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GEOLOGICAL EVOLUTION OF THE SIERRA DE NIPE MOUNTAINS WITH REGARD TO THE GEOLOGICAL HISTORY OF THE BLOCK OF ORIENTE (CUBA)

Abstrakt:

On the basis of the stratigraphic and tectonic studies of the southern part of the Sierra de Nipe Mountains in Oriente Province of Cuba the geological history of the Block of North Oriente is given in the present paper. The block structure of saxonic type of the Block of North Oriente and its synsedimentary development has been ascertained. The Upper Cretaceous and Paleogene evolution of the Block of North Oriente is compared with that one of the Block of South Oriente. Both blocks are defined as new geological units. These two units of the most eastern geological unit of Cuba - Block of Oriente - show a very strong polarity in their geological evolution, the former being a stable saxonic block and the latter forming a mobile Sierra Maestra Paleogene Volcanic trough sinking intensively during the Upper Cretaceous - Lower Eocene Epoch. No indications of the s. c. Cuban Orogeny were found. The structure of the Block of North Oriente can be explained by radial tectonic movements. The Block of South Oriente was more mobile and shows a slight folding. The folding took place during Late Eocene Age according to diastrophic flysch character of San Luiz Formation.

Geologie pohoří Sierra de Nipe s ohledem na geologický vývoj kry Oriente (Oriente, Cuba)

Pohoří Sierra de Nipe je součástí nejvýchodnější geologické jednotky Kuby - kry Oriente (O. Kumpera, V. Škvor 1968). Geologie a geologická historie je zajímavá již z toho hlediska, že oblast je částí mladé orogenetické zóny, jejíž mladá geologická historie je obrazem prehistorie geologicky hotových vrásových pásem.

V práci je podána stratigrafie svrchněkřídových a paleogenních souvrství a vysvětlen vývoj kerné germanotypní stavby jižní části Sierra de Nipe (tab. I — IV), její synsedimentární vývoj a vliv na faciální obraz svrchněkřídových a paleogenních sedimentů **(obr. 1 — 4)**. Jsou definovány dvě nové geologické jednotky kry Oriente — kra Severního Oriente a kra Jižního Oriente **(obr. 6)**. Geologická analýza těchto dvou jednotek vede k poznání jejich polarity v geologickém vývoji **(obr. 5)**. První z nich je od nejsvrchnější křídy stabilní krou s germanotypní stavbou. Má relativně stoupající tendenci a v nadloží křídového (?) ultrabasického intrusivního tělesa Sierry de Nipe, jehož intruze patrně kru relativně konsolidovala, má pouze tenkou pokrývku svrchněkřídových a paleogenních sedimentů. Druhá z nich byla v nejsvrchnější křídě a počátkem paleogénu vulkanickým submarinním příkopem (příkop Sierry Maestry) s klesající tendencí. Nahromadily se v ní až 6000 m mocné vulkanické série souvrství El Cobre. Ve středním eocénu se vývoj obou jednotek vyrovnává, vulkanismus ustává. Vrásnění proběhlo ve svrchním eocénu, kdy mobilnější kra Jižního Oriente byla slabě zvrásněna. V mobilní zóně při styku obou ker současně sedimentují diastrofické, zčásti flyšové sedimenty souvrství San Luiz.

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Отакар Кумпера

Геология горного хребта Сиерра де Нипе с учетом геологического развития формации Ориенте (Ориенте, Куба)

Горный хребет Сиерра де Нипе является частью самой восточной геологической единицы - формации Ориента (О. Кумпера, В. Шквор 1968 г.). Геология и геологическая история представляют интерес, так как данная область является частью молодой орогенетической зоны, более поздняя история которой является праисторией геологически сформированных складчатых зон.

В публикуемой статье автор описывает стратиграфию верхнемеловых и палеогенных свит и объясняет развитие германотипного строения южной части Сиерра де Нипе (**табл. 1 - 4**), его синседиментарное развитие и влияние на фациальную картину верхнемеловых и палеогенных седиментов (рис. 1 — 4). В статье подается определение двух новых геологических единиц формации Ориента: формация Северного Ориента и формация Южного Ориента (рис. 6). Геологический анализ этих двух единиц свидетельствует о параллельности их геологического развития (**рис.** 5). Первая из них от самого верхнего мела является устойчивой формацией, обладающей германотипным строением. Она характеризуется относительно возрастающей тенденцией; в кровле мелового (?) ултраосновного интрусивного тела Сиерры де Нипе, интрузия которого, очевидно, относительно консолидировала формацию, имеется только тонкое покрытие верхнемеловых и палеогенных седиментов. Вторая единица находится в самом верхнем меле, в начале палеогена представляла собой вулканический субмаринный кювет кювет Сиерры Маестры), характеризующийся нисходящей тенденцией. В ней скопились вулканические серии свиты Эл Кобре мощностью до 6000 м. В среднем эоцене развитие обеих единиц уравновешивается, вулканизм приостанавливается. Складкообразование происходит в верхнем эоцене, где более подвижная формация Южного Ориента образовала небольшие складки. В подвижной зоне при соприкосновении обеих формации происходит одновременная седиментация диастрофических, частично и флишевых свит Сан Луиз.

Geologie des Gebirges Sierra de Nipe mit Rücksicht auf die geologische Entwicklung der Scholle Oriente (Oriente, Cuba)

Das Gebirge Sierra de Nipe bildet einen Bestandteil der am weitesten im Osten gelegenen geologischen Einheit Kubas, der Scholle Oriente (O. Kumpera, V. Škvor, 1968). Die Geologie und die geologische Geschichte ist schon von dem Gesichtspunkt aus interessant, dass das Gebiet einen Teil einer jungen orogenetischen Zone bildet, deren junge geologische Geschichte ein Abbild der Vorgeschichte der geologisch fertiggebildeten Faltenzonen darstellt.

Im vorliegenden Artikel wird die Stratigraphie der Oberkreide- und Paläogenschichtenfolge gezeigt und die Entwicklung der germanotypischen Schollenstruktur des südlichen Teils der Sierra de Nipe (Tab. I - IV), deren synsedimentäre Entwicklung und der Einfluss auf das Fazialbild der Oberkreide – und Paläogensedimente **(Abb. 1 - - 4)** erklärt. Es werden zwei neue geologische Einheiten der Scholle Oriente definiert: die Scholle Nordoriente und die Scholle Südoriente. **(Abb. 6)**. Die geologische Analyse dieser beiden Einheiten führt zur Erkennung ihrer Polarität in der geologischen Entwicklung **(Abb. 5)**. Die erstere ist von der obersten Kreide an eine stabile Scholle mit germanotypischer Struktur. Sie weist eine relativ steigende Tendenz auf, und im Hangenden des ultrabasischen intrusiven Kreide (?) körpers der Sierra de Nipe, dessen Intrusion offensichtlich die Scholle relativ konsolidierte, hat sie lediglich eine dünne Oberkreide- und Paläogensedimentdecke. Die letztere war in der obersten Kreidezeit und zu Beginn des Paläogens ein vulkanischer submariner Graben (Graben der Sierra Maestra) mit sinkender Tendenz. Darin häuften sich die bis 6000 m hohen vulkanischen Serien der Schichtenfolge El Cobre auf. Im mittleren Eozän gleichte sich die Entwicklung beider Einheiten aus, der Vulkanismus hört auf. Die Faltung erfolgte im oberen Eozän, wo die beweglichere Scholle Südoriente schwach gefaltet war. In der mobilen Zone, an der Berührungsstelle beider Schollen, setzen sich zugleich diastrofische, teilweise Flyschsedimente der Schichtenfolge San Luiz ab.

Introduction

Sierra de Nipe represents one of the block mountains which form together the most eastern large geological unit of Cuba Island - the Block of Oriente. When studying the geological evolution of Sierra de Nipe, we can explain the principal features of the geological development of the main part of the Block of Oriente. This mountains lie on the boundary between two smaller geological units which form the western part of the Block. The paper represents a contribution to the development of the block structure of the young orogenic zone of Antillean region which was discussed in the previous paper (O. Kumpera - V. Škvor, 1968).

The present paper is the result of the field studies made by the group of Cuban and Czech members of the Department of Geology of the University of Oriente of Santiago de Cuba.

The region under detail study includes the southern part of Sierra de Nipe south of its highest point Loma de la Mensura and the southern border of the mountains which is formed by Tierra Cársica de Pedernal. On the south, the studied region is limited by the Jagua River (Plate I). The results of the field studies in Sierra Maestra Mountains and in other parts of Oriente are included in the present paper as well.

Stratigraphy of the southern flank of Sierra de Nipe Mountains

Stratigraphically, the section of the studied region can be divided into three parts:

1. Intrusive ultrabasic and basic rocks of the Sierra de Nipe intrusive body.
2. Conglomerates of the La Picota Conglomerate Member.
3. Predominantly calcareous and volcanic complex of the Santa Rita Formation, El Cobre Formation and Charco Redondo Formation.

The sedimentary part of the stratigraphic column shows different facies development and different thickness in individual tectonic blocks according to the synsedimentary vertical movements of different intensity and direction of the blocks. In advance, it must be pointed out that this movements represent the main factor which influenced the properties and thickness of the sedimentary rocks, their facies distribution and the recent tectonic structure as well.

Intrusive body of Sierra de Nipe

In the northern part of the studied region the intrusive rocks of the Sierra de Nipe body crop out. Among them the ultrabasic rocks are predominating. According to the petrological composition and the position in the body an i n t e r e s t i n g z o n a l i t y may be observed. The morphologically highest parts of Sierra de Nipe are built by peridotites (harzburgites and lherzolites). Going down along the southern slope of the mountain, we can verify the gradual decrease of the amount of pyroxenes in the intrusive rocks starting from certain level, so that in the lowest parts of the Sierra de Nipe Mountains the rocks of dunitic composition predominate. The boundary between the peridotites and dunites lies in different levels

in individual tectonic blocks varying from about 300 m to about 500 m above the sea level.

The ultrabasic rocks are penetrated by small bodies of basic rocks which belong mainly to fine crystalline gabro. They form small dykes accompanying the fault zones.

The presence of a large amount of pebbles and boulders of gabbro in the overlying conglomerate member and the scarcity of ultramafic rocks in pebbles testify the original existence of the third layer in the highest part of the intrusive body. This layer of gabbro was nearly completely destroyed in the southern part of Sierra de Nipe by erosion before and during the sedimentation of the overlying conglomerate.

The age of the intrusive body cannot be exactly determined. There are no sedimentary rocks penetrated by the intrusion in the area of the Sierra de Nipe Mountains. The oldest sedimentary rocks which cover the intrusive body are those of La Picota Conglomerate Member. According to the fact that this stratigraphic unit is of the Maastrichtian (?)-Paleocene age and according to simple internal structure of the intrusive body, the intrusive rocks are supposed to be Pre-Maastrichtian in age, and probably belong to Upper Cretaceous Epoch. There is no evidence of the existence of younger ultramafic rocks which are mentioned by some authors from other parts of Cuba (R. H. Palmer, 1945, R. C. Mitchell, 1955).

La Picota Conglomerate Member

In the main district of the southern part of Sierra de Nipe, the oldest rocks of sedimentary cover belong to coarse-grained clastic stratigraphic unit named by G. E. Lewis and J. A. Straczek (1955) Picote Conglomerate Member.[1] Lithologically, this unit is rather uniforme. Coarse-grained, very poorly sorted conglomerate predominates. The pebbles and boulders consist mainly of gabbro while the amount of the pebbles of ultrabasic rocks increases upwards. The pebbles and boulders are nearly rounded or even angular and very poorly sorted varying from several millimeters to 40 cm, exceptionally to 1 m in size. The matrix of the conglomerate is variable. In the lower part the psammitic matrix is most abundant passing to the calcareous matrix upwards. In the highest part of the section the tuffaceous matrix occurs at some localities. At other localities even intercalations of andesitic or more acid tuffs are present. Their thickness varies from several decimeters to several meters but at some localities reaches several tens of meters. For example, in the vicinity of Piloto Arriba the tuffs are very thick and in some places predominate over the conglomerates in the highest part of the member. This tuff-conglomeratic highest part of the member near Piloto Arriba contains thin intercalations of limestone and passes gradually without interruption into the overlying predominantly calcareous Santa Rita Formation.

No fauna has been found in this member during our investigations. As far as its age, we can agree with the opinion of G. E. Lewis and J. A. Straczek (1955) who consider the member a little younger than La Habana Formation or a little younger than Maastrichtian. This age may be

[1] Let us note that the correct name of the mountain which serves as a type locality is La Picota.

supposed according to the faunal evidence of the Late Paleocene – Early Eocene age of Santa Rita Formation which overlies conformably La Picota Conglomerate Member in some parts of the studied region.

In the southern part of Sierra de Nipe important differences in the thickness and distribution in tectonic blocks of this member can be observed. La Picota tectonic block is noted for the wide distribution and the great thickness of the member (more than 200 m). The member is much thinner in La Socarrona and La Caridad tectonic blocks and it is nearly completely absent in the Piloto del Medio tectonic block. In the major part of this block the sedimentary cover of the intrusive body starts with the basal conglomerate of the overlaying Santa Rita Formation. These differences were caused by the different sinking of individual blocks during the sedimentation. The origin of the differences in the thickness of the member within the blocks were influenced by the dissected relief of the plane of transgression.

Santa Rita Formation

After the deposition of La Picota Conglomerate Member mainly sandy calcareous rocks were deposited. G. E. Lewis and J. A. Straczek (1955) included these rocks into the El Cobre Formation, which is not correct with regard to the lithologic contain of these rocks, because the El Cobre Formation had ben defined as a predominantly volcanic formation (S. Taber, 1931, 1934). It is therefore necessary to consider these sediments independently as a new stratigraphic unit. The name Santa Rita Formation has been elected with regard to the type locality which is situated in the rock scarp in the Piloto River valley in the southern vicinity of the Santa Rita village in the San Luiz County between the isohypses 380 m and 480 m.

Santa Rita Formation can be defined as a sequence of predominating sandy limestone or calcareous sandstone which form the northern lateral facies of the upper part of the volcanic El Cobre Formation. It contains one or two intercalations of orbitoidal limestone. Sometimes, the pebbles or even boulders of intrusive rocks of the Sierra de Nipe Body disseminated irregularly in sandy limestone matrix can be observed in different stratigraphic levels at some localities. The intercalations of ash and psammitic tuffs are also present in some levels, increasing in number and thickness in the southern direction so that in the vicinity of Pinar Redondo the tuffs are up to 30 m thick. In the southernmost part of the studied region the tuffs predominate and the Santa Rita Formation interfingers with the El Cobre Formation. In the southeast direction the sandy calcareous sequence passes gradually to a series of poorly bedded fine crystalline limestone of cream colour with the disseminated sandy and tuffaceous material. This series represents the southeastern facies of the Santa Rita Formation.

In the upermost part of the region, the Santa Rita Formation rests conformably on the La Picota Conglomerate Member. In the central part of the territory under study, in the Piloto del Medio tectonic block, the La Picota Conglomerate Member is very restricted and the Santa Rita Formation is deposited directly on the intrusive rocks. In this case, its sequen-

ce starts with fine crystalline limestone of rosy and cream colour which includes a calcareous conglomerate in its basal portion just above the intrusive rocks. This conglomerate is noted for its calcareous matrix and pebbles and boulders of the intrusive basic and ultrabasic rocks. Its thickness reaches about 10 m.

The upper and lower stratigraphic limits of the Santa Rita Formation and its relations to the other stratigraphic units were described in a previous paper (O. Kumpera, 1968).

Fossil contents is rather rich and includes mainly benthonic foraminifera. In the lower part *Paleonummulites bermudezi* (Palmer), *Discocyclina mestieri* Vaughan, *Miscellanea antillea* (Hanzawa), *Athecocyclina cookei* (Vaughan), *Boreloides cubensis* Cole and Bermudez, *Dictyoconus sp.* and *Porporocyclina sp.* have been found. According to this fauna the lower part of the formation is of Late Paleocene and Early Eocene age. The upper part of the formation contains *Discocyclina barkeri* Vaughan and Cole, *Cymbalopora cubensis* Kejzer, *Dictyoconus cookei* (Moberg), *Helicostegina sp.*, *Operculinoides sp.*, and *Proporocyclina sp.* The absence of the Paleocene forms indicates the Early Eocene age of the upper part of the formation.

The thickness of the Santa Rita Formation is much smaller than that of the El Cobre Formation of the same age in the more southern parts of Oriente, and reaches up to 150 m, exceptionally to 200 m.

El Cobre Formation

This formation crops out in the most southeastern part of the studied region, representing here the heteropic facies of a part of the Santa Rita Formation. It is formed by the sequences of lapillic tuffs up to 80 m thick (incomplete thickness), which rest directly on the La Picota Conglomerate Member. Its thickness increases rapidly south of the studied region.

Charco Redondo Formation

The highest part of the stratigraphic column is formed by pure limestones which correspond lithologically and stratigraphically to the Charco Redondo Formation in W. P. Woodring's and S. N. Daviess' (1944) conception.[1])

In our region, this formation can be divided into two parts which correspond to the new stratigraphic members (O. Kumpera, 1968): Río Naranjo Mud Limestone Member and La Caridad Orbitoidal Limestone Member.

Río Naranjo Member

This member is formed by hard non-stratified mud limestone of cream or white colour. As for the morphology, it is the most expressive part of the column forming the rock steps and other surface karst phenomena

[1]) Some authors make reference to the Guaso Limestone defined by N. H. Darton (1926) which appears to agree with the Charco Redondo Formation with regard to the lithology and to the stratigraphic position too. If the future studies verify the correspondence of both units, the name Guaso Limestone must be used according to its priority.

(grikes, mogots etc.). In some parts of the region, the thick layer of limestone synsedimentary breccia or conglomerate represents one part of the section. The name of this unit is derived from Río Naranjo River with regard to the type locality which is exposed in its valley.

The member is not distributed in the whole area. First of all, it is absent in the whole Piloto del Medio tectonic block. This block was the element of the secular uplift during the long history of the region and for this reason it was the scene of the relative shalow-water deposition. The mud limestones of this member were deposited under the deep water conditions and therefore they are substituted by the lower part of the other member of Charco Redondo Formation in the above mentioned tectonic block.

The thickness of the member varies from 0 to 180 m and differs mainly in individual tectonic blocks. The type locality of member lies in the mogot situated 1 km E of La Caridad, 1 km S of Río Naranjo. The faunal content includes the rare orbitoid foraminifera which are poorly preserved and undeterminable. According to the determined age of the underlaying Santa Rita Formation and of the overlaying La Caridad Member, the Río Naranjo Member is probably on the boundary between the Early Eocene and Middle Eocene Age.

La Caridad Orbitoidal Limestone Member

The upper part of the Charco Redondo Formation consists of white or cream coloured thick bedded or non-bedded orbitoidal limestones. These limestones were defined as a new stratigraphic unit (O. Kumpera, 1968). Its name is derived from La Caridad village where the member is well exposed.

The principal component of the limestone is formed by the tests of orbitoid foraminifera from several millimeters to one centimeter exceptionally to 3 cm in size, and by algae. Sometimes, the limestones are somewhat marlaceous and in some parts of the studied region the lenticular intercalations of grayish green marl are present. South of Santa Rita, in the region of the supposed area of the most shoal deposition, the intercalation of brachiopod limestone is present.

The stratigraphic limits, the relations to other stratigraphic units and the type locality were described in a previous work (O. Kumpera, 1968).

The paleontologic contents of the La Caridad Member is very abundant and is formed mainly by large foraminifera, which are represented by the following species: *Fabiania cubensis* (Cushman and Bermudez), *Discocyclina cubensis* (Cushman), *Discocyclina marginata* (Cushman), *Proporocyclina havanensis* (Cole and Bermudez), *Proporocyclina teres* (Cole and Grovell), *Proporocyclina sp.*, *Lepidocyclina (Pliolepidina) macdonaldi* Cushman, *Lepidocyclina (Pliolepidina) ariana* Cole and Ponton, *Lepidocyclina sp.* Besides the large foraminifera, many forms of terebratulid brachiopods and of algae are present. The above mentioned fauna testifies the Middle Eocene age of the studied part of the La Caridad Member.

Only incomplete thickness of the member is known, as the upper part is not present in the area under study. It reaches more than 120 m.

Tectonic structure of the southern part of the Sierra de Nipe Mountains

Generally speaking, the most important feature of the structure is the existence of many normal faults, which limit the tectonic blocks, as well as the little importance of the fold structures. The tectonic style may be denominated as a saxonic type of structure.

The form of the Sierra de Nipe intrusive body

The internal structure of the southern flank of the intrusive body may be designated as very simple one. Among the structural planes the joints of primary parting which belong to H. Cloos' Q, L, S joints, predominate. Their distribution reflects the general structural plan of the intrusion, and enables to reconstruct the southern part of the intrusive body as a slightly undulated tabular body dipping a little to the northwest. In the southwest direction, the tendency of the increasing dip of L-joints may be observed. It may be therefore supposed that the whole body could represent an ethmolith or a laccolith. It must be noted that the studies of internal structure also in the northern flank of Sierra de Nipe Mountains are necessary for the corroboration of this hypothesis.

Folding of the sedimentary cover

All the sedimentary rocks are slightly folded forming only slight undulations of a large curvature and of a small amplitude. The dips of beds from 5° to 15° predominate and they values increase only near the normal faults. The folds do not therefore influence the distribution of the stratigraphic units on the earth surface. This role belongs to the normal faults.

Normal faults and block structure (Plate I and II)

The normal faults represent the most important tectonic features of the studied region. It must be noted that their role in the structure and geologic development of the Sierra de Nipe Mountains (and of other parts of Block of Oriente as well) was underestimated in the maps and papers of the previous authors.

The system of normal faults is very dense. With regard to dips and strike, there exists a conformity between the general structural plan of joints in the intrusive body (mainly of Q- and S-joints) and the normal faults, which copy the tectonics of the intrusive body. Therefore, the normal faults of three directions are developed:

1. Normal faults of the direction NE - SW. To this set there belong some important faults, such as the Santa Rosa fault, the Río Piloto fault zone, the Pinalito – Abundancia fault etc.

2. Normal faults of the direction N – S. The most important faults running in this direction are the Pinalito fault zone and the Alto de La Estrella fault.

3. Normal faults of the direction NW – SE. To the most important faults there belong the west marginal fault of Sierra de Nipe, the Santa Rita fault and La Caridad fault.

The major part of the faults dips nearly vertically. There is no difference in age of the faults of different directions. They originated probably at the end of Late Cretaceous Epoch. The faults of different systems displace one another forming the varied mosaic of the tectonic blocks which played a very important role in the geologic evolution of the Sierra de Nipe Mountains and of surrounding regions. They influenced the sedimentation, the distribution of the facies and the tectonic structure as well.

The large tectonic blocks limited by the above mentioned important normal faults are of greatest importance. These large tectonic blocks (Plate II) influenced not only the character of the tectonic structure but also the facies development, the distribution and the thickness of the stratigraphic units during the large history of the Block of Oriente. According to their vertical movements of different intensity and orientation before and during the sedimentation, some of them played the role of positive elements of the crust while the other sunk relatively and acted as negative elements.

The following large tectonic blocks may be distinguished (Pl. II):

1. The group of the central blocks situated north of the Santa Rosa fault. At present, these blocks build the highest part of the Sierra de Nipe Mountains. They lack any sedimentary cover and the intrusive rocks crop out on their surface.

2. The La Socarrona tectonic block is noted for a small thickness of the La Picota Conglomerate Member and for the Santa Rita Formation in the fine crystalline limestone facies.

3. The Pinar Redondo tectonic block contains the very thick and extensive La Picota Conglomerate Member which has several intercalations of tuffs. The Santa Rita Formation is represented by sandy limestone. From the Charco Redondo Formation only the Río Naranjo Member is represented.

4. The La Estrella tectonic block is noted for the small thickness of the La Picota Conglomerate Member. In the Santa Rita Formation the fine crystalline limestones predominate and they include the layers with disseminated pebbles and boulders of intrusive rocks.

5. The Piloto del Medio tectonic block is characterized by the very thin and restricted La Picota Conglomerate Member. The limestone with disseminated pebbles and boulders of intrusive rocks of the lowest part of the Santa Rita Formation rests therefore directly on the intrusive rocks in the prevailing part of the block. The Charco Redondo Formation is represented only by the la Caridad Member.

6. The La Caridad tectonic block differs from the above mentioned tectonic blocks by a very thick mud limestone of the Río Naranjo Member and by a major extension and thickness of the La Picota Conglomerate Member.

Geological History of the southern part of the Sierra de Nipe Mountains

It is very difficult to enlighten the oldest history of the studied region owing to the lack of the pre-intrusive rocks. It may be supposed that the

region had been formed by a rather stable block with a tendency to the secularly uplift and that the ultrabasic and basic rocks penetrated the metamorphic rocks of s. c. Basal Complex (O. Kumpera and V. Škvor, 1968). This Basal Complex (J. Butterlin 1956, P. Bermúdez — R. Hoffstetter 1959, P. Bermúdez 1963) belongs probably to the variscian orogenic cycle. A younger sedimentary rock cover over the rock of Basal Complex had lacked or had been very thin and restricted before the Late Cretaceous intrusive activity.

Late Cretaceous Epoch

During this epoch, the strong crust deformations in the whole America reactivated the tectonic movements along the large faults and deep faults in the Carribean space. The opened deep faults loosened the ways for the ultrabasic magma. In our region predominantly ultrabasic rocks of the Sierra de Nipe Body originated along the deep-fault zone of NE — SW direction which opened the communication with the deep peridotite layer of the mantle. Its southern part has a form of a tabular body and the hole body represents probably a laccolith or an ethmolit. The body is differenciated in the lowest layer of dunits, middle layer of peridotits and the highest one which is formed by gabbro. The serpentinization of the ultrabasic rocks relieved the intrusive body which therefore started to rise intensively forming a mountain relief (fig. 1). By this way, the sedimentary rock cover (if existed) and the highest parts of the intrusive body were destroyed by the erosion. The strong uplift contributed to the origin of normal faults which divided the intrusive body forming many tectonic blocks. It must be pointed out that the simple internal structure of the intrusive rocks testify that the body was not influenced by any orogenic movements connected with fold deformations.

Maastrichtian (?) — Lower Paleocene Epoch

The sea started to invade some parts of the Sierra de Nipe Mountains and under the conditions of mountain relief in the source area coarse-grained basal conglomerate of the La Picota Member was deposited (fig. 2). The deposition was influenced by the oscillatory movements which had different intensity and sense in individual tectonic blocks. The group of central blocks was never invaded by the sea and supplied very coarse and poorely sorted clastics to the sea. On the contrary, the southern blocks sank and were the place of deposition. From these blocks, the Pinar Redondo tectonic block sank most intensively, and very thick conglomerates have been accumulated on its surface. The tectonic blocks of La Soccarona, La Estrella and La Caridad sank less intensively and only thin conglomerates were there deposited. The Piloto del Medio tectonic blocks as the most positive element of the southern area, sank slightly only at the beginning of this epoch but then it was uplifted, the main part of the conglomerate being destroyed by the erosion still during the Paleocene Age.

The intensive erosion and deposition caused partly the levelling of the land surface in the source region. The highest part of the conglomerate is therefore often finer grained than the lower one.

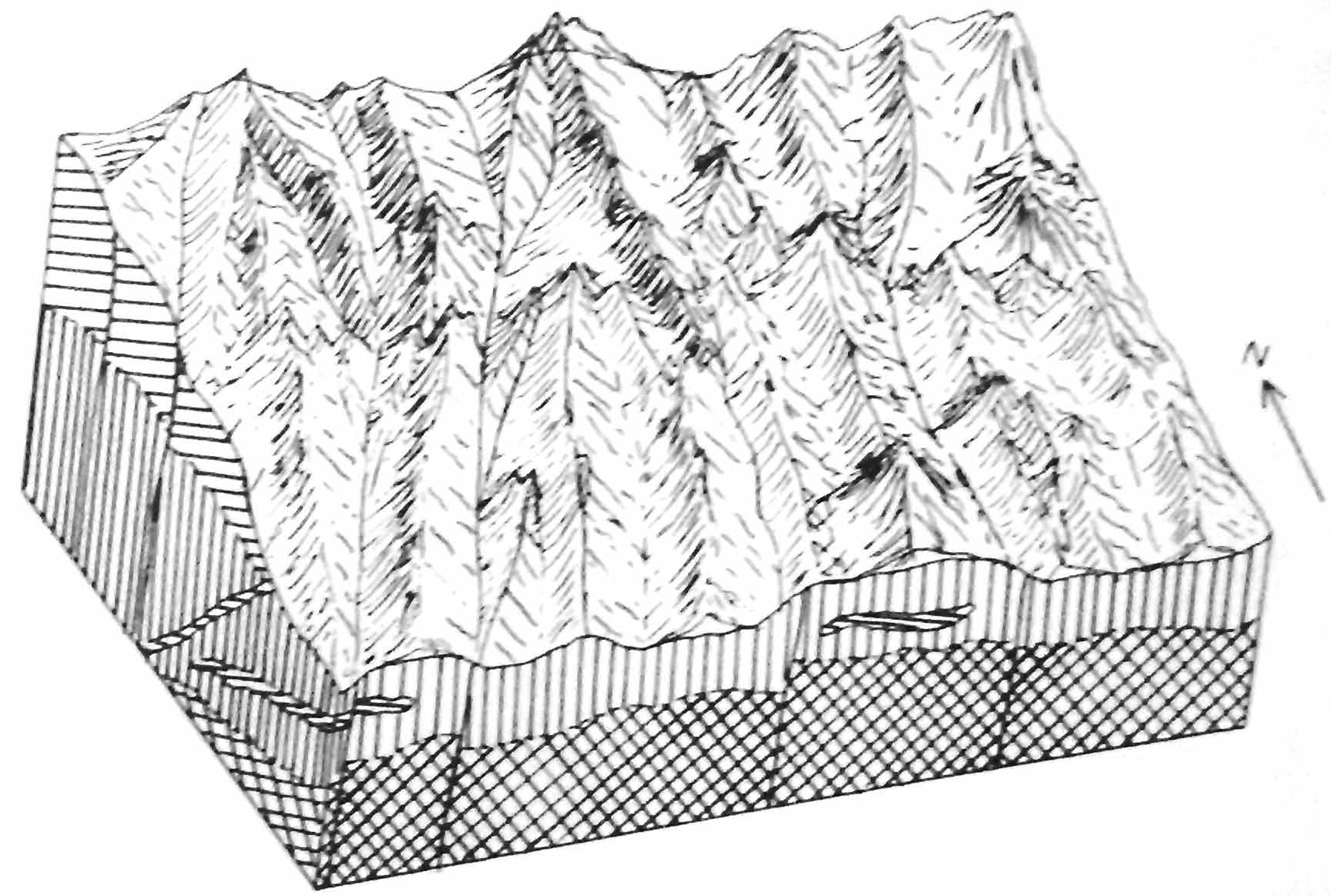

Fig. 1 — Diagrammatic representation of the southern flank of the Sierra de Nipe Mountains during the *Late Cretaceous* Period. Explanations are given in fig. 4.

Obr. 1 Blokdiagram znázorňující geologické poměry jižní části Sierry de Nipe ke konci křídy. Vysvětlivky uvedeny v obr. 4.

At the end of this epoch, the volcanic activity, very strong in the Sierra Maestra trough south of the studied region influenced the sedimentation admixturing the volcanic material to the clastics in the uppermost part of the La Picota Conglomerate Member.

Late Paleocene — Early Eocene Epoch

The sea invaded nearly the whole area of the Sierra de Nipe Mountains covering also the central tectonic blocks. Only few elevations rose over the sea level. The peneplanation of the whole area and its sinking under the sea level caused a sudden change of sedimentation (fig. 3). After the basal conglomerate, predominately sandy calcareous rocks of the Santa Rita Formation were deposited. As in the previous epoch, the intensity of the sinking differs in individual tectonic blocks. The marginal blocks (La Soccarona, La Estrella) sank most intensively and fine crystalline limestones representing relatively deep water facies were there deposited. The other blocks sank less intensively, their highest part rose over the sea level in form of land elevations and supplied the terrigenous material for the deposition of calcareous sandstones and sandy limestones. The Piloto del Medio tectonic block continued in its tendency to be the most positive element of all the southern blocks. This tendency manifests itself in the lack of underlaying conglomerate in the major part of this block, in the disconforme lower limit of the Santa Rita Formation and in the abundancy

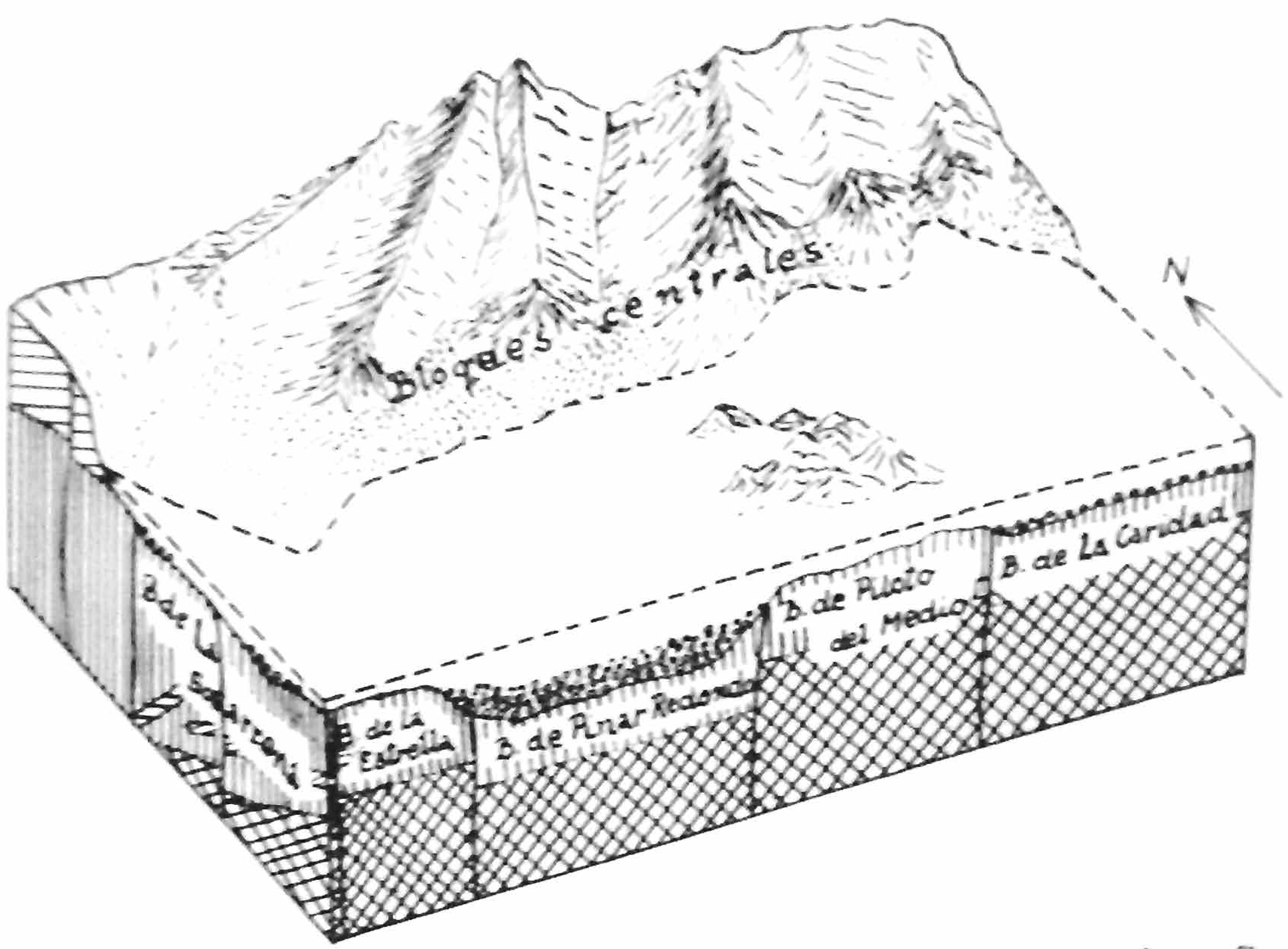

Fig. 2 – Diagrammatic representation of the geological relations in the southern flank of the Sierra de Nipe Mountains during the sedimentation of Maastrichtian (?) - Paleocene sedimentary rocks (La Picota Conglomerate Member). Explanations are given in fig. 4.

Obr. 2 Blokdiagram, znázorňující geologické poměry jižní části Sierry de Nipe v maastrichtu (?) – paleocénu (sedimentace slepenců La Picota). Vysvětlivky uvedeny v obr. 4.

of the sandstones and of the pebbles and boulders of intrusive rocks dispersed in the sediments of the Santa Rita Formation. Let us note the conformity on the base of the Santa Rita Formation in other tectonic blocks.

A very strong extrusive igneous activity in the neighbouring southern tectonic zone – in the Sierra Maestra volcanic trough – influenced the sedimentation by the origin of the ash and psammitic tuff intercalations in the Santa Rita Formation. The quantity of the volcanic sediments and their grain-size increases southward towards the centers of volcanic activity so that in the southern part of the region the volcanic El Cobre Formation interfingers the Santa Rita Formation. From the point of regional geology, the southern part of the Sierra de Nipe Mountains represents a marginal zone of the Eocen volcanic trough of Sierra Maestra.

Midle Eocene Age

The sea regime became still more expressive during the Middle Eocene Age. The whole area including the small land elevations, which acted during Early Eocene Age, and probably also the central parts of the Sierra de Nipe Mountains sank under the sea level. Under these conditions, the

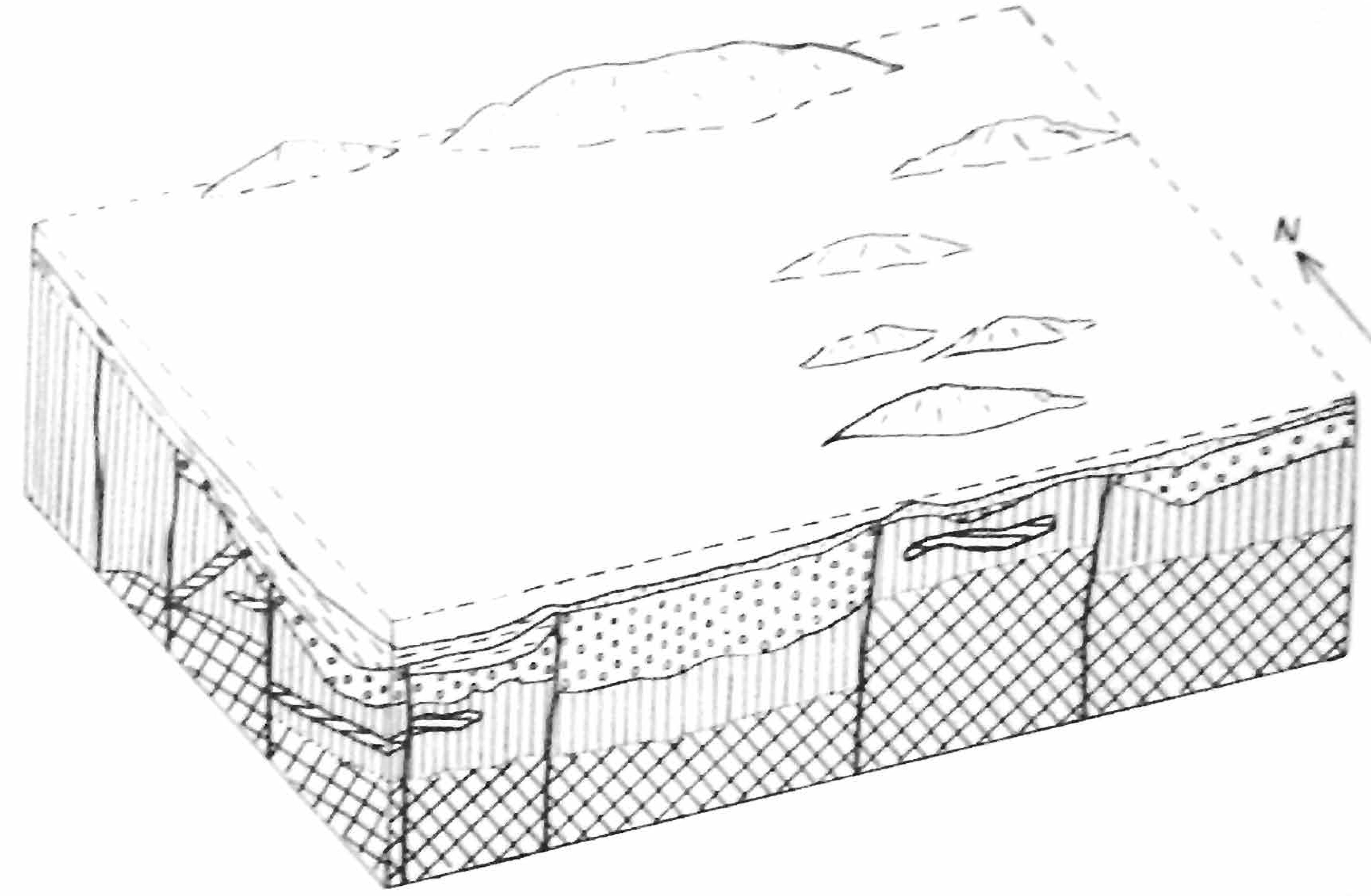

Fig. 3 – Diagrammatic representation of the geological relations in the southern part of the Sierra de Nipe Mountains during the Late Paleocene - Early Eocene Epoch (the deposition of the Santa Rita Formation). Explanations in fig. 4.

Obr. 3 Blokdiagram, znázorňující geologické poměry jižní části Sierry de Nipe v pozdním paleocénu – raném eocénu (sedimentace souvrství Santa Rita). Vysvětlivky uvedeny v obr. 4.

sedimentation of pure limestones without terrigenous admixture predominated. On the beginning of the age, several tectonic blocks sank more intensively and the relatively deep-water mud limestone of the Río Naranjo Member originated in the La Caridad tectonic block and in other southern blocks. On the contrary, in the Piloto del Medio tectonic block, the uplift tendency continued and throughout the whole age the shallow water orbitoidal limestone was being deposited. Later on, the sedimentary conditions equilibrated in all tectonic blocks and the deposition of the orbitoidal limestones predominated in the whole area. Only a few displaced and peneplained elevations rose over the sea level and acted from time to time as sources of marly layers (fig. 4).

In the Midle Eocene strata no traces of igneous activity can be observed.

Contribution to geological history of the Block of Oriente

The Block of Oriente is the most eastern main tectonic unit of the Cuba Island. It was defined by O. Kumpera and V. Škvor (1968). Its western boundary lies nearly on the line connecting the town Manzanillo in the Gulf of Guacanayabo and the Nipe Bay which limited this block from the Blocks of Central Cuba. The Block of Oriente differs from other tectonic units of Cuba by the main directions of the tectonic structures being W – E and WSW – ENE and by different geological

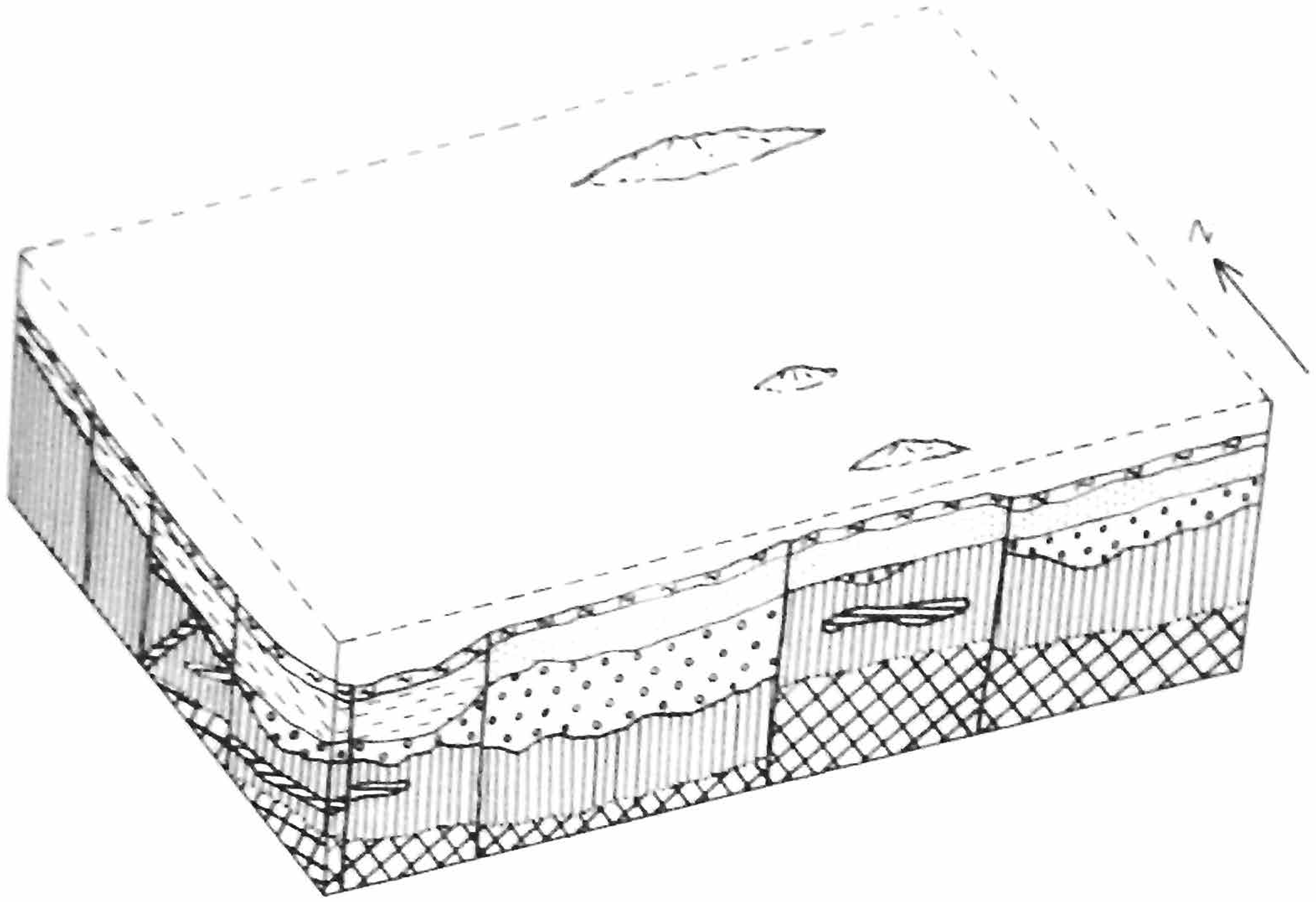

Fig. 4 – Diagrammatic representation of the geological relations in the southern flank of the Sierra de Nipe Mountains during the Middle Eocene Age (the deposition of the Charco Redondo Formation). Explanations of fig. 1 – 4: 1 – Dunite, 2 – Peridotite, 3 – Dykes of gabbro, 4 – La Picota Conglomerate Member, 5 – Santa Rita Formation, 6 – Charco Redondo Formation.

Obr. 4 Blokdiagram, znázorňující geologické poměry jižní části Sierry de Nipe ve středním eocénu (sedimentace souvrství Charco Redondo). Vysvětlivky k obr. 1 – 4: 1 – dunity, 2 – peridotity, 3 – gabbrové žíly, 4 – slepence La Picota, 5 – souvrství Santa Rita, 6 – souvrství Charco Redondo.

history (mainly by the existence of the Early Paleogene Sierra Maestra Volcanic Trough, by a very strong volcanic and intrusive activity of Paleogene age and by the fact that it was a relatively stable element of the crust, so that structure of this unit is mainly of the saxonic type.

Very interesting conclusions for the evolution of the Block of Oriente can be drawn when comparing the lithology and the thickness of the Maastrichtian (?) – Lower Paleocene and Upper Paleocene – Lower Eocene strata of the southern part of the Sierra de Nipe Mountains with the strata of the same age of the Sierra Maestra Mountains. While the northern predominantly limestone facies reaches up to 300 m of thickness, the volcanic El Cobre Formation of the Sierra Maestra Mountains is up to 6000 m thick. Starting from this fact and from the small distance between our region and the supposed volcanic centers of the Sierra Maestra Mountains, we can imagine the basin of Sierra Maestra as a colossal volcanic trough noted for a very intensive subsidency, which sank along the large normal faults of the east and north-east directions. At the same time, the Siera de Nipe Mountains were uplifted as a relative stable block in the northern boundary of the trough.

Comparing the Middle Eocene strata we can see a great similarity in the thickness and lithologic contents of the Charco Redondo Formation in both regions. The very strong volcanic activity which had caused very thick volcanic accumulations in the Sierra Maestra trough during the previous epoch, and the block uplift of the trough at the end of Early Eocene Age had equilibrated the conditions of sedimentation in both regions so that the shallow water limestones of the Charco Redondo Formation were deposited in the whole South Oriente during the Middle Eocene Age (fig. 5).

A conformity can be observed between the Lower Eocene and Middle Eocene strata. This fact indicates that no folding of the s. c. Cuban Orogeny took place in our region. With regard to the intensity of the tectonic deformations, the Sierra Maestra district differs from the region under detail study. The fold deformations of Paleogene strata in the mentioned district reach the embryonal mediotype stage while the saxonic-type structures predominate in the marginal zone of the trough, i. e. in the Sierra de Nipe Mountains. This fact agrees with all the geologic processes during the Paleogene Period: the northern marginal area with the ultrabasic intrusive bodies represents a stable zone where the vertical relative uplift predominated. The zone of the Sierra Maestra trough represented the region of a strong sinking during the Paleocene and Eocene Epochs and owing to its Paleogene history it represents a mobile element of the crust.

As far as the age of the folding and faulting in the southern part of Oriente, there must be emphasized the synsedimentary character of the deformations, i. e. that the folds and faults were originating at the end of the Cretaceous Period and during the Paleogene Period as well. But it must be noted that the strongest tectonic activity took place between the Middle Eocene and Late Eocene Ages, when the diastrophic sediments started to be deposited in the southern part of Oriente (the San Luiz Formation).

The polarity of the Sierra de Nipe zone and the Sierra Maestra zone was expressed by several authors (J. B. Solsona and C. M. Judoley 1964, G. Furrazola – Bermúdez and col. 1964) who included the zone of Sierra de Nipe into the Cauto intrageosynclinal unit. However, according to the analysis of the sedimentation and structure, this zone played a role of a geanticlinal at the end of the Cretaceous Period and at the beginning of the Paleogene Period, while the more southern part of Oriente including Sierra Maestra region was forming a geosynclinal space of enormeous subsidency and accumulation of volcanic rocks. Owing to this fact, it is better to use no more the terms mentioned in the quoted papers. Also the term "anticlinorium Mayarí-Baracoa" used in the paper of J. M. Pucharovski and col. (1967) is not acceptable for the Sierra de Nipe zone. The general structure of the Sierra de Nipe Mountains is a graben and not an anticlinorium. The normal faults play an important role also in the northern part of the Sierra de Nipe Mountains (A. F. Adamovich - D. L. Chejovich 1964, A. F. Adamovich and col. 1963).

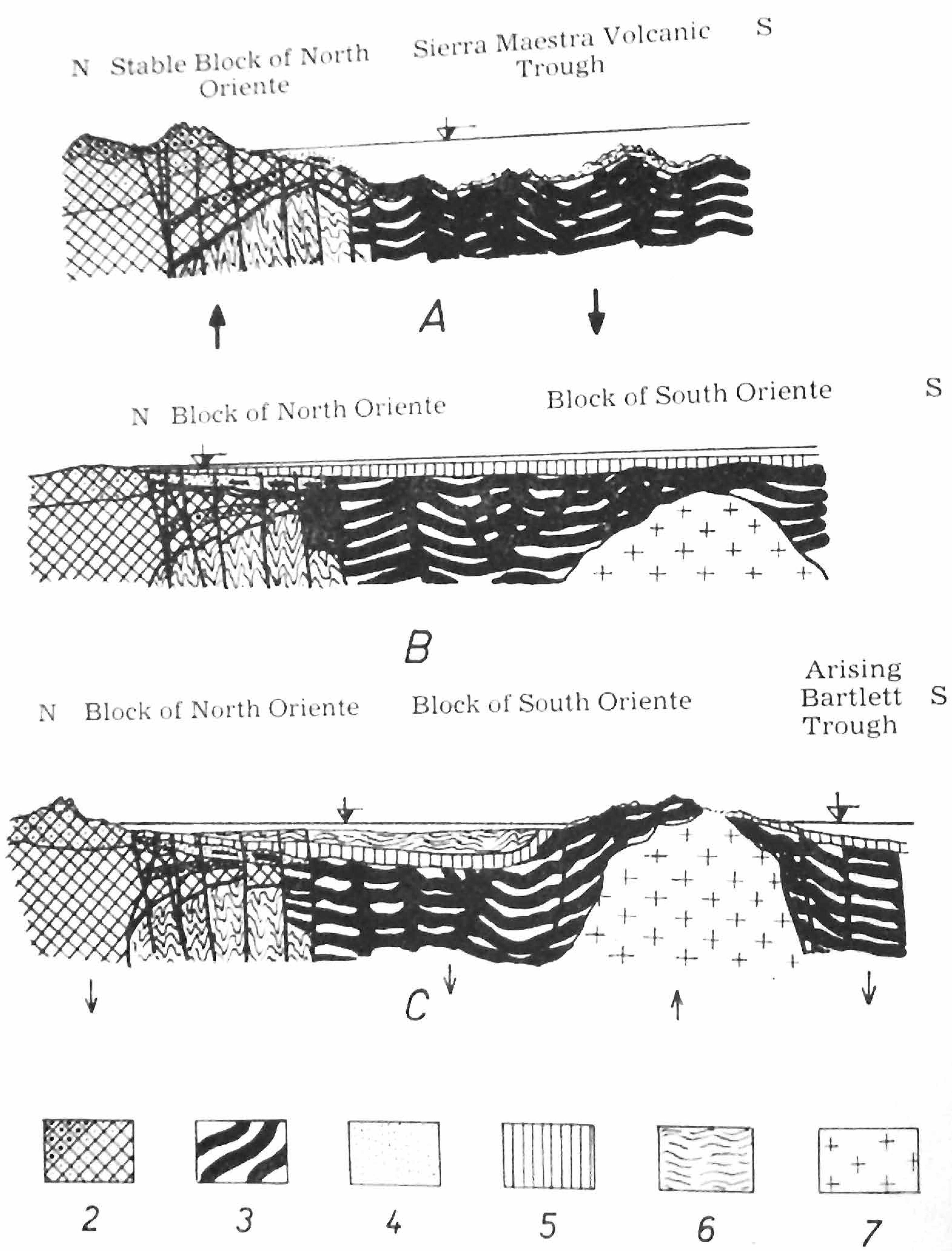

Fig. 5 — Schematic view of the Paleogene history of the Block of North Oriente in comparison with the Block of South Oriente. Explanations: 1 — Probably metamorphic rocks of the s. c. Basal Complex (Variscian), 2 — Ultrabasic and basic rocks of intrusive body of Sierra de Nipe, 3 — volcanic rocks of the El Cobre Formation, 4 — La Picota Member and Santa Rita Formation, 5 — Charco Redondo Formation, 6 — San Luiz Formation, 7 — granitoids pluton of Sierra Maestra Mountains. A — beginning of the Paleogene Period, B — the stage in the Middle Eocene, C — the stage in the Late Eocene.

Obr. 5 Schematické znázornění paleogénní historie kry Severního Oriente ve srovnání s krou Jižního Oriente. 1 — patrně metamorfované horniny tzv. bazálního komplexu (variscidy), 2 — ultrabasické a basické vyvřeliny intrusivního tělesa Sierry de Nipe, 3 — vulkanity souvrství El Cobre, 4 — slepence La Picota a souvrství Santa Rita, 5 — souvrství Charco Redondo, 6 — souvrství San Luiz, 7 — granitoidy plutonu Sierry Maestra, A — stav na počátku paleogénu, B — stav ve středním eocénu, C — stav v pozdním eocénu.

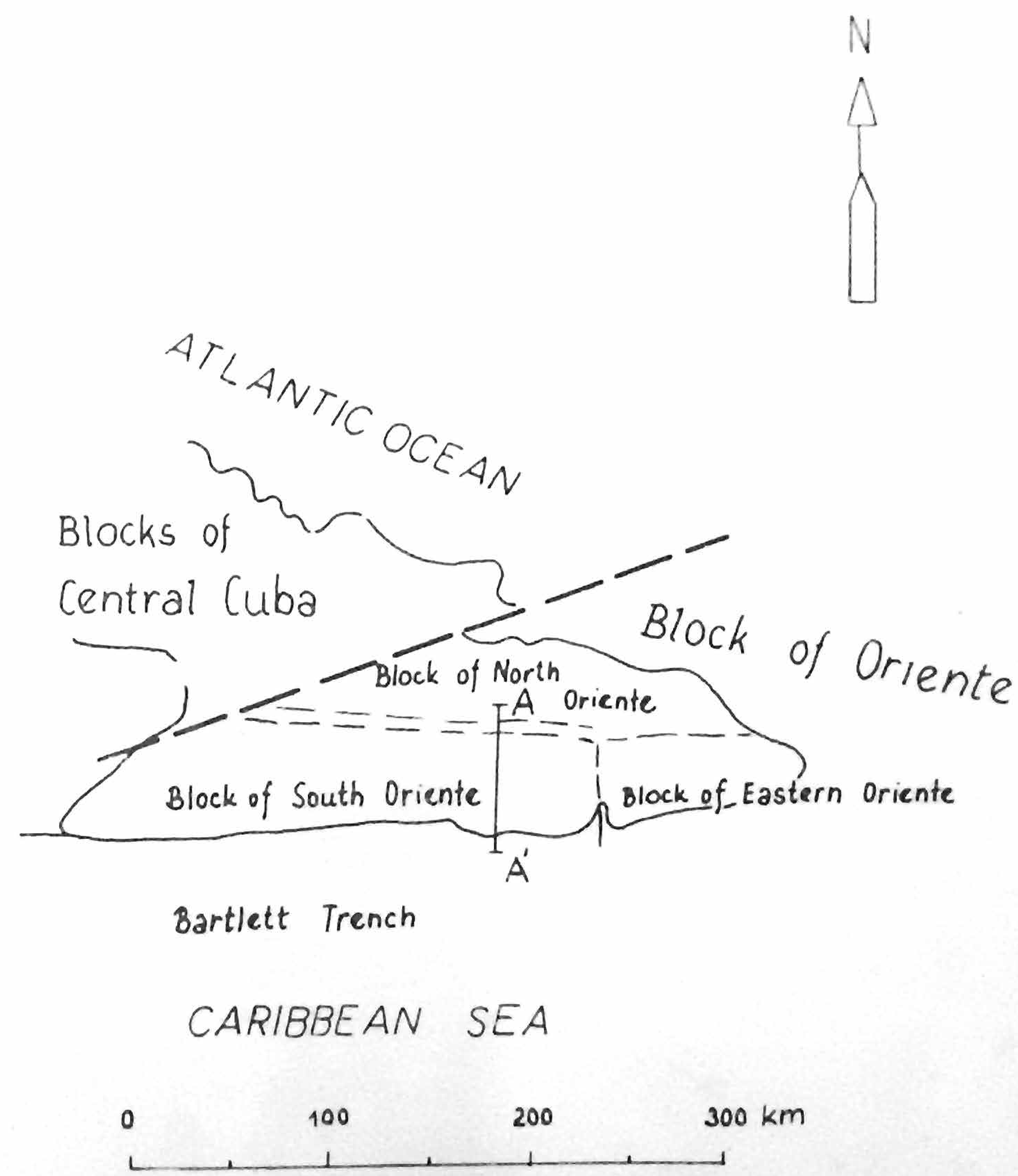

Fig. 6 — The distribution of the main tectonic units in the eastern part of Cuba. A — A' — the line of the schematic sections given in fig. 5.

Obr. 6 Schematická mapka hlavních geologických jednotek ve východní části Kuby. A — A' — profilová linie schematických řezů v obr. 5.

The analysis of the sedimentation and tectonic structure allows to designate the studied region as a passage area between two important parts of the Block of Oriente. The first of them I call **the Block of North Oriente** (fig. 6). It had been rather mobile during the Early Cretaceous Epoch and was relatively consolidated during the Late Cretaceous Epoch by the intrusions of ultramafic rocks. It was then covered by the thin sequence mainly of calcareous sediments predominantly of the Paleogene age. During the long geological evolution, this block has obtained a tectonic structure of the saxonic type. The relative consolidation of this block was contemporaneous with the geologic mobilization of the other block, which I call **the Block of South Oriente.** It was the place of intensive sinking and volcanic activity beginning with the end of the Cretaceous Period till the Early Eocene Age. During this time it was a volcanic trough. During the Middle Eocene Age the intensity of the vertical movements and the conditions of both blocks were levelled. During the Upper Eocene Age there began the main uplift and tectonic deformations of the Block of South Oriente which were accompanied by the intrusions of granitoids. The deformations of the southern block reaches a higher stage than that of the northern block. The boundary between both units lies probably south of the studied region and has a character of a deep fault. Further studies are necessary to verify its exact position.

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Vysvětlivky k tabulkám

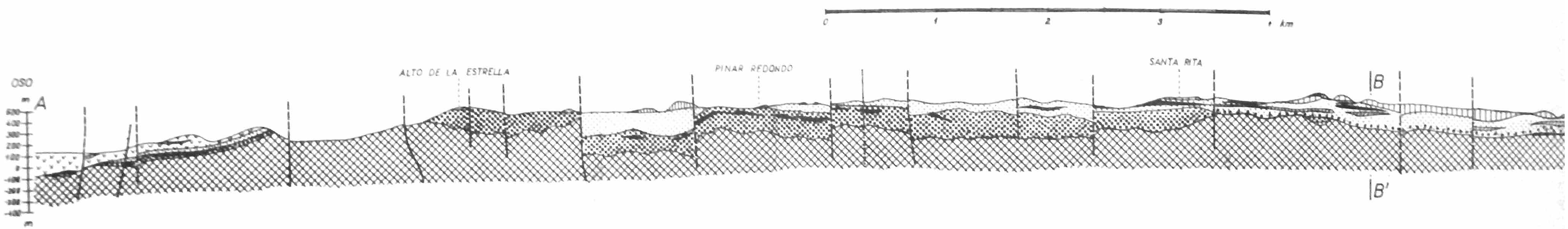
Tab. I Geologická mapa jižní části pohoří Sierra de Nipe (Oriente, Cuba). — Křída (?): intrusivní těleso Sierry de Nipe: 1 — peridotity, 2 — dunity, 3 — gabbro, 4 — polohy s rozptýleným chromitem; maestricht (?) — spodní paleocén: vrstvy La Picota: 5 — hrubozrnné slepence, 6 — vložky tufů; svrchní paleocén — spodní eocén: souvrství Santa Rita: 7 — dobře zvrstvené písčité vápence a vápnité pískovce, 8 — vložky popelových a psamitických tufů, 9 — vložky orbitoidních vápenců, 10 — růžové masivní vápence s valouny ultrabasik, 11 — krémově zbarvené vápence, místy tufitické a písčité, 12 — valouny intrusivních hornin, rozptýlené v horninách souvrství, souvrství El Cobre: 13 — lapillové tufy; střední eocén: souvrství Charco Redondo: vrstvy Río Naranjo: 14 — masivní bílé kalové vápence, 15 — vápencová brekcie, vrstvy La Caridad: 16 — orbitoidní vápence s řasami, 17 — orbitoidní vápence, 18 — vložky slínů, 19 — vložky kalových vápenců; kvartér: 20 — aluviální uloženiny, 21 — terasy řeky Piloto, 22 — eluviální a deluviální uloženiny, 23 — dejekční kužele. Strukturní prvky: 24 — plochy primární foliace v ultrabasickém tělese, 25 — směr a sklon vrstev, 26 — důležité radiální zlomy, 27 — nepřesně lokalizované významné radiální zlomy.

Tab. II Strukturní schéma kerné stavby jižní části Sierry de Nipe. 1 — významné radiální zlomy, 2 — méně významné radiální zlomy, 3 — různé tektonické kry.

Tab. III Geologický řez jižní částí Sierry de Nipe A — A'. Křída (?): 1 — ultrabasické vyvřeliny nerozdělené; maastricht (?) — spodní paleocén: vrstvy La Picota: 2 — hrubozrnné slepence, 3 — vložky tufů; svrchní paleocén — spodní eocén: souvrství Santa Rita: 4 — písčité vápence a vápenité pískovce, 5 — rozptýlené valouny ultrabasik, 6 — vložky tufů, 7 — vložky orbitoidních vápenců, 8 — krémově zbarvené kalové vápence, slabě písčité; střední eocén: souvrství Charco Redondo, vrstvy Río Naranjo: 9 — masivní bílé kalové vápence, vrstvy La Caridad: 10 — orbitoidní vápence.

Tab. IV Geologický řez jižní částí Sierry de Nipe B - B'. Křída (?): intrusivní těleso: 1 — dunity, 2 — peridotity; svrchní paleocén — spodní eocén: souvrství Santa Rita: 3 — růžové kalové vápence s valouny ultrabasik, 4 — písčité vápence a vápnité pískovce, 5 — vložky orbitoidních vápenců, 6 — vložky tufů; střední eocén: souvrství Charco Redondo: 7 — orbitoidní vápence s řasami.

O. KUMPERA: GEOLOGICAL SECTION ACROSS THE SOUTHERN PART OF SIERRA DE NIPE MOUNTAINS



EXPLANATION :

CRETACEOUS /?/

SIERRA DE NIPE MASSIF

1 — ULTRABASIC INTRUSSIVE ROCKS NON DIVIDED

MAASTRICHTIAN /?/ - LOWER PALEOCENE

LA PICOTA MEMBER

2 — COARSE GRAINED CONGLOMERATE

3 — INTERCALATIONS OF TUFFS

UPPER PALEOCENE - LOWER EOCENE

SANTA RITA FORMATION

4 — WELL BEDDED SANDY LIMESTONE AND CALCAREOUS SANDSTONE

5 — PEBBLES OF INTRUSSIVE ROCKS

6 — INTERCALATIONS OF TUFFS

7 — INTERCALATIONS OF ORBITOIDAL LIMESTONE

8 — SANDY MUD LIMESTONE OF CREME COLOUR

MIDDLE EOCENE

CHARCO REDONDO FORMATION

RIO NARANJO MEMBER

9 — NON BEDDED MUD LIMESTONE

LA CARIDAD MEMBER

10 — ORBITOIDAL LIMESTONE

PL. III

OSS THE SOUTHERN PART OF SIERRA DE NIPE MOUNTAINS A-Á

EXPLANATION :

UPPER PALEOCENE - LOWER EOCENE

SANTA RITA FORMATION

WELL BEDDED SANDY LIMESTONE AND CALCAREOUS SANDSTONE

PEBBLES OF INTRUSIVE ROCKS

INTERCALATIONS OF TUFFS

INTERCALATIONS OF ORBITOIDAL LIMESTONE

8 SANDY MUD LIMESTONE OF CREME COLOUR

MIDDLE EOCENE

CHARCO REDONDO FORMATION

RIO NARANJO MEMBER

9 NON BEDDED MUD LIMESTONE

LA CARIDAD MEMBER

10 ORBITOIDAL LIMESTONE

O. KUMPERA: GEOLOGICAL MAP OF THE SOUTHERN PART OF SIERRA DE NIPE MOUNTAINS (ORIENTE, CUBA)

EXPLANATION

CRETACEOUS /?/

INTRUSIVE ROCKS

1 PERIDOTITE
2 DUNITE
3 GABBRO
4 DISPERSED CHROMITE

MAASTRICHTIAN/?/-LOWER PALEOCENE

LA PICOTA MEMBER

5 COARSE-GRAINED CONGLOMERATE
6 INTERCALATIONS OF TUFFS

UPPER PALEOCENE-LOWER EOCENE

SANTA RITA FORMATION

7 WELL BEDDED SANDY LIMESTONE AND CALCAREOUS SANDSTONE

8 INTERCALATIONS OF ASH AND PSAMMITIC TUFFS
9 INTERCALATIONS OF ORBITOIDAL LIMESTONE
10 ROSY MUDDY LIMESTONE WITH PEBBLES OF INTRUSIVE ROCKS
11 CREME COLOURED LIMESTONE ON PLACES TUFFITIC AND SANDY
12 PEBBLES OF INTRUSIVE ROCKS DISPERSED IN THE ROCKS OF THE FORMATION

EL COBRE FORMATION

13 LAPILLITIC TUFF

MIDDLE EOCENE

CHARCO REDONDO FORMATION

RIO NAVANJO MEMBER

14 NON LEDDED WHITE MUD LIMESTONE
15 CALCAREOUS BRECCIA

LA CARIDAD MEMBER

16 ORBITOIDAL LIMESTONE WITH ALGAE
17 ORBITOIDAL LIMESTONE
18 INTERCALATIONS OF MARL
19 INTERCALATIONS OF MUDDY LIMESTONE

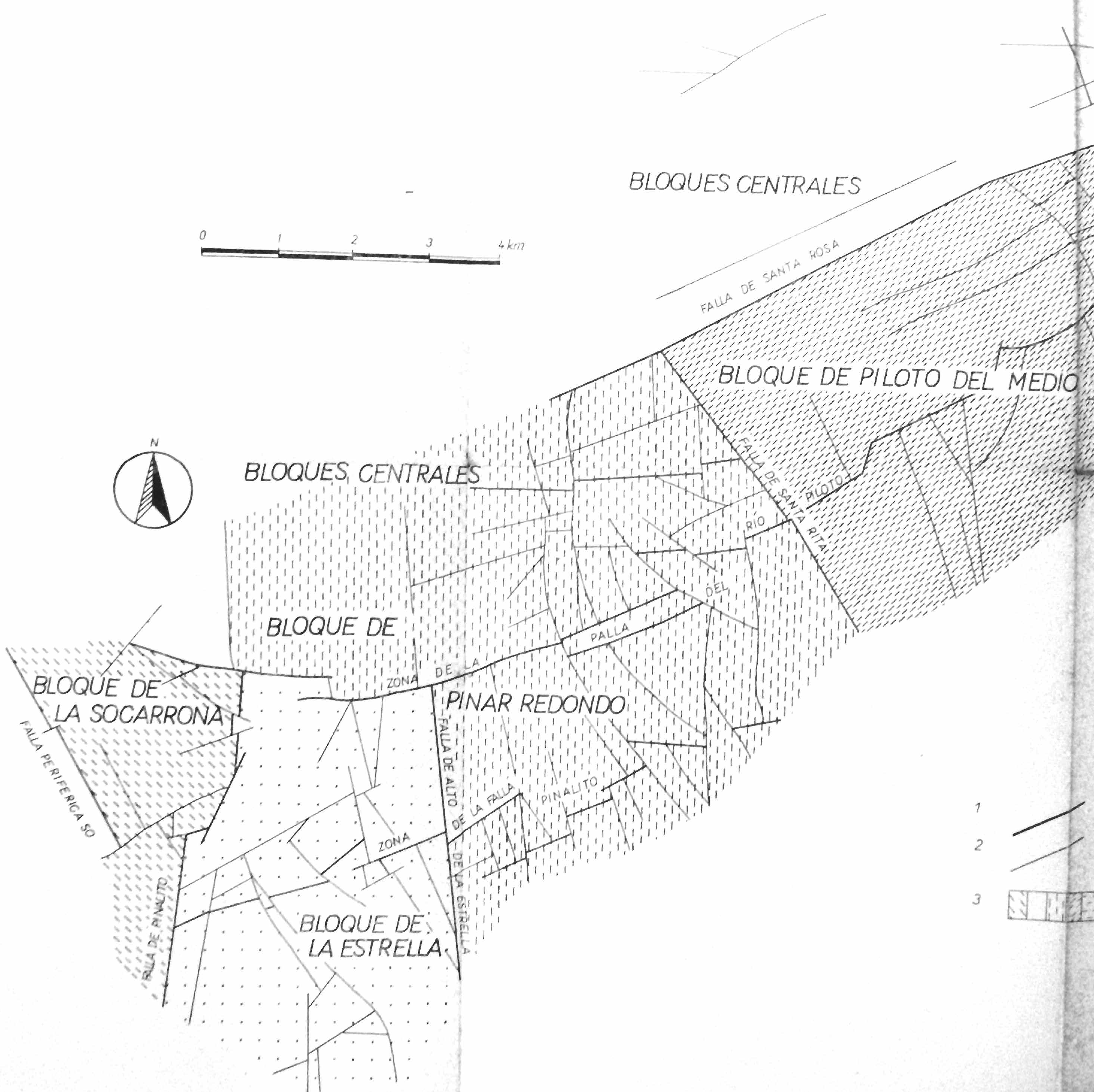
QUATERNARY

20 ALLUVIAL DEPOSITS
21 TERRACES OF PILOTO RIVER
22 ELUVIAL AND DELUVIAL DEPOSITS
23 ALLUVIAL FAN

TECTONIC

24 PLANES OF PRIMARY FOLIATION IN THE ULTRABASIC INTRUSIVE ROCKS
25 STRIKE AND DIP OF BEDS
26 IMPORTANT NORMAL FAULTS
27 APROXIMATE IMPORTANT FA

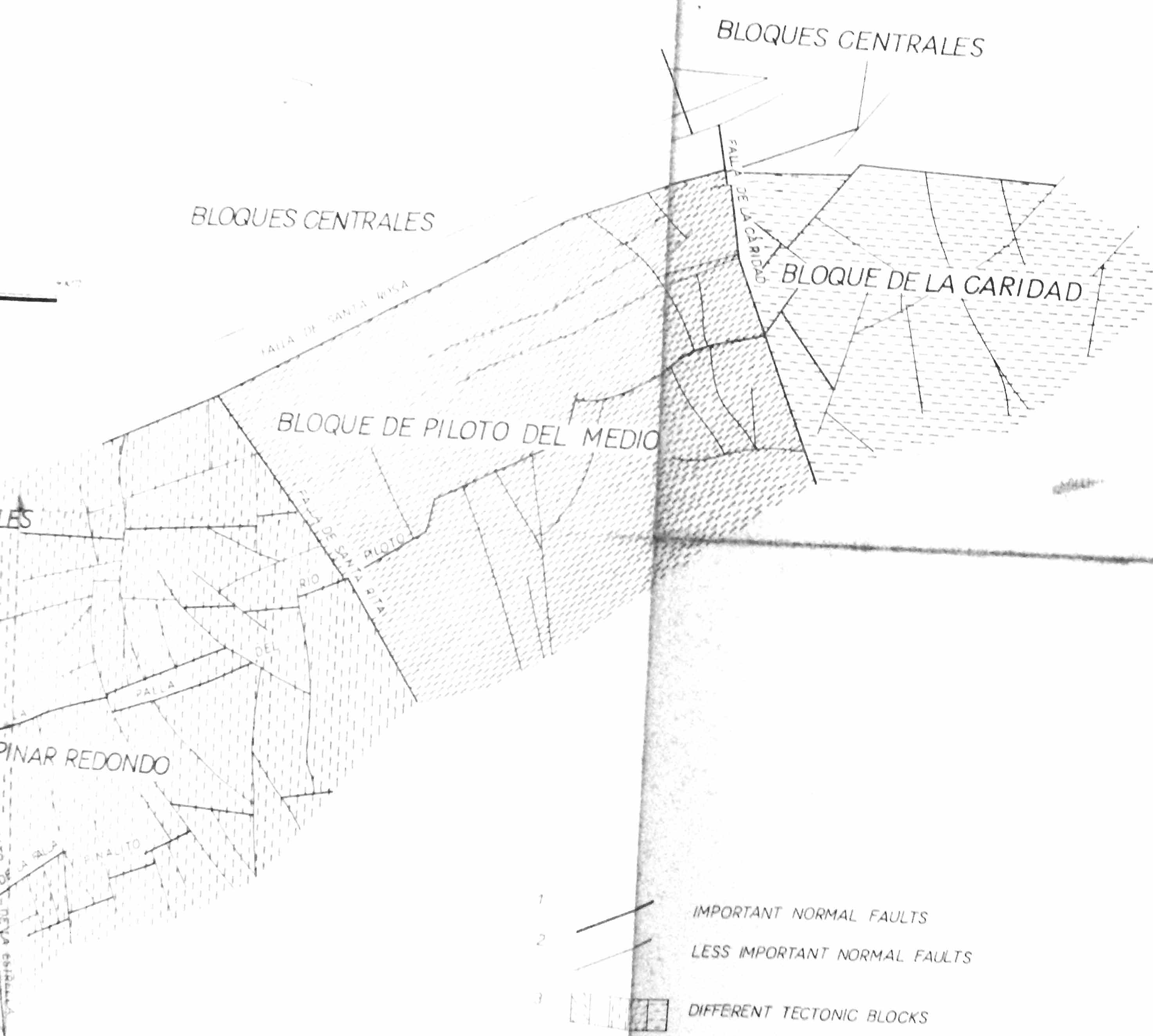
O. KUMPERA: TECTONIC SCHEME OF BLOCK STRUCTURE
SOUTHERN PART OF SIERRA DE NIPE



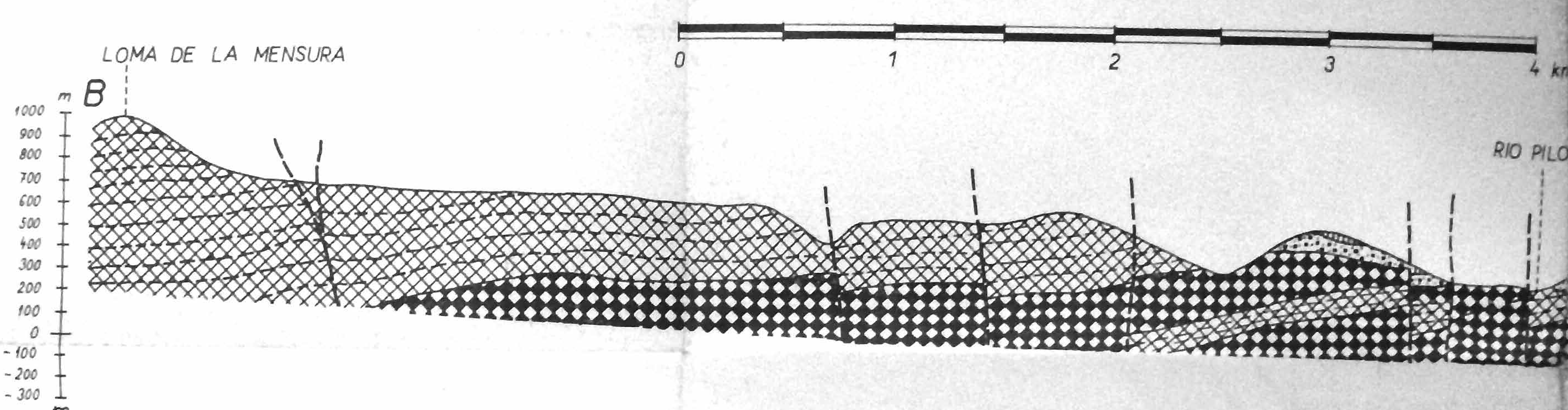
Příloha 2

TONIC SCHEME OF BLOCK STRUCTURE OF THE

THERN PART OF SIERRA DE NIPE



O KUMPERA: GEOLOGICAL SECTION ACROSS THE SOUTHERN PA



EXPLANATIONS

CRETACEOUS/?/
INTRUSIVE ROCKS

1 DUNITE

2 PERIDOTITE

UPPER PALEOCENE -
LOWER EOCENE
SANTA RITA FORMATION

3 ROSY LIMESTONE WITH PEBBLES OF INTRUSIVE ROCKS

4 CALCAREOUS SANDSTONE AND SANDY LIMESTONE

5 INTERCALATIO

6 INTERCALATIO

MIDDLE EC
CHARCORE

7 ORBITOIDL LI

PL. IV

SECTION ACROSS THE SOUTHERN PART OF SIERRA DE NIPE B-B´

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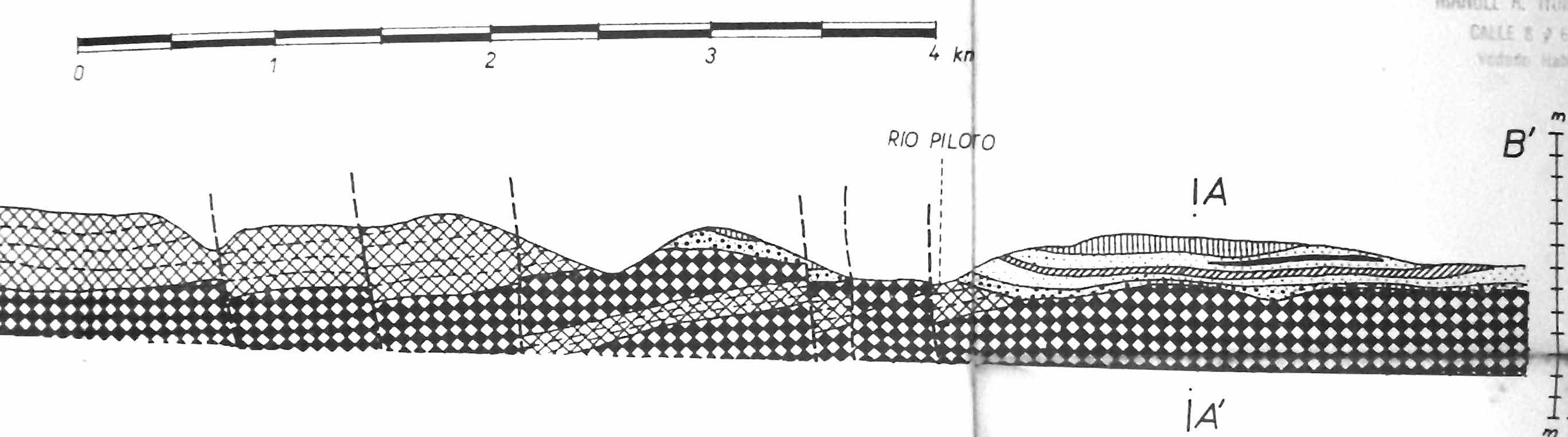
Vedado Habana, Cuba



EXPLANATIONS

UPPER PALEOCENE -
LOWER EOCENE
SANTA RITA FORMATION

3 ROSY LIMESTONE WITH PEBBLES OF INTRUSIVE ROCKS

4 CALCAREOUS SANDSTONE AND SANDY LIMESTONE

5 INTERCALATIONS OF ORBITOIDAL LIMESTONE

6 INTERCALATIONS OF TUFFS

MIDDLE EOCENE
CHARCO REDONDO FORMATION

7 ORBITOIDAL LIMESTONE WITH ALGAE