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PROEFSCHRIFT

TER VERKRIJGING VAN DEN GRAAD VAN DOCTOR IN DE WIS- EN NATUURKUNDE AAN DE RIJKS-UNIVERSITEIT TE UTRECHT, OP GEZAG VAN DEN RECTOR MAGNIFICUS Dr. W. E. RINGER, HOOGLEERAAR IN DE FACULTEIT DER GENEESKUNDE, VOLGENS BESLUIT VAN DEN SENAAT DER UNIVERSITEIT TEGEN DE BEDENKINGEN VAN DE FACULTEIT DER WIS- EN NATUURKUNDE TE VERDEDIGEN OP MAANDAG 22 MAART 1937, DES NAMIDDAGS TE 4 UUR

DOOR

LOUIS WILHELM JOSEPH VERMUNT

GEBOREN TE AMSTERDAM

DEZE DISSERTATIE VERSCHIJNT TEVENS ALS No. 13 VAN DE PHYSIOGRAPHISCH-GEOLOGISCHE REEKS DER GEOGRAPHISCHE EN GEOLOGISCHE MEDEDEELINGEN

Het is mij een behoefte U, Hoogleeraren in de Faculteit der Wis- en Natuurkunde, van wie ik mijn wetenschappelijke opleiding mocht ontvangen, aan het einde van mijne academische studiën, mijn dank te betuigen. Dit geldt in de eerste plaats mijn Promotor, Prof. Dr. L. Rutten.

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INTRODUCTION.

An expedition of the Utrecht University made a geological survey of different parts of the isle of Cuba during the spring and the summer of 1933. The members of this expedition were, the leader Prof. L. M. R. Rutten, Mrs. C. J. Rutten-Pekelharing, Miss A. Röntgen and the following students of geology at the Utrecht University, Dr. M. G. Rutten, Mr. H. J. Mac Gillavry, Dr. A. A. Thiadens, and the author.

From the 18th of May until the 9th of July, we worked in the Western part of Cuba, the province of Pinar del Rio. From the central camps, pitched in the towns of Pinar del Rio, San Diego de los Baños, San Cristobal, the members worked in different directions, whereas small parties consisting of two members surveyed the neighbourhood of Matahambre, La Esperanza, Bahia Honda, Cacarajicara (South West of Bahia Honda), Cabañas, Mariel. The busy traffic along the Carretera Central, Cuba's highway running along the axis of the island, enabled us to work even at large distances from the central camps. All notes made and all material collected by the members of the expedition in Pinar del Rio province were turned over to the author, who worked out the data in this paper.

For general orientation in the field we used military maps, kindly put at our disposal by the Cuban government. These maps, (scale 1 : 100000), proved to be insufficiently accurate in detail, so we had to survey our own roads. This was done by taking direction with a hand-compass and measuring the distances by counting our paces. The map constructed in this way proved to be more reliable than the military maps and sufficiently correct to sketch in our rough geological survey. A detailed geological survey would be impossible without reliable topographical maps.

In the laboratory at Utrecht we used as a basis for the construction of our map the nautical charts of the United States Navy. As fixed points were taken the towns of La Coloma on the Southern coast and Santa Lucia, Puerto Esperanza, Verracos, Puerto Blanco, Bahia Honda, Cabañas and Mariel on the Northern coast. As the reader will see, La Coloma is not to be found on our map. We knew, however, by pace-compass survey, the relative position of the town of Pinar del Rio with regard to La Coloma.

We further had at our disposal a special map of the Carretera Central. The direction of the road on this special map greatly differed from the direction of this same road on the military map, e.g. the town of Santa Cruz de los Piños is situated about 12 km to the North on the latter. We could check the directions of the Carretera Central at various places and as our observations tallied more or less with the military map, we ignored the special map of the highway.

Between the fixed points copied from the U.S. navy chart we mapped down our own surveys. The correction necessary between La Coloma and Puerto Esperanza, was an enlargement of our survey by 6 %. Other corrections were made with the help of the triangles formed by the roads. Several roads were surveyed on horseback. Direction was taken by hand-compass as usual, but the distances were judged at an estimate. This judging of distances proved to require a large experience, especially on the winding mountain roads, and grave errors were made. The survey on horseback, however, was necessary in those parts of the Organos mountains, which were practically uninhabited and large distances had to be covered in one day. On account of the unreliability of the distances of our horseback surveys, we attached only a secondary importance to them when drawing our map.

We prepared two maps, a geological coloured one and another on which the findspots of fossils and rocks are marked. The geological boundaries are also indicated on the latter, in order to facilitate the comparison with the former.

On all the roads sketched in on the map geological observations were made, with the exception of the Carretera Central, which was only partly surveyed. The closeness of the network of our observations and the places where the geological interpretation is unsupported by observations, are therefore clearly visible on the map.

Several regions in Pinar del Rio province could not be visited by us on account of lack of time. One of these regions, the reconnaissance of which is essential in order to understand the geology of Pinar del Rio, is between the towns of San Diego de los Baños and La Mulata. Between Quiebra-Hacha and Cayajabos we left a space blank on the map as two table mountains were seen in this area from some distance. The notable difference of morphologic aspect between the low hills of the Upper-Cretaceous-Lower-Tertiary regions and the table mountains, indicates the possibility that other formations are exposed there. The region of the blank space on the map, West of Cayajabos, seems to be built up predominantly of limestone hills of the same kind as those which are found to the West. The region between Viñales, Matahambre and Sumidero may be expected to consist of limestone "Mogotes" and phyllite/quartzite rocks.

The region between Matahambre, Santa Lucia and La Esperanza has been marked upon the map as San Andres formation. Two members of our expedition passed through this region, noting in general the occurrence of quartzitic phyllitic rock, without having the opportunity to survey the road properly.

As I am indebted to many, both in Cuba and in Holland for their help and kindness, I should like to express my sincere thanks and acknowledgements here.

In the first place I wish to express my gratitude to the members of the expedition :

To Prof. Dr. L. M. R. RUTTEN, the leader of our expedition, whose large experience in field-work and whose support when treating the various geological problems in this paper, have been of inestimable help to me.

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Mr. J. VAN DIJK, of the Utrecht Laboratory, who executed with great accuracy the drawings and micro-photographs reproduced in this paper.

Further I should like to say, that during our stay in Cuba, we met with nothing but the greatest hospitality and kindness from the side of the Cuban people, and I wish to express my gratitude to them.

Chapter I: SUMMARY OF THE GEOLOGY OF THE PINAR DEL RIO PROVINCE.

The oldest rocks exposed in the province of Pinar del Rio are sandstones, quartzitic sandstones, quartzites, slates, phyllites, cherts and limestones. We name this series of rocks the San Andres formation, thus combining the Cayetano formation and the Viñales limestones, both names introduced by DE GOLYER (28). The limestones are partly of Upper Jurassic, partly of Lower Cretaceous age; moreover, we take them to be intercalated in the quartzite-phyllite formation. We cannot differentiate the greater part of the limestones in Upper Jurassic and Lower Cretaceous strata as paleontological evidence is often wanting. Also for this reason we suggest a new name, including the Cayetano formation, until a minute survey will produce evidence justifying a more detailed division. The formation has been named after the village of San Andres, situated in the centre of the wide-spread mountain area, where this formation is exposed.

The San Andres formation can be divided into two parts, respectively found East and West of the town of San Diego de los Baños. In the Western part quartzitic and phyllitic rocks (rocks of Cayetano facies) are predominant. Cherts and limestones of Upper Jurassic and Lower Cretaceous age are intercalated. The Eastern part consists chiefly of limestones with minor intercalation of rocks of Cayetano facies. The age of part of the limestones is Lower Cretaceous on account of *Aptychi* found at various places. These beds are the equivalent of the *Aptychi* limestones of the Santa Clara province described by M. G. RUTTEN (64). BROWN and O'CONNELL (12) mention the occurrence of Jurrassic Ammonites in the Eastern region, consequently older beds, e.g. Upper Jurrassic, may be developed.

Following the sedimentation of the strata of the San Andres formation begins volcanic activity, resulting in the deposition of the Tuff Series. These strata consist of porphyrites, diabases, vitric-tuffs, tuffites, tuff-breccias, *Radiolaria* bearing cherts and grayish-blue well bedded limestones. The latter are especially developed in the lower parts of the Tuff Series. The age of the Tuff Series is uncertain, as no fossils were found in the beds exposed in the province of Pinar del Rio. They are post-Lower Cretaceous, as they rest conformably upon the younger parts of the San Andres formation and pre-Upper Cretaceous (Maestrichtian of Europe) as they are unconformably covered by the beds of the Habana formation.

The orogenetic phase, which followed the sedimentation of the Tuff Series, folded the San Andres formation and the Tuff Series to a large anticline. During this orogenesis, harzburgites, gabbroid dikes and dioritic rocks intruded. The harzburgites, at present for the greater part serpentinized, carry inclusions of rocks partly derived from the Tuff Series (porphyrites and diabases) and rocks of unknown origin (amphibolites, actinolite-schists and hornblende-plagioclase rocks).

After a period of denudation, the Habana formation was deposed disconformably upon the older formations. These strata of Upper Cretaceous age (Maestrichtian of Europe) are characterized by the occurrence of Rudists and Orbitoids. The Habana formation is developed in two different facies; the "Mountain facies" and the "Eastern facies". The former is exposed in the mountain regions, the latter to the North, East and South of them. The rocks of the Mountain facies are dark-blue limestone breccias and conglomeratic sandstones. The rocks of the Eastern facies consist of conglomerates, white to brown calcareous sandstones, marls, chalks and white limestones. These beds cannot be distinguished from the Upper Eocene and Oligocene strata, when paleontological evidence is lacking.

A regression and possibly an orogenesis followed the sedimentation of the Habana formation, as the Lower Eocene is not developed in Pinar del Rio. The Upper Eocene is only found in the belt of younger sediments around the mountain regions; so we assume that after the deposition of the Upper Cretaceous, the central regions rose, thus preventing the penetration of the Upper Eocene transgression.

The Upper Eocene and Oligocene layers consist of white limestones, conglomerates, calcareous sandstones, white marls and chalks.

A renewed orogenetic activity took place after the deposition of the Oligocene beds. These orogenetic phases wedged the Habana formation of Mountain facies into the older formations, whereas the Habana formation of Eastern facies and the Upper Eocene and also the Oligocene beds were strongly folded.

Then follows the sedimentation of the Oligomiocene beds consisting of white or brown limestones (equivalent of the Guinness limestones), carrying an abundant and constant fauna of *Foraminifera*, red sands and purple clays. The Oligomiocene beds are found in horizontal position or with slight dips. The last post-Oligomiocene orogenetic phase must have been of small importance and even locally absent as large areas are covered with horizontal Oligomiocene beds.

Chapter II : STRATIGRAPHY AND PETROGRAPHY.

San Andres formation.

The San Andres formation forms the greater part of the mountain regions in the province of Pinar del Rio. It consists of phyllites, slates, quartzites, sandstones and marbles, which were called the Cayetano formation by DE GOLYER (28), and of massive grayish-blue limestones formerly called the Viñales limestones often cut by thin calcite veinlets.

Moreover, grayish-blue, thin-bedded limestones are found. In the quartzitic and phyllitic beds, which we shall call rocks of "Cayetano facies" and in the limestones, we find intercalations of cherts.

The limestones are a typical feature in the landscape, especially in the Western part of the Organos mountains. They form steep, often isolated hills, called "Mogotes" in Cuba, between which we find a red soil or rocks of Cayetano facies.

We can divide the region, in which the San Andres formation is found, into two distinctly different parts; the boundary between these parts running from near the town of San Diego de los Baños to the North. West of this boundary we find the rocks of Cayetano facies dominating, the outcrops of limestones are in the minority. The Eastern part consists chiefly of limestones, often well bedded, with occasional intercalations of quartzitic rocks of Cayetano facies.

This contrast between the Eastern and Western region is difficult to explain. BROWN and O'CONNELL (12) advance the opinion, that the older strata are stronger developed in the Western part, which in our opinion may be the case, as Upper Jurassic fossils, often found in the Western part, were not met with by us in the Eastern part. Apart from the possibility that strata of different ages are found in the two regions, change of facies is also in all probability of great importance. It may accentuate the difference between the two regions. In the transsitional area we have to our great regret insufficient observations to offer a definite solution of the interesting problem.

We introduce the new name San Andres formation, thus combining the Cayetano formation and the Viñales formation.

DE GOLYER (28) considers the Cayetano formation to overlie the Viñales limestones. He mentions limestone-intercalations at the base of the Cayetano formation. The limestone hills near Sumidero "may be part of the Viñales limestones brought up by faulting rather than a part of the Cayetano formation."

Brown and O'Connell (12) take the Cayetano formation to lie unconformably under the Viñales limestones, to which they ascribe an Upper Jurassic age.

Dickerson and Butt (30) in a recent publication accept the unconformity between the Cayetano formation and the Viñales limestones, but take the *Ammonites* on which the Upper Jurassic age of the Viñales limestones is based by Brown and O'Connell (12), to be derived from the Cayetano formation, which consequently is of Upper Jurassic age in their opinion. The Viñales limestones and the Eastern part of the Organos mountains are reckoned to be of Lower Cretaceous age on account of *Ammonites* and *Aptychi* found at La Catalina and on the trail between San Cristobal and El Rosario.

In our opinion the limestones are partly of Upper Jurassic, partly of Lower Cretaceous age; moreover we take them to be intercalated in the quartzite-phyllite formation (Cayetano formation). As we cannot differentiate the greater part of the limestones in Upper Jurassic or Lower Cretaceous strata, we suggest a new name for a formation which then includes the Cayetano formation, until a minute survey will produce evidence, justifying a more detailed division.

San Andres formation Western part.

A large area of quartzitic and phyllitic rocks runs South of the limestone hills from the town of Guane in the West to San Diego de los Baños in the East. Though these strata are strongly folded, the structure of a large anticline is clear. The Northern and Southern flanks of this anticline are especially evident South East of Luis Lazo, North West of San Juan y Martinez, on the road from the town of Pinar del Rio to Sumidero and South of San Andres. In this zone of rocks of Cayetano facies we find intercalations of marbles and of grayish-blue limestones, North West of the town of Pinar del Rio and North of Consolacion del Sur. At the Northern boundary of this large district of rocks of Cayetano facies, we find the limestone "mogotes" separated from each other in some cases by broad strips of rocks of Cayetano facies and limited in the North also by rocks of Cayetano facies.

Age of the Limestone Hills: The "mogotes" consist of a compact, grayish-blue limestone, often cut by small calcite veinlets, and dark shales. They rise steeply out of level plains, which are for the greater part covered by a red soil. This "mogote" landscape is typically developed in the neighbourhood of Viñales.

In some places, at the foot of these hills we find the *Ammonite* bearing limestone concretions, which are called "quesos" by the peasants on account of their form. The best known findspot of these "quesos", situated North of the town of Viñales at the Puerto Ancon, was discovered by Dr. Carlos

DE LA TORRE (76), who ascribed a Jurassic age to the *Ammonites* found in them. Later publications of SANCHEZ ROIG (67) and BROWN and O'CONNELL (12) corroborated this determination; the limestones and shales, from which the *Ammonite* bearing concretions were considered to be derived, were placed by them in the Oxford.

BROWN and O'CONNELL (12) mention two new findspots of *Ammonites*, namely, San Vicente and Mina Constancia. In both localities the strata from which the fossils are derived, are considered to be of Jurassic age.

We collected *Ammonites*, South East of Guane at loc. V. 585 and at or near the Puerta Ancon. The preliminary examination of this material by JAWORSKI (not yet published) also points to an Upper Oxford or Lower Kimmeridge age of the strata.

DICKERSON and BUTT (30) mention further localities where Jurassic *Ammonites* are found, e.g. at the East foot of the Sierra San Carlos, about two km North of the settlement of Punta la Sierra (between Guane and Sumidero) at the South foot of the Sierra La Abra (South of San Cayetano), and in the neighbourhood of La Jagua Vieja (South East of La Esperanza). As already mentioned, they take the concretions to originate from the quartzitic and phyllitic rocks. We think it highly improbable that the *Ammonites* should occur in the rocks of Cayetano facies only in those places, where, in DICKERSON and BUTT's opinion the limestones cover even unconformably, those rocks. A second and conclusive argument against DICKERSON and BUTT's opinion is the fact that, e.g. at the classical findspot Puerto Ancon, the concretions with *Ammonites* are found on the debris slope of the limestone hills and moreover North of a zone of rocks of Habana formation, found somewhat to the West, which marks the anomalous contact between the limestones and the rocks of Cayetano facies. Lastly, the beds of Cayetano facies do not outcrop, at the findspot of the Ammonites at Puerta Ancon.

At loc. L. 894 situated North West of San Diego de los Baños and near La Catalina, we collected *Ammonites* in distincly northward dipping limestones, intercalated in rocks of Cayetano facies to which JAWORSKI ascribes an Upper Tithonian or more probably Valanginian age. DICKERSON and BUTT mention the occurrence of Lower Cretaceous *Ammonites* and *Aptychi* from probably the same locality.

Resuming we find that the limestones found in the Western part of the San Andres formation are partly of Oxfordian-Kimmeridgian partly of Valanginian, Lower Cretaceous age.

Owing to the complicated tectonical structure and the scarceness of fossils in the limestones, we did not try to separate the limestones of different ages on the map. Moreover they are sketched-in roughly.

Position of the limestone beds (Western Part): As already mentioned BROWN and O'CONNELL (12) and DICKERSON and BUTT (30) consider the limestones to cover unconformably the quartzitic and phyllitic rocks. We do not agree with this opinion. We have evidence of intercalated limestones in the rocks of Cayetano facies West of San Diego de los Baños at locs. V. 675 and V. 680. These limestones are compact, blueish gray of colour and cut by small calcite veinlets, they are not to be distinguished from the limestones occurring at Viñales. East of La Palma at loc. M. 977 we find quartzitic sandstones with a strike of N 110 E, dipping 40 degrees to the South, they are covered by thin bedded blueish gray limestones with a strike of N 110 E also dipping 40 degrees to the South. The limestones are covered again by quartzitic sandstones. At the nearby loc. M. 981 we find the same. Other places, where limestones are intercalated, are South East of La Palma at loc. H. 844 and North East of Sumidero at loc. L. 808. An intercalation of quartzitic rock in the limestone hills was found North of Sumidero at loc. V. 561. The occurrence of a quartzite bed of about one metre thickness in the large limestone mogote proves, that the contrast between the "unmetamorphosed Jurassic limestones and shales and the highly metamorphosed Cayetano schist", as mentioned by WHITNEY LEWIS, (44), is not of such importance, as he suggested. In the area of rocks of Cayetano facies West of San Vicente, a sandy limestone of about 1 metre thickness is decidedly intercalated at loc. L. 1041. This rock contains very badly preserved fossils, which in JAWORSKI's opinion are in all probability Ostreids of Middle or Upper Jurassic age. If this holds true we have evidence that at least part of the quarzite-phyllite formation is of the same age as the limestones or slightly older.

So we consider the quartzitic formation and the limestones and the occasionally occurring cherts as a depositional unit, an opinion already voiced by METCALF in a written discussion with LEWIS. (44). Owing to the difference of material of which the San Andres formation consists, we may expect disharmonious folding which in places gives strongly the impression of an unconformity.

We already mentioned the large quartzitic area South of the limestone hills and the intercalations of larger or smaller strips of quartzitic and phyllitic beds in the mogote regions. A third rather large district of quartzitic rocks occurs North of the limestone hills. In this area the village of Cayetano is situated, after which DE GOLYER (28) named the quartzitic rocks. DE GOLYER considers the quartzitic rocks to be the younger Cretaceous covering of Jurassic limestones, forming the resistent core of an anticline. The Northern and the Southern quartzitic strata are considered to be respectively the Northern and Southern flank of the East-West striking anticline. Our survey does not point to a solution of the Mogote problem in this direction. In general we find Northern dips in limestones and quartzitic strata from the core of the anticline in the Southern quartzitic district to the quartzitic rocks exposed near the Northern coast of Cuba. The numerous Southern dips found in the Limestone hills North of the village of Sumidero are a baffling exception.

Hitherto unknown in this Western part of Pinar del Rio are numerous outcrops of a transgressive formation of Upper Cretaceous age; they are often associated with small strips of serpentines and occur near the large limestone hills. These Habana beds of "Mountain facies" are described on p. 25. These transgressive beds lie in anomalous contact with the older formations. The serpentine seems to have acted as a "slide-expedient" on which overthrusting took place. Strike and dip are not to be measured in the breccious or conglomeratic Upper Cretaceous beds, but their position at the foot of the large limestone hills in the generally North dipping beds of the San Andres formation points to overthrusts. The anomalous contacts were not indicated as such upon the map, because the small occurrences of the Upper Cretaceous layers, already exaggerated on the map, would become wholly invisible.

Resuming we take the phyllitic quartzitic rocks and the limestones to belong to a continued sedimentation cycle in Jurrassic to Lower Cretaceous time. After a period of orogenetic activity, followed by denudation, the Upper Cretaceous transgression covered these regions. During a post-Maestrichtian orogenesis overthrusting took place.

Chert Zone: Intercalations of chert are found in the quartzitic phyllitic zone and in the limestone strata. A large area of cherts, however, was found between San Cayetano and La Esperanza. The trail which runs East from La Esperanza and then to the South, also crosses this chert zone between the locs. L. 1018 and L. 1020. It is also found South of Verracos. The thin bedded cherts, varying from yellow-gray to black in colour often carry *Radiolaria*. The strata are strongly folded in detail. They are reckoned by us to belong to the San Andres formation.

San Andres formation Eastern part.

In contradistinction to the Western part limestones dominate in the mountain regions East of San Diego de los Baños. Rocks of Cayetano facies are so in the minority, and the outcrops of such small dimensions, that we did not put them down on the map. When found, however, the quartzites or quartzitic sandstones are in general appearance and in thin sections practically identical with the rocks found in the Western parts. The strata further consist of black or violet shales, cherts often carrying *Radiolaria*, and calcareous sandstones. The limestones are from light to dark blueish-gray in colour, and mostly thin-bedded. They are more of less crystalline.

The strike of the beds runs in general in East Western direction, dipping to the North; at the Southern part of the area where the San Andres formation is exposed, we find Southern dips.

The strata of the San Andres formation are covered in the North by the beds of the Tuff Series. The Southern boundary is a large fault which is based chiefly on morphologic arguments (the abrupt ending of the mountain region). Outcrops of the belt of younger sediments are scarce. Between the Oligomiocene beds and the rocks of the San Andres formation, the area which is left white on the map, is either without any outcrops or covered by alluvial deposits of which the large boulders are partly derived from the San Andres formation.

North of Guanajay occurs another area of rocks, which are similar to the rocks of the Organos mountains. Contrary to the latter it is a flat country, with only low hills. The strata consists of blueish-gray and greenish-gray, well bedded limestones, often cut by small calcite veinlets, of cherts and of violet shales.

Age of the San Andres formation Eastern part: In several localities (V. 868, A. 653, V. 826) *Aptychi* were collected by us in the limestone beds. They were studied by Prof. TRAUTH (79), who ascribed a Lower Cretaceous age to them. At loc. V. 868, South of Bahia Honda, *Ammonites* were collected with the *Aptychi*. They are, however, in all probability in too bad a state of preservation for determination. BROWN and O'CONNELL (12) mention the occurrence of Ammonites, which they consider to be of Upper Jurrassic age at localities North of Candelaria and North of San Cristobal. At this last locality they collected, however, also *Aptychi*, the resemblance of which with Lower Cretaceous species has been already pointed out by them. DICKERSON and BUTT (30) also collected *Aptychi* and Ammonites on the trail between San Cristobal and El Rosario, which are considered to be of Lower Cretaceous age.

On the whole we may consider the greater part of the San Andres formation in the Eastern regions to be of Lower Cretaceous age, though the occurrence of Upper Jurassic beds is not excluded. The same Lower Cretaceous beds are therefore found in Eastern and in Western parts of the San Andres formation. They are also the equivalent of the *Aptychi* limestones RUTTEN (64) described from Northern Santa Clara, and will be described by MAC GILLAVRY (in litt.) from Camaguey.

With regard to the age of rocks of Cayetano facies we mention the occurrence of a quartzitic sandstone, noted but not sampled, intercalated between the limestones at loc. V. 868, where Lower Cretaceous *Aptychi* were collected.

As in the Western part, numerous overthrusts, indicated by the occurrence of Maestrichtian beds (Habana formation of Mountain facies) and by serpentine-bands, greatly complicate the insight into the relation of the limestones and quartzitic layers.

Description of rocks of the San Andres formation.

Mica sandstones: These rocks are grayish-brown and reddish-brown, at the surface often with a red-brown rim due to weathering. In thin sections the rocks appear to consist chiefly of quartz crystals either rounded or angular of shape and either polluted or clear. Occasionally twinned plagioclase of acid composition (albite) occurs. The mica is a colourless muscovite developed as small or larger plates. The plates are either irregularly arranged or show a linear structure. The matrix is a greenish-brown limonitic substance. In rocks grading into quartzitic sandstones the amount of matrix is small.

Quartzitic sandstones: The rocks consist of the same constituents as the sandstones. The quartz is clear, rounded or angular and in places shows a sutured texture. The limonitic matrix is often replaced by thin sericite layers, accentuating the foliated structure. The twinned albite crystals and the muscovite plates are occasionally bent, due to tectonical stresses. In some rocks the plagioclases are sericitized. As accessory minerals we find zircon and tourmaline. The quartzitic sandstones form with the quartzites a prominent part of the San Andres formation.

Quartzites: Quartzitic rocks are medium to coarse-grained and white-gray to grayish-brown or red-brown in colour. Under the microscope the rocks consist of clear quartz crystals, strongly intergrown with each other and of sericite. The sericite occurs in thin layers or patches. It is often mixed with a limonitic substance and with fine ore grains. Muscovite is developed as small or large plates. The plagioclase crystals, which are nearly always found in small quantities, are of acid composition (albite). Accessory minerals are zircon and tourmaline.

The texture of the rocks varies. Part of the quarzites show a linear arrangement of the muscovite plates or the sericite layers; the quartzes of these rocks, though often showing strain-shadows, are irregularly arranged. Other rocks, however, show apart from the linear arrangement of the micaceous elements, a distinct parallelism of the quartz crystals. Part of the rocks, we called quartzites, thus grade into the higher metamorphic sericite-quartz schists. Taking into consideration, that non-metamorphic sandstones occur besides quartzites and sericite-quartz schists, it is probable that tectonical stresses had an influence upon the rocks apart from the regional metamorphism.

Slates: Slaty rocks often occur in the San Andres formation. They are fine grained and of light grayish or purple colours. Foliated structure is pronounced. Fresh rocks are difficult to obtain, because of the easy weathering. In thin-sections the rocks consist of fine quartz dust in a matrix of chloritic limonitic substance. Small twinned plagioclase laths are found. Sericite occurs in changing quantities. In cases, the matrix is a dark red-brown mass, consisting probably of hematite. Small cubi of pyritic ore are often found.

Phyllites: True phyllitic rocks are found considerably less than the slates. The lustrous rocks are reddish-purple or greenish-gray. Under the microscope the rocks consist of strongly intergrown quartz patches, shaped as lenticles or small bands, conforming with the parallel arrangement. The sericite layers between the quartz patches are often mixed with a limonitic substance.

Limestones: Several authors e.g. Lewis (44) and Dickerson (in private correspondence with Prof. Rutten), pointed to the difference of the highly crystalline marbles intercalated in the quartzite-phyllite beds and the less crystalline "Mogote" limestones. We already discussed the fact that quartzitic rocks occur in the limestone hills. As regards their metamorphism these rocks do not differ from the rocks found in the large quartzite-phyllite areas. With regard to the limestones, which are macroscopically often difficult to separate, we made several thin-sections in order to examine the state of crystallization of the different rocks. We can discriminate fine-grained crystalline rocks and coarse crystalline limestones. The latter show different stages of crystallization. Some rocks consist of idiomorphic calcite rhomboeders, which in other rocks pass into allotriomorphic calcite crystals. Transitional phases are found. In cases the old contours of the rhomboeders are visible in the coarse calcite crystals (loc. V. 710, North of San Diego de los Baños). The limestones occasionally show a linear structure, accentuated in the fine grained rocks by the polluted parts and in the coarse crystalline limestones by the parallel arrangement of the calcite crystals.

With regard to the occurrence of the fine-grained and coarse crystalline limestones, we find the coarse crystalline rocks also in the "Mogotes" and in the Eastern part of the Organos mountains, and the fine-grained limestone intercalated in the quartzite phyllite strata. Outcrops of crystalline limestones in the "Mogotes" are e.g. loc. M. 911, South West of Sumidero and loc. M. 915, North East of La Sierra; in the Eastern Part of the Organos mountains e.g. loc. V. 827, near Saroa, North East of San Cristobal and at loc. V. 756, North of San Diego de los Baños. Near Sumidero, we find fine-grained limestones at loc. L. 767 and coarse crystalline ones at loc. L. 770. Both localities seem to belong to the same level. The extreme crystalline marbles found at loc. L. 780, North of the town of Pinar del Rio, are generally taken as the prototype of the intercalated limestones in the quartzite phyllite formation. They are indeed the strongest crystalline limestones, we found in the Province of Pinar del Rio. The limestones found at loc. A. 619, West of loc. L. 780, in all probability can be connected with the marbles; they are considerably less crystalline. In the neighbourhood of San Diego de los Baños occur fine-grained limestones at the locs. L. 856, L. 858 and V. 703. Coarse crystalline limestones are found at locs. L. 853 and V. 710. We have no reason to differentiate the outcrops mentioned above on account of a different position.

The examination of the material we have at our disposal proves, that there is no contrast between fine-grained "Mogote" limestone and stronger metamorphic limestones intercalated in the quartzite phyllite beds. Both kinds occur in either of them.

Suboolitic limestones are found at loc. H. 812, North of Consolacion del Sur and loc. V. 547, North East of Consolacion del Sur. The fragments of suboolitic limestones found in the breccia-limestones of the Habana-formation of Mountain facies resemble these limestones.

Fine-grained dense limestones, carrying *Radiolaria* are found at loc. H. 834, North East of San Andres and at loc. L. 916, North of Candelaria.

Tuff Series.

The characteristic elements of this series are porphyrites, diabases, glass tuffs, tuff breccias and tuffites, alternating with blueish gray well bedded limestones, cherts and shales. We find these beds exposed at the Northern side of the younger part of the San Andres formation East of San Diego de los Baños. The Tuff Series beds cover these younger parts of the San Andres formation (equivalent of the Lower Cretaceous *Aptychi* limestones described by M. G. Rutten (64) from Northern Santa Clara) conformably, which is clearly shown on the trail South of Bahia Honda, where the boundary between the Tuff Series and San Andres formation runs about 3 km North of an *Aptychi* findspot (loc. V. 686) in the latter. The strikes of the beds of the Tuff Series and of the beds of the San Andres formation run W—E the dip is constantly to the North. The association of volcanic beds and limestones is typical for the Northern facies of the Tuff Series in Santa Clara province. M. G. Rutten reckons the Aptychi limestones and the lower parts of the Tuff Series to be of the same age and only differing in facies. From our observations in Pinar del Rio we conclude that the Tuff Series is younger than the equivalent of the *Aptychi* limestones, the younger parts of the San Andres formation. In the lower part of the Tuff Series, limestones are more frequently intercalated than in the higher parts, where they even may be absent. The limestones found in the lower part of the Tuff Series, in places contain fragments of volcanic material (loc. L. 968, South of Cabañas). All strata containing evidence of volcanic activity are reckoned to the Tuff Series. In these strata we never find the sandstones and quartzites typical for the San Andres formation.

Outcrops of Habana beds of mountain facies occur in the Tuff Series in the same way as in the San Andres formation, marking the overthrusts.

At the Northern side the Tuff Series area is limited by the beds of Habana formation of Eastern facies, described elsewhere, and by Lower Tertiary strata.

North West of Bahia Honda the Tuff Series is found again, however, in this region entirely without intercalations of limestones, same as on the road from Bahia Honda to Cabañas (see map). The Tuff series strata in this region consist of glass tuffs, *Radiolaria* bearing glass tuffites (locs. V. 845, V. 849, M. 1061), porphyrites and diabase-porphyrites. In the tuffites effusive quartz occurs at loc. M. 1066, East of Bahia Honda; the quartz grains show corrosion rims and inclusions of groundmass. In analogy with Santa Clara province, the occurrence of effusive quartz may point to an Upper Cretaceous age (Habana formation) of this tuffaceous rock. On account of the extreme scarceness of the quartz material, we hesitate to reckon this rock to the Habana formation, however, the possibility of the occurrence of tuffaceous Habana formation in this region must be reckoned with. Strike or dip were not measured by us in this part of the Tuff Series. On the map we connected both areas, but a survey of the Eastern side of the bay of Bahia Honda will be necessary to allege this with evidence. West of the bay of Cabañas the possibility of the occurrence of tuffaceous rocks was noted. Outcrops in this regions, however, are too scarce and the rocks too strongly weathered for determination.

In the town of Cayajabos strongly folded, *Radiolaria* carrying cherts, are exposed, whereas North of the town at loc. L. 930, a coarse diabase rock is found. Both rocks are reckoned to belong to the Tuff Series, but the cherts might easily belong to the San Andres formation.

A small outcrop of diabase rock is found at loc. M. 1013, North of San Cristobal. We take this to be an isolated intrusion of the tuffaceous magma through the older San Andres formation. Another isolated outcrop of coarse diabase is found at loc. L. 870, North of La Palma.

A rock, which may be allied to those found in the Tuff Series, occurs at loc. A. 618, West of the town of Pinar del Rio, in the quartzitic phyllitic area. The cataclastic rock consists of crushed augites and quartzitic and calcareous elements. A sparse amphibole crystal is found. This rock might be connected, however, with the dioritic magma.

Age of the Tuff Series: No fossils indicating the age of the Tuff Series have been found. On account of its stratigraphic position, the Tuff Series is younger than the Lower Cretaceous beds of the San Andres formation and older than the transgressive Habana beds of Upper Cretaceous age (Maestrichtian in Europe).

Description of the rocks of the Tuff Series.

Diabases and porphyrites: The rocks are greenish blue to grayish green. The white felspar phenocrists found in the porphyritic rocks are macroscopically clearly visible as tiny white spots. In thin-sections the true ophitic texture of the diabase grades into the porphyritic texture of the porphyrite. The latter have a crystalline matrix of small plagioclase laths and small augite grains or a vitric groundmass. The composition of the felspars forming the matrix and the phenocrists is basic (labradorite). In some rocks well developed augite phenocrists occur besides the plagioclase. Amygdaloidal diabases are also found; the texture is ophitic, the plagioclase laths are polluted and of an acid composition (albite). The amygdales are filled up with calcite or with quartz and calcite. Magnetite is found in smaller or larger quantities in the diabases and in the porphyrites.

Tuffs and tuffites: The tuffs and tuffites are principally found in the region North and East of the town of Bahia Honda. They occur together with diabases and porphyrites. Macroscopically, the rocks are fine-grained, soft and easily weathered. The colour is light green or light gray. Under the microscope we can discriminate glass tuffs consisting of glass, polluted by a green-brown chloritic limonitic substance, with rare angular fragments of clear plagioclase. When these fragments appear in larger quantity, the glass tuffs grade into crystal tuffs. The tuffites often carry numerous *Radiolaria* and larger crystals of clear, well lamellated basic plagioclase. Quartz is rarely found, as already mentioned. The *Radiolaria* bearing tuffites are sometimes cut by veinlets of quartz and sometimes partly silicified. They grade into cherts.

Cherts: The cherts are green to black rocks, strongly cut by veinlets, which in thin-sections prove to be quartz and, in exceptional cases, calcite and quartz. The rocks are often strongly polluted by a limonitic substance, which causes a red-brown weathering. *Radiolaria* occur, e.g. at loc. H. 949, South West of Bahia Honda.

Serpentines.

Outcrops of Serpentine or of partly serpentinized rock occur in the regions, where San Andres formation and the Tuff Series are exposed. They appear as small bands, following the general trend of the strata. Often, but not always, the Serpentines are accompanied by rocks of the Habana formation, in which case the Serpentine seems to have acted as a "slide expedient", when overthrusting took place.

Only one large area of Serpentine is found between La Palma and La Mulata. The rocks form a large flat hill, a very distinct feature in the landscape, recognizable at a large distance.

Many inclusions are found in the Serpentines; part of these are clearly derived from the Tuff Series, whereas more metamorphic inclusions are of unknown origin. The latter are Amphibolites, Actinolite schists and Hornblende-Plagioclase rocks.

Dikes of a gabbroid nature occur especially in the Serpentine outcrops found in the Eastern part of the Tuff Series.

According to M. G. Rutten (64), the contacts of the Serpentine with the older formations in Santa Clara province are tectonical, formed by overthrusting. The greater part of the contacts of the Serpentine zones in the province of Pinar del Rio, support his opinion. Several Serpentine outcrops, found near or in the limestone hills of the San Andres formation, are covered by or cover Upper Cretaceous limestone-breccias, the occurrence

INTRODUCTION.

An expedition of the Utrecht University made a geological survey of different parts of the isle of Cuba during the spring and the summer of 1933. The members of this expedition were, the leader Prof. L. M. R. Rutten, Mrs. C. J. Rutten-Pekelharing, Miss A. Röntgen and the following students of geology at the Utrecht University, Dr. M. G. Rutten, Mr. H. J. Mac Gillavry, Dr. A. A. Thiadens, and the author.

From the 18th of May until the 9th of July, we worked in the Western part of Cuba, the province of Pinar del Rio. From the central camps, pitched in the towns of Pinar del Rio, San Diego de los Baños, San Cristobal, the members worked in different directions, whereas small parties consisting of two members surveyed the neighbourhood of Matahambre, La Esperanza, Bahia Honda, Cacarajicara (South West of Bahia Honda), Cabañas, Mariel. The busy traffic along the Carretera Central, Cuba's highway running along the axis of the island, enabled us to work even at large distances from the central camps. All notes made and all material collected by the members of the expedition in Pinar del Rio province were turned over to the author, who worked out the data in this paper.

For general orientation in the field we used military maps, kindly put at our disposal by the Cuban government. These maps, (scale 1 : 100000), proved to be insufficiently accurate in detail, so we had to survey our own roads. This was done by taking direction with a hand-compass and measuring the distances by counting our paces. The map constructed in this way proved to be more reliable than the military maps and sufficiently correct to sketch in our rough geological survey. A detailed geological survey would be impossible without reliable topographical maps.

In the laboratory at Utrecht we used as a basis for the construction of our map the nautical charts of the United States Navy. As fixed points were taken the towns of La Coloma on the Southern coast and Santa Lucia, Puerto Esperanza, Verracos, Puerto Blanco, Bahia Honda, Cabañas and Mariel on the Northern coast. As the reader will see, La Coloma is not to be found on our map. We knew, however, by pace-compass survey, the relative position of the town of Pinar del Rio with regard to La Coloma.

We further had at our disposal a special map of the Carretera Central. The direction of the road on this special map greatly differed from the direction of this same road on the military map, e.g. the town of Santa Cruz de los Piños is situated about 12 km to the North on the latter. We could check the directions of the Carretera Central at various places and as our observations tallied more or less with the military map, we ignored the special map of the highway.

the larger crystals are blueish pleochroitic (glaucophane). Albite is constantly found in large and smaller quantities. It is developed as very clear allotriomorphic poikilitic crystals. Also zoisite is always found, often in large quantities and in well developed crystals. Garnet is common in most of the amphibolitic rocks. Large, idiomorphic crystals are found in the glaucophane bearing rocks, e.g. loc. A. 773, North of San Cristobal. Muscovite crystals are accessory in most rocks. At loc. V. 726, North East of La Palma, however, large muscovite scales are numerous. Chlorite, titanite and ore are found as accessory minerals. The texture of the rocks is predominantly irregular and without linear arrangement of the minerals, with the exception of a rock found at loc. L. 877, South of La Palma, which shows linear structure. Other localities, where strongly metamorphic amphibolitic rocks were found, are: loc. A. 698, North East of San Cristobal, on the trail to Rosario, loc. M. 1053, South of Bahia Honda and loc. V. 818, near Saroa, which is situated North East of Candelaria.

The greater part of the amphibole plagioclase rocks occur in the Serpentine strip, which can be continued in East West direction South of Bahia Honda. Locs. in this vicinity, where these rocks were sampled, are Loc. M. 1041, M. 1068, M. 1069 and M. 1080. Another findspot of this kind of rock is loc. L. 905, North West of the town of Santa Cruz de los Pinos. The rocks always occur in the Serpentine regions, and we consider them to be inclusions, though geological evidence supporting this supposition is wanting. It is for instance also possible that dikes in the Serpentine have been altered under the influence of tectonical stresses into these hornblende plagioclase rocks.

Thin-sections of these rocks consist of allotriomorphic green and brownish-green, pleochroitic hornblende and an equal quantity of allotriomorphic, polluted plagioclase of andesine-labradorite composition. In cases, the plagioclase crystals are twinned and often they are sericitized. Linear structure occurs, e.g. at loc. M. 1068.

Gabbroid dikes: M. G. RUTTEN (64) mentions the occurrence of gabbroid dikes in the Serpentine areas in the Northern Santa Clara province. He draws the conclusion that the intrusion must have taken place before or during the orogenetic phase following the sedimentation of the Maestrichtian Habana beds, as the intrusions are only found in the Serpentine displaced by this orogenetic activity and not in the nearby situated other formations.

In four places gabbroid rocks were sampled in the province of Pinar del Rio. At locs. A. 731 and A. 733, South West of Cabañas, medium grained green and white speckled rocks consisting under the microscope of large twinned plagioclase of basic composition (labradorite), partly sericitized, and of diallage and rhombic pyroxene. Olivine is found in large quantities, and is partly serpentinized. Magnetite occurs as small crystals. A rock sampled at loc. V. 890, North East of La Palma is more altered. The diallage is partly uralitized, the plagioclase is andesine. Olivine and ore are lacking. A rock, found at loc. L. 946, North of Guanajay, agrees with those found at loc. A. 733. It contains numerous olivine crystals.

All the above mentioned findspots occur in the Serpentine or at its boundary, thus supporting RUTTEN's statement. An exception is loc. M. 1034, South of Bahia Honda, where a gabbroid dike occurs in the Tuff Series. Near to this loc. about 150 m to the South, however, Serpentine is found at loc. M. 1036. In the area between those two findspots tuffaceous porphyrites were noted but not sampled. Exact evidence is consequently wanting, and we may not draw any conclusions.

A rock, collected at the boundary of a Serpentine outcrop (loc. M. 1039, South of Bahia Honda) is a gabbro-diabase. A thin-section shows clear, well twinned lath shaped plagioclase. The composition is basic, varying from labradorite to bytownite. The texture is coarsely ophitic. The monocline pyroxene crystals are allotriomorphic and partly uralitized.

Dioritic rocks.

At two localities in the province of Pinar del Rio we found rocks allied to a dioritical magma. We shall proceed to describe the localities and the rocks separately.

Locality H. 985 is situated between Guane and La Sierra at the Eastern side of the road connecting both places. We drew a small sketch map on which the situation of the outcrops of the adjacent rocks are indicated (fig. 1).

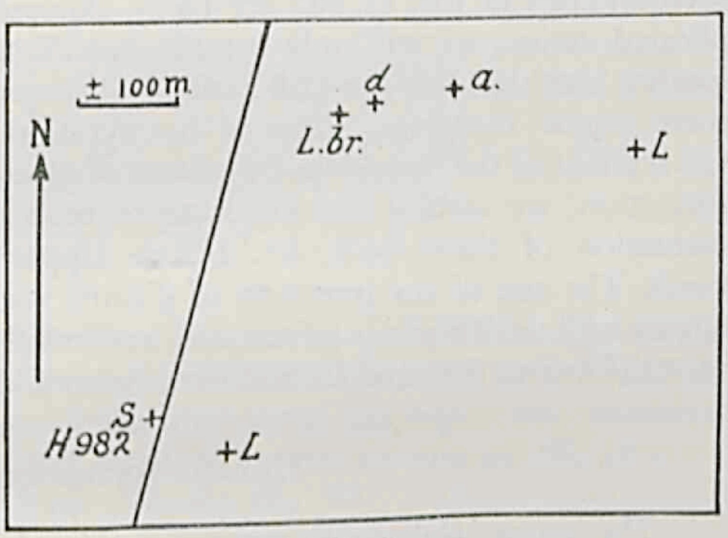

Fig. 1.

The dioritic rock (d on the map) is light grayish white of colour and coarse grained. Under the microscope the rock consists of strongly allotriomorphic quartz with cloudy extinction and of plagioclase, found in smaller quantities than the quartz, of an acid composition (albite) and clearly twinned. The lamels are bent, owing to the influence of tectonical stresses. Thin and irregular bands or patches of mica and chlorite and plates of muscovite occur.

To the West of this outcrop, limestone-breccias were noted (L br.), but not sampled. This limestone-breccia might be an outcrop of Habana formation of Mountain facies. To the East of the outcrop of dioritic rock we sampled a dark eruptive rock (a on the map), which in thin-section proved to consist of fibrous uralite and strongly polluted twinned plagioclase of oligo-andesine composition. Further to the East occur grayish-blue limestones (L on the map), which are also found South West of these outcrops. The limestones greatly resemble the limestones found intercalated in the San Andres formation. West of the last mentioned outcrop of limestone we find Serpentine exposed (S on the map).

On account of the possibility that Upper Cretaceous beds are found in the neighbourhood of the dioritic rock, the latter might be considered to occur as a large boulder in this formation. Taking into consideration the large size of the outcrop, which is several metres, we prefer to consider it as a leucocratic vein of the diorite magma, breaking through the older formations. However, the outcrop is insufficiently exposed, to form a definite opinion.

The other findspot of dioritic rock is situated North West of Bahia Honda at loc. V. 851. Nearby, to the North of this outcrop we find Serpentine exposed, whereas to the South tuffaceous rocks were noted and sampled. The dioritic rock is a strongly crushed diorite-pegmatite, consisting of quartz and felspar, showing for the greater part granophyric intergrowth. Fragments strongly resembling this rock are found frequently in the Habana formation. At the same locality we sampled a malchitic rock, of panallotriomorphic texture, consisting of basic plagioclase and partly chloritized amphibole and quartz. Zoisite and sphene are also found. We take both rocks found at this locality to be directly connected with the dioritic magma.

The age of the rocks at both localities is difficult to establish. As the surroundings of loc. H. 985 are badly exposed and, moreover, of a complicated nature, we will only consider loc. V. 851. The dioritic vein at this locality cuts through the Tuff Series and may be considered younger than these strata. However, signs of contact-metamorphism were not found. On account of the numerous fragments of dioritic rock found in the Habana formation, we assume the intrusion to have taken place before the sedimentation of these beds, i.e. before Upper Cretaceous (Maestrichtian) times. The age of the intrusion of dioritic rock in Pinar del Rio province agrees well with the age of the diorites found in Northern Santa Clara by M. G. Rutten (64) and in Southern Santa Clara by A. Thiadens. (74)

Habana formation.

The name Habana formation was used by Palmer (59) for Upper Cretaceous beds in the vicinity of the town of Habana. M. G. Rutten (64) applies the name Habana formation for beds of the same age exposed in Northern Santa Clara, carrying a fauna identical with the fossils found in the neighbourhood of Habana, but differing petrographically and lithologically. On account of the existence of practically the same fauna in the strata exposed in Pinar del Rio province, we also use the name Habana formation for these beds.

The Habana formation exposed in Pinar del Rio can be divided in two different groups of rocks, representing two sharply contrasting facies. One facies, which we called "Mountain facies", occurs in the mountain regions; its rocks have been wedged into the older rocks of the Tuff Series and of the San Andres formation. The other facies, called "Eastern facies" occurs in the sediment belt around the mountain region. These beds can only be separated from the Upper Eocene and Oligocene strata by paleontological evidence.

The position of the beds of Eastern facies seems to point to a younger age than that of the beds of Mountain facies found at the overthrusts in the San Andres formation and Tuff Series. The Upper Cretaceous-Lower Tertiary complex seems to be sedimentated against or upon the mountain complex. Difference of tectonic style in the two regions, together with the post-miocene faulting which fixed the recent shape of the mountains cause this impression. Both strata, Mountain facies and Eastern facies, however, carry the same *Foraminifera*, e.g. *Vaughanina*, *Orbitoides browni*, *Lepidorbitoides*, *Omphalocyclus*, *Torreina* and *Camerina sp.*, indicating the same age.

	FAUNA OF THE HABANA FORMATION OF EASTERN FACIES																																							
	A 545	A 647	A 674	A 677	A 678	A 730	A 740	A 754	H 774	H 787	H 788	H 802	H 870	H 880	H 893	H 898	H 954	H 951	L 817	L 818	L 930	L 949	L 955	L 957	L 973	M 933	M 940	M 966	M 1021	M 1038	M 1057	M 1063	M 1065	V 614	V 698	V 699	V 795	V 802	V 804	V 841	V 843
Rudists or Rudists fragm.	X	X	X		X		X		X	X	X	X	X		X		X?	X		X		X	X	X	X	X	X	X			X?	X?		X	X		X	X	X	X	X
Vaughanina sp.						X		X															X						X	X	X		X			X	X		X	X	X?
Small Camerina's				X		X		X	X								X		X			X	X						X	X			X								
Orbitoids			X	X	X									X	X	X					X									X											X
Orbitoides browni															X				X																			X			
Omphalocyclus sp.																							X														X		X		
Torreina sp.																						X																X			
Lepidorbitoides sp.						X		X															X						X		X?	X?	X			X			X	X	

	FAUNA OF THE HABANA FORMATION OF MOUNTAIN FACIES .																												
	A 684	A 685	A 761	A 773	H 822	H 825	H 832	H 904	H 905	H 923	H 927	H 928	L 887	L 983	L 985	L 1003	L 1013	L 1024	L 1053	M 914	M 938	M 1009	M 1046	M 1049	M 1073	V 820	V 826	V 875	V 881	V 894
Rudists or Rudists fragm.						X	X?	X?	X	X	X	X		X	X	X	X					X	X	X	X	X	X	X	X	X
Vaughanina sp.				X?	X									X	X	X?						X		X?			X?	X	X	
Small Camerina's														X	X	X				X	X						X			
Orbitoids	X	X		X	X	X	X						X			X	X					X						X	X	
Orbitoides browni			X												X			X	X							X	X			
Omphalocyclus sp.																	X													
Torreina sp.				X																										
Lepidorbitoides sp.															X													X		

Fig. 2.

Numerous well preserved Rudists were found in the Habana formation of Eastern facies, whereas in the beds of Mountain facies only fragments of Rudists are found. The possibility that these fragments are secondary deposits in younger strata is rejected by us on account of the presence of the same *Foraminifera* in both deposits (fig. 2).

Age of the Habana formation: On account of the occurring *Foraminifera*, especially the genera *Orbitoides*, *Omphalocyclus* and *Lepidorbitoides*, we reckon the Habana formation to be of Upper Cretaceous age, corresponding with the Maestrichtian of Europe. At two Rudist-findspots, loc. L. 818, North-West of the town of Pinar del Rio and loc. M. 940, North-West of Tranca, *Orbitoids*, e.g. *Orbitoides browni* were found, consequently we assume the Rudists beds to be of Maestrichtian age.

The disconformity with the older formations is found in the Eastern part of the Organos mountains, where the Habana formation is transgressive over the Tuff Series and the San Andres formation.

Pebbles and small rounded fragments of the Tuff Series and the San Andres formation are found regularly in the conglomerates and breccias of the Habana formation. Apart from pebbles of dioritic rock, found in coarse conglomerates of Upper Cretaceous or Upper Eocene age, we find dioritic material in rocks of undoubtedly "Habana-age". This occurs in rocks of both facies, e.g. at locs. M. 1038 and M. 1049, South of Bahia Honda, loc. A. 754, South East of Mariel, loc. V. 843, North West of Bahia Honda and at loc. H. 923, South East of Las Pozas. Partly these fragments show a fine intergrowth of quartz and felspar, characteristic for the diorite-pegmatites.

Although we found only a few traces of dioritic intrusions in Pinar del Rio, there must exist in the underground of the nearby regions dioritic rocks, from which the detritical material in the Habana formation has been derived.

Eastern facies of the Habana formation: As stated, the Habana formation of Eastern facies is difficult to distinguish from the Lower Tertiary strata. For this reason, the formations were given the same colour on the map. Only those places, where paleontological evidence indicates the exact age, were coloured red in case of the occurrence of Upper Cretaceous beds, whereas a special signature indicates beds of Upper Eocene or Oligocene age. A detailed survey will bring out whether the white chalks and marls and calcareous sandstones occurring in this region, must be reckoned to belong to the Upper Cretaceous or Lower Tertiary strata. We realise that the combining of Upper Cretaceous and Lower Tertiary on the map is far from satisfactory, the more so as a stratigraphical unconformity exists and a tectonical disconformity between the Upper Cretaceous and the Upper Eocene may be expected in analogy with the geology of the Santa Clara province (64). Evidence of this angular unconformity has not been found by us in the Pinar del Rio province.

The localities, where rocks of the Habana formation of Eastern facies are found, are given in table on page 23, together with the occurring *Foraminifera*, Rudists and Rudists fragments, which established the age. The *Foraminifera*, however, occur for the greater part in thin-sections of rocks; thus reliable and typical sections were not always obtained. The mutual association of *Foraminifera* or the association of them with Rudists or Rudist fragments ascertain sufficiently, in our opinion, the age of the rocks. Under the head "Orbitoids" were put down *Foraminifera*, showing indistinct affinities to Upper Cretaceous genera. Their state of preservation is often very bad on account of recrystallization. This recrystallization is not found in specimens of Upper Eocene age. The small *Camerinas* show affinities to *Camerina dickersoni* described by Mrs. D. PALMER (57) from the Upper Cretaceous beds in the Habana province.

For those, interested in well preserved Rudists, we draw the attention to the locs. A. 645, A. 647, H. 774, H. 787, H. 802, H. 870, H. 961, L. 818, M. 938, M. 940, M. 966, V. 614, V. 843a. The material collected by us at these localities has already been described by the author in a paper, accepted for publication by the Journal of Paleontology.

Description of rocks of Habana formation Eastern facies: The rocks are for the greater part fine conglomerates or conglomeratic calcareous sandstones. They are white to gray in colour, in contradistinction with the rocks of Mountain facies, which are dark grayish-blue. They carry a large amount of calcareous matrix. The constituents of the rocks are clear, rounded or angular quartz, well-lamellated and non-lamellated pagioclase of a basic composition (labradorite). The size of the quartz and felspars varies in different rocks from small to large. Rounded porphyrite fragments are always present, in cases even form the main constituents. The porphyrites consist of smaller or larger basic plagioclase phenocrysts in a vitric groundmass, often coloured red by iron infiltration. In cases, when the matrix is more crystalline, it consists of small plagioclase laths and small magnetite ore grains. We mentioned already the occurrence of detritical diorite fragments. Occasionally we find rounded fragments of phyllitic and quartzitic rock, clearly derived from the San Andres formation. These constituents dominate in a rock found at loc. L. 930, North of the town of Cayajabos. Chert fragments, amphibole crystals and zoisite grains rarely occur.

Apart from the conglomerates and the calcareous sandstones we find white to gray limestones or sandy limestones, from which the Rudists may originate ; they have been principally collected out of loose soil, more or less nearby the thin ($\frac{1}{2}$ m) limestone beds.

Also marly, lightcoloured limestone breccias and pure limestone conglomerates are found.

Mountain facies of the Habana formation: Rocks of Upper Cretaceous age (Maestrichtian of Europe) are found wedged into the San Andres formation and the Tuff Series. Exposures of these rocks are found at the foot of many typical "Mogotes" in the Western part of the Organos mountains throwing a new light on the tectonics of this region. Each outcrop, often accompanied by Serpentine, points to an anomalous contact with the older formations. We found them numerously in the Eastern part of the Organos mountains and also in the small area North of Guanajay, were the beds occur partly as steep infoldings.

The rocks of Mountain facies of the Habana formation are, in the field, in many cases difficult to distinguish from the limestones of San Andres formation or Tuff Series. Only the coarser conglomerates or breccias were recognized in the field as Upper Cretaceous strata, because of the Rudists fragments often macroscopically visible. Thin-sections of breccious limestones, sampled by us as "Viñales" limestones proved to be Upper Cretaceous Habana rocks. We mention these errors to show that a part of the outcrops of rocks of Mountain facies, were found more or less by chance. With the knowledge, now obtained in the laboratory, a survey would yield more satisfactory results.

With respect to the fauna found in the rocks of Mountain facies, the same considerations we made with regard to the fauna of rocks of Eastern facies, hold true: consequently, we refer to them. The localities with their respective faunas are given in the table on page 23.

The rocks of the Habana formation of Mountain facies can be divided into two different kinds. One is a coarse to fine bituminous breccia or conglomerate. Its main elements are dark, grayish-blue limestone fragments, derived from the limestones of the San Andres formation and Tuff Series. Porphyritic pebbles, often consisting of basic plagioclase phenocrists in a vitric matrix, occur often. Slaty, phyllitic and quartzitic pebbles are numerous in certain parts, for instance around Cacarajicara, an asphalt mine, South West of Bahia Honda (locs. H. 904, H. 923, H. 927, H. 928). A coarse limestone-breccia collected at loc. H. 906, also in this region carries fragments of pink limestone, the bedrock of which is unknown to us in the Pinar del Rio province. Thin-sections carry sometimes a suboolitic limestone, mentioned from the San Andres formation at p. 15. Further common constituents of the limestone-breccias are clear quartz, acid to basic plagioclase and chert fragments often carrying *Radiolaria*. The occurrence of dioritic material has been already mentioned. The rich amount of the dark grayish-blue limestones in the coarse breccias indicates, that the Upper Cretaceous transgression did not cover all parts of the San Andres formation and Tuff Series. Small isles, probably emerged from the shallow water, supplying the material for the limestone breccias of the Habana formation.

The other rock is a sandstone. The matrix is a brownish-green, chloritic limonitic, calcareous substance. In this matrix we find polluted acid to basic plagioclase as main constituent. Quartz, porphyrite and diorite fragments are in the minority. The difference with the calcareous sandstones of the Eastern facies are the relative large amount of felspar, the small amount of quartz and the impure matrix ; the difference with the rocks of the Tuff Series is the occurrence of quartz and of dioritic material. Indeterminably small *Foraminifera* rarely occur, so that an exact age determination on paleontological data was impossible. On account of the occurrence of dioritic material we favour an Upper Cretaceous age of the beds. The other possibility, that the strata are younger and part of the Upper Eocene, does not seem probable, as we never found evidence of Eocene beds wedged in with the Upper Cretaceous layers in the mountain region.

The beds are found, e.g. North of La Palma at loc. L. 874. The greenish sandy rock consists chiefly of twinned plagioclase felspar, of albiteoligoclase composition, rounded and splintered quartz crystals, rounded porphyrite fragments, dioritic material, chert fragments, greenish brown pleochroitic biotite and muscovite plates. The matrix is a mixture of chlorite-limonite and calcite. Rocks which principally resemble the above described rock are found at loc. M. 949, North East of Viñales, loc. M. 919, North East of Sumidero, loc. M. 914, South West of Sumidero, together with a limestone breccia, carrying small *Camerinas* showing affinities with *Camerina dickersoni* (Upper Cretaceous), loc. L. 1053, East of San Vicente, together with a limestone breccia in which *Orbitoides browni* was found, loc. M. 958, North of San Diego de lós Baños and at loc. V. 950, East of Guane. All localities mentioned above are situated in the Western part of the Organos mountains ("Mogote" regions).

Pebbles in conglomerates of Upper Cretaceous or Eocene age.

Coarse conglomerates are a typical feature in the Upper Cretaceous-Lower Tertiary strata running from San Juan y Martinez to San Diego de los Baños. We shall discuss the constituents of the conglomerates more fully.

One of the richest findspots of pebbles of different nature is loc. A. 608, West of the town of Pinar del Rio, where several samples were collected. Numerous are porphyritic or diabase rocks, the greater part of them strongly weathered and altered. Some of the porphyrites are silicified, and only the two generations of plagioclase felspars can be recognized. The diabases show an ophitic texture, the augites are for the greater part uralitized, the plagioclase felspars are of an acid composition (oligoclase), ore in the form of ilmenite is common, accessory minerals are apatite and sphene. Quartz is often found as a rest-crystallization. The above described rocks are clearly allied to the rocks of the Tuff Series. Rocks deriving from a dioritic magma are also found at loc. A. 608, e.g. an albitite, constisting of polluted plagioclase felspars often granophyriccally intergrown with quartz. Accessory minerals are sphene and epidote and ore. A pebble of malchitic rock consists of twinned plagioclase felspars of a basic composition (andesine-labradorite), clear, strongly allotriomorphic quartz and amphibole. The amphibole crystals are blueish-green pleochroitic and idiomorphic. Accessory minerals are sphene, apatite and magnetite. Blue and violet limestone pebbles occur, probably derived from the San Andres formation; also a white limestone, carrying corals and *Lithothamnium*. One pebble contains a badly preserved *Orbitoid*, pointing to a post-Upper Cretaceous age of the conglomerate at least.

At loc. L. 849, North East of San Diego de los Baños, porphyritic and dioritic pebbles are found. One rock is a diorite-aplite, consisting or allotriomorphic quartz and plagioclase crystals. The plagioclases are sometimes twinned and of an acid composition; they are partly sericitized and contain quartz globules. Some muscovite plates occur, and a few large apatite crystals. Another pebble, which is probably connected with the diorite, is a mica gneiss ; the quartz shows cloudy extinction and a sutured texture. The plagioclase is of an acid composition (albite) and in places granophyriccally intergrown with quartz. Biotite and muscovite occur, the latter in large quantities and as well developed plates, sometimes slightly bent. Apatite is found as an accessory mineral. A rock of the same nature was found at loc. H. 803, West of San Diego de los Baños.

South West of San Diego de los Baños at loc. H. 791, a diorite-pegmatite pebble was collected. The structure is coarse crystalline. Main constituents are large, idiomorphic, polluted, twinned albite crystals and granophyrically intergrown plagioclase and quartz. Accessory minerals are sphene, chlorite and ilmenite. The findspot of this pebble is in the Eocene area on the map. Paleontological evidence establishing the Eocene age nearest to loc. H. 791 is loc. H. 792, where white limestones carry e.g. *Dictyoconus*.

Upper Eocene.

The Upper Eocene strata, which are found in the band of transgressive formations (Upper Cretaceous and Tertiary), exposed South, East and North East of the Organos mountains, consist of white limestones, conglomerates, calcareous sandstones, marls and chalks. We already mentioned the difficulty of separating the Habana formation (Upper Cretaceous) from the Upper Eocene and Oligocene beds. Where paleontological evidence, in most cases consisting of *Foraminifera* was found, the Upper Eocene layers were given a special signature on the map.

The Upper Eocene age of the beds was established by the occurrence of Larger *Foraminifera* of the genera *Dictyoconus*, *Camerina*, *Lepidocyclina*, *Helicolepidina* and *Discocyclina*. The *Foraminifera* occur in different kinds of rock. At loc. L. 829 they are found in calcareous sandstones, together with fragments of Rudists, which clearly are a secondary deposit. As one is inclined to attribute a Maestrichtian age to those strata were Rudist fragments are found, this occurrence in the Upper Eocene beds proves that careful examination for other paleontological data is required. At loc. L. 831 *Foraminifera* of the genera *Dictyoconus*, *Camerina*, *Lepidocyclina* and *Discocyclina* were found in a coarse conglomerate, containing porphyrites and pebbles of grayish blue limestones and cherts, derived from the San Andres formation. Rounded fragments of Rudists also occur. Around the town of Guanajay the Upper Eocene *Foraminifera* are found in white marls and white limestones (Locs. M. 1029 and H. 971). At loc. V. 804, North East of Cayajabos, some rocks were sampled, which were derived from an unknown depth out of an asphalt mine. The conglomeratic rock carries *Omphalocyclus* (Maestrichtian) and badly preserved *Discocyclinae*. Either the *Omphalocyclus* is a secondary deposit or the *Discocyclinae* appear already in the Maestrichtian. Nearby, at loc. V. 802, we find rocks carrying Rudist fragments, *Orbitoides browni* and *Omphalocyclus*, a typical Maestrichtian fauna.

Apart from the larger *Foraminifera*, numerous smaller *Foraminifera* e.g. *Miliolidae*, *Globigerinidae*, *Carpenterias* etc. occur. As they are found principally in thin-sections of limestones, no specific determination was possible.

In a recent publication CUSHMAN and BERMUDEZ (26) describe several smaller *Foraminifera* of Upper Eocene age, which were collected about 4.5 km. North of Guanajay on the road to Mariel. These *Foraminifera* belong to the genera *Bolivina*, *Virgulina* and the new genera *Rectoeponides*, *Stichocibicides* and *Neocarpenteria*. In a second publication the same authors (27) treat some new species of the genera *Cycloloculina*, *Siphonina* and *Cribrogloborotalia*. They were collected at Bermudez station 337 A., which is the same locality where the material studied in the former publication was derived from. However, the situation of this findspot is now said to be found in the last paper 4.5 km West of Guanajay instead of to the North. On account of this controversy we did not mark these Eocene beds on our map.

WEISBORD (84) describes some Eocene, probably Upper Eocene Echinids, collected at a locality situated on the road from San Diego de los Baños to the Carretera Central. We do not agree to his statement that Middle Eocene might occur along this same road, as we have no paleontological evidence supporting this.

The Upper Eocene strata were strongly folded during the inter-Oligocene orogenesis. Evidence of a structural unconformity between the Upper Cretaceous and the Upper Eocene was not found in Pinar del Rio.

Oligocene.

Paleontological data establishing the Oligocene age of layers were only found by us at a few localities. The marls, white limestones and sandstones show a great resemblance with the Upper Eocene strata. The Oligocene beds carry larger *Foraminifera* of the sub-genera *Nephrolepidina* and *Eulepidina*. At loc. M. 1027, West of Guanajay, Oligocene sandstones, carrying *Lepidocyclina favosa* lay concordant upon white limestones and marls of Upper Eocene age. In two localities, North of Guanajay at loc. L. 941 and North of Candelaria at locs. V. 782 and V. 783, white limestones carry *Lepidocyclina* of an eulepidine type. On account of the occurence of these *Foraminifera* in limestones, the more or less accidental thin-sections through them did not show clear characters of the fossils to justify a specific determination. We did, however, get the impression that *Lepidocyclina favosa* occurs, on which fact the Oligocene age of the limestone beds is based. HADLY (37) describes numerous smaller *Foraminifera* collected by Mr. NORMAN E. WEISBORD, 50 m South East of the entrance gate to the Cuban Naval Academy at Mariel. The *Foraminifera* have been collected from a white marl, to which HADLY ascribes an Oligocene, probably Upper Oligocene age. As the situation of this findspot is exactly known, we put it down as Oligocene on our map.

Oligomiocene beds.

This formation is widespread in the province of Pinar del Rio. It is exposed from Fueyo in the West to Guanajay in the East. Numerous outcrops of this formation are found especially along the Carretera Central, between Pinar del Rio and Guanajay. The formation is also found along the Northern coast of Pinar del Rio, between the towns of Mariel and Bahia Honda.

The Oligomiocene strata cover the steeply folded older formations unconformably, their position being either horizontal or with slight dips of less than 10 degrees. The dips are directed to the South in the Southern regions e.g. between Consolacion del Sur and Santa Cruz de los Pinos; to the North in the Northern parts e.g. North of Mariel. However, our observations in the Northern part are scarse; therefore our discussion is mainly founded on facts collected in the Southern parts.

The principal element of these Oligomiocene strata is a white or tan, porous, fossiliferous limestone, corresponding with the Guinness limestones described by PALMER (59) from the vicinity of the town of Habana and by M. G. RUTTEN (64) from Northern Santa Clara. Apart from the limestones we find large areas consisting of red to purple and yellow clays, sandstones and marls. These beds belong to the Oligomiocene strata as they carry the typical Oligomiocene fauna. This is for instance the case at locs. L. 757 and L. 758, North of the town of Pinar del Rio, where *Amphisorus matleyi* and *Archaias* sp. were collected from red brown sands.

In large areas, which are reckoned by us to the Oligomiocene, outcrops are scarce. The typical cavernous limestones only rarely outcrop from a red soil, often covered with "perdigones", the local name for limonitic iron concretions. Sometimes we find coarse conglomerates, consisting mainly of quartzite and phyllite pebbles, derived from the San Andres formation. We have no evidence which establishes the age of these beds, however, we assume an Oligomiocene age but they may be younger.

The thickness of the typical Oligomiocene beds was measured along the road from San Diego de los Baños to the Carretera Central. The minimal thickness amounts to about 300 metres.

The Fauna of the Oligomiocene rocks consists of *Foraminifera*, *Gastropoda*, *Lamellibranchiata*, *Echinidae* and *Anthozoa*. Especially the *Foraminifera* are practically found in each sample of sandy rock or limestone. The most common *Foraminifera* are *Amphisorus matleyi* and *Archaias* sp.; often, but less frequently *Miogypsina* sp. is found. Apart from the *Miliolidae* numerous smaller *Foraminifera* occur. As they occur in thin-sections of the limestones, no determination of this material was attempted. A few

Echinidae were sufficiently preserved for determination. This was done by Mr. J. van Soest, at the laboratory of the Utrecht University. The species *Clypeaster lanceolatus* was discerned. A full description of this species is given in the paleontological part of this paper. Moulds and casts of *Gastropoda* are abundant in the limestone beds. A determination of the *Lamellibranchiata* and the Corals was not made as the age of the beds is sufficiently established by the *Foraminifera* and the *Echinidae*.

Age of the Oligomiocene beds: The Guinness limestones are reckoned by Palmer (59), who gives a summary of the former opinions on the age of these beds, to be a "transitional phase between the Upper Oligocene and the Lower Miocene." He mentions the presence of *Lepidocyclina* and *Miogypsina* in the Guinness limestones. With regard to the latter, we fully agree with Palmer. *Miogypsina*, together with *Amphisorus matleyi* and *Archaias* are typical for the horizontal or slightly dipping Oligomiocene strata. *Amphisorus matleyi* from the Miocene beds in Jamaica has been described by Vaughan (80). *Lepidocyclina*, however, was not found by us associated with *Miogypsina* or *Amphisorus matleyi*. *Lepidocyclina* occurs, so far as we know, in Pinar del Rio, only in the steeply folded strata, underlying unconformably the Oligomiocene beds. *Clypeaster lanceolatus* has been described by Cotteau (22) from the Miocene beds of Matanzas, whereas Lambert (42) reports the occurrence in the Miocene of Antigua. In Jackson's opinion (41), who studied material from Panama and from the vicinity of the town of Habana, it should be an Oligocene species. At the findspot of *Clypeaster lanceolatus* in Pinar del Rio, loc. V. 774, North East of San Cristobal, we noted the occurrence of fossils characteristic for the slightly folded Oligomiocene beds, e.g. moulds and casts of *Gastropoda*, *Lamellibranchiata* and *Amphisorus matleyi*.

Chapter III : **TECTONICS.**

Contrary to former opinions, already mentioned in this paper in the discussion of the San Andres formation, we consider the first orogenetic phase to have occurred after the sedimentation of the Tuff Series, between the Lower Cretaceous and Upper Cretaceous time. The axis of the large anticline, which was the result of this orogenetic activity and of which the Southern flank is exposed only in the Western part of Pinar del Rio, runs in the Western part in a South West to North East direction, dipping to the South West. The general strike gradually changes to the East in West East direction, turning to North North West — East South East in the neighbourhood and North of San Diego de los Baños.

The topography of the limestone hills in this Western part of Pinar del Rio follows the same directions, accentuating the general strike and supporting our opinion that the "Mogotes" are intercalated in the quartzite phyllite beds. If the limestones covered unconformably an already strongly folded quartzite phyllite complex it would be highly improbable that owing to a later orogenesis, the strike of the limestones beds would run in practically the same direction as the strike of the quartzite phyllite beds.

A few deviations of the Northern dip of the Northern wing of the anticline are found. This is for instance the case North West of Sumidero where we found several Southern dips and one well developed, small, local anticline at loc. V. 567. The latter was clearly overturned to the South East. Horizontal limestones, only slightly dipping to the East and West in places and in no way differing from the ordinary limestones intercalated in the quartzite phyllite beds of the San Andres formation, were found along the road from Guane to La Sierra at loc. H. 980.

In the Eastern part of the Organos mountains the strikes of the San Andres formation and the Tuff Series runs rather irregularly, more or less in a West to East direction. The younger parts of the Northern flank of the anticline are exposed in this region (Tuff Series), while a small secondary anticline is developed North of Bahia Honda, where tuffaceous rocks are again exposed. The Tuff Series runs into the sea between La Mulata and Verracos.

At the Southern boundary of the Eastern part of the San Andres formation we found occasionally Southern dips. It is possible, that the anticlinal axis found in the Western part, may be continued along the above mentioned Southern boundary.

East of the Organos mountains the older structures are covered by the Upper Cretaceous and Lower Tertiary strata. The older structures rise to the surface again between the towns of Mariel and Guanajay, where they appear to be folded in detail with irregular Southern, vertical, and Northern dips.

A second orogenetic phase may have taken place after the sedimentation of the Habana formation upon the partially eroded older structures and before the sedimentation of the Lower Tertiary.

After the sedimentation of part of the Oligocene conformably upon the Upper Eocene in the regions around the mountain district a new inter-Oligocene orogenesis occurred. The direction of the strikes of the Upper Eocene and Oligocene beds in the Eastern part of Pinar del Rio, runs generally from West to East, but is also often irregular. On the whole, the dips do not exceed 50 degrees.

The Upper Cretaceous and the Lower Tertiary, exposed South of the boundary of the San Andres formation, show strikes running more or less parallel with the strikes in the San Andres formation. The fact, that the general trend of the second and third orogenesis runs parallel to that of the first, weakens our supposition, made in the beginning of this chapter, that we could expect a different trend in the limestones to that in the quartzite phyllite formation, if an angular disconformity between the two should be found. When, however, limestone beds with a certain strike are present in the underground, we may expect an influence, even a dominating influence, of this resistant structures upon the trends of the later orogenesis. We refer to the neighbourhood of San Diego de los Baños, where the Upper Eocene layers exposed along the road to the Carretera Central, show the same directions of the strike as the San Andres formation (Loma La Guira). The different Rudists findspots, nearby, which may be expected to occur in one level, show a direction crossing the direction of the strikes of the Upper Eocene and San Andres formation. If the findspots of the Rudists, collected out of loose soil, may be reckoned to mark more or less the strike of the Rudists beds (Habana formation), we should have at this place an indication of an angular disconformity between the Habana formation and the Upper Eocene.

In the Southern band of transgressive formations we find generally a Southern dip, with one exception: North East of Consolacion del Sur, where in the core of an anticline the Habana formation outcrops.

In the mountain regions we find the Habana formation of Mountain facies wedged into the San Andres formation and into the Tuff Series. The position of the limestone breccias (Habana formation) at the foot of the "Mogotes" and in the valleys cut through the limestone hills, clearly points to an anomalous contact with the older formations. In the region of the San Andres formation the beds of the Habana formation are often found accompanied by Serpentine. We suggest, that along the soft and smooth surface of the Serpentine rock, overthrusting took place.

From the regions surrounding the mountains we have evidence of an inter-oligocene orogenesis. In the Northern Santa Clara province (64) and in the Southern Santa Clara province (74) we have evidence of an orogenetic phase between the Upper Cretaceous and the Upper Eocene. Either the latter or the inter-oligocene orogenesis caused the overthrusting (wedging) in Pinar del Rio. With regard to the nature of the overthrusting, it appears to be superficial. The beds of the Tuff Series and the beds of the San Andres formation were not displaced with regard to each other. At the anomalous contacts, in the San Andres formation, no rocks of the Tuff Series are found. Even near the boundary between the formations, no evidence of an anomalous contact between the San Andres formation and the Tuff Series has been found. The occurrence of rocks of the San Andres formation in the Tuff Series is, however, difficult to ascertain as the limestones and cherts, the principal elements of the San Andres formation in these parts, are not to be distinguished from the same beds occurring in the Tuff Series. However, rocks of Cayetano facies, typical elements of the San Andres formation have never been found near the anomalous contacts in the Tuff Series.

In some regions of the San Andres formation we find a gentler type of orogenesis. Instead of overthrusts we find the beds of Habana formation of Mountain facies exposed in the synclines. This is for instance the case North of the town of La Palma and in the strata exposed North of Guanajay which are also reckoned by us to the San Andres formation. The tectonic style of the latter parts resembles the tectonic style found in the regions, where the beds of Habana formation of Eastern facies are exposed.

In the greater part of the outcrops of Habana formation of Mountain facies, no strike or dip could be measured. Only in a few localities, did we feel justified to connect some nearby outcrops. However, the outcrops seem to occur in bands running parallel to the limestone hills in the Western part and also parallel to the strike of the San Andres formation and Tuff Series in the Eastern part. The former is demonstrated along the Northern boundary of the Sierra Ancon, West of San Vicente, where in all probability three outcrops of Habana formation of Mountain facies may be connected with each other. If this holds true, we see that, as in the younger sediment belt around the mountains, the trend of the pre-maestrichtian orogenesis runs parallel to that of the post-maestrichtian, orogenetic phase.

The fourth and last orogenetic phase occurred after the deposition of the Oligomiocene beds. This orogenetic phase, however, is not to be compared with the former ones, which were much stronger. The maximum dip of the Oligomiocene beds is 10 degrees, while often they are found in horizontal position.

Post-Miocene faulting fixed the Southern boundary and the recent shape of the Organos mountains. We based the presence of this fault chiefly on morphologic arguments.

As the larger structures are clearly shown on our geological map, we did not draw any sections. Of the detailed structures, we have insufficient data to compose sections, that would approach reality, so we prefer to leave them out.

Chapter IV : **PALEONTOLOGY.**

Parts of the fossils collected by us in the province of Pinar del Rio have been or will be described in other papers in order to make the results more accessible to those interested chiefly in paleontological matters. The faunal lists with the findspots given in a previous chapter and in a paper already published, are copied in this chapter, in order to give a complete summary of the occurring fossils.

The *Aptychi* collected from the beds of the San Andres formation were studied by Prof. TRAUTH (79).

The Ammonites, also collected from the San Andres formation will be specifically determined by Prof. JAWORSKI, who will publish the results of his study in due course. His preliminary investigation fixed the age of the different parts of the San Andres formation.

Some well preserved Echinids were studied by Mr. J. VAN SOEST. The description of them is published in this paper.

The Larger *Foraminifera*, collected out of the Habana formation, Upper Eocene and Oligocene were specifically determined by the author ; the results will be given below.

The Rudists of the Habana formation were also studied by the author. The paper, describing several new species and giving a supplementary description of some known species, will be published in the Journal of Paleontology.

Faunal lists: We shall first give a list of the fossils, the occurrence of which is not confined to a special formation.

Globigerinidae at localities: A. 606, A. 711, H. 820, H. 897, H. 898, H. 970, H. 973, H. 975, L. 924, L. 935, L. 938, L. 940, L. 994, L. 999, L. 1000, M. 1038, V. 790, V. 804.

Radiolaria at localities : H. 820, H. 821, H. 949, L. 916, L. 930, M. 959, M. 1061.

Miliolidae at localities : A. 600, A. 604, A. 621, A. 623, A. 626, A. 684, A. 685, A. 721, A. 726, A. 730, A. 737, H. 801, H. 832, H. 873, H. 880, H. 893, H. 895, H. 896, H. 898, H. 923, H. 970, L. 757, L. 761, L. 832, L. 835, L. 836, L. 838, L. 840, L. 841, L. 913, L. 926, L. 997, M. 905, M. 927, M. 1009, V. 696, V. 699, V. 781, V. 795, V. 804, V. 826, V. 843, V. 919.

List of fossils from the San Andres formation.

Fossils :	Localities :
Ammonites	L. 787a, L. 894, V. 585, V. 869.
Lamellaptychus rectecostatus (*Pet.*) em. Trauth	V. 826.

Lamellaptychus angulocostatus (Pet.) *f. type*	V. 826, V. 868.
Lamellaptychus angulocostatus (Pet.) *var. atlantica* (Henn)	A. 653, V. 826.
Lamellaptychus seranonis (Coqu.)	V. 826.

List of fossils from the Habana formation.

Fossils :	Localities :
Vaughanina sp.	A. 730, A. 754, A. 773 ?, H. 822, L. 955, L. 983, L. 985, L. 1003 ?, M. 1009, M. 1021, M. 1038, M. 1049 ?, M. 1057, M. 1065, V. 699, V. 795, V. 804, V. 826 ?, V. 841, V. 843 ?, V. 875, V. 881.
Camerina sp. (? *dickersoni* D. Palmer)	A. 677, A. 678, A. 754, H. 774, H. 954, L. 817, L. 949, L. 955, L. 983, L. 985, L. 1003, M. 914, M. 938, M. 1021, M. 1038, M.1065, V. 826.
Orbitoids	A. 673, A. 677 ?, A 678, A. 684, A. 685, A. 773, H. 822, H. 823, H. 832, H. 880, H. 893, H. 898, L. 887, L. 930, L. 1003, L. 1013, M. 1009, M. 1038, V. 843, V. 875, V. 881.
Orbitoides apiculata (Schlumb.)	M. 940.
Orbitoides browni (Ellis)	A. 761, H. 893, L. 817, L. 985, L. 1024, L. 1053, V. 802, V. 820, V. 826.
Omphalocyclus macropora Bronn	L. 758.
Omphalocyclus sp.	L. 955, L. 1013, V. 795, V. 804.
Torreina sp.	A. 773, L. 930, V. 802.
Lepidorbitoides sp.	A. 730, A. 754, L. 955, L. 985, M. 1021, M. 1057 ?, M. 1062 ?, M. 1065, V. 699, V. 804, V. 841, V. 875.
Orbignya mullerriedi Vermunt	L. 818.
Orbignya sp.	H. 774.
Vaccinites macgillavryi Palmer	H. 787, M. 966.
Vaccinites sp.	H. 961.
Pironea cf. *peruviana* Gerth	L. 818.
Barrettia sparcilirata Whitfield	H. 774.
Barrettia monilifera Woodward	H. 802, H. 870, M. 966.
Barrettia multilirata Whitfield	H. 802, H. 870.
Parastroma cf. quitarti Palmer	H. 787.

Torreites sanchezi (Douvillé)	H. 870.
Radiolites macroplicatus Whitfield [1])	H. 787, H. 802, M. 966.
Biradiolites cubensis Douvillé	H. 787, H. 802.
Biradiolites cf. aquitanicus Toucas	H. 870, M. 938.
Biradiolites tschoppi Vermunt	H. 870.
Biradiolites macgillavryi Vermunt	H. 802.
Biradiolites sp.	H. 774, H. 802.
Biradiolites sp.	H. 802.
Bournonia thiadensis Vermunt	H. 774, M. 938.
Bournonia sp.	H. 774.
Durania palmeri Vermunt	V. 843*a*.
Durania sp.	V. 843*a*.
Tampsia rutteni Vermunt	H. 870.
Chiapasella pauciplicata Müllerried	H. 774, V. 614.
Chiapasella cubensis Rutten	H. 870.
Chiapasella sp.	H. 870.
Titanosarcolites giganteus Whitfield	A. 645, A. 647, H. 774.
Plagioptychus sp.	H. 787, H. 870.
Sphaerucaprina sp.	H. 787, V. 614.
Caprinula cf. annulata Palmer	H. 774.
Caprinidae	H. 774, M. 940.
Rudists fragments	A. 674, A. 678, A. 740, H. 788, H. 823, H. 832, H. 893, H. 904, H. 906, H. 923, H. 927, H. 928, H. 954, L. 949, L. 955, L. 957, L. 973, L. 983, L. 985, L. 1003, L. 1013, M. 937, M. 968, M. 1009, M. 1032, M. 1046, M. 1049, M. 1057, M. 1062, M. 1073, M. 1077, V. 698, V. 795, V. 802, V. 804, V. 820, V. 826, V. 841, V. 843, V. 875, V. 881, V. 894.

List of fossils from the Upper Eocene.

Fossils :	Localities :
Dictyoconus sp.	H. 792, H. 841, L. 829, L. 831, V. 536, V. 696.
Camerina petri M. Rutten	L. 829, L. 831, M. 1028.
Camerina malbertii M. Rutten	M. 1028.
Camerina sp.	A. 602, L. 832, V. 536, V. 538, V. 696.
Operculina floridensis (Heilprin) Cushman	L. 831.
Heterostegina antillea Cushman	L. 831.
Lepidocyclina pustulosa H. Douvillé	L. 831, M. 1028.

[1]) Thiadens (73).

Lepidocyclina mortoni Cushman	L. 831.
Lepidocyclina meinzeri Vaughan	L. 831, M. 1028.
Lepidocyclina marginata Michelotti	M. 1028.
Lepidocyclina piedrasensis Vaughan	M. 1028.
Lepidocyclina semmesi Vaughan and Cole	M. 1028.
Lepidocyclina sp.	H. 792, L. 827, L. 831, L. 832, L. 1000, V. 536, V. 538.
Helicolepidina spiralis Tobler	M. 1028.
Discocyclina marginata Cushman	L. 831.
Discocyclina cf. clarki Cushman	L. 829, L. 831.
Discocyclina sp.	A. 602, A. 603, H. 896, L. 827, L. 829, L. 832, V. 536, V. 538.
Discocyclina (*Asterocyclina*) sp.	H. 896, V. 536.

List of fossils from the Oligocene.

Fossils :	Localities :
Camerina petri M. Rutten?	H. 971.
Camerina sp.	A. 720, V. 784.
Lepidocyclina piedrasensis Vaughan	H. 971.
Lepidocyclina dilatata Michelotti	H. 971.
Lepidocyclina favosa Cushman	H. 971, M. 1027.
Lepidocyclina sp.	A. 720, L. 941, V. 782, V. 783.

List of fossils from the Oligomiocene.

Fossils :	Localities :
Amphisorus matleyi Vaughan	A. 600, A. 620, A. 621, A. 622, A. 623, A. 624, A. 626, A. 712, H. 762, H. 968, L. 757, L. 758, L. 761, L. 835, L. 836, L. 838, L. 840, L. 841, L. 913, L. 1008, M. 905, M. 927, M. 968, M. 1007, M. 1024, V. 776, V. 777, V. 780, V. 781, V. 919.
Archaias sp.	A. 624, A. 711, H. 762, L. 757, L. 761, L. 835, L. 840, L. 841, L. 1008, M. 905, M. 1007, V. 776, V. 777, V. 780, V. 781.
Camerina sp.	V. 776, V. 777.
Miogypsina sp.	A. 621, A. 623, A. 624, A. 626, H. 895, L. 757, L. 761, L. 838, L. 840, L. 841, L. 1008, M. 905, M. 1007, V. 776, V. 777, V. 780, V. 781.
Clypeaster lanceolatus Cotteau	V. 774.

Systematic descriptions:

Genus Dictyoconus Blanckenhorn, 1900.

Dictyoconus sp.

Plate, figure 6.

The test is conical and the texture coarse. The chamberlets of the marginal trough are divided into 2 to 4 cellules. The distance of the platforms at the base is 160 μ to 250 μ. Diameter of the base, 2.4 mm to 3.6 mm. Height 2 mm to 3 mm. The general appearance of the specimens resembles that of *Dictyoconus americanus*. However, the large distance between the platforms at the base is more in agreement with *Dictyoconus fontabellensis*.

Upper Eocene, Pinar del Rio, Cuba. Min. Geol. Inst., Univ. Utrecht, D. [1]) 14570—14577.

Genus Camerina Brugière, 1792.

Camerina Petri M. Rutten.

Camerina petri M. Rutten, 1935, Jour. Paleontology, Vol. 9, pp. 530, 531. pl. 59, figs. 1—5. textfig. 2.

On the whole our specimens agree well with Rutten's description. Some slight differences occur e.g. one specimen consists of 9 whorls. Number of septa in the last whorl 32. Diameter 7.1 mm, thickness 2.7 mm. Another specimen though agreeing in outer measures with *C. petri* deviates from the inner features, the chambers being higher than long in this respect resembling *C. malbertii*. As only one specimen was found in the Oligocene it may be regarded as washed out of the Eocene strata. Diameter 3.8 mm to 7.1 mm, thickness 1.8 mm to 3 mm.

Upper Eocene and ?Oligocene, Pinar del Rio, Cuba. Hypotypes, Min. Geol. Inst., Univ. Utrecht, D. 14578—14591.

Camerina Malbertii M. Rutten.

Camerina malbertii M. Rutten, 1935, Jour. Paleontology, Vol. 9, pp. 531, 532. pl. 60, figs. 8—10 ; textfig. 2.

Only one specimen was found, which is intermediate between *C. petri* and *C. malbertii* by its outer measures. I reckon this form to *C. malbertii* for the shape of its chambers, which are higher than long. Diameter 8.3 mm, thickness 2.1 mm.

Upper Eocene, Pinar del Rio, Cuba. Hypotype, Min. Geol. Inst., Univ. Utrecht, D. 14592.

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[1]) The D.-numbers refer to the collection of slides in the Miner.-Geol. Institute at Utrecht.

CAMERINA sp.

Involute, small, thick forms, found in slides of Upper Cretaceous limestones of the Habana formation. Number of whorls is 3—4. They are characterized by a conspicuous groove. Diameter 0.74 mm to 0.96 mm; thickness 0.44 mm to 0.63 mm. In all probability the specimens belong to *Camerina dickersoni*. A recent study of VOORWIJK (83) proves that there exist transitional forms between material, agreeing well with our specimens and *Camerina dickersoni*.

Upper Cretaceous, Pinar del Rio, Cuba. Min. Geol. Inst., Univ. Utrecht.

Genus OPERCULINA d'Orbigny, 1826.

OPERCULINA FLORIDENSIS (Heilprin) Cushman.

Operculina floridensis CUSHMAN, 1921, U.S. Geol. Survey, Prof. PAPER 128-E., p. 130, pl. XX, fig. 12.

Flat forms with a sometimes eccentric low umbo over the first whorls. Surface of this umbo ornamented with granules and costae. Septa strongly curved backwards, especially in the last whorl. Chambers 5 times as high as long. Number of whorls $2\frac{1}{4}$ to $3\frac{1}{2}$. No granules on the slightly raised sutures of the last whorl as with *O. vaughani*. Diameter 3.3 mm to 7.7 mm, thickness 0.90 mm, to 1.20 mm. Number of septa in the last whorl 22—30.

Upper Eocene, Pinar del Rio, Cuba. Hypotypes, Min. Geol. Inst. Univ. Utrecht, D. 14593—14598.

Genus HETEROSTEGINA d'Orbigny, 1826.

HETEROSTEGINA ANTILLEA Cushman.

Heterostegina antillea CUSHMAN, 1921, U.S. Geol. Survey, Prof. PAPER 128-E., p. 131, pl. XX. figs. 13, 14.

Flat forms with an eccentric umbo above the first whorls. Surface papillate on the umbo and on the sutures. Diameter 8 mm, thickness 1.2 mm to 1.5 mm. Number of whorls $2\frac{1}{2}$ to 3.

This species is recorded from the Oligocene of the Island of Antigua by CUSHMAN (25). The occurrence of *Heterostegina antillea* in Pinar del Rio, together with typical Eocene Foraminifera, e.g. *Dictyoconus*, proves that this species existed already in the Eocene.

Upper Eocene, Pinar del Rio, Cuba. Hypotypes, Min. Geol. Inst. Univ. Utrecht, D. 14599—14600.

Genus Amphisorus Ehrenberg, 1840.

Amphisorus matleyi Vaughan

Plate, figures 1—3.

Amphisorus matleyi Vaughan, 1929, Jour. Paleontology, Vol. 3, No. 4, pp. 380, 381, 382, pl. 41, figs. 1—4.

A common form in the Oligomiocene of Pinar del Rio. It agrees well with Vaughan's description. Embryonal apparatus on transverse section bicellular, measuring 440 μ × 180 μ. Horizontal section of "eulepidine" type. The big chamber measures 555 μ, the smaller one 260 μ. The pores in the apertural band are alternating.

Oligomiocene, Pinar del Rio. Cuba. Hypotypes, Min. Geol. Inst., Univ. Utrecht. D. 14601—14609.

Genus Orbitoides d'Orbigny, 1847.

Orbitoides apiculata Schlumberger.

Orbitoides apiculata Schlumberger, 1901, Soc. Géol. France, 4° série, tome premier, pp. 465, 466, pl. VIII, figs. 1, 4, 6, pl. IX, figs. 1, 4.

Surface badly preserved. In places, however, coarsely reticulate. Embryonic chambers quadrilocular and embraced by a thick shell. The test asymetrically developed, the flat side strongly filled up with pillars. The layer of equatorial chambers is curved to the conical side. This species closely resembles *O. browni*; only *O. apiculata* is much thinner which is evident when comparing the following measures with those of *O. browni.*

Diameter	Thickness	Ratio
6.8 mm	1.1 mm	6 : 1
5.7 mm	1.1 mm	5 : 1
7.2 mm	0.90 mm	8 : 1
3.8 mm	0.60 mm	6 : 1
5 mm	0.90 mm	5 : 1

Orbitoides palmeri described by Gravell (34) from Cuba, is smaller (up to 4 mm) while its surface shows vermicular costae radiating from the apex to the periphery.

Upper Cretaceous, Pinar del Rio, Cuba. Hypotypes, Min. Geol. Inst., Univ. Utrecht.

ORBITOIDES BROWNI (Ellis).

Gallowayina browni ELLIS, 1932, Am. Mus. Novitates, No. 668, pp. 1—8, 9 figs. in text.
——— PALMER, 1934, Jour. Paleontology, vol. 8, No. 1, pp. 68—70.
Orbitoides browni VAUGHAN, 1934, Jour. Paleontology, vol. 8, No. 1, pp. 70—72.

As this form has already been sufficiently described only some outer measures will be given:

Diameter.	Thickness.	Ratio.
6.9 mm	3 mm	2 : 1
5.3 mm	2.6 mm	2 : 1
5 mm	2.3 mm	2 : 1
4.1 mm	2.3 mm	2 : 1
4.5 mm	2.9 mm	$1\frac{1}{2}$: 1
4.8 mm	3 mm	$1\frac{1}{2}$: 1

Upper Cretaceous, Pinar del Rio, Cuba. Hypotypes, Min. Geol. Inst. Univ. Utrecht, D. 14611—14627.

Genus LEPIDOCYCLINA Gümbel, 1868.

LEPIDOCYCLINA (LEPIDOCYCLINA) MORTONI Cushman.

Lepidocyclina mortoni CUSHMAN, 1920, U.S. Geol. Survey, Prof. PAPER 125-D., pp. 70, 71, pl. 27, figs. 1—4, pl. 28, figs. 1, 2.
Lepidocyclina mortoni, GRAVELL and HANNA, 1935, Jour. Paleontology, Vol. 9, No. 4, pp. 337, 338, 339, pl. 31, figs. 1—11, pl. 32, figs. 1—4.

Flat forms, sometimes with umbo. Surface papillate. Equatorial chambers ogival, exceptionally becoming flat hexagonal and arranged on intersecting curves. Diameter 4.8 mm to 6.8 mm, thickness 0.90 mm to 1.20 mm, embryonal apparatus 0.26 × 0.30 mm to 0.44 mm × 0.52 mm.

Upper Eocene, Pinar del Rio, Cuba. Hypotypes, Min. Geol. Inst. Univ. Utrecht, D. 14654—14668.

LEPIDOCYCLINA (EULEPIDINA) DILATATA Michelotti.

Plate, figures 4, 5.

Lepidocyclina dilatata, LEMOINE and DOUVILLÉ, 1904, Mém. Soc. Géol. France, tome 12—2, pp. 12, 13, pl. I, fig. 2, pl. 2, figs. 8, 21, pl. 3, figs. 10, 15.

Large, flat undulate forms, sometimes with umbo. Surface finely papillate. Embryonal apparatus of "eulepidine" type. Equatorial chambers hexagonal and arranged on concentric circles. Pillars small and numerous. Diameter 7.5 mm to 11.7 mm, thickness 1.2 mm to 2.1 mm, embryonal apparatus 1.11 mm to 1.59 mm.

Oligocene, Pinar del Rio, Cuba. Hypotypes, Min. Geol. Inst. Univ. Utrecht, D. 14728—14732.

Lepidocyclina sp.

Thick lenticular forms. Surface papillate to coarse papillate. Pillars distinct. Equatorial chambers rhomboid to ogival and arranged on intersecting curves. The embryonic apparatus is too badly preserved for determination. It resembles *L. pustulosa*, is, however, larger. Diameter 5.7 mm to 7.5 mm, thickness 1.7 mm to 2.4 mm.

Upper Eocene, Pinar del Rio, Cuba. Hypotypes, Min. Geol. Inst., Univ. Utrecht, D. 14734—14743.

Genus Helicolepidina Tobler, 1922.

Helicolepidina spiralis (Tobler).

Lepidocyclina (Helicolepidina) spiralis, Tobler, 1922, Eclogae geol. Helv., Vol. 17, No. 3, pp. 380—384.
Helicolepidina spiralis, Barker, 1934, Jour. Paleontology, Vol. 8, No. 3, pp. 345, 346, textfigs. 1a, 1c, pl. 47, figs. 1—4.

Only two specimens were found, both megalospherical. Surface of the test is coarsely polygonal with small papillae. No flange. Internal structure agrees with Tobler's description. Diameter 5 mm and 5.3 mm, thickness 1.8 mm and 2.4 mm. Diameter of initial embryonic chamber 150 μ.

Upper Eocene, Pinar del Rio, Cuba. Hypotypes, Min. Geol. Inst., Univ. Utrecht, D. 14752—14753.

Genus Discocyclina Gümbel, 1868.

Discocyclina (Discocyclina) marginata (Cushman).

Plate, figures 7, 8.

Orthophragmina marginata, Cushman, 1919, Carnegie Inst. Wash. Pub. 291, p. 56, pl. 1, fig. 2, pl. 2, fig. 4.

Thick lenticular forms with a broad flange, which is thickened near the periphery. Surface is smooth but the distal end of the pillars is distinct, partly by the different colouring, giving a papillate appearance. The radial diameter of the equatorial chambers is three times larger than the tangential and measures about 65 μ near the periphery. Lateral chambers very small. Pillars are distinct, especially in the central region ; measuring 75 μ to 110 μ.

Embryonal apparatus : one big chamber encircling a small one. The bigger one measures 0.41 mm to 0.59 mm. Diameter 5.4 mm to 9.3 mm, thickness 2.7 mm to 3.6 mm.

Upper Eocene, Pinar del Rio, Cuba. Hypotypes, Min. Geol. Inst., Univ. Utrecht. D. 14754—14762.

DISCOCYCLINA (DISCOCYCLINA) cf. CLARKI (Cushman).

Orthophragmina clarki, CUSHMAN, 1920, U.S. Geol. Survey, Prof. PAPER, No. 125-D., pp. 41, 42, pl. 7, figs. 5, 6.

Flat forms with umbo. Surface papillate. Radial length of the equatorial chambers at 2 mm from the center 74 μ to 130 μ. The largest chambers at the periphery measuring 185 μ. Embryonal apparatus of the "nephrolepidine" type, measuring 0.110 mm $\times$ 0.150 mm to 0.330 mm $\times$ 0.37 mm. Diameter 4.1 mm to 10.2 mm, thickness 0.90 mm to 1.80 mm.

Upper Eocene, Pinar del Rio, Cuba. Hypotypes, Min. Geol. Inst., Univ. Utrecht. D. 14764—14771.

DISCOCYCLINA (DISCOCYCLINA) sp.

Lenticular form of the test. Surface weathered. Radial length of the equatorial chambers at 2 mm from the centre 40 μ to 55 μ; at the periphery 75 μ. Diameter 5.1 mm, thickness 1.8 mm. Embryonal apparatus consists of one big chamber encircling a smaller one. Diameter of the bigger chamber 0.26 mm.

Upper Eocene, Pinar del Rio, Cuba. Hypotype, Min. Geol. Inst., Univ. Utrecht. D. 14774.

Genus CLYPEASTER Lamarck 1801.

CLYPEASTER LANCEOLATUS Cotteau.

Plate, figure 9.

Clypeaster lanceolatus, COTTEAU, Cotteau Bol. Com. Mapa Geol. España vol. 22, p. 39, plate 9, figs. 1—3.

This specimen was found at V. 774 N.E. of San Cristobal. The test measures 75 mm length, 63 mm in width, about 20 mm in height and is rather well preserved. The apical disk is slightly broken although two genital pores are distinctly visible. Poriferous areas are narrow, slightly depressed, terminating in a closed point, each of the plates bearing 4 to 5 tubercles. The 5 ambulacral furrows are not visible because they are too much covered with limestone.

COTTEAU describes his type as Miocene, Matanzas, Cuba; so does LAMBERT with his species from Antigua. According to JACKSON, who studied specimens from Panama U.S.A. and Havana, Cuba, they should be aged as Oligocene.

Genus ANTILLASTER Lambert 1920.

ANTILLASTER ARNOLDI CLARK.

Antillaster arnoldi, CLARK, Memoirs of the Museum of Comp. Zoology at Harvard College Vol. L. No. 1, page 15, fig. 3 and plate 16, 17.

This specimen measures 70 mm in height, the length and width are rather doubtful as the specimen is squeezed together somewhat on one side. Apical system defective because the specimen is broken all over the test, but it corresponds fully with the description of H. L. CLARK.

It was found solitary at V. 699 N.E. of Consolacion Del Sur, in an area where the Upper Cretaceous Havana formation is exposed. However, it might be easily derived from the adjacent lower Tertiary strata.

Chapter V: **ECONOMIC GEOLOGY.**

In the Aptychi limestones of Northern Santa Clara, RUTTEN (64) mentions the occurrence of oil seeps. The equivalent of these beds in Pinar del Rio are the younger parts of the San Andres formation. In the limestones of this formation we also found traces of oil, while a strong bituminous odour is often stated at fresh breaks. On account of the strong orogenetic activity, to which these oil bearing limestones were exposed, no accumulation of oil is to be found in them. The existing overthrust planes do not seem to fulfil the conditions for economic accumulation.

At several places, e.g. at Cacarajicara, South West of Bahia Honda and at loc. V.804 (Mina Mariel), North East of Cayajabos, asphalt is mined. The asphalt is found concentrated along faults in the Habana formation and the Lower Tertiary strata. In all probability, the asphalt has been derived from the oil-bearing limestones of the San Andres formation.

Ore deposits are found numerously in the province of Pinar del Rio. An important coppermine is found at Matahambre. We cannot suggest a theory on the origin of this ore. The chalcopyritic ore is worked to a depth of 700 m. Rocks adjacent to the ore bodies, proved to consist of a quartzitic rock not to be distinguished from the quartzites of the San Andres formation, in which the mine is situated. The levels in which the rounded ore bodies occur cut the strata obliquely. The main level is directed N 42° E., dipping 45 degrees to the West, while a large, transverse fault is found. The management of the Matahambre mine gave a member of our expedition a private report for perusal in which L. C. GRATON, of Harvard, makes use of the existence of Cubanite and possibly Pyrrhotite to prove the hypothermal origin of the copper ores.

In the older literature we found some communications about the Matahambre mine and some information on nowadays unimportant ore deposits. They will be mentioned in the chapter on Previous Literature.

Chapter VI: **COURSES SURVEYED.**

Various courses through the Eastern part of the province of Pinar del Rio will be described in detail in this chapter. No courses through the Western part are described as the rather monotonous San Andres formation does not give geological details, which have not already been discussed in chapter II. The different findspots of Upper Cretaceous Habana formation in these Western parts have also been for a part mentioned already.

1. Caimito — North of Guanajay.

About one km West of Caimito on the Carretera Central we turn to the North. We pass through an area consisting of white to grey porous limestones. At loc. L. 999 the limestones contain *Lithothamnium*, Globigerines and other small, indeterminable *Foraminifera*. North of this spot we find limestones and marls of Eocene age; the former contain *Lepidocyclina* and *Discocyclina*. Near loc. L. 1002 we find badly exposed Serpentines, followed by a dark grey breccious limestone of Maestrichtian age; a thin-section of this breccia carries Rudists fragments and an uncertain *Vaughanina* (Loc. L. 1003). The road runs through a second area of Serpentine and through outcrops of dark blueish limestones resembling the limestones of the San Andres formation. Paleontologic evidence establishing the exact age of the limestones is wanting.

Turning to the South we again reach the region of white limestones marls and calcareous sandstones of Upper Cretaceous or Lower Tertiary age. A loose big fragment of a Rudist (*Parastroma*) has been collected at loc. L. 1004. The right side of the road is covered with large boulders of blue limestones, indicating a nearby boundary of the San Andres formation. To the West we pass into this formation, consisting here of strongly folded shales with intercalated grey-blueish limestones. From loc. L. 1005 to loc. L. 939 we find the Upper Cretaceous-Lower Tertiary sediments well exposed. The direction of the strikes in these sediments varies strongly. The dips run from horizontal in Oligocene limestones at loc. L. 941, carrying eulepidine Lepidocyclines, to 80 degrees in other limestones.

On the Carretera Central halfway between Caimito and Guanajay (loc. H. 971) *Foraminifera* of Oligocene age were collected (*Lepidocyclina favosa*, *Lepidocyclina dilatata*, *Lepidocyclina piedrasensis* and *Camerina petri*).

A survey of the Loma Anafe North of this locality did not yield any *Foraminifera* establishing its age. The hills consist chiefly of white limestones, developed as "Dientes de perro". At loc. A. 712 a thin-section of a white limestone contains *Amphisorus matleyi*, indicating the young Oligo-miocene covering. South of this locality, however, we find dips of 20°—30° in the limestones, which implies a Lower Tertiary age.

2. Martin Mesa — Mariel.

North of the Carretera Guanajay-Cabañas on the road from Martin Mesa to Mariel we find a large outcrop of Serpentine (harzburgite). At loc. L. 983 we pass into the blueish limestone and red shales, which are reckoned to the San Andres formation by us on account of the great resemblance with rocks of this formation. Paleontologic evidence is lacking. The limestones mainly dip 50°—60° to the South. Folded or wedged in the limestones we find calcareous sandstones of Maestrichtian age containing porphyrite material and Rudists fragments. About 150 m North of this outcrop an anticline occurs in the limestones of the San Andres formation; the northern part of this anticline is covered by a gray-blueish limestone-breccia of Upper Cretaceous age (loc. L. 985 carries Rudists fragments, *Orbitoides* and *Vaughanina*). The same limestone-breccia was noted in the field in two other places North of loc. L. 985 wedged into beds of greenish-blue limestones, gray limestones, blueish limestones cut by calcite veinlets and shales of the San Andres formation. An outcrop of Serpentine is found at loc. L.988. 400 m North of loc. L.989, at the Northern boundary of the San Andres formation, a siliceous sandy shale is found; we then pass into an area covered with gray earth and without any exposures as far as loc. L. 990, where we come into the Oligomiocene cavernous limestones, which continue till we reach Mariel.

3. Bahia Honda to the South.

The village of Bahia Honda is situated in the Tuff Series. On the spot, where the road to El Rosario turns off from the main street, we find an outcrop of strongly weathered diabase. To the South at loc. M. 1034 small dikes of gabbroid nature occur. A patch of Serpentine is found at loc. M. 1037. We then pass through a steep syncline of fine conglomeratic calcareous gray-white sandstones (Habana beds in Eastern facies) carrying at loc. M. 1038 *Vaughanina*, *Orbitoides*, small *Camerinas* and dioritic material. It is bordered by a Serpentine area and gabbroid rocks, which may be continued in Eastern and Western direction, forming a large sill, parallel to the general strike in the Tuff Series. The latter consists of partly siliceous, vitric tuffs, thin bedded cherts, porphyrites, shales and grayish-blue limestones. These strata show a constant dip to the North from 40° to vertical. In two localities, M. 1046 and M. 1049, we find outcrops of breccious limestones and conglomeratic calcareous sandstones of a dark gray-blue colour (Habana beds of Mountain facies). The rocks carry rounded fragments of porphyrite and porphyrite matrix, dioritic material, rounded fragments of phyllites and quarzites ; the chief component being fragments of dark gray-blue limestones. Both localities carry Rudists fragments, Orbitoids and probably *Vaughanina*, indicating an Upper Cretaceous age. These strata, in which strike and dip are not to be measured, we take to have been wedged into the older Tuff Series during the post-Maestrichtian orogenetic phases.

About ½ km South of loc. M. 1049 no tuffaceous rocks are found anymore. We then pass into the younger parts of the San Andres formation, consisting of thinly bedded and compact blueish-gray limestones, shales and cherts, sandstones and quartzitic sandstones; all beds constantly dipping to the North. These decidedly intercalated sandstones or quartzites show a great resemblance with the rocks found West of San Diego de los Baños in the probably older parts of the San Andres formation. At loc. V. 868, a small layer of sandstone is intercalated in blueish-gray limestones carrying Ammonites and *Aptychi* of Lower Cretaceous age. At loc. V. 858 and V. 873 small strips of Serpentine are exposed. Three outcrops of Upper Cretaceous rocks are found in these parts of the San Andres formation. The findspot ½ km South of loc. M. 1050 consists of dark blue bituminous limestone-breccia carrying Rudists fragments, Orbitoids and porphyritic matrix. The existence of H_2S gas in this locality points to a fault or an overthrust. At loc. V. 863 we find a coarse conglomerate, containing rounded pebbles of tuffaceous, ? diabasic origine. South of the Serpentine outcrop at loc. V. 873, we find again the bituminous limestone-breccia (loc. V. 875) carrying Rudists fragments and Orbitoids, limestone fragments containing Miliolids and clear quartz. The outcrops of Habana beds in Mountain facies in the San Andres formation are infoldings or more probably wedges. The Serpentines often found near the Habana beds acted as a "slide-expedient", the contacts in that case being tectonical ones.

4. San Christobal to the North.

We pass through the Oligomiocene area. Several outcrops of white, cavernous limestones carry the typical fauna for these beds (locs. M. 1007, H. 895 : *Miogypsina*, *Archaias*, *Amphisorus matleyi*). At loc. H. 896 we find white compact limestones of Upper Eocene age in which are found in thin-sections *Asterocyclina*, *Discocyclina*, Miliolids, and *Operculina*.

At the foot of the Sierra de los Organos we find loose boulders of a grayish limestone-breccia ; they contain Rudists fragments, recrystallized Orbitoids, fragments of gray-blueish limestones, rounded fragments of a suboolitic limestone and a phyllite fragment. Assuming, that these boulders are not transported, we have at this spot (loc. M. 1009) the same Mountain facies of the Habana beds which is found at the overthrusts in the older formations. They are deposits in shallow water, their main elements (blueish limestones) are derived from the adjacent surroundings only partly emerged.

At loc. M. 1010 we run into the San Andres formation, which consists of strongly folded grayish blue calcareous shales and limestones, dipping 40° to the North to vertical.

A very coarse diabase rock containing enclosures of marble is found at loc. M. 1013. We take this rock to be connected with the Tuff Series, breaking through the older San Andres formation.

Aptychi, indicating a Lower Cretaceous age for these parts of the San Andres formation, were found about 2 km West of loc. M. 1013.

Near loc. A. 760 limestones and cherts of the San Andres formation alternate with beds of the Habana formation, consisting here of a blue limestone-breccia carrying *Orbitoides browni*. At loc. A. 763 we find limestones alternating with sandstones (Cayetano facies); the strata generally dip to the North.

North of loc. A. 766 occurs an outcrop of Serpentine rock over a distance of about 600 metres. In this Serpentine area were sampled rocks of a spilitic-diabase nature, which are difficult to account for. The peridotitic magma probably followed the same course as a former magma, connected with the Tuff Series, of which relics are found now as inclusions in the Serpentine. At loc. A. 770 a gabbro-diabase and an amphibolitic rock were collected in the limestone area, which is strongly folded and dipping to the North and to the South.

A limestone breccia of uncertain Upper Cretaceous age occurs at loc. A. 771 I. It contains e.g. fragments of a suboolitic limestone. North of this outcrop serpentinized rock breaks through sandstones of Cayetano facies, carrying inclusions of porphyritic rock, chloritic rock and amphibolites of large dimensions (the largest being about 1 cbm). The chloritic rock and the amphibolites are not considered to be altered rocks of the Tuff Series, as no sign of metamorphism is found at the contacts of the peridotitic magma with the Tuff Series. We prefer indicating these rocks as of "unknown origin".

North of the Serpentine we find again the Habana beds, the limestone breccia carries Rudists fragments, Orbitoids and *Torreina* indicating a Maestrichtian age. At loc. A. 775 occur calcareous shales and a chert-breccia, which is reckoned to the San Andres formation.

5. Artemisa — Cayajabos — Cabañas.

From Artemisa the road runs through a level country. Outcrops are sparse, and the ground is covered with a red soil. Past loc. L. 923 the "Guinness"-limestones of Oligomiocene age are exposed. South of the town Cayajabos (loc. L. 931) occurs an outcrop of yellow crystalline limestones, carrying recrystallized Orbitoids, too badly preserved for determination.

In the main street of the town strongly folded cherts are well exposed, the beds dip to the South and to the North. 400 m North of the last outcrop of chert we find an exposure of a coarse weathered diabase. We reckon the diabase and the cherts to the Tuff Series. The connection of this Tuff Series area with the Tuff Series beds situated in North-Western direction, is not clear.

The road then runs through a large area of limestone-breccia, conglomerates, white and yellow marls and calcareous sandstones. No fossils, indicating the age of these strata were found, but we may safely assume them, on account of the general appearance, to be of Upper Cretaceous or Lower Tertiary age.

At loc. H.886 we enter the Tuff Series, consisting here of porphyrites and vitric tuffs, followed by steeply folded beds of Upper Cretaceous or Eo-Oligocene age. Tuffaceous beds South of San Juan Batista are badly exposed on the road. About one km to the West, we have clear evidence of them. At loc. H. 880a conglomeratic sandstones occur, carrying badly preserved Orbitoids and Miliolids, and fragments of dioritic and porphyritic material. They are part of the Upper Cretaceous to Lower Tertiary strata, consisting further of white chalks and calcareous brown sandstones. The beds are gently folded; the strike running in East-West direction. They continue till we reach Cabañas.

6. Bahia Honda — Sabanilla — Lima.

We leave the town of Bahia Honda in a Western direction. Along the road we find outcrops of strongly weathered tuffaceous rocks. South-West of the town the hills consist of white marls of the Upper Cretaceous or Lower Tertiary strata.

At loc. V.836 we run into the Serpentine, carrying a large inclusion of diabase rock at loc. V.837. The low Serpentine hills continue North of the road in an East-Western direction. These hills are bordered on the Northern side by black clays and conglomeratic sandstones (loc. V. 841) carrying Maestrichtian fossils e.g. *Vaughanina cubensis*, *Asterorbis* and Rudists fragments. The sandstones dip to the South under the Serpentine. This is the only occurrence of Serpentine in the "Upper Cretaceous or Lower Tertiary strata" in the province of Pinar del Rio. On the Southern side we pass through the same transgressive strata, till we reach a Serpentine outcrop South of loc. H. 954.

We run into the Tuff Series, to which is reckoned a chert area extending from loc. H. 951 to loc. H. 948, dipping generally to the North with occasional intercalations of limestones lenses. Rocks of tuffaceous nature, diabases, porphyrites and glass porphyrites have been collected at various places. (locs. H. 933, H. 934, H. 935, H. 936, H. 943). Also shales are often exposed in this area. An old abandoned copper-mine (Mendietta) is found at loc. H. 942.

South of loc. H. 933 we run into the younger parts of the San Andres formation; tuffaceous rocks are no longer found. The strata consist of gray-blueish limestones and yellow or violet shales, sandstones and cherts.

In the neighbourhood of Cacarajicara numerous outcrops of blueish conglomeratic limestones and calcarous sandstones of Upper Cretaceous age occur (locs. H. 904, H. 906, H. 923, H. 932). Strikes and dips are not measurable as is always the case in the Habana beds of Mountain facies. A fault, in which asphalt is found runs in a North-South direction. Two Orbitoids bearing limestone-breccias are found to the South, respectively at loc. A. 684 and at loc. A. 685.

All the Upper Cretaceous limestone-breccia strata are taken to be wedged into the San Andres formation.

South of loc. A. 685 red and yellow sands indicate a frequent intercalation of sandstones (Cayetano facies) in the San Andres formation. North of Sabanilla we find large boulders of Serpentine (loc. A. 686).

The strata South of Sabanilla, consisting chiefly of limestones, continue to dip to the North till we reach loc. A. 658, South of which the beds dip to the South. At loc. A. 658 a quartzite is found, intercalated in the limestones. This rock is not to be distinguished from the quartzites found West of San Diego de los Baños.

A chert-limestone breccia, carrying badly preserved organisms is found at loc. A. 656 and loc. A. 654. We take these beds to be of Upper Cretaceous age by their general appearance.

Aptychi occur at loc. A. 653, establishing a Lower Cretaceous age for these parts of the San Andres formation (TRAUTH, 79).

A dubious Serpentine outcrop is found at loc. A. 651 ; then we leave the mountain region. The red soil is covered by gray limestone-boulders and chert fragments derived from the San Andres formation. Near loc. L. 842 a conglomerate contains porphyrite boulders; it is reckoned to the Upper Cretaceous or Lower Tertiary.

At loc. L. 841 and L. 839 Oligomiocene limestones are exposed. They carry its typical fauna: *Amphisorus matleyi*, *Archaias*, *Miogypsina* and Miliolids.

Chapter VII : PREVIOUS LITERATURE.

There are numerous publications in existence, treating the geological problems, ore deposits or paleontological matters, concerning the province of Pinar del Rio. A great part of these papers were not accessible to us, as they are not found in any library in Holland. However, Prof. RUTTEN, gave us for perusal his bibliographic notes on the geology of Cuba, which enabled us to give short summaries of those parts of the publications, which are of interest for the study of the geology of Pinar del Rio.

In 1884 CASTRO (14) mentions the occurrence of dark Jurassic limestones, outcropping from Guane to South West of Guanajay. He advances the opinion, that limestone conglomerates, found West of the town of Pinar del Rio and in a small zone South of San Diego de los Baños, might be of Cretaceous age, on account of the possible occurrence of Rudists. In the same year a geological map was published by CASTRO and SALTERAIN y LEGARA. On this map we find Paleozoic, Mesozoic and Tertiary formations indicated in the province of Pinar del Rio. Apart from the "Quaternario" also igneous rocks are indicated (Granito, Serpentina, Basalto).

Also in 1884 SALTERAIN Y LEGARA (65) records an earthquake on the 22nd and 23rd of January 1880 in the towns of San Cristobal and Candelaria.

In 1909 DE LA TORRE (76) states the occurrence of Ammonites near Viñales, while in 1909 (77) and 1910 (78) the Jurassic age of the fauna is established by him.

In 1908 CATLETT (15) describes ,,Cambric" shales and slates, situated 25 miles West of the town of Pinar del Rio. The formation is folded and injected by quartz veins. On the axis of the anticlines iron ore is found. The ore is hematite, in which baryte crystals occur.

In 1916 ORTEGA (55) mentions the occurrence of Jurassic-Cretaceous limestones, with intrusive and covering basic eruptive rock, covered once more by limestones, shales and sandstones. The copper ore of the Matahambre mine is said to be connected with the Serpentine. The ore would have been formed by desagration of the Serpentine rock, by the circulation of metal-carrying water.

Corrections of the map of DE CASTRO and SALTERAIN Y LEGARA appear in 1917 (ANONYMUS 4). A large Serpentine area is wrongly sketched-in North of Viñales. A large strip of Serpentine rock is sketched-in running from San Diego de los Baños to North of the town of Pinar del Rio. The improvements on the map are negative.

Another publication in 1917 (ANONYMUS 5) deals with the results of drilling for oil. At Morillo, South East of Bahia Honda a well was sunk to a depth of 1841′, practically passing only through Serpentine rock. Traces of oil and gas were found. The San Felipe well, 1.5 miles South West of La Esperanza also runs through the Serpentine to a depth of 1391′. No gas or oil was found. At about a distance of one mile from the Mina Mariel, a well was drilled to 1850′. Only a little liquid asphalt was found. At La Esperanza a well was drilled entirely through limestones (Medina Oil Cy.). GASTON (33) reports also in 1917 the occurrence of gas and asphalt in a well in the mine "Santa Maria" on the North coast of Pinar del Rio, near Puerto Esperanza. The depth of the well was about 1600′.

HAYES c.s. (38) republish the map of CASTRO and SALTERAIN Y LEGARA, together with a geological survey of Cuba. A large part of the Organos mountains is still taken to be Paleozoic. The Jurassic limestones of Viñales are known to them. In the North of the province of Pinar del Rio, Eocene might occur. Upper Oligocene is reported 6 km North of the town of Pinar del Rio and at Consolación del Sur. The paleontological evidence on which these statements are based are not mentioned. Miocene or Pliocene are in all probability absent according to them.

MAC CORMICK (47, 48) and CORRAL (19) give in 1918 some, partly technical details on the Matahambre mine. When treating the mine "La Niña" and "Mina Concepcion", CORRAL (20) describes Serpentine between La Palma and Las Pozas. The Serpentine is considered to be the marginal facies of a hypothetical granite. In two publications BROWN and O'CONNELL treat the Ammonites and the strata from which they are collected (11, 12). In the last publication sections through the Organos mountains are given. These sections run to the North from the towns of: Candelaria, San Cristobal, San Diego de los Baños, and Viñales. A section from Candelaria or San Cristobal to the North is said to pass through recent or pleistocene deposits in the plain, then through Miocene and Oligocene beds followed by thick Cretaceous limestones and Jurassic beds, the latter forming the Mountain regions (full discussion in our text).

In 1919/20 BURCHARD (13) mentions the occurrence of manganese ore near Viñales and Mendoza.

In 1920 BROWN (10) wrote a private report which has been cited in the literature from time to time. According to a statement of Mr. BROWN this report has never been published.

SUAREZ-MURIAS (72) reports in 1920 the occurrence of Jurassic formations and younger basic eruptive rock in Pinar del Rio. The basic rock consists of Serpentine, diorite and andesite. These rocks contain sediments as xenoliths. He mentions unimportant magmatic copper-ores and lateritic ore in the Serpentine districts.

In 1923 ALLENDE (2) describes 6 zones running parallel to the anticlinal axis of the mountains, in which minerals are found. Peridotites carrying sulfides of Fe and Cu are reported from Sabalo, in the valley of San Juan y Martinez, Valle y Realengo de Lagunillas, Rio Hondo etc. A formation "plumbo-baritica" is found between Bolondron and Isabel Marie. Iron-and manganese ore occur between Mendoza and Consolación del Norte (La Palma), Cu, Fe and Pb sulfides between Matahambre and Malas aguas etc.

In 1928 the same author (2a) mentions the localities where traces of oil or asphalt have been found in the province of Pinar del Rio. This is the case at: Arroyo de Mantua and between this place and Dimas, and near Puerto Esperanza at Las Playelas. An asphalt mine "El Murillo" occurs in the neighbourhood of La Mulata; Asphalt at Cacarajaicara; Traces of oil near Asiento de Echevarria (Cretaceous shales), at the Loma de Rangel and in the hills of San Cristobal and Candelaria, and along the river San Cristobal. Oil is found on the finca Covadonga near San Juan y Martinez, an asphalt mine at "Mariel".

In 1929 ALLENDE (3) gives a geological map of the surroundings of Martin Mesa. Serpentine, Jurassic limestones, and Tertiary (Lower Miocene) are indicated.

CAYADO in 1923 (16) gives information on the mines "Las Mercedas" and "Maria Christina" both near Guane. In the former, copper ore was mined, in the latter manganese ore.

WRIGHT and SWEET (85) discuss in 1924 the asphalt mine "Mariel". The asphalt must have been reduced from 20—30 million barrels of primary oil. The oil is considered to have been derived from the Jurassic limestones.

In 1932 WHITNEY LEWIS (44) discusses the geology of Cuba and publishes a geological map. By comparison the reader will see essential differences with our map. They are too numerous to discuss here. Regarding the Viñales limestones LEWIS considers them to rest unconformably upon the "Pinar schists". Cretaceous beds are reported to occur near Mariel, Cabañas and Bahia Honda. Another publication of the same author in the same year, (46) treats the age of the *Aptychi* occurring in the limestones. They are supposed to be of Jurassic age.

In 1934, WEISBORD (84) describes Echinoids collected on the road between San Diego de los Baños and Paso Real. He mentions the occurrence of Upper Eocene in the heart of the Organos mountains (personal communication of Mr. W. H. BUTT).

In 1935, SCHUCHERT (70) publishes a large study on the "Historical Geology of the Antillean-Caribbean region". Cuba is extensively treated and the map of LEWIS (44) is reproduced.

DICKERSON and BUTT (30) in the same year treat the problems of the "Cuban Jurassic", which paper has been fully discussed in our text.

The publications of L. RUTTEN (60, 61, 62), of M. RUTTEN (63, 64) and of THIADENS (73, 74) are based upon evidence collected during our expedition in 1933.

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EXPLANATION OF PLATE.

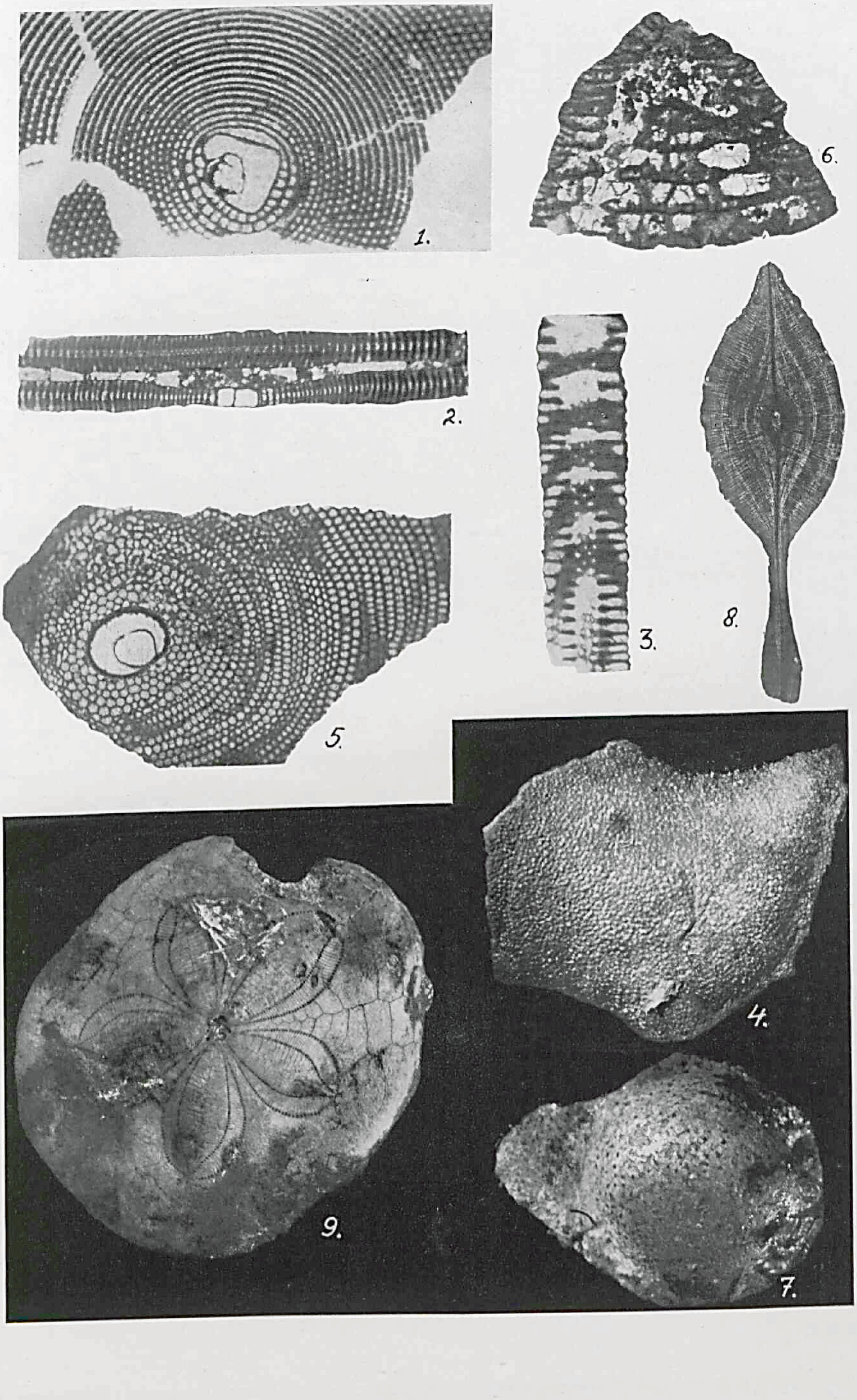
fig. 1—3 —— *Amphisorus matleyi* VAUGHAN, 1, Horizontal section, × 27. 2, Vertical section showing the embryonal apparatus, × 15. 3, Tangential section showing the pores in the apertural band, × 19.

fig. 4—5 —— *Lepidocyclina* (*Eulepidina*) *dilatata* MICHELOTTI, 4, External view, × 6. 5, Horizontal section, × 9.

fig. 6 —— *Dictyoconus sp.*, Vertical section, × 19.

fig. 7—8 —— *Discocyclina* (*Discocyclina*) *marginata* (CUSHMAN), 7, External view, × 7, 5. 8, Vertical section, × 9.

fig. 9 —— *Clypeaster lanceolatus* COTTEAU, natural size.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7.

STELLINGEN.

I.

De meening van HOLWERDA, dat in den Romeinschen tijd een eilandenreeks in de „Hoofden" gelegen zou hebben, moet onjuist geacht worden.

J. VAN VEEN: Onderzoekingen in de „Hoofden" in verband met de gesteldheid der Nederlandsche kust. Nieuwe verhandelingen van het Bataafsch Genootschap der Proefondervindelijke Wijsbegeerte te Rotterdam. 1936.

II.

Ten onrechte wordt Tampsia lopeztrigoi door PALMER tot het genus Tampsia gerekend.

R. H. PALMER: Nuevos rudistas de Cuba. Rev. Agric. Habana, vol. 14. 1933.

III.

De ontstaanswijze van het Boven-Engadiner dal door fluviatiele erosie is aannemelijker dan door tectonische oorzaken.

G. C. F. A. G. ORTH: De Dalontwikkeling van het Boven-Engadin. 1935.

IV.

De kwartsitische gesteenten, welke in de syenitische en hoornblenditische (appinitische) eruptiva te Colonsay voorkomen, moeten als xenoliethen opgevat worden.

D. L. REYNOLDS: Demonstrations in petrogenesis from Kiloran bay, Colonsay. The Mineralogical Magazine, Vol. XXIV, No. 155, 1936.

V.

Men mag het ontstaan van den vogeltrek niet in verband brengen met invloeden van de Diluviale ijstijden.

E. Mayer en W. Meise: Theoretisches zur Geschichte des Vogelzuges. Der Vogelzug, No. 4, I. Jahrgang, 1930.

VI.

De „Viñales kalken" in West-Cuba zijn ingeschakeld in de „Cayetano-formatie".

VII.

De aanwezigheid van het genus Plagioptychus in de Barrettia-lagen wordt door Müllerried ten onrechte aangevoerd als argument tegen den Boven-Senonen ouderdom van deze lagen.

F. K. G. Müllerried: La Edad estratigraphica de la Barrettia y formas cercanas.
Anales del Instituto de Biologia, Tomo VII, No. 1, 1936.

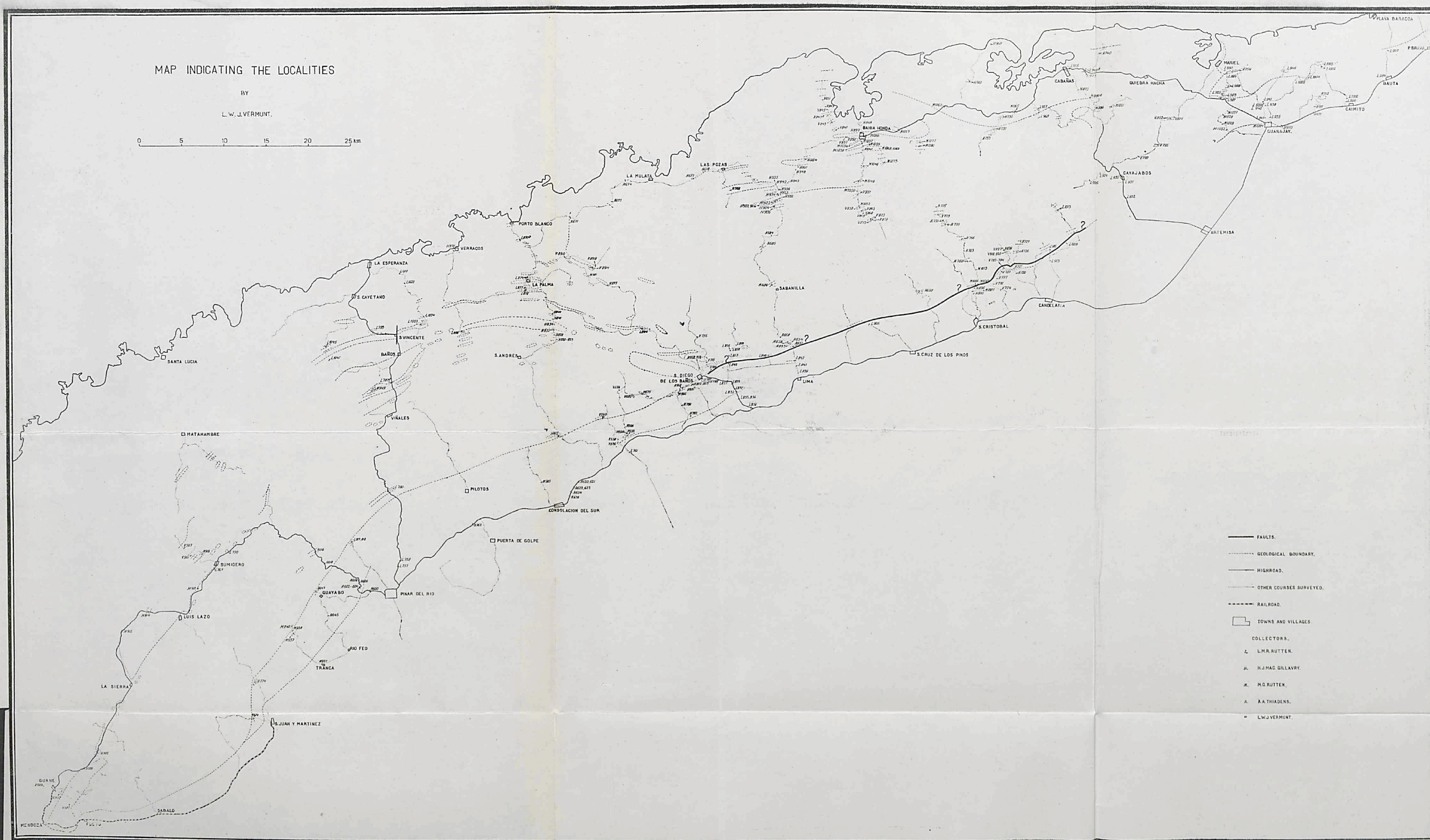
VIII.

De schisten op Jamaica worden ten onrechte door Matley voor Paleaozoisch gehouden.

C. A. Matley: The basal complex of Jamaica etc. Qu. J. G. S. Lond, 85, 1928.

IX.

Het hagelschot op reeën en herten moest in Nederland bij de wet verboden zijn.


MAP INDICATING THE LOCALITIES
BY
L.W.J. VERMUNT.
0 5 10 15 20 25 km.
FAULTS.
GEOLOGICAL BOUNDARY.
HIGHROAD.
OTHER COURSES SURVEYED.
RAILROAD.
TOWNS AND VILLAGES.
COLLECTORS.
L. L.M.R.RUTTEN.
H. H.J.MAC GILLAVRY.
M. M.G.RUTTEN.
T. A.A.THIADENS.
V. L.W.J.VERMUNT.
PLAYA BARACOA
MARIEL
QUIEBRA HACHA
CABAÑAS
BAUTA
CAIMITO
GUANAJAY.
BAHIA HONDA
LAS POZAS
LA MULATA
CAYAJABOS
ARTEMISA
PORTO BLANCO
VERRACOS
LA ESPERANZA
LA PALMA
S.CAYETANO
SABANILLA
CANDELARIA
S.CRISTOBAL
S.VINCENTE
BAÑOS
S.ANDRES
SANTA LUCIA
S.CRUZ DE LOS PINOS
S.DIEGO
DE LOS BAÑOS
LIMA
VIÑALES
MATAHAMBRE
PILOTOS
CONSOLACION DEL SUR
PUERTA DE GOLPE
SUMIDERO
GUAYABO
PINAR DEL RIO
LUIS LAZO
RIO FEO
TRANCA
LA SIERRA
S.JUAN Y MARTINEZ
GUANE
SABALO
MENDOZA

W. VERSLUYS & SCHERJON UTRECHT