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CARIBBEAN BIOGEOGRAPHY: IMPLICATIONS OF RECENT PLATE TECTONIC STUDIES

Two opposing hypotheses for the origin of the Caribbean terrestrial biota are currently being debated (Rosen, 1975; MacFadden, 1980, 1981; Pregill, 1981b). The vicariance model (Rosen, 1975) proposes that the present Caribbean biota is the result of a fragmented ancestral biota that occupied a "proto-Antillean archipelago" situated between North and South America during the Mesozoic. The fragmentation occurred when a portion of the eastern Pacific seafloor began moving eastward along two major faults, carrying the archipelago with it. The islands and their biota moved to their present location during the late Mesozoic and Cenozoic. The classical theory, proposed prior to the general acceptance of continental drift, suggests that the Caribbean terrestrial biota colonized the islands by dispersal (Matthew, 1918; Richards, 1937; Simpson, 1956; Darlington, 1957; Pregill, 1981b). The compatibility of dispersal and vicariance hypotheses has been discussed by McDowall (1978), MacFadden (1980, 1981), and others (see Nelson and Rosen, 1981).

One of the major criticisms of the vicariance model of Caribbean biogeography involves the "proto-Antillean archipelago." Pregill (1981b) considered it a "construct of the vicariance model needed to explain the fragmentation of the overlapping, ancestral biotas." In this paper, I will show that (1) the "proto-Antillean archipelago" of Rosen (1975) is supported by geological evidence published both before and after 1975; (2) the Greater Antilles may have moved considerable distances along a transform fault providing opportunities for intra-Caribbean vicariance; and (3) many radically different plate tectonic scenarios for the Caribbean region have recently been proposed suggesting cautious biogeographic interpretations.

A VICARIANT ORIGIN FOR THE CARIBBEAN BIOTA

Rosen's "proto-Antillean archipelago" was based on the plate tectonic models of Malfait and Dinkelman (1972) and Tedford (1974). Tedford specifically diagrams (p. 111, fig. 1) a Late Jurassic/Early Cretaceous archipelago and writes (p. 112) "the western edge of the Americas plate formed an orogenic zone interrupted only in the Middle American area where differentiating continental crust of the proto-Antilles formed a volcanic island arc linking North and South America." Since Rosen's paper there have been numerous studies bearing on the geologic history of the Caribbean region (Jordan, 1975; Christofferson, 1976; Ladd, 1976, 1980; Burke et al., 1978; Perfit and Heezen, 1978; Mattson, 1979; Case and Holcombe, 1980; Dickinson and Coney, 1980; Salvador and Green, 1980; Goreau, 1980; Mattson and Lewis, 1980; Saunders, 1980; Walper, 1980). Of these, Dickinson and Coney's (1980) reconstruction of Caribbean geologic history is strikingly similar to Rosen's (Fig. 1). In fact, they use the term "proto-Greater Antilles" to describe a magmatic arc situated between North and South America in the late Cretaceous. According to them, the "proto-Greater Antilles magmatic arc" moved eastward and became the present-day Greater Antilles. Although details of Dickinson and Coney's plate tectonic reconstructions differ somewhat from Rosen's, the biogeographic implications are the same: the possibility of a vicariant origin for the Caribbean terrestrial biota.

INTRA-CARIBBEAN VICARIANCE

The possibility that two or more of the Greater Antilles were connected at some time in the past is directly implied by some authors (Freeland and Dietz, 1971;

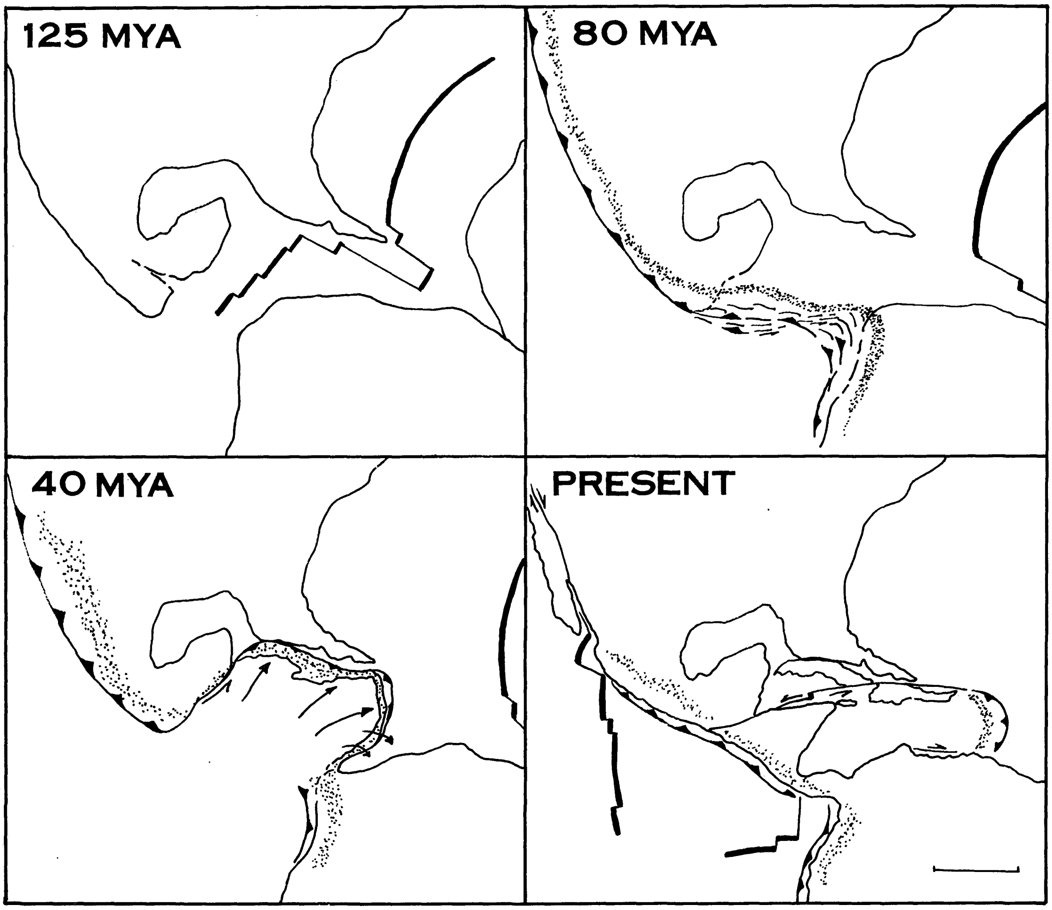

FIG. 1.—Plate tectonic reconstructions of Caribbean geologic history from the Early Cretaceous to Present (after Dickinson and Coney, 1980). Heavy lines indicate spreading centers, thin lines with arrows indicate a subduction zone (arrows on upper plate), and stippling indicates magmatic arc activity. Line in lower right represents 1000 km.

Tedford, 1974; Dickinson and Coney, 1980) and indirectly implied by others when lateral movements along faults are taken into consideration (see Table 1). In fact, lateral motion along a fault that extends from Guatemala through the Cayman Trough, northern Hispaniola, and the Puerto Rico Trench to the Lesser Antilles subduction zone is one point of agreement by most authors (Freeland and Dietz, 1971; Marlow et al., 1974; Moore and Castillo, 1974; Jordan, 1975; Burke et al., 1978; Perfit and Heezen, 1978; Dickinson and Coney, 1980; Ladd, 1980; Mattson and Lewis, 1980; Salvador and Green, 1980). Direct evidence that the Greater Antilles have moved considerable distances along this fault has not been shown as yet (Ladd, 1980). If only 200 km of lateral motion along this fault has occurred (Malfait and Dinkelman, 1972; Perfit and Heezen, 1978), Hispaniola would have been in contact with, or in close proximity to Cuba as recently as the mid-Miocene (17 m.y.a.). On the other hand, if motion along this fault has been equivalent to the subduction rate in the Lesser Antilles Trench (approximately 2 cm/yr; Jordan, 1975), then there may have been a late Pliocene (ca. 5 m.y.a.) land

TABLE 1. A SUMMARY OF GEOLOGIC STUDIES SHOWING OPPORTUNITIES FOR VICARIANCE.

	Past connections			
Island	Land mass[1]	Time (m.y.a.)	Author	Comments
Cuba	NA/SA/LA	80–40	Dickinson and Coney (1980)	"proto-Greater Antilles"
	NA/SA	150–100	Freeland and Dietz (1971)	from an accretionary wedge that may not have been emergent
	HSP	38–16?	Malfait and Dinkelman (1972)	very close proximity
	Yucatan	117–93	Salvador and Green (1980)	proto-Cuba a "volcanic trend" south of present location
	HSP	5	Jordan (1975)	inferred by 2 cm/yr movement along fault
	HSP	65–38?	Perfit and Heezen (1978)	close proximity
Hispaniola	NA/SA/LA	80–40	Dickinson and Coney (1980)	"proto-Greater Antilles"
	JAM/PR/VI	45–?	Freeland and Dietz (1971)	spreading centers split "proto-Hispaniola" into JAM, PR, and VI
	Cuba	38–16?	Malfait and Dinkelman (1972)	very close proximity
	SA/PR/JAM?	93	Salvador and Green (1980)	HSP, PR, and JAM a "volcanic trend"; N. SA a eugeosynclinal volcanic belt
	Cuba	5	Jordan (1975)	inferred by 2 cm/yr movement along fault
	Cuba	65–38?	Perfit and Heezen (1978)	close proximity
Jamaica	NA/SA/LA	80–40	Dickinson and Coney (1980)	"relationship to other land masses uncertain"
	HSP/PR/VI	45–?	Freeland and Dietz (1971)	from "proto-Hispaniola"
	SA/HSP/PR	93	Salvador and Green (1980)	
Puerto Rico	NA/SA/LA	80–40	Dickinson and Coney (1980)	"proto-Greater Antilles"
	HSP/PR/VI	45–?	Freeland and Dietz (1971)	from "proto-Hispaniola"
	SA/HSP/JAM	93	Salvador and Green (1980)	
Lesser Antilles	NA/SA/GA	80–40	Dickinson and Coney (1980)	

[1] NA = North America; SA = South America; GA = Greater Antilles; LA = Lesser Antilles; JAM = Jamaica; HSP = Hispaniola; PR = Puerto Rico; VI = Virgin Islands.

connection between Hispaniola and Cuba. The distribution of groups such as the insectivores (MacFadden, 1980), amphisbaenids, leptotyphlopids, and toads (Pregill, 1981a) among the Greater Antilles may be related to past intra-Caribbean vicariant events rather than inter-island dispersal. The absence of these groups on Jamaica supports this interpretation since reverse movement along the Cayman Trough/Puerto Rico Trench fault system would not place that island appreciably closer to any of the other Antilles.

A CAUTIONARY NOTE

A vicariant origin for some (or all) of the Caribbean biota is possible using many of the plate tectonic reconstructions in the geologic literature (Table 1). None of these authors deal with the origin of the terrestrial biota nor do they deal directly with the possibility of island/mainland or island/island connections (but see Freeland and Dietz, 1971). Also, few are directly concerned with when the Antilles were above sea level. Thus, Table 1 illustrates a variety of geologic scenarios available for interpretation by the biogeographer but does not necessarily indicate the authors' intended usage.

Several studies suggest that the Greater Antilles may never have been attached to a continental landmass. They were formed by either subduction of the Caribbean plate beneath the North American plate (Walper, 1980); subduction of the North American plate beneath the Caribbean plate (Perfit and Heezen, 1978); or a combination of both (Burke et al., 1978; Mattson, 1979; Mattson and Lewis, 1980). The Lesser Antilles are considered by nearly all authors to be an island arc with no past continental attachments although one study (Dickinson and Coney, 1980) suggests a possible late Mesozoic/early Cenozoic connection with North and South America and the Greater Antilles. Thus, it is obvious that caution must be exercised in using plate tectonic reconstructions of the Caribbean region to support biogeographic hypotheses.

CONCLUSIONS

Pregill's (1981b) recent statement that the vicariance model of Caribbean biogeography is "contradicted by current knowledge of Caribbean tectonics" is unjustified. I have shown that many studies provide data supporting vicariance and that one recent study in particular proposes an island arc similar to Rosen's "proto-Antillean archipelago." What can be concluded from current knowledge of Caribbean tectonics is that an extensive fault system is present in the northern Caribbean. The direction and movement of the two plates along this fault system imply that Cuba and Hispaniola were much closer or attached at some time during the Tertiary (ca. 5–20 m.y.a.). Thus, some inter-island faunal relationships may be related to past intra-Caribbean vicariant events.

I agree with MacFadden (1981) that the "historical biogeography of the Greater Antillean biota is exceedingly complex" and is probably the result of both dispersal and vicariance (either of the Rosen model, or intra-Caribbean). This, coupled with a complex geologic history, presents a challenge to biogeographers that will only be met with the accumulation of more data.

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