Ma) (Maze 1984; Bartok 1993; Iturralde-Vinent 1994a); (2) the nearly isochronous oceanic magmatism related with oceanic crust formation in the proto-Caribbean between 170 Ma to 110 Ma (Pindell 1994); (3) the mantle plume that produced the Caribbean flood basalt event ~89 Ma (Dengo and Case 1990); (4) the eruption of alkaline volcanoes related to intraplate tectonic activity along major faults (Dengo and Case 1990); and (5) the evolution of the volcanic island arcs.

Several discrete stages of volcanic-arc magma-
tism are recorded in the Caribbean. These are: (1) Neocomian to Aptian (120 Ma to 110 Ma); (2) Albian to Coniacian-Santonian (100 Ma to 80 Ma); (3) Santonian-early Maastrichtian (80 Ma to 70 Ma); (4) Paleocene to early-middle Eocene (63-55 Ma); and (5) latest Eocene to Recent (37-0 Ma). Each of these regionally discrete magmatic stages is separated by structural unconformities due to tectonic deformation and uplift, hiatus related to erosion and non-deposition, and deposition of coarse clastic and carbonate sedimentary rocks (Iturralde-Vinent 1994a, 1994c, 1995, 1996, 1997). This conception of periodic arc magmatism, punctuated by nonvolcanic intervals, contradicts the widely held view originally formulated by Malfait and Dinkelmann (1972), who envisaged a single “Great Arc” continuously developing on the leading edge of the Caribbean Plate from the Jurassic–Early Cretaceous onward (See also Burke et al. 1984; Pindell 1994).

Recent supporters of the continuous-development model include Mann et al. (1995, Fig. 36A-C), who argue that the convergent front of the Caribbean Plate was active with subduction deepening to the south from Maastrichtian until middle Eocene times (See also Pindell 1994). However, no magmatic activity subsequent to the late Campanian is recorded in western and central Cuba (Iturralde-Vinent 1994a), Aruba-Tobago Belt (Hunter 1978; Jackson and Robinson 1994) or the Caribbean mountains (Bonini et al. 1984; Macellari 1995). Additionally, volcanic-arc rocks of mid-Paleocene to early-middle Eocene age in Eastern Cuba are unconformable on latest Campanian–Maastrichtian conglomerate and sandstone or pre-Maastrichtian Cretaceous arc rocks (Iturralde-Vinent 1994a, 1996), as well as in the Dominican Republic (Iturralde-Vinent 1997) and Puerto Rico (Mattson 1984; and H. Santos, field observations with the senior author). Another prob-

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![Figure 4.2 Plate tectonic reconstruction, Caribbean Region, Eocene-Oligocene transition (35 Ma to 33 Ma). In this and the following two figures, coastlines of present-day islands and continents have been shifted to their correct paleoposition; however they do not represent paleogeographical reality. Structural elements have been subdivided into smaller units (e.g., Nicaragua Rise into Western Jamaica Block, Pedro Bank Block, Rosalind Bank Block, etc.), when necessary in order to preserve tectonic accuracy. Larger crosses superimposed represent intersection of modern geographical coordinates for certain geological units.](image-url)
Figure 4.3 Plate tectonic reconstruction, Caribbean Region, late Oligocene (27 Ma to 25 Ma).

Figure 4.4 Plate tectonic reconstruction, Caribbean Region, middle Miocene (16 Ma 14 Ma).
lem with this concept of a single arc developing on the leading edge of the Caribbean Plate is the position of the subduction zone in eastern Cuba, located to the south of the arc and dipping to the north (Iturralde-Vinent 1994a, 1996; Sigurdsson et al. 1997), rather than vice versa, as required by the most popular models (Pindell 1994; Mann et al. 1995). Furthermore, it is geometrically questionable that the Paleocene-middle Eocene subduction zone in the Greater Antilles would have a different orientation in eastern Cuba with respect to Hispaniola and Puerto Rico/Virgin Islands, mostly since in these regions there is not a clear-cut tectonic framework that suggests any specific orientation (but see Iturralde-Vinent 1994a).

**Stress Field Rotation**

Stress-field rotation during the formation and evolution of the Caribbean was proposed by Iturralde-Vinent (1975). This phenomenon is evident in the present day N–S orientation of the convergence front (island-arc subduction zone) of the Lesser Antillean and Central American arcs, and in the extension of arc magmatism southward in Central America during the last 25 Ma. It is also evident in the location of post-Eocene transform faults and associated deformations along the northern and southern margins of the Caribbean Plate, and in the sequential shifting of plate boundaries along major faults (in the north, from Nipe-Guacanayabo to Oriente to Septentrional; in the south, from the Mérida-Boconó suture toward the Oca-Pilar fault [Fig. 4.2–4.4]).

Migration of volcanic activity and the other phenomena noted above have been interpreted as a consequence of the oblique collision and resulting "escape to the east" (or "escape to the ocean") of the Caribbean Plate, as its leading edge progressively collided with the Bahama platform (e.g., Mann et al. 1995). However, Bralover and Iturralde-Vinent (1997) have rejected this interpretation as it concerns Cuba, on the grounds that the Cuba-Bahama collision is conventionally dated as early-middle Eocene, but arc extinction actually occurred much earlier (15 Ma previously; in the Late Cretaceous; see also Iturralde-Vinent 1994a, 1994c). Earlier extinction of the Cretaceous arc is also seen in the Caribbean mountains (Bonini et al. 1984; Macellari 1995; Beccaluva et al. 1996) and the Aruba-Tobago belt (Jackson and Robinson 1994), indicating that the Cuban case is not anomalous. Therefore, the conventional "wisdom" that the arc volcanism ended in the Greater Antilles as a consequence of collision of the arc with the continental margin must be rejected.

The mechanism of stress-field rotation might be driven by the same deep process that also affects the movement of tectonic plates. From this perspective, tectonic events recorded in the lithosphere may not be thought of only as a consequence of interactions between individual plates, but also as a result of reorientations and rotations of the stress in the deep-seated (mantle-core and mantle-lithosphere) plate-driven mechanisms.

**Palinspastic Reconstruction**

Interactions between plates commonly result in profound deformations of crustal blocks and terranes, not only along plate margins but also within intraplate domains — as is the example of Beata Ridge (Holcombe et al. 1990). Typical deformations include crustal shortening and superimposition of units as a consequence of folding and thrust faulting, as well as the partial or complete destruction of microplates, blocks and terranes at subduction zones. These processes operate at all scales, resulting in modification of the size and configuration of individual blocks as well as entire plates.

Tectonic models which purport to be realistic must take some account of these processes; if not, they will be problematic. The recent tectonic model for the Caribbean published by Hay and Wold (1996) may be cited as an example of the latter. In their model, tectonic blocks and terranes move, but they do not deform, even after many millions of years have elapsed (Hay and Wold 1996, their Figures 2–7). The resulting lack of realism is evident in the evolution of Hispaniola (our Central and Northern Hispaniolan Blocks; Figure 4.1A). Hispaniola is depicted by these
authors as suffering no deformations or alterations from the Late Mesozoic onward. To fit within the space available per time slice, it has to be sequentially moved from a position within the Pacific realm (150 Ma to 130 Ma) to the margin of the Chortis Block (100 Ma), thence to the margin of the Maya Block (67.5 Ma), thence south of western Cuba (58.5 Ma), thence south of eastern Cuba (49.5 Ma), finally to end up east of Cuba at 24.7 Ma (Hay and Wold 1996, their Figures 2–7). Further problems are introduced by unconstrained rotation of the terrane along its major axis from N–S at 130 Ma to ENE–WSW at 49.5 Ma. These proposed lateral displacements and rotations find no support in the geological composition or structure of central and northern Hispaniola (Draper 1989; Mann et al. 1991).

The basic problem of Hay and Wold (1996) was to ignore the need for a palinspastic reconstruction of the area, but such examples are common rather than unusual. In creating reliable tectonic models, it has long been recognized that, to determine the successive sizes of a geologic unit, the effects of movement and deformation have to be palinspastically undone.

Figure 4.5 Simplified palinspastic reconstruction of the Greater Antilles fold belt along a cross-section passing through eastern Cuba and western Hispaniola.
**Palinspastic Reconstruction of Eastern Cuba–Hispaniola**

Figures 4.5 and 4.6 present a schematic example of a palinspastic reconstruction for eastern Cuba–Hispaniola. The two cross-sections in Figure 4.5A represent the structure of the foldbelt in eastern Cuba and western Hispaniola as seen today. In Figure 4.5B, these cross-sections are restored to their relative positions before separation caused by sinistral movements along Fault A-A’ due to the opening of the Cayman Trench (steps 1 and 2). This requires the deletion of entities that have been intercalated as the result of horizontal movement along A-A’ (southern Hispaniolan block and the crust of the Cayman Trench). With these omitted, it can be seen that the two cross-sections can be precisely lined up along their volcanic-arc sequences (step 2). This step is the tectonic framework that resulted from the middle Eocene orogeny. In step 3, we simplify the present-day relative position and width of the geologic units found in the fold belt (carbonate continental margin, ophiolites, volcanic arcs and sedimentary basins), depicting them as a series of superimposed bars. These geologic units were active before the formation of the fold belt, embracing units that were formed even in separate plates (North American and Caribbean Plates). In steps 4 and 5 we sequentially remove the effects of overthrusting and shortening due to internal deformation within the units themselves, thereby conventionally resolving the original width of the fold belt. Step 5 represents the geological units that were involved in the evolution and interactions between the Caribbean and North American Plates. To this framework has to be added the crust consumed in the subduction zone, which will further enlarge the width of the restored section. Although this example is

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**Figure 4.6** Palinspastic reconstruction of the eastern part of the Greater Antilles fold belt, for the period corresponding to late Eocene through mid-Oligocene (37 Ma to 30 Ma). A-A1 are reference points for the cross-section depicted in Figure 4.5.
schematic, it makes the point that the geometry of the present may differ radically from the geometry of the past, because present-day fold belts are built up by a complicated set of older geological units representing different paleogeographic frameworks.

In order to substantiate the palinspastic reconstruction schematically illustrated in Figure 4.6, we will further discuss the basis for constructing the latest Eocene tectonic framework of the Greater Antilles (Fig. 4.1A). For this purpose, the following constraints are taken into consideration:

1. Neocomian-Campanian Cretaceous volcanic-arc rocks outcrop from west-central Cuba across Hispaniola into Puerto Rico and the Virgin Islands (Dengo and Case 1990), suggesting that all this territory was geologically connected during the Cretaceous.

2. Outcropping ophiolites (ultramafic and gabbroids) in Cuba follow the same trend as those in Central Hispaniola, especially when their paleoposition in the early Miocene is reconstructed palinspastically (Fig. 4.6). This suggests that they belong to the same fold belt.

3. Four associated distinctive metamorphic rock units—marble and schists of the Bahama margin complex, amphibolites (meta-ophiolites), serpentinines with blocks of eclogite, and metamorphosed Cretaceous volcanic-arc rocks—outcrop in easternmost Cuba (Baracoa) and northwestern Hispaniola (Samana). They demonstrate that these terranes had a similar tectonic history.

4. Maastrichtian massive conglomerates, dominated by ophiolite pebbles and overlain by Paleocene–early Eocene white tuffaceous rocks only outcrop southeast of Holguin in eastern Cuba and in a small area in northwestern Hispaniola (Fig. 4.6, detail). This rock suite is of unique importance for correlating Cuban and Hispaniolan terranes during that time interval (Draper 1989; Iturralde-Vinent 1994c).

5. Paleocene–early-middle Eocene volcanic-arc rocks outcrop in eastern Cuba as well as the northern peninsula of Haiti, central Hispaniola (Toloczyki and Ramírez 1991), and Puerto Rico. Field observations by the senior author in Puerto Rico (during several seasons between 1993 and 1998) suggest that these rocks are perfectly correlateable with those in eastern Cuba. This suggests that the Paleocene-Eocene volcanic arc embraced each of these territories.

6. Latest Eocene-Oligocene sedimentary rocks in the Guantánamo basin correlate well with those found in the Cibao-Altamira basin of Hispaniola (Calais et al. 1992; Iturralde-Vinent and MacPhee 1996). Such facts indicate that all these sediments were deposited in a single basin before being tectonically disrupted.

7. The paleoposition of Puerto Rico with respect to Hispaniola is not so well constrained as that of Cuba/Hispaniola, although it is known that the Cretaceous volcanic-arc complex outcropping in eastern Hispaniola also forms a large portion of the basement of Puerto Rico. The most important correlateable units are the Duarte complex of Hispaniola (Toloczyki and Ramírez 1991) and the Bermeja Complex of Puerto Rico, which lie along the same trend. Also, outcrops of Paleogene rocks on the eastern side of Hispaniola lie along the same trend as their equivalents in Puerto Rico (Fig. 4.6; Case et al. 1984).

The close match between the main structural fabric and compositional elements of eastern Cuba, Hispaniola and Puerto Rico-Virgin Islands, as illustrated in Figure 4.6 is valid only for the interval between latest Eocene and mid-Oligocene (35 Ma to 30 Ma). This scenario is the consequence of middle-late Eocene overthrusting and extensive superposition of geologic units that took place in the Greater Antilles and gave rise to an extensive fold belt (Meyerhoff and Hatten 1968; Pardó 1975; Mann et al. 1991; Iturralde-Vinent 1994a).

**Palinspastic Reconstruction of Jamaican Basement**

One particular area which needs to be discussed separately is Jamaica. According to Pindell's (1994) model of the origin of Jamaica, the island's basement as a whole was originally part of the Cretaceous volcanic
arc located on the leading edge of the Caribbean Plate. As the Plate moved east toward Bahama during the Late Cretaceous, the basement rocks of Jamaica remained attached to northern Central America. It is assumed by necessity that these rocks were carried to their present-day position later, when the Nicaragua Rise (which originated in the Pacific) was inserted into the Caribbean Region (Pindell 1994, his Figure 2.6). According to Pindell's model (1994), one would expect to find strong similarities between the ophiolitic and Cretaceous arc suites of western Cuba and those of Jamaica, since they were located side by side in the original arc. Yet there is virtually no similarity between relevant geological sections in the regions (Robinson 1994; Iturralde-Vincent 1996b).

By contrast, there are several resemblances in the composition of the ophiolitic and metavolcanic rocks of the eastern Cuban Block and the Blue Mountains, as was discussed by Iturralde-Vincent (1995), suggesting that these terranes belong to the same geological province. Most importantly, the geological composition of the Mesozoic rocks of southern Hispaniola and the Blue Mountains are also remarkably similar (compare descriptions of Mesozoic rocks in southern Hispaniola by Butterlin [1969] and Maurrasse [1982] with descriptions of Blue Mountains Mesozoic rocks by Robinson [1994] and Montadert et al. [1985]).

These facts suggest that Jamaica may be structurally and lithologically divisible into two major terranes, consisting of a large western block (Clarendon and Hanover Blocks of Lewis et al. 1990) and a smaller Blue Mountains Block. These two terranes differ radically in crustal composition, degree and type of metamorphism, and stratigraphy (including the span of Cretaceous-Eocene units), as is evident from several recent papers and mapping projects (Geddes 1994; Montadert et al. 1985; Lewis et al. 1990; Robinson 1994). It is true that, after the middle-late Eocene, resemblances between isochronous formations in both parts of Jamaica greatly increase (e.g., Bonnie Gate Formation is apparently present in both blocks; Robinson 1965, 1994).

However, lithology by itself has limited correlation value in this case, as compositionally similar formations of Late Tertiary age outcrop widely in the Greater Antilles.

If Jamaica proves to be divisible into two independent blocks or terranes, it follows that the terranes may have had different tectonic histories. Stratigraphic data from the basement of the Nicaraguan Rise are spotty, but isolated wells, dredge hauls and seismic stratigraphy confirm that it shared with western Jamaica a considerable amount of geological history. Assuming that the Cretaceous basement of western Jamaica can be correlated with basement rocks of Nicaraguan Rise (also known to be Cretaceous [Holcombe et al. 1990]), it appears that this terrane (i.e. western Jamaica and the Nicaraguan Rise together) was the site of volcanic arc activity in the last part of the Mesozoic, mostly under submarine conditions (Case 1975; Masclle et al. 1985; Perfit and Heezen 1978; Holcombe et al. 1990; Maurrasse 1990). Occurrence of at least one terrestrial vertebrate in early Eocene rocks of western Jamaica (Domning et al. 1997) indicates that it was physically connected to North America in the early Eocene. These observations can be made concordant if it is accepted that western Jamaica evolved from the leading edge of the Nicaraguan Rise (Pindell 1994).

On the other hand, the Blue Mountain Block originated as part of the northern Greater Antilles, as proposed above. In this interpretation, western Jamaica and the Blue Mountains Block maintained separate existences until the middle Miocene, when they were conjoined during tectonic deformations recorded in the island (Montadert et al. 1985). We acknowledge that this dual-origin hypothesis represents a break with the view of the origin of Jamaica, and that further substantiation is required.

**Palinspastic Reconstruction of Aves Ridge/Lesser Antilles/Grenada Basin**

The Aves Ridge/Lesser Antilles/Grenada Basin is part of the southeastward continuation of the Greater Antilles. Cretaceous and Paleogene volcanic and plu-
tonic rocks of island-arc affinities occur on the Aves Ridge, as do Mesozoic and Eocene volcanic rocks in the Lesser Antilles (Bunce et al. 1970; Nagle et al. 1972; Bouysse et al. 1985; Westercamp et al. 1985; Holcombe et al. 1990). This basic compositional similarity suggests that, from Cretaceous through Eocene time, Aves and Lesser Antilles were a single volcanic arc (Pinet et al. 1985; Bouysse et al. 1985). These units were presumably linked geologically (as a single arc) to the Aruba-Tobago magmatic belt in the south, and with the eastern Greater Antilles in the north (Pindell 1994), as all of these territories possess a similar Cretaceous volcanic-arc ophiolite basement (Dengo and Case 1990).

If Aves and Lesser Antilles once comprised a single arc, it can be concluded that, at some time in the past, the Grenada Basin that now separates these two entities did not exist. However, the age of this basin has not been well constrained. Inconclusive seismic evidence suggests that the basin is filled by sedimentary rocks of Paleocene (?) to Recent age (Pinet et al. 1985; Bouysse et al. 1985; Bird 1991), while dredge hauls from the basin's margins consist of mostly Eocene and younger sedimentary and volcaniclastic rocks.

According to Pindell (1994), the Grenada Basin opened between the Paleocene and late Eocene, but we postulate a somewhat younger date (late Eocene and younger), for the following reasons. If the Grenada Basin is interpreted as a back-arc basin, the disjunction of the Aves–Lesser Antilles arc into two independent geological units (Aves Ridge remnant arc and Lesser Antilles active arc) would have probably been caused by a local change in the subduction regime (e.g., alteration of angle of dip of lower slab, or migration of position of subduction zone). We hypothesize that this event was correlated with late Eocene cessation of volcanic activity in Aves Ridge (and a concomitantly great increase in activity in Lesser Antilles) and increased thickness of Oligocene and younger sediments in Grenada Basin (see seismic sections in Nemec 1980, and Pinet et al. 1985).

NEW CARIBBEAN PLATE TECTONIC MODEL FOR THE TERTIARY

The tectonic model presented in this paper may be controversial in the sense that it introduces several new outlooks into the Caribbean Plate tectonic reconstructions. But the issue is not only the model itself, but the concept on which it is based. These principles, properly taken into consideration, will lead to a better understanding of the geologic structure and tectonic evolution of the Caribbean.

To understand the Tertiary tectonic evolution of the Caribbean one must take into consideration the latest Eocene to Recent tectonic scenario (Fig.4.1A) discussed above. In constructing this model, four constraints were defined: (1) Cayman Trench system movements were sequentially absorbed by the sinistral faults of Guacanayabo-Nipe and Oriente, as well as by local underthrusting within Hispaniola (Mann et al. 1995); (2) Jamaica acts as two distinct terranes, western Jamaica (originally associated with the Nicaraguan Rise) and Blue Mountain (part of Caribbean crust, but structurally related to eastern Cuban and southern Hispaniolan Blocks); (3) Southern Central America originates southwest of Chortis Block, accounting for sinistral movements associated with alkali volcanism along the Hess Escarpment; and (4) the Northwest South America (NWSA) Microplate acts as part of the Caribbean Plate for most of Late Tertiary, owing to activity along the Mérida-Boconó dextral fault.

The new plate tectonic model is here presented as three “snapshot” intervals: Eocene-Oligocene transition (35 Ma to 33 Ma), late Oligocene (27 Ma to 25 Ma), and early-middle Miocene (16 Ma to 14 Ma). These maps (Figs. 4.2–4.4) were generated using the program PLATES (Institute for Geophysics, University of Texas at Austin), in which consequences of specific displacements (of blocks, terranes, plates) can be investigated over a set interval (here, 35 Ma to 14 Ma) relative to a fixed master reference unit (here, North American Plate). The complete list of tables showing displacement solutions can be obtained from L. Gahagan.
In the Eocene-Oligocene boundary map (Fig. 4.2) the North American Plate (NOAM) includes the North American continent; Yucatan Basin; Western, West Central, and East Central Cuban Blocks; Bahamas; and North and Central Atlantic oceanic crust (all fixed in the geodetic framework at their latest Eocene positions). Contact between NOAM and the Caribbean Plate (CARIB) occurs along the Motagua/Swan/Nipe-Guacanayabo/northern Hispaniola transform faults, with seafloor spreading occurring in the Cayman Trough. CARIB includes the Chortis Block; Nicaraguan Rise; Cayman Trench crust; Cayman Ridge; eastern Cuban, Hispaniola, and Puerto Rico/Virgin Islands Blocks; Aves Ridge; Lesser Antilles Arc; and NWSA microplate. Contact between CARIB and the South American Plate (SOAM) occurs along the Mérida-Bocónó transform fault trend. Active plate convergence is limited to the Lesser Antilles and the Pacific Ocean margin of the Chortis Block in Central America.

In the late Oligocene (Fig. 4.3), the Cayman Ridge and the eastern Cuban Block became attached to NOAM, and contact with CARIB in eastern Cuba jumped to the Oriente Transform Fault. CARIB-SOAM contact continued to lie along the trend of the Mérida-Bocónó transform faults, but the Oca-Pilar fault trend became active in association with alkaline volcanic activity. This resulted in the eastern translation of Tobago. Active plate convergence continues in the Lesser Antilles and the Pacific Ocean margin of Central America. The Hess Escarpment fault trend was active in association with alkaline volcanoes. Strong deformation and accretion took place along plate margins in the eastern Caribbean.

In the middle Miocene reconstruction (Fig. 4.4), the Northern Hispaniola Block is now attached to NOAM, and contact with CARIB has jumped to the Septentrional Fault in Hispaniola. CARIB-SOAM contact is located as before, but Oca-Pilar fault trend was highly active in this period. Active plate convergence continued in the Lesser Antilles and the Pacific Ocean margin of Central America, with extension of volcanic activity into the Panama area. Pedro and Hess Escarpment fault trends were active, producing extension along the trend of the Chortis-Nicaraguan Rise. At the same time, strong deformation and sediment accretion along underthrusting fronts took place at the plate border in the eastern Caribbean.

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