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The principal features of the geotectonic development of Cuba and the Caribbean region

Hlavní rysy geotektonického vývoje Kuby a karibské oblasti

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Abstract: The central segment of Cuba is formed by three parallel belts of a different Earth's crust. The northern coast belongs to the carbonate province of the region Florida—Bahamas. More southerly runs a crushed and folded zone which links up with the ophiolite complexes. The middle and southern parts are formed by volcano-sedimentary, plutonic and metamorphic sequences. Some problems of the crystalline basement and of the metamorphic massivs of Escambray and Isla de la Juventud are presented in greater detail. The ophiolite complexes which rose along the Principal Suture are associated in space and time with volcanic, plutonic and metamorphic processes. The geological development of the ophiolite belt consisted of the graben-like formation and later elevation. The extreme deformations are related to the movements along the suture, to the serpentinization process, diapirism and gravity slides of the serpentinites. The present-day geotectonic models are discussed from the point of view of the structural heterogeneity of the Carribean region.

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Introduction

The structure and geological development of the Caribbean region has been repeatedly treated in literature. A number of different geotectonic models indicates the complexity of the problem as well as the limits of our notion.

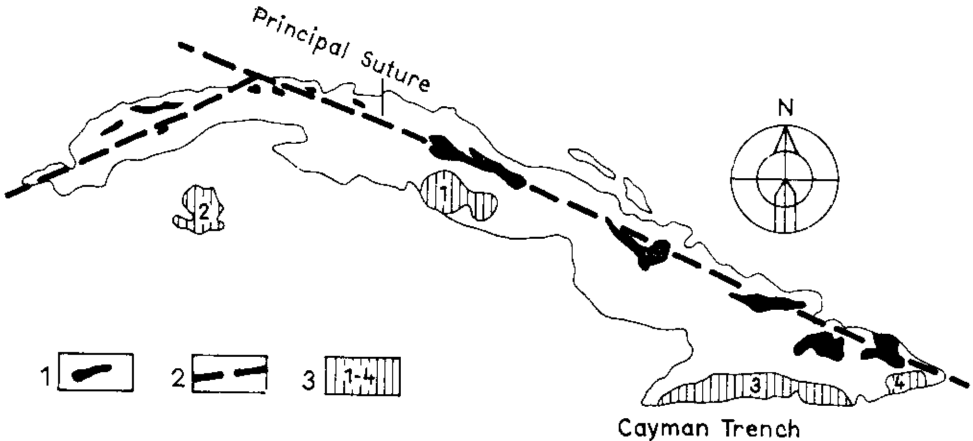
The Caribbean region forms a plate surrounded in the N and S by continents, in the W by the Central American Isthmus and in the E by the Atlantic Ocean. The Precambrian and Paleozoic rock sequences crop out along the northern and southern continental margins of the Caribbean and form the nucleus of the Central American Isthmus. The data which directly indicate the presence of ancient rocks within the Caribbean region are sporadic. For example, the radiometric age (K-Ar method) of phlogopite from the marbles near the village Socorre in western Cuba is 945±25 and 910±25 Ma (Somin - Millan 1981).

The structure of the Caribbean Sea consists of several basins, trenches, ridges and rises. Some structures known outside the plate seem to continue in the Caribbean Sea (Kumpera - Škvor 1969). The geophysical data indicate that the Caribbean crust is transitional between the continental and oceanic types. The expressive structural heterogeneity and its causes represent the principal problem of the geological interpretation of the Caribbean region.

According to the results of the seismic investigations the Earths crust in the Yucatan, Colombian and Venezuelan Basins is similar to the oceanic-type crust. However, the crust of these basins and its individual layers are essentially thicker than in the oceans (Case 1975). On the contrary, the Earth's crust of the ridges (Cayman, Beata, Aves) and the rises (Nicaragua Rise) is similar to the continental type. The mutual relations of these different structural units may be studied in the cross-sections. An example is the section across the Yucatan Basin, Cayman Ridge and Trench and the Nicaraguan Rise (Perfit - Heezen 1978). The Moho discontinuity below the depressions lies at the depth of 12—13 km, below the elevations at more than 20 km. These data show that the depressions are accompanied by a raised mantle.

1. A brief outline of the deeper structure of Cuba

Cuba is the largest island of the Caribbean region, which during the Upper Mesozoic and Paleogene systems formed the border between the stable platform in the N and extreme mobile zones in the S. The northern coast belongs geologically to the carbonate province of the region Florida—Bahamas. More to the S along the northern margin of the island runs an extremely crushed



1. Geographic orientation scheme
1 — ophiolite complex; *2* — weakened zone; *3* — 1 — Escambray Mts., 2 — Isla de la Juventud, 3 — Sierra Maestra, 4 — Sierra del Purial

and folded zone formed of various sedimentary sequences, separated into tectonic blocks, and of the ophiolite complexes. The middle and southern parts are below the young sedimentary cover formed of magmatic and metamorphosed sequences.

The outline of Cuba is strikingly elongated in the proportion 1:10. The width oscillates between 50—120 km. As mentioned above, the central segment of the island is formed by three geologically different belts, parallel to the axis of Cuba. They are as follows:

1. According to the geophysical data (Scherbakova et al. 1973, 1977, Shein ét al. 1975) at the northern margin of Cuba the Earth's crust is of continental type and 25—30 km thick. Its upper part is composed of a pre-Jurassic crystalline basement, which is most probably analogous to the basement of South Florida, and of the sedimentary sequences of Jurassic—Upper Cretaceous age. The geophysical data indicate that the crystalline basement submerges from the N to the S along a system of large faults which are roughly parallel to the northern outline of Cuba. The sedimentary cover is represented by folded sequences of terrigeneous deposits and carbonates of Jurassic—Lower Cretaceous age and by siliceous sediments and carbonates of Aptian—Santonian(?) age.

2. A different crustal type has the "Principal Suture", which forms a violently tectonized, 5—20 km broad zone along the northern coast. Its crust is $\pm$18 km thick, of suboceanic type. The suture extends for more than 2000 km, with branches reaching up to Puerto Rico. In seismic profiles, the mentioned structure is distinguishable by the rapid change of the wave-front velocities (Shein et al. 1975).

Many field observations clearly demonstrate that the suture was used as a channel for the invasion of the subcrustal material of the ophiolite complexes (Kozary 1956, Knipper - Puig 1967, Knipper - Cabrera 1974). According to the geological as well as geophysical criteria, the Principal Suture represents a large old deep-seated fault, which became inactive towards the end of the Cretaceous or in the Paleogene. Its strike is NW, the dip in Central Cuba is 60—70° to the SW (Itturalde-Vinent 1975, Škvor 1982). The marginal trough or leptogeosynclinal of Knipper and Cabrera (1974) filled by deep-sea deposits lay along the superficial projection of the suture. South of the suture crops out the volcano-sedimentary complex of pronounced geochemical polarity, the granitoid massivs and regionally metamorphosed sequences (fig. 6).

The width of the geophysically indicated Moho antiform which corresponds roughly to the dimension of the uprised subcrustal material, is 40—50 km. As known, the density of the ultrabasites and the velocity of seismic waves in these rocks is drastically reduced by serpentinization (Moskaleva 1974). From this point of view the depth gradients of the wave velocities may correspond to the grade of serpentinization of the ultrabasites. The little expressive Moho discontinuity may be explained in the same way.

3. The third zone, also parallel to the long axis of the island, forms the middle and southern parts of the central segment of Cuba. The Earth's crust is here 20–35 km thick and corresponds to the continental or subcontinental type. This part has been classified as eugeosynclinal or compared with the structure of the island arcs. This zone borders in the N on the ophiolite complexes, in the S it is separated by a number of large faults from the Yucatan Basin.

It consists of a crystalline basement overlain by more or less metamorphosed terrigeneous deposits and carbonates of Jurassic—Lower Cretaceous age and by a strongly deformed Cretaceous volcano-sedimentary complex, often intruded by plutonic bodies. The thickness of the mentioned sequences reaches, according to seismic methods, 5 km. In the elevated blocks in central and eastern Cuba, the crystalline basement crops out in the actual erosion level. It is formed mostly by amphibolites with migmatite and gneiss intercalations.

In the W, the Principal Suture exceeds the limits of Cuba and disappears in the Gulf of Mexico. Unlike the Central Cuba striking NW—SE, the outline of the western promontory of the island has a ENE—WSW direction. The Principal Suture is substituted here by another weakened zone striking parallel with the outline of the promontory. The geological structure is similar there to the central segment. A confrontation of central Cuba with its western promontory demonstrates that the strike of the structural elements is strongly influenced by and subordinated to the mentioned deep-seated faults. Different strikes may be observed only in the remoter areas, where they may correspond to previous structural plans.

We may summarize that the major part of Cuba consists of 3 belts of different types of the Earth's crust which are parallel to the length axis of the island. The suboceanic crust of the ophiolite belt has a specific position and significance. Both the geological and geophysical data prove that the subcrustal material used this weakened zone as a channel for its ascent. The invasion of the asthenospheric material, described in some aspects later in this article, played the principal role in the geological development of the island. From this point of view, the Principal Suture has a role of the dorsal spine.

2. Some problems of the regional-metamorphosed sequences of Cuba

The regional-metamorphosed, paleontologically dated Jurassic—Lower Cretaceous deposits crop out in the Escambray Mts. Lithologically similar sequences, most probably of the same age, form the massif of the Isla de la Juventud (former Isla de Pinos) and crop out also in the Sierra del Purial. The radiometric dates prove the Upper Cretaceous age of the metamorphosis.

The radiometrically dated older metamorphites, which may be considered as a part of the crystalline basement, are known from western Cuba. The age and geological position of some other metamorphosed sequences have been repeatedly discussed in literature. The results of recent investigations as well as opinions of earlier authors are presented in Somin and Millan (1981), Staník et al. (1981) and Kantchev et al. (1975). Some new complementary observations and interpretations are presented in this article.

The radiometric age (K-Ar method) 945±25 and 910±25 Ma (Somin - Millan 1981) of phlogopite from the marbles of Socorro near Matanzas is surprising. The granite, cropping out along the river Cañas near Matanzas has the age of 150±5 Ma (K-Ar method). The conglomerates with pebbles and boulders of leucocratic gneisses crop out in the Jurassic formation near the city of Pinar del Río. The most frequently observed rocks of a higher metamorphic facies are the amphibolites, granitized amphibolites and associated migmatites and gneisses, which crop out in tectonically limited blocks in the surroundings of the Escambray Mts. and in the Sierra del Purial. The radiometric ages of these rocks (60—80 Ma) are considered as having been rejuvenated during the Cretaceous tectonothermal events. The mutual relation of these rocks to the epizonally metamorphosed Jurassic—Lower Cretaceous deposits has been discussed by many authors. The focus of the discussion is the relation of the amphibolites of Manicaragua (or Mabujina) to the schists of the Escambray Mts. Some authors hold the opinion that the amphibolites represent an elevated block of the crystalline basement. The other consider the schists of Escambray as an older unit.

The problem could be solved in case one of the neighbouring complexes is polymetamorphosed. However, the course of the metamorphic conditions has an ascendent and descendent trend. If the rock system is not dry, the transformation continues during the decrease of the metamorphic conditions and the rock may get some features which resemble a later metamorphosis. In order to dinstinguish two different tectonothermal events we usually need some specific criteria.

The amphibolite complex of Manicaragua crops out in a broad coherent belt along the northern border of the Escambray Mts. The observable contacts are tectonic. In the southern margin of the Escambray Mts. the amphibolites crop out only sporadically. Partly granitized amphibolites have been found also in the centre of the Escambray Mts., where these rocks form large inclusions in the serpentinites which penetrated along the large fault of Agabama. The results of the geological and geophysical survey (Staník et al. 1981) showed that the complex of amphibolites continues under the Escambray massif in its northeastern part. With respect to the metamorphic grade, the amphibolite complex has been divided in two parts: the first is composed of amphibolites and granitized amphibolites with intercalations of gneisses and migmatites. The second is formed by greenschists, which represent slightly metamorphosed basic volcanics and their pyroclastics. Petrographic transitions between these sequences have not been discovered.

The migmatized amphibolites containing many folded recrystallized aplitic dykes crop out in the valley of the river Jicao and in the valley of an unnamed creek W of Santí Spiritus. The dykes are one centimeter up to several decimeters thick. Some are parallel to the expressive schistosity, which is moderately folded in a pair system $B_1 \perp B_2$. Lenticular forms of the dykes seem to have been formed by boudinage.

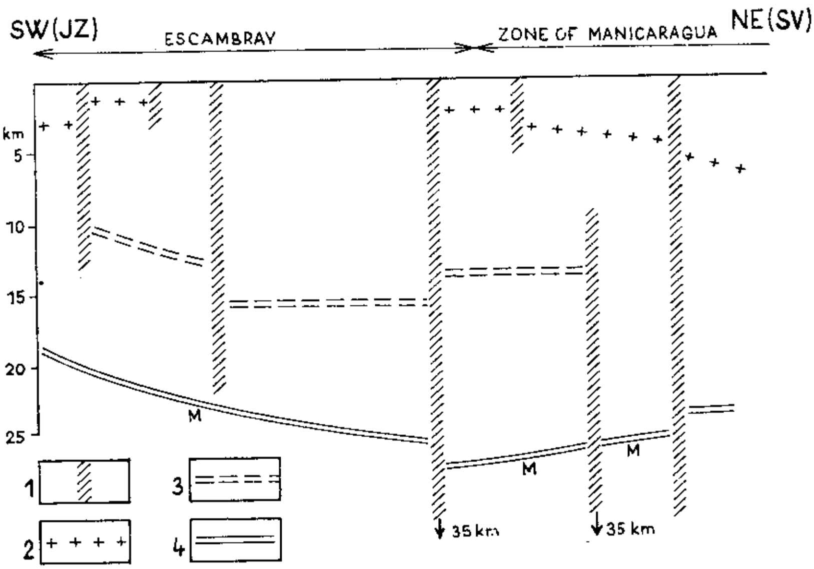
The other set of dykes of the same composition is extremely folded. The folds with nearly vertical axes are of the "similar" type. These dykes represent the primary fillings of the transversal ac-joints. The generation and opening of the abundant joints under the conditions of ultrametamorphosis is considered impossible. The joints could not have appeared before the temperature and volume decrease. On the contrary, the folding and recrystallization of the primary dykes occurred under high plasticity and temperature during another ascent of metamorphic conditions. The spatial orientation of the B_1 folds, which are roughly parallel to the margins of the adjacent domes of the Escambray massif shows that the second tectonothermal activity has been directly associated with that of the Escambray Mts.

The indirect evidence mentioned above is in full agreement with the two separate metamorphic levels observed in the amphibolite complex. The lower is represented by the amphibolite facies, the upper is the Cretaceous greenschist facies. The latter grows weak in the external direction off the complex, where it passes into the slightly metamorphosed and unmetamorphosed volcano-sedimentary complex. Both parts were intruded by younger aplitic and pegmatitic dykes, which remained undeformed. The amphibolites s.s. are considered to be part of the crystalline basement. The age of the older tectonothermal event is unknown.

The results of the absolute age determination show that the regional metamorphism of Cuba was finished towards the end of the Cretaceous (S o m i n - M i l l a n 1981). The commencement of these processes is unknown. The time interval of the activity of tectonothermal processes is difficult to determine. The general estimations are mostly indirect, based on physical calculation of heat transfer and on geological deductions. S u k (1983), summarizing the general conclusions of many authors points out that the regional metamorphosis of the alpine type took some 30 Ma, whereas the regional metamorphosis and ultrametamorphosis of the ancient massifs some 100 Ma. According to these data we may suggest that the geothermal systems had appeared in some areas of Cuba during the Aptian—Albian stages and successively disappeared during and prior to the Maastrichtian.

The massif of the Escambray Mts.

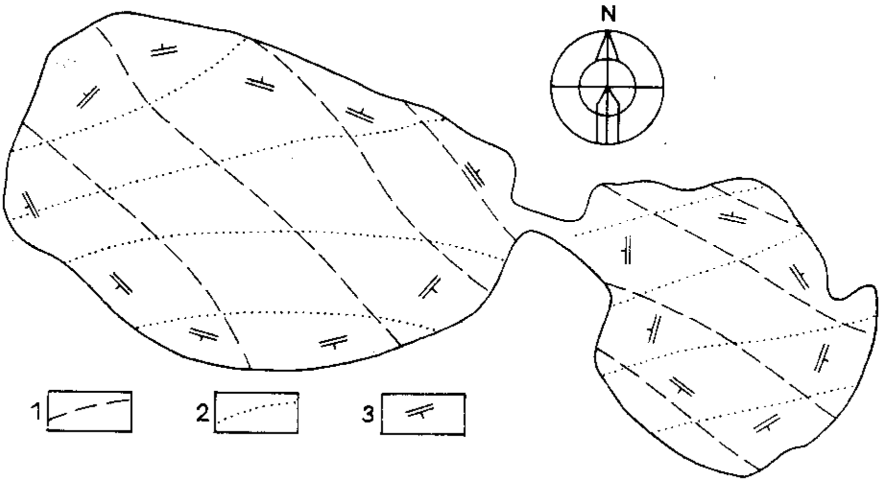
The Escambray Mts. are formed by terrigeneous, carbonate and volcanic deposits metamorphosed in the greeenschist facies. The discovery of the Upper Jurassic ammonites in these rocks (Millan - Myczyński 1978) proves the Mesozoic age of the primary rock sequences and gives the base for the stratigraphy of the massif. The area has been studied recently by Staník et al. (1981) who did the geological and geophysical mapping on the scale of 1 : 50,000 and by Millan and Somin (1981).



2. The scheme of the Earth's crust structure below the Escambray Mts. (after V. E. Scherbakova - V. G. Bovenko, 1973)
1 — deep fault; *2* — upper level of the granite layer; *3* — upper level of the lower crust; *4* — Moho

The massif represents an antiform with steep flanks and subhorizontal central part. The large transversal fault of Agabama divides the structure in two separated domes. The seismic investigation (Scherbakova - Bovenko 1973) brought data on the structure below the Escambray Mts., which has the character of a graben, limited by deep faults (fig. 2).

The strike of the main fold systems and corresponding lineations is NW—SE. The second system is nearly normal, striking NE—SW. Other fold systems reported by Staník et al. (1981) and by Millan and Somin (1981) are of local importance. The data on the structural analysis collected by Staník et al. have been evaluated in a number of tectonograms for different areas of the massif. Their interpretation (Škvor 1982) has led to the following conclusions: The axes of the main fold system (b_1 and b_2) have the same strike in the central subhorizontal part as in the steeply inclined circumference of the domes, where the strike of the foliations changes from one place to the other. This principle is important for the correct explication of the geological development of the massif. The generation of the antiforms is not younger than the fold systems. As the schistosity and folding originated during the metamorphosis, the formation and primary ascent of the domes are synmetamorphic (fig. 3).

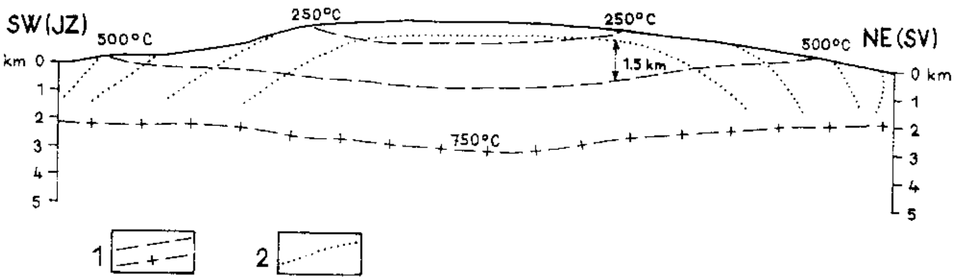


3. The synoptic strike-courses of the main fold axis, lineations and foliations in the Escambray massif (after E. Staník et al. 1981)
1 — fold axis b_1 and lineation l_1; *2* — fold axis b_2 and lineation l_2; *3* — strike and dip of the foliations

M i l l a n and S o m i n (1981) as well as S t a n í k et al. (1981) distinguished 3 metamorphic zones. The first zone (1) corresponds to the low greenschist facies and forms the large central part of the western dome of Trinidad. The second (2) corresponds to the higher greenschist facies and is present between the zones 1 and 3. The last one (3) represent the epidote-amphibolite facies and is developed in the periphery of the antiforms. In the eastern smaller dome of Santí Spiritus zone 2 forms the central and zone 3 the peripheral part. Zone 1 is not present.

According to the usual criteria the metamorphic zonation of Escambray is inverted. The different metamorphic facies are subordinate to the shape of the massif. In whatever cross section of Escambray we may schematically reconstruct the metamorphic isotherms. According to the petrologic literature e.g. (S u k 1983) the temperature of the lowest metamorphic facies of zone 1 corresponds to some 250 °C, the highest temperature of the epidote-amphibolite facies of zone 3 might reach some 500 °C. The schematic cross-section (fig. 4) demonstrates that the course of the metamorphic isotherms was not parallel to the internal structure of the massif. Whereas the structure of the antiforms is characterized by its convex shape, the course of the metamorphic isotherms was concave. The section indicates a high geothermal gradient of cca 170 °C/km.

As the metamorphosis of the circumference of the Escambray massif is distinctly higher than that of its central part, we may consider that the metamorphic conditions might not have been limited to the massif itself but have had a regional character. The course of the geoisotherms must have been motivated geologically. The unconsolidated water-bearing sediments are of a lower thermal conductivity than the consolidated or crystalline sequences.



4. A model of the metamorphic isotherms in the cross-section of the dome Trinidad (1 : 200 000)
1 — metamorphic isotherm; *2* — structure of the dome

In this way the metamorphic heat-flows passing through the unconsolidated sediments are reduced with respect to the marginal parts of the sedimentary basin. The heating of the massif passed not only through the bottom of the basin but also from the margins. From this point of view it is logical that the metamorphic zone 1 is not present in the dome of Santí Spiritus: the central part of the smaller dome has been heated more from the margins.

The petrography and the geological interpretations of Escambray have usually been complicated by the presence of the blueschists. This problems is discussed later in this article.

The seismic data and the structural and metamorphic history of Escambray indicate that the metamorphosed rocks have been primarily deposited as sediments in a graben-like depression, which communicated with the large Jurassic sedimentary basin of the Caribbean region. The presence of volcanic material and serpentinites along the fault system shows the association of the "graben" with the activity of deeper zones.

In the general interpretation of Escambray, the origin of the graben-like subsidence is to be related to the ascent of subcrustal material along the deep faults, which violated the isostatic equilibrium. Later on the heat front, accompanying the invasion of subcrustal material, brought the metamorphic conditions close to the surface. The volume increase of the heated lithosphere motivated the primary uprise of the massif.

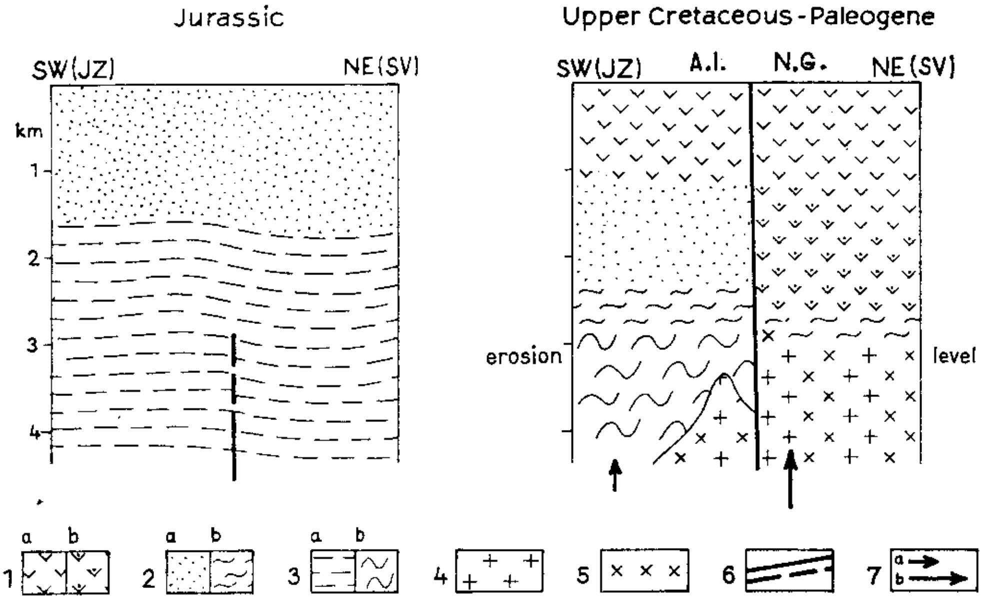
The metamorphosed massif of the Isla de la Juventud

The petrography and metamorphic zonation of this massif have been described by Eguipko et al. (1975) and by Millan (1981). Eguipko distinguished 6 metamorphic zones and described the role of the weakened zones for the metamorphic grade. Millan distinguished 5 metamorphic zones which are related to the block structure of the massif. The lithology of the sequences is similar to the dated sediments of the Province Pinar del Río. From that point of view the massif is considered to be formed by metamorphosed Jurassic—Lower Cretaceous deposits. The upper part of the stratigraphic column, i.e. the Agua Santa Formation, crops out in the highly metamorphosed blocks. On the contrary the Cañada Formation, which belongs to the lower part of the stratigraphic column, crops out in the slightly metamorphosed blocks.

The metamorphic mineral associations oscillate between the greenschist and high amphibolite facies. The above-mentioned authors placed the various types of metamorphites into the schemes proposed by Winkler (1967) and Miyashiro (1961). In this way the zones have been described as the Buchan and Dalradien types and the andalusite-sillimanite and disthene-sillimanite subfacies as Abukuma and Barrow types. Considering the classical terminology of Suess (1936), the metamorphic zones 4 and 5 of Millan (1981) correspond to the periplutonic metamorphosis. In zone 5, known along the weakened zone La Fé, the conditions were close to partial melting. The zones 1—3 may be considered as various types of the anorogenic metamorphosis of Suess.

The intensity of the metamorphosis proves that the processes did not take place at a high near-surface level. The sedimentation was in all probability interrupted by the high Cretaceous geological activity, known all over the Caribbean region. The volcanic effusions and pyroclastics could form a thick heated cover during a short time, which isolated the geothermal system from the top. The existence of this cover is proved by the presence of the volcanic complex preserved in the northwestern margin of the island in the depression Sabana Grande. According to Kuman and Garapko (1965) and Garapko et al. (1974), this complex is represented by effusive-pyroclast formations which lie discordantly above the metamorphosed sequences. The base of the volcanic complex is also metamorphosed. The thickness of the original cover is unknown. It could reach several hundred meters in the western and 2—3 km in the eastern part of the island. In such conditions the thermal gradient in the area of the metamorphic zones 4 and 5 could reach up to 200 °C/km.

The greatest difference of the intensity of the regional metamorphosis exists between the block Río los Indios and the region of Nueva Gerona (Millan 1981), separated by the large fault La Fé. The latter block was mobile. The subcrustal activity loaded this block with a thick volcanic cover, indicated by the preservation of the upper Formation Agua Santa in the actual erosion level (fig. 5). High heat flows brought the metamorphic conditions up to the volcanic cover, which formed a thermal insulating layer. The temperature of the upper crust rose up to the point of partial melting. The granitic melts transported the heat to the uppermost levels.



5. Scheme of the geological development of the Isla de la Juventud
1a — volcano-sedimentary complex; *1b* — idem metamorphosed; *2a* — Formation Santa Agua; *2b* — idem metamorphosed; *3a* — Formation Cañada; *3b* — idem metamorphosed; *4* — granitized rocks; *5* — granite; *6* — deep fault; *7* — heat flow (*a* — moderate, *b* — high); A.I. and N.G. — the blocks „Antiforma los Indios“ and „Nueva Gerona“

On the contrary, the block Río los Indios may be considered as more stable. The occurrence of the Cañada Formation in the present erosion level indicates that the volcanic cover of the Jurassic sediments had a reduced thickness. The heat flows were less intensive.

The volcanic cover and the upper parts of the metamorphosed deposits were eroded. The first results of the investigation of the sediments accumulated in the surrounding sea are in conformity with the presented interpretation.

3. The Cretaceous geological activity

There is no doubt that the principal source of energy of the tectonothermal events is the uprise of the asthenospheric material which is also the direct or derivative source of various types of magmatism.

The large ultrabasic complexes of Cuba are controlled by the Principal Suture and its branch in the western promontory of the island. However, the presence of ultrabasites is by far not limited to these structures. Smaller bodies of ultramafic rocks are known from many areas and localities, where they have penetrated along faults of various strikes. The geological data prove mostly the Cretaceous—Paleogene age of their emplacement (Kozary 1956, Knipper - Cabrera 1974). We may therefore presume that the whole Cuban territory was during the mentioned period strongly affected by the activated mantle material.

The zones of large ascent of ultrabasic material evolved successively to the actual ophiolite complexes which are in space and time associated with the volcanic, plutonic and metamorphic processes in the adjacent zones.

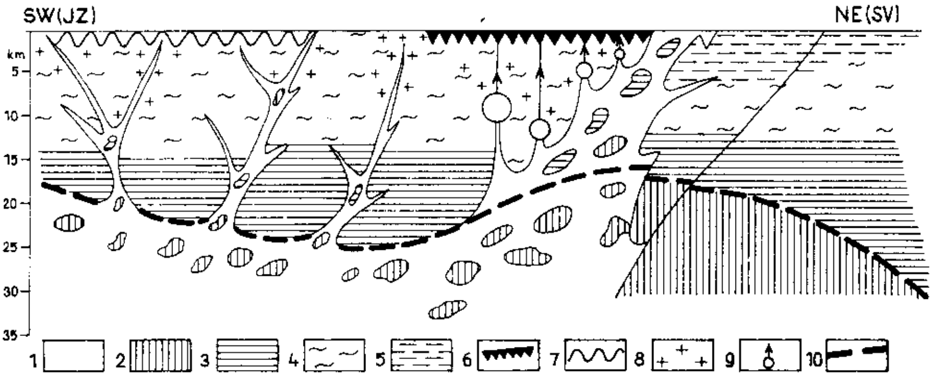
The ophiolite complexes consist generally of ultramafites, gabbro and volcanites (diabase dykes, pillow lavas) and are strongly tectonized. On the actual surface we may observe the ophiolite sequences mainly in thrust sheets or gravity nappes as a serpentinite melange. In this way, the various magmatic sequences lie in the tectonic position.

As known, the bimodal magmatic activity may be explained in various ways: as a consequence of two different contemporaneous magmatic chambers or as a consequence of nearly simultaneous ascent of different melts directly from the mantle. Another model (Nisbet - Chinner 1981) is considering the ascent of a single ultramafic liquid from the depth. This fluid is of a high temperature (1600—1700 °C) and relatively low density (2.75 $g.cm^{-3}$) and viscosity (0.1—0.5 Pa.s). If the permeability of the crust is sufficient and the reserves of the ascending liquid are large, the fluids may reach up to the surface and erupt along the fissures. Such events occurred probably along the Principal Suture (Knipper - Puig 1967).

If the permeability of the Earth's crust is low and/or the reserves of the melt are insufficient, the liquid may be entrapped and form magma chambers of various sizes. The fractionation in the chambers starts with the separation of chromite and olivine, which accumulate in the bottom of the chamber. If the ascent of ultrabasic fluids stops, the melt crystallizes giving from the bottom to the top layers of chromite, dunite, lherzolite, pyroxenite and gabbro. If the successive portion of the ultrabasic liquid is abundant, a semipermanent or long-living magmatic chamber may be formed. The different density between the liquid in the upper part of the chamber and magmatic suspension in the lower part dismember the chamber in two parts (Nisbet - Chinner 1981).

However, only the fluids of the basaltic or more acid composition in the upper parts may due to the lower density erupt.

The overlying structures of the inclined weakened zones form a suitable environment for the development of the magmatic chambers. The Principal Suture in Central Cuba is inclined 60—70° to the SW (fig. 6). The thick volcano-sedimentary complex, which forms a broad belt, is limited on the rocks relatively overlying the Suture. Along its northern rim, the volcano-sedimentary complex is absent. The heat fronts, associated with the ascent of the ultrabasic liquids, may be considered as responsible for the conditions of the regional metamorphosis. In a greater depth, the temperature rose up to the conditions of partial melting. The granitoid melts produced intruded later into the upper crustal levels.



6. Geotectonic model of Central Cuba
1 — ultrabasites; *2* — pre-Jurassic upper mantle; *3* — lower crust; *4* — crystalline basement; *5* — sedimentary formations of the northern coast; *6* — volcano-sedimentary complex; *7* — metamorphosed schists of Escambray; *8* — granitoids; *9* — magmatic chamber; *10* — Moho.

The deep-seated faults represent structures of a high permeability. The subcrustal fluids could relatively easily ascend along these structures up to the surface. However, during the intervals of relative tectonic inactivity, the ascent could be blocked and the melt could differentiate similarly as in the magmatic chambers. The various types of rocks, generated probably in this way, have been later deformed and ejected by the serpentinite diapirism. Occurrences of this kind are abundant in Cuba.

The rapid ascent of the ultrabasic fluids along the opened weakened zones could not be accompanied by a large-scale heat front. The low temperature of the ultrabasic protrusions is explained by the long distance of their transport and by the fact that they do not represent magmatic intrusions but serpentinite flows. Moreover, the serpentinization may also be considered as an endothermic process.

The hydration of the ultrabasites may occur in the presence of moist surrounding rocks. The serpentinization in mass is believed to occur if the seawater penetrates to the deeper zones along the opened faults (S o r o c h t i n 1979). The endothermic nature of the reaction cools down the ultramafites and the thermal fields fail (Š k v o r 1982). In this way, the effects of the regional metamorphosis may sometimes indicate a lower grade of serpentinization of the deeper parts of the ultrabasic bodies. On the contrary, the absence of the regional metamorphosis may indicate a high grade of serpentinization in a greater depth.

The serpentinite diapirism, accompanied always by violent deformations, is easily explained by the density changes and mechanical properties of serpentinite. The schistose serpentinites, cropping out on elevated reliefs, form gravity flows similar to glaciers (C o w a n - M a n s f i e l d 1970). The shear strength of these rocks is very low ($0.8-3 \,.\, 10^{-5}$ N cm^{-2}). The volume increase of the serpentinized rock up to 25 % causes superhigh pressures in the confined space of the rock massif. Under these conditions the rock sequences are crushed, pushed and squeezed out forming the serpentinite mélange. The high-pressure gradient in the vertical direction along the opened faults drives the mélange up to the surface, where it is exposed in thrust-like structures. The serpentinite mélange has been ejected several times in Cuba (K n i p p e r - C a b r e r a 1974).

The blueschists are closely associated with some types of the serpentinite mélange. In Cuba, the glaucophane-bearing rocks were described for the first time from the Escambray Mts. by S o m i n and M i l l a n (1981). The mineral association of these schistose or massive rocks corresponds to typical blueschists. According to the new set of geological maps on 1 : 50.000 scale (S t a n í k et al. 1981) and detailed studies made by the present author, these rocks form lenticular, often narrow bodies surrounded by sequences, which do not contain any critical mineral of the "high-pressure" facies. The occurrences are always accompanied by exotic blocks or fragments of serpentinites. Often present are also blocks or fragments of eclogitic rocks. S o m i n and M i l l a n (1981) described the partial transformation of amphibole into glaucophane and riebeckite in the amphibolites of the Formation Yayabo accompanied by blocks of serpentinite and eclogite. A similar occurrence is known in the Sierra del Purial (C o b i e l l a et al. 1977). The presence of glaucophane-bearing rocks has been reported also from other parts of Cuba. The blueschists are always accompanied by serpentinite in blocks or fragments of various sizes.

Some authors (e.g. M a k u č e v 1973) have drawn attention to the fact that the alkaline amphiboles may originate in the conditions of the greenschist facies under a high natrium concentration. However, the experimental results indicate that the glaucophane, lawsonite and crossite generate in laboratory conditions under the superhigh pressure of 80—120 MPa. The majority of authors consider at present the glaucophane-bearing rocks as a proof of the superhigh pressure metamorphosis. The temperature of this metamorphosis is considered to be as low as 200—250 °C. The mentioned pressure corresponds to the conditions in the depth of 25—35 km. Such pressure cannot be tectonically explained in the upper parts of the Earth's crust. From that point of view many authors interpret the presence of blueschists as a consequence of giant movements of tens of kilometers thick plates coming to collision or subduction. However, such conditions are absent in Cuba as well as in some other regions with blueschists occurrences.

The literature dealing with the blueschists occurrences known from Japan, California, Oregon, the Urals, the Alps, Carpathians and other regions demonstrates that these are associated with mobile zones and accompanied by isolated serpentinite bodies. This fact may be the key-point for the interpretation of the superhigh pressure conditions.

As mentioned above, the serpentinization is associated with reduced density. If this happens in a confined space of a rock massif, the molecular forces of transformed ultramafites produce superhigh pressures. Such conditions come in action especially if the ultramafites form isolated bodies in a rock massif of a different composition. The pressure in the rising serpentinite protrusions is lower, below the level of the blueschist facies.

The radius of the high pressure motivated by the serpentinization of ultramafic bodies depends on many factors. High gradients probably existed in the confined sequences of a low permeability, in which the serpentinized bodies could not escape to the zones of a lower pressure. The temperature of the blueschist metamorphosis is considered to be low. From that point of view it does not seem probable that the metamorphosis took place in a depth of ten or several tens of kilometers as a consequence of collision or subduction. The temperature in such depth, influenced by the external and internal friction during the movements, should be higher.

A special problem represent the fragments or blocks of the eclogitic rocks. These "apoeclogites" or eclogite of the class C (Coleman - Lanphere 1971) are known in the serpentinite mélange in Escambray and in the Sierra del Purial. These rocks are composed mainly of clinopyroxene, garnet and rutile. The origin of these rocks is by far not clear. The mineral association and chemical composition indicate that the rock generated in an environment of a low concentration of SiO_2, high concentration of Ca and lack of water (Ghent - Coleman 1973). The absence of pyrope (the garnet is almandine-grossularite) indicates that the eclogites of the class C do not represent subcrustal rocks. From the geological point of view it should be emphasized that these rocks are always associated with serpentinites. Their mineral association corresponds to a higher temperature and pressure.

In my opinion, the discussed fragments or blocks might represent the primary contacts of the ascending ultrabasic liquids. An active replacement could be expected between the consolidating ultrabasites and their relatively cool contacts. The migration of the volatiles from the exocontacts may provoke the hydration of the ultrabasites and a higher pressure. The serpentinization exhausts the water content of the exocontact and further reactions occur in a dry environment. Later on, during the serpentinite diapirism, the eclogitized contacts have been crushed and as fragments or blocks became part of the mélange.

The deep-sea deposits (Knipper - Cabrera 1974) known to occur in relatively narrow stripes along the ophiolite complexes of Cuba demonstrate that these zones, prior to the ophiolite emplacement, formed deep trenches. These trenches developed during the Lower Cretaceous (Kozary 1956, Knipper - Puig 1967, Itturalde - Vinent 1981, Kantschev et al. 1975). The rapid subsidence has not been compensated by sedimentation. Radiolarites and deep-sea limestones of small thickness were deposited. In the Upper Cretaceous the regime changed. The zones of deep-sea trenches rose up and formed elevations. The inversion of the vertical movements must have been caused by the density changes, in my opinion by the serpentinization of the earlier ascending ultrabasites. The ultrabasic rocks yielded to erosion at the beginning of the Upper Cretaceous.

The Principal Suture does not represent a homogeneous structure. Some parts of this fault system have been used for a mass ascent of the activated subcrustal material, the rest for a relatively sporadic uprise of the same material. In this respect, we may explain the existence and origin of the large blocks, which divide the island of Cuba into elevated and depressed areas along its longitudinal axis. The large ophiolite complexes, granitoid massifs and volcano-sedimentary complexes crop out within the elevated blocks (e.g. in the block of Las Villas and Camagüey). The nearby depressed blocks, covered by young sediments, have according the geophysical data and results of deep drilling distinctly lesser amounts of ophiolitic and plutonic sequences.

The principal cause of the vertical movements is the disturbed isostatic equilibrium. The elevated blocks consist for the most part of serpentinites and granitoids, which are relatively lighter rocks. The depressed blocks, on the contrary, have a lesser amount of these sequences.

Considering the matter from a different point of view it may be concluded that the heterogeneous geological development of Cuba is some respect related to the dip of the weakened zones. For example, the geological construction and development of the central part of Cuba in the block of Las Villas and Camagüey is similar. The Principal Suture is inclined here to the SW. The course of the Suture is accompanied by the ophiolite complexes. Farther to the S in the rock masses overlying of the Suture, the volcano-sedimentary complex, granitoid massivs and metamorphites crop out. A different structure has the block of Holguin, where the ophiolite complex lies in the Cretaceous volcano-sedimentary sequences. The difference is due to the dip of the Principal Suture, which is believed to be practically vertical in Holguin.

4. Commentary on the geotectonic models

The three belts of the different Earth's crust located parallel to the longitudinal axis of Cuba were discussed in this article. In the geosynclinal terminology, these belts are considered as miogeosynclinal and eugeosynclinal; the zone of their articulation, represented by the suboceanic crust and opiolite complexes, was designated by Knipper and Cabrera (1974) as a leptogeosyncline. The vast area of the Caribbean Sea, formed by several basins, trenches, ridges and rises has been usually kept out of discussion in the geosynclinal models. Similarly, the plate tectonic models usually do not classify the actual morphology of the Caribbean Sea genetically. The parallel paleomagnetic anomalies are not developed, the geophysical and geological data indicate neither divergent nor convergent movements. Only the small Mid-Cayman Rise has been considered as a new spreading centre.

The models which explain the complicated structure of Cuba and of its surroundings as a consequence of an obduction of a litospheric plate or a collision of a giant heated nappe, were tested by the analysis of the deformation plans (Škvor 1982). If we assume a horizontal movement of a giant nappe or plate from the S toward the N, the maximum deformation effects are to be expected along the front of the thrust. This front is often assumed to exist along the border of the stable platform. However, it is folded and faulted only moderately. Similarly, the structure of the rest of the Cuban territory does not indicate any large-scale horizontal movements. For example, the strikes in the Escambray Mts. are directly subordinated to the two domes. the strikes in the Isla de la Juventud are almost upright to the axis of Cuba, etc. The proof of the absence of large horizontal movements gives the western promontory of Cuba, in which the structure is turned out nearly 90°.

The root-zones of the assumed giant nappes are unknown. The crustal heterogeneity of the Caribbean region, the physical parameters of the assumed nappes, the motives of their movements and thermodynamic conditions are unclear and mostly in contradiction with these models.

The zone of the extreme deformations links up with the ophiolite complexes which rose along the Principal Suture. These deformations are related to the movements along the weakened zone, to the serpentinization process, diapirism and gravity slides of the serpentinites. The geological development of this zone consisted of the trench formation and later elevation, which was accompanied by folding and thrusting. Some analogous features were reconstructed also in the Escambray Mts., where the sediments were deposited in a graben-like basin.

A similar development may be assumed also in the Cayman System. According to the recent investigations, the system developed along a vast weakened zone. The analyses of the actual focal points indicate that the movements have the character of a sinistral shear (P e r f i t - H e e z e n 1978, S t r o u p - F o x 1981). An important information on the geological development of the Cayman System gives the study of the Sierra Maestra in Cuba, which forms an emerged part of the Cayman Ridge. According to the results of the recent geological investigation (oral communication to Eugenia Fonseca) the stratigraphic profile begins with the Cretaceous deep-sea sediments free from volcanic products. The volcano-sedimentary complex with basic, intermediate and acid volcanics, large gabbro massifs and granitic intrusions belong to the later development stage of Upper Cretaceous—Paleogene. The high activity associated with various types of magmatism turned to the inversion of movements. The present-day Cayman Trench may represent some kind of migration and repetition of the same trend of the geological evolution of the system.

I t u r a l d e - V i n e n t (1981) proposed a new model based on the opening of an intracontinental depression along the present territory of Cuba, in which a new oceanic crust has been created. The comeback of the continental masses toward the N—NE has occurred during the Cenomanian. This model explains many aspects of the geology of Cuba. However, the oceanic crust does not exist in Cuba, the assumed return of the continental masses is in contradiction with the presence of the Upper Cretaceous sediments in the Cayman System (P e r - f i t - H e e z e n 1978), of the Middle and Upper Cretaceous sediments in the surroundings of the Yucatan Peninsula and probably also in the Yucatan Basin S of Cuba. The model does not explain the bended structure of the island.

The author's opinion on the geotectonic development of Cuba and of the Caribbean region is evident from the previous text. It may be explained as a destruction of an older structure of continental and island-arc types. The cause of the lithospheric transformation was the ascent of the asthenosphere, manifested by the abundant basic and ultrabasic rocks. The more resistant parts of the primary crust are preserved and form the nuclei of the continental or subcontinental type. The rest submerged in the risen asthenospheric fluids of relatively lesser density and has been transformed successively under the new physical conditions.

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Hlavní rysy geotektonického vývoje Kuby a karibské oblasti

(Résumé anglického textu)

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Karibská oblast je na S a J omezena americkými kontinenty, na Z středoamerickou šíjí a na V Atlantským oceánem. Prekambrická a paleozoická stavba vystupuje na povrch podél okrajů přilehlých kontinentů a zasahuje ze S až do centrální části Střední Ameriky. V karibské oblasti převládají horniny mezozoického a třetihorního stáří. Horniny prekambrického stáří byly teprve nedávno radiometricky ověřeny v západní Kubě.

Karibské moře se skládá z několika pánví, příkopů, hřbetů a prahů. Deprese mají zemskou kůru suboceánského, elevace subkontinentálního typu. Některé struktury známé na sousední pevnině pokračují i v Karibském moři.

Během svrchního mezozoika a v paleogénu leželo území dnešní Kuby na rozhraní mezi stabilní platformou na S a extrémně mobilní oblastí na J. Centrální část ostrova je tvořena třemi pásmy odlišné geologické stavby, rovnoběžnými s podélnou osou. Severní okraj Kuby náleží karbonátové provincii Florida—Bahamy a je podle geofyzikálních údajů tvořen zemskou kůrou kontinentálního typu o mocnosti 25—30 km. Ve svrchní části kůry je krystalický fundament, asi obdobný jako v jižní Floridě, pokrytý zvrásněnými jurskými a křídovými sedimenty.

Dále na J, podél tzv. hlavního švu probíhá druhé pásmo, široké 5—20 km. Je tvořeno intenzívně deformovanými horninami a ofiolitovými komplexy. Zemská kůra je zde ca 18 km mocná a má suboceánský charakter.

Třetí pásmo zahrnuje střední a j. část centrální Kuby. Zemská kůra dosahuje mocnosti 20—35 km a odpovídá subkontinentálnímu typu s kontinentálními jádry. V současném erozívním řezu vystupují metamorfované jurské a spodně křídové uloženiny, intruzívní granitoidy a křídový vulkanosedimentární komplex. V depresích jsou uvedené horniny zakryty mladým pokryvem.

Hlavní šev, známý podél celého s. pobřeží Kuby, se ztrácí v Mexickém zálivu. V západní části ostrova úlohu hlavního švu nahrazuje oslabené pásmo směru VSV—ZJZ.

Regionálně metamorfované sedimenty doloženého jurského a spodně křídového stáří vystupují v horách Escambray ve střední Kubě. Litologicky podobné horniny tvoří metamorfovaný masív ostrova Isla de la Juventud, velmi slabě metamorfované jsou známé též ze Sierra del Purial na V Kuby. Radiometrická stanovení K-Ar metodou ukazují vesměs svrchně křídové stáří metamorfózy.

Starší metamorfity byly radiometricky zjištěny v z. části Kuby. Stáří flogopitu z mramorů nedaleko města Matanzas je 910+25 a 945+25 Ma., žul z údolí říčky Cañas 150+5 Ma. V literatuře je často diskutované stáří a postavení amfibolitů a granitizovaných amfibolitů, které vystupují v tektonicky omezeném bloku na styku s metamorfovanými břidlicemi Escambray a Sierra del Purial. O větším stáří amfibolitů svědčí úlomky a bloky těchto hornin vynesené podél zlomů serpentinity z podloží masívu Escambray. Silně zvrásněné a rekrystalované aplitové výplně puklin v granitizovaných amfibolitech nasvědčují působení dvou časově oddělených metamorfních pochodů. Břidlice Escambray byly postiženy jediným tektonotermálním procesem.

Terigenní a karbonátové uloženiny jurského a spodně křídového stáří tvoří metamorfovaný masív hor Escambray, zpracovaný nedávno československou expedicí (S t a n í k et al. 1981) a souběžně též pracovníky Kubánské akademie věd (M i l l a n - S o m i n 1981). Masív tvoří výraznou antiformu, rozčleněnou na dvě samostatné klenby. Výsledky seizmického výzkumu, interpretace drobně tektonických dat a metamorfní zonálnosti, uvedené podrobněji v anglické části textu, vedou k následujícím závěrům (obr. 2, 3, 4): Sedimentace proběhla v pánvi příkopového charakteru; zvrásnění a vznik kleneb byly synmetamorfní; „obrácená" metamorfní zonálnost je podmíněna prohříváním uložených sedimentů nejen zespodu, nýbrž i ze stran.

V masívu Isla de la Juventud rozlišil M i l l a n (1981) několik bloků, ve kterých vystupují horniny odlišné metamorfní facie. Zhruba středem ostrova probíhá oslabené pásmo La Fe směru SSZ—JJV, které tvoří strukturní i metamorfní předěl. Bloky na Z od La Fe jsou epizonálně metamorfované, bloky ve v. a zvláště sv. části ostrova jsou metamorfovány v podstatě periplutonicky. M i l l a n (1981) rozlišil 5 metamorfních zón. Nejvyšší subfacie andalusit-sillimanitová je vázána na průběh oslabeného pásma, provázeného malými tělesy intruzívních granitů.

V severozápadní části ostrova je v depresi zvané Sabana Grande zachována část vulkanosedimentárního komplexu křídového stáří, který kdysi pokrýval celý ostrov. Nejspodnější část tohoto komplexu je podle G a r a p k a et al. (1974) regionálně metamorfovaná. Různě intenzívní metamorfózu a stratigrafickou pozici horninových sérií v jednotlivých blocích vysvětluje schéma na obrázku 5. Jurská až spodně křídová sedimentace byla přerušena vulkanickou a tektonotermální aktivitou, která se během křídy projevila v celé karibské oblasti. Vulkanické produkty zatížily masív mocným zahřátým pokryvem, který tvořil tepelnou izolaci geotermálního systému a vedl k zaklesání masívu. Vysoké tepelné toky vytvořily podmínky pro regionální metamorfózu, která hlouběji přecházela až do částečného natavení. Intruze granitoidů podél zón oslabení vedly k periplutonickému typu metamorfózy. Západní část byla stabilnější, vulkanický pokryv zde byl méně mocný, tepelné toky nižší. Pozdější výzdvih a eroze obnažily v z. části ostrova vulkanický pokryv i svrchní část slabě metamorfovaných sedimentů. Ve v. části byl odnesen mocnější pokryv a svrchní část metamorfovaných sedimentů zůstala zachována.

Velké ofiolitové komplexy leží podél hlavního švu a jeho větve v z. části Kuby. Menší tělesa ultrabazických hornin, rozptýlená podél menších zlomů po celé Kubě, svědčí o regionální invazi aktivovaného podkorového materiálu směrem k povrchu. Z geologických údajů je patrno, že většina ultrabazických protruzí je svrchně křídového stáří. Prostorové i časové vztahy vulkanických, plutonických a metamorfních procesů s tělesy ultrabazitů svědčí o vzájemné genetické asociaci.

Ofiolitové komplexy jsou tvořeny více či méně serpentinizovanými ultrabazity, gabry a vulkanity. Vzájemný vztah těchto odlišných typů hornin je ovlivněný serpentinitovým diapirismem a gravitačními příkrovy. Předložená modelová interpretace předpokládá, že část ultrabazické taveniny mohla být v případě vysoké prostupnosti přívodních cest vynesena až na povrch. V případě snížené prostupnosti vytvářela magmatické krby, jejichž diferenciace vedla ke vzniku různých typů hornin. Pro vytváření magmatických krbů bylo vhodné nadloží hlavního švu, který je v centrální Kubě ukloněný k JZ (obr. 6). Vulkanosedimentární komplex s bazickými, intermediárními a kyselými vulkanity je známý jen nad ukloněnou částí švu. Severně od výchozů švu není vulkanismus prakticky známý. Tepelné fronty, vedoucí k regionální metamorfóze a v hlubší zóně k částečnému natavení, je logické vázat na masový výstup zahřátého podkorového materiálu do svrchní části litosféry.

Nízká teplota ultrabazických protruzí může být vysvětlena dlouhým transportem a především okolností, že nejde o magmatické intruze, nýbrž o proudy serpentinitů. K masové serpentinizaci dochází podle Sorochtina (1979) v případě, kdy mořská voda pronikne do hlubších zón podél otevřených hlubinných zlomů. Serpentinitový diapirismus, provázený vždy intenzívní deformací, lze vysvětlit objemovými změnami a mechanickými vlastnostmi serpentinitů. Objemový nárůst činí až 25 % a způsobuje v uzavřeném prostoru horninových masívů vysoké tlaky. Vertikální gradienty vedou k výstupu serpentinitových proudů k povrchu. S vysokými tlaky kolem serpentinitových těles je podle názoru autora spojen i vznik glaukofanových modrých břidlic.

Páry spodnokřídových hlubokomořských sedimentů (Knipper - Cabrera 1974 aj.) provázející kubánské ofiolity svědčí o existenci relativně úzkých příkopů. Rychlé zaklesání nebylo kompenzováno sedimentací. Během svrchní křídy se režim změnil. Na místě příkopů vznikly elevace. Inverze vertikálních pohybů byla pravděpodobně spjata se serpentinizací ultrabazitů, které se v předcházejícím období přiblížily k povrchu.

Uvedené tři rovnoběžné pásy odlišné zemské kůry na Kubě odpovídají podle geosynklinálního modelu miogeosynklinále na S a eugeosynklinále na J. Pásmo mezi oběma označili Knipper a Cabrera (1974) jako leptogeosynklinálu. Morfologické i strukturní rozčlenění heterogenního Karibského moře je v geosynklinálních modelech většinou opomíjeno. Obdobně i modely moderní globální tektoniky zpravidla upouštějí od genetické klasifikace současné morfologie dna Karibského moře, ve kterém nejsou známé paralelní paleomagnetické anomálie a konvergentní a divergentní pohyby většího měřítka. Jen malá oblast prahu ve střední části příkopu Cayman (Mid-Cayman Rise) je některými autory považována za nové centrum rozpínání oceánské kůry. Obtíže modelů spočívají především v tom, že v karibské oblasti nelze s jistotou umístit ani starší, ani moderní subdukční zóny.

Některé současné modely, založené na koncepci horizontálního nasunutí obrovských příkrovů o mocnosti deset i více kilometrů, jsou v rozporu s deformacemi podél předpokládaných čelních front. Tyto modely nevysvětlují ohyb struktur mezi centrální a z. částí Kuby.

Geologická stavba Kuby a karibské oblasti může být podle názoru autora vysvětlena přetvořením starší stavby typu kontinentu nebo ostrovního oblouku. Příčinu destrukce lze hledat ve výstupu asthenosféry, doloženém množstvím ultrabazických a bazických hornin, převážně křídového stáří. Odolnější části původní stavby tvoří jádra s kontinentální nebo subkontinentální zemskou kůrou. Část starší sialické stavby zaklesla do zahřáté, relativně lehčí asthenosféry a byla přeměněna za odlišných fyzikálních podmínek.

Vysvětlivky k obrázkům

1. Schéma geografické situace.
   1 — ofiolitový komplex; *2* — oslabená zóna; *3* — 1 — Escambray, 2 — Isla de la Juventud, 3 — Sierra Maestra, 4 — Sierra del Purial.
2. Schéma zemské kůry pod horami Escambray (podle V. E. Ščerbakovové et al. 1973).
   1 — hlubinný zlom; *2* — svrchní hladina granitové vrstvy; *3* — svrchní hladina spodní kůry; *4* — Moho.
3. Schematický průběh hlavních vrásových os, lineací a foliací v masívu Escambray (podle E. Staníka et al. 1981).
   1 — průběh vrásových os b_1 a lineací l_1; *2* — průběh vrásových os b_2 a lineací l_2; *3* — směr a sklon foliací.
4. Model metamorfních izoterm v příčném řezu klenbou Trinidad (1 : 200 000).
   1 — metamorfní izotermy; *2* — struktura klenby.
5. Model geologického vývoje masívu Isla de la Juventud.
   1a — vulkanosedimentární komplex; *1b* — vulkanosedimentární komplex metamorfovaný; *2a* — formace Santa Agua; *2b* — formace Santa Agua metamorfovaná; *3a* — formace Cañada; *3b* — formace Cañada metamorfovaná; *4* — granitizované horniny; *5* — granit; *6* — hlubinný zlom; *7* — tepelný tok (*a* — střední, *b* — vysoký); A.I. a N.G. — bloky „Antiforma los Indios“ a „Nueva Gerona“.

6. Geotektonický model centrální Kuby.

1 — ultrabazity; *2* — předjurský svrchní plášť; *3* — spodní kůra; *4* — krystalinický fundament; *5* — sedimentární formace severního pobřeží; *6* — vulkanosedimentární komplex; *7* — metamorfované břidlice Escambray; *8* — granitoidy; *9* — magmatický krb; *10* — Moho.

Главные черты геотектонического развития Кубы и Карибской области

Центральная часть Кубы сложена тремя параллельными полосами с различной земной корой. Северное побережье относится к карбонатной провинции Флоридско-Багамской области. Южнее простирается сильнонарушенная зона, сопровождаемая офиолитовыми комплексами. Среднюю и южную части слагают вулканогенно-осадочные породы, плутонические и метаморфические свиты. В настоящей статье более детально решаются некоторые проблемы кристаллического фундамента и метаморфических массивов Эскамбрай и Исла де ла Хувентуд. Офиолитовые комплексы поднялись к поверхности вдоль зоны ослабления и во временном и пространственном отношениях они связаны с вулканизмом, плутонизмом и процессами регионального метаморфизма. Геологическое развитие офиолитовой зоны началось с формирования глубоководного океанского желоба. Крайние деформации были обусловлены, с одной стороны, движениями вдоль упомянутой зоны ослабления, а с другой — процессами серпентинизации и серпентинитовым диапиризмом. Современные геотектонические модели обсуждаются, прежде всего, с точки зрения структурной гетерогенности Карибской области.

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