GEOLOGY AND PALEONTOLOGY OF CENTRAL CAMAGUEY, CUBA

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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 L. VAN VUUREN, HOOGLEERAAR IN DE FACULTEIT DER LETTEREN EN WIJSBEGEERTE, VOLGENS BESLUIT VAN DEN SENAAT DER UNIVERSITEIT TEGEN DE BEDENKINGEN VAN DE FACULTEIT DER WIS- EN NATUURKUNDE TE VERDEDIGEN OP VRIJDAG 11 JUNI 1943, DES NAMIDDAGS TE 3 UUR

DOOR

AART VAN WESSEM

GEBOREN TE ARKEL

DRUKKERIJ J. VAN BOEKHOVEN - UTRECHT - AMSTERDAM

AAN MIJN OUDERS

Bij het beëindigen van mijn academische studie wensch ik U, Hoogleeraren en Lectoren der Faculteit der Wis- en Natuurkunde, die leiding aan mijn studie hebt gegeven en wier onderwijs ik mocht volgen, mijn oprechten dank uit te spreken.

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INTRODUCTION

In December 1938 an expedition of the Utrecht University went to Cuba to explore the geology of this island. The leader of the expedition was Prof. Dr. L. M. R. RUTTEN, accompanied by six of his students: Mr. J. J. HERMES, Mr. F. G. KEYZER, Mr. TH. J. KINGMA, Mr. B. VAN RAADSHOOVEN, Mr. D. R. DE VLETTER and the author of this paper.

The purpose of this expedition was first of all to study the geology of the region between the province of Santa Clara, the northern and southern part of which had been described, respectively by Dr. M. G. RUTTEN (121) and Dr. A. A. THIADENS (123), and the eastern part of the province of Camaguey, described by Dr. H. J. MAC GILLAVRY (120). In the second place we would visit the province of Oriente in order to give a geological account of parts of that region too.

From the 8th of January 1939 until the 5th of February we worked in the eastern part of the province of Santa Clara and in the western part of Camaguey Province. This large area was divided into two pieces by a line about 5 km West of Ciego de Avila, running due North. Mr. B. VAN RAADSHOOVEN will describe the western part of this area. The samples, which were taken in the eastern part, were handed over to me, together with the notes and maps; they have provided the material for this paper.

Most of the work was done from our camp at Majagua, where we camped about 2½ week on the beautiful estate of Mr. MARIO ARTEÁGA. Later on several trips were made from our second base at Moron.

In the field we had the military maps of Cuba at our disposal. These maps, on the scale of one inch to a mile, appeared to be insufficiently accurate in detail, so we had to survey the country and draw our own maps. Azimuts of the roads were taken with a geological hand-compass, while the distances were measured by counting our paces or by noting down the distances given by the hodometer of our motor-car. A slight correction was made in the distances as given by the hodometer, the error of this instrument proving to be systematical. The errors, which were made in compass-reading as well as in measuring by the paces of the several members, are certainly not systematical, but they are likely to neutralize each other in the end.

The topographical map, which forms the base of our geological map, was constructed in the following way: the map of Dr. THIADENS gives us the position of Sancti Spiritus and Jatibonico, the map of Dr. MAC GILLAVRY the position of La Florida. The distance between Sancti Spiritus and La Florida is exactly known from the kilometerstones of the Carretera Central, while the several azimuts were measured with great accuracy. So this stretch of the Carretera could be plotted and put into position. The other courses

were then mapped out and it appeared that nowhere very great corrections had to be made in order to link up the several courses. On the map of MAC GILLAVRY we can see that the distance between La Florida and the great fault between the Sierra de Cubitas and the Serpentine is 38,2 km as the crow flies in a direction N 37 E from La Florida. When our map is drawn independently of MAC GILLAVRY's map, the same distance is 36,5 km, a difference of less than 5 percent. To link up our district with that of MAC GILLAVRY, we have presumed that MAC GILLAVRY's map is correct. The position of Jucaro on the South Coast is by no means quite sure, as we have not visited that town ourselves, but copied it from the map of Dr. TSCHOPP.

The area surveyed has by no means been exhaustively explored, as our work had the nature of a preliminary survey. As the reader may see from the map, the courses surveyed form a maze, sometimes with rather wide gaps. From this network of roads the reader will at once be able to judge where the author leaves the path of direct observation and begins to interpolate. Where interpolation becomes too hazardous, blank spaces are left on the map. Boundaries between the formations have been drawn only in those cases, where there was sufficient evidence for their probability. All findspotnumbers, strikes and dips are indicated on the geological map, except in the areas around Ciego de Avila and Estrella. In these two areas the network of roads and observations was so dense, that separate maps were drawn, on which the observations were indicated.

As this paper is the first geological description of Central Camaguey, a separate chapter has been devoted to the description of the surveyed courses. So the reader will be able to check the statements made in the general part of the paper.

Being 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 the expedition, whose large experience in field-work, whose enthusiasm and constructive criticism, when treating several geological problems in this paper, have been of invaluable help to me.

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Last but certainly not least I wish to express my gratitude to the Cuban people. We have always met with the greatest kindness and hospitality.

Chapter I: SUMMARY OF THE GEOLOGY OF CENTRAL CAMAGUEY.

The greater part of Central Camaguey is occupied by young sediments as the district forms the eastern part of the Moron Basin. At its eastern side this basin is bordered by older deposits, while on a structural „high", ranging from La Florida to the West, the older formations are also outcropping over large distances.

The oldest rocks we find in our district, belong to the Aptychi Limestone Formation. They are exposed in the north-eastern and northern strip of the area surveyed. The formation is built up by limestones, calcareous sandstones, cherts, clay-shales and thick layers of gypsum. The only fossils found in the formation, are *Radiolaria*. For this reason it is impossible to establish the proper age of the rocks regarded as Aptychi Limestones. We regard it, however, as very probable, that they are of the same age as in Eastern Camaguey, viz. Lower Cretaceous, for habitually there is not any difference between limestones of that region and ours.

After the sedimentation of the strata of the Aptychi Formation, a period of volcanity sets in with the deposition of the beds of the Tuff Series. They are for the greater part built up by volcanic products: porphyrites, porphyrite-breccias and crystal-tuffs. Alternating with these volcanic products, we find limestones. In one of these limestones, a Rudist, *Barrettia sparcilirata*, was found. That points to the possibility of parts of the Tuff Series reaching as far up as Lower Senonian or *Barrettia sparcilirata* reaching as far down as the Turonian. At any rate the formation is of a pre-Diorite age as the limestones have been contactmetamorphically altered by the Diorite intrusion.

Following up the sedimentation of this formation, a time of orogenetic activity began. During this orogenetic phase, the rocks of the Aptychi Formation and Tuff Series were strongly folded and at the same time, harzburgites, wehrlites and eclogites intruded, which in their turn were followed by the intrusion of Diorite and other rocks, belonging to the Diorite Series. The harzburgites and wehrlites have been serpentinized for the greater part in later stages. In our district we cannot prove that the Serpentines are older than the Diorite, but we do not see any reason why the Serpentines should not be of the same age as in Eastern Camaguey, where rocks of dioritic origin intruded the Serpentines.

After this period of intrusions and orogenesis the older rocks were denuded and in the Upper Cretaceous the Habana Formation was deposited. The Habana Formation is transgressive with regard to the Diorite and Tuff Series, numerous fragments of which are found in the conglomerates of the Habana Formation. The formation is very rich in fossils; Larger as well as Smaller *Foraminifera* and Rudists are abundant. The fauna as a whole

points to a Maestrichtian age, the Molluscs, however, possibly indicating a somewhat older age of the formation. Besides Orbitoidal and Rudist limestones, we find calcareous sandstones, conglomerates, tuffs, tuffites, porphyrites and tuff-porphyrite breccias. While in Santa Clara volcanic products form only a minor part of the formation, they are of far greater importance in Central Camaguey, whereas in Eastern Camaguey they form the major part of the Habana Formation. In our district the rocks of the Habana Formation are considered to have been deposited in a shallow sea, although deposits of somewhat deeper water are also encountered.

After the deposition of the Upper Cretaceous rocks of the Habana Formation a second orogenesis took place between the Maestrichtian and the Eocene. There follows again a period of denudation and after this the beds of the Eocene were deposited, which are unconformably overlying the tuffs of the Habana Formation.

Judging from the tectonical style of the rocks of the Habana Formation, this second orogenesis was more intensive in the eastern part of the district than in its western part; the observations are, however, rather poor.

The Eocene in our district is divided over two separate areas. In the first place we find limestones of eocene age in the Sierra de Cubitas and secondly eocene marls, limestones and conglomerates are found in the southern part of the described area. A different facies between the two regions is apparent; some difference of age may exist as well.

The Cubitas Limestones are dense, white rocks, occasionally rich in fossils, especially in *Miliolidae*, but we find also *Discocyclina*, *Dictyoconus* and *Alveolinidae*. In the limestones we find, though rarely, detritic material of Serpentines, Diorites and porphyrites. The opinion of MAC GILLAVRY, that the Cubitas Limestones would be somewhat older than Upper Eocene, cannot be affirmed nor contested by our observations. The deposits in the southern area are of an uppereocene age as they contain several genera of Larger *Foraminifera*, which, in combination, are typical for upper eocene deposits e.g. *Discocyclina*, *Lepidocyclina*, *Camerina*, *Pellatispirella* and *Dictyoconus*. In the conglomeratic members of the Eocene in this area pebbles of dioritic material and Habana-porphyrites are found.

After the sedimentation of these upper eocene strata there followed a third orogenetic phase, which caused gentle structures in the eocene beds. The age of this orogenesis must be pre-Guines, as these oligo-miocene strata are found in an almost horizontal position everywhere. The oligo-miocene formation is built up by limestones and marls, which contain several typical *Foraminifera* e.g. *Archaias*, *Peneroplis*, *Marginopora*, *Amphisorus* and *Miogypsina*. It is possible that a fourth, post-Guines orogenesis occurred, as we find, although very small, dips in the limestones at some places. This orogenesis, however, was of little importance.

On Isla Turiguanao very coarse breccias were found at some places. They contain fragments of Aptychi Limestones and fragments of gypsum. They are considered to be of quaternary age.

Chapter II: STRATIGRAPHY.

Aptychi Formation.

This formation is exposed in the north-eastern corner of our district, where it forms low ridges. These ridges trend in a direction N.W.—S.E. On Isla Turiguanao the formation is outcropping again and at last we find it on the western side of Bahia Buenavista in the Loma de Yeso, a low ridge, whose general direction is also about South-East. The Aptychi Formation is built up of limestones, calcareous sandstones, cherts, clayshales and thick layers of gypsum.

The age of the formation could not be established with certainty, since the only fossils we had at our disposal were *Radiolaria* and some Smaller *Foraminifera* which, however, were indeterminable. After the habit of the limestones, however, there is a striking resemblance with the Aptychi Limestones from Eastern Camaguey and Northern Santa Clara, which were collected in 1933 and described by M. G. Rutten (121) and H. J. Mac Gillavry (120). They reported also limestones rich in *Radiolaria*. The above mentioned reasons, combined with the tectonical style of the formation, make it highly probable, that the Aptychi Formation is of the same age as in the adjacent areas.

The limestones are blue, grey to nearly black, dense rocks which often show a good stratification. Very thinly bedded rocks are not unfrequent. Detritic material occurs as small quartzgrains, but always in small quantities. A few samples proved to be very rich in *Radiolaria* and occasionally a badly preserved *Globigerina* and *Miliolid* was found. Many limestones are coarsely crystalline and cut by numerous small veinlets, filled up with calcite. Oolitic structures are found in a few cases. Magnetite and limonite are nearly always present, but never in large quantities. At V 116, on Isla Turiguanao, we find limestones which are very rich in hematite. It is not impossible, that this ore is of pneumatolytic origin, caused by an intrusion of magmatic rocks in the neighbourhood. Later on when describing the gypsum layers we shall have another opportunity to see that there are more reasons which lead us to suppose the existence of intrusive activity in the neighbourhood. B 13 is an aberrant limestone. It is very cavernous and though it has been mapped as an „Aptychi Limestone", this remains questionable.

Calcareous sandstones are only found at one place (K 59). The rocks are built up of fragments of quartz, plagioclase, muscovite, biotite, epidote, magnetite and zircon; these fragments are cemented by calcite. Most of the same minerals are found in the Habana Formation and Eocene as detritic products, originating from the Diorites. As the Diorites are younger than the Aptychi Formation, it is obvious, that the crystal fragments

in the Aptychi Formation must be derived from another source; their habit, indeed, is quite a different one. Since no detritic material of any kind has been found in the Aptychi Limestones from Eastern Camaguey, it is not likely, that we will find our „source" in that region. Neither on Isla Turiguanao, nor West of Bahia Buenavista, detritic material of the kind above mentioned was found in the limestones. Thus we are inclined to assume, that the old region, which furnished the material for the Aptychi sandstones, was situated in the centre of Camaguey, the area, which is now covered by the younger sediments of the Moron Basin. It is hardly necessary to say, that this assumption is a speculative one.

Cherts were only found South-West of Donato. They are compact, dark coloured rocks.

Gypsum was found in thick layers on Isla Turiguanao and near Central Punta Alegre. The gypsum is light-green or white; macroscopically we see small folds in some samples. Other samples contain fragments of Aptychi Limestones. These breccias obviously came into existence when folding took place. Microscopically the gypsum is seen to be rather pure, but in a number of samples, we observe beautiful rhombohedrons of calcite. Occasionally a grain of zircon and some apatite needles are found. Remarkable, however, is the occurrence of a good many idiomorphic quartzcrystals and the appearance of tourmaline in small, strongly pleochroitic columns. It is not impossible, that the quartz came into existence *in situ*, but one wonders where the tourmaline came from. Apparently it has not been transported over a long distance as the tourmaline does not show traces of such a long transport. A neighbouring area, which supplied the tourmaline, is thus probable. It may be noticed that the richness in tourmaline becomes still greater in the gypsum-layers and clay-shales West of Bahia Buenavista. As this last mentioned area lies to the North-West of Isla Turiguanao, one is inclined to seek our tourmaline supplying area to the North, in the direction of the Bahamas.

The limestones in this region do not contain detritic material. An explanation for this phenomenon may be the fact, that the sea at the time when limestones were deposited, also covered the „tourmaline-area". Later on, when regression took place, this area could be denuded and furnish the detritic material for the remaining desiccating basins, in which the gypsum was deposited.

The clay-shales, found near Central Punta Alegre, are very fine-grained, thin-bedded rocks, with an intense red colour, caused by limonite. They consist for the greater part of clay minerals, quartz, limonite and very much tourmaline. We regard them as rocks which were formed during local transgressions in the above mentioned area.

The Aptychi Formation has been intensely folded. The exact time of this folding could not be established, but must certainly have been in pre-eocene times, for South of Donato we find only little disturbed Cubitas Limestones, whereas the Aptychi Limestones have been intensely folded. On

Isla Turiguanao and near Punta Alegre tectonics are very complicated. From the map it can be seen, that strikes and dips run in all directions and for this reason it is impossible to say, whether the gypsum is intercalated between the limestones or that it forms the upper parts of the Aptychi Formation. The last supposition is taken as the most probable one. Breccias of tectonical origin, gypsum with limestone fragments, are frequently met with.

The structural discordance between clay-shales and covering limestones (see the reproduction of the profile drawn by Ir. BAGGELAAR, page 71) is considered not to be a true angular disconformity, but to have been produced by disharmonic folding. Here, too, the gypsum played an important role when the formation was folded. The above mentioned opinion is strengthened by the fact that the limestones, lower in the profile, can not be distinguished from those, which unconformably overlie the clay shales.

Tuff Series.

From the map we can see that the rocks of this formation are found at several places in the district. In the neighbourhood of Magarabomba thick layers of porphyrites and tuffs are found. More to the West, North of the Carretera Central, the formation is outcropping again. The Loma Carolina, to the North-East of Ciego de Avila, seems to consist wholly of altered rocks belonging to the Tuff Series, and finally the formation is found about two kilometers West of Ciego de Avila.

Nothing can be said with certainty about the absolute thickness of the formation. The fact, however, that the tuffs and porphyrites near Magarabomba show the same strike and dip over great distances makes it probable that the formation reaches a considerable thickness here.

Both volcanic and sedimentary rocks are comprised in the Tuff Series. The volcanic rocks are represented by porphyrites, porphyrite-breccias, tuffs and strongly altered rocks, the nature of which could not always be identified with certainty but which in a single case show a porphyritic texture. The sedimentary rocks are rare; only a small number of limestones, more or less altered by the later Diorite intrusion have been found. The limestones are alternating with the porphyrites and tuffs. A. A. THIADENS (123) has given them the name of „Provincial limestones". This name will henceforth be used in this description.

The age of the Tuff Series is not quite certain in our district as, only at one place fossils were found in the formation. Corals which were found could not be determined as we could study them only in thin-section. According to DOUVILLÉ a Rudist, *Barrettia sparcilirata*, points to a Campanian age. H. J. MAC GILLAVRY and H. BOISSEVAIN (103) describing this species from Pinar del Rio also assume a Senonian age. It would thus appear that the youngest parts of the Tuff Series range as high as the Lower Senonian. On account of its statigraphical position a pre-Diorite age is certain as the lime-

stones, in which the above mentioned fossils were found, have been contact-metamorphically altered by the Diorite intrusion.

Petrographic description.

The porphyrites are mostly weathered rocks although several samples of fresh rocks were taken. When in the neighbourhood of bedded tuffs, they are found to occur in concordant beds. Mostly the rocks are dark-green to dark-grey, fine-grained with a clearly porphyritic texture. Macroscopically small, white or greenish-white felspar-phenocrysts can be seen. When the rocks are weathered, they get a brown colour. Sometimes we find amygdaloidal rocks, the amygdules filled up with epidote or quartz. Under the microscope, we observe a well developed porphyritic texture; the amount of the groundmass is in most cases larger than that of the phenocrysts. The phenocrysts are plagioclase and augite; plagioclase-phenocrysts are always found, augite-phenocrysts on the contrary are rather scarce. The plagioclase- phenocrysts are often found drifted together. When they form the only phenocrysts in the rock, their composition is rather acid, about albite-oligoclase, but when they occur together with augite a more basic composition is found, andesine-labradorite or labradorite. These basic felspars are rather fresh and often show beautiful zonal crystals with a basic core and an acid periphery. Polysynthetic twinning is often observed in them. Albitisation is often met with. The more acid felspars are idiomorphic, dusty, simply twinned. Apatite is often found as inclusion in the felspar-phenocrysts. As secondary products of the felspars we see sericite, chlorite, epidote, zoisite, clinozoisite and dust.

The pyroxene is a colourless diopsidic augite. It occurs in large, clear idiomorphic phenocrysts, which in some cases show beautiful twins. Smaller grains, which gradually pass into the augite microlites of the groundmass, are also found. Sometimes the augite is completely replaced by aggregates of chlorite and epidote. In one case (D 24193) we observe contours of phenocrysts, which might have been amphibole [1]). Owing to strong chloritisation, it is impossible to become certain of this point.

The groundmass is holocrystalline and is built up of the following components. Plagioclase occurs in small laths, which may become fluidally arranged (D 24196), giving the rock a trachytic habit. Their composition varies from albite to albite-oligoclase. When occurring together with augite, they have an oligoclase or oligoclase-andesine composition. Chlorite, zoisite, epidote and sericite can be regarded as their alteration products. Augite has been in most cases completely replaced by chlorite and epidote. The amount of magnetite and limonite varies considerably; sometimes it is predominating over the other minerals and the rocks become black or dark-red. Apatite in small needles is often found in the groundmass.

In W 59 (D 24196) we observe rockfragments of porphyrites, which

[1]) The numbers with D „in parentheses" indicate the number in the thin-section collection of the Mineralogical-Geological Institute of the State University at Utrecht.

are particularly rich in magnetite. This rock, a brecciaceous porphyrite, is also rather strongly silicified, a phenomenon, which is very often found, resulting in the occurrence of secondary quartz throughout the groundmass and sometimes in silicification of the plagioclases. Some rocks are also strongly epidotised and chloritised. These two minerals, together with quartz, are often found in the amygdules.

Tuffs and tuff-porphyrite breccias. Starting from fine crypto-crystalline and microcrystalline tuffs, we gradually pass into coarser crystal-tuffs, which often contain rock-fragments and thus give rise to the very coarse tuff-porphyrite breccias. While in the fine-grained tuffs an often well-developed stratification can be seen, there is not a single trace of bedding in the coarse breccias. Joints perpendicular to the bedding are often observed in the fine-grained tuffs. The colour varies from dark-green to greyish-green in the breccias while the tuffs are blue, grey or yellow. When weathered the rocks get a brownish colour, caused by limonite. Microscopically the rocks are found to vary over a wide range. We find rocks, which consist almost entirely of crystal- and rock-fragments, while in other rocks the groundmass predominates and only dimunitive crystal fragments are found. When these last mentioned tuffs become more or less silicified they get a cherty habit.

The dense cryptocrystalline tuffs consist of fine volcanic dust with a small number of tiny plagioclase laths and their alteration products.

The coarser crystal-tuffs possess a „groundmass" built up of acid plagioclase, chlorite, limonite, magnetite, zoisite and epidote. This „groundmass" is often strongly silicified. Under the fragments of pheno-crysts acid plagioclase, mainly albite-oligoclase, takes the first place. In most cases they are cloudy and considerably altered; zoisite, epidote and sericite are often seen to replace them. In one case (W 54) a plagioclase-phenocryst was found in which a large titanite-grain was enclosed, the outlines of the plagioclase being neatly parallel to those of the titanite. Occasionally an amphibole-phenocryst is found, and these phenocrysts too are often strongly altered. Epidote, chlorite and magnetite may be regarded as their weathering products.

The tuff-porphyrite breccias are built up of many large fragments of phenocrysts and rocks. The fragments are cemented by secondary minerals as quartz, limonite, chlorite, epidote and calcite. The rocks undergo also chloritisation and epidotisation. Crystal-fragments are mainly, often solely, represented by acid plagioclases with their alteration products. The embedded fragments of porphyrites found in the coarsest breccias are lumps of ground-mass, silicified or not, of true porphyrites with clearly visible plagioclase-phenocrysts.

North of km 488 of the Carretera Central we find rocks of the Tuff Series exposed over large distances. These rocks, however, have for the greater part so greatly changed, that it is very difficult to ascertain what they originally were. Mostly the rocks are totally silicified, sometimes very fine-grained, so that they become cherty; in other cases when the quartz-

grains become coarser, one gets the impression of a quartzitic rock. In one thin-section (D 24270), we observed peculiar streaks throughout the rock. We did not succeed in determining the nature of those streaks. In D 24281 we see large quartz-grains with strings of sericite across them; they are probably sericitised plagioclases, which in a later stage were silicified. In a few cases outlines of more or less altered plagioclase-phenocrysts are observed, and so we can be pretty sure that all these rocks belong to the Tuff Series. Moreover we find patches of epidote and chlorite, probably pseudomorphic after plagioclases. Limonite and magnetite are always found, sometimes in very large amounts. At W 100 we found rocks with a considerable amount of prehnite and some muscovite. At T 926 we found a benthonitic rock. This rock is regarded to be a heavily weathered tuff.

At the Loma Carolina these silicified rocks are found again. Here the rocks contain very much alunite. The refractive index of this mineral is 1,57—1,59. It is uniaxial positive and the character of the principal section is negative. It shows a well-developed cleavage after (0001) and a straight extinction. When heated it smells of SO_3. It is quite uncertain where this mineral originated from. It is not impossible that all these traces of metamorphism in the afore-mentioned rocks are caused by Diorite-intrusions, which at the moment are hidden in the underground. At H 58, the most easterly tip of the large area of Tuff Series rocks in W. Camaguey, which will be described later by Mr. B. van Raadshooven, we find a tuffite with calcareous cement. Fragments and phenocrysts of albite-oligoclase with its alteration products are clearly visible. Moreover a few quartz grains are seen. The rock has been chloritised and epidotised. Sponge needles are often found.

Cataclastic phenomena are often encountered in the rocks of the Tuff Series, especially in those which have been silicified. Quartz and plagioclase grains have often been broken, and nearly always undulatory extinction can be observed.

The Provincial limestones are outcropping at only two places. To the West of Magarabomba the limestones are found clearly intercalated in the porphyrites and tuffs. They are dark-yellow limestones with many Rudist-fragments. West of Ciego de Avila at K 40, K 41 and R 16 we find tuffs and porphyrites alternating with dark-blue, strongly recrystallized limestones. One of these limestones consists for the greater part of Rudist-fragments and it is here that one specimen of *Barrettia sparcilirata* was found. Moreover we find here contactmetamorphic limestones. Their weathering colour varies from greyish-white to light-green. In some cases such quantities of garnet are observed microscopically that we may speak of a garnet-rock. The garnet occurs in large crystals which are colourless or light-yellow. Often hexagonal sections are seen; the refractive index is about 1,75. Zonal structure is often met with. Generally the garnet is isotropic, but we find also crystals which are anomalously birefringent. In that case they show bluish polarisation-colours. Obviously, we have to do here with „common

garnet". Sometimes considerable amounts of the primary calcite has been left. Epidotisation, zoisitisation and silicification are observed in many samples. A single magnetite-grain and some limonite are found.

Serpentines.

Exposures of Serpentine are found in the north-eastern corner of our district, where it joins up with the district described by H. J. Mac Gillavry. The western margin of its large Serpentine mass has been indicated on our map. H. J. Mac Gillavry was obliged to assume a fault between the Serpentines and the Cubitas Limestones in order to explain the observed facts. In our district these same facts exist. South-East of Donato the Cubitas Limestones are in a nearly horizontal position or are gently dipping towards the South and South-West, that is to say towards the contact. In consequence we have also drawn a fault between the two formations. South of Donato and Woodin we find the Serpentines in contact with Aptychi Limestones and we believe that these contacts are also tectonical ones.

Near K 59 e.g. we find Aptychi Limestones which show a strike of about N 30 E. As we may see from the map, the general „strike" of the Serpentines is N 120—130 E, thus cutting the bedding of the Aptychi Limestones at an almost right angle. The fact that nowhere contactmetamorphically altered limestones were found, although we took many samples in this region, seems to support this opinion. So the several contacts between the two formations in this region are thought to be of a tectonical nature, formed by faulting.

As for the age of the Serpentines nothing can be said with certainty, but there is no reason why we should not assume the same age as was proved by H. J. Mac Gillavry in the neighbouring district.

Vegetation is very scarce in these Serpentine-areas and this, combined with the absence of roads and tracks, does not make a walk very enjoyable.

Macroscopically the Serpentines are dark-green rocks with large discernable grains of bastite. Under the microscope, they appear to consist of antigorite, whose fibres are arranged in more or less regular patches. Rests of the olivine crystals from which the antigorite has arisen are also found. The olivine is more idiomorphic than the diallage. The latter has often been replaced by large patches of bastite. Besides Serpentines with diallage, we find also rocks with bronzite, which also has been weathered into bastite. The last mentioned Serpentines have clearly originated from harzburgites, while the rocks containing diallage have originated from wehrlites.

Magnetite sometimes occurs in considerable amounts, by preference aong the patches closed in by the antigorite fibres. Several times Serpentine-residuals, consisting of quartz, limonite, occasionally accompanied by magnetite, were found. Magnesite, magnetite and quartz (also chalcedony)

can also be regarded as secondary products, coming into existence when the olivine-crystals were weathering. Once, in a rather fresh rock, large grains of chromite were found.

Near K 59 we found a dark-green coloured rock. Under the microscope we see a rock without any texture, very rich in small idiomorphic grains of garnet. Besides garnet, we find small, always allotriomorphic grains of colourless to light-green pyroxenes; these pyroxenes have often been replaced by chlorite. Further we find large, more or less idiomorphic amphiboles, which in part have been weathered to epidote or clinozoisite. Magnetite occurs in small quantities. Surveying the composing minerals, we must rank this rock with the Eclogites, and regard it as an inclusion in the Serpentine (see M. G. RUTTEN (121) and H. J. MAC GILLAVRY (120)).

Diorites.

Considerable masses of dioritic rocks and other rocks belonging to the quartz-diorite intrusion are found outcropping near Ciego de Avila and in the south-eastern corner of the described area.

The age of the dioritic rocks is Upper Cretaceous. At km 459, East of Ciego de Avila, we find the above mentioned contact-metamorphically altered limestones of the Tuff Formation where these are in contact with the Diorite; in consequence the intrusion must be younger than the Tuff Formation. On the other hand it must be older than the Habana Formation as the latter contains pebbles of dioritic rocks.

The Diorite intrusion is strongly differentiated. We find quartz-diorites, granodiorites, diorite-porphyrites, quartz-diorite-porphyrites, albitised rocks, malchite, plagiaplites, granodiorite-aplites and aplite.

It is a remarkable fact that so many aplitic rocks are found. This may be caused by the fact that the aplitic rocks are singled out by selective erosion as they are rather resistent, but it is also possible, that we are in more acid parts of the Diorite intrusion. The quartz-diorite-porphyrites, diorite-porphyrites, leucocratic and melanocratic rocks are especially found in the neighbourhood of Piedrecitas and Cespedes, where they occur as dikes in the larger intrusions.

The rocks of the dioritic intrusion have been affected only to a slight degree by cataclasis. Only in a single case broken crystals have been found. Undulatory extinction of the quartz- and felspar-phenocrysts occurs. Erosion and denudation are acting very rapidly on these Diorite masses. All that remains is a brownish loose diorite-sand, which permits only a scarce vegetation and one has to look very carefully for a fresh sample.

Quartz-Diorites. The quartz-diorites are medium- to coarse-grained rocks, white or pinkish-white with dark spots of the amphibole and biotite grains. The texture is holocrystalline and hypidiomorphic-granulose. Depending on the presence or absence of biotite and amphibole, we can

distinguish quartz-amphibole-diorite, quartz-biotite-diorite and quartz-biotite-amphibole-diorite. In some cases, when the quantity of biotite and amphibole becomes very small, the rocks get an aplitic habit. Besides amphibole and biotite, the most important minerals are plagioclase and quartz. The plagioclase is more or less idiomorphic, tabular or lath-shaped in section. Simple and polysynthetic twinning is often met with, while zonal structure is often found; the peripheric zones consist of albite-oligoclase, while the core is formed by oligoclase-andesine or andesine. The non-zonal unaltered plagioclases have a composition, ranging from oligoclase-andesine to andesine. In nearly all samples, we see a sometimes rather coarse, almost graphic, granophyric intergrowth of plagioclase and quartz. Myrmekite is also found in one case. Sometimes small amphibole crystals are enclosed in the plagioclase. Mostly the plagioclases are very clear; when they are weathered, they become dusty, and small sericite plates are found. Zoisite has replaced the plagioclase to a large extent in D 24156. Albite is always present in allotriomorphic grains. Orthoclase is of little importance.

The amphiboles are more idiomorphic than the plagioclases. They are often drifted together in groups, but occur also regularly distributed in the rock. Their form is mostly prismatic, cleavage is often well developed and twins can be observed. Pleochroism, colour and extinction point to the common green hornblende. Very often the amphiboles are replaced by chlorite, epidote and iron-ore. The lavenderblue polarisation-colours of the chlorite point to pennin.

When biotite occurs, it is found in large, broad, tabular, idiomorphic prisms. Its colour varies from brown to brownish-green and pleochroism is strong (D 24174). As its alteration products we find chlorite and ore.

Quartz in allotriomorphic crystals fills the spaces between the other minerals. Sometimes we see fine inclusions in it. Its amount varies strongly.

As the eldest components of the rock, we find the following accessory minerals: titanite in large idiomorphic or angular grains, apatite needles and magnetite grains. Zircon is rare.

Granodiorites. In two cases, V 76 (D 24151) and H 71 (D 24118), we have to deal with rocks of a granodioritic composition. Besides plagioclase, these rocks possess a considerable amount of orthoclase. In D 24151, we observe that nearly all the orthoclase forms a perthitic intergrowth with the plagioclase. For the rest these rocks are of the same type as the quartz-diorites. They also contain biotite, amphibole and the same accessories. As already stated above, cataclastic phenomena are rare in these rocks.

Quartz-diorite-porphyrites. Most rocks of this type were sampled in the area of Piedrecitas and Estrella. Some of these rocks, e.g. V 43*a*, R 44*b*, H 61 and H 75, might have been called quartz-porphyrites as they have an originally glassy matrix with a perlitic texture. Very often this texture was more or less effaced by a secondary silicification. Near H 70 and somewhat to the North silicified tuffs and quartz-porphyrites are found. In these quartz-porphyrites, however, pebbles of granophyric aplite were

found and so we must assume a younger age for these tuffs and porphyrites; they are considered to belong to the Habana Formation.

Macroscopically the quartz-diorite-porphyrites are gray to white rocks. If weathered, their colour varies from brownish-green to dark-green. In a fine-grained groundmass plagioclase and quartz-phenocrysts are visible.

Microscopically the following details can be observed: the plagioclase phenocrysts are tabular or lath-shaped in section; they are often simply twinned. Their composition ranges from albite through albite-oligoclase to oligoclase-andesine. Most crystals are dusty, and alteration-products occur frequently. We see chlorite, sericite, epidote and zoisite as their weathering-products. Silicification and albitisation can also be observed.

Quartz occurs in clear, idiomorphic to hypidiomorphic crystals, often carrying tiny inclusions. Corrosion phenomena are often seen. Sometimes the quartz-phenocrysts are broken, the fragments lying close to each other with the groundmass between them. Here we find an indication for the occurrence of stresses during the consolidation of the magma.

In some thin-sections relics of amphibole-phenocrysts are found. They have been nearly always strongly altered and pass into aggregates of chlorite and epidote. With the exception of the above-mentioned four „quartz-porphyrites" (V 43*a*, R 44*b*, H 61 and H 75), which have a partly glassy groundmass, the quartz-diorite-porphyrites possess a holocrystalline, medium- to fine-grained groundmass with a panallotriomorphic-granulose texture. It is built up of quartz, plagioclase, chlorite, epidote, zoisite and iron-ore. Very often the groundmass is strongly silicified.

Diorite-porphyrites. In these rocks, which are marked by a distinct holocrystalline porphyritic texture, we find phenocrysts of plagioclase and sometimes of augite. The plagioclase phenocrysts form large idiomorphic crystals with simple or polysynthetic twins. The average composition ranges from oligoclase to andesine. As a rule they are dusty and chlorite, epidote and sericite are often seen as their alteration products. In one sample, H 72 (D 24119), we observe an almost complete albitisation of the small plagioclase-laths.

The augite-phenocrysts are in most cases uralitised. Chlorite and epidote are found as its alteration products.

The groundmass is holocrystalline and is built up of plagioclase, augite, epidote, chlorite, apatite and magnetite. In D 24062 a trachytic texture was found and in D 24119 a sub-ophitic texture can be seen. Silicification of the groundmass is very common. These diorite-porphyrites can be distinguished from the porphyrites of the Tuff Series and of the Habana Formation by the coarseness of their groundmass.

Melanocratic dike rocks. Only at one place, near H72, a lamprophyric dike rock was found. The dike is formed by a very fine-grained greenish rock, which microscopically proves to be a malchite. The rock has a panallotriomorphic-granular texture and consists mainly of amphibole and plagioclase with a certain amount of quartz. The plagioclase is albite, very clear

and allotriomorphic. The amphibole is hypidiomorphic or allotriomorphic, has a green colour and is rather strongly pleochroitic. Quartz fills the interstices between the other components. Magnetite is an accessory. The rock has been silicified to a certain extent.

Leucocratic dike rocks. Several samples of these rocks were taken and, after microscopical research, we can divide them into two groups, viz. the granodiorite-aplites and the plagiaplites. Owing to weathering conditions and the lack of good exposures, only in one or two cases the rocks were found to occur as true dikes, cutting the quartz-diorites. Generally, the rocks have a white or pinkish-white colour, which becomes brownish if they are weathered. Microscopically we see medium- to coarse-grained, holocrystalline, panallotriomorphic rocks, mainly built up of felspars and quartz.

The granodiorite-aplites are built up of the following components. Felspars are represented by orthoclase, albite, albite-oligoclase and oligoclase-andesine. The more basic felspars are fresh, show fine polysynthetic twinning, and often zonal crystals are seen, the core being of an oligoclase-andesine composition. Albite and especially orthoclase are dusty and nearly always these two minerals form a granophyric intergrowth with quartz. This intergrowth is sometimes developed over large distances and in some cases it may be very coarse. In V 72 spherulites of this granophyric intergrowth are well developed throughout the whole rock. Sericite, epidote and chlorite are found as weathering products of the felspars.

Quartz occurs in large amounts in clear, xenomorphic crystals. Biotite occurs accessorily in small, pleochroitic flakes with inclusions of zircon-grains. Other accessories are magnetite, apatite, titanite and zircon.

The plagiaplites differ from the granodiorite-aplites in having no kalifelspars. They have the same plagioclases with the exception of a single rock, the felspars of which are of a more basic composition. Biotite may occur. It has been altered into chlorite, epidote and magnetite. In K 24 amphibole was observed. This amphibole was replaced by chlorite to a large extent. Moreover we find the same accessories and the same weathering products as in the granodiorite-aplites. The aplites are affected by cataclasis, but only to a slight degree. Undulatory extinction occurs, sometimes crystals are broken, but nowhere has mortar structure or even recrystallization been observed.

Contactmetamorphism. As was stated already at the beginning of this chapter, the Diorite-intrusions have altered limestones of the Tuff Series. Garnetisation took place in these limestones and at other places porphyrites and tuffs from the Tuff Formation were silicified and epidotised.

Habana Formation.

In Central Camaguey we find outcrops of this formation in several places. The extension of the formation now is rather small, but as we may

see from the map, e.g. near Ciego de Avila and Cespedes, it is likely that in former times its rocks have outcropped over large parts of the district.

The age of the Habana Formation is Upper Cretaceous, which statement is based on the following evidence. The Larger *Foraminifera* of the genera *Orbitoides* and *Lepidorbitoides* are found in Europe in the Maestrichtian beds. *Lepidorbitoides minima*, several specimens of which were found in our district, was also found in the Upper Cretaceous of Mexico; *Lepidorbitoides nortoni* was described from the Upper Cretaceous of Louisiana.

The two Rudist species we found, *Titanosarcolithes giganteus* and *Mitrocaprina tschoppi* are also well-known species from the Upper Cretaceous of Cuba. Both have been recorded and described by H. J. MAC GILLAVRY from Eastern Camaguey, but they occur also in other parts of the island. The marls, sampled at V 36, V 78 and V 79*a*, proved to be very rich in Smaller *Foraminifera*. In chapter IV we will give a complete list and a description of some known and other new species, but a careful examination of this fauna as a whole, and a comparison with other faunas may be given here.

When we examine the quantitative composition of the fauna, the richness in *Globotruncanas* and *Gümbelinas* is striking and these genera are not only rich in individuals, but also in species. Besides these two genera, which are excellent indices for Upper Cretaceous strata, several other characteristic genera are found e.g. *Pseudotextularia*, *Planoglobulina*, *Eouvigerina*, *Ventilabrella* etc. Pelagic forms, such as *Globigerinas*, are represented, but only very few specimens were found. The greater part of the genera which were found, are animals which by preference live in shallow to fairly deep, warm waters.

When we compare the fauna, described by G. H. VOORWIJK from the province of Habana, with ours, the resemblance is conspicuous.

A fauna of Smaller *Foraminifera* from the Upper Cretaceous of Antigua, described by J. A. CUSHMAN, may be regarded as an equivalent of the Cuban fauna. A comparison with Upper Cretaceous Foraminifera from Trinidad, described by J. A. CUSHMAN and P. W. JARVIS (45, 46), reveals also a certain relationship, but as was already emphasized by Dr. CUSHMAN, this fauna seems to be somewhat higher in the section than the fauna of Antigua.

Mexico offers us several possibilities for comparison. In the Tampico embayment extensive and detailed work has been done by M. P. WHITE (86, 87). From this region several hundreds of species are recorded; of one hundred and forty-three species, which are regarded to be index-*Foraminifera*, a full description has been given. These descriptions are accompanied by tables, showing the ranges and the relative abundance of these species. After a careful examination of these tables, we came to the conclusion that there is a very close relationship between the Mexican and Cuban faunas and that especially the Mendez-fauna shows much affinity with Cuba. Some characteristic species, which the Mendez-fauna has in common with that of Cuba may be enumerated: *Bolivina incrassata*, *Bolivinoides draco*, *Gümbelina excolata*, *Planoglobulina acervulinoides*, *Flabellina interpunctata* and *Pseudotextularia*

varians. This is only a short and incomplete enumeration, but a significant one. *Bolivinoides draco*, *Gümbelina excolata* and *Pseudotextularia varians* with its varieties, e.g., occur only in the Mendez or even in parts of that. *Globotruncana arca* is not mentioned by WHITE, but CUSHMAN (12) reports an abundant occurrence of this species in the Mendez.

In the Gulf States of the U.S.A. we find again comparable faunas. From the Annona Chalk, the middle part of the Taylor-formation, which several authors regard as an equivalent of the Mendez in Mexico, the same typical Upper Cretaceous species have been recorded e.g. *Cibicides excolata*, *Globotruncana arca*, *Flabellina interpunctata*, etc. The resemblance with the Saratoga Chalk — Upper Taylor — is only small. In this part of the Taylor *Cibicides excolata* becomes very rare, while it is abundant in the Annona Chalk and our material.

From Western Alabama and Kansas comparable faunas have been described respectively by MORROW (62) and SANDIDGE (79).

With Europe finally, there are less distinct but undeniable affinities. Several species we found in Cuba were described from Bohemia by REUSS, from the Bavarian Alps by EGGER and from Pomerania by FRANKE. All these facts point, as we have seen, to the same — Upper Cretaceous — age and we feel rather sure, that the Cuban-, Antiguan-, Mendez- and Taylor-fauna belong to the same complex.

Near T 1426 and T 1427 Dr. TSCHOPP sampled some *Mollusca* from Habana marls. The three *Pectinidae*, *P. irregularis*, *P. bellula* and *P. georgetownensis* have also been described from Texas and Mexico, but there they occur in the lower parts of the Cretaceous, Middle- and Upper Albian. That would mean that the Habana Formation might be slightly older or that we have to assume that the above mentioned species persisted during the Upper Cretaceous. The last supposition is regarded as highly probable.

As was already pointed out, the composition of the fauna at the find-spots V 78 and V 79*a*, indicates a shallow to fairly deep sea. Rudists and Larger *Foraminifera* cannot be expected in such deeper basins, nor have they been found here. Indications for a littoral sedimentation during the Habana-time, however, are found at several places. West of Piedrecitas and East of Ciego de Avila e.g. we find coarse brecciaceous limestones with large pebbles from the Diorite and the Tuff Series. In these deposits very many Larger *Foraminifera* and Rudists are found, whereas Smaller *Foraminifera* are very scarce.

The rocks of the Habana Formation are transgressive over the Diorites and the Tuff Series. Detritic material of these two formations is found in the conglomerates of the Habana Formation. As we have already mentioned, these fragments are often found together with typical Upper Cretaceous fossils.

At F 52, about two kilometers E. of Ciego de Avila, on a small hill a very coarse conglomerate is found. In the field one gets the impression of finding oneself in an outcrop of dioritic rocks or of the Tuff Series. This

impression is further strengthened by the fact that the components of this conglomerate are found in enormous loose blocks, the diameter of which may reach a yard or more. Moreover the cementing material of the conglomerate was not found. Under the microscope, however, the variegation of this assembly of rocks is clear. The following rocks were found in the conglomerate: porphyrite-breccias, amphibole-porphyrites, quartz-amphibole-diorites, granodiorite-aplites, tuff-porphyrite-breccias, tuffs, quartz-diorite-porphyrites and diabases.

A stratigraphical gap between the Habana Formation on the one side and the Diorite and the Tuff Series on the other is thus clear.

On the Carretera Central at km 513 we see that there is a structural discordance between the Habana Formation and the Eocene. Here the strikes of the Tertiary and Upper Cretaceous strata are diverging. While the structures of the Habana Formation in the western part of Central Camaguey are simple, the folding in the eastern part has been more intense and rather steep dips are found here. Just North of Cespedes, the layers are nearly vertical.

The Habana Formation includes porphyrites, porphyrite-breccias, quartz-porphyrites, tuffs, tuffites, limestones (conglomeratic or not), calcareous sandstones and marls. As already was pointed out by MAC GILLAVRY, it is often very difficult to distinguish the tuffs and porphyrites from those of the Tuff Series. M. G. RUTTEN attaches great importance to the occurrence of primary quartz in the tuffs of the Habana Formation and this characteristic was also found in our district. At any rate, not a single rock, clearly belonging to the Tuff Series, was found to possess a primary quartz-grain, whereas several tuffs and porphyrites, the Habana age of which for several other reasons could not be doubted, proved to contain primary quartz.

The occurrence of detritic material of dioritic rocks in tuffs and porphyrites, belonging to the Habana Formation, is one of the most valuable indications.

Porphyrites. Most porphyrites we find in the Habana Formation are dense, green or brownish-gray rocks. Their porphyritic texture is evident; white felspar-phenocrysts and sometimes dark green ones, likely of augite, are clearly visible. Rocks with amygdules were found several times.

Microscopically we see a holocrystalline porphyritic texture. Plagioclase, augite and biotite are seen to occur as phenocrysts in a fine-grained groundmass. The plagioclase is found in large, tabular, idiomorphic to hypidiomorphic crystals. Lamellar twinning is frequent. The composition of the unaltered plagioclases ranges from andesine-labradorite to labradorite-bytownite. The phenocrysts often show magnificent zonal structure, the core being distinctly of a more basic composition than the periphery. The tooth of time, however, has gnawed tremendously on the plagioclases. Albitisation is often encountered just as sericitisation. With these processes quartz and calcite have come into existence. Saussurite, epidote and chlorite are also often met with as their weathering products. Sometimes we find

inclusions of augite and magnetite in the plagioclases and in D 23981 we find numerous small needles, also hexagonal sections of apatite in the plagioclase. The augite occurs in colourless to light-green crystals. In most cases they are nicely idiomorphic. Twins are often seen. As their alteration products we find chlorite, sometimes in large quantities, zoisite and ore. Biotite was found only in two cases. Here it occurs in idiomorphic, large flakes. Some crystals still have their original brown colour and in consequence they are strongly pleochroitic. In many cases, however, strong chloritisation of the biotite took place and here the brownish-green polarisation-colours of the chlorite betray its origin. Besides chlorite, oxydic ore has originated from the biotite.

The groundmass is holocrystalline, fine-grained and mainly built up of tiny laths of plagioclase and augite. The alteration products of these two minerals are also found, sometimes in large quantities. We see chlorite, epidote, sericite and also limonite, apatite, leucoxene and magnetite. Especially magnetite may occur in large quantities. The groundmass has often undergone strong alterations. Silicification is very common, but sericitisation, epidotisation and calcitisation are also encountered. Calcite and quartz are sometimes seen to occur is small veinlets throughout the whole rock.

The amygdules, which occasionally are found in the rocks, are filled up of quartz, calcite or epidote. In one case secondary quartz in the groundmass occurs in beautiful spherulites. Cataclastic phenomena are rarely found. Only in D 23980 we find traces of stress. Here the plagioclase-phenocrysts are broken for the greater part.

The quartz-porphyrites differ from the porphyrites by the occurrence of primary quartz. It is found as more or less idiomorphic phenocrysts. One of these quartz-porphyrites (D 24117) contains a large xenolith of an aplite with the characteristic granophyric intergrowth of quartz and orthoclase. Sometimes we observe very minute gas-inclusions in the quartz-phenocrysts. For the rest the rocks have the same phenocrysts and the groundmass is built up of the same components, together with quartz. Silicification is also common in these rocks.

Tuff-porphyrite-breccias. These rocks are mainly built up by large fragments of porphyrites and phenocrysts or fragments of them. Among the latter, plagioclase takes a predominant place, but quartz-grains are also encountered. The plagioclases are represented by albite-oligoclase, oligoclase as well as by more basic ones, such as andesine-labradorite. Only in a few cases the plagioclases are fresh. Mostly they are strongly weathered, dusty, and for a great part replaced by their weathering products as e.g. chlorite, epidote, zoisite, sericite, etc. Rock-fragments take an important place. Large porphyrite-fragments, silicified or not, occur. In these porphyrite-fragments plagioclase-phenocrysts of an intermediate composition are readily observed. The porphyrite-fragments are often marked by their richness in magnetite. In D 23965 (K 44) we see a fragment of a tuffite with

calcareous cement. In this tuffite idiomorphic quartz-grains, showing corrosion-phenomena, are observed. The „groundmass" which by the large quantities of crystal- and rock-fragments may fall into the background, is composed of plagioclase, quartz, chlorite, epidote, zoisite, limonite, magnetite, apatite and leucoxene. Again we find often silicification in these rocks. There are also coarse porphyrite-breccias which are cemented by calcite (K 44, K 46).

The tuffs are for the greater part fresh-looking, light-coloured, greenish or reddish rocks. If weathered, their colour becomes brown and that is the reason why in the field they are so readily confounded with tuffs from the Tuff Series. Microscopically the tuffs consist of a microcrystalline basis with splinters and fragments of crystals. These crystal-fragments are: plagioclase, average composition about andesine-labrador, often twinned, albitisation not rare, with their alteration products chlorite, epidote, sericite, etc. Quartz, especially in D 23972 and D 23991, occurs in pretty large quantities, sometimes with corrosion-phenomena.

The groundmass consists of plagioclase, quartz, chlorite, zoisite, epidote and limonite. Silicification of the groundmass occurs frequently. H 70 is a very fine-bedded tuff, which has been nearly completely silicified.

Tuffites were found at only two places. Both are strongly calcified rocks with many splinters and crystal-fragments of plagioclase and quartz. In D 23982, we find moreover rounded fragments of porphyrites.

From the foregoing it may be clear that the volcanic activity during Habana times was still great in Central Camaguey. This is in accordance with the fact that during this time volcanic activity increased, going from West to East on Cuba.

The clastic sediments, conglomerates and calcareous sandstones, sometimes contain very much detritic material: fragments of quartz-diorite, quartz-diorite-porphyrite, diorite-porphyrite, granophyric aplite, tuffs and porphyrites from the Tuff Series and grains of plagioclase, quartz, biotite, epidote and chlorite. Occasionally these conglomerates contain also fragments of Rudists. In F 49 we observe that the calcite, which cements the coarse rock-fragments, extinguishes over large distances at the same time.

The limestones of the Habana Formation are yellow, if weathered, brownish-yellow rocks with many fossils. In the landscape these limestones give rise to a black or grayish soil, which occasionally may become rather sandy and which is in sharp contrast with the soils which we encounter on Tertiary rocks. Under the microscope we see brownish-yellow rocks with an oolitic or suboolitic structure. This feature was found to be very common and even when the rock does not contain any fossil, one may be rather sure about the age of the rock. Often the limestones carry small grains of quartz and plagioclase.

In thin-sections we found the following fossils: *Orbitoides*, *Lepidorbitoides*, *Vaughanina*, *Sulcoperculina dickersoni*, Corals, *Lithothamnia*, Rudist-fragments,

Archaias-like fossils and another new genus, belonging to the *Peneroplidae*. The marls are white, contain also detritic material and most of them proved to be rich in Smaller *Foraminifera* as well as in Larger *Foraminifera*. Macrofossils such as *Echinidae*, *Pectinidae*, *Inoceramus* and *Actaeonella* were often sampled in these marls. The fossils which could be determined will be described in Chapter IV.

Eocene.

In Central Camaguey this formation crops out in two separate areas; firstly in the north-eastern corner of the district, in the so-called Sierra de Cubitas and secondly in the South. As there is a distinct difference in facies between these two regions, we will discuss them separately.

The Cubitas Limestones are white or yellowish-white, mostly finegrained rocks, which at some places become marly. Occasionally a coarse-crystalline rock is met with. Some rocks proved to have a well-developed oolitic structure. It is striking that these limestones are so extraordinarily rich in *Miliolidae*, several samples are crowded with them and do not contain any other fossil. There are, however, rocks where they are found together with *Discocyclina*, *Dictyoconus*, *Camerina*-like fossils, *Alveolinidae*, *Gastropoda* and several genera of Smaller *Foraminifera*, such as *Globigerina* and *Globorotalia*. In T 1461 (D 24255) we find several species of *Radiolaria* together with sponge needles and Smaller *Foraminifera*.

Calcareous sandstones, although scarce, also occur in the Sierra de Cubitas. Near K 58 (D 24226 and D 24227) we find rocks, which on microscopical examination prove to consist of detritic material, originating from Serpentines, Diorites and porphyrites. The fragments are cemented by calcite. In D 24226 we find, together with these fragments, some specimens of *Discocyclina*.

The Cubitas Limestones have been disturbed only to a slight degree. Frequently we found the rocks in an almost horizontal position and we never found dips exceeding 35 degrees. As was already mentioned in describing the Serpentines, these dips show all a southern or south-western direction, where the Cubitas Limestones are bordered by the Serpentines. H. J. MAC GILLAVRY explained this fact in that way, that the Cubitas Limestones have been brought into tectonical contact with the Serpentines. Although there are only a few measurements in the Cubitas Limestones of our district, as may be seen from the map, we do not hesitate to extend the fault from Eastern into Central Camaguey. Although we have only two samples from the stretch Donato-Woodin, one of which contained a doubtful *Discocyclina*, and a limestone, sampled just South of Woodin, not containing any fossil, we reckon this whole area to belong to the Cubitas Limestones. As the evidence of a fault South and South-East of Woodin is weak, the fault in this region has been indicated as hypothetical.

The age of the Cubitas Limestones is without doubt Eocene, on the

ground of the faunal assemblage. Our observations, paleontologically as well as stratigraphically, do not allow of giving a judgment about MAC GILLAVRY's opinion, that the Cubitas Limestones possibly are somewhat older than Upper Eocene.

In the southern part of our district we find outcrops of eocene rocks in a broad tongue, extending from La Florida to the West. Tectonically this tongue must be regarded as a „high", for in the „axis" of the tongue, we find the older formations, Habana Formation and Diorite, exposed. North of km 488 of the Carretera Central a large area of Tuff Series rocks is surrounded by rocks of eocene age. In this area of Tuff Series rocks we find small strips of eocene rocks, while, at last, North of this region the Eocene pierces the Guines Limestones in a small anticline.

The Eocene in this region is transgressive over Tuff Series, Diorite and Habana Formation. At several places fragments or pebbles of these formations are found in the conglomeratical limestones and marls of the Eocene. The structural discordance between the Habana Formation and Eocene is clearly demonstrated near V 42 on the Carretera Central. On the southern side of the road we find a small hill of about 150 m long. The core of the hill is formed by green tuffs, which belong to the Habana Formation. The strike of these tuffs is about N 70 E and their dip 60 degrees to the South. The western flank of the hill consists of dirty eocene marls; these show a north-eastern strike and a dip of 10 degrees to the North-West. On the eastern flank of the hill we find the basal conglomerate of the marls with worked elements of the Habana-tuffs. These last mentioned marls possess a small dip to the South-East.

The Eocene in this region, too, is marked by very gentle structures. Dips exceeding 10 degrees are rare. When we compare the structures of this region with those found in the north-eastern area and the adjacent part of Camaguey, it seems that the orogenesis causing these structures was less active in the southern than in the northern part of Camaguey.

The Eocene in this area comprises limestones, sandy limestones, marls and conglomerates. The limestones are white, sometimes coarsely crystalline rocks with varying amounts of detritic material. Quartz is often encountered in angular or rounded grains, but we find also fragments of felspar, biotite, epidote and rock-fragments of porphyrites and tuffs. The soil on the eocene limestones and marls is grayish-black, clayey; as a rule it contains only little quartz-sand. Sugar cane seems to thrive on this soil.

The limestones are sometimes rich in fossils. We found the following genera and species: *Discocyclina*, *Lepidocyclina* (among others *L. maracaibensis*), *Pellatispirella bermudezi*, *Pellatispirella antillea*, *Camerina pellatispiroides* (and several other *Camerinae*), *Dictyoconus americanus*, *Amphistegina*, *Alveolinae*, Corals, Oysters, *Lithothamnia*, *Miliolidae* and several other genera of Smaller *Foraminifera*. Near V 89 we find limestones which are completely silicified. They also contain Larger *Foraminifera* such as *Discocyclina* and *Dictyoconus*, accompanied by numerous *Miliolidae*.

The marls are dirty white, contain but little detritic material and some of them contain many Larger and Smaller *Foraminifera* e.g. at V 39 and H 77. A list of species, together with descriptions of some known and new species will be given in the chapter on Paleontology. An ample discussion of this fauna may be omitted here. Species, typical for eocene deposits in the West Indies, Mexico and the Gulf States of the U.S.A., are also found in the Eocene of Central Camaguey e.g. *Globorotalia spinulosa*, *Globorotalia aragonensis*, *Clavulinoides guayabalensis* and *Gümbelina wilcoxensis*. A remarkable fact is the occurrence, though infrequent, of *Globotruncana arca*. We are in doubt whether the *Globotruncanas* are a secondary deposit or that this genus persisted in the Eocene.

The sandy limestones and conglomerates contain much detritic material from older formations. At K 20 and K 21, in a very coarse conglomerate, we find large pebbles of Habana tuffs and limestones. At H 98 we find pebbles of Habana limestones (containing *Orbitoides palmeri*, *O. browni*, *Vaughanina cubensis* and Rudist fragments) in a coarse eocene conglomerate.

The age of the rocks described above is without any doubt Eocene; to be more exact Upper Eocene. The joint occurrence of *Discocyclina*, *Lepidocyclina*, *Dictyoconus* and *Pellatispirella* (especially *P. antillea*) is typical for deposits of this age.

Guines Formation.

From the map it may be seen that this formation is the most common geological element in Central Camaguey. We find it exposed over the whole area, but especially in the western part, as there the Moron Basin has its deeper parts. The eastern border of this Basin coincides almost with the eastern boundary of our district, where the older formations are exposed, and to the West the Basin reaches as far as the eastern part of the province of Santa Clara.

Age of the Guines Formation. PALMER (120*a*), who gives a summary of the former opinions on the age of the Guines Limestones, reckons these beds to be a „transitional phase between the Upper Oligocene and the Lower Miocene". The combination *Miogypsina-Lepidocyclina*, which, according to PALMER, is typical for the Guines Formation, was not found in our district. We did find *Miogypsina* and *Lepidocyclina* indeed, but never together. Near H 134 we found limestones, crowded with *Lepidocyclinae* and without *Discocyclinae*. One of these *Lepidocyclinae* was determined as *L. maracaibensis* and the limestones therefore were mapped as Eocene. As this determination is not quite certain, the possibility remains that the limestones at H 134 belong to the Lower Oligocene.

The determination of the age of the Guines Limestones in our district is based upon *Miogypsina hawkinsi* and a number of Smaller *Foraminifera* which, however, are very characteristic for the oligo-miocene beds. In thin-sections we recognized: *Amphisorus matleyi*, *Archaias*, *Marginopora*, *Sorites*,

Peneroplis, *Spirolina* and several other less characteristic ones. *Miogypsina hawkinsi*, *Amphisorus matleyi* and *Archaias* have also been described by THIADENS from the oligo-miocene beds of Southern Santa Clara, and VERMUNT reports the occurrence of *Amphisorus matleyi* and *Archaias* in the Guines Limestones of Pinar del Rio. The Smaller *Foraminifera*, found in the marlsamples, seem to indicate the same age; the fauna, however, is rather poor. The frequent occurrence of several species of the genus *Elphidium*, *Clavulina tricarinata* and *Gypsina globulus* must, according to my colleagues, who have all a richer oligo-miocene fauna at their disposal, be regarded as very characteristic for strata of this age.

Tectonics of the Guines Formation.

The Guines Limestones cover the more or less strongly folded older formations unconformably. The position of the beds is at most places nearly horizontal and dips of more than 10 degrees are scarce. The only place where they are more strongly folded is the Loma Cunagua. On the southern flank of this ridge, which has a general trend of N 250 E and a lenght of about 5 kilometers, we measured dips up to 20—25 degrees. Here we have an example that the post-lower-miocene orogenesis locally shows a greater intensity. The drainage of the Loma Cunagua takes place by the eastward running Rio Yeso and, although this name seems to contain a promise for the presence of older formations in the Loma, these were not found. A peculiarity of the Loma Cunagua is that its top consists of vast, flat grounds.

Petrographic description.

The limestones of the Guines Formation are white or yellowish-white, porous rocks with a typical cavernous habit caused by the weathering out of abundant *Gastropoda*, *Lamellibranchiata* and other fossils. Moulds and casts of these fossils were found almost everywhere. Very often the limestones become more or less crystalline and the outlines of the fossils are wiped out in such cases. The recrystallization of the limestones can reach such an extent, that the fossils they contain „disappear" as it were. In order to give expression to this fact, all those find-spots, where limestones with well-preserved and determinable fossils were found, have been marked on our map by a special sign. (With the discussion of the age of the Guines Formation we mentioned already the occurrence of several characteristic fossils in the limestones e.g. *Amphisorus matleyi*, *Archaias*, *Marginopora*, *Peneroplis*, etc.). Habitually, there is a great difference between limestones from the Habana and the Guines Formation, but in many cases it is very difficult to distinguish them from eocene limestones, especially when the last mentioned ones are also non-fossiliferous. The boundary between the Eocene and Oligo-Miocene is at many places based on habitual differences and for this reason it is quite possible that it does not give the true local demarcation.

At some places the limestones become sandy and pass gradually into true sandstones. These sandstones, chiefly composed of quartz-grains, are found in the region West and North-West of Ceballos. It is almost certain that this quartz has been derived from the Diorite-area, which lies to the South in the environment of Ciego de Avila. Other detritic material of Diorites, felspars and grains of epidote is also encountered, but never in large quantities. Sometimes we find limestones, which are completely silicified, e.g. near K 7.

At T 935, W. from Moron, a very remarkable limestone was sampled. This limestone belongs without any doubt to the Guines Formation, as it contains *Amphisorus matleyi* and *Archaias*. We found, however, also fragments of Rudists and well-preserved specimens of *Discocyclina* in this sample. In this case we are quite sure, that the Rudists and *Discocyclinae* are on a secondary deposit. Moreover this limestone contains coarse fragments of tuffs and granophyric material, originating from the Diorite Series, besides crystal-fragments of quartz and felspar. The coarseness of the detritic material and the soundness of the *Discocyclinae* suggest a short transport, but nowadays the older formations in this region have been covered by the younger limestones of the Guines Formation.

When the limestones are weathered, they have a reddish colour caused by limonite, which is also seen in small, round concretions in the weathering rock. The residuum of these limestones is a red or purple, lateritic clay, which covers large areas of the district; only sporadically outcrops of limestones are found in this soil. Often the clay is very rich in „perdigon", a local name for the limonitic iron concretions just mentioned. The limonite grains sometimes are luted and a true iron-ore is formed. The perdigon seems to be relatively independent of the underground in Cuba, as we find it on oligo-miocene limestones as well as on schists and Serpentines. It is quite possible that the perdigon is a result of typical climatological factors. In this region of the Caribbean Sea we have an alternating dry and wet season. In the wet season there is a descending movement of water, which transports calcite and iron downwards, but in the dry season an ascending movement of water carries them upwards and they become precipitated around numberless „nuclei", and in several cases we observed the perdigon in „*statu nascendi*".

The thickness of the limestone beds from which the weathering-soil originates, must have been very considerable. Owing to the low elevation of most of the country under discussion, natural sections in the red eluvial soils are rare. When they are found, we observe a covering layer, no less than 5—7 m thick, over the Guines Limestones. Several hundreds of meters of limestones must have been denuded in order to yield such a thick weathering soil. Sugar cane seems to prefer this soil, as most of the sugar-factories in Central Camaguey are found on Guines Limestones.

The marls are yellow or white. Only in a few cases, H 67, K 255 and V 121, they contain Smaller *Foraminifera*. A list of genera and species will

be given in Chapter IV. On Isla Turiguanao a Guines-marl was sampled which proved to be very rich in gypsum.

Quaternary Deposits.

At only two places we found deposits which were reckoned to be of Quaternary age. In the eastern tip of the Loma Cunagua, North of K 64, we found a coarse breccia, consisting of large limestone-fragments, cemented by calcite. In these breccias we observed almost recent *Gastropoda*. A determination of them was not possible, as we had only fragmentary specimens at our disposal. The breccias are certainly of Quaternary age.

On Isla Turiguanao we find again limestone-breccias, e.g. at V 112 and V 117. They contain several large, angular fragments of Aptychi Limestones and also fragments of gypsum. A Quaternary age of these breccias is highly probable.

Chapter III: **TECTONICS.**

In Central Camaguey we can distinguish four different phases of orogenesis, namely:

1°. The post Tuff Series — pre Habana orogenesis.
2°. The post Habana — pre Upper Eocene orogenesis.
3°. The post Eocene — pre Guines orogenesis.
4°. post Guines movements.

The first three of these orogenetic phases are also known from the eastern part of the Province of Camaguey, while in Southern Santa Clara they were all found.

The first period of orogenetic activity in this area was before the Habana Formation became deposited, during the Upper Cretaceous. This orogenesis must have been rather strong in our district as may be concluded from the steep dips in the Aptychi Limestones in the north-eastern part of the described area. Just the same is found on Isla Turiguanao and West of Bahia Buenavista. Often the beds are found in a nearly vertical position. Owing to the plasticity of the gypsum, the structures are very complicated here and it is impossible to say from which direction the movement came. We did not find a structural discordance between the Habana Formation and the underlying Tuff Series where these two formations are exposed West of Ciego de Avila. We are, however, under the impression that the Tuff Series is rather strongly folded here, whereas the Habana Formation, just East of Ciego de Avila, is marked by very gentle structures. At any rate, the existence of a stratigraphical gap between the two formations is proved by the occurrence of coarse conglomerates at the base of the Habana Formation. These conglomerates contain large pebbles of porphyrites and tuffs from the Tuff Series, together with fragments of rocks from the Diorite intrusion. Moreover, the Habana Formation overlaps the older formations in several parts of the district, e.g. East of Ciego de Avila and in the environment of Piedrecitas and Estrella. While this first orogenesis took place, considerable masses of Diorite and related rocks intruded.

The second phase of orogenetic activity was in Lower Eocene times. As for this orogenesis there seems to be a marked difference in intensity between the western and eastern part of Central Camaguey. In the western part, near Ciego de Avila, the beds of the Habana Formation have been disturbed only to a slight degree, and they show very low dips, not exceeding 10 or 15 degrees. In the eastern part on the contrary, folding was much more intense. Dips of forty or fifty degrees are common and at some places layers were found in an almost vertical position. In the last mentioned area we find also a proof of the structural unconformity between the Habana For-

mation and the Upper Eocene. On the Carretera Central, near km 513, we find steep-dipping tuffs of the Habana Formation disconformably overlain by marls of the Upper Eocene, which show a rather low dip. The discordance between the two formations is further brought to light by the occurrence of pebbles of porphyrites, tuffs and limestones from the Habana Formation in the conglomeratic members of the Upper Eocene. On a closer view, the strikes and dips in the eastern part seem to indicate that the direction of this lower or middle eocene movement was from South to North.

The third orogenesis took place before the Guines Limestones were deposited, in the Lower- or Middle Oligocene. Just as there is a difference in facies between the eocene deposits of the north-eastern and south-eastern part of our district, there is also one in the way in which they have been tectonically affected. In the South-East the upper eocene beds have only been slightly disturbed, but distinctly enough to make it clear that they are unconformably overlain by the Guines Limestones, the latter being in an almost horizontal position in this part of the district. In the North-East, however, we find dips of 20 to 30 degrees in the Cubitas Limestones and on the map of MAC GILLAVRY, which in the North-West almost joins up with our map, we find dips even of 40—50 degrees. It is clear that the orogenesis was rather strong here.

As was already mentioned in describing the eocene deposits, the limestones of the Sierra Cubitas dip towards the contact with the Serpentines. In order to explain this fact, we assumed a fault between the Cubitas Limestones and the Serpentines. The age of this fault is clearly post Eocene. Whether the faults between the Aptychi Limestones and the Serpentines, also found in this area, are of the same age or older cannot be said.

The fourth orogenesis finds expression in the very gentle dipping of the Guines Limestones, which are so widespread in our district. At most places the intensity of this orogenesis must have been very weak, since the beds of the formation seldom show dips exceeding 5 degrees. The Loma Cunagua is the only instance where the orogenetic forces were more active. Here dips of 20 to 25 degrees are found.

Chapter IV: **PALEONTOLOGY.**

In this chapter we will give lists of Smaller and Larger *Foraminifera*, respectively from the Upper Cretaceous, Upper Eocene and Oligo-Miocene.

The lists, in which the localities are indicated, are accompanied by descriptions of the new species as well as of some species already known, which in one or more respects differ from the holotypes. All species, which are described or commented upon, are figured. Except *Praerhapydionina cubana*, which was studied in thin-sections, all other species have been determined as complete specimens.

Lists of Smaller and Larger Foraminifera see page 32—40.

Descriptions of the smaller Foraminifera.

a) Upper Cretaceous species.

Gaudryina cretacea (KARRER).

Plate 1, figures 1, 2.

Gaudryina cretacea (KARRER), CUSHMAN, 1937, Contr. Cushm. Lab. For. Res. Spec. Publ. no. 7, p. 40, pl. 6, figs. 3—9.

When we look at the figures given by CUSHMAN, we observe great differences between some specimens e.g. fig. 5 and fig. 8. The differences are so great that it would be better to separate them.

Length 0,7 mm, breadth 0,55 mm. Upper Cretaceous, Camaguey, Cuba. Min.-Geol. Inst. Univ. Utrecht, D 22367.

Pseudoclavulina camagueyensis VAN WESSEM *nov. sp.*

Plate 1, figures 3, 4.

Test elongate, the early stage distinctly triserial and somewhat larger than the following uniserial stage. The triserial portion is bordered by three planes, which are flat or even somewhat concave. The angles between the intersecting planes are sharp. Chambers in the triserial as well as in the uniserial stage indistinct. Sutures can hardly be distinguished. Wall coarsely arenaceous; aperture terminal with a distinct neck.

Max. length 1,3 mm, max. diameter 0,35 mm. Type locality, Upper Cretaceous, Loc. V 79*a*, Camaguey, Cuba. Syntypes, Min.-Geol. Inst. Univ. Utrecht, D 22376.

Dorothia nov. sp.

Plate 1, figures 6, 7.

In transverse section nearly circular. Ratio between length and maximum diameter $1\frac{1}{2}:1$. Initial chambers rounded with about five chambers in the

first whorl. Only two biserial chambers. Periphery very smooth; chambers only slightly inflated, sutures somewhat depressed. Wall finely arenaceous. Aperture of the *Karreriella*-type: neck-shaped, but distinct at the base of the inner margin. Obviously we have to deal with a new species of *Dorothia*.

Lenght 0,75 mm, maximum diameter 0,5 mm. Type locality, Upper Cretaceous, Loc. V 79*a*, Camaguey, Cuba. Holotype. Min.-Geol. Inst. Univ. Utrecht, D 22386.

Dorothia sp.

Plate 1, figures 8, 9.

Test elongate, length 2½ times as long as breadth, circular in transverse section. Chambers distinct, early stages multiserial, in the adult biserial. Chambers gradually enlarging and somewhat inflated. Sutures slightly depressed, nearly horizontal. Wall finely arenaceous. Aperture a low, broad slit at the base of the last chamber.

Diameter 0,35 mm, length 0,9 mm. Upper Cretaceous, Loc. V 79*a*, Camaguey, Cuba. Min.-Geol. Inst. Univ. Utrecht, D 22387.

Textulariella sp.

Plate 1, figure 5.

Test elongate, more or less conical, length about twice as long as breadth. Initial stage multiserial, bluntly pointed. Chambers very gradually enlarging; the largest diameter is reached towards the apertural end.

The adult stage is biserial, chambers somewhat inflated and subdivided towards the periphery. Sutures depressed. Wall rather coarsely arenaceous. Aperture cannot be seen. This species resembles in many respects *Textulariella miocenica* CUSHMAN.

Length 1,4 mm, diameter 0,75 mm. Upper Cretaceous, Loc. V 78, Camaguey, Cuba. Min.-Geol. Inst. Univ. Utrecht, D 22388.

Robulus excisus (BORNEMANN).

Plate 1, figures 10, 11.

Cristellaria excisus BORNEMANN, 1855, Zeitschr. d. deutsch. Geol. Gesell. vol. 7, p. 328, pl. 13, figs. 19—20.

There is only a slight difference from BORNEMANN's figures. Our specimens do not have a distinct keel, but this may have been worn off, as they show a rather bad preservation. Diameter up to 1 mm.

Upper Cretaceous, Camaguey, Cuba. Geol.-Min. Inst. Univ. Utrecht, D 22491.

Robulus stephensoni CUSHMAN.

Plate 1, figures 12, 13.

Robulus stephensoni CUSHMAN, 1939, Contr. Cushm. Lab. For. Res. vol. 15, pt. 4, p. 90, pl. 16, figs. 2—3.

Our specimens are somewhat more evolute than those of CUSHMAN, but in other respects they show a striking resemblance. The diameter of our specimen is rather small, about 0,65 mm. *Continued on page 41.*

Lists of Smaller Foraminifera.

a) From the Habana Formation.

Genus.	Species.	Localities.					
		V 36	V 78	V78b	V79a	H94b	T 938
Textularia	*mississippiensis* Cushm. var. *alazanensis* Nuttall		×				
Verneuilina	*cretosa* Cushm.		×				
”	*limbata* Cushm.		×				
Tritaxia	*tricarinata* (Rss).		×		×		
Gaudryina	*cretacea* (Karrer)				×		
Pseudogaudryina	*pyramidata* Cushm.				×		
Pseudoclavulina	*camagueyensis* v. Wessem *nov. sp.*				×		
Clavulinoides	*aspera* (Cushm.)	×					
”	*trilatera* (Cushm.)				×		
Heterostomella	*americana* Cushm.				×		
”	*austinana* Cushm.				×		
”	*cuneata* Sandidge				×		
Clavulina	*parisiensis* d'Orb.				×		
Arenobulimina	*americana* Cushm.				×		
”	*brevicona* (Perner)				×		
”	*d'orbignyi* (Rss.)				×		
”	*preslii* (Rss.)		×		×		
Marssonella	*indentata* (Cushm. a. Jarvis)				×		
”	*oxycona* (Rss.)	×	×		×		
Textulariella	*sp.*		×				
Dorothia	*bulletta* (Carsey)		×		×		
”	*conula* (Rss.)		×		×		
”	*pupa* (Rss.)				×		
”	*nov. sp.*				×		
”	*sp.*				×		
Robulus	*aldrichi* Sandidge		×				
”	*convergens* (Bornemann)				×		
”	*cultratus* Montfort				×		
”	*declivis* (Bornemann)				×		
”	*discrepans* (Rss.)				×		
”	*excisus* (Bornemann)	×					
”	*gibbus* (d'Orb.)		×				
”	*incomptus* (Rss.)				×		
”	*inornatus* (d'Orb.)				×		
”	*limbosus* (Rss.) var. *hockleyensis* Cushm. a. Applin	×					
”	*midwayensis* (Plummer)					×	
”	*orbicularis* (d'Orb.)				×		
”	*stephensoni* Cushm.				×		
”	*subangulatus* (Rss.)					×	
”	*sp.*	×					
Lenticulina	*nuda* (Rss.)				×		
”	*rotulata* (Lam.)				×		
Astacolus	*crepidulus* (Fichtel u. Moll)				×		
Planularia	*cooperensis* Cushm.	×					
Vaginulina	*parallela* (Rss.)		×		×		
Lingulina	*arteagai* v. Wessem *nov. sp.*	×					
”	*wilcoxensis* Cushm. a. Ponton	×					
Flabellina	*interpunctata* von der Marck				×		
Frondicularia	*archiaciana* d'Orb.	×					
”	*gracilis* Franke				×		
Marginulina	*bullata* Rss.				×		
”	*elongata* d'Orb.				×		
”	*grata* (Rss.)	×					
”	*inaequalis* Rss.		×				
”	*laeviuscula* Cushm. a. Berm.		×				
”	*navarroana* Cushm.		×				
”	*regularis* d'Orb.		×				
”	*scitula* (Berthelin)				×		
”	*siliqua* Cushm.				×		
”	*soluta* Rss.		×				

Lists of Smaller Foraminifera.

a) From the Habana Formation.

Genus.	Species.	Localities.					
		V 36	V 78	V78b	V79a	H94b	T 938
Textularia	*mississippiensis* CUSHM. var. *alazanensis* NUTTALL		×				
Verneuilina	*cretosa* CUSHM.		×				
"	*limbata* CUSHM.		×				
Tritaxia	*tricarinata* (RSS).		×		×		
Gaudryina	*cretacea* (KARRER)				×		
Pseudogaudryina	*pyramidata* CUSHM.				×		
Pseudoclavulina	*camagueyensis* v. WESSEM *nov. sp.*				×		
Clavulinoides	*aspera* (CUSHM.)	×					
"	*trilatera* (CUSHM.)				×		
Heterostomella	*americana* CUSHM.				×		
"	*austinana* CUSHM.				×		
"	*cuneata* SANDIDGE				×		
Clavulina	*parisiensis* D'ORB.				×		
Arenobulimina	*americana* CUSHM.				×		
"	*brevicona* (PERNER)				×		
"	*d'orbignyi* (RSS.)				×		
"	*preslii* (RSS.)		×		×		
Marssonella	*indentata* (CUSHM. a. JARVIS)				×		
"	*oxycona* (RSS.)	×	×		×		
Textulariella	*sp.*		×				
Dorothia	*bulletta* (CARSEY)		×		×		
"	*conula* (RSS.)		×		×		
"	*pupa* (RSS.)				×		
"	*nov. sp.*				×		
"	*sp.*				×		
Robulus	*aldrichi* SANDIDGE		×				
"	*convergens* (BORNEMANN)				×		
"	*cultratus* MONTFORT				×		
"	*declivis* (BORNEMANN)				×		
"	*discrepans* (RSS.)				×		
"	*excisus* (BORNEMANN)	×					
"	*gibbus* (D'ORB.)		×				
"	*incomptus* (RSS.)				×		
"	*inornatus* (D'ORB.)				×		
"	*limbosus* (RSS.) var. *hockleyensis* CUSHM. a. APPLIN	×					
"	*midwayensis* (PLUMMER)					×	
"	*orbicularis* (D'ORB.)				×		
"	*stephensoni* CUSHM.				×		
"	*subangulatus* (RSS.)					×	
"	*sp.*	×					
Lenticulina	*nuda* (RSS.)				×		
"	*rotulata* (LAM.)				×		
Astacolus	*crepidulus* (FICHTEL u. MOLL)				×		
Planularia	*cooperensis* CUSHM.	×					
Vaginulina	*parallela* (RSS.)		×		×		
Lingulina	*arteagai* v. WESSEM *nov. sp.*	×					
"	*wilcoxensis* CUSHM. a. PONTON	×					
Flabellina	*interpunctata* VON DER MARCK				×		
Frondicularia	*archiaciana* D'ORB.	×					
"	*gracilis* FRANKE				×		
Marginulina	*bullata* RSS.				×		
"	*elongata* D'ORB.				×		
"	*grata* (RSS.)	×					
"	*inaequalis* RSS.		×				
"	*laeviuscula* CUSHM. a. BERM.		×				
"	*navarroana* CUSHM.		×				
"	*regularis* D'ORB.		×				
"	*scitula* (BERTHELIN)				×		
"	*siliqua* CUSHM.				×		
"	*soluta* RSS.		×				

Lists of Smaller Foraminifera.

a) From the Habana Formation.

Genus.	Species.	Localities.					
		V 36	V 78	V 78b	V 79a	H94b	T 938
Marginulina	*tenuis* Bornemann				×		
,,	*tumida* Rss.				×		
,,	*sp.*				×		
Saracenaria	*proximocostata* v. Wessem *nov. sp.*				×		
Dentalina	*bierigi* Berm.				×		
,,	*communis* d'Orb.				×		
,,	*inornata* d'Orb.						
,,	*legumen* Rss.		×				
,,	*mucronata* Neugeboren		×				
,,	*semilaevis* Hantken		×				
,,	*siliqua* Rss.				×		
Nodosaria	*aff. boffalore* Martinotti				×		
,,	*bohemiensis* (van Bellen)				×		
,,	*concinna* Rss.				×		
,,	*cylindroides* (Rss.)		×		×		
,,	*hispida* d'Orb.				×		
,,	*grandis* Rss.				×		
,,	*latejugata* Gümbel				×		
,,	*limbata* d'Orb.				×		
,,	*oligostegia* Rss.				×		
,,	*paupercula* Rss.				×		
,,	*polygona* Rss.				×		
,,	*radicula* (Linn.)		×				
,,	*schlichti* Rss.				×		
,,	*simplex* Silvestri				×		
,,	*tenuicaudata* (Rss.)		×				
,,	*tenuicollis* (Rss.)				×		
,,	*velascoensis* (Cushm.)		×		×		
,,	*vermiculum* Rss.				×		
,,	*vertebralis* (Batsch)				×		
Pseudoglandulina	*bistegia* (Olszewski)		×				
,,	*cylindracea* (Rss.)				×		
,,	*aff. laevigata* (d'Orb.) var. *inflata* Bornemann				×		
,,	*parallela* (Marsson) var. *cylindrica* Alth.		×				
,,	*radicula* (Linn.)				×		
Lagena	*orbignyana* (Seguenza)				×		
,,	*aff. L. orbignyana* (Seg.) var. Nuttall 1928				×		
,,	*sulcata* Walker a. Jacob				×		
,, (*Oolina*)	*apiculata* Rss.				×		
,, ,,	*emaciata* Rss.				×		
,, ,,	*simplex* (Rss.)				×		
,, ,,	*simplex* (Rss.) var. *lacrima* White				×		
Lagena (*Fissurina*)	*marginata* (Walker a. Boys)				×		
Glandulina	*dimorpha* (Bornemann)		×				
Sulcoperculina	*dickersoni* (Palmer)	×				×	×
Gümbelina	*carinata* Cushm.				×		
,,	*costulata* Cushm.		×		×		
,,	*excolata* Cushm.		×		×		
,,	*globifera* (Rss.)		×		×		
,,	*globulosa* (Ehrenberg)		×		×		
,,	*moremani* Cushm.		×		×		
,,	*nuttalli* Voorwijk		×		×		
,,	*plummerae* Loetterle		×		×		
,,	*pseudotessera* Cushm.		×		×		
,,	*punctulata* Cushm.		×		×		
,,	*pupa* (Rss.)				×		
,,	*reussi* Cushm.				×		
,,	*striata* (Ehrenberg)		×		×		
,,	*ultimatumida* White				×		
Pseudotextularia	*varians* Rzehak				×		
,,	*varians* Rz. var. *mendezensis* White		×				
,,	*varians* Rz. var. *textulariformis* White				×		

Lists of Smaller Foraminifera.

a) From the Habana Formation.

Genus.	Species.	Localities.					
		V 36	V 78	V 78b	V 79a	H94b	T 938
Marginulina	*tenuis* BORNEMANN				×		
,,	*tumida* RSS.				×		
,,	*sp.*				×		
Saracenaria	*proximocostata* v. WESSEM *nov. sp.*				×		
Dentalina	*bierigi* BERM.				×		
,,	*communis* D'ORB.				×		
,,	*inornata* D'ORB.						
,,	*legumen* RSS.		×				
,,	*mucronata* NEUGEBOREN		×				
,,	*semilaevis* HANTKEN		×				
,,	*siliqua* RSS.				×		
Nodosaria	*aff. boffalore* MARTINOTTI				×		
,,	*bohemiensis* (VAN BELLEN)				×		
,,	*concinna* RSS.				×		
,,	*cylindroides* (RSS.)		×		×		
,,	*hispida* D'ORB.				×		
,,	*grandis* RSS.				×		
,,	*latejugata* GÜMBEL				×		
,,	*limbata* D'ORB.				×		
,,	*oligostegia* RSS.				×		
,,	*paupercula* RSS.				×		
,,	*polygona* RSS.				×		
,,	*radicula* (LINN.)		×				
,,	*schlichti* RSS.				×		
,,	*simplex* SILVESTRI				×		
,,	*tenuicaudata* (RSS.)		×				
,,	*tenuicollis* (RSS.)				×		
,,	*velascoensis* (CUSHM.)		×		×		
,,	*vermiculum* RSS.				×		
,,	*vertebralis* (BATSCH)				×		
Pseudoglandulina	*bistegia* (OLSZEWSKI)		×				
,,	*cylindracea* (RSS.)				×		
,,	*aff. laevigata* (D'ORB.) var. *inflata* BORNEMANN				×		
,,	*parallela* (MARSSON) var. *cylindrica* ALTH.		×				
,,	*radicula* (LINN.)				×		
Lagena	*orbignyana* (SEGUENZA)				×		
,,	*aff. L. orbignyana* (SEG.) var. NUTTALL 1928				×		
,,	*sulcata* WALKER a. JACOB				×		
,, (*Oolina*)	*apiculata* RSS.				×		
,, ,,	*emaciata* RSS.				×		
,, ,,	*simplex* (RSS.)				×		
,, ,,	*simplex* (RSS.) var. *lacrima* WHITE				×		
Lagena (*Fissurina*)	*marginata* (WALKER a. BOYS)				×		
Glandulina	*dimorpha* (BORNEMANN)		×				
Sulcoperculina	*dickersoni* (PALMER)	×				×	×
Gümbelina	*carinata* CUSHM.				×		
,,	*costulata* CUSHM.		×		×		
,,	*excolata* CUSHM.		×		×		
,,	*globifera* (RSS.)		×		×		
,,	*globulosa* (EHRENBERG)		×		×		
,,	*moremani* CUSHM.		×		×		
,,	*nuttalli* VOORWIJK		×		×		
,,	*plummerae* LOETTERLE		×		×		
,,	*pseudotessera* CUSHM.		×		×		
,,	*punctulata* CUSHM.		×		×		
,,	*pupa* (RSS.)				×		
,,	*reussi* CUSHM.				×		
,,	*striata* (EHRENBERG)		×		×		
,,	*ultimatumida* WHITE				×		
Pseudotextularia	*varians* RZEHAK				×		
,,	*varians* RZ. var. *mendezensis* WHITE		×				
,,	*varians* RZ. var. *textulariformis* WHITE				×		

Lists of Smaller Foraminifera.

a) From the Habana Formation.

Genus.	Species.	Localities.					
		V 36	V 78	V78b	V79a	H94b	T 938
Planoglobulina	*acervulinoides* (EGGER)		×		×		
Ventilabrella	*austinana* CUSHM.		×		×		
"	*carseyae* PLUMMER		×		×		
"	*decurrens* (CHAPMAN)				×		
Bolivinoides	*draco* (MARSSON)			×			
Eouvigerina	*lobatula* v. WESSEM *nov. sp.*				×		
Bulimina	*brevis* D'ORB.				×		
"	*intermedia* RSS.				×		
"	*mendezensis* WHITE		×		×		
"	*ovula* RSS.				×		
Bolivina	*eggeri* CUSHM.		×				
"	*incrassata* REUSS		×		×		
"	*primatumida* WHITE				×		
Nodosarella	*acus* CUSHM. a. BERM.		×				
"	*constricta* CUSHM. a. BERM.		×		×		
"	*morrowi* v. WESSEM		×				
"	*subnodosa* (GUPPY)		×				
Ellipsonodosaria	*lepida* (RSS.)				×		
"	*torrei* PALMER a. BERM.				×		
Patellina	*subcretacea* CUSHM. a. ALEXANDER	×					
Discorbis	*obtusa* (D'ORB.)		×				
Valvulineria	*nov. sp.*				×		
Gyroidina	*alabamensis* SANDIDGE				×		
"	*anomalinoides* WHITE				×		
"	*depressa* (ALTH.)				×		
"	*guayabalensis* COLE				×		
"	*minuta* WHITE				×		
"	*vortex* WHITE		×				
Rotalia	*beccarii* (LINN.)				×		
Eponides	*minima* CUSHM.				×		
"	*umbonatus* (RSS.)		×				
Pulvinulinella	*culter* (PARKER a. JONES)				×		
Allomorphina	*allomorphinoides* (RSS.)				×		
"	*globulosa* PLUMMER		×				
Pullenia	*jarvisi* CUSHM.		×				
"	*quinqueloba* RSS.		×				
"	*nov. sp.*		×				
Globigerina	*cretacea* D'ORB.				×		
"	*Mc. kannai* WHITE				×		
"	*aff. quadrata* WHITE				×		
"	*voluta* WHITE				×		
Globotruncana	*arca* (CUSHM.)		×		×		
"	*arca* (CUSHM.) var. *contusa* CUSHM.				×		
"	*convexa* SANDIDGE				×		
"	*cretacea* CUSHM.				×		
"	*nov. sp.*				×		
Globorotalia	*menardii* (D'ORB.)	×					
"	*velascoensis* (CUSHM.)				×		
"	*nov. sp.*				×		
Anomalina	*ammonoides* (RSS.)				×		
"	*avilensis* v. WESSEM *nov. sp.*	×					
"	*bentonensis* MORROW				×		
"	*clementiana* (D'ORB.)				×		
"	? *ornata* (COSTA)		×		×		
"	*polyrraphes* (RSS.)		×		×		
"	*rubiginosa* CUSHM.		×		×		
Cibicides	*arteagai* v. WESSEM *nov. sp.*	×				×	
"	*camagueyensis* v. WESSEM *nov. sp.*		×		×		
"	*excolata* (CUSHM.)				×		
"	*lobatulus* (WALKER a. JACOB)					×	
"	*trinitatensis* (NUTTALL)					×	

Lists of Smaller Foraminifera.

a) From the Habana Formation.

Genus.	Species.	Localities.					
		V 36	V 78	V78b	V79a	H94b	T 938
Planoglobulina	*acervulinoides* (EGGER)		×		×		
Ventilabrella	*austinana* CUSHM.		×		×		
”	*carseyae* PLUMMER		×		×		
”	*decurrens* (CHAPMAN)				×		
Bolivinoides	*draco* (MARSSON)			×			
Eouvigerina	*lobatula* v. WESSEM *nov. sp.*				×		
Bulimina	*brevis* D'ORB.				×		
”	*intermedia* RSS.				×		
”	*mendezensis* WHITE		×		×		
”	*ovula* RSS.				×		
Bolivina	*eggeri* CUSHM.		×				
”	*incrassata* REUSS		×		×		
”	*primatumida* WHITE				×		
Nodosarella	*acus* CUSHM. a. BERM.		×				
”	*constricta* CUSHM. a. BERM.		×		×		
”	*morrowi* v. WESSEM		×				
”	*subnodosa* (GUPPY)		×				
Ellipsonodosaria	*lepida* (RSS.)				×		
”	*torrei* PALMER a. BERM.				×		
Patellina	*subcretacea* CUSHM. a. ALEXANDER	×					
Discorbis	*obtusa* (D'ORB.)		×				
Valvulineria	*nov. sp.*				×		
Gyroidina	*alabamensis* SANDIDGE				×		
”	*anomalinoides* WHITE				×		
”	*depressa* (ALTH.)				×		
”	*guayabalensis* COLE				×		
”	*minuta* WHITE				×		
”	*vortex* WHITE		×				
Rotalia	*beccarii* (LINN.)				×		
Eponides	*minima* CUSHM.				×		
”	*umbonatus* (RSS.)		×				
Pulvinulinella	*culter* (PARKER a. JONES)				×		
Allomorphina	*allomorphinoides* (RSS.)				×		
”	*globulosa* PLUMMER		×				
Pullenia	*jarvisi* CUSHM.		×				
”	*quinqueloba* RSS.		×				
”	*nov. sp.*		×				
Globigerina	*cretacea* D'ORB.				×		
”	*Mc. kannai* WHITE				×		
”	*aff. quadrata* WHITE				×		
”	*voluta* WHITE				×		
Globotruncana	*arca* (CUSHM.)		×		×		
”	*arca* (CUSHM.) var. *contusa* CUSHM.				×		
”	*convexa* SANDIDGE				×		
”	*cretacea* CUSHM.				×		
”	*nov. sp.*				×		
Globorotalia	*menardii* (D'ORB.)	×					
”	*velascoensis* (CUSHM.)				×		
”	*nov. sp.*				×		
Anomalina	*ammonoides* (RSS.)				×		
”	*avilensis* v. WESSEM *nov. sp.*	×					
”	*bentonensis* MORROW				×		
”	*clementiana* (D'ORB.)				×		
”	? *ornata* (COSTA)		×		×		
”	*polyrraphes* (RSS.)		×		×		
”	*rubiginosa* CUSHM.		×		×		
Cibicides	*arteagai* v. WESSEM *nov. sp.*	×				×	
”	*camagueyensis* v. WESSEM *nov. sp.*		×		×		
”	*excolata* (CUSHM.)				×		
”	*lobatulus* (WALKER a. JACOB)					×	
”	*trinitatensis* (NUTTALL)					×	

Lists of Smaller Foraminifera.

b) From the Upper Eocene.

Genus.	Species.	Locality V 39.
Vulvulina	*pennatula* (Batsch)	×
Clavulinoides	*guayabalensis* (Cole)	×
Nodosaria	*ewaldi* Rss.	×
Gümbelina	*wilcoxensis* Cushm. a. Ponton	×
Bulimina	*ovata* d'Orb.	×
"	*pupoides* d'Orb.	×
Ellipsonodosaria	*verneuili* (d'Orb.)	×
"	*sp.*	×
Pulvinulinella	*camagueyensis* v. Wessem *nov. sp.*	×
Chilostomelloides	*ovicula* Nuttall	×
Globigerina	*bulloides* d'Orb.	×
"	*conglomerata* Schwager	×
"	*trilobata* Rss.	×
Globotruncana	*arca* (Cushm.)	×
Globorotalia	*aragonensis* Nuttall	×
"	*spinulosa* Cushm.	×
Cibicides	*floridanus* (Cushm.)	×

c) From the Oligo-Miocene.

Genus.	Species.	Localities.		
		H 67	V 121	K 255
Verneuilina	*nov. sp.*	×		
Valvulina	*oviedoiana* d'Orb.		×	
Clavulina	*tricarinata* d'Orb.	×	×	×
Quinqueloculina	*glomerata* d'Orb.	×		
"	*plana* d'Orb.	×		
"	*seminulum* (Linn.)			×
"	*venusta* Karrer			×
Nonion	*affine* (Rss.)	×		
"	*cubense* v. Wessem *nov. sp.*	×		
Elphidium	*antoninum* (d'Orb.)	×		
"	*minutum* (Rss.)		×	
"	*rotum* Ellis	×		
"	*rugosum* (d'Orb.)	×		
"	*rutteni* Hermes	×	×	×
"	*sp. I*	×		
"	*sp. II*	×		
Discorbis	*valvulata* (d'Orb.)		×	
Eponides	*punctulatus* (d'Orb.)	×		
Gypsina	*globulus* (Rss.)	×		

Lists of Smaller Foraminifera.

b) From the Upper Eocene.

Genus.	Species.	Locality V 39.
Vulvulina	*pennatula* (BATSCH)	×
Clavulinoides	*guayabalensis* (COLE)	×
Nodosaria	*ewaldi* RSS.	×
Gümbelina	*wilcoxensis* CUSHM. a. PONTON	×
Bulimina	*ovata* D'ORB.	×
”	*pupoides* D'ORB.	×
Ellipsonodosaria	*verneuili* (D'ORB.)	×
”	*sp.*	×
Pulvinulinella	*camagueyensis* v. WESSEM *nov. sp.*	×
Chilostomelloides	*ovicula* NUTTALL	×
Globigerina	*bulloides* D'ORB.	×
”	*conglomerata* SCHWAGER	×
”	*trilobata* RSS.	×
Globotruncana	*arca* (CUSHM.)	×
Globorotalia	*aragonensis* NUTTALL	×
”	*spinulosa* CUSHM.	×
Cibicides	*floridanus* (CUSHM.)	×

c) From the Oligo-Miocene.

Genus.	Species.	Localities.		
		H 67	V 121	K 255
Verneuilina	*nov. sp.*	×		
Valvulina	*oviedoiana* D'ORB.		×	
Clavulina	*tricarinata* D'ORB.	×	×	×
Quinqueloculina	*glomerata* D'ORB.	×		
”	*plana* D'ORB.	×		
”	*seminulum* (LINN.)			×
”	*venusta* KARRER			×
Nonion	*affine* (RSS.)	×		
”	*cubense* v. WESSEM *nov. sp.*	×		
Elphidium	*antoninum* (D'ORB.)	×		
”	*minutum* (RSS.)		×	
”	*rotum* ELLIS	×		
”	*rugosum* (D'ORB.)	×		
”	*rutteni* HERMES	×	×	×
”	*sp. I*	×		
”	*sp. II*	×		
Discorbis	*valvulata* (D'ORB.)		×	
Eponides	*punctulatus* (D'ORB.)	×		
Gypsina	*globulus* (RSS.)	×		

Lists of Larger Foraminifera.

a) From the Habana Formation.

Genus.	Species.	Localities.						
		V 36	F 49a	F 50a	H 94	H 94b	T 938	T 1425
Lepidorbitoides	*estrellae* v. WESSEM *nov. sp.*				×	×		
,,	*minima* DOUVILLÉ	×				×		
,,	*minor* (SCHLUMBERGER)	×						
,,	*nortoni* (VAUGHAN)	×						
,,	*palmeri* THIADENS	×		×				
,,	*tschoppi* v. WESSEM *nov. sp.*	×						
,,	*sp.*							×
Orbitoides	*browni* (ELLIS)	×	×			×	×	
,,	*palmeri* GRAVELL				×		×	

b) From the Upper Eocene.

Genus.	Species.	Locality H 77 B.
Camerina	*pellatispiroides* WRIGHT BARKER	×
Pellatispirella	*bermudezi* (PALMER)	×
Discocyclina	*sp. A*	×
,,	*sp. B*	×

c) From the Oligo-Miocene.

Genus.	Species.	Locality K 255
Miogypsina	*hawkinsi* HODSON	×

Upper Cretaceous, Camaguey, Cuba. Min.-Geol. Inst. Univ. Utrecht, D 22343.

Robulus sp.

Plate 1, figures 14, 15.

Test strongly compressed, closely coiled; the last chambers, however, are uncoiling. Periphery bluntly keeled. Fourteen to sixteen chambers in the last whorl, gradually increasing in size and somewhat inflated. Sutures broad, somewhat raised and slightly curved. On both sides a rather large flat umbonal knob. Aperture terminal with a median slit.

Length 1,8 mm, breadth 1,4 mm, thickness 0,45 mm. Upper Cretaceous, Loc. V 36, Camaguey, Cuba. Min.-Geol. Inst. Univ. Utrecht, D 22493.

Lenticulina nuda (REUSS).

Plate 1, figures 16, 17.

Cristellaria nuda REUSS, 1862, Sitz. K. Akad. Wiss. Wien, vol. 46, (1), 1862 (1863), p. 72, pl. 8, figs. 2a-b.
Lenticulina nuda (REUSS), CUSHMAN and JARVIS, 1932, Proc. U.S.N.M. vol. 80, art. 14, p. 24, pl. 7, figs. 6a-b.

This species differs only in one respect from *Robulus discrepans* (Rss.) The latter reaches its maximum thickness in the last chamber, whereas *Lenticulina nuda* reaches its maximum thickness in the umbilical region.

Length 0,9 mm, breadth 0,6 mm, thickness 0,35 mm.

Upper Cretaceous, Camaguey, Cuba. Min.-Geol. Inst. Univ. Utrecht, D 22434.

Marginulina sp.

Plate 1, figure 23.

The initial chamber globular, the following two or three chambers very slightly inflated, the last chamber on the contrary again rather strongly inflated. Sutures in the early stages slightly, in the later stages, however, very strongly depressed. Sutures rather broad and limbate. Last chamber somewhat oblique. Aperture terminal, eccentric, spout-like. This species represents obviously a macrospheric form.

Length up to 1,5 mm. Upper Cretaceous, Loc. V 79*a*, Camaguey, Cuba. Min.-Geol. Inst. Univ. Utrecht, D 22422.

Nodosaria concinna REUSS.

Plate 1, figure 26.

Nodosaria concinna REUSS, 1860, Sitz. Ak. Wiss. Wien, vol. 40, p. 178, pl. 1, fig. 3.
Nodosaria concinna REUSS, CUSHMAN and JARVIS, 1928, Contr. Cushm. Lab. For. Res., vol. 4, p. 97, pl. 14, figs. 5, 11.

In most respects there is a striking resemblance with the original description and figures of REUSS. The American specimens, however, have a rather strongly inflated initial chamber, which, in most cases, lacks a distinct spine.

Length up to 1 mm. Upper Cretaceous, Camaguey, Cuba. Min.-Geol. Inst. Univ. Utrecht, D 22351.

Saracenaria proximocostata VAN WESSEM *nov. sp.*
Plate 1, figures 24, 25.

The test consists of five to six visible chambers; not swollen, except the last one. Sutures slightly curved and somewhat limbate. Between the last two chambers, the suture is depressed. The early chambers have a small keel and the periphery is sharp-angled. The apertural face is broad, somewhat rounded, frontally strongly arched and ornamented with costae, which run up towards the aperture.

Height 0,5 mm, breadth 0,35 mm, thickness 0,3 mm. Type locality, Upper Cretaceous, Loc. V 79*a*, Camaguey, Cuba. Holotype Min.-Geol. Inst. Univ. Utrecht, D 22436.

Lingulina arteagai VAN WESSEM *nov. sp.*
Plate 1, figures 18, 19.

Test large, elongate, compressed. The periphery is rather sharp, somewhat rounded; maximum thickness in the middle of the test. In the adult the sides of the test are nearly parallel. The first four chambers are planispiral, the following five chambers in a rectilinear series. On the ventral side all chambers show a lobe, in the direction of the spiral. The chambers show a strong increase in size and overlap to some extent. The sutures are distinct, depressed, arcuate, with their lowest end pointing towards the spiral. Aperture terminal, a narrow slit.

The species is named in honour of Mr. M. ARTEÁGA, Majagua, Cuba.

Type locality, Upper Cretaceous, Loc. V 36, Camaguey, Cuba. Syntypes Min.-Geol. Inst. Univ. Utrecht, D 22487.

Flabellina interpunctata VON DER MARCK.
Plate, 1, figure 20.

Flabellina interpunctata V. D. MARCK, WHITE, 1928, Journ. Pal. vol. 2, p. 204, pl. 29, fig. 1.
Flabellina interpunctata V. D. MARCK, WEDEKIND, 1940, N. Jahrb. Bd. 84, p. 190, pl. 10, fig. 11.

WHITE's figures give the impression that we are dealing with *Flabellina sphenoidalis*, as his specimens are distinctly lozenge-shaped.

Length 0,8 mm, breadth 0,35 mm, thickness 0,18 mm. Upper Cretaceous, Camaguey, Cuba. Min.-Geol. Inst. Univ. Utrecht, D 22398.

Frondicularia gracilis FRANKE.
Plate 1, figures 21, 22.

Frondicularia gracilis FRANKE, 1925, Abh. Geol. Pal. Inst. Univ. Greifswald, vol. 6, p. 50, pl. 4, fig. 9.
Frondicularia gracilis FRANKE, CUSHMAN, 1930, Contr. Cushm. Lab. For. Res. vol. 6, pt. 2, p. 37.

The characteristics enumerated by CUSHMAN are present in our specimens. The ornamentation, which, according to CUSHMAN, in the later stages is restricted to the chambers, is actually limited to the sutures. This species,

as may be seen from his figures, shows a great variation; the same is true for the number of chambers.

Length 1,8 mm, max. breadth 0,5 mm.

Upper Cretaceous, Camaguey, Cuba. Min.-Geol. Inst. Univ. Utrecht, D 22397.

Sulcoperculina dickersoni (PALMER).

Plate 1, figures 27, 28.

Camerina dickersoni PALMER, 1934, Mem. Soc. Cub. Hist. Nat. vol. 8, p. p. 243—245, textfigures 4,5, pl. 14, figs. 1, 2, 4, 6, 8.

Camerina dickersoni PALMER, VOORWIJK, 1937, Proc. Kon. Akad. Wetensch. A'dam, vol. 40, p.p. 191—192, pl. 2, figs. 11—16, pl. 3, figs. 3, 6.

Sulcoperculina dickersoni (PALMER), THALMANN, 1938, Ecl. Geol. Helv., vol. 31, p. 330.

VOORWIJK noticed the occurrence of a groove in the spiral suture of this species, but found it unnecessary to distinguish it from the other „*Camerinae*", which, however, do not possess such a groove. It was pointed out by THALMANN that this difference is of such importance, that it justifies the creation of a new genus. This opinion is shared by the author and so we used the new generic name of *Sulcoperculina*.

Upper Cretaceous, Camaguey, Cuba. Min.-Geol. Inst. Univ. Utrecht, D 22498 and D 24473—24475.

Praerhapydionina cubana VAN WESSEM *nov. gen., nov. sp.*

Plate 3, figures 2—7.

Test elongate, round in transverse section, conical; chambers in the early stages planispirally coiled, later in a rectilinear series, uniserial, entirely divided into chamberlets by septa radiating inward from the outer wall. Wall porcellaneous. One central aperture, terminal. The external features can not be given as we studied the genus in thin-section. It was found in Upper Cretaceous limestones together with *Lepidorbitoides*. The above mentioned characteristics leave no doubt as to the place of this new genus. It certainly belongs to the *Peneroplidae*. It differs from *Rhapydionina* in having only one central aperture. The latter may have arisen from our new genus.

Length up to 1 mm, diameter 0,4—0,5 mm.

Type locality, Upper Cretaceous, Loc. F 51*a*, Camaguey, Cuba. Genoholotype. Min.-Geol. Inst. Univ. Utrecht, D 25255—25258.

Gümbelina costulata CUSHMAN.

Plate 1, figures 29, 30.

Gümbelina costulata CUSHMAN, 1938, Contr. Cushm. Lab. For. Res. vol. 14, pt. 1, pl. 3, figs. 7—9.

This species differs from *Gümbelina excolata* in having a smaller test and very fine costae. The periphery of the initial end has a small keel.

Upper Cretaceous, Camaguey, Cuba. Min.-Geol. Inst. Univ. Utrecht, D 22329.

Gümbelina globulosa (EHRENBERG).
Plate 1, figures 31, 32.

Gümbelina globulosa (EHRENBERG), VOORWIJK, 1937, Proc. Kon. Ak. Wetensch. A'dam vol. 40, p.p. 192—194.
Gümbelina globulosa (EHRENBERG), CUSHMAN, 1938, Contr. Cushm. Lab. For. Res., vol. 14, pt. 1, p. 6, pl. 1, figs. 28—33.

VOORWIJK emphasizes that it would be better to comprise *Gümbelina globulosa*, *G. globifera* and *G. pupa* in one species, but he did not carry through this combination. To the combination of the three above mentioned species we have the following objections.

Although *G. globulosa* in many ways resembles *G. globifera* and *G. pupa*, we see some characteristic differences: the outline of *G. globulosa* has the shape of a V with concave sides, whereas the „V" of *G. globifera* and *G. pupa* has convex sides. Moreover it differs from the other two by its smaller dimensions (the specimens figured by EHRENBERG do not even exceed 0,06 mm) and the convexity of its chambers. A combination of *G. globifera* and *G. pupa*, however, seems justified. This may be elucidated by the dimensions of the three species (together with the dimensions as given by VOORWIJK and by WHITE).

	Our material	VOORWIJK's material	WHITE's material
G. globulosa	0,3 ×0,22×0,15 mm	0,3×0,25×0,15 mm	0,4×0,3 ×0,17 mm
G. globifera	0,45×0,26×0,2 „	0,4×0,24×0,18 „	0,6×0,35×0,23 „
G. pupa	0,35×0,2 ×0,2 „	0,4×0,26×0,26 „	0,6×0,3 ×0,25 „

Upper Cretaceous, Camaguey, Cuba. Min.-Geol. Inst. Univ. Utrecht, D 22323.

Gümbelina moremani CUSHMAN.
Plate 1, figures 33, 34.

Gümbelina moremani CUSHMAN, 1938, Contr. Cushm. Lab. For. Res. vol. 14, pt. 1, p. 10, pl. 2, figs. 1—3.

The ratio between length and breadth is characteristic for this species. The thickness of our specimens is greater than the dimensions given by CUSHMAN. One of our specimens shows an abnormal adult stage.

Length 0,45 mm, breadth 0,22 mm, thickness 0,15 mm.

Upper Cretaceous, Camaguey, Cuba. Min.-Geol. Inst. Univ. Utrecht, D 22330.

Gümbelina nuttalli VOORWIJK.
Plate 1, figures 35, 36.

Gümbelina nuttalli VOORWIJK, 1937, Kon. Ak. Wetensch. A'dam. Proc. vol. 40, no. 2, p. 192, pl. II, figs. 1—9.

Looking over VOORWIJK's material, many specimens appeared to be distinctly ornamented, they sometimes even possess coarse costae. He does not mention this in his description and his pictures do not show this ornamentation. It is therefore rather certain, that the material described by VOORWIJK as *G. nuttalli* belongs to more than one species. Without any doubt much of his material belongs to the new species, but we saw also

representatives of *Gümbelina striata* (EHRENBERG) and *Gümbelina plummerae* LOETTERLE. As for the measurements of *G. nuttalli*, these vary strongly.

Upper Cretaceous, Camaguey, Cuba. Min.-Geol. Inst. Univ. Utrecht, D 22328.

Gümbelina plummerae LOETTERLE.
Plate 1, figures 37, 38.

Gümbelina plummerae LOETTERLE, CUSHMAN, 1938, Contr. Cushm. Lab. For. Res. vol. 14, pt. 1, p. 15, pl. 3, figs. 3—5.

This species in many respects resembles *Gümbelina nuttalli* VOORWIJK of which it possibly may be derived. *Gümbelina plummerae*, however, has a coarse ornamentation, is keeled in the early stages and its chambers are sometimes irregularly sausage-shaped.

Length 0,4—0,6 mm, breadth 0,25—04 mm, thickness 0,3—0,45 mm.

Upper Cretaceous, Camaguey, Cuba. Min.-Geol. Inst. Univ. Utrecht. D 22327.

Gümbelina striata (EHRENBERG).
Plate 1, figures 39, 40.

Gümbelina striata (EHRENBERG), VOORWIJK, 1937, Proc. Kon. Akad. Wetensch. vol. 40, p. 194, pl. 1, figs. 9—10.
Gümbelina striata (EHRENBERG), CUSHMAN, 1938, Contr. Cushm. Lab. For. Res. vol. 14, pt. 1, p. 8, pl. 1, figs. 34—40.

The figures given by VOORWIJK and CUSHMAN are rather different. Those of CUSHMAN are more elongate specimens. The ratio between length and breadth is two to one in CUSHMAN's figures and one and a half to one in VOORWIJK's figures. Our specimens resemble closely the description and figures given by CUSHMAN. I am under the impression that the specimens of VOORWIJK, ascribed to G. *striata*, belong to another new species.

Length 0,45—0,55 mm, breadth 0,25 mm, thickness 0,15 mm.

Upper Cretaceous, Camaguey, Cuba. Min.-Geol. Inst. Univ. Utrecht, D 22324.

Ventilabrella carseyae PLUMMER.
Plate 1, figures 41, 42.

Ventilabrella carseyae PLUMMER, 1926, Univ. Texas Bull. no. 2644, p. 172, pl. 2, figs. 1, 4.
Ventilabrella carseyae PLUMMER, CUSHMAN, 1938, Contr. Cushm. Lab. For. Res. vol. 14, pt. 1, p. 26, pl. 4, figs. 20—24.

One of our specimens has two chambers towards the apertural end, while the other ones have more chambers in the adult stage. All specimens are distinctly striated.

Length 0,55 mm, breadth 0,4 mm, thickness 0,2 mm.

Upper Cretaceous, Camaguey, Cuba. Min.-Geol. Inst. Univ. Utrecht, D 22341.

Ventilabrella decurrens (CHAPMAN).
Plate 1, figures 43, 44.

Textularia decurrens CHAPMAN, 1892, Quart. Journ. Geol. Soc. vol. 48, p. 515, pl. 15, fig. 6.
Ventilabrella decurrens (CHAPMAN), CUSHMAN, 1938, Contr. Cushm. Lab. For. Res. vol. 14, pt. 1, p. 27, pl. 4, fig. 18.

This species resembles in many respects *V. austinana*. *V. decurrens*, however, has the adult chambers arranged round a distinct depression.

Length 0,5 mm, breadth 0,35 mm, thickness 0,15 mm.

Upper Cretaceous, Camaguey, Cuba. Min.-Geol. Inst. Univ. Utrecht, D 22340.

Eouvigerina lobatula VAN WESSEM *nov. sp.*
Plate 1, figure 45.

Test elongate, subelliptical in outline, slightly tapering towards the apertural end; the initial chambers planispiral, very soon uncoiling and followed by an indistinct biserial stage. In this stage the chambers are very small and separated by nearly horizontal, slightly depressed sutures. The adult chambers are large, irregularly triserial, overlapping completely and separated by heavily curved, deeply depressed sutures. Wall very finely striated. Aperture circular, terminal, at the end of a neck with a lip.

Length 0,45 mm, max. breath 0,15 mm, thickness 0,1 mm.

This species differs from *E. americana* by its strongly depressed, broad and heavily curved sutures.

Type locality, Upper Cretaceous, Loc. V 79*a*, Camaguey, Cuba. Syntypes Min.-Geol. Inst. Univ. Utrecht, D 22445.

Bolivina incrassata REUSS.
Plate 1, figure 46.

Bolivina incrassata REUSS, 1851, Haidingers Nat. Abh. Bd. 4, p. 45, pl. 4, fig. 13.
Bolivina incrassata REUSS, CUSHMAN, 1937, Contr. Cushm. Lab. For. Res. Spec. Publ. no. 9, p. 38, pl. 5, figs. 19—28.

As it appears from the figures of several authors, the exterior shape of this species varies strongly. The ten specimens figured by CUSHMAN differ distinctly from each other and a ratio length to breadth seems therefore rather out of place. Generally the chambers are somewhat inflated, sutures somewhat depressed and very oblique. Our specimens vary also rather strongly, but the above mentioned features can always be recognized.

Length about 1 mm, breadt 0,23—0,4 mm.

Upper Cretaceous, Camaguey, Cuba. Min.-Geol. Inst. Univ. Utrecht, D 22408.

Bolivina primatumida WHITE.
Plate 1, figure 47.

Bolivina primatumida WHITE, 1929, Journ. of Pal. vol. 3, p. 44, pl. 4, fig. 20.

According to CUSHMAN this species must be reckoned to *B. incrassata* REUSS. In my opinion the differences between the two species are too great

to allow this identification. *B. primatumida* has a swollen initial chamber, sutures slightly oblique and moreover broad and strongly limbate.

Length 0,7 mm, breadth 0,20 mm.

Upper Cretaceous, Camaguey, Cuba. Min.-Geol. Inst. Univ. Utrecht, D 22409.

Nodosarella morrowi VAN WESSEM.

Plate 1, figure 48.

Nodosarella nov. sp. MORROW, 1934, Journ. of Pal. vol. 8, p. 197, pl. 29, figs. 2—3.

This species was described by MORROW as *Nodosarella nov. sp.* from the Upper Cretaceous of Kansas. His description and figures closely agree with our specimens. The species is named in honour of A. L. MORROW.

Length 1,2 mm.

Upper Cretaceous, Camaguey, Cuba. Min.-Geol. Inst. Univ. Utrecht, D 22403.

Valvulineria nov. sp.

Plate 1, figures 49—51.

Test somewhat longer than broad; periphery broadly rounded. Chambers few in number; five in the last whorl. The last-formed chamber somewhat inflated with an elongation over the umbilicus. Umbilicus with a plug. Sutures distinct, the last one slightly depressed; radiate and limbate on both ventral and dorsal side. Aperture on the ventral side, in the vicinity of the umbilicus.

Length 0,4 mm, breadth 0,2 mm, thickness 0,3 mm.

Type locality, Upper Cretaceous, Loc. V 79*a*, Camaguey, Cuba. Holotype, Min.-Geol. Inst. Univ. Utrecht, D 22494.

Pullenia nov. sp.

Plate 1, figures 52, 53.

Test planispiral, only slightly compressed, completely involute. Periphery rounded, somewhat lobulate. Five or six chambers in the last whorl, very rapidly enlarging; they are indistinct, somewhat inflated, except the last one, which is strongly inflated. Umbilicus nearly invisible. Sutures indistinct, depressed, slightly curved. Aperture an elongate crescentic opening from one umbilicus to the other. Apertural face rounded, rather high and strongly bent backwards.

Length 0,4 mm, breadth 0,35 mm, thickness 0,28 mm.

Type locality, Upper Cretaceous, Loc. V 78, Camaguey, Cuba. Holotype, Min.-Geol. Inst. Univ. Utrecht, D 22484.

Globotruncana arca (CUSHMAN) var. *contusa* CUSHMAN.

Plate 1, figures 54—56.

Pulvinulina arca CUSHMAN var. *contusa* CUSHM., CUSHMAN, 1926, Contr. Cushm. Lab. For. Res. vol. 2, pt. 1, p. 23.

Cushman gives a full description of this species, but no figures. As the characteristics in his description agree with our specimen, we do not doubt but we are dealing with the same species.

Diameter up to 0,9 mm.

Upper Cretaceous, Camaguey, Cuba. Min.-Geol. Inst. Univ. Utrecht, D 22472.

Globotruncana nov. sp.

Plate 1, figure 57; plate 2, figures 1, 2.

Test strongly plano-convex, dorsal side flattened, ventral side strongly convex. Five chambers in the last whorl, which are rapidly enlarging. Periphery with a double keel on dorsal and ventral sides, lobulate. Sutures on both sides depressed, slightly curved, on the ventral side radiate. The umbilicus is large. Aperture ventral, extending towards the umbilicus. First chambers and periphery rough and cancellated.

Length 0,4 mm, breadth 0,32 mm, thickness 0,2 mm.

Type locality, Upper Cretaceous, Loc. V 79*a*, Camaguey, Cuba. Syntypes, Min.-Geol. Inst. Univ. Utrecht, D 22475.

Globorotalia nov. sp.

Plate 2, figures 3, 4.

Test biconvex, the dorsal side strongly convex, the ventral side to a less degree. Periphery acute, later chambers somewhat rounded. Chambers distinct, five in the last whorl, gradually increasing in size, separated by rather strongly depressed sutures, which extend nearly radially; they appear as compressed spheres. Chambers perforated and ornamented with small spines. Aperture ventral, at the base of the last formed chamber extending towards the umbilicus. In some respects this species resembles *Globorotalia wilcoxensis* Cushman and Ponton; the latter, however, is thicker, flat on its dorsal side, strongly convex on its ventral side.

Length 0,45 mm, breadth 0,38 mm, thickness 0,15 mm.

Type locality, Upper Cretaceous, Loc. V 79*a*, Camaguey, Cuba. Holotype, Min.-Geol. Inst. Univ. Utrecht, D 22481.

Anomalina avilensis van Wessem *nov. sp.*

Plate 2, figures 5—7.

Test biconvex, strongly compressed, periphery acute. Both sides evolute, especially so on the dorsal side, where $2\frac{1}{2}$ to 3 whorls are visible. The whorls descend at right angles to the umbilicus, which is strongly developed ventrally as well as dorsally. Eleven chambers in the last whorl, which overlap like scales; their foreside dips underneath the following younger chamber. The chambers have an irregularly quadrangular form and run towards the periphery in a pointed lobe. The periphery thus gets a dentated aspect. Sutures broad, depressed and rather strongly curved. Aperture at the base of the last chamber.

Length 1,2 mm, breadth 1 mm, thickness 0,35 mm.

Type locality, Upper Cretaceous, Loc. V 36, Camaguey, Cuba. Syntypes, Min.-Geol. Inst. Univ. Utrecht, D 22499.

Anomalina ?ornata (COSTA).

Plate 2, figures 8—10.

Anomalina ornata (COSTA), CUSHMAN and JARVIS, 1930, Journ. of Pal. vol. 4, p. 367, pl. 34, figs. 9a-c.

This species resembles in many respects *Cibicides trinitatensis* (NUTTALL). *C. trinitatensis*, however, has a greater thickness and has more depressed sutures. Compared with the figures, given by CUSHMAN and JARVIS, we note the following differences: our specimens have a far less developed umbonal knob, a rather sharp periphery and often somewhat broader and limbate sutures. Because we could not consult the original figures of COSTA, we have put a question-mark before the species.

Length 0,65 mm, breadth 0,55 mm, thickness 0,2 mm.

Upper Cretaceous, Camaguey, Cuba. Min.-Geol. Inst. Univ. Utrecht, D 22460.

Anomalina polyrraphes (REUSS).

Plate 2, figures 11—13.

Rotalina polyrraphes REUSS, 1846, die Versteinerungen der Böhmischen Kreideformation, pt. 1, p. 35, pl. 12, fig. 18.

Anomalina polyrraphes (REUSS), CUSHMAN and JARVIS, 1932, Proc. U.S.N.M. vol. 80, art. 14, p. 51—52, pl. 16, figs. 2a-c.

This species, in some respects, resembles *Anomalina ammonoides* (REUSS). *Anomalina polyrraphes*, however, has a narrow umbilicus and is stronger involute. The American representatives of this species have somewhat broader, limbate and raised sutures.

Length 0,5 mm, breadth 0,4 mm, thickness 0,25 mm.

Upper Cretaceous, Camaguey, Cuba. Min.-Geol. Inst. Univ. Utrecht, D 22463.

Cibicides arteagai VAN WESSEM *nov. sp.*

Plate 2, figures 14—16.

Test planoconvex, periphery sharply rounded. On the flattened dorsal side ten chambers are visible in the last whorl; they enlarge very gradually. Sutures on the dorsal side broad, limbate, slightly curved, assembling in a flat umbonal knob. Ventral side convex, ten chambers visible. Sutures on this side broad, limbate and rather strongly curved; only the last two somewhat depressed. Ventrally a large, spherical umbonal knob. Aperture on the periphery, extending somewhat ventrally.

Length up to 0,65 mm, breadth 0,5 mm, thickness 0,25 mm.

This species shows some resemblance to *Cibicides sp.* CUSHMAN a. GARRETT 1939. This species is named in honour of Mr. M. ARTEÁGA, Majagua, Cuba.

Type localities, Upper Cretaceous, Locs. V 36 and H 94 *b*, Camaguey, Cuba. Syntypes, Min.-Geol. Inst. Univ. Utrecht, D 22495.

Cibicides camagueyensis VAN WESSEM *nov. sp.*

Plate 2, figures 17—19.

Test plano-convex; dorsal side flattened and evolute, ventral side strongly convex and involute. Periphery rounded. On the ventral side about ten indistinct chambers can be observed in the last whorl, which gradually increase in size. Sutures flat, except the last one, which is depressed; they are faintly curved and somewhat limbate. The dorsal side is marked by thick, raised, curved sutures and a nice, regular, spiralshaped thickening, which follows the coiling of the chambers. Aperture peripheral, at the base of the last-formed chamber, extending somewhat dorsally.

Length up to 0,65 mm, breadth up to 0,55 mm, thickness 0,35 mm.

Type localities, Upper Cretaceous, Locs. V 78 and V 79*a*, Camaguey, Cuba. Syntypes, Min.-Geol. Inst. Univ. Utrecht, D 22458.

b) Upper Eocene species.

Ellipsonodosaria sp.

Plate 2, figure 20.

Test fragmentary, consisting of three chambers. Chambers longer than broad, somewhat pear-shaped. Sutures depressed. All chambers, except the last one, ornamented with coarse, high, plate-like costae, which pass over the sutures. Aperture narrow, terminal, subelliptical.

Length of broken test 1,25 mm.

Upper Eocene, Loc. V 39, Camaguey, Cuba. Min.-Geol. Inst. Univ. Utrecht, D 23096.

Pulvinulinella camagueyensis VAN WESSEM *nov. sp.*

Plate 2, figures 21—23.

Test biconvex. On the dorsal side six chambers in the last whorl. The preceding whorls can not be observed as they are covered by a mass of clear shell substance. Sutures on the dorsal side rather broad, limbate and strongly oblique. Periphery with a narrow blunt keel. Ventrally six chambers, rapidly increasing in size, flattened. Sutures limbate and oblique. Aperture at the base of the last chamber on the ventral side of the peripheral face, elongate and nearly parallel to the plane of coiling. On the ventral side a small umbonal boss.

Diameter 0,75 mm, thickness 0,40 mm.

Type locality, Upper Eocene, Loc. V 39, Camaguey, Cuba. Syntypes, Min.-Geol. Inst. Univ. Utrecht, D 23105.

c) Oligo-Miocene species.

Verneuilina nov. sp.

Plate 2, figures 24, 25.

Test triserial, forming an isosceles triangle in transverse section, pointed in the early stages, greatest transverse section reached towards the apertural end. Sides of the test slightly concave, the angles between them are sharp. Chambers not inflated, gradually enlarging. Sutures flat, nearly horizontal. Test rather coarsely arenaceous. Aperture textularian, a low opening at the base of the inner margin of the last-formed chamber.

Length 0,8 mm, breadth 0,65 mm.

Type locality, Oligo-Miocene, Loc. H 67, Camaguey, Cuba. Holotype, Min.-Geol. Inst. Univ. Utrecht, D 23089.

Nonion cubense VAN WESSEM *nov. sp.*

Plate 2, figures 26, 27.

Test involute, strongly compressed, periphery rounded. Ten to twelve chambers in the last whorl, gradually increasing in size and somewhat swollen. Sides of the test nearly parallel, last chamber high and rather broad. Sutures depressed, slightly curved. In consequence the periphery is somewhat lobulate. Umbilicus depressed, sometimes filled up with clear shell material. Aperture a slit at the base of the last-formed chamber.

Length 0,5 mm, breadth 0,4 mm, maximum thickness 0,3 mm.

Type locality, Oligo-Miocene, Loc. H 67, Camaguey, Cuba. Syntypes, Min.-Geol. Inst. Univ. Utrecht, D 23082.

Elphidium rutteni HERMES.

This new species will be fully described by my colleague Mr. J. J. HERMES in the description of the Geology and Paleontology of the western part of the Province of Oriente, Cuba.

Oligo-Miocene, Camaguey, Cuba. Min.-Geol. Inst. Univ. Utrecht, D 23076.

Elphidium sp. I.

Plate 2, figures 28, 29.

Test completely involute, somewhat compressed, periphery rounded. Chambers numerous, fourteen or fifteen in the last whorl, perforate, narrow and slightly curved; the last one is low and broad. Sutures radial, very slightly curved to almost straight, very distinctly raised. Aperture a row of fine openings at the base of the apertural face.

Diameter 0,6 mm, thickness 0,35 mm.

Oligo-Miocene, Loc. H 67, Camaguey, Cuba. Min.-Geol. Inst. Univ. Utrecht, D 23077.

Elphidium sp. II.

Plate 2, figures 30, 31.

Test involute, strongly compressed. Periphery in the early stages with a narrow keel, in the adult rounded. Eleven chambers in the last whorl, rapidly increasing in size and especially also in breadth. Last chamber broad and rounded. Sutures raised, slightly curved. Umbilicus filled up with shell material. Aperture a narrow, elongate opening at the base of the last-formed chamber.

Diameter 0,5 mm, greatest thickness 0,3 mm.

Oligo-Miocene, Loc. H 67, Camaguey, Cuba. Min.-Geol. Inst. Univ. Utrecht, D 23078.

Descriptions of the Larger Foraminifera.

a) Upper Cretaceous species.

Orbitoides browni (ELLIS).

Plate 2, figure 34; plate 3, figures 21, 22.

Gallowayina browni ELLIS, 1932, Am. Mus. Novitates, no. 568, p.p. 1—8, 9 figs. in text.
D. PALMER, 1934, Journ. of Pal. vol. 8, no. 1, p.p. 68—70.
Orbitoides browni VAUGHAN, 1933, in CUSHMAN J. A.; *Foraminifera*, Key to Genera and Species, pl. 40, figs. 3, 4; 1934, Journ. of Pal. vol. 8, no. 1, p.p. 70—72.
M. G. RUTTEN, Journ. of Pal. vol. 9, no. 6, p.p. 527—545, pls. 59—62, 1935.

This form is rather abundant in the Upper Cretaceous. It is characterized by its size, strong pillars and dome-shaped equatorial layer.

Diameter 3 tot 5 mm, thickness 2,5 mm to 3 mm, embryonal apparatus 240—320 $\mu \times$ 170—240 μ; its wall is about 40 μ in thickness.

Upper Cretaceous, Camaguey, Cuba. Min.-Geol. Inst. Univ. Utrecht, D 24438—24444.

Orbitoides palmeri GRAVELL.

Plate 3, figures 23, 24.

Orbitoides palmeri GRAVELL, 1930, Journ. of Pal. vol. 4, p.p. 269, 270, pl. 22, figs. 1—10.
A. A. THIADENS, Journ. of Pal. vol. 11, no. 2, 1937, p.p. 91—109, pls. 15—19 text figs. 1—3.

The embryonic apparatus is somewhat smaller than indicated by GRAVELL. The ornamentation of the test cannot be seen in our forms, owing to the state of preservation.

Measurements of *Orbitoides palmeri*.

Diameter.................. 2—2,5 mm.

Thickness .... 1—1,25 mm.

Embryonic apparatus 320—240 μ to 440 $\times$ 300 μ.

Equatorial chambers horizontally about 100 $\times$ 65 μ.

Height of equatorial chambers 80—160 μ (periphery).

This form differs from *Orbitoides browni* by the absence of the strong pillars, smaller diameter, thickness and its larger embryonic apparatus.

Upper Cretaceous, Camaguey, Cuba. Min.-Geol. Inst. Univ. Utrecht, D 24445—D 24450.

Lepidorbitoides estrellae VAN WESSEM *nov. sp.*

Plate 2, figure 32; plate 3, figures 12, 13.

Test of small size, circular, symmetrical with regard to the equatorial layer. Surface very finely papillate, pillars about 40 μ in thickness. In cross-section about ten layers of lateral chambers can be distinguished. Equatorial chambers truncate, ogival to short-hexagonal. Measurements 50 μ (radial) $\times$ 65 μ (tangential) to 80 $\times$ 105 μ. On vertical section the equatorial layer increases in height from 26 μ in the centre to 40 μ on the periphery. Embryonic apparatus consisting of one, nearly spherical chamber, measuring 80 $\times$ 80 μ to 70 $\times$ 105 μ, followed by a larger reniform second one, measuring from 70 $\times$ 105 μ to 105 $\times$ 170 μ. The two initial chambers are followed by five to eight chambers, gradually diminishing in size, but all larger than the other equatorial chambers, spirally arranged. Measurements of the test: diameter 1,5—2 mm, thickness 0,7—0,8 mm.

Remarks: this species differs from *L. macgillavryi* and *L. planasi* in having distinct pillars, from *L. macgillavryi* in having a smaller and thicker test and from *L. planasi* in having a larger embryonic apparatus.

Type locality, Upper Cretaceous, Locs. H 94 and H 94*b*, Camaguey, Cuba. Syntypes, Min.-Geol. Inst. Univ. Utrecht, D 24466—24472.

Lepidorbitoides minima DOUVILLÉ.

Plate 3, figure 14.

Lepidorbitoides minima H. DOUVILLÉ, 1927, C. R. Soc. Géol. France, février 21, p. 34. — M. G. RUTTEN, Journ. Pal. vol. 9, no. 6, p.p. 527—545, pls. 59—62, 1935.
Orbitocyclina minima VAUGHAN, 1929, Journ. Pal. vol. 3, no. 2, p.p. 174, 175, pl. 22, figs. 3—6.

Measurements of *Lepidorbitoides minima*.

Diameter............................	1,6 to 3,2 mm.
Thickness	1,1 mm.
Diam. first embryonic chamber	80 to 110 μ.
Diam. second chamber	110 $\times$ 80 tot 160 $\times$ 110 μ.
Equatorial chambers horizontally	70 $\times$ 55 μ.
Height of equatorial chambers.........	20 to 60 μ.

Upper Cretaceous, Camaguey, Cuba. Min.-Geol. Inst. Univ. Utrecht. D 24456.

Lepidorbitoides minor (SCHLUMBERGER).

Plate 3, figure 15.

Orbitoides minor SCHLUMBERGER, 1901, Bull. Soc. Géol. de France, vol. I, 4me série, p.p. 459—467, pls. VII-IX.
Lepidorbitoides socialis race minor DOUVILLÉ, 1920, Bull. Soc. Géol. de France, vol. XX, 4me série, p.p. 220—226, pl. 8, figs. 3, 4.
Lepidorbitoides minor (SCHLUMBERGER), M. G. RUTTEN, 1935, Kon. Akad. Wetensch. A'dam, Proc. vol. 38, no. 2, p.p. 186, 187, pl.

The determination of this species is based upon the external features of the test and a median section, as we had only one specimen at our disposal. The large test and the strong pillars, added to the measurements of the

embryonic apparatus and the form of the equatorial chambers, however, are very characteristic.

Measurements of *Lepidorbitoides minor.*

Diameter............................ 5 mm.
Thickness .... 1,5 mm.
Pillars .... 150—180 μ.
Diameter first embryonic chamber ..... 148 × 148 μ.
Diameter second embryonic chamber .. 120 × 200 μ.

Equatorial chambers are diamond-shaped to ogival, 105 (radial) × 150 μ (tangential).

Upper Cretaceous, Camaguey, Cuba. Min.-Geol. Inst. Univ. Utrecht, D 24459.

Lepidorbitoides nortoni (VAUGHAN).
Plate 3, figure 16.

Orbitocyclina nortoni VAUGHAN, 1929, Journ. Pal. vol. 3, no. 2, p.p. 170—175, pl. 22.

Having only one specimen, the determination of this species is based upon its external features and a median section. The flatness of the test, its very finely papillate surface combined with the very small embryonic apparatus, make it fairly probable, that we have to do with *Lepidorbitoides nortoni.*

Measurements of *Lepidorbitoides nortoni.*

Diameter............................ 3,5 mm.
Thickness .... 0,5 mm
Papillae .... 35 μ.
Diam. first embryonic chamber .... 60 μ.
Diam. second embryonic chamber..... 50 × 80 μ.
Equatorial chambers horizontally...... 75 × 85 μ.

Upper Cretaceous, Camaguey, Cuba. Min.-Geol. Inst. Univ. Utrecht, D 24458.

Lepidorbitoides palmeri THIADENS.
Plate 3, figure 17.

Lepidorbitoides palmeri THIADENS, 1937, Journ. Pal. vol. 11, p. 101, pl. 17, figs. 2, 9, 10.

Our forms agree closely with the description and figures given by THIADENS. There is only a small difference in the size of the embryonic apparatus.

Measurements of *Lepidorbitoides palmeri.*

Diameter......................... 3,5 to 5 mm.
Thickness .... 1 to 1,8 mm.
Diam. first embryonic chamber ... 135 to 150 μ.
Diam. second chambers .... 95 × 160 μ to 110 × 180 μ.
Equatorial chambers horizontally . 70 to 110 μ (radial) × 80 to 115 μ (tangential).

Upper Cretaceous, Camaguey, Cuba. Min.-Geol. Inst. Univ. Utrecht, D 24451—24455.

Lepidorbitoides tschoppi VAN WESSEM *nov. sp.*

Plate 2, figure 33; plate 3, figures 18, 19.

Test of small size, very flat, circular, symmetrical with regard to the equatorial layer, discoid, slightly thicker in the centre than on the periphery. Surface smooth, reticulate, no papillae and no pillars. Lateral chambers open, thick-walled, ten to twelve layers, in vertical section measuring about 40 × 80 μ. Equatorial chambers diamond shaped to hexagonal or ogival. Measurements 110 μ (radial) × 95 μ (tangential) to 80 μ × 65 μ. On vertical section the equatorial layer increases in height from 30 μ in the centre to 70 μ on the periphery. Embryonic apparatus consisting of one, nearly spherical, chamber, measuring 107 × 107 μ to 135 × 135 μ, followed by a larger, reniform, second one, measuring 95 × 135 μ to 115 × 17 5μ. The two initial chambers are followed by a number of chambers, gradually diminishing in size, but all larger than the other equatorial chambers, spirally arranged.

Both microspheric and megalospheric forms were found. Measurements of the microspheric form: diameter 2—2,6 mm, thickness 0,4—0,7 mm. Diameter of macrospheric form 3—3,5 mm.

Remarks: this new species resembles in many respects *L. rutteni* THIADENS. There are, however, striking differences: *L. rutteni* has a much smaller embryonic apparatus, fewer lateral layers and the dimensions of the test are larger.

Type locality, Upper Cretaceous, Loc. V 36, Camaguey, Cuba. Syntypes, Min.-Geol. Inst. Univ. Utrecht, D 24461—24465.

Lepidorbitoides sp.

Plate 3, figure 20.

As we had only one specimen, only a description of the external features of the test and of the equatorial layer can be given. Test flat, thin, circular in outline, greatest thickness towards the centre; diameter 8 mm, thickness in the centre 0,7 mm. In horizontal section we observed a tripled embryon. It consists of two subequal chambers, the wall between them is slightly curved. The greatest diameter is 300 μ, the lesser 240 μ. The wall is about 50 μ in thickness. The eqautorial chambers are short-hexagonal to hexagonal. The tangential diameter and the radial are nearly equal at the periphery; they are about 110 μ in diam.

Upper Cretaceous, Camaguey, Cuba. Min.-Geol. Inst. Univ. Utrecht, D 24460.

b) Upper Eocene species.

Camerina pellatispiroides BARKER.

Plate 2, figure 35; plate 3, figures 8, 9.

Camerina pellatispiroides R. WRIGHT BARKER, Proc. U.S.N.M. 86, 1939, no. 3052, p. 326, pl. 20, fig. 10, pl. 22, fig. 4.

Our forms closely resemble the description and figures given by WRIGHT BARKER. The large initial chamber, the thick walls and septa and the thickness of the test compared with its diameter are very characteristic.

Upper Eocene, Camaguey, Cuba. Min.-Geol. Inst. Univ. Utrecht, D 24476—24479.

Pellatispirella bermudezi (PALMER).

Plate 2, figures 36, 37; plate 3, figures 10, 11.

Operculina bermudezi PALMER 1934, Mem. Soc. Cub. Hist. Nat. 8, 1934, p. 238—240, pl. 12, figs. 3, 6, 9.
Pellatispirella bermudezi (PALMER), HANS E. THALMANN, Ecl. Geol. Helv. 1938, p. 331.

Our material closely resembles the description and figures given by PALMER.

Upper Eocene, Camaguey, Cuba. Min.-Geol. Inst. Univ. Utrecht, D 24482—24487.

Discocyclina sp. A.

Plate 3, figure 26.

Owing to the fact, that we had only one specimen, a full description cannot be given.

Test circular without umbo or raised central part. The whole surface is covered with papillae with a diameter of about 120 μ. Diameter 2,8 mm, thickness 0,8 mm. The equatorial chambers near the periphery have a radial diameter of 50 μ and a tangential diameter of 20—25 μ. The nucleoconch is composed of a round embryonic chamber, partly embraced by a second one. Measurements of the embryon are 110 $\times$ 110 μ. The wall measures about 25 μ.

Upper Eocene, Camaguey, Cuba. Min.-Geol. Inst. Univ. Utrecht, D 24480.

Discocyclina sp. B.

Plate 3, figure 27.

Test circular, flat, surface covered with papillae with a diameter of about 100 μ. Diameter 1,75 mm, thickness 0,4 mm. The equatorial chambers have a radial diameter near the periphery of about 70 μ and a tangential diameter of 30 μ. The embryonic apparatus consists of one nearly spherical chamber, almost entirely embraced by a reniform second one. Measurements of the nucleoconch: 360 $\times$ 360 μ. This species may belong to *Discocyclina blumenthali* GORTER and v. D. VLERK, 1932. This cannot be proved with certainty,

however, owing to the fact, that we could not make a vertical section, having only one specimen.

Upper Eocene, Camaguey, Cuba. Min.-Geol. Inst. Univ. Utrecht, D 24481.

c) Oligo-Miocene species.

Miogypsina hawkinsi HODSON.
Plate 3, figure 25.

Miogypsina hawkinsi HODSON, 1926, Bull. Am. Pal., vol. 12, no. 47, p.p. 28, 29, pl. 7, fig. 9 ; pl. 8, figs. 1, 2. — A. A. THIADENS, J. Pal. 11, 1937, p. 107, pl. 17, fig. 4 ; pl. 18, fig. 3 ; pl. 19, figs. 2, 3, 6, 7.

Our forms closely resemble the material of THIADENS. There is a great variation in the diameter of the papillae, but they are for the greater part rather coarse, measuring up to 110 μ.

Oligo-Miocene, Camaguey, Cuba. Min.-Geol. Inst. Univ. Utrecht, D 24488—24490.

Rudistids.

Mitrocaprina tschoppi (PALMER).

Plagioptychus tschoppi PALMER, 1933, Rev. Agric. Habana, 14, nos. 15, 16, p.p. 103, 104, pl. 10, figs. 1—3.
Mitrocaprina tschoppi (PALMER), THIADENS, 1937, Geol. Geogr. Med. Utrecht, no. 12, p. 43.
Mitrocaprina tschoppi (PALMER), MAC GILLAVRY, 1937, Geol. Geogr. Med. Utrecht, no. 14, p.p. 158—163, pl. 7, figs. 1, 4, 5, 7, 8.

The material was given to us by TSCHOPP and comes from Ciego de Avila, probably from the type locality of PALMER. MAC GILLAVRY has given an extensive description of this species. His material also comes from Ciego de Avila and we were able to compare it with ours. As there is not the slightest difference between them, no further details are given here.

Locality: T 1425, Upper Cretaceous, Camaguey, Cuba. Min.-Geol. Inst. Univ. Utrecht, M.C. 61.

Titanosarcolithes giganteus (WHITFIELD).

Caprinula gigantea WHITFIELD, 1897, Bull. Am. Mus. Nat. Hist. 9, p.p. 194—196, pls. 18, 19 (figs. 1—2), 20, 21, 22 (figs. 1—3).
Titanosarcolithes giganteus (WHITFIELD), TRECHMANN, 1924, Geol. Mag. vol. 61, p.p. 397—400, pl. 23, figs. 1—2, text fig. 1.
Titanosarcolithes giganteus (WHITFIELD), MAC GILLAVRY, 1937. Geol. Geogr. Med. Utrecht, no. 14, p.p. 85—92.

The outer shell-layer of this species is characterized by many canals, a feature, which makes cross-sections almost superfluous.

Localities: V 36, V 69, K 12, K 17, H 95 often together with *Orbitoididae*, *Vaughanina* and *Sulcoperculina*.

Upper Cretaceous, Camaguey, Cuba. Min.-Geol. Inst. Univ. Utrecht, M.C. 4, 293, 429, 608.

Barrettia sparcilirata WHITFIELD.

Barrettia sparcilirata WHITFIELD, 1897, Bull. Am. Mus. Nat. Hist. vol. 9, p.p. 245—246, pls. 36, 37.
Barrettia sparcilirata WHITFIELD, BOSSEVAIN and MAC GILLAVRY, 1932, Proc. Kon. Ak. Wetensch. A'dam, vol. 35 no. 10, p.p. 1303—1308, with 3 text figs.

We had the disposal of only one incomplete, rather heavily recrystallized specimen. It has a small living room and a thick outer shell-layer. We counted 18 infoldings of the outer shell-layer over a distance of about $\frac{3}{4}$ part of the circumference. Further details could not be observed.

Locality R 16. Cretaceous, Camaguey, Cuba. Min.-Geol. Inst. Univ. Utrecht, M.C. 611.

Lamellibranchiata and Gastropoda.

Ostrea sp. aff. O. cymbula LAMK. or *O. flabellula* LAMK.

Owing to the fact that we could not consult all the literature on Cretaceous *Ostreae* of America, the determination of this species was almost impossible. It was compared with *Ostrea cymbula* LAMK. and *O. flabellula* LAMK. from the eocene deposits of Paris, described by DESHAYES (113). Our species shows close affinity with the European species. The hinge area of the latter species, however, is sharply pointed, while our species shows a more rounded hinge.

Locality T 1426, Upper Cretaceous, Camaguey, Cuba. Min.-Geol. Inst. Univ. Utrecht, M.C. 619.

Pecten irregularis (BÖSE).

Vola irregularis BÖSE, 1910, Instituto geológico de Mexico, p. 97, pl. 15, figs. 10—18.
Pecten irregularis (BÖSE), ADKINS and WINTON, 1919, Univ. Texas Bull. no. 1945, p. 67, pl. 11, figs. 11—15.
Pecten irregularis (BÖSE), ADKINS, 1928, Univ. Texas Bull. no. 2838, p. 126, pl. 17, fig. 8.

The occurrence of tertiary ribs cannot be seen in our specimen. After the original description of BÖSE (112), these tertiaries are indeed seldom seen, in contrary with the Texan material of ADKINS (110).

Locality T 1427, Upper Cretaceous, Camaguey, Cuba. Min.-Geol. Inst. Univ. Utrecht, M.C. 616.

Pecten georgetownensis (KNIKER).

Neithea georgetownensis KNIKER. 1918, Univ. Texas Bull no. 1817, p. 31, pl. 6, figs. 1—3.
Pecten georgetownensis (KNIKER), ADKINS and WINTON, 1919, Univ. Texas Bull. no. 1945, p. 70, pl. 12, figs. 5—6.

The rather strongly elevated right valve with its six prominent primary ribs and the two lower secondaries in each interspace, all divided by one or two small linear furrows, is very characteristic.

Locality T 1427, Upper Cretaceous, Camaguey, Cuba. Min.-Geol. Inst. Univ. Utrecht, M.C. 615.

Pecten bellula (CRAGIN).

Pecten bellula (CRAGIN), ADKINS, 1919, Univ. Texas Bull. no. 1945, p. 69, pl. 11, figs. 3—7.
Pecten bellula (CRAGIN), ADKINS and WINTON, 1928, Univ. Texas Bull. no. 2838, p. 125, pl. 17, fig. 5.

This species is recognized by its sharply recurved umbo, strong convexity and its numerous fine, nearly equal ribs. ADKINS and WINTON say that every sixth or seventh rib is more elevated or differs in another way from the others. This feature was not observed in our specimens.

Locality T 1427, Upper Cretaceous, Camaguey, Cuba. Min.-Geol. Inst. Univ. Utrecht, M.C. 617.

Harpagodes sp.

As we had only casts at our disposal, we cannot give a specific determination of these *Gastropoda*.

Locality T 1426 and T 1427, Upper Cretaceous, Camaguey, Cuba. Min.-Geol. Inst. Univ. Utrecht, M.C. 618.

In Texas and Mexico the above mentioned *Pectinidae* occur in the Lower Cretaceous, and in the Upper and Middle Albian. In Cuba, however, they are found in the Upper Cretaceous, together with *Orbitoides browni*, *Sulcoperculina dickersoni* and *Vaughanina*.

Chapter V: SURVEYED COURSES.

Ciego de Avila — La Florida.

The Carretera Central leaves Ciego de Avila in its eastern part and we find decomposed sandy Diorite as far as the first curve in the road. Here we pass into the Habana Formation. At F 48 in a quarry, just South of the road, we find limestones and marls with *Orbitoides palmeri*, *Vaughanina cubensis*, *Sulcoperculina dickersoni*, fragments of Rudists, *Inoceramus*, Oysters, *Gastropoda* and Echinids. On microscopical examination the rocks are found to contain a certain amount of dioritic material. The quartz- and plagioclase-fragments are not rounded but show sharp angles; this can be easily explained from the fact, that they have been transported over a very short distance, as the Diorite lies in the direct vicinity. At V 35 we find again outcrops of limestones, also with detritus of dioritic rocks and with several Larger *Foraminifera* e.g. *Orbitoides browni*, *Sulcoperculina dickersoni* and Rudist-fragments. Between km 464,4 and km 464,9 the road is cutting a small hill in which we found the following section:

km 464,44	Fragments of Rudists e.g. *Mitrocaprina tschoppi.*
km 464,47	Limestones with *Orbitoides browni*, *Lepidorbitoides* and *Sulcoperculina dickersoni* (D 23923). Strike of the limestones N 65 E, dip 10—15° N.
km 464,5	Limestones, dipping 10 degrees to the West, with fragments of Rudists, *Sulcoperculina dickersoni*, a great number of *Lepidorbitoides*, Corals and *Lithothamnia.*
km 464,6	Limestones with Rudist-fragments, probably of *Durania.* Further a marl sample was taken at this point which proved to be very rich in Larger and Smaller *Foraminifera.* It contains *Orbitoides browni*, *Lepidorbitoides minor*, *L. nortoni*, *L. minima*, *L. palmeri*, *Sulcoperculina dickersoni*, *S. sp.* and many Smaller *Foraminifera*, belonging to the genera *Marssonella*, *Cristellaria*, *Frondicularia* etc.
km 464,61	Marls and coralreefs.
km 464,74	Limestones containing Larger *Foraminifera.*
km 464,87	Marls and limestones with *Sulcoperculina dickersoni.*
km 464,94	Calcareous sandstones and limestones with *Sulcoperculina dickersoni.*

Until km 466 is reached, several exposures of Habana limestones can be seen e.g. near V 36*a*. These limestones contain the same characteristic Upper Cretaceous fossils as mentioned above. In the following 3 km, however, we do not find outcrops, but the soil, which has a red or purple colour, and

the occurrence of much „perdigon" make it pretty sure, that we are in Tertiary deposits.

At V 37, V 37*a*, V 37*b* and T 922 we find yellowish-white limestones which are somewhat crystalline. We cannot prove their Guines age, as they do not contain any organism, but we do not see any habitual difference from the limestones, exposed near V 37*f*. The limestones from the last-mentioned find-spot are rich in characteristic oligo-miocene genera, such as *Marginopora*, *Archaias* and *Sorites*. All these limestones seem to lie nearly horizontal. Further on, up to V 37*j*, we find the same cavernous, red-weathering limestones, the same red or brown soil and locally much perdigon, but near km 491,7, in a small valley, we see platy limestones under a covering layer of yellow soil, containing perdigon. The limestones are gently dipping southwards and contain rather much detritus of dioritic rocks. This, combined with the fact that the soil in the last one or two kilometers has become more sandy, makes it likely that we have passed into older, eocene, deposits.

Near km 496 there occur light-green, heavily weathered rocks, so called bentonites, which originate from tuffs. They are considered to belong to the Tuff Series. East of this small area of Tuff Series rocks at V 39, we find dirty, white marls, which are rather rich in Smaller *Foraminifera*, though poor in genera and species. The genus *Globorotalia* is represented by the species *G. spinulosa* and *G. aragonensis*. These two species, together with *Gümbelina wilcoxensis* and *Clavulinoides guayabalensis*, make it more than probable that we are in the Eocene. Certainty about this subject is obtained in the 3 kilometers, which now follow. On this stretch one encounters several outcrops of white or yellowish-white limestones and marls. These limestones and marls present an unmistakable eocene fauna: *Discocyclina*, *Dictyoconus*, *Pellatispirella bermudezi*, *P. antillea*, *Camerinae* and Smaller *Foraminifera*. As a rule the limestones are rich in detritic material of Diorite, tuffs and porphyrites.

At km 513 we find a small hill of about 150 meters long, on the right side of the Carretera Central. The western side of this hill consists of non-fossiliferous white marls, dipping gently to the North-West. They unconformably overlie red and green tuffs and silicified porphyrites of the Habana Formation, which have a strike of about N 70 E and a dip of 70 degrees to the South. The south-eastern flank of the hill consists of the same dirty white marls as were found on the western flank, this time, however, with large boulders of the tuffs and porphyrites. These marls and conglomerates have a small dip to the South-East. Obviously they represent the basal part of the Eocene.

Following the Carretera Central to the South-East, we now pass into an area, in which volcanic rocks of the Habana Formation are exposed. We find several outcrops of light- to dark-green or brownish-green porphyrites, porphyrite-breccias and tuff-porphyrite-breccias. Often these rocks have been silicified to a considerable degree.

From km 514,8 onwards we see some quarries in which quartz-diorite-porphyrites, regarded to belong to the dioritic sequence, are outcropping.

Under the microscope we can distinguish the quartz-diorite-porphyrites from the quartz-porphyrites of the Habana Formation by their much coarser groundmass. In the field, however, it is often very difficult to establish whether a porphyrite occurs in a dike or not. The distinction between the quartz-porphyrites and quartz-diorite-porphyrites is thus based upon the difference in the coarseness of the groundmass and sometimes upon their geological occurrence in the field. Mineralogically the differences between the two types of rocks are minimal.

Just East of R 44 we are again in tuffs, tuff-porphyrite-breccias and porphyrites of the Habana Formation, the eastern limit of which is reached at R 43. At this point we find an outcrop of limestone-breccias, which are fossiliferous in part. The occurrence of *Discocyclina* removes any doubt as to the age of the limestones. They are certainly eocene.

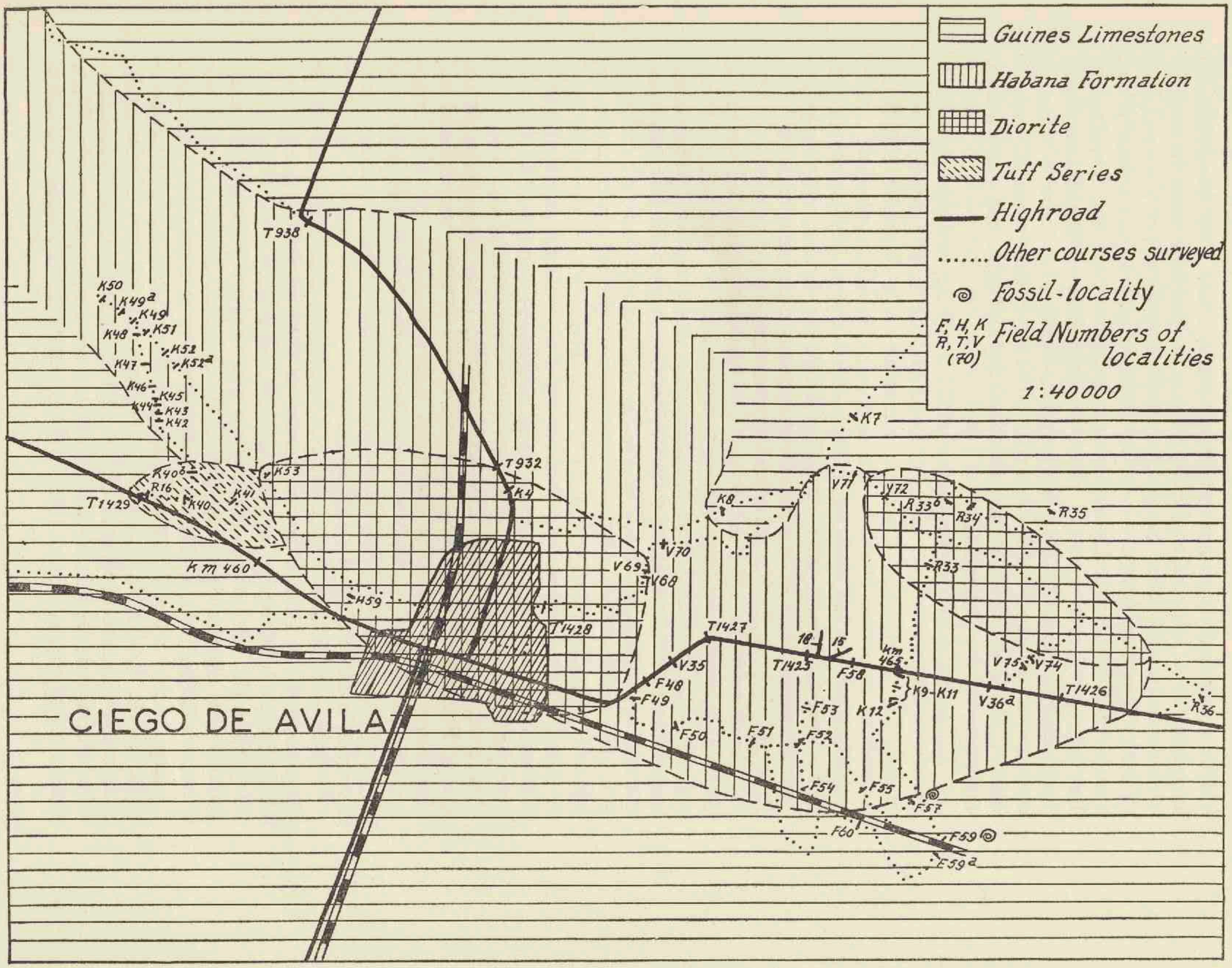
The next kilometers we find gray to black soil, clayish and without any outcrop. This continues until km 519; here we find yellow limestones, which on account of their habit are considered to belong to the Habana Formation and two kilometers further on we find the same brownish-yellow limestones, this time with typical Upper Cretaceous fossils e.g. *Orbitoides browni*, *Sulcoperculina dickersoni* and Rudist-fragments. Somewhat further we again find rocks of the Diorite Series exposed. At V 44*b* there is an outcrop of aplitic quartz-amphibole-diorites and at V 44*c*, in a small dike, a granophyric granodiorite-aplite was sampled. Immediately after this point we are again in the grayish-black soil, which we also saw between km 517 and km 519 and which proved to be a weathering soil on eocene deposits and, indeed, at V 44*d* we find white limestones, strike N 15 E, crowded with *Discocylinae* and *Camerinae*.

At km 526, where the highroad turns to the South, we encounter the same limestones, this time again full of organisms: *Discocyclinae*, *Camerinae* and *Pellatispirella antillea*. A limestone sampled by Dr. Tschopp at T 943 contains the same faunal assemblage, accompanied here by some doubtful *Lepidocyclinae*. The eocene limestones in this region possess rather much detritic material of Diorites. The last kilometers, as far back as V 44*d*, were already surveyed in 1933 by Mac Gillavry and his observations exactly fit in with ours, as may be concluded from a comparison of the two maps.

The environment of Ciego de Avila.

As for the findspot-numbers in this area we refer to the special map of this region on page 63.

I. We leave the Carretera Central a few hundred meters East of the boundary of the Diorites and we go in the direction of the railway, which runs roughly parallel with the Carretera Central to Florida. A hundred meters South of the Carretera we meet with conglomeratic calcareous sandstones with rounded pebbles of porphyrites and rocks of dioritic


Guines Limestones
Habana Formation
Diorite
Tuff Series
Highroad
Other courses surveyed
Fossil-locality
F, H, K R, T, V (70) Field Numbers of localities
1:40000
CIEGO DE AVILA
T938
T932
K4
K7
K8
K53
T1429
Km 460
H59
V69
V70
V68
T1428
T1427
V35
F48
F49
F50
F51
F52
F53
F54
F55
F57
F58
F59
F59a
F60
T1425
K9-K11
K12
V36a
T1426
V71
V72
R33a
R34
R35
R33
V75
V74
R36

origin e.g. porphyrites and amphibole-porphyrites. This basal Habana conglomerate is followed to the South by marls and limestones. In the field we sampled several loose Larger *Foraminifera* e.g. South of F 49 and East of F 50. They belong to *Orbitoides browni* and *Lepidorbitoides palmeri*. These fossils, characteristic for Upper Cretaceous deposits, are also found in the limestones, together with the rarely wanting *Sulcoperculina dickersoni* and Rudist-fragments. In F 51 we find *Archaias*-like fossils. Probably these are the same as described by THIADENS from the Upper Cretaceous of Southern Santa Clara. They are found together with *Lepidorbitoides* and a new genus, belonging to the *Peneroplidae*.

Still going eastwards we reach a small hill at F 52, which is wholly built up of boulders and pebbles of the older formations, in a very coarse conglomerate. The assemblage of pebbles comprises rocks from the Tuff Series as well as from the Diorites. We sampled albitised porphyrite-breccias, amphibole-porphyrites, quartz-amphibole-diorites, granophyric granodiorite-aplites, uralitised porphyrites, strongly silicified porphyrites, tuff-porphyrite-breccias, aplitic quartz-diorite-porphyrites, quartz-containing diabases, silicified tuffs and porphyrites with a glassy matrix.

At all sides this hill is surrounded by limestones, which, on account of the fossils they yielded, must belong to the Habana Formation. At F 55 we still find rocks, which do not contain fossils, it is true, but by their habit must be considered to belong to the Upper Cretaceous. When we approach the railway, rocks have ceased to outcrop and the only rock, we find here, is a granodiorite-aplite, clearly originating from the railway-embankment, which is built up by such rocks.

At F 56 the railway is reached and till F 57 we walk over red-brown soil with perdigon and numerous single limestone-fragments. They do not give the impression of having been supplied from other places. The fossils they contain, *Amphisorus matleyi* and *Archaias*, place these rocks in the Guines Formation. South of the railroad we found them several times and they have always the same cavernous habit, caused by the weathering out of *Gastropoda* and *Lamellibranchiata*. Their moulds and casts, with those of *Amphisorus* and *Archaias*, are very often met with, without permitting, however, a more close determination.

Going north-westwards from F 57 we again find white and yellow limestones of the Habana Formation and at K 12 we find large quantities of Rudists, all belonging to *Titanosarcolithes giganteus*.

Before the Carretera is reached, we pass through Habana limestones, always with characteristic fossils, such as *Orbitoides browni*. Crossing the Carretera Central at km 465, we pursue the road in a northerly direction. During the first 500 meters we still are in Habana limestones with an occasional single Rudist, but then we pass into yellowish-grey Diorite sands, alternating with loose Diorite blocks. At R 33 there is a small lake, surrounded by aplitic quartz-amphibole-diorites, which are also found to the West. Somewhat further we come upon a dike, cutting the Diorites. It consists

of a dark-coloured rock, which, on microscopical examination, proves to be a strongly uralitised diorite-porphyrite.

Only a hundred meters North of this dike we reach the boundary between the Diorites and the Tertiary. This boundary is as sharp as a knife and marked by the appearance of sugar cane and the typical red soil with perdigon. We follow this boundary to the South-East, always walking in the Diorites. A narrow cross-road, to the North, brings us at once in the Guines Limestones at R 35. Returning from this path, we pursue our way to the South and then again to the South-East. For a considerable distance, about one kilometer, we have to go through loose Diorite sands, before the Guines Limestones are reached. Here again the soil is red and covered with numerous loose limestone-fragments. We reach the Carretera Central about 200 meters West of km 467.

II. We start at the „Plaza" of Ciego de Avila and leave the town in an easterly direction. Owing to the „pavement" of the streets, being not always in an excellent condition, and which allows a glance at the „underground" of the town at many places, we are sure that the town, at any rate its eastern part, is built upon solid fundaments, namely upon Diorite. The Diorite sands continue until V 68, where we cross the boundary between the Diorites and the Habana Formation. Here this formation is represented by limestones, which are rich in fossils e.g. *Sulcoperculina dickersoni* and *Vaughanina cubensis*.

At V 70 we turn to the East and in the following 600 meters we encounter several times outcrops of yellow fossiliferous Habana limestones. Then our road leads us into a strip of ground, which is marked by an intensely red colour. Loose limestone-fragments are found here. Their habit unquestionably points to the Guines age. Our road coincides for a small stretch with the Ciego de Avila — Santa Theresa road, but we very soon leave this highway.

At V 71 the Habana Formation is found again; limestones with *Orbitoides palmeri*, *Vaughanina cubensis* and Rudist-fragments are outcropping here, but only a hundred meters further on we pass into the Diorites and this point marks the most north-western tip of this Diorite mass. At V 72 we sampled light coloured rooks, which prove to be granodiorite-aplites and these rocks are also found to the East of this point. A good 500 meters West of the eastern boundary of the Diorite mass, we turn southwards to find the boundary between the Diorites and Habana Formation in this part. This boundary appears to lie just North of V 74. From this point, until the Carretera Central is reached, we find Habana limestones with much detritic material of the Diorites and crowded with *Orbitoides*, Rudist-fragments and *Sulcoperculina dickersoni*.

III. From the „Club de Cazadores" at km 459 on the Carretera Central, West of Ciego de Avila we go to the East. At the very beginning we already find dark-blue, strongly recrystallized limestones, some of which contain

fragments of Rudists. One of these larger fragments could be determined as *Barrettia sparcilirata*. East of the Club we find outcrops of heavily weathered, lightgreen rocks. These rocks are very heavy and they contain very much garnet. We are dealing with quartz-garnet-calcite rocks, often epidotised and zoisitised. The garnet may be regarded as a product of contactmetamorphism, caused by the Diorites. The same contactmetamorphically altered Provincial limestones are found North of K 40, alternating with augite-porphyrites and silicified tuffs, all belonging to the Tuff Series. North of K 40*b* the road bifurcates. The south-eastern branch goes in the direction of Ciego de Avila and passes through contactmetamorphic limestones, again with garnet and porphyritic rocks.

The north-western branch leads at first through black soil without any outcrop. A clay-sample taken at K 42 yielded some characteristic Upper Cretaceous *Foraminifera* e.g. *Meandropsina rutteni* and *Orbitolina!!* From this point up to K 47 we find numerous outcrops of volcanic rocks, belonging to the Habana Formation: porphyrites, porphyrite-breccias, quartz-containing tuffs and quartz-porphyrites. The porphyrite-breccias and conglomerates have often been strongly calcified and are cut by veins of calcite, a characteristic, which is mentioned by M. G. RUTTEN from the same rocks of Northern Santa Clara and which he regards as a very distinguishing feature, in contrast with the tuffs and porphyrites of the Tuff Series.

At K 47 we find the porphyrites alternating with conglomerates and calcareous sandstones with dioritic and porphyritic material. As a proof of their age, the conglomerates contain also fragments of Rudists. The next hundred meters are occupied by yellow limestones with *Orbitoides*, *Sulcoperculina dickersoni* and Rudist-fragments, which, in their turn, are followed by more or less silicified porphyrites and accompanied by tuffites with calcareous cement (K 49*a*).

At K 50 we again find Habana limestones with Orbitoids and Rudists, just as at K 51, where the same limestones crop out over a short distance. Then we again find porphyrite-breccias, silicified porphyrites, quartz-containing tuffs, quartz-porphyrites and tuffites with calcareous cement. These volcanic rocks continue to outcrop over a long distance, gradually they disappear and near K 53 the Diorites begin to outcrop.

At K 53 we find a broad dike of a white rock, strike N 100 E, which turns out to be a plagiaplite. From this point until we entered Ciego de Avila from the West, we saw several times dioritic rocks. Now we turn to the South, cross the Carretera Central and with the railway on the left, we go in the direction of Silveira and Jucaro. Already in the beginning the Diorites disappear and we reach a very monotonous landscape. Only now and then we find an outcrop of cavernous, red-weathering limestone, belonging to the Guines Formation. This formation continues till Silveira.

IV. We leave the road Ciego de Avila — Moron where this road turns to the North-East at T 938 and we go to the North-West. The soil is red

and covered with perdigon and loose limestone-fragments and it is beyond doubt that we are in the Guines Formation. This soil continues during two kilometers, then we come to a road junction. The northern road leads to El Masio and passes through sugar-cane fields. On this road we find only red soil and perdigon. The western road, however, immediately brings us into an older formation, the Habana Formation. This formation is represented by limestones, marls and conglomerates with pebbles of dioritic rocks, tuffs, diabases and porphyrites. Here the soil is black. At H 57 we sampled a limestone which contained Orbitoids, *Vaughanina*, *Sulcoperculina dickersoni* and Rudist-fragments. Directly after this point our road turns to the South in the direction of the Carretera. During a kilometer we find the same Habana limestones, but then the soil becomes red instead of black, perdigon appears and we are again in the Guines Limestones; 300 meters before the Carretera Central we meet beds of tuffs and calcareous tuffites with sponge needles (H 58). These Tuff Series rocks can be followed during a six or seven hundred meters, when we reach again the Guines Formation, characterized by its red soil and cavernous limestones. We turn eastwards and walk in the direction of Ciego de Avila with the railway on our right hand. Just before the highroad, we reach the boundary with the Diorite, marked by gray or yellow, sandy soil. Following the Carretera in a westerly direction, we cut the Tuff Series between km 460 and 459, but further on we always are in the Guines Formation until the Tuff Series at H 58 is reached.

Ciego de Avila — Moron.

From the centre of the town to the water-tower of Ciego de Avila, which is situated near K 4, we are in Diorites. At this point we find grano-diorite-aplites. Somewhat to the North-West we are already in the Habana Formation (T 932). We cross the railway, the soil has a brownish colour and we do not see any outcrop until T 938, where we find outcrops of marls and limestones. In the marls we found some Larger *Foraminifera*, typical for the Upper Cretaceous: *Orbitoides palmeri* and *Sulcoperculina dickersoni*. The limestones contain the same fossils. Here the road turns sharply to the North and at once we reach the brownish-red soil of the Guines Limestones, „sprinkled" with perdigon. This continues until Ceballos, to the North of which we find more outcrops. At W 30 we find whitish, porous, oolitic Guines Limestones without recognizable *Foraminifera*. North of the village Fontanals we find loose fragments of dioritic rocks, but we are certain, that they have come from the railway-embankment, which is in the immediate vicinity. We continue to walk in the red soil with an occasional outcrop of recrystallized Guines Limestones without a chance of finding fossils in such limestones, but at W 34, in the neighbourhood of El Manguito, we find outcrops of very fine-grained limestones with a characteristic oligo-miocene fauna: *Amphisorus matleyi*, *Archaias*, *Peneroplis*, *Sorites*, *Marginopora*.

These fossiliferous limestones continue to outcrop along the road till the town of Moron is reached. At W 36*a* and F 47 we took groundsamples which proved to be rather rich in quartz with much perdigon, the soil becoming more and more sandy as we proceed from W 36*a* to the North.

The country to the left of this road.

From Ceballos there is a small road to the West. It leads through sugar-cane fields and offers but few opportunities for good outcrops. At R 29 and R 30 we found limestones, somewhat recrystallized, reddish weathered and with traces of organisms. From the sugar-factory „Moron" we go again to the West. On this road we find limestones, sometimes strongly recrystallized (W 41 and R 17), occasionally with fossils e.g. at W 39, where we find *Peneroplis*, which indicates an oligo-miocene age of the limestones. Together with limestones and marls we find here also calcareous sandstones and quartzitic ! ! sandstones. The quartz probably originated from the Diorite masses in the neighbourhood of Ciego de Avila.

On the road which leads from Moron to Adelaide Dr. Tschopp took three samples. At T 935 a very remarkable limestone was sampled. The age of the limestone, oligo-miocene, is certain, as it contains *Amphisorus matleyi* and *Archaias*. Together with those fossils we also observe in thin section *Discocyclinae* and Rudist-fragments. Moreover detritic material of dioritic rocks and tuffs is seen. The *Discocyclinae* and Rudists are without any doubt a secondary deposit. More to the West we find Guines Limestones with *Peneroplis*, *Amphisorus matleyi* and other Smaller *Foraminifera*.

The country East of the road Ciego de Avila — Moron.

We start at the railway-station of Moron and go to the East to reach the Loma Cunagua. In the first ten or twelve kilometers we do not find any outcrop. The soil is intensely red and occasionally a single limestone-fragment is found. They are reddish-weathered, sometimes rather crystalline and do not contain recognizable fossils. At T 1151, however, we find oligo-miocene fossils in outcropping rocks: *Amphisorus matleyi*, *Archaias* and *Peneroplis*. The limestones often also contain moulds and casts of *Gastropoda* and *Lamellibranchiata*. All along the road we find the same cavernous limestones, occasionally somewhat brecciaceous and when we ascend the Loma Cunagua we do not find any trace of older formations. At the eastern tip of the Loma Cunagua we sampled Guines Limestones with the same oligo-miocene fossils as mentioned above. At K 64*a*, however, a brecciaceous limestone was found with fragments of almost recent *Gastropoda*. This breccia is considered to be younger than the Guines Limestones, plistocene or even younger.

The road, which runs due South of Moron and which passes through the hamlets Eden and Desengaño to reach the road Moron — Ciego de Avila about three kilometers North of the sugar-factory „Moron", yields no new facts. All rocks we find are the same, red-weathered, cavernous limestones, occasionally with the fossils (R 32), which are so typical for the Guines Formation.

The same monotonous landscape, an endless plain covered with sugar cane, is seen when we go to the South-East from the Central „Moron". This road passes Francisco and Santa Theresa before Ciego de Avila is reached. A few samples were taken of more or less strongly recrystallized limestones, which do not contain fossils, but which from their habit are likely to belong to the Guines Formation. Locally the red soil is very rich in perdigon e.g. near K 6. At K 7, which is approximately at the junction of roads, one of which runs straight on to Ciego de Avila, we find very many yellowish-blue rocks. They consist entirely of quartz and chalcedony. We are pretty sure, that we have to do with silicified limestones from the Guines Formation. At the junction itself we find limestones of the Habana Formation, but to the West we pass again into red soil and at K 8 we find Guines Limestones. After this point we come immediately in the Habana Formation, while the last stretch passes through dioritic rocks.

When we take the road, just South of Ceballos, we remain in the red soil, which is also found on the road Ciego de Avila — Moron. The soil is covered with limestone-fragments, which, by the characteristic fossils, found in V 56 (*Marginopora* and *Archaias*) belong to the Guines Limestones. We do not find anything else until, taking a cross-road, we reach the Loma Carolina. This hill forms a small ridge, its length is about 2 kilometers. Although we did not visit it at its western end, it seems to consist entirely of whitish or pink, rather porous rocks with a brecciaceous habit. Under the microscope we observe strongly silicified rocks, which contain considerable amounts of alunite ! ! The Loma Carolina is thought to be a large exposure of Tuff Series rocks. From V 58, where we find Guines Limestones, the road runs to the South to Santa Theresa.

Isla Turiguanao.

This island can only be reached by boat from San Fernando. The way from Moron to San Fernando leads through a swampy country and not a single outcrop was found on this stretch. On the other side of the „Laguna de Leche" we first pass into a red-brown soil with outcrops of white limestones, which on account of their habit are reckoned to belong to the Guines Formation. These limestones, sometimes rather coarsely crystalline and occasionally very rich in limonite, continue until V 102, for here the white limestones are replaced by blue and gray, fine-grained limestones, which contain traces of organisms, the preservation of which is too bad to permit a determination.

These limestones are exposed in a low ridge, which trends from South-East to North-West, its length being several kilometers. Tectonics are very complicated here, owing to the plasticity of the gypsum, which is found alternating with the Aptychi Limestones. Over a short distance we find the following strikes and dips: N 150 E, layers nearly vertical; N 165 E, very steep dips; N 110 E, 70 S; N 130 E, 65 S; N 100 E, very steep; N 130 E and N 150 E, both with a steep dip to the South. The blue limestones become sometimes brown-coloured, which is caused by limonite. For this reason they resemble the Guines Limestones at V 101. The tectonical style of the limestones at V 103 and V 104 being taken into account, a Guines age of these limestones, however, is out of the question. At V 105, where we find a strike of N 180 E, there occur thick layers of gypsum. At the „contact" of limestones and gypsum we see coarse crush-breccias, mostly large fragments of the limestones, cemented by gypsum.

Further to the N.E. we find the same blue limestones and gypsumlayers. The limestones, being the more resistent rocks, are singled out by selective erosion and form small hills, wheras the soft gypsum is roughly confined to the depressions between those hills. It is a remarkable fact, that the gypsum contains numerous small needles of tourmaline!!! As it is not likely, that the tourmaline has come into existence *in situ*, we have to accept the supposition, that it came from another region, probably from the North. At V 109 we leave the Aptychi Formation to pass into an area where we find marls, rich in gypsum and the same brecciaceous, brownish-weathering limestones as near V 100, which we take for Guines Limestones.

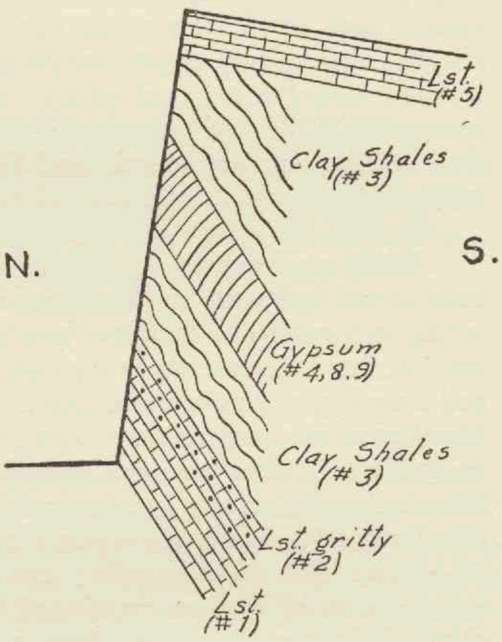
When we follow the small path, branching off near V 100, we first encounter porous, brown limestones, somewhat brecciaceous, which evidently are the equivalent of the limestones at V 100 and V 101. During the following 500 meters we meet with red breccias, consisting of luted limestone- and gypsum-fragments and covered with a reddish crust. We regard these breccias as very young: plistocene or possibly even younger. After these young breccias we find white or yellow limestones with an oligo-miocene fauna: *Marginopora*, *Amphisorus matleyi*, *Archaias* and *Peneroplis*. These limestones are exposed only over a very short distance, then they have to make room again for the Aptychi Limestones. These are the same blue and gray rocks, as found to the East, near V 105; we find them alternating with gypsum layers, which here also are rich in tourmaline as well as in quartz and beautiful rhombohedrons of calcite. At V 116 we find brownish limestones wich are very rich in hematite. At the end of this path, near V 117, we again find young breccias with elements of the Aptychi Limestones and gypsum-fragments.

The country South of Central Punta Alegre.

This area was not visited by us and the data given below come from Ir. H. Baggelaar, who had been kindly permitted by Mr. Poliakoff to

visit this region. The samples which he took there, were studied by us in Utrecht. A description of the rocks follows in brief. All particulars are adopted from the extensive account of Ir. BAGGELAAR, which accompanied his samples.

About one kilometer to the W.S.W. of the sugar-factory „Punta Alegre", there is a detached hill, the so-called „Loma de Piedra", which lies somewhat to the North of the „Loma de Yeso". From this hill we have got three samples, B 10—12, which do not contain any organism, but which on account of their habit are reckoned to belong to the Aptychi Formation. Some twelve hundred meters to the South-East of Punta Alegre, there is a quarry, from which BAGGELAAR gives the following profile:



On a very coarse crystalline limestone, B 1, which has a strike of N 125 E and a dip of 60 degrees to the S.S.W., there rests a rather thin layer of the same coarse crystalline limestone, which, however, contains some quartz. Then follow strongly undulating, very soft, blood-red clayshales, conformably resting upon these limestones. The clayshales are exceptionally rich in tourmaline-needles. The fact may be remembered, that this same feature was also found on Isla Turiguanao in the gypsum-layers. Indeed, the gypsum-layers or „stöcke", found in the clayshales, are also rich in this mineral, but also in idiomorphic quartz-grains and apatite. The clayshales are covered unconformably by limestones (B 5), their strike varies from N 100 E to N 110 E and the dip is about 13 degrees to the South. Macroscopically as well as microscopically we do not see any difference between the limestones at the base of the profile (B 1 and B 2) and the limestones of the covering layer. Mindful of the complicated structures we found on Isla Turiguanao, we believe, that the discordance, drawn by BAGGELAAR, is only apparent and that it is the result of disharmonic folding, caused by the plasticity of the underlying weak sediments.

The loose limestone B 7 which was found at the base of the quarry is a typical Aptychi Limestone. BAGGELAAR makes the same suppostion. The limestone B 13, South of this quarry, beyond the Loma, is a recrystallized limestone, the same as B 1 and B 2. Although in discovering fossils in these limestones we had no more success than Ir. BAGGELAAR, and for that reason, no paleontogical support can be given to our supposition, we firmly believe

that the whole complex, including the discordant layer of limestones at B 5, belongs to the same formation, namely the Aptychi Formation. According to BAGGELAAR, the formation is not restricted to this small area, but may be found far to the South of Punta Alegre.

The country South of the Carretera Central in the neighbourhood of Baragua and Vicenta.

Here the country is very flat and only now and then we find outcrops of limestones. These limestones are sometimes rather coarsely crystalline, very porous, reddish-weathered and often rich in limonite. They do not contain any fossil, except moulds and casts of *Lamellibranchiata*, a very characteristic feature of the limestones, belonging to the Guines Formation.

The country North and South of the Carretera Central in the central part of the district.

When we leave the highroad, near km 486,5 and go northwards, we start in red soil with an occasional single limestone fragment and covered with much perdigon. Judging from the scarce facts we have at our disposal, the first km at least leads us through the Guines Formation. Afterwards the soil looses its red colour and becomes more grey and sandy. This fact, combined with the occurrence of eocene fossils in a limestone, found at V 45, makes it sure, that we have already passed the boundary between Oligo-Miocene and Eocene. The sandy soil continues to K 46, where we reach silicified rocks, which are exposed on small hills. These silicified rocks are sometimes rich in magnetite; one sample contains much sericite. The composition of the last mentioned rocks does not allow of a statement about their genesis and age, but as we shall see somewhat further on the road, it is pretty sure, that they belong to the Tuff Series.

At one of these hills the road splits up and we go to the right. For nearly one kilometer we remain in the silicified rocks, which are followed by a strip of sandy soil, where eocene limestones are exposed. In the limestones we found some specimens of *Dictyoconus americanus*. Beyond the limestones we come again to a hill, on which we find outcrops of quartz-sericite-epidote rocks. In the following depression near a complex of houses at V 49 we find very much limestone, which contains characteristic eocene fossils e.g. *Dictyoconidae* and *Camerinae*. As the limestones are restricted to the direct environment of the houses, it is not quite sure whether they occur at the place itself or have been transported from elsewhere. As may be seen from the map, we regard the first supposition as the most probable one.

Hereafter we meet with rocks, which, on microscopical examination, prove to be more or less strongly silicified tuffs and porphyrites. Sometimes

they have also been strongly epidotised and chloritised. They are much like the rocks found at V 46, whose age we could not establish. Here, however, it is clear, that we are dealing with altered rocks of the Tuff Series.

Now, we leave the Tuff Series definitely and come to the Tertiary. It becomes evident that the Tuff Series in this region is bordered by eocene rocks, as we find limestones everywhere, one of which was sampled at V 51, containing the following fossils: *Dictyoconus*, several *Camerinae* and many Miliolids. These limestones, sprinkled in a brown, somewhat sandy soil, continue a good kilometer, then they become scarce and at last disappear. Now we come to sugar cane fields with intensely red soil and a single limestone-fragment. Although it cannot be proved by fossils, we are almost sure, that we are again in the oligo-miocene deposits of the Guines Formation.

We leave the Carretera Central again, somewhat East of km 488. As we do not find outcrops in the first two kilometers, it is not sure whether we are in oligo-miocene or in eocene sediments. At K 35, however, this problem is solved, for here there occur white limestones with unmistakable eocene fossils: *Discocyclinae*. The soil has now become more sandy and outcrops are almost wanting. This goes on for some 2500 meters, when we reach the Tuff Series: silicified tuffs and porphyrites. Obviously we are in the most easterly tip of the area, which is occupied by the Tuff Series, for the tuffs and porphyrites continue only for some six or seven hundred meters, where they have to make room for white limestones and marls of the Eocene. In accordance with other areas, where eocene deposits are encountered, the soil is here also grayish-black and rather sandy. At K 38 we probably are already in the Oligo-Miocene as the soil has a distinct red colour. Fossils, supporting this opinion, are not found before K 39 and K 39*b* where we find *Amphisorus matleyi* and *Archaias* in porous, red-weathered limestones.

A small path in this area starts at km 491,4 on the Carretera Central. The first part of it, about one kilometer, leads over a red-brown soil, with much perdigon and not a single outcrop. At W 104 and W 100 we encounter the same silicified rocks as were found at V 46 and K 36. One of the samples contains very much prehnite and muscovite, others are very rich in magnetite and limonite. These rocks apparently represent altered rocks of the Tuff Series. Then there is another stretch where outcrops are scarce till we reach W 91. Here we find several fragments of limestones and as we do not see any reason why they should have been brought from elsewhere, they are considered to belong to the underground. In W 91 as well as in W 89 and W 86 we found characteristic eocene fossils: *Dictyoconus* and *Discocyclinae* together with calcareous *Algae* belonging to the genus *Meminella*. At W 84 we already are at the eastern margin of the afore mentioned strip of the porphyrites and tuffs and somewhat to the West we cross the road, which leaves the Carretera Central at km 488,2.

After the cross-road we still are in the tuffs and porphyrites, but at

V 87 the Eocene covers the road over a small distance. The limestones are fossiliferous e.g. *Discocyclinae* and *Camerinae* and they also contain rather much detritic material of tuffs and porphyrites. Apart from another small strip of ground, where we find almost wholly silicified eocene limestones with *Dictyoconus* and *Discocyclina*, we remain in the rocks of the Tuff Series until the trifurcation near V 49.

The north-western branch of the trifurcation, North of V 46, passes first through quartz-limonite-rocks of the Tuff Series. About one kilometer after F 89 has been passed, we come to dark-red or brown soil with outcrops of white limestones, the eocene age of which is proved by the occurrence of *Discocyclinae* and *Dictyoconus*. We have the impression that the eocene limestones to the North-West are bordered by the Guines Limestones. This impression is based upon the colour of the soil and the habit of the limestones.

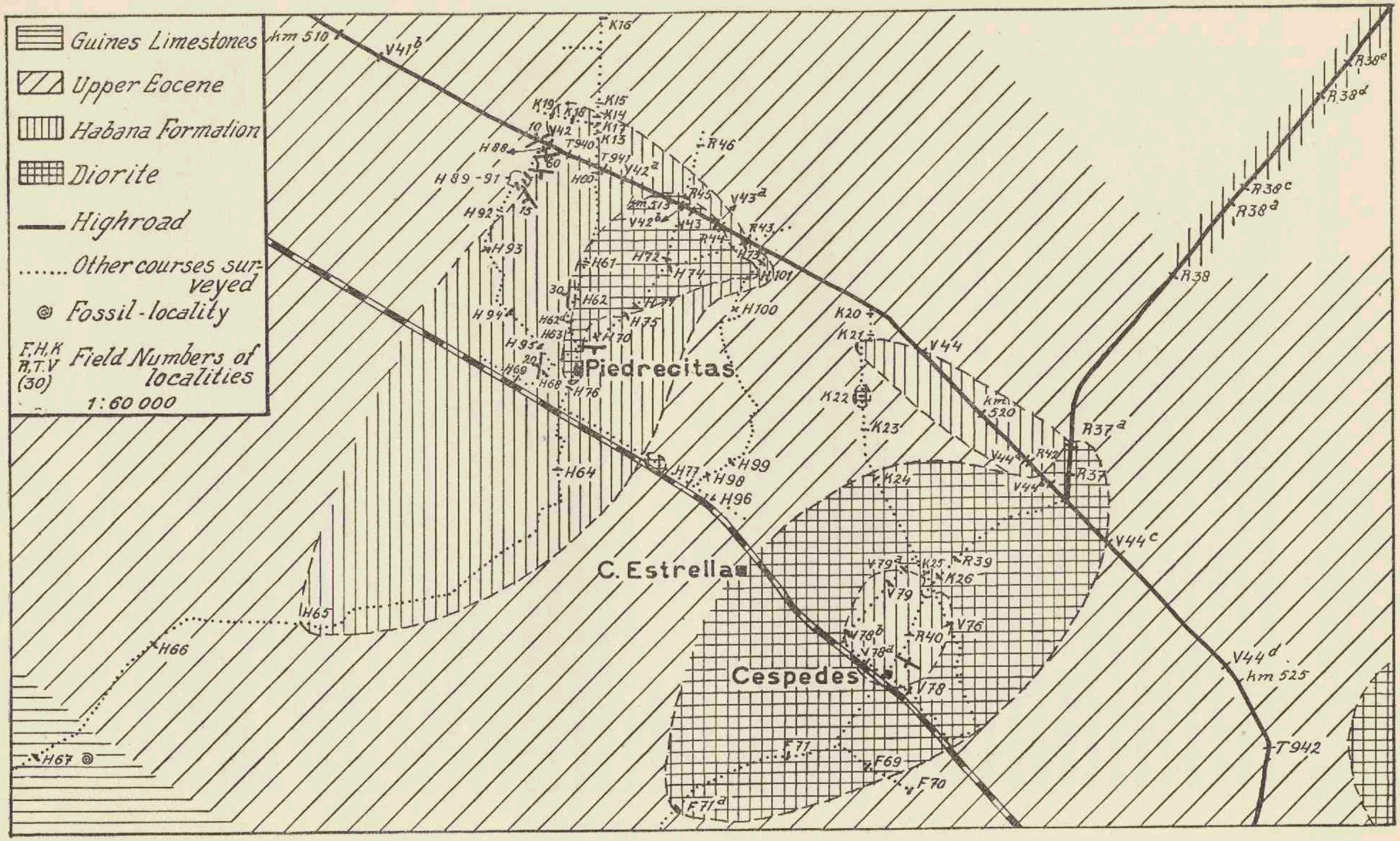
The roads, leading to the South from km 488,2 and km 497,6, lead us through a country where we do not find a single outcrop, apart from F 87, where there occur limestones, which for their cavernous habit with moulds and casts of *Gastropoda* are considered to belong to the Guines Formation. North of km 497,6 we enter grayish-black sandy soil with some perdigon. At R 47 there occur bentonite-like rocks, probably the result of weathering of tuffs. The same rocks were found near T 926 on the Carretera Central.

The country in the neighbourhood of Piedrecitas.

For findspot-numbers in this area, see the map on page 75.

We begin North of K 16, on the road, which runs due North from km 513,8 on the Carretera Central and go to the South. The soil has a black colour, is clayey and only at some places do we find single plate-like limestone-fragments. One of these limestones contains eocene fossils, namely *Discocyclina*, but whether the boundary between the Eocene and the Habana Formation has to be drawn more northward than is indicated on the map, or not, cannot be said, as the limestones at K 15 do not contain fossils. Anyhow at K 14 and K 13 we find limestones and conglomerates of the Habana Formation with intercalated layers of silicified tuffs. On the road, which is running to the West from K 13, we first find several Rudists, belonging to *Titanosarcolithes giganteus*. The Rudist limestones are followed by a zone of tuffs, which in their turn are followed again by Rudists.

When we continue our way to the South of K 13, we are passing black soil with loose fragments of Habana limestones. The Carretera Central is crossed a little to the West of km 514 and immediately to the South of it, we come to tuffs and tuff-porphyrite-breccias, also belonging to the Habana Formation. More to the South, however, we find silicified quartz-diorite-porphyrites, which can only be distinguished from the quartz-porphyrites of the Habana Formation by the coarseness of the groundmass, while, as a rule, the plagioclase-phenocrysts of the quartz-diorite-porphyrites


Guines Limestones
Upper Eocene
Habana Formation
Diorite
Highroad
Other courses surveyed
Fossil-locality
F.H.K R.T.V (30) Field Numbers of localities
1:60 000
Piedrecitas
C. Estrella
Cespedes

are cloudy and more weathered than those of the quartz-porphyrites. This characteristic, however, should not be overestimated.

For a short distance we leave the Diorites and find ourselves in sandy limestones and calcareous sandstones of the Habana Formation. The strike of the limestones is N 180 E, the dip 30 W. They contain much detritic material of the Diorites and with this material several Larger *Foraminifera*: *Orbitoides browni*, *O. palmeri* and *Sulcoperculina*. Moreover we find here several fragments of *Titanosarcolithes giganteus*. At H 62*d* we are again in the Diorites. At this point we find plagiaplites with beautiful granophyric intergrowths and a little further to the South we sampled quartz-amphibole-diorites also with granophyric intergrowths. This phenonemon is indeed very common in all dioritic rocks of the described area. 150 meters further on we cross a road and then pass through the village of Piedrecitas. The railway-station of this village lies in the Habana Formation. Outcrops are very scarce when we have passed the railroad. At H 64 there occur limestones with *Orbitoides*, *Sulcoperculina dickersoni* and Rudist-fragments, but from this point on we only find a dark soil, which later on becomes very sandy. Not until H 65 is reached, do we find an outcrop of calcareous sandstones, exposed in a fresh well. These resemble very closely the sandstones found near H 62 and, though the sandstones at H 65 did not contain fossils, we reckon them to belong to the Habana Formation. Hereafter we pass a strip of ground which has a clayey, black soil and at last we pass into the Guines Formation. At H 67 we took a sample of white marls, which yielded a rather rich fauna of Smaller *Foraminifera* among which large quantities of *Elphidium*, *Clavulina* and *Nonion*.

Now we leave the Carretera Central about 200 meters to the West of km 513 at the boundary between the Eocene and the Habana. South of the contact we are first in silicified tuffs, but soon we find the limestones of the Eocene, which separate several small hills, consisting of Habana tuffs. Then we find successively Habana limestones (H 90) with Rudists, eocene limestones (H 91 and H 92) with *Discocyclinae* and then again the Habana Formation. The eocene limestones have a strike N 125 E, 10—15 S, they are white, often sub-oolitic and contain sometimes relics of Corals. At H 92 we leave the boundary between Habana and Eocene and reach the limestones and marls of the Habana Formation. The marlsamples at H 94 are very rich in Larger *Foraminifera*. We found the following characteristic Upper Cretaceous species: *Orbitoides browni*, *O. palmeri*, *Lepidorbitoides minima*, *L. estrellae* and *Sulcoperculina dickersoni*. The limestones are also rich in fossils.

After H 95, where we find enormous quantities of *Titanosarcolithes giganteus*, together with *Actaeonella*-limestones and *Gastropoda*, we come upon a bifurcation. The south-western road leads through Habana marls and limestones, always with fragments of Rudists and the easily recognizable *Sulcoperculina dickersoni*. The limestones here have a strike N 180 E, 20 W. To the North-West of the above-mentioned bifurcation we very soon pass into the Diorites. Having crossed this Diorite strip, we find purple and pink

tuffs with a distinctly flowing texture. Together with these tuffs we find quartz-porphyrites; one sample contained a large fragment of granophyric material. Evidently both the quartz-porphyrites and the tuffs belong to the Habana Formation. At H 75, however, we find quartz-diorite-porphyrites and still more to the North aplitic biotite-granodiorites. It becomes clear, that we are again in the Diorite Series. At H 72 we find dikes of diorite-porphyrite, quartz-amphibole-diorite-porphyrite and a dike of very fine-grained malchite. Continuing our way northward, we cross the Carretera Central 200 meters East of km 515. Near the intersection we find diorite-porphyrites, but now we are very soon in the Habana Formation. At R 45 we already find coarse porphyrite breccias. The Habana Formation, however, forms only a narrow margin along the Diorites, for some three hundred meters from R 45, we reach eocene deposits. At R 46 we find white limestones with rather much detritic material and eocene fossils e.g. *Discocyclinae*, *Pellatispirella antillea* and *Camerinae*.

Our next road starts to the North-East of km 516 in eocene deposits. The highroad is crossed near km 516 and we come at once in silicified and chloritised porphyrite-breccias and silicified quartz-augite-porphyrites. The margin of Habana rocks along the Diorites proves to be very narrow here, for 700 meters further on we find quartz-diorite-porphyrites, which are also encountered near H 74. South-West of this point we come upon a bifurcation. We go to the South along the road, which has already been described, until the railway-station of Piedrecitas, where we turn to the left, following the railroad. At first we walk in Rudist limestones of the Habana Formation, but after some 1300 meters, we come to a small hill, on which we sampled quartz-diorite-porphyrites. After the descent we are in eocene deposits, consisting of limestones and marls. In the marls we found specimens of two species of *Discocyclina*, together with *Camerina pellatispiroides* and *Pellatispirella bermudezi*. Going northward through the fields in the direction of the Carretera Central, we find eocene limestones and conglomerates with large pebbles of Habana limestones. The eocene limestones are rich in fossils e.g. *Discocyclinae*, *Pellatispirella bermudezi* and Corals and occasionally we find *Lepidocyclinae*. Before we reach the highroad we cross the Habana Formation, after this the quartz-diorite-porphyrites of the Diorite Series and then again the Habana Formation, which consists here of coarse porphyrite-agglomerates.

The country in the neighbourhood of Cespedes.

For findspot-numbers in this area, see the map on page 75.

We start at a point South of F 71*a* in black, sandy soil. Although we do not find any outcrop, we are pretty sure, that this soil represents the weathering-products of Tertiary rocks, to be more exact, of eocene deposits. This goes on to F 71*a*, where the soil becomes yellowish-brown and more sandy. This betrays the presence of dioritic rocks in the underground and

at some places we indeed find outcrops of plagiaplites and quartz-amphibole-diorites. F 70 lies already in the Eocene; here we find sandy marls with very badly preserved Smaller *Foraminifera*. The Diorites continue until we cross the railroad just S. of Cespedes, where the Habana Formation crops out. The limestones have a strike of N 115 E and a dip of about 90 degrees. At R 40 we find calcareous sandstones with pebbles of the Diorites e.g. fragments of plagiaplites. They also contain fossils, such as *Sulcoperculina dickersoni*, Rudists and *Inoceramus*. The limestones continue to outcrop during some 700 meters. Then we pass into rocks of the Diorite Series of which we took samples at K 26 and R 39, respectively a quartz-biotite-diorite and a granophyric plagiaplite. Still being in dioritic rocks we cross the Carretera Central at km 521,6 and North of this road we find outcrops of aplitic quartz-amphibole-diorites and strongly silicified diorite-porphyrites.

After this area of dioritic rocks we do not find outcrops over a considerable distance. Not until we have reached R 38 do we find limestones with much quartz and some badly preserved *Foraminifera*. Somewhat further to the North there occur marls, which are rich in detritic material of Diorites and still further northward, there are sandy limestones with *Lepidorbitoides* and *Sulcoperculina dickersoni*. It is therefore pretty certain, that we are in the Habana Formation, as far back as H 38.

Going southward from km 518 on the Carretera Central, we come immediately to conglomerates of the Eocene; they contain pebbles of Habana porphyrites. The conglomerates are followed by limestones with *Discocyclinae* and after the limestones we encounter the conglomerates again. A narrow strip of Habana limestones and calcareous sandstones is then met with on the road, but very soon they again have to make room for the eocene limestones. At K 22 we ascend a small hill, which proves to consist of dioritic rocks. Among other rocks we sampled a granodiorite-aplite. In the neighbourhood of K 23 we find eocene limestones, which are very rich in fossils. We only mention the occurrence of *Discocyclina*, *Pellatispirella bermudezi*, *Camerinae* and *Alveolinae*. At K 24 we cross the boundary between Eocene and Diorites. Here, the Diorite Series is represented by plagiaplites and quartz-amphibole-diorite, both with granophyric intergrowths. Just before we reach the cross-road, near K 25, we touch the boundary between Diorites and Habana Formation. On our right hand we find Habana limestones with Rudists, while to the left occur quartz-amphibole-biotite-diorites. Some distance after the intersection we pass the boundary between Diorites and Habana Formation again, just as near V 76, where we find amphibole-biotite-granodiorites. We walk to the South-East till we reach the boundary with the Tertiary, then turn to the West and now follow the railroad to find the southeastern boundary between Diorites and Habana Formation. This is found near V 78, where we come upon steep dipping limestones and marls. The limestones contain *Orbitoides browni*, *Lepidorbitoides* and *Sulcoperculina dickersoni*. The marls, which we sampled at V 78 and V 79*a* (near the northern boundary of the Habana Formation) are exceptionally rich in

Smaller *Foraminifera*, especially in the genera *Gümbelina*, *Globotruncana*, *Pseudotextularia* and *Planoglobulina*.

The country South and North of La Florida.

The road, which leads from La Florida over San Jeronimo to Baños, was not surveyed by our party. The Diorite mass South of La Florida was drawn after the map of MAC GILLAVRY. It may be noted, that the southern boundary of this Diorite mass is by no means certain, as MAC GILLAVRY did not reach this boundary. At any rate, near T 1140 there occur limestones, which on account of their cavernous habit are reckoned to belong to the Guines Formation.

North of La Florida, we are first in Diorites, but soon pass into upper eocene or lower oligocene limestones with *Lepidocyclinae* (*L. maracaibensis*) and *Lithothamnia*. At H 133, however, we find limestones with *Sulcoperculina dickersoni* and Rudist-fragments, and it becomes evident, that we are in the Habana Formation. The Habana limestones occupy only a very narrow strip of ground; we very soon reach loose Diorite sands. Plagiaplites were sampled near H 132. About one kilometer to the South of San Rafael, the Diorite ceases to outcrop and we enter grayish-black soil with very scarce outcrops of limestones. One of these limestones was sampled near H 131. It contains *Discocyclinae* and *Camerinae*. As far as La Quinta, we find the same gray-black, locally sandy, soil.

The area of Magarabomba.

The road, which leaves Magarabomba to the West, passes over a very considerable distance through tuffs and porphyrites. The monotony of these volcanic rocks is interrupted at one place only, viz. near K 254, where we find intercalated layers of blue Provincial limestones between the tuffs and porphyrites of the Tuff Series. To the West and North-West, the Tuff Series is bordered by the Guines Formation. At K 255 we find white marls, containing *Miogypsina hawkinsi* as well as a number of Smaller *Foraminifera*. The eastern boundary of the Tuff Formation lies some kilometers East of Magarabomba. Here the formation is also bordered by younger sediments.

The southern boundary lies somewhat to the North of the point, where the road is crossed by the railway, which links up La Florida with Magarabomba. When we continue our way in a northern direction, we pass a hilly landscape, where we find numberless outcrops of volcanic rocks. We sampled deeply weathered, green and brown tuffs as well as porphyrites and porphyrite-breccias. All these rocks are more or less strongly silicified, chloritised and epidotised. The tuff-layers show often steep dips. Compared with the tuffs

and porphyrites of the Habana Formation, they have an old, weathered habit. About $1\frac{1}{2}$ kilometer North of Magarabomba we reach a flat landscape with black and brown soils and without any outcrop.

Woodin-Magarabomba.

Just South of the place, where the railway branches off, we find marly limestones, without fossils. Habitually they can not be distinguished from the Cubitas Limestones which are found further to the East. In a quick succession we then pass Serpentines, Aptychi Limestones, Serpentines and again Aptychi Limestones. The Serpentines in this area have originated from harzburgites as may be inferred from their composition. Besides rather fresh Serpentines, we also find residual rocks of the Serpentines, such as quartz-magnesite-magnetite and quartz-limonite rocks. The Aptychi Limestones are well-bedded rocks, sometimes with traces of organisms, which, however, cannot be determined, owing to their recrystallization. At one place we found a strike N 10 E, the dip being about vertical. The strike is almost perpendicular to the trend of the Serpentine masses. This phenomenon may point to a tectonical contact between Aptychi Limestones and Serpentines.

After these older rocks we come to deposits of the Guines Formation. At V 120 and V 121 we find marls with Smaller *Foraminifera*, indicating an oligo-miocene age. Some 500 meters further South there occur brown and gray limestones, which habitually belong to the Aptychi Formation, but after this the soil becomes grayish and outcrops are scarce. Without any doubt we are again in oligo-miocene deposits.

The environment of Donato.

The road which runs to the South from Donato first passes through limestones with Miliolids, *Discocyclinae*, *Camerinae* and *Alveolinae*, a faunal assemblage which is also reported by MAC GILLAVRY from Eastern Camaguey. The typical Cubitas Limestones are followed by calcareous sandstones with *Discocyclina* and much detritic material of Serpentines, Diorites and porphyrites. The limestones and sandstones dip southward, towards the contact with the Serpentines, thus indicating a tectonical contact. The Serpentines are rather fresh rocks. Judging after their composition, they originated from wehrlites. Together with the Serpentines we also find outcrops of ultrabasic rocks, eclogites (K 58). The road, which now has a westerly direction, follows the Serpentines until the trifurcation at K 59. At this point we find blue, thin-bedded Aptychi Limestones, which have a strike of N 30 E and show a steep dip to the West. Here we again find an indication that the Serpentines have been brought into tectonical contact with the Aptychi

limestones, as the „strike" of the Serpentines is nearly perpendicular to the strike of the limestones. South of the trifurcation, where, besides oolitic limestones, there occur also calcareous sandstones as well as *Radiolaria*-containing limestones (a remarkable combination); we find zones of Aptychi Limestones and cherts alternating with strips of Serpentine.

Going northward from K 59, we are first, for some 1300 m in the Serpentines, then we pass the fault between the Serpentines and Cubitas Limestones and these are still outcropping when we are back in Donato.

Dr. TSCHOPP sampled two limestones between Woodin and Donato, which habitually as well as paleontologically also belong to the Cubitas Limestones. At T 1468, apparently somewhat to the South of Donato, amidst the Cubitas Limestones, there seems to be a small area, where the Aptychi Formation crops out.

The roads North and South of Jaronu.

The road running to the North of this place as well as that running southward, was surveyed by Dr. TSCHOPP. On both roads he met only one formation, namely Eocene. The Cubitas Limestones in this area do not differ in any way from those which were found near Donato, apart from the amount of detritic material, which is very small here. We find the following fossils: *Discocyclinae*, *Dictyoconidae*, *Miliolidae*, *Camerinae*, *Radiolaria* and sponge needles.

The road far to the South of Jaronu, in the large Serpentine area, was also surveyed by Dr. TSCHOPP. Sample T 1127 is a residuum of Serpentines.

Chapter VI: **PREVIOUS LITERATURE.**

There is a rather extensive literature treating of the geology and paleontology of Cuba, but as far as our district is concerned, it is of little importance. C. W. HAYES, T. W. VAUGHAN and A. C. SPENCER (118) gave a report of the geology of Cuba in 1901. The map of DE CASTRO-SALTERAIN has been added to their description, but it is not in accordance with the text.

According to HAYES c.s. Serpentines which are thought to be of Paleozoic age are widespread in Camaguey and they also report fossiliferous Cretaceous limestones from this area. The map of DE CASTRO and SALTERAIN is only of historic value.

A rather recent report on the geology of Cuba comes from J. WHITNEY LEWIS (119). Although LEWIS made his flying survey only 11 years ago, the difference between his map and ours is astonishing. Serpentines, eo-oligocene and miocene deposits are distributed in his map in a rather queer way. According to LEWIS, Cretaceous rocks are not found in our district.

MARIO SANCHEZ ROIG (122) mentions several Cretaceous Rudists from the central part of Cuba.

The work which was done in Eastern Camaguey and Santa Clara, respectively by MAC GILLAVRY (120), THIADENS (123) and M. G. RUTTEN (121), has been of great value to us. They have given an extensive description of the several formations with their paleontological and petrographical features. Nearly all formations which were mentioned by them are also found in our district, as the reader may already have noticed.

BENNETT and ALLISON (116) in 1928 gave an extensive description of all weathering soils of Cuba.

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PLATE I

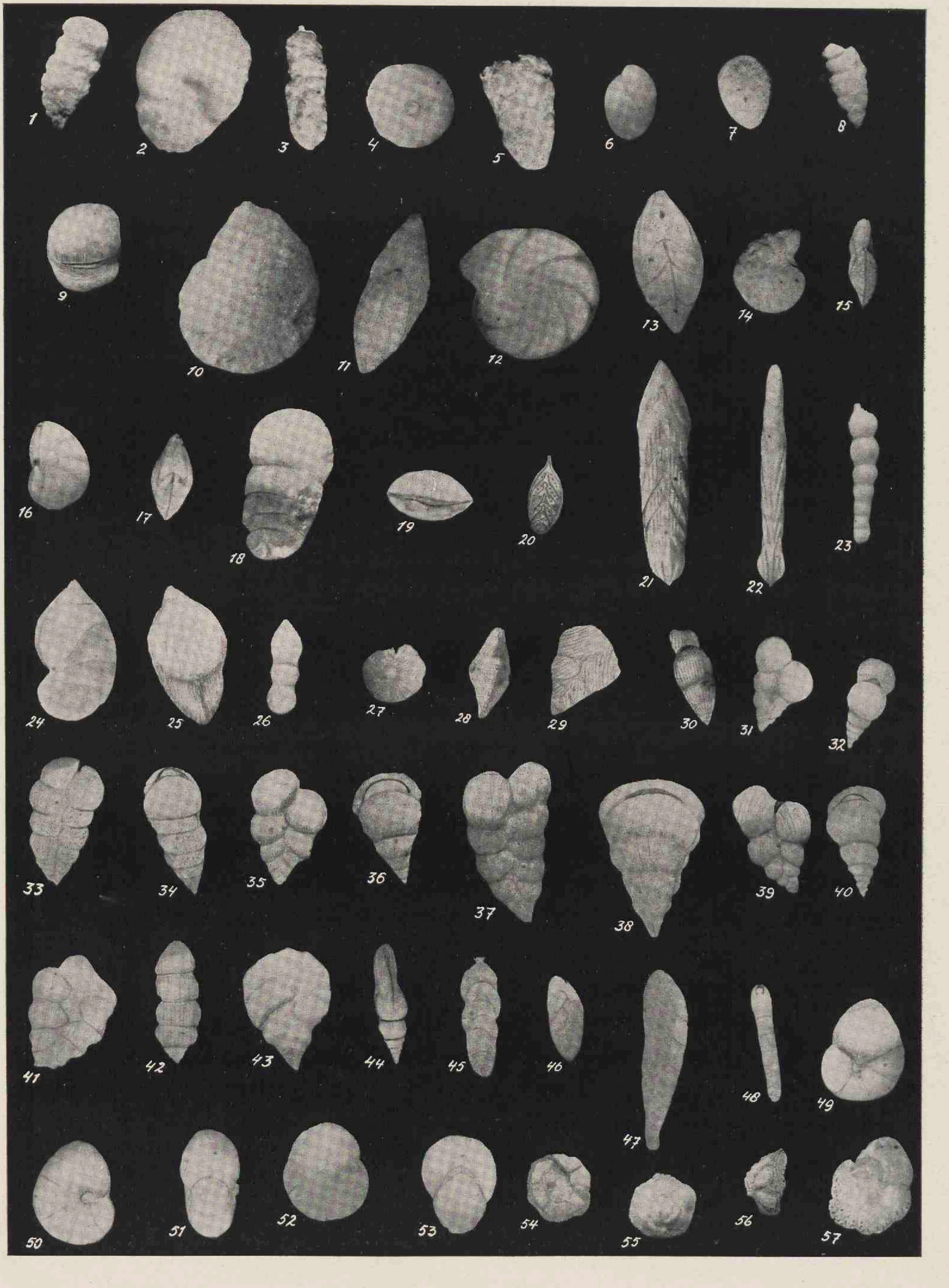
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Plate I.

All figures on plate I are of Upper Cretaceous species.

Fig. 1. *Gaudryina cretacea* (KARRER), front view × 35.
Fig. 2. *Gaudryina cretacea* (KARRER), apertural view × 105.
Fig. 3. *Pseudoclavulina camagueyensis* VAN WESSEM *nov. sp.*, front view × 35.
Fig. 4. *Pseudoclavulina camagueyensis* VAN WESSEM *nov. sp.*, apertural view × 85.
Fig. 5. *Textulariella sp.* × 18
Fig. 6. *Dorothia nov. sp.*, side view × 22.
Fig. 7. *Dorothia nov. sp.*, front view × 22.
Fig. 8. *Dorothia sp.*, side view × 22.
Fig. 9. *Dorothia sp.*, apertural view × 55.
Fig. 10. *Robulus excisus* (BORNEMANN), side view × 35.
Fig. 11. *Robulus excisus* (BORNEMANN), apertural view × 35.
Fig. 12. *Robulus stephensoni* CUSHMAN, side view × 50.
Fig. 13. *Robulus stephensoni* CUSHMAN, apertural view × 50.
Fig. 14. *Robulus sp.*, side view × 10.
Fig. 15. *Robulus sp.*, apertural view × 10.
Fig. 16. *Lenticulina nuda* (REUSS), side view × 22.
Fig. 17. *Lenticulina nuda* (REUSS), apertural view × 22.
Fig. 18. *Lingulina arteagai* VAN WESSEM *nov. sp.*, front view × 22.
Fig. 19. *Lingulina arteagai* VAN WESSEM *nov. sp.*, apertural view × 22.
Fig. 20. *Flabellina interpunctata* VON DER MARCK × 22.
Fig. 21. *Frondicularia gracilis* FRANKE, front view × 27.
Fig. 22. *Frondicularia gracilis* FRANKE, side view × 27.
Fig. 23. *Marginulina sp.* × 22.
Fig. 24. *Saracenaria proximocostata* VAN WESSEM *nov. sp.*, side view × 60.
Fig. 25. *Saracenaria proximocostata* VAN WESSEM *nov. sp.*, apertural view × 60.
Fig. 26. *Nodosaria concinna* REUSS × 22.
Fig. 27. *Sulcoperculina dickersoni* (PALMER), front view × 10.
Fig. 28. *Sulcoperculina dickersoni* (PALMER), side view × 15.
Fig. 29. *Gümbelina costulata* CUSHMAN, front view × 70.
Fig. 30. *Gümbelina costulata* CUSHMAN, side view × 70.
Fig. 31. *Gümbelina globulosa* (EHRENBERG), front view × 70.
Fig. 32. *Gümbelina globulosa* (EHRENBERG), side view × 70.
Fig. 33. *Gümbelina moremani* CUSHMAN, front view × 60.
Fig. 34. *Gümbelina moremani* CUSHMAN, side view × 60.
Fig. 35. *Gümbelina nuttalli* VOORWIJK, front view × 60.
Fig. 36. *Gümbelina nuttalli* VOORWIJK, side view × 60.
Fig. 37. *Gümbelina plummerae* LOETTERLE, front view × 60.
Fig. 38. *Gümbelina plummerae* LOETTERLE, side view × 60.
Fig. 39. *Gümbelina striata* (EHRENBERG), front view × 60.
Fig. 40. *Gümbelina striata* (EHRENBERG), side view × 60.
Fig. 41. *Ventilabrella carseyae* PLUMMER, front view × 50.
Fig. 42. *Ventilabrella carseyae* PLUMMER, side view × 50.
Fig. 43. *Ventilabrella decurrens* (CHAPMAN), front view × 50.
Fig. 44. *Ventilabrella decurrens* (CHAPMAN), side view × 50.
Fig. 45. *Eouvigerina lobatula* VAN WESSEM *nov. sp.* × 50.
Fig. 46. *Bolivina incrassata* REUSS × 22.
Fig. 47. *Bolivina primatumida* WHITE × 55.
Fig. 48. *Nodosarella morrowi* VAN WESSEM × 22.
Fig. 49. *Valvulineria nov. sp.*, ventral view × 50.
Fig. 50. *Valvulineria nov. sp.*, dorsal view × 50.
Fig. 51. *Valvulineria nov. sp.*, side view × 50.
Fig. 52. *Pullenia nov. sp.*, side view × 50.
Fig. 53. *Pullenia nov. sp.*, apertural view × 50.
Fig. 54. *Globotruncana arca* (CUSHMAN) var. *contusa* CUSHMAN, ventr. v. × 16.
Fig. 55. *Globotruncana arca* (CUSHMAN) var. *contusa* CUSHMAN, dorsal view × 16
Fig. 56. *Globotruncana arca* (CUSHMAN) var. *contusa* CUSHMAN, side view × 16.
Fig. 57. *Globotruncana nov. sp.*, ventral view × 50.

Plate II.

The nos 1—19 and 32—34 are from the Upper Cretaceous; the nos. 20—23 and 35—37 from the Upper Eocene; the nos. 24—31 from the Oligo-Miocene.

Fig. 1. *Globotruncana nov. sp.*, dorsal view × 50.
Fig. 2. *Globotruncana nov. sp.*, side view × 50.
Fig. 3. *Globorotalia nov. sp.*, ventral view × 50.
Fig. 4. *Globorotalia nov. sp.*, dorsal view × 50.
Fig. 5. *Anomalina avilensis* VAN WESSEM *nov. sp.*, ventral view × 22.
Fig. 6. *Anomalina avilensis* VAN WESSEM *nov. sp.*, dorsal view × 22.
Fig. 7. *Anomalina avilensis* VAN WESSEM *nov. sp.*, side view × 22.
Fig. 8. *Anomalina ? ornata* (COSTA), ventral view × 22.
Fig. 9. *Anomalina ? ornata* (COSTA), dorsal view × 22.
Fig. 10. *Anomalina ? ornata* (COSTA), side view × 22.
Fig. 11. *Anomalina polyrraphes* (REUSS), ventral view × 50.
Fig. 12. *Anomalina polyrraphes* (REUSS), dorsal view × 50.
Fig. 13. *Anomalina polyrraphes* (REUSS), side view × 50.
Fig. 14. *Cibicides arteagai* VAN WESSEM *nov. sp.*, ventral view × 50.
Fig. 15. *Cibicides arteagai* VAN WESSEM *nov.* sp., dorsal view × 50.
Fig. 16. *Cibicides arteagai* VAN WESSEM *nov. sp.*, side view × 50.
Fig. 17. *Cibicides camagueyensis* VAN WESSEM *nov. sp.*, ventral view × 50.
Fig. 18. *Cibicides camagueyensis* VAN WESSEM *nov. sp.*, dorsal view × 50.
Fig. 19. *Cibicides camagueyensis* VAN WESSEM *nov. sp.*, side view × 50.
Fig. 20. *Ellipsonodosaria sp.* × 30.
Fig. 21. *Pulvinulinella camagueyensis* VAN WESSEM *nov. sp.*, ventral view × 22.
Fig. 22. *Pulvinulinella camagueyensis* VAN WESSEM *nov. sp.*, dorsal view × 22.
Fig. 23. *Pulvinulinella camagueyensis* VAN WESSEM *nov. sp.*, side view × 22.
Fig. 24. *Verneuilina nov. sp.*, side view × 22.
Fig. 25. *Verneuilina nov. sp.*, apertural view × 22.
Fig. 26. *Nonion cubense* VAN WESSEM *nov. sp.*, side view × 52.
Fig. 27. *Nonion cubense* VAN WESSEM *nov. sp.*, apertural view × 52.
Fig. 28. *Elphidium sp. I*, side view × 55.
Fig. 29. *Elphidium sp. I*, apertural view × 55.
Fig. 30. *Elphidium sp. II*, side view × 50.
Fig. 31. *Elphidium sp. II*, apertural view × 50.
Fig. 32. *Lepidorbitoides estrellae* VAN WESSEM *nov. sp.*, external view × 22.
Fig. 33. *Lepidorbitoides tschoppi* VAN WESSEM *nov. sp.*, external view × 16.
Fig. 34. *Orbitoides browni* (ELLIS), external view × 6.
Fig. 35. *Camerina pellatispiroides* BARKER, external view × 9.
Fig. 36. *Pellatispirella bermudezi* (PALMER), external view × 10.
Fig. 37. *Pellatispirella bermudezi* (PALMER), partly ground off × 10.

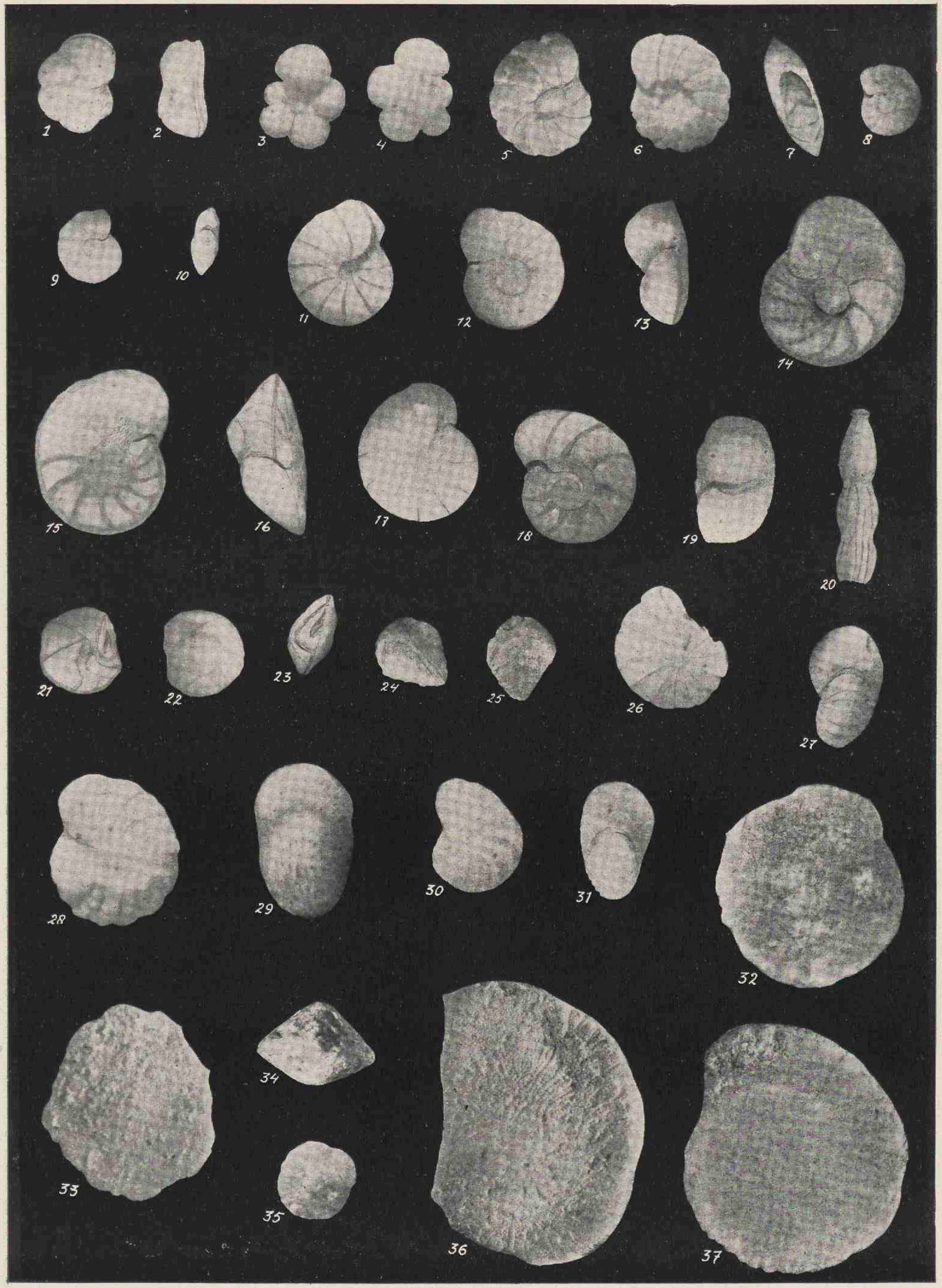
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PLATE III

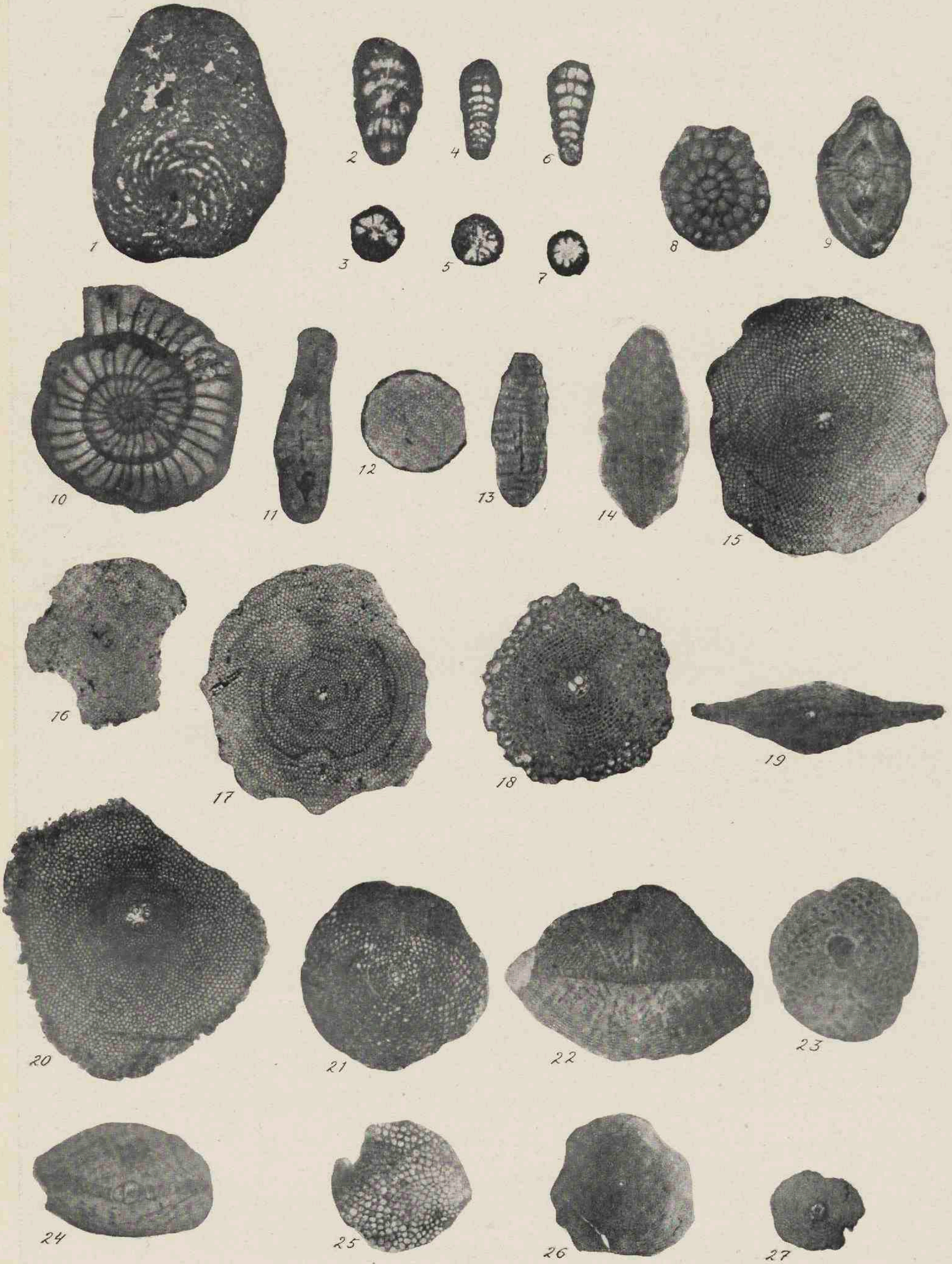


Plate III.

The nos. 1—7 and 12—24 are from the Upper Cretaceous; the nos. 8—11 and 26—27 from the Upper Eocene; no. 25 from the Oligo-Miocene.

Fig. 1. ? *Archaias sp.* × 22.
Fig. 2. *Praerhapydionina cubana* VAN WESSEM *nov. gen. nov. sp.*, vertical section × 22.
Fig. 3. *Praerhapydionina cubana* VAN WESSEM *nov. gen. nov. sp.*, vertical section × 22.
Fig. 4. *Praerhapydionina cubana* VAN WESSEM *nov. gen. nov. sp.*, vertical section × 22.
Fig. 5. *Praerhapydionina cubana* VAN WESSEM *nov. gen. nov. sp.*, cross section × 22.
Fig. 6. *Praerhapydionina cubana* VAN WESSEM *nov. gen. nov. sp.*, cross section × 22.
Fig. 7. *Praerhapydionina cubana* VAN WESSEM *nov. gen. nov. sp.*, cross section × 22.
Fig. 8. *Camerina pellatispiroides* BARKER, hor. section × 15.
Fig. 9. *Camerina pellatispiroides* BARKER, vert. section × 15.
Fig. 10. *Pellatispirella bermudezi* (PALMER), hor. section × 10.
Fig. 11. *Pellatispirella bermudezi* (PALMER), vert. section × 8.
Fig. 12. *Lepidorbitoides estrellae* VAN WESSEM *nov. sp.*, hor. section × 13.
Fig. 13. *Lepidorbitoides estrellae* VAN WESSEM *nov. sp.*, vert. section × 13.
Fig. 14. *Lepidorbitoides minima* DOUVILLÉ, vert. section × 18.
Fig. 15. *Lepidorbitoides minor* (SCHLUMBERGER), hor. section × 10.
Fig. 16. *Lepidorbitoides nortoni* (VAUGHAN), hor. section × 10.
Fig. 17. *Lepidorbitoides palmeri* THIADENS, hor. section × 10.
Fig. 18. *Lepidorbitoides tschoppi* VAN WESSEM *nov. sp.*, hor. section × 10.
Fig. 19. *Lepidorbitoides tschoppi* VAN WESSEM *nov. sp.*, vert. section × 20.
Fig. 20. *Lepidorbitoides sp.*, hor. section × 7½.
Fig. 21. *Orbitoides browni* (ELLIS), hor. section × 10.
Fig. 22. *Orbitoides browni* (ELLIS), vert. section × 10.
Fig. 23. *Orbitoides palmeri* GRAVELL, hor. section × 12.
Fig. 24. *Orbitoides palmeri* GRAVELL, vert. section × 18.
Fig. 25. *Miogypsina hawkinsi* HODSON, hor. section × 10.
Fig. 26. *Discocyclina sp. A*, hor. section × 10.
Fig. 27. *Discocyclina sp. B*, hor. section × 10.

STELLINGEN

I.

Voor zoover denudatieniveau's van beperkte oppervlakte in een gebied niet kennelijk de resten van een schiervlakte vormen, mogen zij niet gebruikt worden als basis voor tectonische beschouwingen.

II.

Ten onrechte heeft men tot nu toe bij de beschouwingen omtrent de oorspronkelijke samenstelling der aarde geen rekening gehouden met de radioactieve omzetting van K 40 in Ca 40.

III.

De opvatting van KUHN en RITTMANN over de samenstelling van de aardkern is waarschijnlijk onjuist. Een uit vrijwel onveranderde „zonnematerie" bestaande aardkern is met het gemiddelde soortelijk gewicht der aarde niet in overeenstemming.

W. KUHN und A. RITTMANN: „Ueber den Zustand des Erdinnern und seine Entstehung aus einem homogenen Urzustand." Geol. Rundschau, Bd. 32, H. 3, 1941.

IV.

Wanneer men in de toekomst in Noord-Amerika, Zuid-Amerika, Europa en Afrika over nauwkeurige lengte- en breedtegraadsbepalingen beschikt zal men zijn oordeel kunnen uitspreken over de vraag of de door DREHER, op grond van recente loodingen, aangeno[illegible] horizontale verschuivingen onder den Atlantischen [illegible]erusten op verschillen in snelheid, waarmee de[illegible]n zich verplaatsen.

V.

Frank heeft aangetoond, dat in de Zuid-Duitsche en kalkalpine Trias synchrone lijnen de facieslijnen scheef snijden.

M. Frank: „Der Faziescharakter der Schichtgrenzen der süddeutschen und kalkalpinen Trias."
Zentralblatt f. Min., Geol. und Pal. Abt. B, 1936.

VI.

Het ontstaan van „perdigon" (boonerts) op Cuba is hoogstwaarschijnlijk een gevolg van typisch klimatologische factoren. De ondergrond is hierbij van weinig belang.

VII.

De ellipsvormige bassins in de kuststrook van Zuid-Carolina zijn hoogstwaarschijnlijk ontstaan door inslag van meteorieten en niet het gevolg van de werking van den wind, zooals Cooke aanneemt.

C. Wythe Cooke: „Discussion of the origin of the supposed meteorite scars of South-Carolina". Journ. of Geol. vol. 42, 1934.

VIII.

Wanneer men het veelvuldig voorkomen van kaliummineralen in de aardkorst in aanmerking neemt, komt de door K 40 radioactief ontwikkelde warmte, vooral in het geologisch verleden, een even belangrijke, zoo niet belangrijker plaats toe als de door Uraan en Thorium ontwikkelde warmte.

W. Wahl: „Die Bedeutung der Isotopenforschung für die Geologie." Geol. Rundschau, Bd. 32, H. 4, 5, 1942.

IX.

De door Birot gegeven verklaring voor de waargenomen verschijnselen in het Ampollino-dal is in lijnrechte tegenspraak met de door hem geteekende dwarsprofielen van dit dal.

P. Birot: „Réflexions sur le problème des Piedmonttreppen." Comptes Rendus du Congrès International de Géographie Amsterdam, tome 2, 1938.

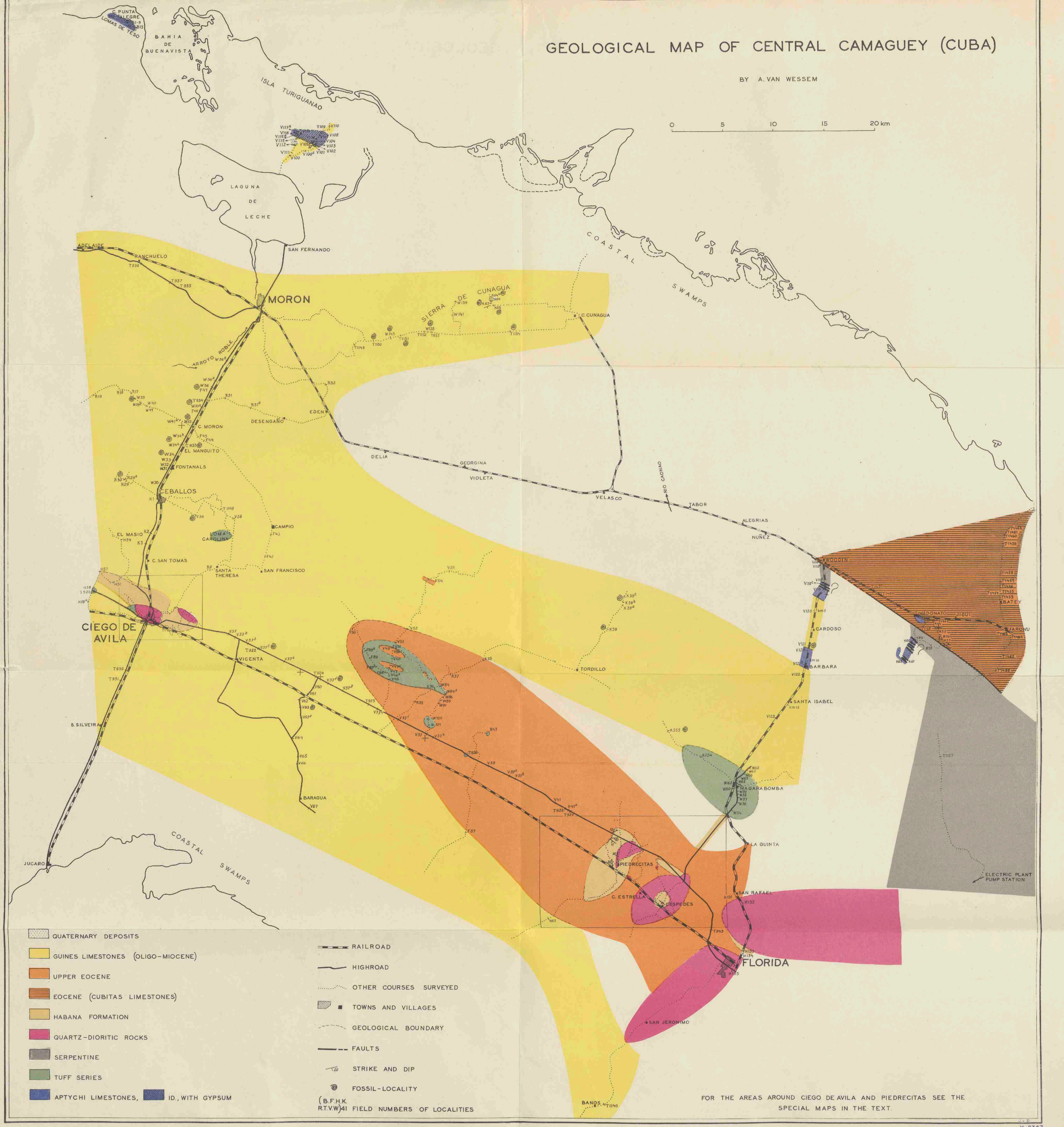
X.

De sprongsgewijze afname in de snelheid der longitudinale en het geheel verdwijnen der transversale bevingsgolven op ongeveer 2900 km diepte in de aarde berust niet op een stoffelijke discontinuiteit, doch is het gevolg van geleidelijk veranderende eigenschappen der materie.

W. KUHN und A. RITTMANN: Ueber den Zustand des Erdinnern und seine Entstehung aus einem homogenen Urzustand." Geol. Rundschau, Bd. 32, H. 3, 1941.

XI.

De beteekenis van de nuttige delfstoffen op zichzelf en de met hun geografische verspreiding samenhangende problemen hebben de laatste tientallen jaren dermate aan belangrijkheid gewonnen, dat het invoeren van geologie als onderwijsvak aan de middelbare scholen alleszins gerechtvaardigd zou zijn.


GEOLOGICAL MAP OF CENTRAL CAMAGUEY (CUBA)
BY A. VAN WESSEM
0 5 10 15 20 km
BAHIA DE BUENAVISTA
ISLA TURIGUANAO
LAGUNA DE LECHE
SAN FERNANDO
ADELAIDE
RANCHUELO
MORON
SIERRA DE CUNAGUA
C. CUNAGUA
COASTAL SWAMPS
ARROYO ROBLE
C. MORON
DESENGAÑO
EDEN
EL MANGUITO
FONTANALS
CEBALLOS
DELIA
GEORGINA
VIOLETA
VELASCO
RIO CAONAO
TABOR
ALEGRIAS
NUÑEZ
CAMPIO
LOMA CAROLINA
EL MASIO
C. SAN TOMAS
SANTA THERESA
SAN FRANCISCO
CIEGO DE AVILA
VICENTA
S. SILVEIRA
BARAGUA
JUCARO
COASTAL SWAMPS
TORDILLO
WOODIN
CARDOSO
BARBARA
SANTA ISABEL
BATEY
JARONU
MAGARABOMBA
LA QUINTA
PIEDRECITAS
C. ESTRELLA
CESPEDES
SAN RAFAEL
FLORIDA
SAN JERONIMO
BANOS
ELECTRIC PLANT PUMP STATION
QUATERNARY DEPOSITS
GUINES LIMESTONES (OLIGO-MIOCENE)
UPPER EOCENE
EOCENE (CUBITAS LIMESTONES)
HABANA FORMATION
QUARTZ-DIORITIC ROCKS
SERPENTINE
TUFF SERIES
APTYCHI LIMESTONES, ID., WITH GYPSUM
RAILROAD
HIGHROAD
OTHER COURSES SURVEYED
TOWNS AND VILLAGES
GEOLOGICAL BOUNDARY
FAULTS
STRIKE AND DIP
FOSSIL-LOCALITY
(B.F.H.K. R.T.V.W.) 41 FIELD NUMBERS OF LOCALITIES
FOR THE AREAS AROUND CIEGO DE AVILA AND PIEDRECITAS SEE THE SPECIAL MAPS IN THE TEXT.
K. 2347