An Expanding Earth Model Explanation of the Origin and Evolution of Cuba

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The geology of Cuba has been evaluated by many geologists from different lines of thought in earth sciences, and therefore, models to explain the origin and evolution of the country were elaborated in the last two decades according to plate tectonics (Malfait & Einkemmen 1972, Iturralde-Vinent 1975, Mattson 1979, and others), basinification (Purrazola and others 1964, Khudoley 1967), contraction (Meyerhoff & Hatten 1968, Iturralde-Vinent 1975, Illich & Meyerhoff 1980), expansion (Carey 1963, Levenken 1979, Iturralde-Vinent 1981), and a few others not classified (Knipper & Cabrera 1972, 1974, Somin & Millán 1976, Somin 1979, and several others).

In this paper the author presents the main points of his model according to Earth expansion by pulsation, a model previously developed more fully (Iturralde-Vinent, 1981).

**GEOLOGICAL SETTING**

The geological composition and structure of Cuba has been delineated in several recent papers which can be useful references to enlarge the description that follows. These are the papers mentioned above along with those of Meyerhoff & Hatten (1974), Khudoley & Meyerhoff (1971), Iturralde-Vinent (1978), Pardo (1975), Millán & Somin (1976).

In the following paragraphs a general overview of the Cuban geology is presented considering three epochs: Mesozoic, Palaeocene- Early Late Eocene, and Late Eocene-Recent. Palaeozoic and older evolution of Cuban territory is as yet not understood.

**Mesozoic**

The Mesozoic rocks sequences of Cuban territory can be considered separately in three main suites: (1) the northern continental margin, (2) the central oceanic crust - eugeosyncline, and (3) the southern metamorphics. Each of these suites is usually divided into several facies-structural units.

(1) The northern continental margin suite of Jurassic to Late Cretaceous age includes from north to south the following facies-structural units: Canal viejo de Bahamas, Cayo Coco, Remedios, Camajuaní and Placetas (Núñez & Vuagnat, 1962; Meyerhoff & Hatten, 1968, 1974). It is the natural prolongation to the south of the Bahamian platform (Figure 1). Sedimentary environs clearly show a transition from continental to oceanic conditions toward the south; it is, a lateral gradation from evaporitic and carbonate rocks of shallow water origin to carbonate and cherts (radiolarites) of deep marine environment. The whole territory formed over continental crust.

(2) The central oceanic crust-eugeosyncline suite is generally south of the former. The oceanic crustal rocks correspond to the ophiolitic association (serpentinitized ultramafics, gabbroids, diabases and amphibolites) strongly deformed, that, as a rule, lies at the base of the eugeosynclinal prism. Different ages and origins have been proposed for this complex, but the opinion here expressed is the most generally accepted. The age of these rocks, according to the author, is latest Triassic to Late Jurassic and younger (as in the Bartlett trough), but its emplacement within the eugeosyncline occurs as protrusions by Late Cretaceous and Palaeogene (Knipper & Puig Rifà, 1967). The eugeosynclinal prism (the Zara facies-structural unit of Purrazola et al., 1964) is a complex of subvolcanics, water-laid and terrestrial volcanics, tephroids and sedimentary carbonates, and terrigenous rocks several kilometres thick. Volcanic rocks are of basaltic to rhyolitic composition. The fauna of the sediments within the sequence has been found to be from Albian to Lower Campanian (Purrazola et al., 1964; Khudoley & Meyerhoff, 1971; Cabrera et al., 1979), but volcanic rocks have been found in Oxfordian and older rocks (Piotrowski, 1977; Pęczkołowski, 1978). The author believes, as Meyerhoff & Hatten (1968), that eugeosynclinal evolution in large part probably started by latest Jurassic (Tithonian). The volcanics were intruded by granitoid magmas (diorites to syenites) about Late Cretaceous and suffer general uplift. Late Campanian and Maastrichtian terrigenous and carbonate rocks discordantly cover the deformed eugeosyncline, containing clastic material from the former but in minor amounts from continental crust suites.

(3) The southern metamorphics outcrop at Isla
de la Juventud, Escambray and eastern Purial mountains (Figure 1). It is a metacarbonate-terrigenous complex with few intercalations of metavolcanites and cherts whose age is Early Jurassic to pre-Campanian Cretaceous (Somin & Millán, 1972; Millán & Somin, 1976; Millán & Wyczynski, 1978). These rocks lie under continental crust and are metamorphosed up to the lowest greenschist facies (Purial), garnet-glaucophanic facies (Escambray), and amphibolitic facies (I. Juventud), with inverted zonality (Somin & Millán, 1980)

The present tectonic position of the three suites just described is of great importance in the understanding of the origin of Cuba. In the north, the central oceanic crust-eugeosynclinal suite is imbricated with slivers of the northern continental margin forming a mélangé that is overthrust above the continental margin (Figure 1). This tectonic picture has been usually described as a northward overthrust, but the author believes that it is a consequence of sinistral wrenching and obduction of the central suite because underthrusting of the northern continental margin. The relationships between the central and southern suites were established in the most logical way by Somin (Somin & Millán, 1976, 1980). He showed that the oceanic crust-eugeosynclinal lies in tectonic position above the metacarbonate-terrigenous complex that outcrops at tectonic windows (Figure 1).

Palaeocene-Early Late Eocene

During this time interval the geological development of Cuban territory was markedly different from that of the Mesozoic. Volcanic activity of calcalkaline type concentrated along southeastern Cuba (Sierra Maestra mountain range) during Late Palaeocene to Middle Eocene, but pyroclastic products reached even western Cuba (Bresnýnský & Iturralde-Vincent, 1978, and in press). Intrusions of granitoids (diorites and granodiorites) occurred by Early Late Eocene in the area of the volcanic centres (Figure 1). Away from the volcanic area sedimentation took place with a markedly flyschoid character, and carbonate-terrigenous rocks formed. Olistostrome sedimentation occurred mainly at the contact area between the northern continental margin and the central oceanic crust-eugeosynclinal suites. The sequences of the present epoch suffered the rather strong movements that occurred all along the interval, connected with the general compression of the eugeosynclinal prism, and were thrusted again toward the continental areas. Rock deformation has a clear zonality, strongest at the contact between the continents and oceanic-eugeosynclinal areas, and along the line of the transverse wrench faults (Figure 1).

Late Eocene-Recent

The geological evolution of this time interval was described by Iturralde-Vincent (1977, 1978) and Bresnýnský & Iturralde-Vincent (1978, and in press). Neither volcanic nor plutonic activity is evident and mostly sedimentation and erosion took place. Oligocene basaltic bodies are found along the Sierra Maestra mountains but are related probably with opening of the Cayman trough. Movements were vertical and a set of blocks — horst and graben — characterized the tectonic picture of the epoch. Wrench movements have taken place along the Pinar, Trocha and Bartlett faults. The rocks formed throughout this time interval are slightly deformed.

**FIGURE 1**

Principal features of Cuban geology excluding most of Cenozoic sediments. 1: northern continental margin suite. 2: central oceanic crust-eugeosynclinal suite. 3: Late Cretaceous granitoids. 4: Palaeogene volcanic centre. 5: Late Eocene granitoids. 6: southern metamorphic suite. 7: line of thrusts. 8: Palaeogene wrench faults. 9: selected deep wells that found suite (1) underlying suite (2). 10: outcrops of the ophiolitic associations.
EXPLORING EARTH MODEL

The author believes that the main features of the Cuban geological composition and structure can be explained by a model of expansion by pulsation of the Earth within the territory (Figure 2).

According to this model (Iturralde-Vinent, 1981), before Latest Triassic the Cuban area was a continental mass that extended from the Bahamas up to the present place of the Yucatan basin. About Latest Triassic to Lower Jurassic began a process of subsidence, and a terrigenous intracratonic basin formed, that later evolved to a riftogenic oceanic deep. The origin and evolution of the oceanic basin was a consequence of a southward migration of the relative southern half of the former continental mass, and segregation of oceanic crust, a process that lasted until Late Jurassic. About Tithonian time an important volcanic activity started in the area of the oceanic basin that took the shape of a volcanic island arc (eugeosyncline).

Starting by Albanian-Cenomanian time the southern continental mass divided again and the opening of the Yucatan basin began (Dillon & Vedder, 1973). Therefore a microcontinental mass was left behind and started to move relatively backward to the north and the east. It was the beginning of compression at the southwestern margin of the intracontinental oceanic basin and volcanic chain - compression that up to Early Late Eocene migrated toward the north and east. During the movement northward, the southern continental mass was inserted below the oceanic crust and eugeosynclinal prism (obduction) and metamorphism of its carbonate-torridogenous cover took place giving rise to the southern metamorphic suite. At the northern margin of the oceanic basin sinistral wrench movements occurred at the same time, and shortly after obduction also began.

Since Latest Eocene no further movement of the southern continental mass has taken place, and therefore, relaxation and vertical oscillatory movements characterized this time interval. During this epoch, isostatic uplift of both - southern and northern - continental masses steepened the marginal faults and erosion of the allochthonous cover brought the continental suites up to the level of erosion. By the same time volcanic activity migrated toward the southeast along the Greater Antilles and riftogenesis took place at the Cayman trough since Oligocene.

As a consequence of the opening and later closing of the continental crust within Cuban territory, the opening of the Yucatan basin and Cayman trough, resulted an expansion of several kilometres within the western Caribbean.

REFERENCES


Furrazola, C., Khudokey, C. et al., 1964: Geologia de Cuba. Edit. Universitaria,
La Habana, 1 vol & maps.
Nauka, Moscow.
Nauka, Moscow.