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THE FAULT SYSTEMS IN THE BLOCK OF ORIENTE (CUBA)

Abstrakt:

The Block of Oriente is penetrated by three main fault systems: the system of Sierra Maestra, the transversal system and the system of Sierra del Purial. The faults are mostly normal faults. They originated secularly from the Pre-Cretaceous Periods up to the Recent Epoch and influenced by an important way the geological development of the whole Block of Oriente. At present time, the Block of Oriente represents a system of horsts and grabens.

Abstrakt:

Zlomové systémy ve kře Oriente

Kra Oriente je prostoupena třemi hlavními zlomovými systémy: systémem Sierry Maestry, příčným systémem a systémem Sierry del Purial. Zlomy těchto systémů jsou většinou poklesy. Vytvářely se sekulárně od předkřídového období až po recent a významně ovlivňovaly geologický vývoj celé kry. Dnešní tektonický stav celé kry je soustava hrástí a příkopů.

Отакар Кумпера

Системы разломов глыбы Ориенте (Куба)

Глыбу Ориенте проступают три главных системы разломов: система Сиерра Маэстра, поперечная система и система Сиерра дэл Пуриал. Разломы этих систем представляют собой в большинстве нормальные сбросы. Эти системы нормальных сбросов формировались долгое время с передмелового времени до современной эпохи и существенным образом влияли на геологическое развитие всей глыбы. Современный образ глыбы это система горстов и грабенов.

Die Bruchsysteme in der Oriente-Scholle (Cuba)

Die Oriente-Scholle ist von drei Hauptbruchsystemen durchgesetzt: Sierra Maestra-System, Quersystem und Sierra del Purial-System. Es handelt sich am meisten um radiale Dislokationen. Diese Systeme entwickelten sich von den vorkretazischen Perioden bis zum Rezent und beeinflussten in bedeutender Weise die geologische Entwicklung der ganzen Oriente-Scholle. Heute ist diese Scholle durch die Systeme von Horsten und Graben gebildet.

Introduction

Cuban Island represents a part of the Caribbean geosyncline which has been formed between the both American continents probably since Cretaceous Period /O. Kumpera – V. Škvor 1969/. Together with the other islands of the Antilles it has a very expressive block structure. The Block

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of Oriente represents the most eastern large block of Cuba. It occupies an especial position between the blocks of cuban island. From the tectonic point of view, it represents the stablest geological unit of the whole island. The geological evolution of this unit differs from that of the other part of Cuba in the substantionally less intensive young tectonic deformations. On the other hand, the Block of Oriente is noted for an uncommonly intensive intrusive and effusive magmatic activity during the Cretacous Period and Paleocene and Eocene Epochs.

The Block of Oriente is penetrated by a dense net of ruptures. The author had a possibility to study the systems of ruptures in several parts of the Block of Oriente. The ruptures can be very well studied photogrammetrically because of the morphology of the greater part of the block surface being very expressive. Moreover, the mantle of waste and the young unconsolidated sediments are either absent or they are very thin in the areas under study. During the field works, the results of the photogrammetrical studies were verified.

The present paper represents an attempt at the precision of our knowledge about the faults in the Block of Oriente. Up today, the systems of faults have been figured in the geological maps only schematically /see for example Yu. M. Pushcharovsky, A. L. Knipper and M. Puig-Rifá 1967, A. Adamovich and V. Chejovich 1964, F. G. Keijzer 1945, G. E. Lewis and J. A. Straczek 1955. A. Núñez Jimenez and coll. 1962 and others/. Generally, our knowledge of the fault systems in the Block of Oriente is very weak.

The more precise map representation of the faults, the determination of their strikes and dips and their frequency has a fundamental importance not only for the right interpretation of the geological history of the Block of Oriente, but also for the scientifically substantiated research of the ore deposits. There are known cases of metalliferous accumulations and the origin of the ore deposits along the faults or in the points of intersection of the faults of different strikes in the Block of Oriente /see e. g. N. P. Lavyorov and R. Cabrera-Ortega 1967/.

Main rupture systems

The different geological units of the Block of Oriente are penetrated by three main systems of the faults, as it is seen in the map /pl. I/.

1) The principal system includes the faults of the strike ENE-WSW. It may be designated as *the Sierra Maestra fracture system* because it manifests itself most conspicuously in this volcanic mountains. This fault system may be observed in the whole Block of Oriente. According to the prevailing prolongation of the majority of the geological units, this system represents the longitudinal fault system of Oriente in fact.

2) Another conspicuous system is *the cross fault system* striking in the N - S direction. In this system, a slight variability in the NEN-SWS or NWN-SES direction may be observed. Olso the faults of this system are present in all the parts of the Block of Oriente.

3) The third system is the fault system of the WNW - ESE up to NW - SE direction. It may be designated as *the fault system of Sierra del Purial*. The faults of this system are present first of all in the metamorphic rocks in the Sierra del Purial Mountains in the eastern part of

the Block of Oriente. They are only sporadic in the other parts of the block.

Very striking feature of the faults in the Block of Oriente is their straight-line course, especially their rectilinear course without respect to the different geological units. Another striking feature is the great length of the majority of the faults. From this point of view, the most expressive are the faults of the Sierra Maestra system. Some ruptures of this system may be followed without interruption on a distance up to 50 km. Also some transversal faults can be followed for a long distance, some of them crossing the whole island in the north - south direction. Besides the very long ruptures there are also the short ruptures in the Block of Oriente. Some of them do not reach more than several kilometers.

The majority of the faults of the Block of Oriente belongs to the normal faults.

Sierra Maestra fault system

The faults of this system may be observed in the whole block. But they are most expressive in the Sierra Maestra Mountains and are subparallel to their long axis. The faults of this system are not developed uniformly in the whole Sierra Maestra Mountains. They are concentrated on its northern rim and on its southern rim near the caribbean shore as well. In the central part of the mountains, the ruptures of this system are less expressive or even they lack completely. This disposition of the longitudinal faults is the result of the horst structure of the Sierra Maestra Mountains.

Among the faults of Sierra Maestra, the most conspicuous is undoubtedly the fault striking along the southern coast from the vicinity of Candelario over Cuevas del Turquino to the north vicinity of Chivirico. It is probable that this fault runs further to the east up to the vicinity of Santiago de Cuba. It could not be followed up to this part of the mountains for the lack of the data. This expressive fault can be designated as *the fault of the south coast*. It breaks as the volcanic rocks of Paleogene and (?) Upper Cretaceous age as the intrusive bodies of quartz diorite which penetrate them.

Likewise, on the northern rim of the Sierra Maestra Mountains several parallel faults striking from the east vicinity of Vicano Arriba over Las Mercedes and the neighbourhood of Cabeza de Limones and Vega Grande up to the vicinity of Las Carreras are present. This faulted zone consisting of a set of subparallel faults broken in some places by transversal faults can be designated as *the Sierra Maestra marginal faulted zone*.

The faulted zones parallel to the axis of the Sierra Maestra Mountains have the same direction as the submarine Caiman Ridge. Probably, the Caiman Ridge represents the west continuation of the volcanic mountains of Sierra Maestra /O. Kumpera — V. Škvor 1969/. It is founded on the faults of the Sierra Maestra system. Also the large submarine structure - the Bartlett Trough and its east continuation - the Oriente Trough are of the same direction and of the similar origin. The coincidence of the direction of the extensive volcanic mountains, of the submarine ridge and of the significant submarine trough with the strike of the faults of the Sierra Maestra system shows a great significance of these faults for the origin and evolution of the geological units in this part of the Caribbean geosyncline.

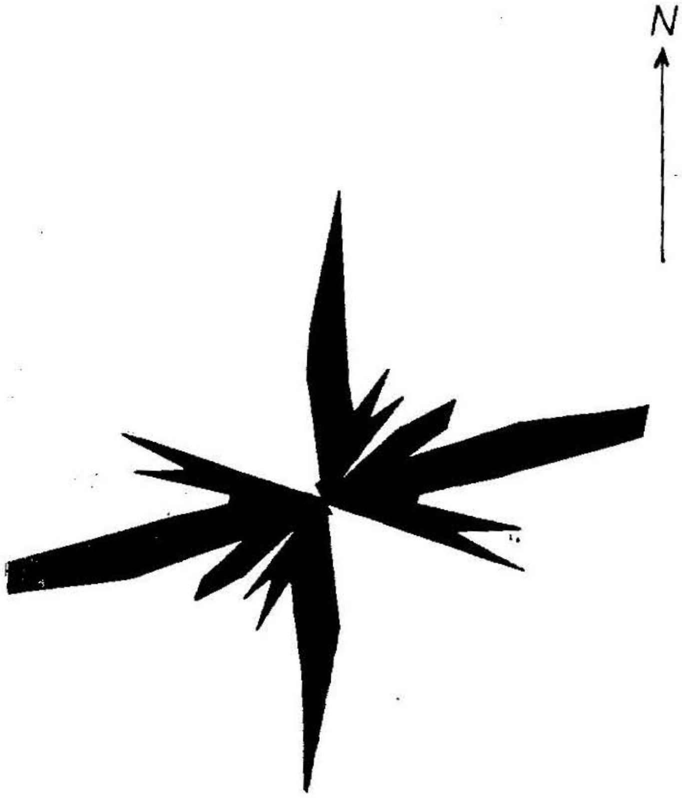

Fig. 1: Rose diagram showing the strikes of the faults in the metamorphic rocks (Pre-Cretaceous Periods) of the Sierra del Purial massif.
M ~ 1 mm = 1 km, intervals 5°.

The fault system of Sierra Maestra manifests itself distinctly also in other parts of the Block of Oriente. The well known B o n i a t o f a u l t bordering the Santiago de Cuba Basin pertains to the ruptures of the Sierra Maestra system. It is one of the faults with recent movements.

The faults of this direction disturb also the ultrabasic bodies in the northern part of the Block of Oriente - the Sierra de Nipe and the Sierra de Cristal intrusive bodies and the Cuchillos de Toa intrusive body and the sediments of the Cretaceous and younger age in its vicinity as well. T h e

Sierra del Mica fault, which can be followed from the northern vicinity of La Prueba over Sierra del Mica up to the north-western vicinity of La Quijada, belongs to the most significant ruptures of this area. It disturbs the Paleogene beds in the central part of Oriente in the Cauto Basin. The southern marginal faulted zone of Sierra de Nipe bordering this mountains and the Cauto Basin, runs aproximately in the same direction. It continues to the NE up to the Sagua de Tánamo Bay. Likewise, the central faulted zone of Sierra de Nipe belongs to the faults of the Sierra Maestra fault system, as well as the Nicaro fault which limits the Sierra de Nipe intrusive body to the north. Last three mentioned faults and faulted zones are not exactly parallel. They converge into the vicinity of the Sagua de Tánamo Bay. In this place, we are up against a very interesting structural feature. The Sagua de Tánamo Bay represents a structural junction.

The eastern part of the Block of Oriente is penetrated by the numerous faults of this system, but they cannot be followed for a long distance owing to the frequent disturbance by the faults of other directions.

Transversal fault system

The faults of this system may be designated as transversal faults first of all that they form a right angle with the main longitudinal fault system of Sierra Maestra. Besides, they run transversally to the geological units of the Block of Oriente, the majority of which being elongated equatorially.

Transversal faults are very important structural features in the volcanic mountains of Sierra Maestra. Beginning from the eastern part of Sierra Maestra, the Río Silantros fault belongs to the main ruptures of this system. It may be observed from the neighbourhood of Cieneguilla in the north up to La Marea del Portillo on the southern coast. The Camaron Grande fault passes from the southern coast from the locality of its name northward over the mountain Pico El Frijol up to the SW vicinity of Cayo Espino. The Alto del Macio fault is slightly convergent to the last mentioned rupture. It may be observed from Camaron Grande on the southern coast over the hill Alto del Macio up to the western vicinity of San Lorenzo. Very expressive ruptures may be seen in the La Magdalena faulted zone. It runs from the southern coast near La Magdalena northward up to the eastern vicinity of Zarzal. Río Turquino fault reaches furthermost to the north. It passes with interruptions due to the faults of Sierra Maestra system from the mouth of Río Turquino on the southern coast over Pinar Quemado up to Palmarito. The Punta Bayamito faulted zone represents a set of subparallel faults which can be followed from Punta Bayamito on the southern coast over the granitoid elevation, El Diablo vicinity up to the vicinity of El Corojo and Pueblo Nueve on the northern slope of Sierra Maestra.

On the eastern margin of Sierra Maestra, the graben of the Santiago de Cuba Basin may be observed. Its westernmost dislocation is the **El Cobre fault**. All the transversal faults of Santiago de Cuba vicinity form the faulted zone of Santiago de Cuba. Besides the very known **El Cobre** fault, the Cabañas fault, San José fault, **Punta** Morillo fault and San Juan fault belong to this struc-

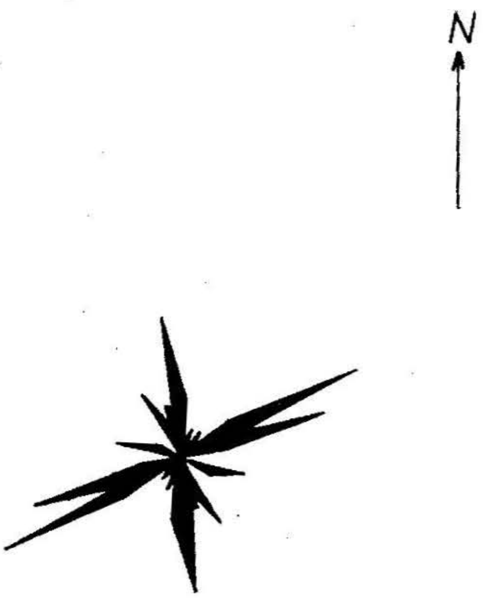

Fig. 2: Rose diagram showing the strikes of the faults in the Upper Cretaceous beds in the Block of Oriente.
M ~ 1 mm = 1 km, intervals 5°.

ture. Together with the longitudinal faults of the Sierra Maestra system they constitute a graben of Santiago de Cuba. The lowest sunken blocks of the graben are overlapped by the marlaceous sediments of the La Cruz Formation. According to the Miocen Age of this stratigraphical unit, several authors believe that the graben of the Santiago de Cuba Basin originated during the Miocen Epoch. The graben interrupts the Sierra Maestra horst. East of the graben, in the Gran Piedra Mountains, the transversal fault system is less evident. Let us mention the Alto de Escandel faulted zone, which passes from Del Pozo up to the vicinity of El Cristo. Another rupture in this part of the volcanic mountains is the Siboney fault, which may be followed from Siboney on the southern coast northward up to El Oro.

In the northern part of the Block of Oriente, a conspicuous San Benito fault may be observed. It disturbs the Eocene sediments of the Cauto Basin. The ultrabasic body of Sierra de Nipe is limited on the west by the transversal faulted zone, which continues southward up to the vicinity of El Manzano and northward reaches the vicinity of Jubal. It may be designated as the El Manzano-Pinalito-Jubal faulted zone. Similarly, the Sierra de Nipe Mountains are limited in its eastern part by a transversal faulted zone. This zone continues southward on the western rim of the ultrabasic body of Sierra de Cristal Mountains and it may be followed, with interruptions due mostly to the faults of the Sierra Maestra fault system, further southward up to the vicinity of Serobuca and Jarahueca. This zone may be designated as the faulted zone of Mayarí. This zone follows the direction of the Río Mayarí. Last mentioned two zones limit the Sierra de Nipe Mountains in west and east. To-

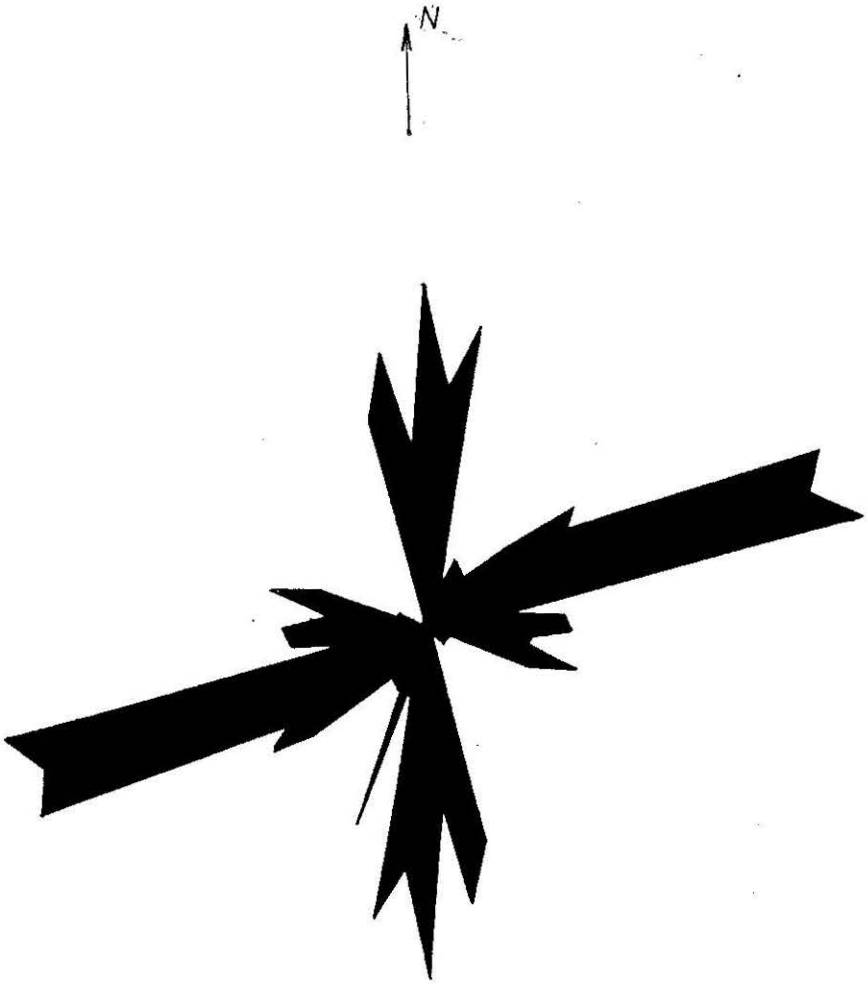

Fig. 3: Rose diagram showing the strikes of the faults in the ultramafic intrusive bodies in the Block of Oriente.
M ~ 1 mm = 1 km, intervals 5°.

gether with the faults of the Sierra Maestra system they form a system of the upthrown and sunken blocks of the horst structure of Sierra de Nipe.

South of the Sierra de Cristal Mountains, the Eocene series are disturbed by the transversal faulted zone of Río Bayate, which is denominated according to the río following partly the rupture. The faulted zone may be observed from Cuneiro in the south northward up to Calaboras. To the east of here, a wide faulted zone of Sierra Maguey disturbs the Cretaceous and Paleogene beds and the ultrabasic intrusive rocks as well. It passes northward of the area between Santa Fe and Santa Cruz on the south up to the area between Sagua de Tánamo and Canavora.

T h e t r a n s v e r s a l f a u l t o f V e r d e M o n t e represents one of the most expressive ruptures in this part of Oriente. It divides practically all the eastern part of the island passing from the eastern vicinity of Guantá-

Fig. 4: Rose diagram showing the strikes of the faults in the rocks of Paleocene age in the Block of Oriente.
M ~ 1,5 mm = 1 km, intervals 5°.

namo Bay over Verde Monte up to the northern coast in the eastern vicinity of Yaguanegue Bay.

The eastern part of the Block of Oriente is penetrated by very dense zones of the transversal faults. But the faults of the north-east strike are often crossed by the faults of the Sierra Maestra system and by the faults of the Sierra del Purial system as well, so that it is very difficult to follow the ruptures on a long distance. Nevertheless, some more conspicuous faulted zones and independent faults may be seen in the varied block mosaic of the eastern part of Oriente. In the Oligocene beds north of Tortuguilla transversal faulted zone of Río Yateras can be observed. Río Yateras river passes in its upper course partly along this zone. In the north, this zone reaches up to the stream head of Río San Andrés. East of the northern end of this zone, the faulted zone of the western part of Cuchillos de Toa begins to strike to the north. This faulted zone may be followed up to the southern vicinity of Moa. Its faults disturb as the Eocene and Oligocene beds as the ultrabasic rocks. The faulted zone of Río Sabanalamar represents another expressive transversal faulted zone in the eastern part of Oriente Province. The lower course of Río Sabanalamar follows this zone. The faulted zone separates the metamorphic rocks of Sierra del Purial from the Oligocene beds in the south. In its northern part, it disturbs the metamorphic rocks and the ultramaphic and basic rocks of the Cuchillos de Toa intrusive body. This faulted zone is expressively developed still near Punta Gorda on the northern coast.

The San Antonio del Sur fault represents the most conspicuous rupture of the metamorphic rocks of Sierra del Purial. It begins near San Antonio del Sur on the southern coast and passes across the whole metamorphic massif up to the ultrabasic intrusive body of Cuchillos de Toa. East of the San Antonio del Sur fault, shorter ruptures - the Bahía de Jaraguá fault and the Playa Pinca fault may be observed. A very known mountain - Loma el Yunque is disturbed by a transversal fault, which may be denominated as the Loma el Yunque fault. East of here, the Baracoa fault occurs. All these shorter ruptures disturb the ultrabasic and basic rocks and metamorphic rocks as well.

Sierra del Purial fault system

This system is conspicuously developed only in the metamorphic massif of Sierra del Purial Moutains in the eastern part of the Block of Oriente and in the nearest vicinity of the massif. The faulted zone of Puriales de Caujeri beginning in the Oligocene beds north of Palenquito and passing over Puriales de Caujeri up into the metamorphic massif, represents one of the most expressive ruptures of this area. Its continuation is formed by the faulted zone of Sierra de Imias, which passes from these mountains up to the Miocene beds on the south coast near Playitas. North of here, the metamorphic rocks of Sierra del Purial massif are separated from the ultrabasic intrusive body by the faults of the faulted zone of La Farola and by the Loma del Salto del Indio faulted zone. These zones are here denominated after the peaks lying in blocks limited by the faults. The northwestern part

of the metamorphic massif is disturbed by the Pico Galan faulted zone.

Outside the metamorphic massif of Sierra del Purial, the expressive faults of this system are rather sporadic. The fault of Mina La Melba in the ultrabasic intrusive body of Cuchillos de Toa Mountains is one of these sporadic ruptures. East of here, the Sierra de Mateo fault and other shorter parallel faults occur. The Upper Cretacesous beds south of Sagua de Tánamo Bay are disturbed by the Sagua de Tánamo fault. Near the southern coast of Oriente Province, some sporadic ruptures have the strike of the Sierra del Purial system. The

Fig. 5: Rose diagram showing the strikes of the faults in the rocks of Eocene age in the Block of Oriente.
M ~ 1 mm = 1 km, intervals 5°.

Cuatro Caminos fault, Sierra de Los Ciegos fault, Río Bacanao fault, Laguna Sigua fault, La Perla fault and Cabañas fault belong to these ruptures. East of Santiago de Cuba, the El Cobre Formation is disturbed by the El Caney fault and Ocaña fault. Very short ruptures of this system may be sporadically observed also in the Sierra Maestra Mountains.

Time distribution and space distribution of the ruptures

Studies of the directions of the ruptures and of their frequency in different parts of the stratigraphic column have been done. These studies can show either the stability or the changes of the strain field. For this purpose, the frequency of the directions of the ruptures are figured in the rose diagrams constructed by the author and his fellow-workers on the basis of the author's measurements for each stratigraphic system or series, which are developed in the block of Oriente.[1]

The analysis shows that the majority of the diagrams has two peaks (fig. 1 — 8). In all diagrams the most conspicuous peaks are formed by the ruptures of the longitudinal faults of the Sierra Maestra fault system. It is evident that there are slight variations of the directions of faults in different series, but they can be explained by different mechanical qualities of the rocks. It is clear that the fracturing in the Sierra Maestra direction played a very important role in the geology of the Block of Oriente during the large Mesozoic and Kainozoic evolution. In this direction, the volcanic zones of Sierra Maestra originated during the Late Cretaceous and Early and Middle Paleogene Epochs. The facies of the Paleogene rocks are often elongated in this direction .The internal structure of some intrusive ultrabasic rocks testifies the intrusions along this direction as well /O. Kumpera 1968, 1969/. The faults of this fault system influence the recent morphology of the Oriente Province. Some faults of this fault system are considered to be recent faults. For example, the Boniato fault near Santiago de Cuba originated during the Recent Epoch. Some mountains of Oriente represent the horsts upthrown mainly along the faults of the Sierra Maestra system (Sierra de Nipe, Sierra Maestra). It is very probable that the horst structure of the Siera Maestra Mountains has its continuation in the mentioned submarine Caiman Ridge. According to Ph. B. King /1959/, the Bartlett and Oriente Trench represents a graben, originated along this fault system.[2]) Likewise, the course of the southern shoreline of Oriente is influenced mainly by this direction. From the above mentioned facts the longtermed movements along these faults are evident. Consequently, the faults of Sierra Maestra system represent the ruptures founded already during the Mesozoic Era and influencing the geological evolution of the Block of Oriente up to the Recent Epoch.

The second peak in all the rose diagrams constructed lies in the direction of the transversal faults. Comparing the diagrams, an interesting relation may be seen: the angle between both maxima remains constant in the ma-

1) The boundaries of the stratigraphical units have been taken from the geological map of A. Núñez Jimenez and col. (1962).

2) This situation is well seen in the cross section through Oriente and a part of the Barlett Trench published in the author's previous work /O. Kumpera 1969/.

Fig. 6: Rose diagram showing the strikes of the faults in the Oligocene beds in the Block of Oriente.
M ~ 0,5 mm = 1 km, intervals 5°.

jority of the diagrams. This fact indicates the synchronous evolution of both the fault systems. At the same time it shows the stability in the strain field during the long geological evolution of the Block of Oriente. The rose diagram of the faults in the Neogene series is exceptional, the angle between both maxima being substantionally smaller (fig. 7). It indicates a changed tectonic situation during the Neogene Period in this part of Cuba.

The third maximum is less conspicuous. It coresponds to the direction of the faults of the Sierra del Purial fault system. It is evident, that these faults played an expressive role only in the metamorphic massif of the Sierra del Purial Mountains in the eastern part of the Block of Oriente. Nevertheless, the analysis of the rose diagram shows scarce occurence of these ruptures also in the younger series. The strike of the Sierra del Purial fault system corresponds practically to the main direction of the central

cuban blocks /O. Kumpera and V. Škvor 1969/. This tectonic direction plays probably a very significant role in the central part of the island, but it is subordinate in the geological development of the Block of Oriente.

The relation between the main rupture strikes and the tectonic processes in the Caribbean geosyncline

Two principal groups of tectonic hypothesis exist as far as the tectonic evolution of the Caribbean region is concerned. The mobilistic hypothesis suppose the farreaching shifting of the tectonic blocks. Such a hypothesis was described e. g. by J. J. Corral /1941/. He supposed that the islands of Great Antilles were joined with the Southamerican continent up to the Miocene Epoch. They drifted to the north to their present position only in the Miocene Epoch. Likewise, H. H. Hess and J. C. Maxwell /1953/ supposed farreaching movements of the blocks along the great fault bordering the Bartlett Trough to the south and north. According to these authors, some blocks were shifted from the area of present Yucatan to the east. H. J. MacGillawry (1970) presented a hypothesis of the rotation of the whole Carribean area and of the translation of the blocks. The second group of the hypothesis explains the geological evolution of the Caribbean region without any expressive shifting of the lithosphaerial segments. Such a fixistic hypotheses were described e. g. by G. Furrazola-Bermúdez and coll. /1964/ and by O. Kumpera and V. Škvor /1969/.

Analysing the directions of the ruptures and their representation in the series of different age, we can draw a conclusion of the distribution of the strain in this crust segment and define the changes of the strain during the development of the Caribbean geosyncline. The results of such an analysis may suggest the translation of the blocks or the geological development "in situ". First of all, the problem of the evolution of the ruptures must be decided, viz. it must be resolved if the faults originated all at once at the end of the evolution of the Block of Oriente or if they developed during the longtermed Mesozoic and Kainozoic evolution. Several reasons give evidence for the second supposition. First of all, the distribution of the ruptures remains the same in all the rocks of different age (with the mentioned exception of faults in the Neogene series) starting from the metamorphic rocks of the Sierra del Purial Mountains and finishing by the Recent limestone. At the same time, the decrease of the frequency of the faults may be seen without any expressive changes of the strikes. Describing the faults of different systems we have demonstrated the important role played by the faults in the volcanic and magmatic activity during the Cretaceous and Paleogene Periods, the influence of the faults of the Sierra Maestra system in the origin of the Paleogene facies etc. All these facts testify the old origin of the three main fault systems and secular movements along them.

According to the analysis given above the following history of the fracturing and its influence in the geological development may be drawn. The crust segment in this part of the Caribbean region formed mainly by the metamorphic rocks of the probably variscian origin was penetrated by the main fault systems described above already during the Pre-Cretaceous Periods. During the Cretaceous and Paleogene Period the ruptures of the

Fig. 7: Rose diagram showing the strikes of the faults in the Neogene beds in the Block of Oriente.
M ~ 2 mm = 1 km, intervals 5°.

Sierra Maestra and (less) Sierra del Purial direction were utilized for the intrusions. Simultaneously, a process of the dilatation of the blocks along the faults of the Sierra Maestra system advanced and the volcanic zones of the Sierra Maestra Mountains and (probably) of the submarine Caiman Ridge arose. The intrusions and the accumulation of the volcanic rocks contributed to the stabilisation of the crust in the Block of Oriente, so that further movements along these longitudinal faults did not cause the volcanic activity but they formed the grabens and horsts. This process was influenced also by the movements along the transversal faults. The existence of the "high blocks" and "low blocks" in the block mosaic of Oriente then influenced the facies picture of the Paleogene and younger series /see also O. Kumpera 1968, 1969/.

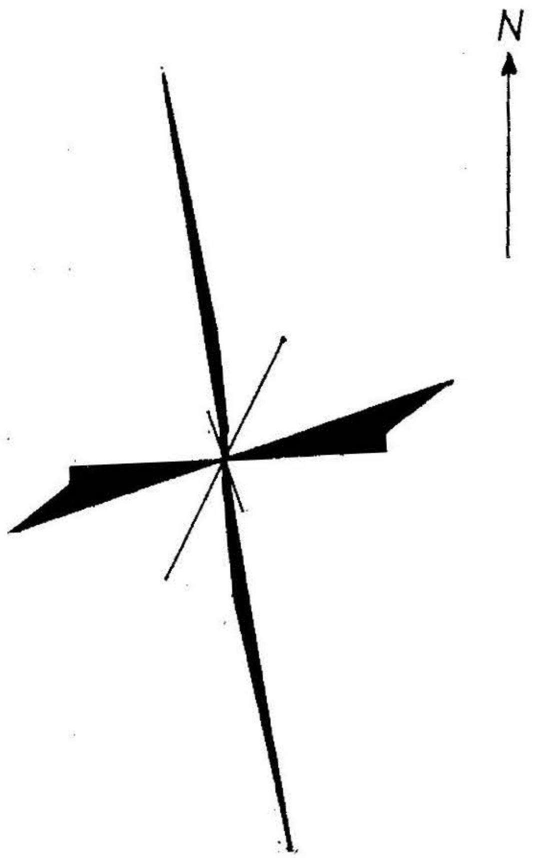

Fig. 8: Rose diagram showing the strikes of the faults in the Quarternary beds in the Block of Oriente.
M ~ 1 mm = 1 km, intervals 5°.

A more expressive deviation of the fault direction can be seen only in the Neogene deposits (fig. 7), where the transversal ruptures deviate into the NE – SW direction. Without doubt, this deviation represents the result of the change of the strain field in the Block of Oriente either already during the Neogene Period or on the Neogene-Quarternary boundary. It is very difficult to evaluate the cause of this change. The present author believes that it is the result of the total uplift of the island. The deviation is so small, that the explication by the translations of blocks according to the mobilistic hypotheses is of no account.

The character of the tectonic evolution of the Block of Oriente

The verified faults testify that the tectonic structure of the Block of Oriente was formed during the Late Mesozoic and Kainozoic Eras under the

controll of the constant strain field. This fact indicates the validity of the fixistic hypothesis in the geological evolution of the Block of Oriente. Large horizontal movements of the blocks must have caused much more complicated net of ruptures in the regions under study.

The verifications and conclusions given above hold only for the Block of Oriente. This block differs from the other blocks of the island first of all by smaller mobility /see also O. Kumpera – V. Škvor 1969, p. 44/. Its Late Mesozoic and Kainozoic tectonic development is typical of the predominance of the normal faults over the thrust faults and folds, which are, with the exception of the folds in the metamorphic rocks of the Sierra del Purial massif, very flat. The tectonic style of the Block of Oriente can be designated as the saxonic type. On the other hand, the neoidic evolution of the western block of the island is more mobile and their structure is much more complicated, being mediotype or even alpinotype.

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Otakar Kumpera

Zlomové systémy ve kře Oriente

Kuba představuje součást karibské geosynklinály, jež se vyvíjí mezi oběma americkými kontinenty patrně od spodní křídy. Spolu s dalšími ostrovy Antill má výraznou blokovou stavbu (O. Kumpera — V. Škvor 1969). Kra Oriente zaujímá mezi krami kubánského ostrova zvláštní postavení. Představuje nejstabilnější geologickou jednotku celého ostrova. Vývoj této jednotky se odlišuje od ostatních částí ostrova podstatně méně intenzivními mladými tektonickými deformacemi. Na druhé straně se kra Oriente vyznačuje neobyčejně intenzívní magmatickou a vulkanickou činností v křídě, v paleocénu a eocénu.

Hlavní směry ruptur

Jak je patrno z přiložené mapy ruptur, v celé kře Oriente dominují ruptury směru ZJZ — VSV (h 4 — 5), které můžeme označit jako zlomový systém pohoří Sierry Maestry, neboť se nejvýrazněji projevuje v tomto nejvyšším kubánském pohoří. Systém Sierry Maestry je patrný v celé kře Oriente. Jiným nápadným systémem je severojižní systém, u něhož pozorujeme mírnou variabilitu do směru SSV — JJZ až do směru SSZ — JJV. Třetím výrazným systémem je systém směru ZZS — VVJ až SZ — JV, jejž můžeme označit jako systém pohoří Sierry del Purial. S tímto systémem se setkáváme především v tomto pohoří na východě provincie Oriente, v ostatních částech kry se buď nevyskytuje, nebo je vyvinut pouze sporadicky.

Nápadný na všech zjištěných rupturách je jejich značně přímočarý průběh, a to často bez ohledu na průchod různými geologickými jednotkami. Jiným nápadným jevem je vzdálenost, na kterou lze rupturu sledovat. Nejvýraznější je v tomto ohledu systém Sierry Maestry, jehož některé ruptury můžeme bez přerušení sledovat až na vzdálenost 50 km. Vedle toho jsou však i ruptury krátké, sledovatelné jen na vzdálenost několika km. Většina ruptur jsou poklesy.

Zastoupení ruptur v různých útvarech

Sledování směru ruptur a jejich četnosti v různých útvarech může ukázat, zda v různých údobích se ruptury tvořily vé stejném poli napětí nebo zda došlo během vývoje kry Oriente k výrazným změnám v rozložení napětí, které by se odrazily ve vzniku odlišných systémů ruptur. Četnosti směrů ruptur v různých útvarech jsou zobrazeny ve Stinyho diagramech na obr. 1 — 8. Je zřejmé, že ve všech útvarech jsou diagramy zřetelně dvouvrcholové.

Nejvýraznější vrchol tvoří ve všech případech zlomy podélného systému ZJZ — VSV, tj. zlomy systému Sierry Maestry. V různých útvarech se sice projevují mírné variace směru (až 10°), ty je však možné vysvětlit materiálovými rozdíly. Je zřejmé, že v celém vývoji kry Oriente neztrácel tento směr ruptur dominantní úlohu.

Je možné předpokládat, že rozpukání podle směru Sierry Maestry sehrávalo velmi důležitou úlohu v geologickém vývoji kry Oriente. Podél to-

hoto směru se otevřela vulkanická pásma Sierry Maestry. Je tedy zřejmé, že významnou úlohu hrály tyto zlomy již během křídy a paleogénu. Porušují pak všechny mladší uloženiny; nejen to, v tomto směru jsou často protaženy facie paleogénu /O. Kumpera, 1969/. Také recentní morfologie je výrazně ovlivněna zlomy tohoto směru. Některá pohoří představují hrástě, vyzdvižené hlavně podle tohoto systému zlomů (např. Sierra de Nipe), jiná mají monoklinální stavbu, s úklonem k severu, modifikovanou hrásťovým výzdvihem centrálních ker proti krám okrajovým (Sierra Maestra). Podle Ph. B. Kinga /1959/ představuje Bartlettův příkop a příkop Oriente příkopovou propadlinu, vzniklou podél tohoto systému zlomů.

Z toho je zřejmé, že vývoj kry byl ovlivňován pohyby podél zlomů systému Sierry Maestry dlouhodobě. Zlomy systému Sierry Maestry jsou tedy patrně zlomy založené v mezozoiku, s pohyby, oživovanými až do kvartéru. Poznamenejme ještě, že některé zlomy tohoto systému se považují za zlomy recentní. Např. zlom Boniato u Santiaga de Cuba vznikl v nedávné minulosti.

Druhé maximum ve všech diagramech odpovídá systému příčných zlomů. Je zajímavé, že úhel sevřený oběma maximy zůstává ve většině diagramů prakticky stejný — 70 — 75°. Pouze v neogénních vápencích je úhel podstatně menší. To nasvědčuje tomu, že vývoj obou systémů zlomů probíhal současně.

Mnohem méně výrazné je třetí maximum, odpovídající zlomovému systému Sierry del Purial. Významnější úlohy hrají tyto zlomy pouze v krystaliniku Sierry del Purial na východě kry Oriente. Je však pozoruhodné, že také s těmito zlomy se setkáváme prakticky ve všech útvarech, s výjimkou kvartérních uloženin. Od nejstarších hornin k mladším však jejich četnost zřetelně klesá.

Analýza ukazuje, že vývoj zlomů ve kře Oriente probíhal sekulárně. Segment zemské kůry v této části karibského prostoru, tvořený převážně metomorfovanými horninami krystalinika typu krystalinika Sierry del Purial, byl rozpukán podél uvedených tří hlavních směrů již v předkřídovém období. Během křídy a paleogénu pronikla do tohoto segmentu intruziva, která využila k proniku hlavních ruptur směru ZJZ — VSV a SZ — JV. Současně postupoval proces dilatace ker podél dislokací směru Sierry Maestry, vedoucí k výlevům láv andesitového a rhyolitového složení a nakupení vulkanického pásma Sierry Maestry a (patrně) podmořského hřbetu Caimanů. Intruze a nakupení vulkanitů vedly k zesílení zemské kůry ve kře Oriente. Další pohyby podél dislokací směru ZJZ — VSV již nevedly k výlevům láv, nýbrž k tvorbě hrástí a příkopových propadlin (např. Sierry Maestry a Barlettova příkopu). Při tomto procesu spolupůsobily i příčné dislokace přibližně severojižního směru. Existence „vysokých ker" a „nízkých ker" v takto vzniklé mozaice ker pak podmiňovala faciální vývoj paleogénních a mladších uloženin /viz např. O. Kumpera **1968**, 1969/.

Výraznější odchylku ve směru dislokací vidíme pouze v diagramu neogénních uloženin. V neogénních vápencích se významně odchylují příčné ruptury do směru SV — JZ. Tato odchylka je bezpochyby výsledkem změny v poli napětí. Příčiny této odchylky je obtížné zjistit.

Ráz tektonického vývoje kry Oriente

Zjištěné ruptury svědčí tedy spíše o tom, že tektonický vývoj kry Oriente koncem mezozoika a v kenozoiku probíhal v neměnném poli napětí. To se zdá nasvědčovat tomu, že vývoj kry Oriente probíhal „na místě“ podle představ fixistických hypotéz. Velké horizontální posuny hmot, předpokládané hypotézami mobilistickými, by se zde musely odrazit v podstatně složitější síti ruptur v horninách kry Oriente.

Uvedená zjištění a závěry platí pouze pro kru Oriente. Tato kra se odlišuje od jiných ker, budujících kubánský ostrov, podstatně nižší mobilitou. Její pozdně mezozoický a kenozoický tektonický vývoj je charakterizován převahou radiálních dislokací nad tangenciálními zlomy a nad vrásami, jež jsou, pokud existují, většinou velmi ploché. Tektonický styl kry je germanotypní. Naopak mladý vývoj západnějších ker Kuby je podstatně mobilnější a jejich tektonický styl je buď mediotypní, nebo dokonce alpinotypní.

THE MAP OF THE MAIN FAULTS IN THE BLOCK OF ORIENTE – MAPA SMĚRŮ HLAVNÍCH DISLOKACÍ VE KŘE ORIENTE

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