Geology and paleontology of Bonaire (D.W.I.)

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PROEFSCHRIFT

TER VERKRIJGING VAN DEN GRAAD VAN DOCTOR IN DE WIS- EN NATUURKUNDE AAN DE RIJKS-UNIVERSITEIT TE UTRECHT, OP GEZAG VAN DEN RECTOR-MAGNIFICUS DR. C. G. N. DE VOOYS, 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 13 JANUARI 1933**, DES NAMIDDAGS TE **4 UUR**

DOOR

PETRUS JOHANNUS PIJPERS
GEBOREN TE ROTTERDAM

N.V. A. OOSTHOEK'S UITGEVERS-MIJ. — UTRECHT 1933

AAN MIJN OUDERS

Met de voltooiing van dit werk ben ik aan het einde gekomen van mijn academische studiën.

Wanneer ik op dit tijdstip terugzie op mijn academischen studietijd, dan grijp ik deze gelegenheid gaarne aan om woorden van dankbaarheid te richten tot U, Hoogleeraren der Wis- en Natuurkundige Faculteit, voor de wetenschappelijke opleiding, die ik van U mocht ontvangen.

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CONTENTS.

INTRODUCTION

In the summer of 1930 Prof. L. RUTTEN, his wife and six students, among whom the author of this paper himself, made a journey to the West Indies. The main object was to make geological researches on the islands of Curaçao, Aruba and Bonaire. From the 10th of May to the 10th of June we spent our time on Bonaire. An idea of the closeness with which our observations were made on the island can be got from the accompanying map showing points where and routes along which observations have been made (fig. 1). The basis for our geological fieldwork furnished the topographical map 1: 20.000.

Before 1930 geological fieldwork was done on Bonaire by Prof. K. MARTIN, viz. in 1885. Although Prof. MARTIN could spend only four days on the island, he succeeded in composing a rough scheme of its geology (lit. 27). He found quaternary limestones, cretaceous sediments (cherts and sandstones — the latter rocks are coarse tuffs), diabases, porphyrites and tuffs, but he did not notice the relation between the "Cretaceous" and the volcanic rocks.

The rocks collected by MARTIN were described by J. H. KLOOS in 1887 (lit. 23), his fossils by T. W. VAUGHAN (corals, 1901, lit. 65) and I. LORIÉ (mollusks, 1887, lit. 68).

Afterwards collections of rocks (and some fossils) have been made on Bonaire by Dr. I. BOLDINGH (1910), by Ir. G. DUYFJES (1911?) and by Prof. J. A. GRUTTERINK. Never was anything published about these rocks. Dr. BOLDINGH gave a sort of pedological map (lit. 3), in which the boundaries of the Cretaceous in E. Bonaire (called by him "non calcareous soil") were roughly drawn, but already with more accuracy than on MARTIN'S map.

BOLDINGH'S collection is in the Mineralogisch Geologisch Instituut of the State University of Utrecht, those of DUYFJES and GRUTTERINK are in the Instituut voor Mijnbouwkunde of the Delft Technical University. I have taken the rocks of BOLDINGH, DUYFJES and GRUTTERINK also into account and have revised the rocks of MARTIN, described by KLOOS. The collection of MARTIN is in the Rijksmuseum van Geologie en Mineralogie at Leiden. The rocks of MARTIN mentioned in the text are indicated with "Ma", followed by the number originally given by MARTIN, under which number the rocks are described by KLOOS. Our own collection is in the Mineralogisch Geologisch Instituut at Utrecht; the rock samples of Bonaire are indicated with the letter "B": B. 1, B. 2, etc.; the slide numbers are indicated with "D." Our annotations and our maps used on Bonaire with the numbers corresponding with the annotations are kept in the Mineralogisch Geologisch Instituut at Utrecht.

In my descriptions I have used some words of Papiamento, used on the topographical map:

Boca, bay; Seroe, hill; Rooi, plural Rooien (derived from the Spanish arroyo), river beds only carrying water in the rainy season.

Some geographical names are used both in E. and W. Bonaire. They are: Seroe Grandi, Seroe Largoe, Seroe Montagne, Punta Blanco. When used in the text these names are followed always by E., resp. W. Bonaire.

This work has been written in English in order to make it more accessible

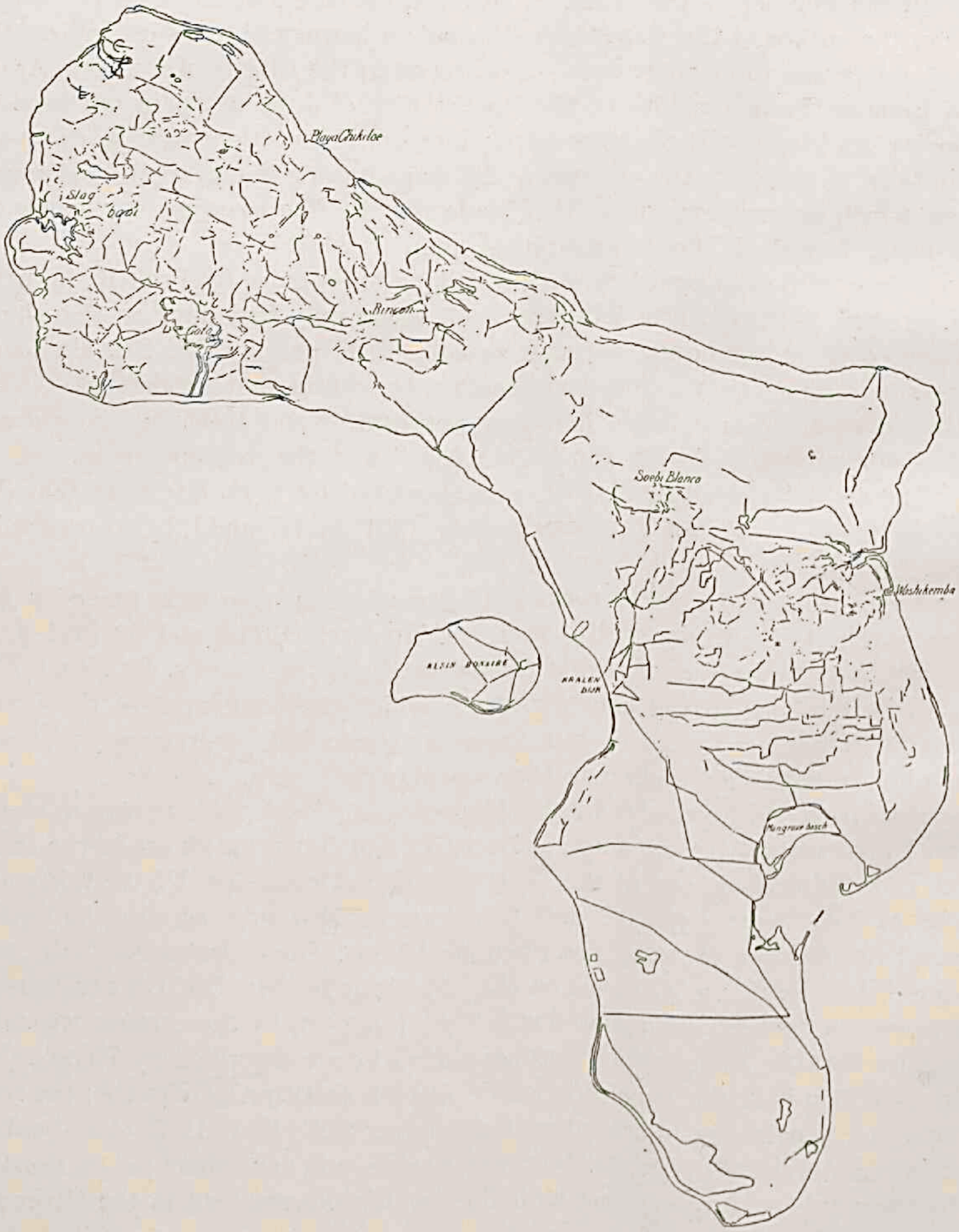

Fig. 1.

which is of much interest in view of the great many American geologists and paleontologists who make researches in the West Indies.

I wish to express my sincere thanks to many who, directly or indirectly, have rendered assistance to me during our journey to the West Indies or during the examination of the material in Holland:

In the first place I owe many thanks to my fellow-travellers to the West Indies:

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CHAPTER I.

TOPOGRAPHY AND GEOLOGICAL FORMATIONS.

Topographically the isle of Bonaire can be divided into two distinct parts: a NW.—SE. running part and a N.—S. running part. The NW.—SE. running part is higher and largely dissected by numerous "rooien". It consists of numerous small hills ("Seroe's"), generally with gentle slopes; the highest hill is the Seroe Brandaris (240 m.).

The NW.—SE. running part contains the older, prae-quaternary formations of the island. Large areas of it, however, are taken up by quaternary limestone. The N.—S. running part is very low and flat; it is entirely built up of quaternary limestone and alluvial deposits (detritus of the oldest formation, coral sands, coral shingle).

The oldest deposits of the island are of volcanic origin: they are lavas and tuffs, mainly of diabase and porphyrite, with intercalations of cherts and limestones. The greater part of the hills is built up of these rocks. We called the formation "Washikemba formation" after the Washikemba Plantation, where this formation was found one of the first days of our stay on the island. It is almost certain that the Washikemba formation is of upper cretaceous age. Throughout the formation intrusions occur (necks, dikes and sills) of porphyrite and diabase, petrographically belonging to the Washikemba formation. A more detailed description of it will be given in Chapter II.

At one place in the Washikemba formation (W. of Seroe Grita Kabai, W. Bonaire) an intrusion of a porphyritic diorite has been found (see Chapter III).

Younger than the Washikemba formation, but still Cretaceous, is a series of limestones, conglomeratic limestones and conglomerates found exclusively in the surroundings of the village of Rincon (W., NE. and SW. of Rincon). We called it the "Rincon formation". It lies unconformably upon the Washikemba formation. Remarkable is the occurrence of pebbles of foreign rocks in the Rincon formation, being granodiorites and granodiorite aplites (see Chapter IV).

A conglomerate which is a little younger than the Rincon formation shows a great increase of foreign pebbles. The pebbles are more numerous, generally of larger size and besides granodiorites and granodiorite aplites there occur gneisses, quartzites and some other foreign rocks. After its occurrence near to the Soebi Blanco the conglomerate has been called the "Soebi Blanco conglomerate" (Chapter V).

Tertiary deposits on Bonaire are restricted to the Upper Eocene. A great many fossils have been found in them, chiefly echini and foraminifera. A foraminifera marl, which yielded a rich fauna of smaller foraminifera was found in a well near Porta Spaño (Columbia Plantation). Upper eocene limestones occur SW. of the Seroe Montagne (W.Bonaire), near to Punta Blanco (cirque of Rincon), in the Columbia Plantation between Fontein and Morèke and NW. of Terra hoendoe (Chapter VI).

As has been mentioned before large areas of the NW.—SE. running part of the island are covered with quaternary limestones, partly encircling the older formations. Like the low N.—S. running part, the islet Klein Bonaire is entirely built up of quaternary limestones. In Chapter VII more will be found about the Quaternary of Bonaire.

CHAPTER II

THE WASHIKEMBA FORMATION.

Among the rocks of the Washikemba formation can be distinguished: diabases, diabase porphyrites, amygdaloidal diabases, amygdaloidal diabase porphyrites, quartz bearing diabases and quartz diabases, amygdaloidal quartz bearing and quartz diabases, quartz bearing diabase porphyrites, porphyrites, quartz bearing porphyrites and quartz porphyrites, mica bearing porphyrite(s), mica bearing quartz porphyrite(s), amygdaloidal porphyrites (s.l.), porphyries, diabase crystal tuffs, diabase tuffs, crystal tuffs, porphyrite crystal tuffs, quartz bearing porphyrite crystal tuffs and quartz porphyrite crystal tuffs, porphyrite tuffs, quartz bearing porphyrite tuffs and quartz porphyrite tuffs, diabase breccias, porphyrite breccias, cherts, radiolarites, jaspers, jasper breccias, limestones. There were, besides, found a conglomerate and a pebble of a pyroxene porphyrite.

In this chapter the names "diabase", "porphyrite", "diabase tuff" and "porphyrite tuff" will be used in sensu lato. Thus "diabase" stands for diabases, diabase porphyrites, amygdaloidal diabases, etc.; "diabase tuff" stands for diabase crystal tuffs and diabase tuffs; etc.

The strike of the Washikemba formation is predominantly NW.—SE., especially in the W. part of the formation. The strike N. 130 E. is the most frequent.

Some strikes in the E. part. which diverge strongly from the NW.—SE. direction and which we find especially in a region W. and SW. of the Washikemba Plantation, run principally N. 160 E. to N.—S. The Washikemba rocks exhibit an almost monoclinal dip to the N.E., with an average of 35°—40°. Dips to the SW. are very exceptional, in W. Bonaire they form 3,1% of the dips measured (227), in E. Bonaire 3,4 % (of a total of 116 dips measured).

The distribution of the Washikemba rocks is as follows. There occurs a wide zone of diabases and diabase tuffs in the lower part of the formation. Here and there cherts are intercalated among these rocks and in places some porphyrites and porphyrite tuffs appear. Exposures of diabases and diabase tuffs are found everywhere between Terra hoendoe and Lamoenchi (E. Bonaire) and W. of Goto (W. Bonaire).

Higher up in the Washikemba formation the situation in E. and W. Bonaire becomes different. The large cirque of Rincon will be considered apart, it differs from both regions. We will first treat W. Bonaire.

Higher up in the Washikemba formation in W. Bonaire, the diabases and diabase tuffs decrease gradually, they pass into porphyrites and porphyrite tuffs. In the highest part of the formation, in the flat coastal plain near the NE. of the Seroe Mangel, Seroe Soempina and Seroe Caracao, and in the southeastern continuation of this coastal plain, diabasic rocks appear again in abundance.

In E. Bonaire the distribution of diabases and porphyrites NE. of the zone of diabasic rocks is much more irregular. Porphyrites and porphyrite tuffs are most common here, but in several places large areas with outcrops of diabase are found, e.g. NE. of the Seroe Grandi (E. Bonaire), N. and NW. of the Washikemba Plantation and E. of the Seroe Barra di Carta.

In the large cirque of Rincon outcrops are rather scarce. The outcrops that were found, chiefly consist of diabase. Consequently it is most likely that the whole region predominantly consists of diabasic rocks, all the more likely as diabase is less able to resist erosion than porphyrite.

Cherts, though occurring throughout the Washikemba formation, are most numerous in the higher parts.

Fine exposures of cherts occur NE. of Boca Bartool, in the Rooi Grandi and N. of Rincon; a very fine complex of various tuffs, alternating with cherts, was found in the Rooi Camia.

The limestones occur here and there among the other rocks, in thin beds, which seldom exceed 1 dm. No definite distribution can be given. It is possible that the limestones are more numerous in the higher than in the lower parts of the formation.

By the re-appearance of diabases in the highest part of the Washikemba formation in W. Bonaire one could get the impression that isoclinal folding had taken place. But this is, certainly, not the case. The zone of porphyrite is quite asymmetrical: in the lower part there is a gradual transition from the zone of preponderating diabases and diabase tuffs into the zone of porphyrites and porphyrite tuffs. This transition cannot be observed in the higher part. Cherts are much more abundant in the higher than in the lower part of the porphyrite zone.

In the zone between that of predominating diabases and diabase tuffs and that of predominating porphyrites and porphyrite tuffs, the different rocks often alternate at short distances. This can be clearly illustrated by the following section , surveyed in the E. of Boca Slagbaai.

m.	3—4 m.	well bedded porphyrite tuffs. N. 120 E. 45N.
l.	1 m.	fine grained diabases.
k.	? 7 m.	porphyrite tuffs.
j.	7 m.	porphyrites.
i.	3,5 m.	porhyrite tuffs, in places green coloured.
h.	ca. 7 m.	green porphyrite tuffs, finer grained than i.
g.	0,2 m.	0,2 m. thick bed of tuff, coarser grained than h.
f.	1 m.	porphyrite tuff, in places green coloured, coarser grained than g.
e.	0,1 m.	bed of tuff, like g.
d.	4 m.	green porphyrite tuffs, with numerous diabase enclosures.
c.	ca. 80 m.	diabases.
b.	ca. 7 m.	diabase breccia, with large enclosures of diabase and amygdaloidal diabase.
a.		diabases, with enclosures of tuff.

The following is a section found N. of Goto.

k.	ca. 1,25 m.	fine grained, well bedded grey tuffs. N. 125E 35N.
j.	ca. 15 m.	diabases.
i.	0,5 m.	tuff.
h.	0,3 m.	chert.
g.	0,5 m.	silicified tuff, finer grained than i.
f.	9 m.	party coloured tuffs.
e.		bed of diabase, weathering with ellipsoidal structure.
d.	1,25 m.	? silicified tuffs.
c.	20 m.	diabases or diabase tuffs.
b.	10 m.	porphyrite tuffs.
a.	50 m.	diabase, weathering with ellipsoidal structure.

Diabases, weathering with ellipsoidal structure, can often be observed on Bonaire. In this feature the Bonaire diabases differ from the Curaçao and Aruba ones. MARTIN too was struck by this difference. On p. 74 of his geological description of Bonaire (lit. 27) he writes: ,,. . . einen niedrigen, aus kleinkörnigem Diabas gebildeten Hügel, dessen Gestein in grosse, sphaeroidische Blöcke zerfallen ist. Diese Verwitterungsform findet sich überhaupt auf Bonaire weit häufiger als auf den beiden anderen Inseln . . .". MARTIN ascribes this difference in weathering to a difference in the structure of the diabases of the three islands: ,,. . . denn sie (viz. weathering with spheroidal structure) ist nur dem körnigen Diabase eigen, der auf Bonaire fast ausschliesslich vorkommt, während auf Curaçao und Aruba dichte Varietäten vorherrschen".

The porphyrites often show columnar jointing, this may be observed with several porphyrite outcrops, e.g. the Seroe Brandaris and the Seroe Kibra Guarati.

The Washikemba formation reaches an enormous thickness, which we must fix, at all events so far as W. Bonaire is concerned, at 5000 m. at the least. This seems to be very much and one would expect that a considerable time was necessary for its deposition. But one should not forget that the greater part of the rocks of the Washikemba formation are of volcanic origin. Lava flows often get a considerable thickness, and a complex of tuffs can be deposited in a much shorter time than e.g. a complex of shales or marine sands of the same thickness. Non-volcanic rocks are rather scarce in the Washikemba formation. A part or all of the cherts may be silicified tuffs, only the limestones are doubtless non-volcanic. Consequently we see that thousands of meters of rocks in the Washikemba formation are purely volcanic.

We may declare almost with certainty that the Washikemba formation is of cretaceous age. In the highest parts of the formation, S. of the Seroe Ventana (W. Bonaire), was found a coarse grained conglomerate. This conglomerate contains pebbles of Washikemba rocks in a calcareous matrix. The pebbles consist of diabase, porphyrite, tuff, and porphyritic rock fragments with chloritized and silicified matrix and crystals of feldspar. In this conglomerate were found two rounded corals, *Multicolumnastraea parvula* Gerth and *Actinacis martiniana* d'Orbigny. *Multicolumnastraea parvula* is know from Curaçao, where it was found by G. J. H. MOLENGRAAFF in the Seroe Teintje limestone.

Actinacis martiniana comes from the Upper Cretaceous of Gosau. Consequently the corals point to Upper Cretaceous. The conglomerate must be younger than the corals that occur in it. But the difference in age between the corals and the conglomerate may be very slight, because corals, occurring in a marine conglomerate, may have been broken from a living reef by the surf, which formed the conglomerate. Thus we can be sure that the conglomerate is Upper Cretaceous. This would indicate an upper cretaceous or cretaceous age for the Washikemba formation, if the conglomerate belongs to it. Though personally am I convinced that it really does, it will be good just to face this question.

The following data, are at our disposal. The coastal region, where the conglomerate was found, is flat and arid, and exposures are scarce and bad there. As a result of this the connection between the conglomerate and the other Washikemba rocks (these being principally diabases here) is not clearly visible. Like the surrounding rocks, the conglomerate lies under the quaternary basal conglomaratic limestones of the Seroe Ventana, by which it is unconformably covered. Approximately the conglomerate has the ordinary NW.—SE. strike of the Washikemba formation. Southwestward as well as northeastward of the conglomerate there appear weathered diabases and waste of diabase rocks. The conglomerate was also found SE. and E. of the Seroe Mei Mei, bordered by diabase breccias, diabase tuffs and porphyrite tuffs (tuffs: N. 120—130 E.; 25° NE.). If the conglomerate does not belong to the Washikemba formation, it must lie on the Washikemba rocks with an angular unconformity, but with equal strike. The question can only be solved, when dips can be measured of the conglomerate and of the rocks in the immediate neighbourhood. In my opinion there can be little doubt that the conglomerate belongs to the Washikemba formation, however, I do not wish to reject the possibility that it does not belong to it.

There will be given a regional geological argument in support of the cretaceous age of the Washikemba formation when discussing the correlation of the Washikemba rocks with rocks of adjacent regions.

DESCRIPTION OF THE ROCKS OF THE WASHIKEMBA FORMATION.

DIABASES.

In the field the diabases are generally strongly weathered rocks, often showing spheroidal structure. If not weathered, the rocks are dark green to grey, in some cases bluish grey to nearly black; weathering changes the colour into dirty brown, greyish brown or dirty green. The diabases are medium to fine grained; in the medium grained diabases crystals of feldspar, occasionally of ferro-magnesium minerals and ore, can be recognized with the naked eye. The dimensions of the crystals in these diabases are up to or slightly exceed 1,5 mm.; the average dimension is 0,8 mm. The diabases are holocrystalline, and generally they show a typical ophitic structure. There are no indications that glass is ever present.

The principle constituents are feldspar, pyroxene, and ore (magnetite); other occurring minerals are apatite, ilmenite, haematite, chlorite, quartz, uralite, limonite, calcite, epidote, sericite. The occurrence of some dust among these minerals is not rare.

Feldspar. Plagioclase, varying from labrador to albite; most common are albite and albite oligoclase; labrador and even andesine are very rare. The composition of the feldspars has been defined by means of a refraction index. The predominance of acid plagioclase is due to albitization, a diminution of the basicity of the feldspars. We cannot assume that these rocks, with their quite typical diabase structure, originally contained acid plagioclase. It is worth mentioning that in one rock sample labrador and andesine as well as oligoclase and albite can occur at the same time. Sometimes the crystals are dusty-stained; then the dustiest spots have the lowest refraction index, consequently corresponding with the strongest albitization, and conversely.

In most cases feldspar is lath shaped, big crystals are often prismoid, small ones occasionally xenomorphic. Almost all the feldspar crystals show polysynthetic twin structure, zonal structure is occasionally present. Nearly without exception the feldspar crystals are dusty and they have not seldom greatly decomposed, then containing chlorite and occasionally sericite, quartz and epidote. In some cases the feldspar is permeated with a clear, colourless or cream coloured zeolitic mineral. In some sections the feldspar laths are provided with a central tubular cavity, which cavity runs through the whole crystal (as is clear to see in longitudinal sections of the laths). The nature of the material with which the central cavity is filled, cannot be verified, because it has entirely changed into chlorite and limonite.

Pyroxene. It is a monoclinic, diopsidic pyroxene, generally colourless; if coloured, very pale violet, pale yellow or pale green. Remarkable in this pyroxene is the great dispersion of the optic axes for different wave lengths. In polarized light extinction can hardly, if at all, be obtained; in the latter case the extinction does not go farther than a very dark green or deep blue. The appearance of the pyroxene is generally fresh and transparant, sometimes with dull shades. Pleochroism, in connection with the light colouring, is wanting or very weak. As to the cleavage, the common system of interrupted cleavage cracks, crossing one another at nearly right angles is only rarely developed; in most cases one can observe merely strong, very irregular cracks. Twinning occurs only exceptionally. The dimensions of the pyroxene crystals are on the whole smaller than those of the plagioclase; idiomorphism is less common and less pronounced. In many diabases the pyroxene is merely xenomorphic; when idiomorphic, it is prismoid.

The pyroxene can have greatly altered, mostly into green chlorite, whether or not accompanied by quartz and limonite; here and there alteration into epidote or sericite has taken place.

The quantitative proportion of feldspar and pyroxene is difficult to define. Without doubt it is varying; there are diabases in which the percentage of feldspar and of pyroxene is about equal, and there are diabases in which feldspar is positively dominating. But most of the diabases contain a certain quantity of secondary minerals, especially chlorite, and it is possible and even probable that in these diabases the ferro-magnesium minerals have been greatly replaced by the secondary minerals, so that a clear view of the proportion between the quantities of feldspar and pyroxene cannot be obtained any longer. In a few diabases pyroxene is lacking; seeing, however, that all these diabases contain a large quantity of secondary minerals, it is most likely that the pyroxene in them has been entirely altered.

Mica. This mineral was found in some diabases. We can distinguish biotite, discoloured, generally occurring together with pyroxene and being of the same date, and fine scales of fibrous sericite. The presence of mica in the diabases is very exceptional. The sericite is probably secondary.

Magnetite. It occurs in nearly all diabases, generally in numerous small grains, regularly scattered over the rocks. Magnetite crystals of larger dimensions are less numerous, occurring in square, rectangular and parallelopipedic sections or irregularly shaped; as an exception ore skeletons and needles occur. The magnetite has often changed into limonite. Sometimes it is titanium bearing — titano magnetite — and has partly changed into titanite and leukoxene. The amount of titanite and leukoxene is never large; at the most some crystals of strongly refracting titanite, bordering on the magnetite, or an incomplete rim of white flaky leukoxene aggregates are to be seen.

The amount of magnetite in the diabases is very variable. As has been stated, nearly all diabases contain magnetite in larger or smaller quantities, but there are diabases in which magnetite is entirely wanting, others in which the eventual presence of it is only indicated by some very sparse particles of limonite.

Ilmenite. This has been found in only one of the diabases (B. 55, D. 12082), in numerous big and small grains, of an irregular idiomorphic shape.

Haematite. Possibly haematite is represented in some diabases by several small limonitized needles of ore.

Apatite. In a few diabases it appears like small needles which are locally numerous, and also as an enclosure in the feldspar.

Chlorite. Green to nearly colourless, mostly light green, occasionally light brown, yellowish brown, greenish brown to brown, probably because of an addition of limonite. In general the chlorite is fibrous, often spherolitic. Pleochroism feeble or wanting; birefringence generally low, in some cases relatively high. Abnormal interference colours (blue) are rare. The optical character of elongation (in sections approximately perpendicular to the acute bisectrix) is nearly always positive, always with the green varieties. Most likely this green chlorite is delessite, a chlorite, which is very common in the diabases of Curaçao too. The brown colours may be due to limonite.

The chlorite is very abundant in most of the diabases; it occurs in the feldspar and in the pyroxene and as irregularly shaped aggregates among these minerals, especially among the feldspar rods. In the latter case it may have been derived from the pyroxene in a large extent.

Epidote. Ordinary epidote (pistacite): colourless to light green, if coloured, pleochroitic. Birefringence high. Generally it occurs in small grains, as secondary mineral in the pyroxene, and in places among the other secondary products.

Quartz. Quartz can occur in fine grained aggregates among the other secondaries, especially among the chlorite. Bubbles of liquid matter can often be observed.

Uralite. Fibrous uralite is present in a few diabases. It is partly chloritized.

Calcite. Here and there fine grained calcite has been found among the chlorite aggregates.

DIABASE PORPHYRITES.

These rocks differ in one respect from the diabases, viz. the presence of phenocrysts of feldspar, sometimes of feldspar and pyroxene. The constitution of the feldspar in the diabase porphyrites does not differ from that in the diabases. The feldspar phenocrysts are in general less modified than the feldspar of the matrix. The pyroxene is the same diopsidic pyroxene that occurs in the diabases. The feldspar phenocrysts are developed into prismoid crystals, the dimensions of which seldom exceed 2 mm. The pyroxene phenocrysts never reach the dimensions of the feldspar phenocrysts. The quantity of phenocrysts in the diabase porphyrites is never very large. The matrix is holocrystalline; it has the ophitic structure as we know from the diabases. In a part of the diabase porphyrites the matrix is finer grained than in the diabases. The fact that feldspar predominates to a great extent in the phenocrysts of the diabase porphyrites, is again a result of the riches of feldspar of these rocks, a phenomenon that we can observe in all the Washikemba rocks.

In some very weathered diabase porphyrites the phenocrysts have entirely or almost entirely changed into a granular or fibrous aggregate of chlorite or, more rarely, of calcite, sometimes together with quartz, in such a manner that nothing but the shape of the crystal is recognizable. Some of the feldspar phenocrysts can give us an idea how the albitization may have taken place. Without crossing the nicols we see one idiomorphic crystal; when we cross the nicols the crystal falls apart into numerous irregularly shaped feldspar aggregates with different orientation. In other phenocrysts the modification is not so far advanced, so that a part of the original crystal has been preserved, though greatly decalcified.

Enclosures in the feldspar phenocrysts are rare; if present, they are granules of magnetite; in one diabase porphyrite enclosures of pyroxene were found in the feldspar phenocrysts.

In a few diabase porphyrites silicification of the matrix has taken place, a phenomenon that we shall meet with on a much larger scale among the tuffs.

Diabases and diabase porphyrites have been treated here separately; it is obvious, however, that we cannot draw a sharp line of demarcation. Apart from typical diabases and typical diabase porphyrites, there are diabasic rocks with crystals of different dimensions, varying from the dimensions of phenocrysts to those of the matrix. Those rocks, not showing two distinct generations of crystal growth, have been invariably placed with the diabases. Anyhow, diabases are far more numerous than diabase porphyrites.

AMYGDALOIDAL DIABASES.

The amygdaloidal diabases distinguish themselves from the diabases by the occurrence of amygdales. Number, size, shape and filling of these amygdales vary in a large measure. The dimensions can exceed 1 cm. As constituent parts of the amygdales occur quartz, chlorite, calcite, chalcedony, zeolitic minerals, prehnite, feldspar, ? epidote. Amygdales with quartz, chlorite, calcite and with quartz and chlorite are most frequent. The quartz is generally not very fine grained and provided with a spherolitic, fine grained, often dusty rim. In some cases the spherolitic rim is composed of chalcedony. Bubbles of liquid matter, possibly gas bubbles too, are not unusual. The chlorite is generally fibrous or spherolitic; it does not differ from the chlorite that, for the rest, is found in the diabases as an alteration product of the different constituents.

In one amygdaloidal diabase (B 60, D. 12087) occur vesicles provided with feldspar. As this rock will be discussed later on, this occurrence will be treated in that place (p. 25).

Calcite too was frequently observed in amygdales. It appears in big crystals, to some extent pan-idiomorphic, or fine grained fibrous to spherolitic or granular. Beside the occurrence in amygdales, calcite is often present as an impregnation in the diabasic rocks. The zeolitic minerals form small fibres or grains of fresh crystals. Generally they have a high refraction index and varying, birefringence, which is generally low, sometimes abnormal.

Two amygdaloidal diabases (B. 81, D. 12108 and B. 82, D. 12109; localities: Guatemala Plantation, resp. N. of Deenterra) contain clinozoisite (not in the vesicles), in long prismoid to lath shaped crystals, with well developed crossways running cracks. The colour of this clinozoisite is brownish violet, the pleochroism is very feeble or failing, the birefringence low, maximal extinction 35 degrees.

AMYGDALOIDAL DIABASE PORPHYRITES.

As the characters of these rocks do not differ from those of the diabase porphyrites, or, of the amygdaloidal diabases respectively, I need not say anything more about them petrographically. As far as their frequency is concerned, they can be compared with the diabase porphyrites; like the latter they are, among the diabasic rocks, in the minority.

QUARTZ BEARING DIABASES AND QUARTZ DIABASES.

These diabases are quite comparable with the other diabases except for a certain quantity of primary quartz being present. We have little evidence as to the nature of this quartz. I feel justified in considering the quartz as a primary constituent in these diabases for the following reasons:

1. The quartz is very regularly spread among the other components. 2. There are no direct evidences that the quartz is of secondary origin. Among such evidences I reckon a certain connection or co-ordination or an interweaving of quartz and unquestionable secondary minerals (e.g. chlorite), among such evidences I also reckon a replacement of certain minerals bij quartz. 3. The quartz, xenomorphic, is always pressed in the interstices of the idiomorphic or hypidiomorphic feldspar. The impression one gets is that the quartz crystallized out of a residual liquor, filling all the existing room.

Besides primary quartz these diabases can contain some secondary quartz. One of the quartz diabases is amygdaloid.

QUARTZ BEARING DIABASE PORPHYRITES.

Seeing that these rocks combine the characters of both diabase porphyrites and quartz diabases it suffices to mention the occurrence of one quartz bearing diabase porphyrite on Bonaire (B. 68, D. 12095; W. of Goto).

MARTIN collected some diabases on Bonaire. These diabases do not differ from the diabases described. KLOOS, who examined them (lit. 23) mentions olivine in one of them (Ma. 196, l.c.p. 94). I had an opportunity to have a look at MARTIN's material, but I could not find olivine in No. 196. KLOOS speaks of: ,,vollständig serpentinisierten, durch . . . staubförmigen Magnetit deutlich zu erkennen" (l.c.p. 94). Most likely KLOOS took aggregates of chalcedony, surrounded by a rim of magnetite crystals, for serpentinized olivine. In the corresponding section one can see fresh, hardly coloured or pale green aggregates of fibrous chalcedony, surrounded by a rim of finely divided magnetite grains. Occasionally some fibrous chlorite is present in these aggregates of chalcedony, giving, though very faintly, the idea of ,,Maschenstruktur". Similar aggregates occur in some other diabases (e.g. Ma. 183b), but smaller sized.

SUMMARY OF THE DIABASES S.L.

To give a short summary of the diabases, we can state the following facts:

1. The diabases are undoubtedly one coherent group of rocks.

2. Most of the diabases are non-porphyritic and most of them are amygdaloidal. The mineral matter of the amygdales varies greatly in composition and in the arrangement of the components.

3. The spareness of the primary composing minerals. As such only feldspar and pyroxene deserve consideration, and in the quartz (bearing) diabases, quartz; other minerals are failing or, when present, they are of minor importance. Sometimes magnetite can be of some importance.

4. The predominance of feldspar, which the diabases have in common with all the other Washikemba rocks.

5. The absence of olivine. I wish to point out that there is nothing peculiar about the absence of olivine, since olivine-free diabases are well known rocks, but the character is worth mentioning.

PORPHYRITES S.L. AND PORPHYRIES.

The porphyrites are the most important rocks of the Washikemba formation, in the first place because they have the greatest variation of all the Washikemba rocks, in the second place because they form a great many intrusions in the Washikemba beds, in the third place because the greater part of the Washikemba tuffs are derived from a diorite magma.

Because the intrusions of porphyrite correspond entirely with the lava flows, the following descriptions are based both on intrusions and lava flows.

PORPHYRITES.

When fresh, the porphyrites are mostly light brown rocks, also brown, red, reddish brown, grey or violet grey. When weathered the colour is generally dark brown or reddish brown, occasionally grey. The porphyrites invariably show scattered phenocrysts of feldspar in a dense matrix. The phenocrysts are, with very few exceptions, medium grained; phenocrysts smaller than 1 mm. are exceptional; in some porphyrites phenocrysts of more than

5 mm. are present, up to 8,5 mm. The matrix is fine, mostly very fine grained, the greatest dimensions not exceeding 0,3 mm. This matrix is holocrystalline and its mineralogical constituents are predominantly feldspars, next to which magnetite and apatite can be present and a varying amount of secondary minerals, represented by chlorite, sericite, quartz, epidote, limonite, ? haematite and chalcedony. Not unusual is the presence of some dust in the matrix. The predominance of feldspar in the porphyrites is very striking, even much more so than in the diabases. The phenocrysts always consist of feldspar, the other minerals being restricted without exception to the matrix.

We will first treat the feldspar of the matrix, then the remaining components of the matrix and after that the phenocrysts.

M a t r i x. *Feldspar.* The feldspar is merely plagioclase, orthoclase is not present in any porphyrite. The plagioclase shows, just as in the diabases, a large variety in constitution, owing to an advanced state of albitization of the greater part of the feldspar, for the characteristics of which I refer entirely to the diabases. The feldspars show a divergence from labrador to albite; commonest are albite and albite-oligoclase. The plagioclase is generally lath shaped or xenomorphic; prismoid plagioclase crystals are less common. Twinning occurs only in the bigger crystals. Mostly the plagioclase has a dusty appearence, and here and there the crystals have been partially modified into chlorite or sericite, less common is a modification into epidote, whether or not accompanied by limonite.

Magnetite. Probably this mineral occurred in all the porphyrites and it is still to be found in the greater part of them; in a few porphyrites, however, it seems to have been entirely modified into limonite or haematite, since these ores were found only in the rocks concerned. It chiefly occurs as numerous small grains, in places in bigger crystals. Modification of a part of the magnetite into limonite or haematite is very common, though only in a few cases all the magnetite has been modified (see above).

Apatite. Scattered needles of apatite occur in many porphyrites.

Chlorite. The chlorite, which is generally accompanied by limonite, the commonest secondary mineral, is the same that we know from the diabases. It usually has a green colour, but it is often yellow or yellowish brown, as a result of the accompanying limonite.

Epidote was found in a small number of porphyrites, accompanying the other secondary minerals. Both pistacite and zoisite occur.

P h e n o c r y s t s. The constitution is the same as that of the plagioclase in the matrix. The form is chiefly prismoid and twinning is usual. A certain amount of secondary minerals in the phenocrysts is common. These secondaries are chiefly sericite and chlorite, in places accompanied by epidote, limonite or quartz. By way of exception the entire crystal can be chloritized. Enclosures in the phenocrysts are apatite and magnetite, apatite being commonest.

It is possible that some aggregates of chlorite and limonite have been derived from ferro-magnesium minerals. Most probably these ferro-magnesium minerals are mica, for we shall see later on, under the mica bearing porphyrites that the mica can change in a large measure into chlorite and limonite (see p. 17). Since we are not able to become better informed about the nature of the chlorite and limonite aggregates, it is not possible to make sure that under the described "porphyrites" mica bearing porphyrites do not occur. Should these aggregates turn out to be decomposition minerals of mica or other ferro-magnesium minerals, then it may also be likely that there really existed phenocrysts of those ferro-magnesium minerals, for some porphyrites contain aggregates of the said secondaries of the size of feldspar phenocrysts, moreover provided here and there with a certain crystal shape.

QUARTZ BEARING PORPHYRITES AND QUARTZ PORPHYRITES.

Among these rocks we can distinguish p o r p h y r i t e s w i t h o u t q u a r t z p h e n o c r y s t s, c o n s e q u e n t l y o n l y p r o v i d e d w i t h a q u a r t z b e a r i n g m a t r i x, and those p r o v i d e d w i t h q u a r t z p h e n o c r y s t s.

The former are ordinary Washikemba rocks, because they occur throughout the Washikemba formation, and are in fact the commonest kind of porphyrites, if not of all Washikemba eruptive rocks. The latter (quartz bearing porphyrites and quartz porphyrites with quartz phenocrysts) are represented by a few rocks, some of which are only known as pebbles while the petrographic nature of the others is dubious. About those dubious rocks I will speak further on (see p. 17 and 22). Differences between the two kinds of quartz bearing and quartz porphyrites as regards constitution and structure will follow from the following descriptions.

QUARTZ BEARING PORPHYRITES AND QUARTZ PORPHYRITES WITH QUARTZ RESTRICTED TO THE MATRIX.

In the field these rocks are not distinguishable from the porphyrites, since their habit is the same as that of the porphyrites and the quartz crystals, being limited to the matrix, are not big enough to be discovered without the aid of the microscope. The sizes of phenocrysts and matrix minerals are somewhat less divergent than those of the porphyrites: phenocrysts smaller than 1 mm. are not exceptions (phenocrysts of little more than 0,5 mm. were found); on the other hand the phenocrysts do not exceed 5 mm; the matrix constituents amount to more than 0,5 mm (in the porphyrites up to 0,3 mm.). In one quartz porphyrite there could not even be made a distinction between phenocrysts and matrix, this rock thus showing a pilotaxitic texture (B. 526, D. 12359; Fontein).

The quartz of these porphyrites appears in the same way as described under the quartz bearing diabases and quartz diabases, viz. generally as xenomorphic crystals in the interstices of the rods of feldspar. The motives, why the quartz is considered primary, are the same as mentioned there. Moreover, by way of exception, the quartz can be hypidiomorphic.

In general the plagioclase is the same as that of the porphyrites. Remarkable is the appearance of small spherolites of plagioclase in some of the porphyrites in question, forming as it were, miniature variolites. The largest diameter of these spherolites is 0,5 mm., the average size is only a little smaller. These spherolites are often accompanied by rods, needles and small granules of ore (haematite and (or) limonite). These ore particles can encircle the spherolites of feldspar, or can occur among the fibres of the spherolites and in the latter case, they are consequently arranged radially. In places the spherolites are imperfect, so that part of them (generally the centre) shows small idiomorphic feldspar crystals. In one section (D. 12368, of rock No. B. 535; S. of Seroe Oom Wie) there was observed feldspar and quartz with granophyric intergrowth, partially developed as more or less complete spherolites.

Spherolites of feldspar have only been met with in the quartz bearing porphyrites and quartz porphyrites. I do not know whether their presence in these rocks is an essential character or merely accidental.

Nearly one fourth of the quartz bearing porphyrites and quartz porphyrites contain a small quantity of orthoclase. I have not separated the orthoclase bearing porphyrites from the orthoclase free ones, because the former do not differ from the latter in any other essential point than the presence of potash feldspar. The orthoclase was found in the matrix as well as in the phenocrysts.

In a few quartz bearing porphyrites uralite occurs, for the greater part chloritized. As to the minerals magnetite, apatite, chlorite and epidote, I can refer to what has been said about the porphyrites; the same applies to the aggregates of chlorite and limonite.

QUARTZ PORPHYRITES WITH QUARTZ PHENOCRYSTS.

Some unquestionable rocks of this group occur among the pebbles of the Rincon formation and of the Soebi Blanco conglomerate. In the Rincon formation one pebble of this kind was found (B. 29, D. 11907), in the Soebi Blanco conglomerate two (B. 21, D. 11899 and B. 24, D. 11902). Further a quartz porphyrite with quartz phenocrysts is present in Delft in the collection of Duyfjes, labelled: ,,vallei van Rincon, Bonaire''. Probably this rock was gathered as a pebble, which is also the impression I got, when seeing the sample. It is possible that the rock sampled by Duyfjes, is also a pebble of the Rincon formation.

We do not know if these quartz porphyrites with quartz phenocrysts belong to the Washikemba formation. Solid rock exposures of unquestionable quartz porphyrites with quartz phenocrysts have not been met with on Bonaire. The exposures that have been found, are of rocks of doubtful nature (see also p. 22). These have been found on the W. slope of the Seroe Brandaris (collection GRUTTERINK), E. and W. of the Seroe Dos Poos (W. Bonaire) and between the Guatemala and Lamoenchi Plantations (E. Bonaire).

Because it is likely that the pebbles under consideration of the Rincon formation and the Soebi Blanco conglomerate belong to the Washikemba formation, I will describe them here with the restriction: unquestionable exposures of quartz porphyrites with quartz phenocrysts are not known on Bonaire. Below I shall return to the subject of the dubious rocks.

The porphyrites with quartz phenocrysts contain in a very fine grained matrix phenocrysts of feldspar and quartz. The matrix is built up of xenomorphic feldspar and quartz; the quartz may be partly secondary. Here and there lath shaped feldspar occurs. The feldspar of matrix and phenocrysts is chiefly acid plagioclase, occasionally rather basic plagioclase. Other components of the matrix are granules of magnetite and chlorite, the latter being secondary. The size of the phenocrysts amounts to 2,5 mm. The feldspar phenocrysts can contain some sericite. The quartz phenocrysts frequently show some resorption.

In connection with the preceding I shall say a few words about the dubious rocks. These rocks are unstratified and provided with big feldspar crystals, partially also with quartz, in a very fine grained matrix of xenomorphic mineral matter. This mineral matter is feldspar or feldspar and quartz, accompanied by some small grains of magnetite and secondary minerals (chlorite and limonite). Silicification of the matrix has frequently taken place. Sometimes some idiomorphic lath shaped feldspar occurs in the matrix; in those cases there is a great probability that the concerning rock is a porphyrite. Some of the rocks in question show accumulations of feldspar crystals, a phenomenon, pointing out as well that most likely we have to do with porphyrites. But in many of these rocks it is very difficult or impossible to decide: porphyrite or tuff. It is most difficult to come to a decision in the case of the quartz porphyrites with quartz penocrysts, because the mineral matter of the matrix of those rocks is mostly xenomorphic. When, moreover, the matrix is largely silicified or chloritized, it is obvious that it becomes almost impossible to decide, what the nature is of the rock in question. I may add that almost without exception the dubious rocks in the field gave the impression of tuffs or tuffbreccias. This fact does not plead so strongly for the tuffaceous origin of the dubious rock as it seems to do, for it has occurred once or twice that a rock, called a tuffbreccia in the field, turned out to be a porphyrite under the microscope.

Be that as it may, we are guaranted in considering the occurrence of quartz porphyrites with quartz phenocrysts among the Washikemba rocks to be most likely.

MICA BEARING PORPHYRITE (B. 530, D. 12363) AND MICA BEARING QUARTZ PORPHYRITE (B 531, D. 12364).

These two rocks will be considered together, since their only difference is the absence or presence of primary quartz, and since they are the only two rocks in which mica was found with certainty.

B. 530 was found on the Seroe Wamari (E. Bonaire), B. 531 on the Seroe Dos Poos (W. Bonaire).

Besides the presence of mica, the rocks are ordinary Washikemba porphyrites. The mica is brown biotite. In the porphyrite (B. 530, D. 12363) it occurs as phenocrysts and in the matrix, in the quartz porphyrite (B. 531, D. 12364) it is restricted to the matrix. The biotite of the matrix is developed as small scales, that of the phenocrysts forms fine idiomorphic crystals, grown simultaneously with the feldspar phenocrysts. The phenocrysts of biotite are smaller than the greater part of the feldspar phenocrysts. Many of the biotite scales of the matrix also show idiomorphism to some extent. Chlorite and limonite occur with the biotite as a result of the alteration of the mineral. In extreme cases the entire crystal has changed into an aggregate of chlorite and limonite. As similar aggregates occur in a great many other porphyrites, it is most likely that mica bearing porphyrites are much more frequent than one would be inclined to judge from the mica, that has been actually found (see p. 15).

PYROXENE PORPHYRITE (B. 537, D. 12370).

Exposures of pyroxene porphyrite of Bonaire are not known. But in the waste of the Rooi Toena (NE. Bonaire) a pebble of this rock has been found.

It is a holocrystalline rock, containing in a fine grained matrix phenocrysts of pyroxene and feldspar. The matrix is built up of feldspar, pyroxene and magnetite; the feldspar chiefly is very fine grained and xenomorphic, for the rest lath shaped; the pyroxene consists of small grains and small prisms; the magnetite of highly limonitized granules. The feldspar, both of matrix and phenocrysts, is albite and oligoclase, the pyroxene of matrix and phenocrysts is the well known diopsidic pyroxene, here being colourless or pale green. The pyroxene phenocrysts exceed those of feldspar in number and size (up to 7 mm.). Some pyroxene crystals are twinned. The pyroxene can have changed into chlorite and limonite. Magnetite also occurs as an enclosure in the pyroxene. A few amygdales that are present in the rock, contain chlorite and calcite.

AMYGDALOIDAL PORPHYRITES (S.L.).

Amygdaloidal porphyrites are rarer than amygdaloidal diabases. Among the minerals in the amygdales only silica is common. In many porphyrites geodes and amygdales with agate occur, often accompanied with quartz. Fine agates were found on the Seroe Bezoe, the Seroe Hobau, the Seroe Largoe (all the three W. Bonaire) and on the Seroe Grandi (E. Bonaire). The rim of many amygdales consists of agate, which passes into quartz towards the core. Other minerals occurring in the vesicles are chlorite, calcite, magnetite and epidote. In all cases the principal constituent is quartz, the other ones being mere accessories. The magnetite often forms a rim of fine granules in the amygdales; generally it is limonitized in some degree.

One porphyrite deserves to be specially described (B. 354, D. 12449; findspot: SE. of Washikemba Plantation. The mineral matter of the amygdales of this porphyrite is prin-

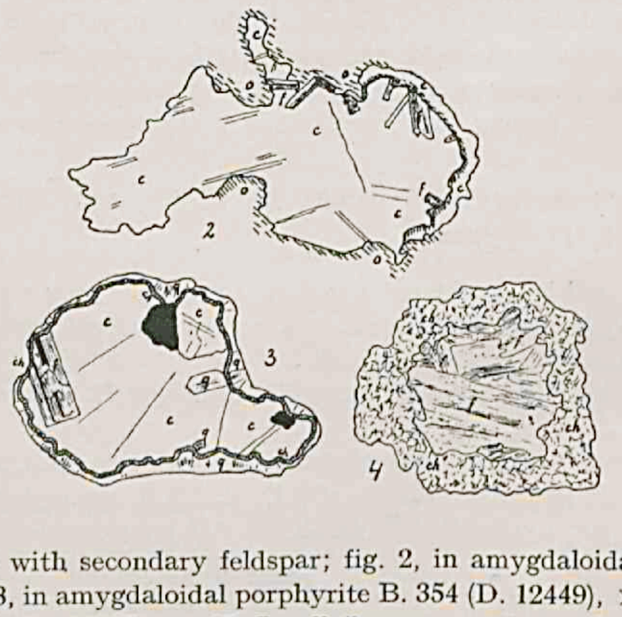

Fig. 2—4. Amygdales with secondary feldspar; fig. 2, in amygdaloidal porphyrite B. 354 (D. 12449), × 30; fig. 3, in amygdaloidal porphyrite B. 354 (D. 12449), × 26; fig. 4, in amygdaloidal diabase B. 60 (D. 12087), × 15. In all figures: c, calcite; ch, chlorite; f, feldspar; o, ore; q, quartz (and — or chalcedony). The black patches in the calcite in fig. 3 are Canada balsam. Nichols crossed. As to figs. 2 and 3 see pp. 18, 19; as to fig. 4 see pp. 25.

cipally chlorite, calcite and quartz. The quartz forms the rim of the amygdales, in the centre of which chlorite or calcite is found. Some of the calcite amygdales are surrounded by a rim of chlorite, which in its turn is surrounded by a quartz rim, other calcite amygdales are surrounded by a rim of fine grained ore, this being surrounded again by quartz. Other amygdales contain within a quartz rim — chlorite or ore rim, a core of calcite and feldspar. Judging from refraction index this feldspar is a potash natron feldspar, possibly a potash bearing albite (fig. 2, 3).

The feldspar is partly xenomorphic, being of the same date as the calcite, partly it shows idiomorphic lath shaped and prismoid crystals, which are often twinned. In the second case the feldspar is consequently of earlier date than the calcite, in one vesicle the idiomorphic feldspar crystals occur in the chlorite rim, thus being of earlier date than the chlorite. Some vesicles are filled with epidote, partly accompanied with feldspar. The occurrence of feldspar in amygdales was already mentioned under the amygdaloidal diabases (p. 13). Because the diabase in which this feldspar was found, belongs to the intrusive diabases, the occurrence of this feldspar will be described under those rocks (p. 25). As far as I know, secondary feldspar in amygdales was never found before. Without doubt the find is very interesting, but there is nothing strange or incomprehensible about it.

Just as in the amygdaloidal diabases we see that the arrangement of the different minerals that fill the amygdales, greatly varies.

Quartz, chalcedony, chlorite, epidote and limonite also occur in veinlets in several porphyrites; here too the quartz is by far the most important constituent.

PORPHYRIES.

Washikemba rocks with a considerable amount of potash feldspar are very rare. There is only one rock that can be called without doubt a porphyry (B. 524, D. 12357); beside this one more rock might bear the name of porphyry (B. 511, D. 12344). But for the occurrence of a great quantity of orthoclase these two rocks agree with the porphyrites. Both rocks also contain plagioclase (albite and oligoclase). In D. 12357 some primary quartz was found. In both rocks the orthoclase is present in the matrix and among the phenocrysts. It is important to know that the two rocks very much resemble each other. It is possible that they are connected intrusions (see p. 26), though the distance between their exposures is considerable, B. 524 being exposed on the Kibra Guarati (E. Bonaire), B. 511 on the Hobau (W. Bonaire).

A few words may yet be said about possible vitrophyric parts in the matrix of some porphyrites. On p. 15 it was stated that the matrix is always holocrystalline. However, I do not wish to reject the possibility, that glass though only in traces, occurs or occurred in certain porphyrites. As such we may consider small, generally brown coloured masses with dusty appearance and very feeble birefringence.

Kloos describes from the collection of Martin "mica porphyrites" and an "orthoclase porphyry".

His mica porphyrites correspond with the porphyrites I described that contain numerous accumulations of chlorite and limonite, for which porphyrites I pointed out the possibility that they have been mica bearing porphyrites. In none of the mica porphyrites, described by Kloos, the occurrence of mica is convincing. Should all the chlorite and limonite of these "mica porphyrites" been originated from mica, the rocks would be mica bearing porphyrites, the "mica" never occurring in such quantities that the rocks would deserve the name of "mica porphyrites".

SUMMARY OF THE PORPHYRITES S.L. AND PORPHYRIES.

Giving a short summary of the porphyrites, we can state the following facts:

1. Just like the diabases the porphyrites are one coherent group of rocks.

2. Quartz bearing porphyrites and quartz porphyrites are most numerous, the porphyrites coming next.

3. The scantiness in kinds of primary constituents. Important are feldspar, quartz and ? mica.

4. The abundance of feldspar.

TUFFS.

The Washikemba tuffs are equal to the eruptive rocks, especially the porphyrites, in monotony, so far as their mineralogical constitution is concerned. In habit, colour, grain, stratification and structure, however, they show a considerable variation.

A first distinction has been made between tuffs provided with rock enclosures and those containing only crystal enclosures. This seems to be a good distinction, but the distinction has always been based on the examination of one, exceptionally two, sections of one rock. It is clear that a rock, described as a "crystal tuff", can contain in other parts, very near to the slide, rock enclosures.

As far as possible, a second distinction is made between diabase tuffs, porphyrite tuffs, etc.

In the descriptions only unquestionable tuffs have been considered. As far as necessary, the rocks of doubtful tuffaceous origin (dubious rocks) will be mentioned apart (p. 22).

DIABASE CRYSTAL TUFFS.

In the main diabase crystal tuffs are dark coloured grey rocks, occasionally dark green or dark brown, very fine grained and finely stratified. However, they can be unstratified. When weathered, which is often the case, these rocks are brown coloured. In a very fine grained dusty matrix they contain small enclosures of crystals, which can be feldspar, pyroxene, quartz and magnetite. One tuff contains needles of apatite. The matrix is always highly changed; the modifications can be chloritization, silicification, limonitization, calcitization and epidotization. Zeolitic minerals were also found. In one section (B. 86, D. 12113) there was found a brown coloured sericite-like mica. Of these modifications chloritization and silicification are commonest. Under these circumstances it is difficult to say what has been the original constitution of the matrix. That plagioclase was, and even is, an important constituent, is certain. In places fine granules of magnetite occur, but these might be secondary. A certain amount of glass may originally have been present in the matrix too. The chlorite is the same as we know from the other rocks: colour greenish yellow to pale green, birefringence feeble or wanting. When mixed with limonite the colour can be brown. The epidote is a pale green to colourless pistacite.

The enclosures vary greatly in quantity and size. Sizes above 0,3 mm. are rare. The most important enclosure is feldspar, it is not absent in a single tuff. The enclosures of feldspar are rather fresh crystals or fragments of crystals of, mostly twinned, plagioclase. This plagioclase varies from labrador to albite, albite and oligoclase being again commonest. Pyroxene is less common and, if present, less abundant than feldspar; it is the well known diopsidic pyroxene, colourless or nearly so. In a few sections quartz enclosures occur, in those cases we might be allowed to speak of quartz bearing diabase crystal tuffs. The magnetite forms small scattered grains. Small vesicles occurring in some tuffs are filled with quartz or zeolitic minerals.

DIABASE TUFFS.

As these tuffs only differ from the foregoing by the presence of rock enclosures, I need not repeat what has been said there about habit of rock, matrix, crystal enclosures and secondary changes in the rocks. The rock enclosures are never very abundant. They consist of fine grained diabase, while in one section (D. 12114, rock No. B. 87) an enclosure of diabase porphyrite was found. A rock of doubtful place (B. 90, D. 12117), but probably being a diabase tuff contains rock enclosures of diabase, diabase porphyrite, ? porphyrite and ? chert. All the rock enclosures are highly changed, principally chloritized and limonitized.

CRYSTAL TUFFS, PORPHYRITE CRYSTAL TUFFS, QUARTZ BEARING PORPHYRITE CRYSTAL TUFFS, QUARTZ PORPHYRITE CRYSTAL TUFFS.

I decided to take the porphyrite crystal tuffs, quartz bearing porphyrite crystal tuffs and quartz porphyrite crystal tuffs together, because they are by their very nature closely related and their differences are based upon a single character, while, for the rest, the rocks are of the same kind. I added the crystal tuffs, partly because of the same considerations, partly because I am convinced that they conceal some porphyrite crystal tuffs, etc., the enclosures, however, being too scanty to say more of the rock than that it is a "crystal tuff". The tuffs in question are far more abundant than the diabase crystal tuffs and diabase tuffs. Generally they are very fine grained and thinly bedded rocks, often with fresh appearance and highly differing colours: from yellowish brown to dark brown, beige, sandy-coloured, grey, greyish brown, greenish brown, light green, when silicified often dark grey. When bedding is well developed, the various layers can have different colouring: grey, dark brown, beige, sand-coloured layers alternating in one rock. Weathering gives predominantly brown to greyish brown, sometimes red colours, chloritization green colours, silicification dark grey colours.

Just as in the diabase crystal tuffs and diabase tuffs the very fine grained, often dusty, matrix can be highly changed, the modifications being chloritization, silicification, limonitization, calcitization and epidotization. As an exception zeolitic minerals occur. Especially silicification is very common. Few tuffs are free from secondary quartz. It is possible that the calcite in certain tuffs is not due to secondary calcitization, but to the fact that those tuffs were primary calcite bearing. In one tuff thin layers of limonitized pyrite occur. Here and there glass might have been present in the matrix. In these tuffs too, little can be said about the original constituents of the matrix; plagioclase and in some cases orthoclase are important. The chlorite is the same as we know from the other rocks; the epidote is colourless or yellow or pale green pistacite or zoisite. The epidote occurs in small, fine grained aggregates.

The enclosures in these tuffs can be feldspar, quartz, magnetite and apatite. Beside apatite, which is always very scarse, the enclosures vary considerably in number and size. Since the tuffs in question are sometimes difficult to separate from some dubious rocks and since those latter rocks can have crystal enclosures of 1,5 mm. and bigger, it is impossible to give a maximum size. We can only say that the enclosures in the distinct, well bedded tuffs, seldom exceed 0,3 mm. The feldspar can be acid plagioclase and orthoclase; the most frequent of all enclosures is acid plagioclase, but, relatively, orthoclase is also common. Feldspar, especially plagioclase, is the only kind of enclosure in many tuffs, in others again it is only accompanied with some magnetite granules. In most cases the magnetite is limonitized in some degree. The percentage of quartz among the enclosures is very variable.

Certain tuffs contain small aggregates of chlorite and limonite, like those described in the porphyrites; originally these tuffs may have contained mica. I must point out the fact, however, that mica itself was not found in any tuff.

In the section one tuff (B. 562, D. 12396) having a dull black colour, turned out to contain a dark brown organic substance, this being the cause of the colour of the rock.

Some tuffs contain remains of organisms; these are principally radiolaria; in a few tuffs they are foraminifera. The skeletons of the radiolaria, and the cavities they enclose, can have undergone the same changes as the rocks in which they occur. Thus chloritized, calcitized and entirely silicified radiolaria were found. MARTIN has also found some radiolaria in his samples of Bonaire tuffs.

PORPHYRITE TUFFS, QUARTZ BEARING PORPHYRITE TUFFS, QUARTZ PORPHYRITE TUFFS.

As these rocks differ only from the respective crystal tuffs by the presence of rock enclosures, it is sufficient to treat the latter ones here. The rocks in question are not so numerous as the respective crystal tuffs. Occurring rock enclosures are porphyrite, chert, diabase, ? diabase porphyrite.

PORPHYRY CRYSTAL TUFFS AND PORPHYRY TUFFS.

When treating the porphyrite crystal tuffs and similar tuffs, we said that orthoclase is relatively common in those tuffs. Crystal tuffs, however, in which orthoclase predominates, are very rare or fail on Bonaire. I examined two rocks, which we might call porphyry crystal tuff: B. 547, D. 12380 and B. 549, D. 12382; one that might be a porphyry tuff: B. 550, D. 12383 and D. 12384. Of these rocks B. 547 is a rock of doubtful tuffaceous origin. The rock enclosures that were found in D. 12383 are chert.

The bad state of conservation of these rocks, the alteration and albitization of the feldspar make it difficult to take a decision. Be that as it may, when porphyry crystal tuffs and porphyry tuffs do occur on Bonaire, they certainly do not occur in abundance and then they are porphyry (crystal) tuffs relatively poor in orthoclase. Tuffs in which plagioclase fails or almost fails are unknown.

DIABASE BRECCIAS AND PORPHYRITE BRECCIAS.

Under the names diabase breccias and porphyrite breccias some breccious, conglomeratic or agglomeratic volcanic rocks, composed of rock fragments, are united. In the diabase breccias the rock fragments are diabase, diabase porphyrite and amygdaloidal diabase; in the porphyrite breccias these are porphyrite. The nature of the matrix varies, now resembling that of the non-stratified tuffs, now that of the diabases or porphyrites. In the latter cases it can be amygdaloidal, the vesicles being filled with chlorite or quartz or both. The matrix is always highly changed, the most important secondary mineral being chlorite; other occurring secondaries are limonite, quartz, chalcedony and epidote. Without exception the matrix contains several crystals and fragments of crystals. In the diabase breccias these crystals can be feldspar (from anorthite to albite!), magnetite and apatite. In one and the same rock anorthite, bytownite, labrador and andesine or labrador, andesine and oligoclase can occur together! In the porphyrite breccias acid plagioblase, orthoclase and quartz occur. In places the feldspar can be chloritized, sericitized, silicified, epidotized or calcitized.

It is obvious from the preceding that the breccias are apt to be mixed up with tuffs provided with rock enclosures.

DUBIOUS ROCKS.

The principal things about these rocks have already been said in connection with the quartz porphyrites with quartz phenocrysts (p. 17). To give a summary, we have to do here with unstratified rocks, with a very fine grained matrix, composed of xenomorphic mineral matter; in this matrix crystals of feldspar or feldspar and quartz of various dimensions have been found. Generally these rocks are highly altered. The impression one gets in the field and in the section, the crystals of varying size and the nature of the matrix point to tuffs; the want of stratification, the large, often idiomorphic, crystals, the fact that in places lath shaped feldspar can appear in the matrix, and finally the total want of remains of organisms point to eruptive rocks.

In his descriptions of Bonaire tuffs Kloos indicates several times the presence of „hyaline Substanz" in the matrix (lit. 23, pp. 101 ff.). The original presence or absence of glass in the matrix of the tuffs cannot be proved anymore. When re-examining the tuffs collected by Martin, I noticed that they are highly silicified and chloritized. Consequently nothing certain can now be said about their original nature. At present the tuffs are entirely crystalline. One of them (No. 194) contains a brown, dusty substance that may have been glass, but at present it is crystalline too. As things are, it is possible and even probable that glass occurred in the matrix of a part of the tuffs, but it is not to be proved.

CHERTS (INCLUDING RADIOLARITES AND JASPERS).

The cherts, radiolarites and jaspers are hard, dark coloured rocks, stratified or unstratified, often with splintery cracks. Generally the original colour is black or bluish black, weathering causes grey, sometimes brown or brownish grey colours. The red varieties — jaspers — contain ore, which can be magnetite, pyrite, haematite, and (or) limonite. Impregnation with chlorite causes dark green colouring.

The silica in the cherts is very fine grained, granular or spherolitic. In some degree calcitization has taken place in many cherts. Often chlorite and ore are present, the latter being principally limonite and haematite, sometimes magnetite or pyrite. Veinlets, which are often present in the cherts, can be filled with quartz or calcite.

In some of the cherts there occur small crystal enclosures, being feldspar and quartz. I do not doubt that a part of the cherts are silicified crystal tuffs. But whether all the cherts must be considered as such, which was supposed by G. J. H. Molengraaff regarding the Curaçao cherts, is doubtful (lit. 32, pp. 20,21). Tuffs can be highly silicified, but they could nearly always be distinguished from the cherts, Transitions from tuffs to cherts are not known on Bonaire.

Many cherts contain radiolaria. Of the radiolaria in the radiolaria bearing cherts and in the radiolarites only the cavities have generally been preserved, filled with silica or calcite.

In one radiolaria bearing chert some foraminifera were found.

Molengraaff says that the cherts cannot have been deepsea deposits, his argument being the occurrence of foraminifera in some cherts. As long as the foraminifera in the Curaçao cherts have not been proved to be shallow water foraminifera, however, this argument is not decisive. We do not really know foraminifera from the extreme deepsea deposits, where radiolarian ooze is found. But we do know foraminifera from considerable depths.

It is a different case with the discovery of tuffites, real conglomerates and foreign material in the Knip (lit 47). This foreign material must have been brought to Curaçao by land or by the bottom of a very shallow sea. So here at least we have the evidence that the cherts alternate with shallow water deposits.

So far as Bonaire is concerned, the cherts of that island and their relation with the other Washikemba rocks do not give any evidences about their origin.

JASPER BRECCIAS.

These rocks consist of fragments of jasper, sticked together by silica. The ore that was found in the jasper breccias, is magnetite and haematite. The jasper breccias can contain radiolaria. Jasper breccias were found here and there accompanying the cherts, chiefly in the lower parts of the Washikemba formation and chiefly in W. Bonaire (W. of Goto and E. of Dochila).

LIMESTONES.

The Washikemba limestones are dense, fine grained rocks, generally dark coloured: grey, greenish grey, dark grey, black, brown, Pure limestones are grey to black, the other colours being due to accessories. These accessories can be chlorite, pyrite, limonite. In places the calcite can be recrystallized. No trace of organisms was ever found in the limestones.

Intrusions of diabase.

Clear intrusions of diabase are not numerous; except one, perhaps two, exceptions they are limited to a region in W. Bonaire approximately situated between Rincon and the Seroe Soempina. The principal one is that which forms the Seroe Caracao (B. 53), which possibly is a sill. SE. of the Seroe Caracao occur a few more sills, among which the Seroe Piedra Pretoe; the other intrusions of diabase in this region must be considered as necks. Several exposures of the same diabase intrusions lie E. and SE. of the Seroe Caracao. They have been marked on the geological map. Outside this region an exposure was found in Terra Hoendoe (E. Bonaire — B. 540). Possibly another intrusion of the same diabase occurs W. of Goto (B 74, D 12101). Finally rock No. 3259 (section No. 2318) of the collection of Grutterink is a similar diabase, but of this we do not know the solid rock. It was found on the NW. slope of the Seroe Grandi. It may be a pebble out of the Soebi Blanco conglomerate. The intrusive diabases under consideration are easily distinguishable from the ordinary Washikemba diabases. In the field already one sees that one has to do with another kind of rock: the intrusive diabases are fresh, dense, hard, dark coloured rocks, the colour being dark grey to dark greyish green. Hence the name "Piedra Pretoe" (black rock). With the naked eye feldspar, ferro magnesium minerals and ore are to be distinguished. As a result of their hardness the diabase necks and sills form in the landscape small, generally isolated, bare hills, more or less dome shaped.

In the museum of the St. Thomas college in Curaçao there are preserved several axes, originating from Bonaire, and formerly made by the Indians. The material which some of these axes have been made of, is diabase. Without doubt these axes were made of the hard diabase of the necks.

Under the microscope the intrusive diabases turn out to be medium to coarse grained rocks (crystals of more than 6 mm. occur) with gabbroid or doleritic structure. Chief components are feldspar, pyroxene and magnetite, other components are apatite, uralite, chlorite, sericite, limonite and zeolitic minerals.

Feldspar. The feldspar varies from bytownite to albite, of which oligoclase and andesine are most numerous. The feldspar is oblong shaped to prismoid. Generally the feldspar is strongly modified; dusty and with sericite, chlorite and zeolitic minerals; among the secondary minerals the latter are commonest. Probably only sericite and chlorite are to be considered as minerals originated as a result of the decomposition of the feldspar, the zeolitic minerals being a secondary impregnation in the feldspar. For these zeolitic minerals occur in great quantity outside of the feldspar crystals, in amassments and veinlets. One can often observe that these veinlets continue into the big feldspar crystals. Two zeolitic minerals can be distinguished, the one being a natrolite-like pale brown to creamy mineral, finely and indistinctly fibrous, with a very low refraction index and birefringence, sometimes with feeble pleochroism; the other one in appearance agreeing with the first one, but with a high refraction index.

Enclosures in the feldspar are apatite and magnetite.

Pyroxene. The pyroxene is the same that is present in the other diabases, a monoclinic, diopsidic pyroxene, colourless, pale green to pale yellow or pale violet, sometimes with feeble pleochroism (from pale green to yellow); generally with distinct and strong cleavages, irregularly cracked or with well developed sub-quadratic cleavage. Enclosures are sparse apatite needles and magnetite granules. The pyroxene can to some extent be decomposed to chlorite or secondary mica, sometimes accompanied with quartz.

Idiomorphism is less developed and less common than with the feldspar, that is to say a part of the pyroxene may possess well developed idiomorphism, the remaining pyroxene being hypidiomorphic and (or) xenomorphic. Nevertheless one gets the impression that feldspar and pyroxene are of the same date or for the greater part of the same date, part of the pyroxene then being of later date than the feldspar. Here and there feldspar and pyroxene crystals have grown together, occasionally the pyroxene gives the impression of being an enclosure in the feldspar crystals.

In places small accumulations of pyroxene crystals are to be observed, indicating an early crystallization of the pyroxene.

Magnetite. It is a common constituent of these diabases, occurring in small grains and some bigger crystals.

Apatite. Rather common.

Uralite. This mineral is seen in many spots, showing a dirty green colour. It is generally associated with chlorite into which it passes.

Chlorite. In occurrence and habit the chlorite does not differ from the kind found in the other diabases.

For the sake of completeness I may add that the diabase in the collection of GRUTTERINK (No. 3259), which is a quartz diabase, has a sub-gabbroid structure, and contains several big uralite aggregates, partly with a core of pyroxene. It is all but certain that the uralite in this diabase and also in the other ones resulted from the pyroxene. The quartz in quartz diabase no. 3259 occurs in the same way as in the other quartz diabases; partly the quartz crystals are bigger.

Also in the collection of BOLDINGH a gabbroid diabase was found. However, the findspot of this diabase is not given. This rock consists of a coarse grained fabric of bytownite and diopsidic pyroxene with magnetite and numerous chlorite aggregates and with the zeolitic mineral with low refraction index that we know from the other intrusive diabases.

The rock B. 74 (D. 12101), which may also be an intrusive diabase is a medium grained rock with doleritic structure, essentially consisting of acid plagioclase, diopsidic pyroxene and magnetite, with accessory apatite and secondary minerals: chlorite, sericite, epidote, quartz, limonite. Part of the quartz may be primary. It shows some likeness with the gabbroid diabase of the BOLDINGH collection. In the field this rock was recognized as an intrusion.

Though the intrusive diabases differ in several respects from the ordinary Washikemba diabases and the two kinds of diabases clearly represent distinct types, they doubtless belong together, only being different manifestations of the same geological event.

The close connection of the intrusive diabases with the ordinary Washikemba diabases is made the more admissible, since a few intermediate types have been found. These are diabases, by their geological relation belonging to the normal Washikemba diabases, by their mineralogical structure and texture, however, reminding one of the gabbroid intrusive diabases. As such may be considered B. 62 (NE. of the Seroe Grandi, E. Bonaire; D. 12089) and B. 73 (250 m. N. of Saliña Tam, W. of Goto, W. Bonaire; D. 12100); possibly B. 74 (see above) too. These diabases are principally characterized by the considerable amount of diopsidic pyroxene they contain, this pyroxene being predominantly xenomorphic.

On the other hand there has been found an exposure of an amygdaloidal diabase which matches quite well with the corresponding Washikemba rocks (B. 60, D. 12087) The rock is exposed approximately 400 m. NW. of the Seroe Grandi, W. Bonaire. In the field this exposure shows itself as an intrusion: amidst a flat country, principally showing diabase waste with here and there exposures of weathered and easily weathering Washikemba rocks, lies a small outcrop of hard, dark coloured, unweathered diabasic rock. Under the microscope this rock turned out to be an amygdaloidal diabase (B. 60). This rock contains, among others, amygdales of feldspar (already mentioned on p 13 and p. 19). The feldspar occurs in amygdales up to 1,5 mm. diameter; the rim consists of fibrous chlorite, in the centre is found the feldspar, relatively coarse grained or fibrous. In some vesicles chlorite and feldspar lie pell-mell, showing no arrangement whatever. According to its refraction index the feldspar is an acid plagioclase (fig. 4).

The above proves the great uniformity of all the diabasic rocks; the same holds good for the porphyrites.

INTRUSIONS OF PORPHYRITE.

When consulting the accompanying geological map one sees, several long, narrow stripes running roughly parallel to the summits of the "Seroes" and marked as "Intrusions of porphyrite." Many of these stripes correspond in broad outline with the general strike of the Washikemba formation. Others, on the contrary, make an acute angle with this general strike. Finally there are many areas, indicated in the same way, which show no definite direction.

The stripes that run parallel to the general strike of the Washikemba formation, generally show very limited dimensions in the direction of that strike. They are porphyrites that are normally intercalated among the rocks of the Washikemba formation. Their impersistence in the direction of the general strike of that formation make it most unlikely that we have to do with lava flows here. In my opinion all of them must be considered as sills. The stripes of porphyrite that make an acute angle with the general strike are undoubtedly discordant intrusions. On the geological map we can see that in some cases these latter intrusions are connected with the sills. (Seroe Hobau: Seroe Palmit; Seroe Dos Poos; SE. prolongation of the Seroe Matado di Pascoe — NE. of the Seroe Kimeterio). In these cases we see the part that runs parallel to the general strike, in close and unseparated connection with the dike, making approximately an acute angle (in the case of the Seroe Hobau more than 90 degrees). There can be no doubt that the NW.—SE. directed part of the porphyrites under consideration are sills. In connection with the N. dip of the Washikemba rocks it is impossible that the approximately NE.—SW. running part of these intrusions represents the volcanic pipe that fed the N.W.—SE. running part. The only explanation for these intrusions is that they are sills, from which discordant intrusion in the overlying strata has taken place. Another fine example of a discordant intrusion connected with a sill can be seen N. of the Washikemba Plantation (ca. 1250 m. WNW. of Boca Washikemba).

The intrusions that have no definite direction (apparently), must partly be considered as necks, partly as discordant intrusions. Examples of the latter are the Seroe Bezoe and the Seroe di Camina (W. Bonaire).

Stripes of porphyrite like the Seroe Brandaris, Seroe Largoe (W. Bonaire), SE. prolongation of the Seroe Largoe, Seroe Joewa, Seroe Makoetoekau and E. of the Seroe Kimeterio (all of them in W. Bonaire) may be also sills. In these cases, however, we have no proof that they are so. In my opinion they are sills and on the geological map I marked them with the signature of the intrusions. The same may be said of the large stripe of porphyrite N. and E. of the Seroe Corra and including this hill.

Remarkable are the numerous small outcrops of porphyrite SE. of the Seroe Pietji Lang. These may be necks, but I am inclined to think that they once formed, together with the Seroe Pietji Lang itself and with the porphyrite outcrop NW. of the Seroe Pietji Lang, an extensive coherent intrusive mass of porphyrite, which has been largely dissected by subsequent erosion. The same may be said of the Seroe Bezoe and its northwestern prolongation.

As has been mentioned already (p. 14), the intrusive porphyrites resemble the ordinary Washikemba porphyrites in every respect. The rock examination in the laboratory cannot tell us anything about the geological nature of the rock; we must entirely rely on the field data.

CORRELATION OF THE WASHIKEMBA FORMATION WITH ROCKS OF ADJACENT REGIONS.

It is not my intention to give here a detailed summary of the occurrence of late-cretaceous volcanic rocks in the West-Indies, their points of resemblance with and divergence from the Washikemba formation. Giving such a summary would be totally unnecessary because the occurrence of late-cretaceous volcanic rocks on several Antillean islands and their relationship have been given several times by authors. Such rocks have become known from Curaçao, Aruba, Cuba, Haiti, San Domingo, Jamaica, Porto Rico, the Virgin Islands, St. Croix, St. Barts, St. Martin, ? Anguilla, ? St. Kitts. Possibly the igneous basement of the isle of Antigua (up to now considered as being of eocene age) is also the result of cretaceous volcanic activity. Cretaceous sediments from Antigua have been described recently by CUSHMAN (lit. 7). The connection between this Cretaceous (foraminifera bearing chalk) and the igneous basement is not known. At any rate it is important that Cretaceous has become known on Antigua. There is a great similarity of rocks from the igneous basement of Antigua with some Washikemba rocks, as is illustrated by a description of rocks of the igneous basement of Antigua, given by K. W. EARLE (lit. 10).

The co-occurrence of diabases, porphyrites, tuffs, clastic volcanic rocks and cherts with intercalations of limestones on Bonaire is very characteristic of late-cretaceous volcanic formations in the West-Indies. Blue beach rocks, so common and wide-spread on Antillean islands, occur also on Bonaire. They are my porphyrite and diabase breccias. Intercalations of limestones are a common phenomenon. Cherts have become known from Porto Rico, San Domingo, chert breccias from St. Barts, jasper from Porto Rico. For several islands it is proved that the volcanic series under consideration is of late-cretaceous age. Cherts only occur in the Cretaceous throughout the West-Indies. In Venezuela too the cherts are Cretaceous (Cogollo—La Luna series). The resemblance of these cherts with those of the Knip beds on Curaçao and of the Washikemba formation is striking.

If we did not have a paleontological prove for the cretaceous age of the Washikemba formation, the similarity of the Washikemba rocks with rocks of cretaceous formations in adjacent regions would be a very strong argument for the cretaceous age of the Washikemba formation.

We shall occupy ourselves a little longer with the relation of the Knip beds on Curaçao with the Washikemba formation, because it is, as a consequence of the situation of Curaçao with regards to Bonaire, of more importance.

Without doubt there are many common features in the oldest formations of both islands. Diabases, diabase porphyrites, diabase tuffs, cherts, radiolarites, quartz porphyrite crystal tuffs, porphyrite crystal tuffs, porphyrite tuffs, crystal tuffs, jasper (lit. 32), limestones (lit. 47), calcareous crystal tuffs (lit. 36) occur on both islands in the respective formations. The diabase of Curaçao is older than the Knip beds. Diabase tuffs are the oldest rocks of the Knip beds. Likewise the diabase and diabase tuffs of the Washikemba formation predominate in the lower parts of the formation. The constitution of the Curaçao diabases agrees quite well with that of the Bonaire diabases. Quartz diabases seem to be rare on both islands.

However, there are several differences between the formations in question of the two islands. I set the highest value on the following differences:

1. the probable absence of lavas in the Knip beds;

2. the occurrence of tuffites in the Knip beds, which fail in the Washikemba formation;

3. the occurrence of foreign material in the Knip beds (see VERMUNT and RUTTEN); on Bonaire foreign material does not appear before the Rincon formation;

Especially 2 and 3 are of importance. They point out that during the sedimentation of the Knip beds and the Washikemba formation the geological facial circumstances were very different for Curaçao and Bonaire. The connection with the continent that was accomplished for Bonaire during Rincon time must have been brought about on Curaçao much earlier.

The facts that lavas are absent in the Knip beds and that tuffites, apparently with rounded detritical enclosures of the same material that has built up the tuffs, do occur, is very remarkable. The tuffites point to nearness of land, land that was overflowed by torrents of lavas. These torrents, however, could not reach the region where the Knip beds were deposited. On Bonaire the conditions were quite the inverse. Here tuffites are failing, but still we find lava flows between the tuffs.

Differences of minor importance are:

4. the place taken by the diabase on Curaçao and on Bonaire: on Curaçao the diabase does not form part of the Knip beds, on Bonaire the diabase is an integral part of the Washikemba formation, it is found as far as the highest parts of the formation. However, I stated already that diabase is most abundant in the lower parts of the Washikemba formation, in this respect showing some resemblance with the situation as it is on Curaçao. Moreover, diabase tuffs occur in the lower Knip beds.

5. the thicknesses of the Knip beds and the Washikemba formation are very different. While the Knip beds get at their utmost a thickness of some hundred meters (see VERMUNT and RUTTEN), the Washikemba formation is several thousands of meters thick, consequently deposited under distinct geosynclinal conditions.

6. the tuffs of the two islands only show a rough and general resemblance. In the field there is often a good likeness and the tuffs agree as far as they have been derived on both islands from a gabbroid, resp. dioritic magma. However, the diabase tuffs of Curaçao contain green hornblende, which was not found in the diabase tuffs of Bonaire. The hornblende in the latter ones might have been chloritized, but then it must have been present in the diabases too and it is not probable that it should not have been preserved in a single tuff or diabase. Moreover, why should it have been chloritized on Bonaire and not on Curaçao.

I had the opportunity to occupy myself before with the porphyrite tuffs from Curaçao, when giving some remarks on the geology of Ronde Klip (E. Curaçao) (lit. 36). I then found that:

a. the minerals in the Curaçao tuffs are more diversified, being plagioclase. quartz, hornblende, pyroxene, mica;

b. quartz is generally more abundant in the Curaçao tuffs than it is in the Bonaire ones;

c. the crystal enclosures in the Curaçao tuffs are more abundant;

d. the quantity of remains of organisms is generally greater in the Curaçao tuffs.

From the descriptions of tuffs given by G. J. H. MOLENGRAAFF one can read that *a.* is valid for whole Curaçao.

CHAPTER III

INTRUSION OF A PORPHYRITIC QUARTZ HORNBLENDE DIORITE DIKE.

To the W. of the Seroe Grita Kabai an intrusion of a porphyritic quartz hornblende diorite is exposed (B. 696, D. 12442, B. 112, D. 12448). It is a weathered grey to greenish grey rock; with the naked eye quartz, feldspar and a ferro magnesium mineral are recognizable. The rock is fine to medium grained; most crystals do not exceed 1 mm., in places larger crystals occur, up to 5 mm. In rock sample No. B. 696 one gets the impression that scarce phenocrysts of ferro magnesium minerals are present. In the corresponding section (D. 12442), however, no phenocrysts can be observed: the rock appears to consist of a hypidiomorphic tissue of feldspar, hornblende and quartz, with some granules of magnetite, some needles of apatite and with secondary minerals. The feldspar is the most common constituent, next to the feldspar hornblende is commonest. The feldspar is albite, albite oligoclase and a small quantity of ? orthoclase. The feldspar is usually prismoid, partially twinned, dusty and in places chloritized or sericitized. Enclosures in the feldspar are needles of apatite. The hornblende is pleochroitic: almost colourless to green; full of cracks and in places chloritized. Enclosures in the hornblende are apatite and magnetite. The quartz is predominantly xenomorphic with enclosures of apatite and of liquid matter.

The feldspar is clearly of the same date as the hornblende; the quartz is partly of later date than the feldspar and the hornblende, partly of the same date: granophyric intergrowths of quartz and feldspar are rather common. The other section (D. 12448, of rock number B. 112) is almost alike the first one, the only difference being the appearance of scarce phenocrysts of acid plagioclase, up to 2,5 mm is length.

The discovery of this veinrock on Bonaire is very interesting. It has nothing to do with the other intrusive porphyrites, in fact it is a rock different from any Washikemba rock. In order to find comparable rocks we must go to Aruba and Curaçao. WESTERMANN pointed out that the diorite dikes of Aruba belong to the batholith of quartz diorite and that the diorite porphyrites of Curaçao may be derived from the same batholith, as well as the diorite dike of Bonaire. (lit. 52).

This very coherence is the interesting point of the find of the quartzhornblende diorite of Bonaire.

It connects Bonaire petrographically with Aruba. For details I can entirely refer to the paper of J. H. WESTERMANN (lit. 52).

CHAPTER IV

THE RINCON FORMATION.

The formation consists of limestones, conglomeratic limestones and conglomerates, most of which are exposed W. and SW. of the village of Rincon. Beside the area W. and SW. of Rincon outcrops of the formation occur in the village itself and in some areas more to the SW. (SE. of the Seroe Dochila). Moreover some limestone outcrops near the Mangasina di Rey (ENE. of Rincon) can be reckoned to the formation. The limestones contain a great many, generally ill-preserved fossils; gastropoda, lamellibranchiata, two specimens of a nautiloid, corals, foraminifera and lithothamnia.

The following forms could be recognized:

Nerinea sp.
Ostrea sp.
Hercoglossa sp.? cf. *ulrichi* White.
Diploctenium sp.
Eugyra sp.?
Orbicella sp. A.
Orbicella sp. B.
Palaeopsammia sp.
Siderastrea sp., ? cf. *hilsboroensis* Vanghan.

An indeterminable solitary coral which is most likely a new species belonging to the family of the Turbinolidae but which is not sufficiently preserved to describe under a new name will be discussed on p. 77.

The foraminifera mostly belong to the Miliolidae, beside which *Textularia*, *Globigerina*, *Globotruncana*, *Operculina*, *Orbitoides* and Rotalidae-like forms were found. As the foraminifera could only be examined in slides it is impossible to give accurate determinations.

In many slides sections of foraminifera occur which give strongly the impression of *Nummulites* species. I am of the opinion that we have to do here with nummulitiform *Operculinas*. Finds of *Nummulites sp.* have been mentioned by Bela Hubbard and (with a ?) by E. T. Hodge from the Cretaceous of Porto Rico. It is of some interest to draw the attention to the fact that also in these cases the fossils may be nummulitiform *Operculinas*, so that the occurrence of *Nummulites* in the Cretaceous of the West-Indies is not yet certain at all.

The occurrence of a *Nerinea sp.* points to Cretaceous, those of *Diploctenium* and *Palaeopsammia* to Upper Cretaceous.

The genus *Hercoglossa* in America points to Upper Cretaceous or Eocene. The fact that the Bonaire species is closest to two eocene forms (*H. ulrichi* and

H. peruviana; see p. 80) should indicate Eocene. However, the species is too deplorably preserved to set much value to the determination. In connection with the above mentioned and with the following, we can say that the occurrence of *Hercoglossa sp.* fortifies an uppermost cretaceous age of the Rincon formation.

The Rincon formation lies unconformably upon the Washikemba formation. The strata of the Rincon formation exhibit rather inconsequent strikes, but mainly running parallel to the strikes of the Washikemba formation, with low dips to the NE. and E. [1]. In places higher dips were found (40°—60°). The unconformity of the Rincon formation and Washikemba formation results from the occurrence of pebbles of Washikemba rocks in the conglomeratic Rincon rocks and from the gentle dipping of the Rincon strata. At one place on the old road from Rincon to Dos Poos, ca. 700 m.W. of Rincon we were able to see the plain of unconformity (it was hidden under soil and plantgrowth, but could easily be made visible by taking away about 2 dm. of the covering soil). As the Rincon formation is younger than the upper cretaceous Washikemba formation I consider the Rincon formation to be Uppermost Cretaceous. The formation reaches a thickness of about 200 m.

The limestones are for the greater part hard, dense rocks, mainly brown, greyish brown or greenish brown coloured, occasionally with green or greyish green colour.

Some limestones contain numerous rock and crystal enclosures, generally together with a great many chlorite aggregates. The rock enclosures are Washikemba rocks: cherts, diabases, diabase porphyrites, porphyrites, tuffs. The crystals and crystal fragments are chiefly plagioclase (albite to labrador; most occurring is andesine) and quartz. Besides ore (magnetite) also occurs. A part of the chlorite aggregates is due to chloritization of enclosed eruptive rock fragments. In a former paper (lit. 38) I considered the crystals as being of tuffaceous origin. However, both rounded off and angular crystals occur. Moreover no predominating tuffaceous rocks are known of the Rincon formation. At present I am of the opinion that the crystals are not of tuffaceous origin, but that they are all derived from eroded Washikemba rocks.

The amount of crystals and of small rock fragments in the Rincon rocks can become so great that we can almost speak of calcareous sandstones or calcareous micro-conglomerates.

Other limestones contain very few or no enclosures. Those latter limestones generally contain a great number of foraminifera, so that we can even distinguish *Globigerina* bearing limestones and Miliolidae bearing limestones. Limestones with Miliolidae in abundance were found e.g. at the Mangasina di Rey. On the whole the limestones of the Mangasina di Rey are poor in crystal and rock enclosures. Also the coral bearing limestones generally contain only small enclosures.

The pebbles of the conglomeratic limestones and conglomerates consist for the greater part of Washikemba material: cherts, diabases, porphyrites, diabase

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[1] In a former paper (lit. 38, p. 705) I spoke of a predominating N. dip; this is not correct and must be NE. and E. dip.

porphyrites, tuffs (partly silicified), chloritized and limonitized eruptive rock fragments. Besides pebbles of rocks which are foreign to the isle of Bonaire were found. These are granodiorites and granodiorite aplites.

Granodiorites. Medium to coarse grained, lightly coloured rocks, with rather fresh habit and the structure of a granite. In most of the granodiorites quartz is abundant. In nearly all cases a great quantity of albite is present, together with orthoclase and with oligoclase and often with a granophyric intergrowth of quartz and feldspar. The feldspar may be more or less idiomorphic and is often strongly sericitized, in places chloritized and epidotized. Biotite is occasionally present. Other ferro-magnesium minerals are either failing or altered into chlorite and epidote. Magnetite in small quantities never fails. Accessories are apatite, titanite and zircon.

Granodiorite aplites. These rock differ from the granodiorites by a less pronounced crystallization sequence. Partially the granodiorite aplites are finer grained than the granodiorites. I must observe, however, that there are transitions between the two kinds of rocks and that it is difficult in certain cases to say whether the rock is a granodiorite or a granodiorite aplite. In those cases we can speak of aplitic granodiorites.

The origin of the foreign pebbles will be discussed on p. 37 together with the foreign pebbles of the Soebi Blanco conglomerate. To the W. of the village of Rincon MARTIN has found a conglomerate with porphyry (? porphyrite) enclosures and a calcareous cement. This rock may belong to the Rincon formation.

The only formation with which we can compare the Rincon formation is the Seroe Teintje limestone on Curaçao.

Prof. GERTH ascribes a lower-senonian age to the Seroe Teintje limestone but he could not give an exact age on the strength of the data that were accessible to him (lit. 13). MAC GILLAVRY considers it to be Campanian or Maestrichtian (lit. 25). I favour the view of MAC GILLAVRY who had more and new material at his disposal. It is not of great importance that till now there have not been found rudistids in the Rincon formation. A more important difference between the two formations is that in the Seroe Teintje limestone does not occur foreign material. This, however, has nothing astonishing.

CHAPTER V

THE SOEBI BLANCO CONGLOMERATE.

In general the pebbles in the various "rooien" of Bonaire turned out to consist of ordinary Washikemba rocks, in places mixed together with quaternary limestones. The pebbles of the "rooien", lying N. and S. of the Seroe Largoe or Montagne (E. Bonaire) form a curious exception, however. A part of the material in the mentioned "rooien" consists of Washikemba rocks and quaternary limestones, but the greater part of these pebbles are entirely different from any Bonaire rocks. The foreign pebbles were also found on the W. slope of the Seroe Grandi (E. Bonaire), but here they are not so numerous.

The foreign pebbles are generally more rounded and partly they have greater dimensions than the pebbles of the Bonaire rocks. Dimensions of 10 cm. are not rare; the biggest surpass 12,5 cm. We do not know the primary origin of the foreign rocks. Some suggestions about their origin will be given in the following. But still we know a secondary deposit of the foreign rocks on Bonaire. To the N. and S. of the easternmost part of the Seroe Largoe limestone (quaternary limestone), we find several outcrops of a conglomerate, which has a calcareous cement and the pebbles of which consist for the greater part of foreign rocks: the Soebi Blanco conglomerate. The outcrops of the conglomerate are distributed over three regions, which together do not exceed an area of about half a square km. We may be sure, however, that the extension of the Soebi Blanco conglomerate is, or was, very much greater, because we find the same pebbles, as was said before, in all the "rooien" N. and S. of the Seroe Largoe (E. Bonaire), from Gabilan to the E. and from Terra hoendoe to the NE. as far as eastward of the Coeroe Boeroe Plantation. Again SE. of Coeroe Boeroe they were found on the slope of the Seroe Grandi (E. Bonaire). Moreover the same pebbles have been found in the basal conglomerate of the quaternary Seroe Largoe limestone, and on the slope of the Seroe Grandi there were found pebbles of a quaternary conglomeratic limestone (probably part of the basal conglomerate), containing small foreign pebbles. Quaternary limestone does not occur in situ on the Seroe Grandi. In the basal conglomerate of the Seroe Largoe limestone the foreign pebbles are exposed, with interruptions, over a distance of more than 6 km., according with a surface of at least 4 square km. It is impossible that all of those pebbles should originate from the little areas N. and S. of the easternmost part of the Seroe Largoe (fig. 5).

Fig. 5.

The remarkableness of the pebbles is that the Washikemba and Rincon rocks have little share in them: most of them are granodiorites and granodiorite aplites, gneisses, quartzites and some other rocks, which for the rest do not occur on Bonaire.

Foreign pebbles have also been mentioned from the Rincon formation, but their occurrence in the Rincon formation differs in some regards from that in the Soebi Blanco conglomerate:

1. the percentage of foreign pebbles in the Soebi Blanco conglomerate is much greater than in the Rincon formation,

2. the foreign pebbles in the Soebi Blanco conglomerate are, generally speaking, much bigger than those in the Rincon formation,

3. more kinds of rocks are known from the Soebi Blanco conglomerate; this will become clear from the list of foreign rocks that will be given in the following.

The strike of the Soebi Blanco conglomerate obviously differs from the strikes of the older formations, being EW.; the strata generally show a low dip to the N. In places nearly vertical strata have been found. Fine exposures of low N. dipping strata can be seen N. of the easternmost part of the Seroe Largoe; vertical strata are in places exposed S. of the Seroe Largoe.

The deviation of the horizontal plane of the Soebi Blanco strata must be considered rather as a result of faulting with drag dip than as a real folding. The conglomerate may attain a thickness of about 400 m, an exact value cannot be given.

The greater part of the rocks of the following list has been given already in my "The occurrence of foreign pebbles on the isle of Bonaire" (lit. 34). The list has been enlarged with rocks of the GRUTTERINK collection.

1. *Granodiorites*. These rocks do not differ from those described from the Rincon formation (see p. 32).

2. *Granodiorite aplite*. Medium grained, slightly pressed rock, chiefly consisting of plagioclase and quartz. Feldspars: acid plagioclase, microcline microperthite and orthoclase. The quartz has undulose extinction. Some biotite, muscovite and magnetite occur. Secondary minerals are epidote and chlorite.

3. *Plagiaplite*. Distinct aplitic rock, for the greater part consisting of albite and oligoclase, with a few orthoclase and quartz and some ore (ilmenite). In places the feldspar has been changed into sericite or epidote. Some chlorite points probably to modified ferromagnesium minerals. The constitution of the feldspar places this rock among the plagiaplites in the vicinity of the diorite-aplites; its scarcity of ferro-magnesium minerals, of quartz and of ore give it more resemblance with the albitites.

4. *Albiteaplites*. Medium to coarse grained rocks, principally consisting of quartz and acid plagioclase, with frequent granophyric intergrowth. The plagioclase is chiefly idiomorphic and hypidiomorphic, the quartz chiefly xenomorphic. Some magnetite is present. Secondary minerals: epidote, chlorite, calcite (aggregates in places with crystal shape: hornblende?).

5. *"Breccious aplites"*. Under this name I have taken together some rocks in which quartz and feldspar (plagioclase) predominate or in which quartz predominates and which rocks show a distinct gneissose or breccious structure. The granulation of these rocks is highly varying, even in the same rock: feldspar and quartz partly occurring in small crystals and fragments of crystals, partly in large crystals.

In all these rocks the quartz possesses strong undulose extinction and is cataclastic; the plagioclase often has bent and broken twins. Some of these rocks give the impression of a graywacke-quartzite, but the angular hypidiomorphic feldspar crystals and the way of intergrowth of feldspar and quartz can leave no doubt that the rocks in question are gneissose or brecciated eruptive rocks. The feldspar can be strongly sericitized. Other occurring minerals are biotite (large pressed crystals), magnetite, chlorite, epidote.

6. *Gneisses*. Medium to fine grained rocks with more or less pronounced gneissose appearance and texture. The feldspars can be orthoclase, microcline, microperthite, microcline microperthite, acid plagioclase (mostly being albite and oligoclase; in some gneisses also andesine is abundant). In some gneisses myrmekite was found. The feldspars, especially the plagioclase, are frequently altered, usually into sericite and zoisite. Other occurring minerals are quartz, biotite, muscovite, sericite, pyroxene, amphibole, magnetite, ilmenite, pyrite, haematite, titanite, apatite, zircon. With the exception of biotite and sericite, these components are present in nearly all cases in small quantities and even biotite and sericite rarely occur in greater quantities. Generally the biotite is completely chloritized, occasionally epidotized. The greater part of the gneisses has been exposed to great pressure; the quartz possesses strong undulose extinction and is cataclastic; the plagioclase has bent and broken twins; the biotite has been pressed between the other minerals; occasionally the whole rock is cataclastic.

Following gneisses could be distinguished:

Microcline gneiss. Striking in these gneisses is the small quantity or failing of ferromagnesium minerals.

Plagioclase gneiss. Some of these gneisses are strongly cataclastic. They are rich in sericite. One of them shows fine ,,Schachbrettstruktur" in the feldspars.

Microcline plagioclase gneiss. Parallel structure fails in these gneisses. Without doubt they are orthogneisses.

Albite gneiss.

Albite microcline gneiss.

Breccious diorite gneiss. This rock resembles the breccious aplites, but it has a pronounced gneissose structure.

Hornblende gneiss. This gneiss contains very few quartz crystals.

7. *Zoisite quartz feldspar schist.* The chief components of this rock are quartz, feldspar, mica's and zoisite. The feldspar is principally acid plagioclase; the mica's are muscovite and chloritized biotite. This rock was also exposed to high pressure, in such degree that it has almost obtained a mortar texture.

8. *Quartzites.* Generally rather fresh, fine grained rocks. Some quartzites are medium to coarse grained. Beside quartz the quartzites can contain some acid plagioclase, biotite, sericite, ore, chlorite, calcite, bituminous matter.

9. *Graywacke quartzite.* Quartz largely predominates in this rock, next to which a considerable quantity of acid plagioclase, microperthite and sericite has been found. Furthermore ore, zircon, apatite and some chert inclusions occur.

10. *Quartz epidote rock.* Strongly altered rock, consisting of epidote and quartz. The quartz forms, as it were, a fine grained matrix between the epidote, the latter occurring in more or less globular aggregates.

11. *Polygeneous conglomerate.* In a graywacke-like matrix, chiefly containing quartz, with acid plagioclase and mica, there occur small pebbles of quartz, quartzite, chert and plagioclase gneiss. As it is almost certain that the chert is derived from the Washikemba formation, perhaps the quartz too, foreign pebbles and Washikemba material must have been consolidated to a conglomeratic rock and very shortly after this portions of this conglomerate must have been taken up in the Soebi Blanco conglomerate.

12. *Silicified mica bearing shale.* Fine grained, stratified, brown rock with small crystals of quartz, plagioclase and mica (muscovite and biotite). In my "The occurrence of foreign pebbles on the isle of Bonaire" I allowed for the possibility that this rock should belong to the Washikemba formation. By this time I am able to say that this is certainly not the case. The rock may be compared with similar rocks from the Midden Curaçao strata on Curaçao, although silicification of rocks of the Midden Curaçao strata is not known.

13. *Amphibolite,* with vein of quartz diorite and vein of epidote. Similar rocks have been found on Aruba; in fact the rock under consideration is quite identical with certain amphibolites described by WESTERMANN. I shall return to this amphibolite when discussing the origin of the foreign pebbles.

14. *Uralite diabase porphyrite.* A very fine grained holocrystalline diabase porphyrite. The rock has been subject to strong uralitization, in places some pyroxene has been preserved. Diabases with a small quantity of uralite have been found as an exception in the Washikemba formation, but rocks comparable with the uralite diabase porphyrite in question are not known. It is possible that this rock belongs to the Washikemba formation; to my opinion it is foreign.

In places finer grained sediments occur in the Soebi Blanco conglomerate, being conglomeratic calcareous sandstones, with mineral and rock enclosures: quartz, feldspar (acid plagioclase), magnetite, mica, chert, diabase, quartzite.

Beside the rocks, to which I referred, rocks of the Washikemba and Rincon formations occur among the pebbles of the Soebi Blanco conglomerate. The Washikemba rocks are represented by diabases, porphyrites, quartzporphyrites, tuffs, cherts, jaspers and radiolarites; with respect to a pyroxene porphyrite that has also been found, we have no evidence that it belongs to the Washikemba formation, because pyroxene porphyrites have not been found as solid rock. The Rincon rocks are represented by conglomeratic limestones and a lithothamnium bearing limestone.

The Rincon formation and the Soebi Blanco conglomerate correspond in being both conglomeratic and both containing foreign material. The differences are: the Rincon formation is only partially conglomeratic, the pebbles are smaller than those of the Soebi Blanco conglomerate and chiefly consist of Washikemba material; the Soebi Blanco conglomerate is almost entirely conglomeratic, there is more diversity among the foreign pebbles and the percentage of the Washikemba material among the pebbles is decidedly smaller than that of foreign material.

What has been said about tuffaceous material in the Rincon formation also applies to the Soebi Blanco conglomerate: here too I must repeal my view that tuffaceous material is present.

The age of the Soebi Blanco conglomerate cannot be fixed with certainty. No trace of fossils has been found in it. The conglomerate is younger than the Rincon formation, which is uppermost Cretaceous. It is older than the upper eocene limestones, by which it is covered unconformably. This follows from the situations as seen NW. of Terra hoendoe and E. of Gabilan. NW. of Terra hoendoe there are approximately horizontal upper eocene limestones. In the hillside waste E. of these limestones foreign pebbles occur. The outcrops of the Soebi Blanco conglomerate E. of the limestones show low N.dipping strata, common to the conglomerate. E. of Gabilan we see foreign pebbles in abundance on the hillsides and in the "rooien" N. and E. of the limestones. These limestones are partially Upper Eocene.

As to the origin of the foreign pebbles nothing is known, we can only presume, but nothing can be said with certainty.

The degree of rounding of the pebbles may be due to long transport, in that case pointing to remote origin, but likewise it may be the result of wave action before definite cementing in the conglomerate.

So far as the metamorphic rocks are concerned we know metamorphic rocks in adjacent regions from the Greater Antilles and from the Caribbean Coastrange in Venuzuela. In connection with the situation of the Greater Antilles and Venezuela with regard to Bonaire, it is more likely that the metamorphic rocks among the Soebi Blanco pebbles originated from the Venezuelan Coastrange. Prof. RUTTEN described some rocks from the Caribbean Coastrange, collected during our journey (lit. 39); he also took the origin of the Soebi Blanco pebbles under consideration. He came to the conclusion that the gneissic rocks, occurring as pebbles on Bonaire may have been derived from the Venezuelan coastrange and more especially from the hinterland of Puerto Cabello. As to the origin of the quartzites we cannot get any evidence.

The granodiorites and aplites of the Soebi Blanco conglomerate agree well with some rocks from Aruba. The same can be said of the amphibolite. From a description of rocks from the Venezuelan islands between Bonaire and Trinidad by Prof. RUTTEN (lit. 40) we can draw the conclusion that comparable rocks occur on Los Roques (aplitic granites, l.c.p. 1103) and Blanquilla (biotite granodiorite, l.c. p. 1104). Biotite granodiorite is also known from Venezuela (l.c. p. 1109). The intrusions of granodiorite and of aplite on Aruba are probably more or less synchronical with the intrusions on Curaçao, which partly are younger than the Midden-Curaçao strata. Dr. TRECHMANN examined some fossils from the Midden-

Curaçao strata, collected by us in E.Curaçao. On the strength of some of these fossils he thought it most likely to be of eocene age. If this determination is exact, then there is some probability too that the intrusions on Aruba are younger than the Rincon formation and than the Soebi Blanco conglomerate. The same can be said of the amphibolite, because the metamorphism of the Aruba metamorphic rocks most likely took place at the same time.

It is to regret that no more is known about the rocks occurring in NW. Venezuela (between Puerto Cabello and the Gulf of Venezuela). All speculations about the origin of the foreign pebbles must remain hypothetical. We can only say that rocks, comparable with some of the foreign pebbles on Bonaire, are known to occur in the neighbourhood of Bonaire, which was a priori to be expected, and that the pebbles with most probability have originated from Venezuela or, perhaps partially, from somewhere W., S. or E. of Bonaire. In the first case we must assume a connection between Venezuela and Bonaire, in the second case there must have been at least a considerable landmass in the vicinity of Bonaire, of which Bonaire, anyway the "Bonaire" of Soebi Blanco and Rincon time, made up a part.

The tectonical complications with which we have to reckon in those times will be discussed in Chapter VIII.

I must call attention to one thing yet. In the collection of Dr. Boldingh two samples of "foreign rocks" from Bonaire occur, a gneiss and a gneissose granite. The rocks are labeled; ,,Karpat Bonaire". Probably they were collected on the beach at Karpat. They differ distinctly from the pebbles of the Soebi Blanco conglomerate:

1. their habit is entirely different; 2. the gneiss texture of the gneiss is more pronounced than in any of the Soebi Blanco gneisses; 3. mica is more numerous and is fresher; 4. the conservation of the rocks is better than of any of the Soebi Blanco rocks; 5. they are not rounded off.

One should be careful not to confound these or similar rocks with the Soebi Blanco rocks: the former have no relation at all with the geology of Bonaire; probably they were brought to the island from Venezuela on board sailing vessels as ballast and thrown ashore. During our visit we saw such rocks on the beach in Slagbaai; here it were angular, unweathered, big cobbles of amphibolite, in every respect different from whatever Bonaire rock.

CHAPTER VI

UPPER EOCENE.

In all probability the Upper Eocene on Bonaire had a great extension. There are two facts pointing to that. The first is the occurrence of generally small patches of eocene deposits at several, relatively remote places. They were found SW. of the Seroe Montagne (W. Bonaire), at three places S. and SW. of the cirque of Rincon (at Punta Blanco and SW. of it), in the waste on the hill side SE. of Seroe Dochila, at several places in the N.part of the Columbia Plantation (between Fontein and Morèke) and finally NW. of Terra hoendoe. The second fact is the wanting of terrigenous material in the upper eocene rocks, which makes it almost certain that the entire northern part of Bonaire was covered at the time by the eocene sea.

The Upper Eocene is represented by limestones and a foraminifera marl. The extensiveness of the limestones is certainly larger than has been marked on the geological map. The reason is that the upper eocene limestones can only be distinguished from some of the quaternary limestones by the presence of characteristic fossils. Now one sees in several places eocene, foraminifera bearing limestones interchange abruptly or gradually with uninforming fossil-less or lithothamnia bearing limestones. Thus in many cases one cannot say whether these limestones are Quaternary or Tertiary. Only localities of doubtless tertiary limestones have been marked on the geological map. An eye cast on the map will make it probable for the extensiveness of those limestones to be larger.

Data about the situation of the Eocene could only be obtained in the region SW. of the Seroe Montagne. There we found an EW. strike of the strata with a low dip to the S. (15°—30°).

Of all the formations on Bonaire the Upper Eocene is richest in fossils. The area SW. of the Seroe Montagne (W.Bonaire) yielded most of the echini and so called "larger" foraminifera. We owe the discovery of this rich locality to a small nigger boy Aloysius, who had found some fossils there and brought them to our camp in Dos Poos. There could be distinguished two zones in this region: a lower zone characterized by a species of large lamellibranchiata, which could not be determined more exactly as only internal casts have been found, and an upper zone containing echini and larger foraminifera.

In the areas S. and SW. of the cirque of Rincon echini were found, in the N.part of the Columbia Plantation and NW. of Terra hoendoe larger foraminifera. Other fossils found in the upper eocene limestones are corals, mollusks, a *Terebratula*, a decapod. Of the material that allowed determination a list will be given below and, as far as necessary, descriptions will be given in Chapter X: Paleontology.

The echini bearing limestones are generally beige to light brown rocks, the foraminifera bearing limestones are light brown or they have the colours of the quaternary limestones: white, pink, grey, yellowish, brown.

In a limestone, which he considered to be quaternary, MARTIN has found fragments of foraminifera, which he thought to belong to the genus *Orbitoides*. He supposed the foraminifera fragments to be of cretaceous age and to have drifted into the quaternary limestone. We may be sure that MARTIN has found an eocene limestone.

List of fossils found in the upper eocene limestones.

Foraminifera.

Lepidocyclina (*Lepidocyclina*) *r. douvillei* Lisson 1921
,, ,, *hieronymi* (M. Rutten & Vermunt 1932)
,, ,, *schotborghi* M. Rutten & Vermunt 1932
,, ,, *trinitatis* H. Douv. 1917
,, (*Helicolepidina*) *spiralis* Tobler 1922
Lepidocyclina sp. sp.
Discocyclina (*Asterocyclina*) *aurarensis* Hodson 1926
,, ,, *bontourana* Hodson 1926
,, ,, *georgiana* Cushman 1917
,, ,, *sp. sp.*
Operculina curasavica M. Rutten & Vermunt 1932
,, *nummulitiformis* L. Rutten 1928
,, *bonairensis n. sp.*
,, *sp.*
Nummulites vanderstoki M. Rutten & Vermunt 1932 (In lit. 62, p. 239 this species was called by error *N. caribensis*).
Nummulites sp.

Echinoidea.

Cidaris melitensis Forbes 1855
Bonaireaster rutteni n. gen. n. sp.
Amblypygus cf. *merrilli* Twitchell 1915
Pauropygus ovum serpentis (Guppy 1866)
Antillaster sp.
Brissoides (*Rhabdobrissus*) *aloysii* n. sp.
Maretia sp.
Agassizia conradi (Bouvé 1851)
,, *sp.*, cf. *conradi* (Bouvé 1851)
Prenaster jeanneti n. sp.
Moira sp.
Schizaster sp., cf. *subcylindricus* Cotteau 1875
,, *gerthi* n. sp.

Lamellibranchiata.

Pholadomya trechmanni n. sp.

Brachiopoda.

Terebratula bonairensis n. sp.

Corals.

Astrocoenia cf. *portoricensis* Vaughan 1919
Turbinaria sp.

Vermes.

Serpula clymenioides Guppy.

The occurrence of *L. r. douvillei*, *L. trinitatis*, *H. spiralis*, *Discocyclina*, *O. nummulitiformis*, *Nummulites*, *Serpula clymenioides* point to Eocene; *Agassizia conradi* is in the West Indies only known from the Eocene; *Amblypygus merrilli* is an upper eocene species; the occurrence of *L. hieronymi*, *L. schotborghi*, the subgenus *Asterocyclina*, *O. curasavica* point to Upper Eocene. *Pauropygus ovum serpentis* is known from the Eocene and from the Oligocene; *Cidaris melitensis* has become known hitherto from the Oligocene and from the Miocene. *Schizaster subcylindricus* is an eocene species. *Astrocoenia portoricensis* has only been found hitherto in the Oligocene (see p. 77). As the Bonaire species was found in a region with exclusively eocene rocks, I also consider it to be of eocene age. Comparing the Bonaire fauna of larger foraminifera with Table I of GORTER and VAN DER VLERK (lit. 60) and retaining the old "margin" of Eocene and Oligocene, the tertiary limestones of Bonaire get approximately a middle-upper eocene age. If we place this margin at the Paloma alta-series as is proposed in the mentioned paper, then the Bonaire limestones are transitional between Oligocene and Eocene. The same can be said of the Seroe di Cueba limestone on Curaçao, although that limestone may be slightly older.

The foraminifera marl was found in a newly dug draw-well near Porta Spaño (NW. part of the Columbia Plantation), at ca. 15 m. depth. The well was dug in quaternary limestones, which cover the marl. The locality has been marked on the geological map with a special signature. The foraminifera marl is a grey coloured, soft rock. It yielded a large fauna of so called "smaller" foraminifera and some ostracoda.

Most likely the marl is slightly older than the upper eocene limestones: at a distance of 600 m. upper eocene limestones, lying ca. 50 m. higher, were found; at a distance of 850 m. upper eocene limestones, lying 35—40 m. higher, occur. We can get no certainty, however, because nothing is known about the position of the strata in this region.

Little can be said about the thickness of the upper eocene limestones. Probably they do not attain a considerable thickness. About the thickness of the marl nothing is known.

List of foraminifera found in the upper eocene marl.

Textularia mexicana Cushman. Few.
,, *martini* n. sp. Common.
Textulariella barrettii (Jones & Parker)? Common.
Vulvulina molengraaffi n. sp. Rather common.
Gaudryina bonairensis n. sp. Few.
Tritaxia cognata (*Verneuilina* Rss.) Few.
,, *schotborghi* n. sp. Rather common.
Triloculina sp. Very rare.
Cristellaria (*Planularia*) *thalmanni* n. sp. Rather common.
,, ,, ,, var. *portaspañoensis* n. var. Rather common.
,, ,, *thalmanni* var. *costata* n. var. Rather common.
,, ,, *subminuta* n. sp. Rare.
,, ,, *kochi* n. sp. Few.
,, ,, *westermanni* n. sp. Few.
,, ,, *sp.*, juv. of *C. thalmanni* n. sp. Rare.

Cristellaria (*Planularia*) *sp.*
,, (*Robulus*) *cultrata* (Montf.). Common.
,, ,, *curvisepta* Seg. Few.
,, ,, *inornata* d'Orb. Common.
,, ,, *mexicana* Cushman, juv. Rare.
,, (*Saracenaria*) *acutauricularis* Fichtel & Moll. Few.
,, ,, *vermunti* n. sp. Few.
,, ,, *macgillavryi* n. sp. Rare.
,, ,, *sp.*
,, ?*schloenbachi* Rss., anomalous specimen.
Frondicularia tenuissima Hantken. Rare.
Glandulina discreta Rss. Common.
,, *globulus* Rss. Few.
,, *laevigata* d'Orb. Rather common.
,, *strobilus* Rss. Rather common.
Nodosaria acuminata Hantken. Few.
,, *globifera* Rss. Few to rather common.
,, *radicula* (L.). Rather common.
,, *subnitida* Nuttall. Few.
,, *vertebralis* (Batsch). Few.
,, *rutteni* n. sp. Rare.
,, (*Dentalina*) *consobrina* d'Orb. Rather common.
,, ,, *soluta* Rss. Common.
,, ,, *verneuili* d'Orb. Rather common.
,, ,, ,, var. *paucicostata* n. var. Few.
,, ,, cf. *conferta* Neugeboren. Rare.
,, ,, *sp.* Few.
Lagena acuticostata Rss. Few.
,, *laevis* (Montagu). Few.
,, *orbignyana* (Seguenza). Few.
,, *trigona* Koch. Few.
,, *sulcata* (Walker & Jacob). (*Nodosaria scalaris* d'Orb.?). Rare.
,, *sp.* (*Nodosaria hispida* d'Orb.). Few.
Nonion umbilicatulus (Montagu). Few.
,, *bonairensis* n. sp. Fairly rare.
,, *hummelincki* n. sp. Few.
Plectofrondicularia rutteni n. sp. Few.
,, *sp.* Rare.
Hantkenina longispina Cushman. Fairly rare.
Angulogerina molengraaffi n. sp. Rare.
,, *macgillavryi* n. sp. Few to rather common.
Bolivina advena Cushman, var. *elongata* n. var. Few.
,, *plicata* d'Orb. Few.
,, *martini* n. sp. Rather common.
Bulimina affinis d'Orb. Very common.
,, *inflata* Seguenza. Common.
Siphonodosaria abyssorum (Brady). Rather common.
Uvigerina mediterranea Hofker. Very common.
,, *pygmaea* d'Orb. Common.
,, *westermanni* n. sp. Rare.
,, *bonairensis* n. sp. Rare.
Baggina thalmanni n. sp. Common.
Discorbis vilardeboana (d'Orb.). Rare.
Lamarckina vermunti n. sp. Few to rather common.

Eponides byramensis Cushman. Common.
,, *cocoaensis* Cushman. Common.
Siphonina ? pulchra Cushman. Common.
Cassidulina californica Cushman. Few.
,, *laevigata* d'Orb. Rare.
,, *subglobosa* Brady. Rather common.
Pullenia bulloides (d'Orb.). Rare.
Globigerina bulloides d'Orb. Rather common.
,, *cretacea* d'Orb. Common.
,, *inflata* d'Orb. Common.
,, *triloba* Rss. Common.
,, *sp. sp.*
Orbulina porosa Terquem. Few.
,, *universa* d'Orb. Few.
Globorotalia crassula Cushman & Jarvis. Rather common.
,, *lehneri* Cushman & Jarvis. Rather common.
,, *bonairensis* n. sp. Few.
,, *kochi* n. sp. Rather common.
Anomalina subbadenensis n. sp. Few to rather common.
Bonairea coronaeformis n. gen. n. sp. Few to rather common.
Cibicides dispars d'Orb. Very common.
,, *kallomphalius* (Guembel). Rare.
,, *americanus* Cushman. var. *bonairensis* n. var. Common.
,, *megalocephalus* n. sp. Very common.
Dyocibicides rutteni n. sp. Few to rather common.
Planulina mexicana Cushman. Very common.
,, *cocoaensis* Cushman. Few.

The marl has been brought to the Upper Eocene on the strength of the following fossils: *Cristellaria* (*Robulus*) *mexicana* (M. and U. Eocene of Mexico), *Hantkenina longispina* (Upper part L. Eocene to basal part U. Eocene), *Eponides cocoaensis* (Jackson Eocene — Priabonian — Cocoa Sands of Gulf Coast), *Globorotalia lehneri* (Eocene of Trinidad), *Cibicides dispars* (Mostly Cretaceous, also Eocene of Dalmatia), *C. megalocephalus* n. sp. (U. Eocene of Mexico — see p. 74), *C. kallomphalius* (Eocene of the Bavarian Alps), *Planulina cocoaensis* (Jackson Eocene — Priabonian — of the Gulf Coast).

It contains some species known from the Eocene and Oligocene: *Glandulina strobilus* (Germany), *Nodosaria acuminata* (U. Eocene and Oligocene of Hungary), *N. subnitida* (Trinidad); some species only known till now from the Oligocene: *Frondicularia tenuissima* (in Mexico), *Eponides byramensis* (L. Oligocene of the Gulf Coast), *Siphonina? pulchra* (U. Oligocene), *Planulina mexicana* (In E. Mexico L. Oligocene). The other species are either occurring in younger formations (*Lagena trigona*, Pliocene of Java; *Cassidulina californica*, Pliocene of California; *Bolivina advena*, Miocene of California) or occurring both fossil and recent.

According to Dr. THALMANN the marl has most probably a basal upper eocene age; about its facies he informed me that the marl is a typical offshore deposit with similar conditions as the Chapopote formation of E. Mexico („deep-water phase" of the Tantoyuca formation, according to STORRS COLE, lit. 54, p. 8, lit. 55, p. 204) and of the Aragon formation of E. Mexico.

CHAPTER VII

QUATERNARY.

A. Limestones.

Most of the quaternary limestones are coral limestones, in places they are lithothamnia bearing limestones and mollusk (mostly bivalve) bearing limestones. An exact age of the quaternary limestones cannot be given, nor a differentiation in age either. Fossils characteristic for distinct zones have not been found. Of course the horizontal limestones of S. Bonaire and of Klein Bonaire as well as the limestones of the lowest terrace are younger than the limestones of the Seroes Montagne (E. Bonaire: 133 m.; W. Bonaire: 143 m.) or than the tilted limestones W. of Goto.

It is not necessary to give general remarks about the quaternary limestones, e.g. about the terraces, about the nature of the limestones, about erosion and ,,lapiés" (Karren), etc. All these generalities have been fully described by MARTIN: to say more about them would be a repetition of the remarks made by him.

MARTIN tried to classify the limestones, but he did hardly succeed. Probably the lowest terrace agrees with that on Curaçao, but it cannot be entirely due to DALY's "subrecent worldwide sinking of ocean-level", since it is very inconstant. It lies at a height of ca. 2—2,5 m., ranging from 0,5—3 m.; in places it consists of two terraces. The terraces on Bonaire are real terraces of abrasion, with fossil seacliffs, coves and fossil "boca's".

The higher terraces are as inconstant as the lowest terrace(s): of varying height and in places merging. These terraces cannot either be the result of eustatic movements only, they point to differential movements of the island in quaternary time.

MARTIN considered the inclination of all the quaternary limestones to be primary dips. For the relatively strong dipping limestones (e.g. the Seroe Domi limestone on Curaçao) his view is abandoned. He may be right, however, as far as the very low dipping limestones are concerned. On Bonaire we can find such limestones, mostly with seawards dips or with dips of some degrees in various directions (e.g. near Deenterra). The irregular dips and flexures in the quaternary limestones, which are most distinct in NW. Bonaire (near Goto dips to 35° occur, near Boca Slagbaai to 20°) are in my opinion due to upwarping.

Phosphate. In contrast with Curaçao and Aruba the quantity and quality of phosphate found on Bonaire are nowhere such as to motify their working. As far as I know Santa Barbara is the only place which called some attention but mining never was carried through.

Small patches ("pockets") of phosphate have been found at several places on the island. I can fortify MARTIN'S experience that the phosphate on Bonaire is generally strongly alternating and mixed with carbonate of lime. In slides of limestones small concretions of phosphorite among the calcite often occur: these are the very phosphoritic limestones, mentioned by MARTIN (lit. 27, p. 474).

HUGHES, who paid a short visit to the Dutch West Indian islands Curaçao, Aruba and Bonaire and had a view at the phosphate deposits of these islands, mentions the remarkable particulars as follow about Bonaire (see lit. 20, p. 81):

"In the next island to Curaçao (Bonaire) I have seen the coral over an area of two miles to contain fossil bones and teeth scattered in all directions". It is quite incomprehensible where HUGHES has seen these bones and teeth, as we have not found anywhere phosphate deposits of any importance on the island. I even wonder, if HUGHES with the "next island to Curaçao" has not mixed up Bonaire with Klein Curaçao.

List of fossils.

Corals.

Orbicella cavernosa (L.)
,, *annularis* (Ell. & Sol.)
Favia ? fragum (Esper)
Meandrina cerebrum (Ell. & Sol.)
,, *labyrinthiformis* (L.)
Pectinia maeandrites (L.)
,, *quadrata* Edw. & H.
Siderastrea siderea (Ell. & Sol.)
Agaricia ? fragilis (Dana)
Dichocoenia sp?
Stephanocoenia intersepta (Esper)
Stylophora imperatoris Vaughan. ? Quaternary.
,, *sp*. ? Quaternary.
Acropora muricata (L.)
,, *palmata* (Lmk.)
Porites astreoides Lmk.
,, *porites* (Pallas)

Lamellibranchiata.

Arca deshayesii Hanley (*A*. aff. *deshayesii* Reeve)
Lucina tigerina L.
Venus cancellata Lmk.
Venus sp.

Gastropoda.

Bulla media Phil.
Strombus gigas L.
Volutolyria musica L.
Cyclostoma megachile Pot. & Mich.
Pupa uva L.

All of these are Quaternary species (for *Stylophora* see p. 77). Follows a list of fossils found by MARTIN in the Quaternary of Bonaire or mentioned in his publications.

Corals: *Orbicella annularis* (lit. 65, p. 27; lit. 66, pp. 364 ff.; lit. 41, p. 655); *Meandrina labyrinthiformis* (lit. 65, p. 48; lit. 41, p. 655); *M. strigosa* (Dana) (lit. 65, p. 57; lit. 66, p. 420; lit. 41, p. 655).

Lamellibranchiata: *Perna sp.* (?) (lit. 26, pp. 475, 479; lit. 41, p. 661); *Pecten sp.* (lit. 27, p. 126; lit. 41, p. 661).

Gastropoda: *Strombus gigas* (lit. 27, p. 127; not mentioned in lit. 41); *Vermetus sp.* (lit. 26, pp. 475, 479; lit. 41, p. 663).

Vertebrata. Pisces: *Carcharodon* (aff.) *megalodon* Ag. (lit. 26, pp. 475 ff.; lit. 27, pp. 81, 104, 105, pl. I, fig. 3—7; lit. 41, p. 666) I do not think it impossible that this specimen has been found in tertiary rocks; *Oxyrhina* (?) *gomphodon* Müll. & Henle (lit. 26, pp. 475 ff.; lit. 27, p. 105, pl. I, fig. 8—10; lit. 41, p. 666); *Myliobatis sp.* (lit. 27, p. 105, pl. I, fig. 11; lit. 41, p. 666); ?? *Diodon* (lit. 27, p. 105, pl. I, fig. 12; lit. 41, p. 666). Mammalia: *Manatus sp.* (lit. 27, p. 104; lit. 41, p. 667).

B. Alluvial deposits.

To the alluvial deposits detritus, waste, coral sands, coral shingle and dunes belong. Waste is found in the rooien and in the handshaped inland bays as far as they are dry land. Coral sands are principally found in S. Bonaire. Sometimes among the coral sands thin beds of limestones are found, which are composed of coral sands, stuck together in wet season. These limestone beds contain numerous shells of land snails (*Cyclostoma megachile*). Coral shingle is found along the coast, where it is not too high above sea-level, that is chiefly in S. Bonaire, on Klein Bonaire and at the entrance of most of the bays and "saliña's" (former bays). There are only few dunes on Bonaire; on the topographical map they are marked along the E. coast (E. of Lamoenchi and ca. 2½ km. S. of Lac), along the W. coast of S. Bonaire and on Klein Bonaire. Along the E. coast of S. Bonaire and on Klein Bonaire, however, walls of coral shingle are predominating.

CHAPTER VIII

GEOLOGICAL HISTORY AND TECTONICS.

The oldest rocks on Bonaire are of volcanic origin: the lavas, tuffs, etc. of the Washikemba formation. The intercalations of marine sediments (limestones, cherts, calcareous cherts) among the volcanic rocks and the occurrence of foraminifera in the tuffs point out that the formation is a marine deposit. The thickness of the formation (at the least 5000 m.) proves it to be deposited under real geosynclinal conditions. If we may consider cherts and radiolarites as deep sea deposits, then there must have been oscillations of the unknown basement of the Washikemba formation during its sedimentation. The find of a real conglomerate with calcareous cement and evidently a coral fauna in the highest part of the Washikemba formation indicates that the youngest layers of the formation certainly were deposited in shallow water.

In upper cretaceous time and probably very soon after the deposition of the formation, at any rate before Rincon time (Uppermost Cretaceous) the formation was folded or tilted, in the latter case with some complications. The deviations from the general direction of the strike, though being scanty, the variation in the dip, the occurrence of some dips to the S., and especially the analogy with Curaçao, where we find the strongly folded Knip beds, make it more probable that real folding took place and that the Washikemba formation on Bonaire is the N. wing of a flat anticline. As to the intrusions it is probable that the greater part or all of them took place before the folding: as has been stated before the intrusions are petrographically closely connected with the volcanic rocks of the Washikemba formation, in fact only the intrusive diabases could be distinguished (and even not in all cases) from rocks of the Washikemba formation. All of them must be intrusions brought about while the Washikemba formation came into existence. Of course this does not hold good for the porphyritic diorite vein rock: in all probability this rock is synchronous with similar intrusions on Curaçao and Aruba (Lower Eocene?).

On the folded and denuded Washikemba formation the limestones, conglomerates and conglomeratic limestones of the Rincon formation transgrediated. After the denudation of the Washikemba formation there has been tilting, because the Rincon rocks lie unconformably on the Washikemba formation and the pebbles found in the conglomeratic rocks of the Rincon formation are for the greater part Washikemba rocks. The Rincon formation with its corals and conglomerates is a typical shallow water deposit. As the Rincon formation has only N.dips and it is found, especially in its N.parts, in a flat country, it must be faulted in the N. and NE.

In the interval between Rincon formation and Soebi Blanco conglomerate there has been tilting again: the Rincon formation emerged from the sea, other parts of the Washikemba formation sank below sea level, on these parts the Soebi Blanco conglomerate was deposited. For the same reason as the Rincon formation the Soebi Blanco conglomerate must be faulted at its N. border.

The deviation from the horizontal plane of the layers of Rincon formation and Soebi Blanco conglomerate must rather be considered as tilting than as real folding. In that direction points the monoclinal dip; not even secondary folds have been found. I can only ascribe the steep dips occurring in places in the Soebi Blanco conglomerate to faulting, taking into consideration the generally low dips of the strata of the conglomerate.

There must have been complicated tectonical movements during the sedimentation of Rincon formation and Soebi Blanco conglomerate. Of the foreign pebbles only granodiorites and granodiorite aplites occur in the Rincon formation. At the time of the sedimentation of the Rincon rocks the configuration of the land S. of Bonaire has evidently been in such a way that only those rocks could get into the Rincon formation. With the transgression of the Soebi Blanco conglomerate the supply of foreign pebbles increased in a high degree; at the same time the Rincon formation rose above the sea level, for we find Rincon rocks among the Soebi Blanco pebbles.

Tertiary. The foraminifera marl points to a strong positive change in level in post-Soebi Blanco time, followed by a negative change in level: the foraminifera marl is an off-shore deposit of the deeper sea; the upper eocene limestones are shallow water deposits.

At present the tertiary deposits (Upper Eocene) are found only over a relatively small surface of the island. In chapter VI I made it probable that the Tertiary is more widely spread than has been marked on the map, and that it might have covered all the older formations, because almost nowhere terrigenous material from the older formations was found in it. Data about the strike and dip of the Eocene were only obtained in the region SW. of the Seroe Montagne (W. Bonaire). We find there a slight upwarping of the Eocene. We do not know whether this upwarping is only local, but a priori this is not probable. The upwarping is certainly prae-quaternary, as the quaternary limestones of the Seroe Montagne lie unconformably on the Eocene limestones. It is quite comprehensible that most of the Eocene has been taken away by erosion, because the isle of Bonaire or what was the isle of Bonaire in that time seems to have been dry land during the rest of the tertiary period.

Quaternary. The quaternary limestones are most certainly not all of the same age: the low limestones of S. Bonaire are younger than e.g. the limestones of the Seroe Montagne or than the inclined limestones W. of Goto. Exact relations in age cannot be given. The inconstant character of the terraces of abrasion and the local upwarpings in the quaternary limestones point to differential movements of the island or part of the island in quaternary time.

Remarkable are the considerable sea depths in the immediate vicinity of Bonaire and even between Bonaire and Klein Bonaire. They give a strong suggestion of tectonical movements in subrecent times.

Summary.

During the Upper Cretaceous there have been geosynclinal conditions, ceasing before the main orogenesis in upper cretaceous time. Till upper eocene time we find shallow water deposits, after and perhaps during their sedimentation tilted and faulted. At the base of the Upper Eocene there must have been a considerable positive change in level, followed by a negative change in level. Differential movements of the island continued till quaternary time.

As it is, the conditions are different from those on Curaçao and the N. part of S. America. On Curaçao the main orogenesis falls after Midden-Curaçao time that is almost certainly later than the main orogenesis on Bonaire. In the N. part of S. America: NW. Venezuela and Columbia, the Eocene has geosynclinal development and the main orogenesis occurs in post-eocene time. The tectonics on Bonaire and Curaçao have more similarity with the Laramid orogenesis in N. America.

CHAPTER IX

HYDROLOGY.

Our geological survey of Bonaire was made for reasons of pure scientific nature. Consequently we did not make detailed investigations concerning the geohydrology of the island. Nevertheless something can be said about the geohydrology, the watersupply and its improvement being of so much importance on this and many other Antillean islands.

On Curaçao experience has learned that the diabase is the best water-bearing rock of the island. Porphyrite is not known of Curaçao. The fact that the rich well of Dos Poos lies in a porphyrite region demonstrates that the porphyrite can be also water bearing (I also mention the well N. of Tres Kroes, S. of Coeroeboeroe).

In the region E. and NE. of Kralendijk there is much diabase: a wide strip of diabase (ca. 1 km.) runs from SE. of Terra hoendoe in ESE. direction to Rooi Lamoenchi. In this region there lie the good wells of the Aruba Plantation and the well W. of the Guatemala Plantation (property of the government). N. of this region porphyrites and tuffs are chiefly found, in places also diabase.

As on Curaçao the building of dams at the right places would be of much importance. They may stop the superficially running water, so that it penetrates into the ground and becomes groundwater and as such flows much slower to the lower parts of the island. Downstream the dams wells can be dug.

In E. Bonaire (Third District) the "rooien" suitable to build dams are: [1])

1. the rooi between Seroe Kima and Seroe Grandi;
2. the rooien that debouch into Lagoen;
3. the rooi that runs E. of Seroe Bara di Carta to Punta Blanco (not to confuse with Punta Blanco in the cirque of Rincon);
4. the small rooien that run to the W. through the Aruba Plantation (to dam up upstream of the Aruba Plantation).

The cirque of Rincon is chiefly a diabase region. Through the building of dams in the various rooien (rather high upstream) it must be possible to hold more water. The Put Dominica (put = well) is a good well. It lies at a height of ca. 75 m. at the S. border of the cirque of Rincon. Probably it gets its water under similar conditions as the spring of Fontein and the spring of Hato on Curaçao: the rain-water sinks through the limestones till it reaches the unweathered

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[1]) Some of the names mentioned here are not given on the geological map. One should consult the topographical map 1 : 20.000.

less permeable basement, then it floats over the basement to the lowest point. When we visited the well known St. Thomas College on Curaçao, Pater EUWENS told me an interesting experiment that he took when being a priest in Rincon. The wells in the village of Rincon are rather bad. They only carry water when there is plenty of rainfall. In dry season the villagers have to fetch their water in Dos Poos and in the Put Dominica. Pater EUWENS had a siphon made from Put Dominica to the foot of the hill, so that it was no longer necessary for the villagers to climb the hill. The siphon was used some time, but later on it was neglected and got out of use. If Put Dominica really is a rich well it would be worth while to build a new siphon with a waterpipe to the village of Rincon.

Wells with similar conditions as Put Dominica can be dug at other places along the boundary of the limestone; NNE. of Punta Blanco there is a good chance to get water; between Punta Blanco and Put Dominica the waterparting is probably too close to the N. boundary of the limestone.

In W. Bonaire (Fourth District) there is a rather strong difference in the levels, consequently the rooien have a strong fall and one runs the risk that, when one builds dams, the ground upstream of the dam will be very soon silted up. Apart from this difficulty there can be obtained much more water in W. Bonaire, because a great part of the rain-water flows down to the sea. There is much diabase in this part between Boca Slagbaai and Goto.

Rooien suitable to build dams, are:

1. the rooi Camia, which can be dammed up at the foot of the Seroe Jarabi di Mangle, but which has strong fall;

2. the rooi coming from the Seroe Kimeterio. Downstream it can be dammed up as far as close to Goto; it is recommendable to build also dams higher upstream;

3. the rooi Hoeba;

4. the rooi of Poos Chikitoe (it can be dammed up very well near Poos Chikitoe);

5. the rooi that debouches into Saliña Tam; it drains a region with much diabase and porphyrite (Seroe Wekoewa).

DUYFJES pointed out that the building of overground dams is insufficient, because the water floats too rapidly through the weathered top-soil (lit. 9). He proposes to build subterranean dams, resting on the unweathered, hardly permeable rock. I cannot judge if the suppositions of DUYFJES are founded, nor can I appreciate at their proper value the objections made by MOLENGRAAFF to the proposals of DUYFJES (lit. 32). Should subterranean dams ever be built on Bonaire, then the high and relatively flat limestone regions can furnish excellent "cisterns." Subterranean dams might be built with success S. of Fontein, near and NNE. of Punta Blanco; the validity is dependent on the thickness of the limestones and on the physical condition of the underground. However, in view of the precarious economical condition of an island as Bonaire and the great expenses, which the construction of subterranean dams undoubtedly brings along and finely the uncertainty whether it will really settle the matter, I should never advise to pass on to so strong a measure on this island.

As to the limestone regions no definite rules concerning the digging of wells can be given. As to the higher limestone regions it must be dissuaded at any rate to dig wells. The low limestone regions of S. Bonaire and Klein Bonaire have everywhere a calcareous subsoil till below sea-level. As there are many wells in S. Bonaire (I only mention the well S. of Terra corrá and the many wells of Lima Plantation), the groundwater floats in all probability upon the sea-water.

I will draw the attention to one thing yet. On Bonaire, as well as on Curaçao and Aruba, many trees have been cut and are still being cut for the charring of charcoal. Where the forest has been cut down, it is nowhere planted again, so that large regions have been deforested in the course of time. This is a very serious fact, because a thorough afforestation is very important for the islands for several reasons:

1. it is a well-known fact that the flowing down of the rain-water on an afforested hill-side is much smaller than on a bare one, so that a much greater quantity of water can sink into the ground;
2. the evaporation of an afforested hill-side can be much smaller;
3. the washing of an afforested hill-side is much smaller;
4. the barren soil soon becomes and remains unsuitable or at the least less suitable for cultivation.

For the benefit of the water supply and of the agriculture it is very recommendable to re-afforest the barren ground as far as possible and to cut for the production of charcoal on a more reasonable base. Perhaps it will be best to stop charring entirely for a couple of years. One must not forget that a "forest" on Bonaire can be cut down in some months, but that it takes years and years to get a good forest back again.

CHAPTER X

PALEONTOLOGY.

FORAMINIFERA

In my descriptions I have principally followed CUSHMAN's "Foraminifera, their classification and economic use" (lit. 57). Only in some respects I have deviated from his views. Thus I retained the genus *Cristellaria*, with subgenera *Robulus, Planularia*, etc. This was done in the consideration that the species of the genus "*Cristellaria*" form a coherent group, and that there is no more difference between forms like e.g. *Robulus* and *Saracenaria*, which *Cushman* considers to be distinct genera and forms like e.g. *Eulepidina* and *Nephrolepidina*, which are usually considered as subgenera. For the same reason I take *Dentalina* as a subgenus of *Nodosaria* (the differences between *Dentalina* and *Nodosaria* are, moreover, very inconstant). I refuse to accept the name *Camerina* instead of *Nummulites*, even though the name *Camerina* has the priority. The name *Nummulites* with its derivations is so generally used, it has found its way so far and wide in the paleontology and geology that I think it justified in this special case not to live up to the principle of priority.

The figures given, chiefly of new species, are all pen-drawings. I have made pen-drawings instead of photographs in the first place because of financial considerations, in the second place because of technical ones: in a drawing more details can be given that would be invisible in a photo.

LARGER FORAMINIFERA

Family Orbitoididae.

Genus *Lepidocyclina* Guembel.
Subgenus *Lepidocyclina* Guembel.

Lepidocyclina (*Lepidocyclina*) *r. douvillei* Lisson 1921.

Some specimens of this form were found among the material and one of the slides contains a specimen with large embryonal chambers (330 × 210 μ). Upper range of diameter ca. 2,5 mm.

Age. Upper Eocene.

Localities. SW. of Seroe Montagne (W. Bonaire), SE. of Fontein (Columbia Plantation, Bonaire).

Lepidocyclina (*Lepidocyclina*) *hieronymi* (M. Rutten & Vermunt 1932).

Lepidocyclina (*Lepidocyclina*) *canellei* Lem. & R. Douv., var. *hieronymi* M. Rutten & Vermunt 1932, Proc. Kon. Akad. Wetensch. 35,2, p. 234 pl. I, fig. 3, pl. II, fig. 10.

This is the most common form among the material. The small, square median chambers that distinguish this form from *L. canellei* Lem. & R. Douv. are so characteristic and constant that I think it justified to separate it from the species of LEMOINE and R. DOUVILLÉ. The diameter ranges from 2,2 mm. to 3,0 mm., the embryon from 320 × 230 to 410 × 250 μ.

Age. Upper Eocene.

Localities. SW. of Seroe Montagne (W. Bonaire), SE. of Fontein (Columbia Plantation, Bonaire).

Lepidocyclina (*Lepidocyclina*) *trinitatis* H. Douv. 1917.

This species is rather common among the material and in the slides. The diameter ranges from 2,3 to 3,1 mm, the embryon from 400 × 310 to 550 × 360 μ.

Age. Upper Eocene.

Localities. SW. of Seroe Montagne (W. Bonaire), SE. of Fontein (Columbia Plantation, Bonaire).

Lepidocyclina (*Lepidocyclina*) *weeksi* Hodson 1926.

This species was only found in the slides, where it is rather common. The upper range of its embryon is 640 × 550 μ.

Age. Upper Eocene.

Localities, SW. of Seroe Montagne (W. Bonaire), SW. of Punta Blanco (W. Bonaire).

Lepidocyclina (*Lepidocyclina*) *schotborghi* M. Rutten & Vermunt 1932.

A flat form, measuring 1,45 mm. in diameter with an embryon of 450 × 250 μ may be brought to L. *schotborghi* of M. RUTTEN and VERMUNT. In the slides two forms, measuring 1,2 and 1,35 mm., both with an embryon of 550 × 500 μ were found that most probably also belong to *L. schotborghi*.

Age. Upper Eocene.

Localities. SW. of Seroe Montagne (W. Bonaire), SE. of Fontein (Columbia Plantation, Bonaire).

M. RUTTEN and VERMUNT make mention (lit. 62, p. 234) of "a quite baffling *Lepidocyclina*" in which the layer of median chambers is not an even plane but branched. I found four of those forms in my slides, showing, just like the specimens of RUTTEN and VERMUNT, three branches going out from the embryon. Two of them could be seen to be isolepidine, but they certainly do not belong to *L. weeksi*. I consider them to be mere monstruosities.

Age. Upper Eocene.

Localities. SW. of Punta Blanco (W. Bonaire), SE. of Fontein, N. of Morèke (Columbia Plantation, Bonaire).

Most of the *Lepidocyclinas* are microspherical. These microspherical forms range from 4, 5—8 mm. in diameter. Distinct types could not be distinguished among them. I cannot say to which species these microspherical forms belong. The common microspherical *Lepidocyclina* of Curaçao, L. *curasavica* is certainly not represented among them.

Subgenus *Helicolepidina* Tobler.

Lepidocyclina (*Helicolepidina*) *spiralis* Tobler 1922.

Several specimens of this form have been found, both megalo- and microspherical. The megalospherical specimens agree well with the description given by TOBLER. Among the microspherical specimens I could distinguish two forms. The first shows only feeble spirally arrangement in the centre; so it agrees with the type that TOBLER considered as B-forms of *H. spiralis*. Its diameter ranges up to 7,7 mm. The second shows spirally arrangement from the centre to the periphery, consequently with two kinds of median chambers, such as occurs in the megalospheric forms. The microspheric specimens of *H. spiralis* mentioned by M. G. RUTTEN and L. W. J. VERMUNT from Curaçao (lit. 62, p. 238) belong to this second form. I found the diameter ranging up to 7,2 mm.

There are four possibilities: 1. the first form is the microspheric form of *H. spiralis*, as is supposed by TOBLER. Then the second form is the microspheric form of another new species of *Helicolepidina*. 2. the second form is the microspheric form of *H. spiralis*. Then it was not found by TOBLER and his microspheric specimens were microspheric forms of other *Lepidocyclina* with spirally arrangement in the centre as it was found by *Douvillé* (lit. 59, p. 601) and *Cushman* (lit. 56, pl. 34, fig. 4). 3. neither of the two forms represent the microspheric form of *H. spiralis*. 4. both microspheric forms belong to *H. spiralis*.

Age. Upper Eocene.

Locality. SW. of Seroe Montagne (W. Bonaire).

Genus *Discocyclina* Guembel.

Subgenus *Discocyclina* Guembel.

Fragments of *Discocyclina* s.s. are common in the slides of upper eocene limestones and some specimens have been found SW. of Seroe Montagne. The specimens are not in such a state of preservation that they could be determined. I mention the occurrence of specimens of *Discocyclina* s.s. here, with their find-spot, because the genus is of so much stratigraphic significance.

Subgenus *Asterocyclina* Guembel.

Discocyclina (*Asterocyclina*) *georgiana* Cushman 1917.

The Bonaire specimens that I have brought to A. *georgiana* agree well with the form of CUSHMAN .The small raised areas in the triangular flat parts are very prominent. CUSHMAN says of these areas; "the sides . . . convex in the centre"; N. E. GORTER and I. M. VAN DER VLERK (lit. 60) draw more attention to these areas: "The parts between the arms are flat. Sometimes these flat parts have a small raised spot near the periphery". In the Bonaire specimens these raised parts have been developed into narrow ridges coinciding with the bisectrices of the diagonals of the square test. Thus one gets the impression that the form is 8-rayed, but the section shows a normal 4-rayed form. The dimensions of the diameter do not exceed those given by GORTER and VAN DER VLERK, but my specimens are thinner, 0,66—0,80 mm. Measurements of embryonal chambers ca. 140 × 100 μ. The radial diameter of the aequatorial chambers in the areas of the arms is at a distance of 1 mm. from the centre 55—80 μ, their tangential diameter is 15—30 μ. In the intermediate areas the radial diameter of the aequatorial chambers is at a distance of 1 mm. from the centre 20—45 μ, their tangential diameter 20—30 μ.

With *A. bontourana* this is the most common *Asterocyclina* on Bonaire.

Age. Upper Eocene.

Localities. SW. of Seroe Montagne (W. Bonaire), SW. of Punta Blanco (W. Bonaire), SE. of Fontein (Columbia Plantation, Bonaire).

Discocyclina (*Asterocyclina*) *bontourana* Hodson 1926.

The following may be added to the description of Miss HODSON:

The diameter of the Bonaire specimens ranges up to 3,6 mm; a lower range cannot be given, because it is often impossible to see whether a specimen is complete or whether it is broken off and rounded at the ends of the rays. Thickness up to 0,78 mm; ca. 20—26 % of diameter. The raised terminals of the pillars (pustules) in the centre are ca. 75 μ in diameter. Miss HODSON says that "the rays are small and carry only a few large pillars". If she means by "rays" the highest ridge of the arms the Bonaire specimens agree in this respect, but in some of the specimens there can be seen that there are pustules on the rest of the arms (sideways of the ridge) and on the small intermediate areas as well. These latter pustules are somewhat smaller than those of the central part (ca. 50 μ). Miss HODSON found that the centre formed the larger part of the test. This holds good for the smaller specimens; in the larger specimens the increase in size is more due to a lengthening of the arms than to a relative enlargement of the centre, so that the centre is no more the larger part of the test.

The embryonic chambers that are more isolepidine than nephrolepidine, measure, of two small specimens (ca. 2,5 mm), together 180 μ and 160 μ respectively. The radial diameter of the aequatorial chambers in the areas of the arms is at a distance of 1 mm. from the centre 75—80 μ in one specimen, at a distance of 0,75 mm. from the centre 55 μ in another specimen; their tangential diameter in both specimens is 20 μ. In the intermediate areas the radial diameter of the aequatorial chambers is 20—35 μ; their tangential diameter 25—30 μ.

Age. Upper Eocene.

Localities. SW. of Seroe Montagne (W. Bonaire), SW. of Punta Blanco. (W. Bonaire), SE. of Fontein (Columbia Plantation, Bonaire).

Discocyclina (*Asterocyclina*) *aurarensis* Hodson 1926.

Two specimens of *A. aurarensis* Hodson have been found, each being 5-rayed. Diameter ca. 2 mm? The two half embracing embryonal chambers measure together respectively 180 μ and ca. 210 μ. The radial diameter of the aequatorial chambers in the areas of the arms is at the greatest distance from the centre (ca. 1 mm) 55 μ; their tangential diameter 20—25 μ. In the intermediate areas the radial diameter of the aequatorial chambers is 35 (—?60) μ; their tangential diameter is 25 μ.

Age. Upper Eocene.

Localities. SW. of Seroe Montagne (W. Bonaire), SE. of Fontein (Columbia Plantation, Bonaire).

Discocyclina (*Asterocyclina*) *sp.*

Outwardly this species resembles *A. bontourana*. Diameter of test 2,6 mm.? (probably larger). The megaspheric test carries 4 distinct rays and shows a tendency to form 4 more rays, coinciding with the bisectrices of the first 4 rays. Thus one sees in the aequatorial layers an uninterrupted peripheral series of rows of chambers between two arms. More to the centre the rows of chambers coming from two arms converge to one point in the middle of the intermediate area. The most central rows of chambers again run uninterrupted from one arm to the other. In no intermediate area it comes to the forming of a real "arm." The character is not equally obvious in all the four intermediate areas. The species is megalospheric, but the embryon is too badly preserved to give the dimensions. The radial diameter of the aequatorial chambers in the areas of the arms is at a distance of 1 mm. from the centre 70 μ; their tangential diameter is 20 μ. In the intermediate areas the radial diameter of the aequatorial chambers is at 1 mm. from the centre 35 μ; their tangential diameter is 20 μ.

Though the species is very characteristic and entirely different from all other species of *Asterocyclina* I have not given it a name because the present material is very insufficient. Besides the possibility remains that it is a monstruosity.

Age. Upper Eocene.

Locality. SW. of Seroe Montagne (W. Bonaire).

Family Nummulinidae.

Genus *Operculina* d'Orb.

Operculina bonairensis n. sp. Pl. I, fig. 32, 33.

Test very thin, planospirally coiled. Greatest diameter ranging up to 17,5 mm. Thickness seldom surpasses 0,5 mm. There are ca. 2,5 whorls visible in adult specimens, rapidly increasing in width. Chambers very numerous, ranging from ca. 15—32 in the last-formed whorl.

Greatest diameter:	17,5	ca. 17,5	14,5	13,5	12	11,5	11,5	11,5	8,5	8,1	8	7,6	5,8	2,75 mm.
Number of chambers in last-formed whorl:	28	32	23	26	22	26	24	23	ca. 21	19	20	18	17	ca. 15

Chambers very narrow and high, height (that is radial dimension) ca. 15 times the length (tangential dimension). Sutures very limbate and bent like in *O. cookei*, with which this species is closely related. Chambers widest in the middle, narrowing towards the centre and towards the periphery. Like *O. cookei* some specimens of *O. bonairensis* have the central part and some of the earlier sutures ornamented by separate knobs.

As has been mentioned before this species is very near *O. cookei*, from which it differs by its dimension, number of chambers (being always less than in *O. cookei* for specimens that agree in size with *O. cookei*), and form of the chambers.

Age. Upper Eocene.

Locality. SW. of Seroe Montagne (W. Bonaire).

Smaller foraminifera

For the measures of the described smaller foraminifera I refer to the explanations of the figures.

Family Textulariidae.

Genus *Textularia* Defr. 1824.

Textularia martini n. sp. Fig. 6—10.

Species of small size, conical, compressed, with rounded sides. Initial end pointed, test regularly increasing in width towards the apertural end, where it is widest. Wall smooth, finely arenaceous, with much cement. Sutures (except in the early portion) distinct, depressed. Course of the sutures rather varying. Chambers first gradually, later rapidly increasing in size; early chambers low and broad, later chambers higher. Aperture elongate, occasionally slightly curved, at the inner margin of the last formed chamber and perpendicular to that margin.

The species has some resemblance with *T. subagglutinans* Cushman from the Miocene of Panama. *T. subagglutinans* differs by its truncated sides, by its wall being composed of rather coarse arenaceous material and by the shape of its aperture, being more rounded.

The species has been named in honour of Prof. K. Martin.

Age. Upper Eocene.

Locality. Well near Porta Spaño (Columbia Plantation, Bonaire).

Genus *Textulariella* Cushman 1927.

Textulariella barrettii (Jones & Parker)? Fig. 11—13.

The Bonaire species agrees in almost every respect with the species described by Jones and Parker, which was brought to a new genus *Textulariella* by Cushman. I never noticed, however, the labyrinthic chambers in my specimens. I did not separate the Bonaire specimens from *T. barrettii* because they equal this species in every other respect.

The course of the sutures is rather irregulør.

Age. Upper Eocene.

Locality. Well near Porta Spaño (Columbia Plantation, Bonaire).

Genus *Vulvulina* d'Orb. 1826.

Vulvulina molengraaffi n. sp. Fig. 14—19.

Species of large size, with a wide, square, biserial part with sharp angles and a narrower, flattened, uniserial part. Test arenaceous, surface rather smooth, with bluish grey to brown colour. Chambers in biserial part low, in uniserial part higher. There are up to 4 chambers

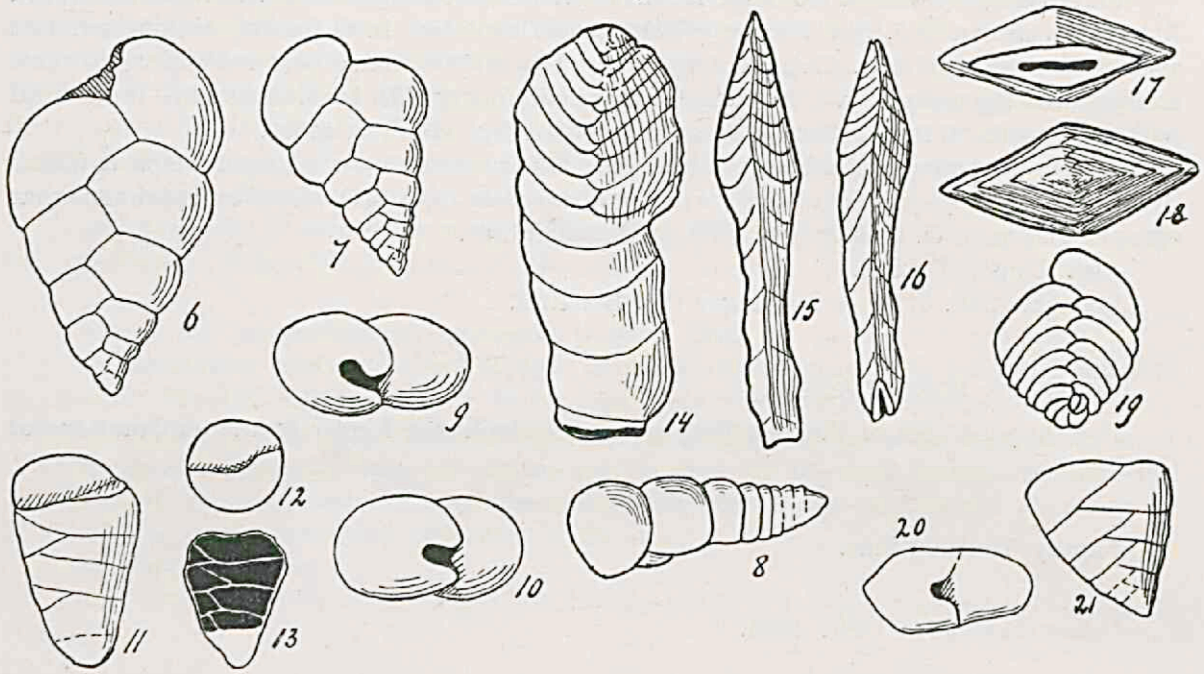

Fig. 6—10. *Textularia martini* n. sp., 6 front view 340 × 210 μ, 7 front view 230 × 150μ 8 side view 250 × 85 μ, 9 apertural view 155 × 95 μ, 10 apertural view 145 × 80 μ; fig. 11—13 ?*Textulariella barrettii* (Jones & Parker), 11 half front view, half apertural view 610 × 390 μ, 12 apertural view, dm. 390 μ, 13 front view showing interior 490 × 360 μ; fig. 14—19 *Vulvulina molengraaffi* n.sp., 14 front view, length 1180 μ, width of biserial portion 440 μ, width of uniserial portion 340 μ, 15 front view, greatest width 250 μ, 16 front view 1070 × 200 μ (greatest width), 17 apertural view: specimen 480 × 125 μ, aperture 225 × ca. 30 μ, 18 view of initial end 750 × 325 μ, 19 juvenile specimen 500 × 420 μ; fig. 20, 21 *Gaudryina bonairensis* n. sp., 20 front view 490 × 410 μ, 21 apertural view 420 × 250 μ.

in the uniserial part. Aperture an elongate slit. In a young, apparently microspheric, specimen (fig. 19), only showing the biserial stage, the coiled early chambers are distinctly visible.

The species strongly resembles *V. pennatula* (Batsch 1791). It is clearly different, however, by the square, angled biserial part and by the flat and high uniserial chambers.

The species has been named in honour of Dr. G. J. H. MOLENGRAAFF, who by his paper on the geology and geohydrology of Curaçao, has enriched our knowledge of the geology of the West Indies so much,

Age. Upper Eocene.

Locality. Well near Porta Spaño (Columbia Plantation, Bonaire).

Family Verneuilinidae.

Genus *Tritaxia* Rss. 1850.

Tritaxia schotborghi n.sp. Fig. 22—26.

Species of large size, from the pointed initial end rapidly increasing in width to largest width of test, so that generally two third of the test has (roughly speaking) parallel sides. Test in cross section triangular, with acute angles. Wall arenaceous, grey coloured. Sutures curved, distinct, depressed, Chambers low, gradually increasing in size. Aperture very indistinct, a transverse elongate opening in the midst of the apertural face.

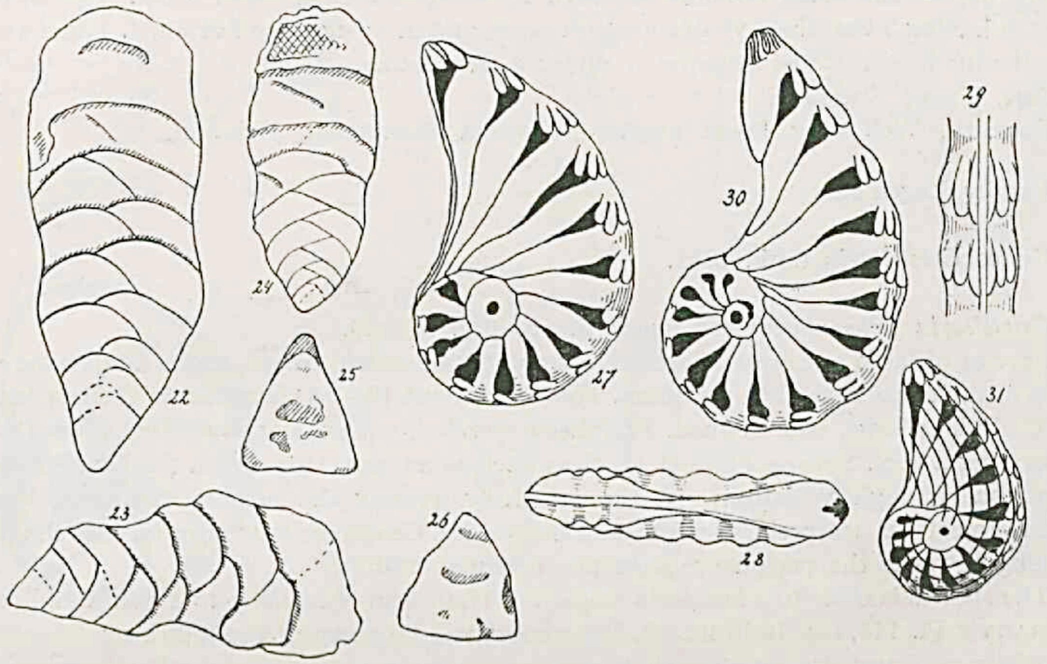

Fig. 22—26 *Tritaxia schotborghi* n. sp., 22 front view 1800 × 690 μ, 23 front view 1270 × 590 μ, 24 front view 1200 × 500 μ, 25 apertural view, greatest width 420 μ, 26 apertural view, greatest width 510 μ; fig. 27—29 *Cristellaria* (*Planularia*) *thalmanni* n. sp., 27 front view 1810 × 1100 μ, 28 peripheral view, showing apertural face 1570 × 360 μ, 29 peripheral view, showing sacks of white shell-substance, thickness 310 μ; fig. 30 *Cristellaria* (*Planularia*) *thalmanni* n. sp. var. *portaspañoensis* n. var., front view 1920 × 1650 μ; fig. 31 *Cristellaria* (*Planularia*) *thalmanni* n. sp., var. *costata* n. var., front view 1550 × 720 μ.

This species has been named in honour of Mr. H. B. C. SCHOTBORGH, Commander of Bonaire.

Age. Upper Eocene.

Locality. Well near Porta Spaño (Columbia Plantation, Bonaire).

Genus *Gaudryina* d'Orb. 1839.

Gaudryina bonairensis n. sp. Fig. 20, 21.

Test fairly large, triangular in outline, with pointed initial end and largest width near aperture. In apertural view roughly equilateral triangular with truncated apex; the base being formed by the shortest side, provided with a more or less pronounced ridge, not forming a distinct keel. Surface fairly rough, with much cement. Chambers few, gradually increasing in size. Sutures not distinct, slightly depressed, straight. Aperture at the base of the inner margin of youngest chamber, small, suboval or rounded. Triserial portion of test very small.

Age. Upper Eocene.

Locality. Well near Porta Spaño (Columbia Plantation, Bonaire).

Family Miliolidae.

Genus *Triloculina* d'Orb. 1826.

Triloculina sp.

Test elongate-oval in outline, about 2 ½ times as long as wide, chambers rather narrow and elongate. Peripheral margin rounded. There are 3 chambers visible from the exterior on both sides; ends of the chambers rounded. Sutures distinct, deep.

The species has some resemblance with *T. laevigata* d'Orb., from which it principally differs in having 3 chambers visible on both sides, and in being more flattened. The material is too badly preserved to describe it under a new name.

Age. Upper Eocene.

Locality. Well near Porta Spaño (Columbia Plantation, Bonaire).

Family Lagenidae.

Genus *Cristellaria* Lmk. 1812.

Cristellaria (*Planularia*) *thalmanni* n. sp. Fig. 27—29.

Species of large size, test bilaterally symmetrical, coiled except in the adult where the last formed chambers tend to uncoiling. There are about 13—15 chambers in the last formed coil. Umbilicus large, well defined. Periphery rounded, with a slightly raised ridge though not forming a keel. Sutures distinct, of clear shell-substance, very much thickened towards the periphery, slightly limbate. At the periphery, joining the sutures, there are 5 sack-shaped projections composed of white shell-substance. Chambers low; later formed chambers widening towards the periphery. Aperture terminal, radiate.

The species is close to *Planularia magnifica* Thalmann, var. *elongata* Thalmann, defined by Brady's Pl. 114, fig. 16 in lit. 63. Differences will be given in the following description of *P. thalmanni*, var. *portaspañoensis* n. var., which is even more close to *P. magnifica*, var. *elongata*.

This species has been named in honour of Dr. H. E. Thalmann.

Age. Upper Eocene.

Locality. Well near Porta Spaño (Columbia Plantation, Bonaire).

Cristellaria (*Planularia*) *thalmanni* n. sp., var. *portaspañoensis* n. var. Fig. 30.

This variety differs from *P. thalmanni* in having more chambers in the last formed coil (in the strict sense of the word one can no longer speak of a coil here) and in the greater individuality of the chambers, the last formed chambers not reaching the coil.

The variety is closest to *P. magnifica* Thalmann, var. *elongata* Thalmann, defined by Brady in lit. 63, Pl. 114, fig. 16. (*Cristellaria compressa*, d'Orb.). It differs in being thicker, in having more limbate sutures, in being provided with sack-shaped projections at the periphery and in the failing of a distinct keel.

Age. Upper Eocene.

Locality. Well near Porta Spaño (Columbia Plantation, Bonaire).

Cristellaria (*Planularia*) *thalmanni* n. sp., var. *costata* n. var. Fig. 31.

The only difference of this variety with *P. thalmanni* n. sp. is the presence of several well marked costae. In most specimens there are 8—12 costae on both sides. Generally this variety is smaller than *P. thalmanni*, but this character has of course no varietal value.

Age. Upper Eocene.

Locality. Well near Porta Spaño (Columbia Plantation, Bonaire).

Cristellaria (*Planularia*) *subminuta* n. sp. Fig. 34, 35.

Species of small size, test bilaterally symmetrical, close coiled, in the adult tending to uncoiling. There are 11 chambers in the last formed coil; chambers low, gradually increasing in height. Sutures fairly distinct, gently curved. Aperture radiate.

The species is very close to *Cristellaria minuta* Bornemann 1854 from the Lias of Göttingen (not *C. minuta* Hantken 1875 or *C. minuta* Hosius 1892). It differs in being more compressed, in having less chambers in the last formed coil, while the last formed chambers are higher and not turned backward at the periphery (there is in the sutures between the last formed chambers a very slight tendency to curve back at the periphery).

Age. Upper Eocene.

Locality. Well near Porta Spaño (Columbia Plantation, Bonaire).

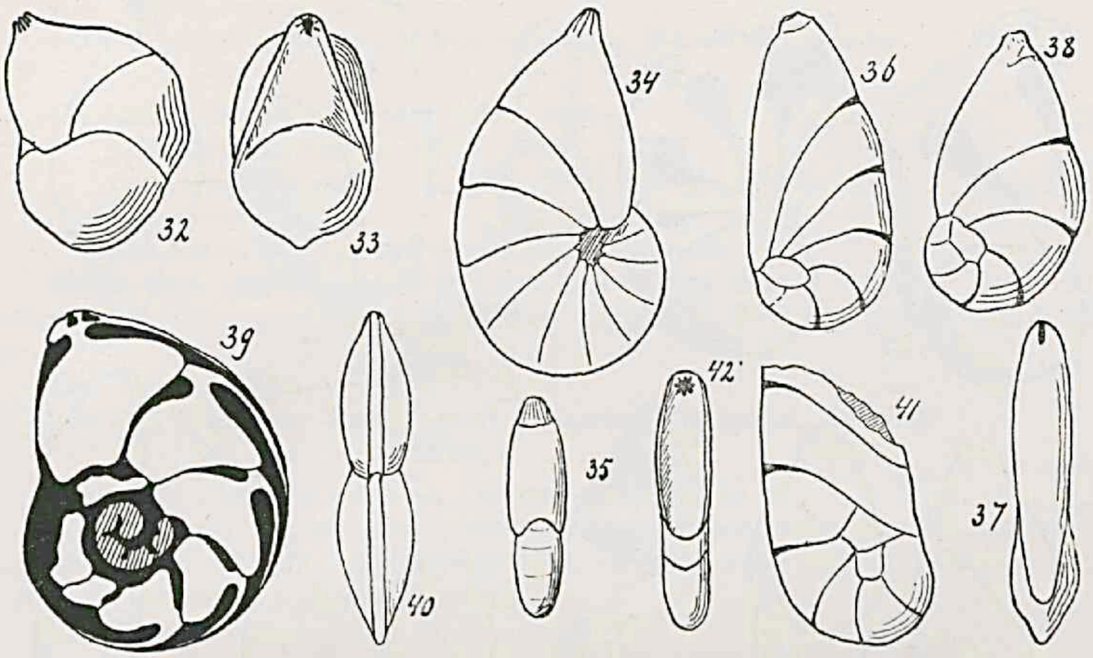

Fig. 32, 33 *Cristellaria* (*Robulus*) *mexicana* Cushman, juv., 32 front view 410 × 310 μ, 33 apertural face 410 × 250 μ; fig. 34, 35 *Cristellaria* (*Planularia*) *subminuta* n. sp., 34 front view 340 × 200 μ, 35 apertural face 340 × 100 μ; fig. 36—38 *Cristellaria* (*Planularia*) *kochi* n. sp., 36 front view 560 × 265 μ, 37 apertural face of fig. 36 560 × 110 μ, 38 front view 500 × 255 μ; fig. 39, 40 *Cristellaria* (*Planularia*) *westermanni* n. sp., 39 front view 590 × 490 μ, 40 side view 590 × 145 μ; fig. 41, 42 *Cristellaria* (*Planularia*) sp., 41 front view 500 × 270 μ, 42 side view (apertural view), width 100 μ.

Cristellaria (*Planularia*) *kochi* n. sp. Fig. 36—38.

Test much compressed, elongate-oval in outline, with rounded periphery. There are only few (7) chambers in the last formed coil; the latest chambers have uncoiled. Sutures fairly distinct, slightly curved, almost flush with the surface, narrow, widening towards the periphery. There is an indistinct, raised umbilicus. Apertural face more or less flattened, aperture at the peripheral angle of latest chamber, robuline.

The species resembles *Cristellaria crepidula* Ficht. & Moll as given by Brady in lit. 53, Pl. 67, fig. 20. However, it has less chambers in the last formed coil and the chambers in *C. crepidula* are more uncoiling than they are in *P. kochi*. Further *P. kochi* has an umbilicus, though indistinct, and it is raised at the umbilicus.

The species has been named in honour of Dr. R. Koch.

Age. Upper Eocene.

Locality. Well near Porta Spaño (Columbia Plantation, Bonaire).

Cristellaria (*Planularia*) *westermanni* n. sp. Fig. 39, 40.

Test compressed, suboval. Surface smooth with much clear shell-substance. There are about 7 or 8 chambers in the last formed coil. Periphery with a broad keel of clear shell-substance. Umbilicus large. Sutures distinct, thick, flush with the surface. Like the keel, the umbilicus and sutures are composed of clear shell-substance. Chambers with complicated form, as is to be seen in fig. 39. Aperture radiate, at peripheral angle of the last formed chamber.

The species resembles to some degree *Lenticulina guayabalensis* Cole 1927 and *Lenticulina velascoensis* White 1928. However, both species are thicker; *L. guayabalensis* has no keel and its chambers are more uniform in size; *L. velascoensis* has a more rounded shape and its chambers are more uniform in size.

The species has been named in honour of Dr. J. H. Westermann, the author of the geology of Aruba and one of my fellow-travellers to the West Indies.

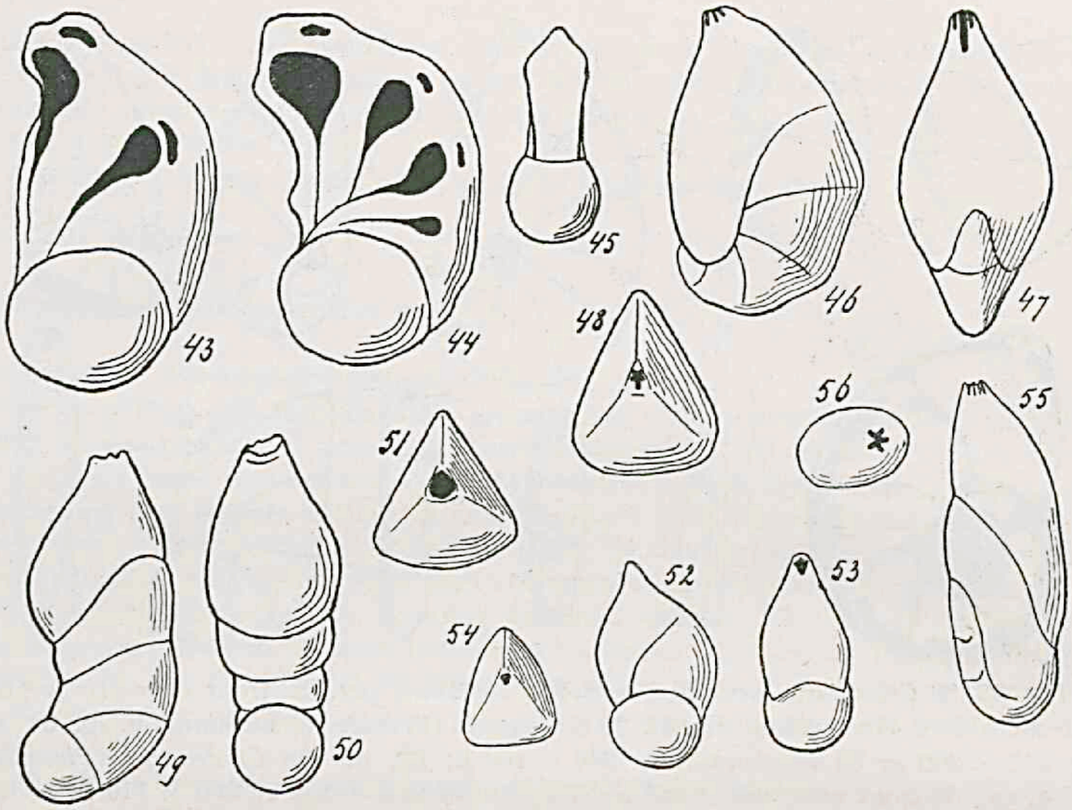

Fig. 43—45 *Cristellaria* (*Planularia*) sp., ? juv. of *P. thalmanni* n. sp., 43 front view 400 × 235 μ, 44 front view 400 × 230 μ, 45 apertural face 370 × 155 μ; fig. 46—48 *Cristellaria* (*Saracenaria*) *vermunti* n. sp., 46 front view 520 × 320 μ, 47 apertural face 500 × 270 μ, 48 apertural view 320 × 290 μ; fig. 49—51 *Cristellaria* (*Saracenaria*) *macgillavryi* n. sp., 49 front view 610 × 230 μ, 50 side view (with apertural face) 610 × 235 μ, 51 apertural view 250 × 235 μ; fig. 52—54 *Cristellaria* (*Saracenaria*) sp., 52 front view 330 × 200 μ, 53 apertural face 330 × 170 μ, 54 apertural view 200 × 160 μ; fig. 55, 56 Anomalous specimen of ? *Cristellaria schloenbachi* Rss., 55 front view 590 × 210 μ, 56 apertural view.

Age. Upper Eocene.
Locality. Well near Porta Spaño (Columbia Plantation, Bonaire).

Cristellaria (*Planularia*) *sp.*, ? juv. of *P. thalmanni* n. sp. Fig. 43—45.

Species consisting of a subglobular initial chamber and 2 or 3 younger chambers. Sutures highly thickened towards the periphery, of clear shell-substance, such as is found in the sutures of *P. thalmanni*. Peripherally of the sutures there is another small patch of clear shell-substance. It is possible that this species represents a juvenile form of *P. thalmanni* n. sp.

Age. Upper Eocene.
Locality Well near Porta Spaño (Columbia Plantation, Bonaire).

Cristellaria (*Planularia*) *sp.* Fig. 41, 42.

Fragment of a species with few chambers, of which the last formed ones uncoil. The species is much compressed, with parallel sides. Sutures flush, fairly distinct, thickened at the periphery. The apertural face is not preserved, but in the last septum one can see that it is radiate. Because the specimen is damaged I did not give it a new name.

The species is close to the form figured by Brady on Pl. 67, fig. 20 in lit. 53, *Cristellaria crepidula* F. & M., which is a *Planularia subarcuatula* (Williamson 1858) (see lit. 63). *P. subarcuatula* has more chambers in the coiled portion of the test.

Age. Upper Eocene.
Locality. Well near Porta Spaño (Columbia Plantation, Bonaire).

Cristellaria (*Robulus*) *inornata* d'Orb. 1846.
Cristellaria intermedia d.Orb. 1846.
Lenticulina convergens Cole 1927, Bull. Am. Pal. 14, no. 53, p. 8, pl. I, fig. 4, 5 (non Bornemann 1855).
Not *Cristellaria inornata* Sherborn & Chapmann 1886.

The Bonaire specimens have the chambers varying from 5 to 7. The course of the sutures is also fairly variable: from entirely straight to markedly, though always gently, curved.

Age. Upper Eocene.
Locality. Well near Porta Spaño (Columbia Plantation, Bonaire).

Cristellaria (*Robulus*) *mexicana* Cushman. Fig. 32, 33.

One small specimen was found, with large subglobular initial chamber and two more chambers. Sutures distinct, slightly depressed, curved. Surface smooth. I consider it to be a juvenile form of *R. mexicana* Cushman.

Age. Upper Eocene.
Locality. Well near Porta Spaño (Columbia Plantation, Bonaire).

Cristellaria (*Saracenaria*) *vermunti* n. sp. Fig. 46—48.

Test biconvex, coiled, with 6 chambers in the last formed coil; last formed chamber with a slight prolongation over the umbo. Surface smooth. Periphery rounded. Chambers gradually increasing in size. Sutures thin, not very distinct, gently curved. The periphery is bent outwards where sutures reach it, so that the periphery forms a broken line. Aperture robuline, apertural face flattened.

The species is characterized by its prolonged last chamber and by its periphery forming a broken line. It has some resemblance with C. *acutauricularis*, but it has less chambers in the last formed coil and is distinctly different by the characterization mentioned.

The species has been named in honour of Mr. L. W. J. VERMUNT, one of my fellow-travellers to the West Indies.

Age. Upper Eocene.
Locality. Well near Porta Spaño (Columbia Plantation, Bonaire).

Cristellaria (*Saracenaria*) *macgillavryi* n. sp. Fig. 49—51.

Test elongate, consisting of 5 chambers. Surface smooth. Species broadly rounded throughout. The initial chamber has approximately the form of a semi-sphere. Third to fifth chamber uncoiling. Youngest chamber swollen, narrowing towards the aperture, which is broken in the single specimen, but must have been radiate. Although there is only one specimen present and although this specimen is damaged at the aperture, I have given the species a name, because it is quite characterized by its semi-spherical initial chamber, its rapid uncoiling and the swollen last formed chamber, so that it is almost impossible to mix it up with another species.

The species has been named in honour of Mr. H. J. MAC GILLAVRY, one of my fellow-travellers to the West Indies.

Age. Upper Eocene.
Locality. Well near Porta Spaño (Columbia Plantation, Bonaire).

Cristellaria (*Saracenaria*) sp. Fig. 52—54.

Species consisting of a big, subglobular initial chamber and two younger chambers. The younger chambers are rounded triangular in cross-section. Surface smooth. Aperture radiate, slightly robuline.

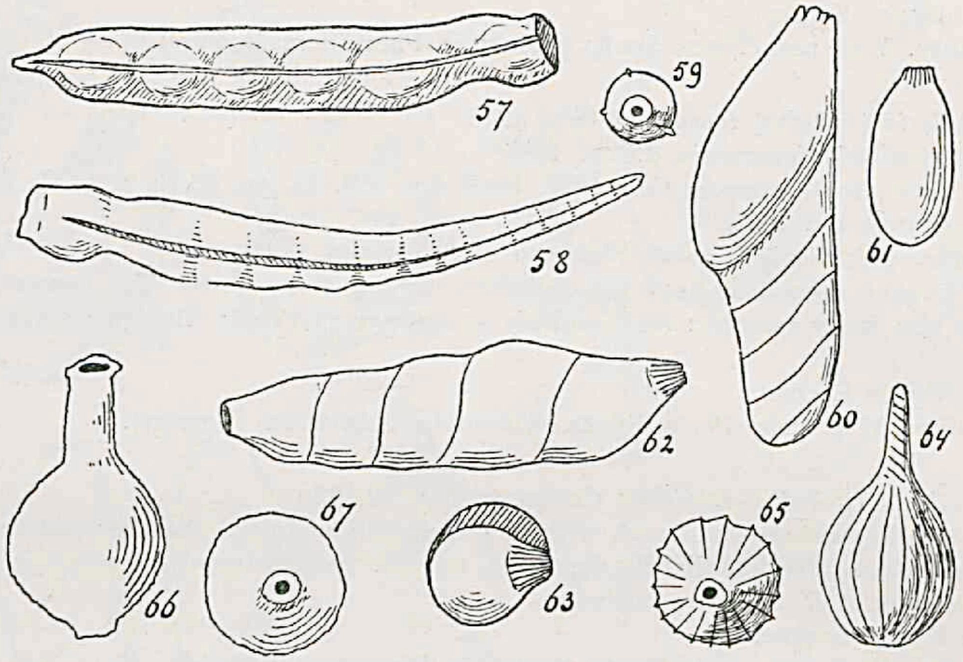

Fig. 57. *Nodosaria rutteni* n. sp. 1410 × 190 μ; fig. 58, 59 *Nodosaria* (*Dentalina*) *verneuili* d'Orb., var. *paucicostata* n. var., 58 1800 × 220 μ, 59 apertural view, dm. 220 μ; fig. 60, 61 *Nodosaria* (*Dentalina*) cf. *conferta* Neugeboren, 60 720 × 345 μ, 61 apertural view, thickness 160 μ; fig. 62, 63 *Nodosaria* (*Dentalina*) sp., 62 770 × 220 μ, 63 apertural view, dm. 160 μ; fig. 64, 65 *Lagena sulcata* Walker & Jacob (*Nodosaria scalaris* d'Orb.?), 64 side view 400 × 230 μ, 65 view of side opposite to side with neck, dm. 230 μ; fig. 66, 67 *Lagena sp.* (*Nodosaria hispida* d'Orb.?) 66 side view 455 × 260 μ, 67 view of side opposite to side with neck, dm. 240 μ.

The species represents a juvenile form, possibly of *Planularia thalmanni* n. sp.

Age. Upper Eocene.

Locality. Well near Porta Spaño (Columbia Plantation, Bonaire).

Anomalous specimen of? *Cristellaria schloenbachi* Rss. Fig. 55, 56.

The species has two large chambers with oblique sutures and some small earlier chambers. Aperture radiate. In cross section it is short-elliptical. The specimen has some resemblance with fig. 8, pl. 67 of BRADY 1884 (lit. 53), being probably an anomalous specimen of *C. schloenbachi* Rss.

Age. Upper Eocene.

Locality. Well near Porta Spaño (Columbia Plantation, Bonaire).

Genus *Nodosaria* Lmk. 1812.

Nodosaria rutteni n. sp. Fig. 57.

Test consisting of 6 ellipsoidal chambers, provided with 5 well developed, rather heavy costae, which are continuous, bridging the space between the chambers. Initial part pointed. Aperture large, rounded. Near the apertural end there is a slight curvation of the test. The species is very characteristic by its few, pronounced costae and its pointed initial part.

The species has been named in honour of Mr. M. G. RUTTEN, one of my fellow-travellers to the West Indies.

Age. Upper Eocene.

Locality. Well near Porta Spaño (Columbia Plantation, Bonaire).

Nodosaria (*Dentalina*) *verneuili* d'Orb. 1846, var. *paucicostata* n. var. Fig. 58, 59.

This variety differs from *D. verneuili* d'Orb. in being provided with 3 longitudinal costae. These costae are varying in size and development. There are specimens in which only one costa is developed over the entire length of the test, the other two being fragmentary; in other specimens the costae are minutely raised so as to be only visible in the sutural grooves.

Age. Upper Eocene.

Locality. Well near Porta Spaño (Columbia Plantation, Bonaire).

Nodosaria (*Dentalina*) cf. *conferta* Neugeboren 1856. Fig. 60, 61.

The Bonaire species differs from the species described by Neugeboren in its number of chambers, being much less than in *N. conferta* and in its form, being straight throughout, while *N. conferta* is curved.

Age. Upper Eocene.

Locality. Well near Porta Spaño (Columbia Plantation, Bonaire).

Nodosaria (*Dentalina*) sp. Fig. 62, 63.

There are some specimens belonging to the sub-genus *Dentalina* with oblique sutures and a peripheral radiate aperture, having moreover a rounded or oval opening at the opposite side. Their number of chambers is varying from 3—5. The specimens are ill-preserved; I only mention them because of the peculiar opening at the opposite side.

Age. Upper Eocene.

Locality. Well near Porta Spaño (Columbia Plantation, Bonaire).

Genus *Lagena* Walker & Jacob 1798.

Lagena sulcata Walker & Jacob 1798 (*Nodosaria scalaris* d'Orb.?). Fig. 64, 65.

It is possible that Hofker is right in considering *L. sulcata* to be a single chamber of *N. scalaris* (lit. 61). In the Bonaire specimens I noticed an opening at the side opposite the neck (fig. 65). However, as long as we have no certainty about this question it is better to keep the name ,,*Lagena sulcata*'' for this form.

Age. Upper Eocene.

Locality. Well near Porta Spaño (Columbia Plantation, Bonaire).

Lagena sp. (*Nodosaria hispida* d'Orb.?). Fig. 66, 67.

A *Lagena* species with the form of a decanter: a globular chamber and a stout neck. Surface rough. It has an aperture at the end of the neck and a second opening at the opposite side. It is possible that we have a similar case here as with *L. sulcata* and that this *Lagena* species represents nothing but broken chambers of *Nodosaria hispida* d'Orb.

Age. Upper Eocene.

Locality. Well near Porta Spaño (Columbia Plantation, Bonaire).

Family Nonionidae.

Genus *Nonion* Montf. 1808.

Nonion bonairensis n. sp. Fig. 68—70.

Test bilaterally symmetrical, slightly asymmetrical, on both sides involute; on one side with large umbilicus. Periphery broadly rounded. There are ca. 8 chambers in the last formed coil. Chambers very slowly increasing in size, two last formed chambers tending to uncoil or at the least attaining greater individuality than the preceding chambers. Sutures fairly distinct, almost straight, slightly depressed. Aperture indistinct, at the base of the apertural face.

Age. Upper Eocene.

Locality. Well near Porta Spaño (Columbia Plantation, Bonaire).

Nonion hummelincki n. sp. Fig. 71—73.

Test slightly asymmetrical, involute on both sides. Periphery rounded. Umbilicus large, especially on one side where it is slightly raised. There are about 12 chambers in the last formed coil. Chambers low, slowly increasing in height; last formed chambers becoming much longer. Sutures distinct, depressed, gently curved. Aperture not distinct, at the base of the last chamber; apertural face more or less flattened.

This species has the general shape of test and chambers of *Nonionina medio-costata* Cushman 1926 from the Miocene of California. However, *N. hummelincki* is not costate, it has a larger umbilicus, less chambers in the last formed coil and the transition of the peripheral margin to the apertural face is less rounded than it is in *Nonionina medio-costata*.

The species has been named in honour of Mr. P. HUMMELINCK, one of my fellow-travellers to the West Indies.

Age. Upper Eocene.

Locality. Well near Porta Spaño (Columbia Plantation, Bonaire).

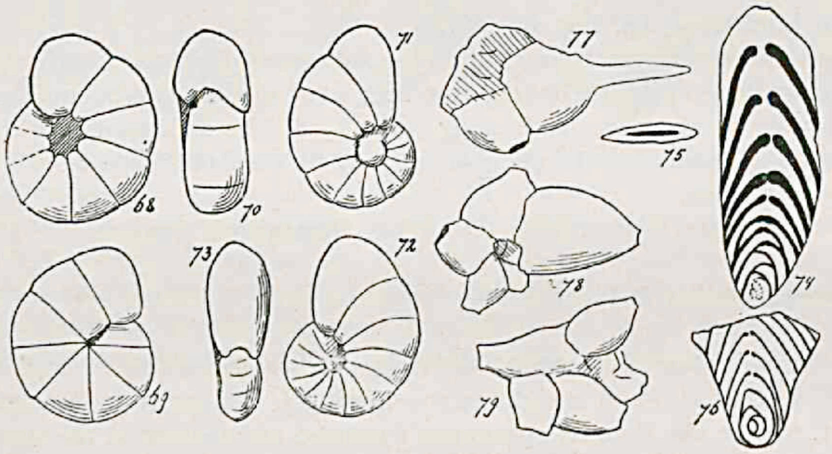

Fig. 68—70 *Nonion bonairensis* n. sp. 68 & 69 front views 470 × 380 μ, 70 peripheral view with apertural face 470 × 180 μ; fig. 71—73 *Nonion hummelincki* n. sp., 71 & 72 front views 430 × 290 μ, 73 peripheral view with apertural face 420 × 150 μ; fig. 74, 75 *Plectofrondicularia rutteni* n. sp., 74 775 × 270 μ, 75 apertural view 250 × 45 μ; fig. 76 *Plectofrondicularia sp.*, length of fragment ca. 850 μ; fig. 77—79 *Hantkenina longispina* Cushman (all the figured specimens are broken), 77 665 × 345 μ, 78 500 × 405 μ, 79 450 × 320 μ.

Family Heterohelicidae.

Genus *Plectofrondicularia* Liebus 1903.

Plectofrondicularia rutteni n. sp. Fig. 74, 75.

Test much flattened, initial end bluntly pointed. From initial end rapidly increasing to greatest width. Sutures distinct, very thick, flush. There are 4—6 rows of biserial chambers. Chambers irregularly and slowly increasing in height. The later sutures of the biserial stage and the sutures of the uniserial stage are thickened at the end. Sutures between the later chambers are not continuous. Aperture an elongate slit.

The species has been named in honour of Prof. L. RUTTEN.

Age. Upper Eocene.

Locality. Well near Porta Spaño (Columbia Plantation, Bonaire).

Plectofrondicularia sp. Fig. 76.

The species has a rounded initial end; from the initial end it is rapidly increasing in width. Sutures relatively thin. Sutures in the uniserial stage not continuous, thickened at the free ends.

The species shows most resemblance with P. *vaughani* Cushman 1927 from the Lower

Oligocene of Mexico, but the latter species has continuous sutures in the uniserial stage.

Age. Upper Eocene.

Locality. Well near Porta Spaño (Columbia Plantation, Bonaire).

Family Hantkeninidae.

Genus *Hantkenina* Cushman 1924.

Hantkenina longispina Cushman 1924. Fig. 77—79.

Hantkenina dumblei Weinzierl and Applin, Journ. of Pal. 3, no. 4, 1929, p. 402, pl. 43, fig. 5a, b.

The species is fairly rare in the Bonaire material and most of the specimens have the spines broken. I have made *H. dumblei* a synonym, because the length of the chambers is a rather varying characteristic (among the Bonaire material I often could not decide between *H. longispina* and *dumblei* on that characteristic), as is shape and size of the spines; moreover the latter characteristic cannot be of specific rank.

Age. Upper Eocene.

Locality. Well near Porta Spaño (Columbia Plantation, Bonaire).

Family Buliminidae.

Genus *Angulogerina* Cushman 1927.

Angulogerina molengraaffi n. sp. Fig. 80, 81.

Test elongate, from the bluntly pointed initial end rapidly attaining largest width. Triangular in cross-section, with rounded angles. Sutures distinct, depressed. Chambers in the early portion slowly increasing in height, in the later portion rapidly increasing in height. Aperture terminal, a rounded neck.

I named this species in honour of Dr. G. J. H. Molengraaff.

Age. Upper Eocene.

Locality. Well near Porta Spaño (Columbia Plantation, Bonaire).

Angulogerina macgillavryi n. sp. Fig. 82—86.

Test roughly, but clearly triangular in cross-section, with bluntly pointed initial end. Angles sharp or somewhat rounded; sharp especially in the last formed chamber or chambers. Sides flat, in the last formed chamber more or less concave. Chambers very individual, with distinct sutures. Chambers with blunt prolongations over the earlier chambers. Wall smooth. Aperture terminal, rounded, with a very short neck; in some specimens the neck is entirely failing.

The species is nearest to *Uvigerina selseyensis* Heron-Allen & Earland 1909 which is an *Angulogerina*. *A. macgillavryi*, however, is a much smaller form, with less chambers than *A. selseyenisis*; the chambers of *A. macgillavryi* are more individual and the triangular shape of its last formed chamber is more pronounced than in *A. selseyensis*.

The species has been named in honour of Mr. H. J. Mac Gillavry.

Age. Upper Eocene.

Locality. Well near Porta Spaño (Columbia Plantation, Bonaire).

Genus *Bolivina* d'Orb. 1839.

Bolivina advena Cushman 1925, var. *elongata* n. var. Fig. 87, 88.

This variety differs from *B. advena* in being longer and narrower, and more tapering towards the initial end. In shape it resembles *B. advena*, var. *striatella*, but it is not striate at all. It also resembles *B. incrassata* Rss, var. *limonensis* Cushman, but Cushman does not give a figure of the apertural face of this variety: if the apertural face has the same shape as *B. incrassata*, the Bonaire variety is certainly different, being much flatter and having a more elongate and narrower aperture.

Age. Upper Eocene.

Locality. Well near Porta Spaño (Columbia Plantation, Bonaire).

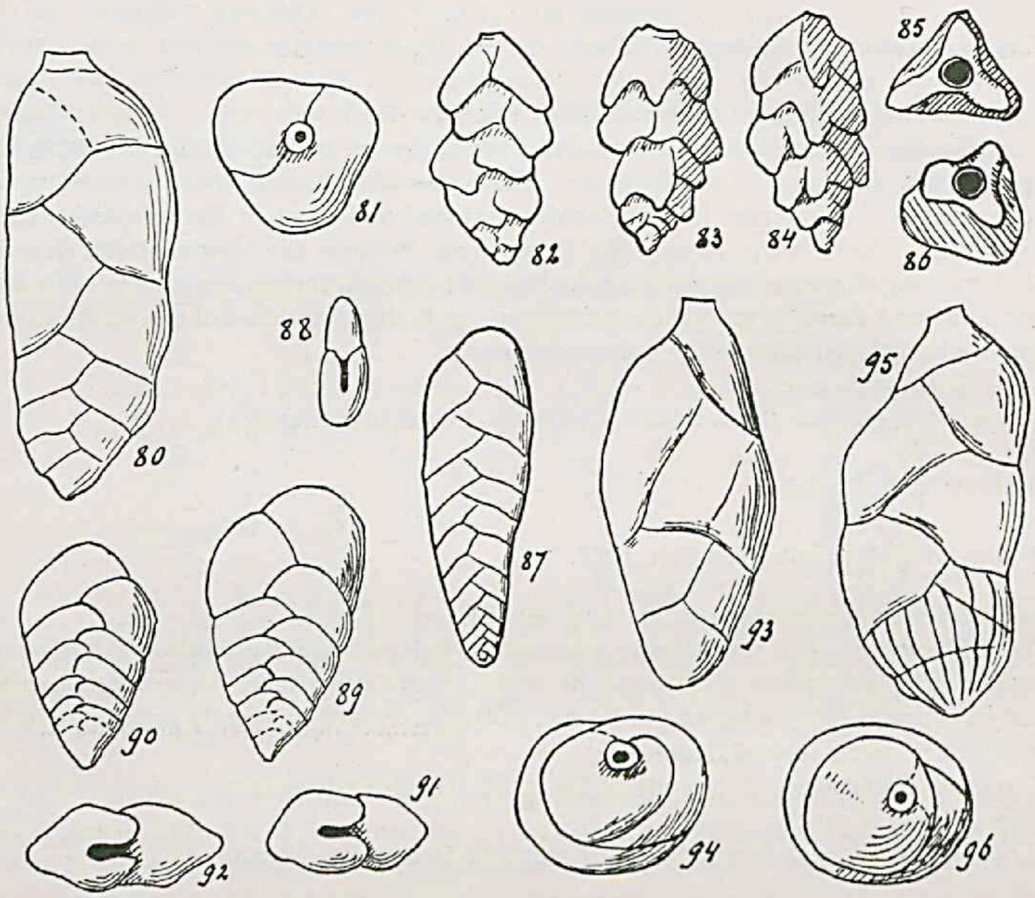

Fig. 80, 81 *Angulogerina molengraaffi* n. sp., 80 front view 370 × 140 μ, 81 apertural view, greatest width ca. 150 μ; fig. 82—86 *Angulogerina macgillavryi* n. sp., 82 view on one side 360 × 190 μ, 83 view on two sides 350 × 160 μ, 84 view on two sides 360 × 155 μ, 85 apertural view, greatest width 160 μ, 86 apertural view, greatest width 160 μ; fig. 87, 88 *Bolivina advena* Cushman, var *elongata* n. var., 87 front view ca. 300 × 09 μ, 88 apertural view 90 × ca. 35 μ; fig. 89—92 *Bolivina martini* n. sp., 89 front view 225 × 130 μ, 90 front view 190 × 125 μ, 91 apertural view 130 × 65 μ, 92 apertural view 160 × 70 μ; fig. 93, 94 *Uvigerina westermanni* n. sp., 93 front view 320 × 145 μ, 94 apertural view, greatest dm. 320 μ; fig. 95, 96 *Uvigerina bonairensis* n. sp., 95 front view 330 × 150 μ, 96 apertural view greatest dm. 330 μ.

Bolivina martini n. sp. Fig. 89—92.

Test small, compressed. Initial end pointed, width gradually increasing towards apertural end. Surface smooth. In cross-section the species is flat hexagonal, as can be clearly seen in apertural views. The youngest chambers are more or less pentagonal in apertural view. Angles not so sharp as to form a keel. Sutures not distinct, hardly or not depressed, curved. Chambers gradually increasing in size. Aperture elongate, perpendicular to inner margin of last formed chamber. The species is very characteristic by its flat hexagonal shape in cross section.

The species has been named in honour of Prof. K. Martin.

Age. Upper Eocene.

Locality. Well near Porta Spaño (Columbia Plantation, Bonaire).

Genus *Uvigerina* d'Orb. 1826.

Uvigerina mediterranea Hofker 1932.

CUSHMAN had already pointed to the fact that the name *U. pygmaea* of D'ORBIGNY was often applied to species with striated latest chambers (lit. 58), while D'ORBIGNY'S *U. pygmaea* has punctate latest chambers. CUSHMAN did not give a name for the entirely striated species, but this was lately fulfilled by HOFKER, who called it *U. mediterranea*, because the species was found at two places in the Mediterranean (lit. 61). Perhaps it was not necessary to give a new name, because there are certainly species described by authors, synonym with *U. mediterranea*. However, to avoid errors, it is much better to give a new name to this very common form than to use one of the old names. It is only to regret that HOFKER has not chosen a better, more general name for this form, so common and wide-spread fossil as well as recent.

Age. Upper Eocene.

Locality. Well near Porta Spaño (Columbia Plantation, Bonaire).

Uvigerina westermanni n. sp. Fig. 93, 94.

Test with rounded initial end; from initial end gradually widening till about halfway the length of test where it is widest, then narrowing first slowly, later rapidly, towards the aperture. Surface fairly smooth, sutures distinct, depressed; course of the sutures very peculiar. There are only few, high chambers, differing in shape and size. The species is sub-oval in cross section. Aperture terminal, a rounded neck with minute lip.

This species resembles in its general shape and more or less in the course of its sutures *Uvigerinella parva* Cushman & Jarvis 1929, but the aperture of *U. westermanni* is distinctly uvigeriniform.

The species has been named in honour of Dr. J. H. WESTERMANN.

Age. Upper Eocene.

Locality. Well near Porta Spaño (Columbia Plantation, Bonaire).

Uvigerina bonairensis n. sp. Fig. 95, 96.

Uvigerina cocoaensis, in CUSHMAN & APPLIN, Bull. Am. Ass. Petr. Geol. X, 1926, p. 174, pl. 8, fig. 15. (not *U. cocoaensis* Cushman 1925, Contr. Cushm. Lab. Foram. Res. 1, pt. 3, p. 68, pl. lo, fig. 12, and not *U. cocoaensis* Cushman, in CUSHMAN & SCHENCK, Univ. Calif. Publ. Bull. Dep. Geol. Sci. vol. 17, no. 8, 1928, p. 312, pl. 43, fig. 17—19).

Test sub-oval in cross section. Initial end bluntly pointed. Test rapidly attaining largest width. Width decreasing near apertural end. Sutures rather distinct, depressed. Chambers few, high, early chambers irregularly arranged, with indistinct sutures and ca. 17 well marked costae. Aperture terminal, rounded, with distinct neck.

The Bonaire species is closest to *U. oligocaenica* Andreae. The latter species is longer and narrower, more tapering towards the apertural end, with a longer and thinner neck.

U. cocoaensis Cushman 1925 has less and coarser costae, not restricted to the earliest chambers, though becoming less conspicuous in later chambers and costae of one chamber usually not confluent with those of adjacent chambers; its sutures are more depressed; it has a distinct lip and its neck is shorter than in *U. bonairensis*.

Age. Upper Eocene.

Locality. Well near Porta Spaño (Columbia Plantation, Bonaire).

Family. Rotaliidae.

Genus *Baggina* Cushman 1926.

Baggina thalmanni n. sp. Fig. 97—99.

Test biconvex, thick. Chambers few, inflated and rounded, rapidly increasing in size, with huge last formed chamber. Sutures distinct, depressed. On the dorsal side somewhat more than one coil is visible. Ventral side involute. Wall coarsely perphorate. Aperture ventral, not distinct; above the aperture (on the last formed chamber) is a clear white space, consisting of the largest part of a circle, truncated towards the (apertural) inner margin of the chamber. At or quite near the border of this white space there are ca. 9 supplementary apertures.

The find of this species of *Baggina* is very interesting, in the first place because the genus *Baggina* was not yet known in the Eocene, in the second place because supplementary apertures were not observed hitherto in *Baggina* species.

I named this species in honour of Dr. H. E. THALMANN.

Age. Upper Eocene.

Locality. Well near Porta Spaño (Columbia Plantation, Bonaire).

Genus *Eponides* Montf. 1808.

Eponides byramensis Cushman 1922.

Eponides incerata Cushman 1922, Carn. Inst. Wash. Publ. 311, p. 51, pl. 9, fig. 1—3. *Eponides jacksonensis* Cushman & Applin 1926, Bull. Am. Ass. Petr. Geol. X, p. 181,pl. 9, fig. 24, 25.

Age. Upper Eocene.

Locality. Well near Porta Spaño (Columbia Plantation, Bonaire).

Genus *Lamarckina* Berthelin 1881.

Lamarckina vermunti n. sp. Fig. 100—103.

Test biconvex, dorsal side more convex than ventral side. Periphery acute. Wall coarsely perphorate. Dorsal side showing about two whorls; in the last formed whorl there are ca. 6 chambers. Ventral side smooth, involute. Chambers gradually increasing in size. Sutures on dorsal side rather distinct, not so on ventral side. Sutures gently to strongly curved dorsally, less curved ventrally. Most specimens have an umbilicus, but it is not always very distinct and in some specimens it fails. Aperture ventral, nearer to the umbilical part of the chamber than to the peripheral part. In specimens with a well developed umbilicus, the chambers have distinct incisions on the ventral side; in specimens where the umbilicus is not distinct or fails, this character cannot be verified.

The species resembles *L. rugulosa* Cushman 1926 and *L. ocalana* Cushman 1926; principally it differs from both species by its much stronger incisions of the chambers. *L. ocalana* has a more rounded shape.

The species has been named in honour of Mr. L. W. J. VERMUNT.

Age. Upper Eocene.

Locality. Well near Porta Spaño (Columbia Plantation, Bonaire).

Genus *Siphonina* Rss. 1849.

Siphonina ?pulchra Cushman 1919. Fig. 104—106.

Most probably the Bonaire specimens belong to *S. pulchra*: they agree on the whole with the descriptions, but the figures given are very indistinct. In the Bonaire specimens the dorsal side is generally slightly more convex than the ventral one; the periphery is subacute, there is no keel. The wall is coarsely perphorate. Sutures on the dorsal side flush, on the ventral side slightly depressed. On the dorsal side the sutures are running strongly backwards. Dorsally there are at most three whorls visible; the last whorl has about 5 chambers. The peculiar ornamentations mentioned by CUSHMAN are not distinct on the Bonaire specimens. The Bonaire specimens are relatively small sized.

Age. Upper Eocene.

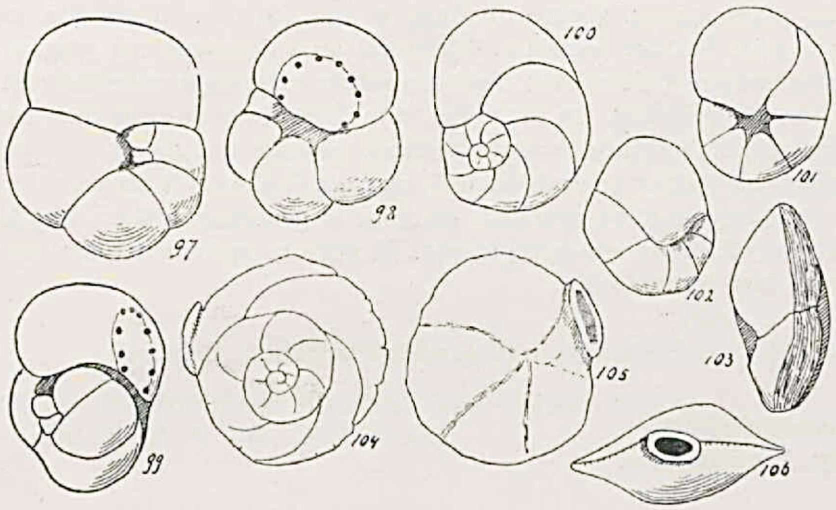

Fig. 97—99 *Baggina thalmanni* n. sp., 97 dorsal view 660 × 500 μ, 98 ventral view 560 × 450 μ, 99 peripheral view 540 × 380 μ; fig. 100—103 *Lamarckina vermunti* n. sp. 100 dorsal view 540 × 400 μ, 101 ventral view of specimen with large umbilicus and distinct incisions 470 × 360 μ, 102 ventral view of a specimen in which no umbilicus is visible 770 × 630 μ, 103 peripheral view 540 × 250 μ; fig. 104—106 *Siphonina ?pulchra* Cushman, 104 dorsal view 560 × 540 μ, 105 ventral view 570 × 540 μ, 106 apertural view 510 × 265 μ.

Locality. Well near Porta Spaño (Columbia Plantation, Bonaire).

Family Globigerinidae.

Genus *Globigerina* d'Orb. 1826.

Globigerina sp. sp.

Beside the species mentioned in the list on p. 43, there are some other species of *Globigerina* in the material. Their variability, however, is so great that I did not succeed in distinguishing distinct forms. They are mostly subglobular specimens with 4 or 5 large chambers visible, occasionally with some small chambers, resembling species like *G. conglobata* Brady or *G. quadrilobata* d'Orb.

Family Globorotaliidae.

Genus *Globorotalia* Cushman 1927.

Globorotalia kochi n. sp. Fig. 111—115.

Test small, planoconvex: dorsal side flat or slightly concave, ventral side conical. Periphery lobulate, acute, not keeled. There are 2 to 2½ whorls visible on the dorsal side, with 5 or 6 chambers in the last whorl. Sutures fairly distinct; on the dorsal side flush, curved backwards; on the ventral side depressed, straight, radiate or nearly so. Surface rough. Aperture elongate, indistinct, from the umbilical area extending towards the periphery, widest near the umbilical area.

Globorotalia kochi resembles to some degree *G. micheliniana* (d'Orb.), but it has less chambers in the last coil, the sutures on the dorsal side more curved backward, the periphery less acute, not keeled, the sutures on the ventral side not curved, a less conspicuous aperture and a rough surface.

The species has been named in honour of Dr. R. Koch.

Age. Upper Eocene.

Locality. Well near Porta Spaño (Columbia Plantation, Bonaire).

Globorotalia bonairensis n. sp. Fig. 107—110.

Test small, planoconvex. Sutures distinct on the conical ventral side, not so on the flattened dorsal side. Surface papillate. Umbilical area depressed on ventral side. In the last formed coil there are 4 chambers; these are rather individual, especially on the ventral side, more or less overlapping. On the dorsal side there are little more than 2 whorls visible, though very indistinct. Aperture elongate, ventral, on inner margin of last formed chamber.

At first sight this species reminds us of *G. crassula* Cushman & Stewart, but it is clearly different: its periphery is more rounded, its form is generally higher, its chambers more individual and the coiling is less conspicuous. In not one specimen there are more than 4 chambers in the last formed coil.

Age. Upper Eocene.

Locality. Well near Porta Spaño (Columbia Plantation, Bonaire).

Family Anomalinidae.

Subfamily Anomalininae.

Genus *Anomalina* d'Orb. 1826.

Anomalina subbadenensis n. sp. Fig. 116—120.

Test nearly bilaterally symmetrical, with broadly rounded periphery. Dorsal side showing 2—2 ½ whorl, with 6—8 chambers in the last formed whorl. Sutures very distinct, depressed, gently curved. Chambers fairly individual, very gradually increasing in size. Wall coarsely perphorate. Aperture not distinct, on inner margin of last formed chamber.

The species is very close to *A. badenensis* d'Orb., from which it chiefly differs in being more bilaterally symmetrical, so not having the last formed chamber projecting over the dorsal side.

Age. Upper Eocene.

Locality. Well near Porta Spaño (Columbia Plantation, Bonaire).

Genus *Bonairea* n.gen.

Test compressed, planispirally coiled, dorsal side flat, evolute; ventral side concave, involute. Last formed coil with large chambers, more individual than earlier chambers and dorsally rising above the flattened dorsal side. Aperture peripheral.

The genus *Bonairea* is nearest related to the genus *Anomalina*, from which it chiefly differs by its most characteristic features: the planispirally coiling, the concave ventral side, the individuality and peculiar arrangement of the chambers of the last formed coil.

Bonairea coronaeformis n. gen. n. sp. Genotype. Fig. 121—129.

Species of small size, test as in genus. Early chambers close coiled, on the dorsal side there are ca. 2 coils visible. In the last formed coil there are 5—6 chambers, much larger and higher than the preceding chambers, more individual and with blunt processes directed half backward, half dorsal. As a consequence of the size of the chambers of the last formed coil, the ventral side is strongly concave, the dorsal side is flat, except the prolongations of the chambers of the last formed coil. Surface smooth. Sutures fairly distinct, slightly depressed in the early chambers, more so in the last formed coil, curved. Aperture not distinct, peripheral, possibly with a continuation on the dorsal side.

As a result of the peculiar form of the last formed chambers, the species gives in side view the impression of a small crown, to which feature it owes its specific name.

Age. Upper Eocene.

Locality. Well near Porta Spaño (Columbia Plantation, Bonaire).

Subfamily Cibicidinae.

Genus *Cibicides* Montf. 1808.

(Reprinted from the CONTRIBUTIONS CUSHMAN LAB. FORAM. RES.
Vol. 9, pt. 2, June 1933, p. 30.)

130. RUTTENIA, A NEW NAME FOR BONAIREA PIJPERS, 1933

By P. J. PIJPERS

I am proposing the following new name, *Ruttenia*, in place of *Bonairea* which is already preoccupied.

Genus **RUTTENIA** Pijpers, new name

Bonairea PIJPERS, Geol. & Pal. Bonaire (D. W. I.), Diss. Utrecht, 1933, p. 72 (not of H. BURRINGTON BAKER, 1924).

The generic name *Bonairea* has been already used by H. Burrington Baker in 1924 for a subgenus of gastropods (Occ. Papers Mus. Zool. Univ. of Michigan, vol. 6, No. 152, 1924, p. 42, Genus *Tudora* Gray, Subgenus *Bonairea*).

The genotype of *Ruttenia* will be *Ruttenia coronaeformis* (Pijpers) = *Bonairea coronaeformis* Pijpers, Geol. & Pal. Bonaire (D. W. I.), 1933, p. 72.

My thanks are due to Mr. P. Hummelinck, biologist, for calling my attention to Burrington Baker's name.

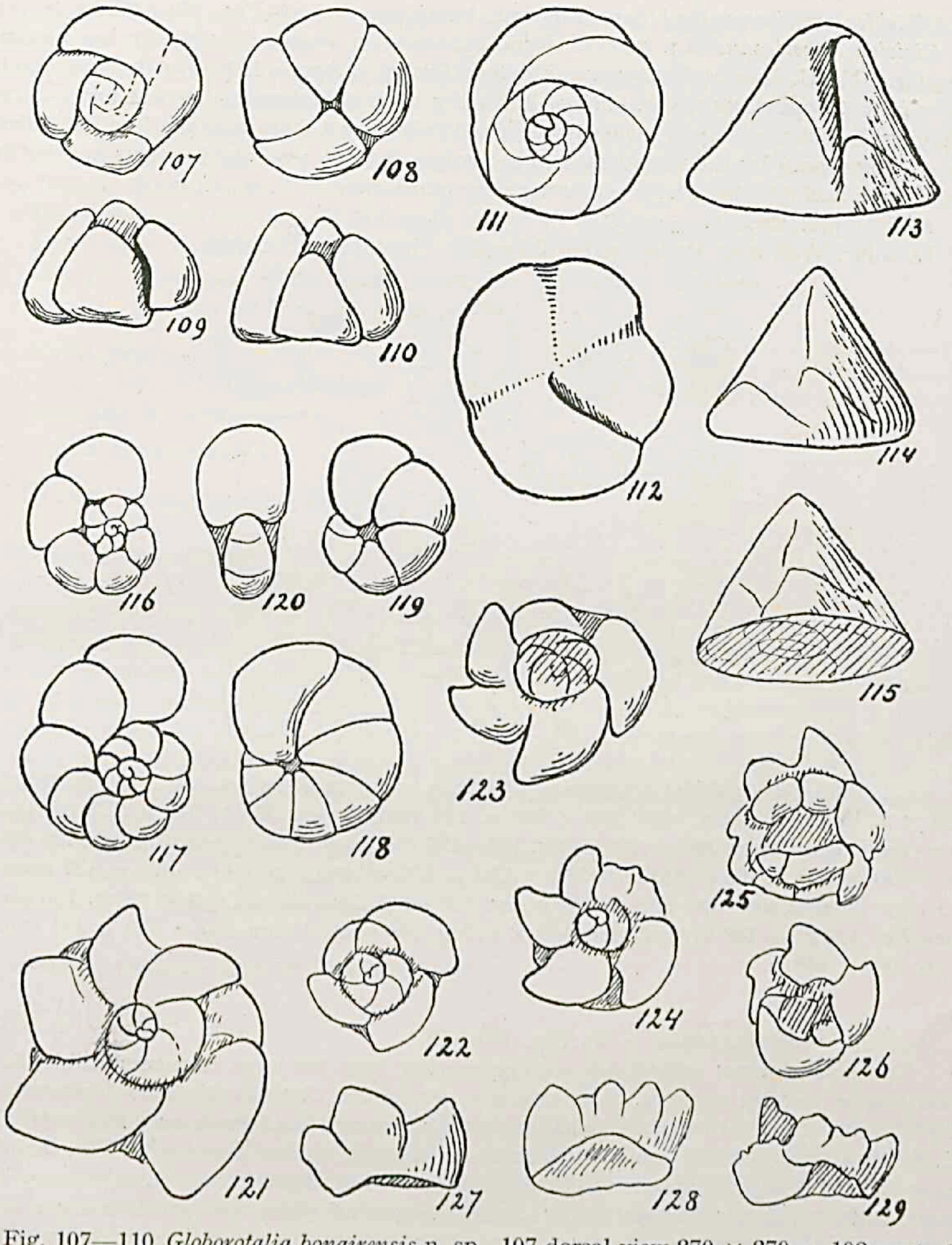

Fig. 107—110 *Globorotalia bonairensis* n. sp., 107 dorsal view 270 × 270 μ, 108 ventral view 300 × 240 μ, 109 peripheral view showing aperture 290 × 210 μ (greatest dm. × height), 110 peripheral view 305 × 220 μ (greatest dm. × height); fig. 111—115 *Globorotalia kochi* n. sp., 111 dorsal view 230 × 220 μ, 112 ventral view, showing aperture 260 × 225 μ, 113 peripheral view, showing aperture, dm. 270 μ, 114 peripheral view 230 × 180 μ (dm. × height), 115 half dorsal, half peripheral, dm. 230 μ; fig. 116—120 *Anomalina subbadenensis* n. sp., 116 dorsal view 290 × 230 μ, 117 dorsal view 355 × 290 μ, 118 ventral view 355 × 290 μ, 119 ventral view 280 × 230 μ, 120 peripheral view showing apertural face 290 × 170 μ; fig. 121—129 *Bonairea coronaeformis* n. g.n.sp., 121 dorsal view, dm. ca. 370 μ, 122 dorsal view, dm. 230 μ, 123 dorsal view 360 × 325 μ, 124 dorsal view (broken specimen), dm. 270 μ, 125 ventral view, dm. 290 μ, 126 ventral view 250 × 230 μ, 127 peripheral view, dm. 280 μ, 128 peripheral view, dm. 290 μ, 129 peripheral view, dm. 290 μ.

Cibicides americanus Cushman 1918, var. *bonairensis* n. var. Fig. 130—133.

Cibicides americanus is a miocene form, occurring in Panama; a variety has become known from the U. Eocene of Antigua: var. *antigua* Cushm. & Applin 1926. The Bonaire variety differs from *C. americanus*, var. *antigua* in having more chambers in the last formed coil, in having the chambers more regularly built and in having a more rounded form. It differs from *C. americanus* by the same features, by its less distinct, not raised sutures and by the absence of a keel (this keel, however, is not very pronounced in *C. americanus*).

Age. Upper. Eocene.

Locality. Well near Porta Spaño (Columbia Plantation, Bonaire).

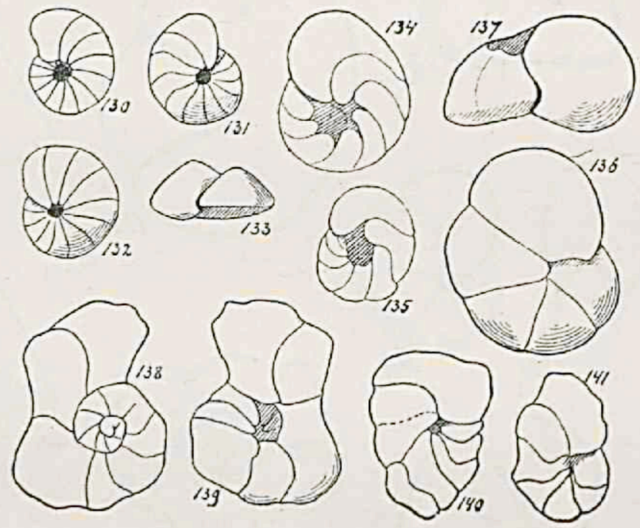

Fig. 130—133 *Cibicides americanus* Cushman, var. *bonairensis* n. var., 130 dorsal view 290 × 230 μ, 131 ventral view 290 × 230 μ, 132 ventral view 305 × 270 μ, 133 peripheral view showing aperture 330 × 150 μ; fig. 134—137 *Cibicides megalocephalus* n. sp., 134 dorsal view 430 × 340 μ, 135 dorsal view 315 × 250 μ, 136 ventral view 540 × 470 μ, 137 peripheral view showing aperture 500 × 290 μ; fig. 138—141 *Dyocibicides rutteni* n. sp. 138 dorsal view 540 × 410 μ, 139 ventral view 540 × 410 μ, 140 ventral view 430 × 320 μ, 141 ventral view 380 × 250 μ.

Cibicides megalocephalus n. sp. Fig. 134—137.

Test planoconvex: ventral side strongly convex, with few large chambers visible; dorsal side flat or slightly concave. Wall coarsely perphorate. Sutures distinct, depressed and slightly curved on ventral side, flush and strongly curved backwards on dorsal side. Only chambers of the last coil (generally 6 or 7) are distinct on the dorsal side. The chambers have more or less pronounced incisions on the dorsal side. Last formed chamber very large sized, highly inflated; dorsally rising above the general plane. Peripheral margin acute; occasionally the ventral side has a gentle rounding towards this margin. Aperture peripheral.

Through personal communication of Dr. THALMANN, I was informed that this species is common in the U. Eocene of Mexico.

Age. Upper Eocene.

Locality. Well near Porta Spaño (Columbia Plantation, Bonaire).

Genus *Dyocibicides*.

Dyocibicides rutteni n. sp. Fig. 138—141.

Test much compressed, dorsally flattened and more or less evolute; ventrally minutely convex, only the chambers of the last formed coil visible. Margin acute. Wall coarsely perphorate. Chambers very irregularly arranged, closely coiled in the early portion; later chambers with irregular form and irregularly running sutures. Aperture indistinct, probably entirely at the ventral side.

It is possible that this species represents the juvenile form of *D. uniserialis* Thalmann (lit. 63) which is defined by BRADY's fig.7, pl. 93, in lit. 53 (named *Truncatulina variabilis* d'Orb. by BRADY). In that case it would be remarkable that there is not one specimen with more series of uncoiled chambers among the Bonaire material, though several specimens were found.

This species has been named in honour of Mr. M. G. RUTTEN.

Age. Upper Eocene.

Locality. Well near Porta Spaño (Columbia Plantation, Bonaire).

ANTHOZOA

SUBCLASS ZOANTHARIA

ORDER HEXACORALLA.

Family Amphiastraeidae Ogilvie.

Genus *Eugyra* From.

Eugyra sp.? Fig. 142*a*, *b*.

Fragment of a meandroid form with the valleys united by simple walls. The fragment is more or less conical, compressed. The lower side of the fragment has a length of 20 mm. a width of 5 mm.; probably the colony was fixed with a narrow elongate base.

Valleys not very sinuous, width 1,5—3 mm., generally 2 mm. Septa rather thick, 36—44 to 1 cm., long septa with thickened inner ends alternating with very short ones. Walls relatively thick, generally 0,2 mm., in places 0,4 mm. Dissepiments are rather numerous. Costae not distinct.

L. of fragment 48 mm.; W. 29 mm.; H. 44 mm.

Age. Uppermost Cretaceous. Rincon formation.

Locality. W. of Rincon (W. Bonaire).

Family Astraeidae Edw. & Haime (emend).

Genus *Orbicella* Dana.

Orbicella sp. A. Fig. 147.

Corallites 5—6 mm., in well developed coenenchyma. There are 3 complete cycles of septa and an incomplete 4th cycle. Two cycles of septa reach the columella, the remaining septa are shorter. These two cycles consist of moderately thick septa, the other septa are thin. The columella is trabecular, well developed, to 1,5 mm. in diameter. There are costae corresponding with all septa uniting the corallites. Dimension of intercorallite areas very variable: distance of two corallites ranging from 1 mm. or less to 3,5 mm. Walls and dissepiments are well developed, dissepiments both endo- and exothecal.

The species shows most resemblance with *O. brevis* (Duncan 1864) of the Nivajé shale, San Domingo, of unknown horizon. The Bonaire species differs by its equal costae and development of endothecal dissepiments and by the 2 cycles of thick septa.

Age. Uppermost Cretaceous. Rincon formation.

Locality. W. of Rincon (W. Bonaire).

Orbicella sp. B. Fig. 148, 149.

Small corallites in a varying, generally rich mass of coenenchyma. Corallites mostly 1 mm. in diameter. Distances of corallites 0,5—1,75 mm. I counted 14—19 septa, of which

8—10 septa reach the columella; remaining septa are shorter, but relatively long, more than half the length of the longer ones. Longer septa are thicker than shorter ones. Columella small but well developed, trabecular. Costae well developed, to all septa. In the wall septa and costae are thickening.

Age. Uppermost Cretaceous. Rincon formation.

Localities. W. of Rincon, SE of Seroe Dochila (W. Bonaire).

Family Fungidae Dana (emend).

Genus *Siderastrea* de Blainv.

Siderastrea sp.,? cf. *hilsboroensis* Vaughan 1919.

Species with irregular, polygonal corallites, with distinct wall. Corallites 3—7,5 mm., chiefly 4 and 5 mm. There are 44—62 septa. In a corallite with ca. 60 septa there are ca. 15 long septa, ca. 15 shorter ones, the remaining being very short. The long septa are perforated. Synapticulae generally well developed. Columella trabecular, not strongly developed.

The main differences with *S. hilsboroensis* are the ill developed columella and few synapticulae in some corallites.

Age. Uppermost Cretaceous. Rincon formation.

Locality. W. of Rincon (W. Bonaire).

Family Eupsammidae Edw. & Haime.

Genus *Palaeopsammia* Wanner.

Palaeopsammia sp. Pl. I., fig. 29.

Corallum simple, cornute, with narrow base. Calices elliptical, short cup shaped to long conical.

Measures:

Calice		Septa
12,5 × 19 mm.	(100: 152)	> 80
19 × 21,5 mm.	(100: 113)	
13 × 27 mm.	(100: 208)	ca. 63
17,5 × 24 mm.	(100: 137)	ca. 78
18,5 × 28,5 mm.	(100: 154)	ca. 96

Smaller corallites have 4 cycles and a few quinaries, larger ones 5 cycles or 4 cycles and many quinaries. The septa of 3 cycles are thick, of the 4th and 5th cycle thin. Septa closely arranged, granulated, in the older parts rather thick and united with the columella, in the younger parts thinner, partly united with the columella, partly with distinct pali, in the youngest parts (that is in the calices, where there is no columella) partly with pali. The septa are also joined inter se. Near the wall the septa are perphorate. Columella very well developed, trabecular or spongy. Costae rather thick, with narrow interspaces, equal. Probably there are costae to all septa. Wall porous in the interspaces of the costae; in places, generally being in the older parts of the corallites, the wall is secondarily thickened. In the latter case the porosity of the wall is no longer noticeable. There is no epitheca.

I have hesitated a long time whether to bring this species to the genus *Balanophyllia* S. Wood or to *Palaeopsammia*. The genera are closely related. Chief differences of the present species with *Balanophyllia*, wherefore it was brought to *Palaeopsammia*, are: 1. the occurrence of thickenings at the ends of all septa (pali); 2. the occurrence of numerous shorter septa, generally three shorter septa between two longer ones; 3. junctions among the septa near the wall (in *Balanophyllia* these junctions are more common towards the columella).

Wanner says that in Palaopsammia the septa are not numerous (lit. 67) and consequently are not closely arranged. This character is doubted by Oppenheim (lit. 64, p. 316); moreover, Wanner himself gives for *P. aegyptica* 5 cycles of septa. Indeed the number of septa is no generic criterion.

The genus *Palaeopsammia* is known of Palestina and of the Libyan desert (Egypt) in the Upper Cretaceous.

Age. Uppermost Cretaceous. Rincon formation.

Localities. W. of Rincon, SE. of Seroe Dochila (W. Bonaire).

Family Turbinolidae Edw. & Haime 1848 (emend. Ogilvie).

Subfamily Turbinolinae Ogilvie (Turbinolidae simplices).

The following is a description of a species belonging to the subfamily Turbinolinae, which, however, is not preserved well enough to give it a generic and specific name. Pl. I, fig. 30, 31.

Corallum simple, free, short-conical, straight or sub-cornute. Corallites elliptical, with numerous septa.

Measures:

Calice		Septa
ca. 7 × 14,5 mm.	(100: 207)	ca. 48
9 × 14 mm.	(100: 156)	> 44
9,5 × 15,5 mm.	(100: 163)	ca. 63
9 × 17 mm.	(100: 189)	> 48
10,5 × 22 mm.	(100: 210)	ca. 80
12,5 × 18 mm.	(100: 144)	ca. 85
14 × 24 mm.	(100: 171)	> 48
16 × 23 mm.	(100: 144)	> 48

There are 4 complete cycles of septa and a varying number of septa of the 5th cycle. Approximately 3 cycles of septa are long, thick and swollen at the ends. They alternate with small and thin septa of the 4th and 5th cycle. The pali before the septa are arranged in one crown. The septa are finely granulated. Columella short and compact, only in the oldest parts of the corallites and fused with the pali. In the younger parts there is no columella, the septa are thinner, generally without pali. Wall thick, especially in the oldest parts of the corallites, with well developed epitheca.

Age. Uppermost Cretaceous. Rincon formation.

Localities. W. of Rincon, SE. of Seroe Dochila (W. Bonaire).

Subfamily Trochosmilinae Ogilvie.

Genus *Diploctenium* Goldf.

Diploctenium sp. Fig. 143, Pl. II, fig. 16.

Only one specimen is present in the material. The species has strongly and beautifully curved wings, first downwards, then backwards to the midline. The shorter axis is 20 mm. For the other dimensions I can refer to fig. 143. There are ca. 14 septa to 1 cm. The strong backward curvation, immediately after the downward curving of the wings, is very typical. and distinguishes this species from all the other *Diploctenium* species. The Bonaire species is nearest to *D. haidingeri* Reuss and *D. conjungens* Reuss. It differs from both species by the strong curvation of the wings. *D. haidingeri* is bigger and the downwards running branch of the wings is longer; *D. conjungens* is smaller.

Age. Uppermost Cretaceous. Rincon formation.

Locality. W. of Rincon (W. Bonaire)).

Family Stylophoridae Edw. & Haime.

Genus *Stylophora* Schweiger.

Stylophora imperatoris Vaughan 1919.

Fragment of corallum with a height of 75 mm. The calices generally have a diameter

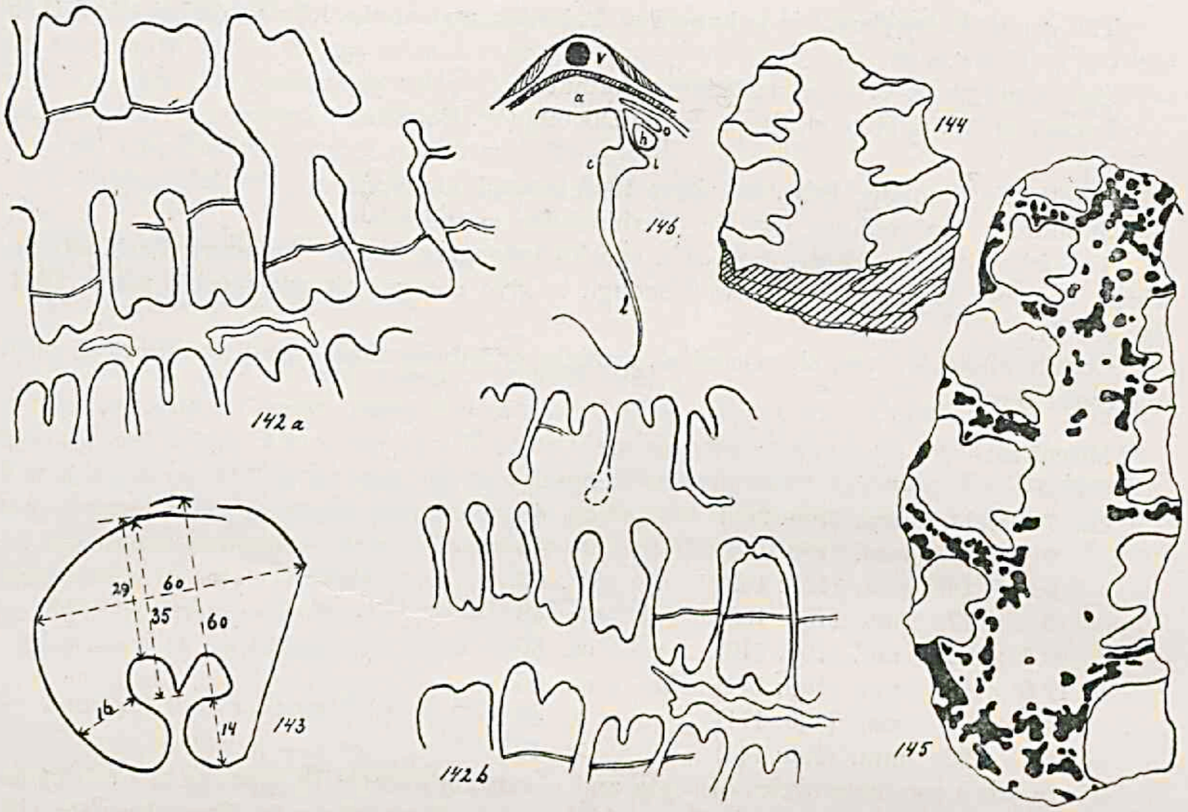

Fig. 142*a*, *b* ?*Eugyra sp.*, much enlarged; fig. 143 *Diploctenium sp*, dimensions in mm.; fig. 144, 145 *Nerinea sp.*, reduced, fig. 145 showing cavities; fig. 146 Horizontal section through *Terebratula martini* n. sp. showing outer socket ridge (o), inner socket ridge (i), crurum (c), course of loop (l) and hinge tooth (h); v ventral valve with foramen, d dorsal valve.

of 1 mm., the intervening walls are 0,75—1 mm. There are 6 distinct septa and a styliform columella. Costae 24, 6 prominent and 18 smaller ones.

Hitherto the species was only found in the Oligocene of Anguilla (horizon of Anguilla formation) and of Panama (Emperador limestone and Culebra formation). The Bonaire specimen was found in a limestone, occurring among quaternary limestones and I consider it here to be of quaternary age too.

Age. Quaternary(?).

Locality. W. of Goto (W. Bonaire).

Stylophora sp. Pl. II, fig. 15.

Corallum forming compressed branches or masses. Scattered over the surface are numerous monticules, generally reaching a height of 2 mm. and generally not exceeding a diameter of 3 mm. at the base. Calices 0,5 mm., without definite arrangement; distances between the calices varying, equal to or exceeding the diameter of the calices. Calices fairly deep, margins of many calices slightly raised. There are 6 septa running to the styliform columella, nearly reaching the top of the calices. Number of costae varying, at least 12; between 2 septa there are 1, 2 or 3 costae. The costae never extend from one calice to the next. There is no groove, defining the limits of the individual corallites. The coenenchyma is granulated.

The species shows some resemblance with *S. monticulosa* Hoffmeister 1925, but the diameter of the calices is slightly smaller. It is also related to *S. panamensis* Vaughan 1919, but the diameter of the calices is smaller, the distances of the calices are generally larger and it never has the indistinct upper lip of the upper wall of the calices.

Age. Quaternary.

Locality. SE. of Gabilan (E. Bonaire).

Genus *Astrocoenia* Edw. & Haime.

Astrocoenia cf. portoricensis Vaughan 1919. Pl. II, fig. 14.

Calices 1—1,5 mm in diameter. There are 8 long septa, reaching the relatively thick columella, and 8 shorter ones. The shorter septa are not visible in all calices.

The Bonaire specimen differs only from *A. portoricensis* by its thicker columella.

A. portoricensis was found in the Oligocene of Antigua (Antigua formation), Porto Rico (Pepino formation) and Panama (Emperador limestone). The Bonaire specimen occurs in upper eocene limestone.

Age. Upper Eocene.

Locality. N. of Morèke (Columbia Plantation, Bonaire).

Genus *Multicolumnastraea* Vaughan 1899.

Multicolumnastraea parvula Gerth 1928. Fig. 150—152.

The specimen is rounded, 6,7 × 6 × 4,7 mm. There are 10—14 septa, reaching the columella and a very incomplete cycle of very small septa alternating. Pali are present, the columella is thick. The Bonaire specimen shows some slight differences with the species described by Gerth of Curaçao (Seroe Teintje limestone): 1. the very rudimentary 3rd cycle; 2. there is generally more coenenchyma between the calices than is the case in the Curaçao specimens; 3. the columella is thicker than in the Curaçao specimens.

The wall of the Bonaire specimen gives a good notion of the "geschlossene, ringförmige Mauer" as described by Gerth (lit. 13).

Age. Upper Cretaceous. Washikemba formation.

Locality. S. of Seroe Ventana (W. Bonaire).

Family Madreporidae Dana (emend. Ogilvie).

Genus *Actinacis* d'Orb.

Actinacis martiniana d'Orb. 1849. Fig. 153.

Fragment, 7 × 6,8 × ca. 4,5 mm. Diameter of calices generally 1,75 mm. Septa 24—26. Septa of the 2nd cycle long and thickening at the free ends, septa of the 3rd cycle short, as thick as the septa of the 1st and 2nd cycle, but without the thickening at the ends. In places the septa of the 3rd cycle fuse with septa of higher cycles. The septa are almost as thick as the interseptal loculi. Distances between the corallites are approximately equal to the diameter of the corallites. Distances of centres of calices ca. 3,5 mm. The coenenchyma is chiefly retiform, concentric around the calices. The cavities in the coenenchyma often coincide with the interseptal loculi.

A. martiniana is known of the Upper Cretaceous of Gosau.

Age. Upper Cretaceous. Washikemba formation.

Locality. S. of Seroe Ventana (W. Bonaire).

Genus *Turbinaria* Oken.

Turbinaria sp.

Only one small fragment was found. Calices depressed, 1,5—2 mm. diameter. There are 8 or 9 septa. Columella well developed, ?trabecular. Between the calices is much coenenchyma granulated or striated. Distances between 2 calices 3, 3,5 and 4 mm.

Age. Upper Eocene.

Locality. SW. of Seroe Montagne (W. Bonaire).

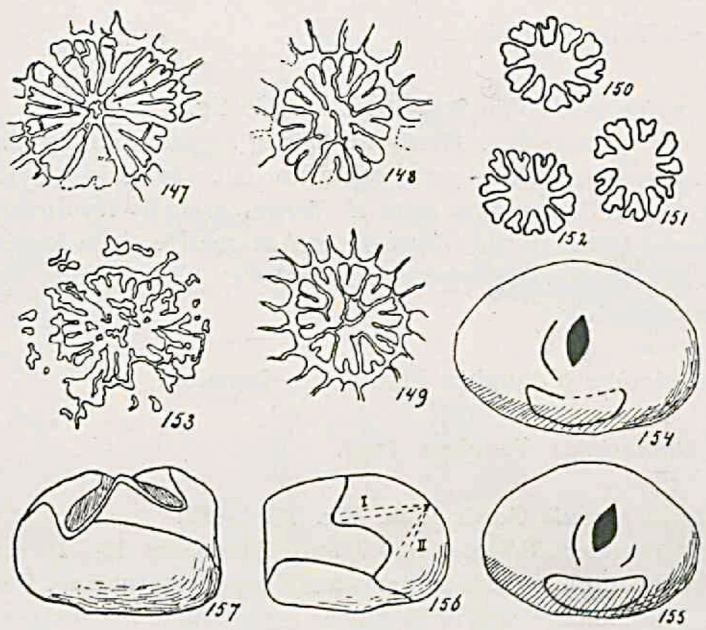

Fig. 147 *Orbicella sp. A.*, dm. of corallites 5 mm.; fig. 148, 149 *Orbicella sp. B*, dm. of corallites 1,4 mm; fig. 150—152 *Multicolumnastraea parvula* Gerth, dm. of corallites 1,4—1,5 mm.; fig. 153 *Actinacis martiniana* d'Orb., dm. of corallites ca. 2 mm.; fig. 154, 155 *Brissoides* (*Rhabdobrissus*) *aloysii* n. sp., posterior surface and part of ventral surface, showing fascioles; both specimens are slightly deformed, 154 width 51 mm., 155 width 46 mm.; fig. 156 *Prenaster jeanneti* n. sp., showing fascioles; fig. 157 *Schizaster gerthi* n. sp., showing fascioles.

Cephalopoda

Order Tetrabranchiata.
Suborder Nautiloidea.

Family Nautilidae Owen.

Genus *Hercoglossa* Conrad.

Hercoglossa sp., ? cf. *ulrichi* White 1926. Pl. II, fig. 13.

There are 2 specimens, both badly preserved. The larger has a diameter of 60 mm, the smaller of ca. 50 mm. The smaller specimen has a thickness of ca. 32 mm. The species is involute; the sutures are well marked, S-shaped. The altitude of the whorls is ca. 3 times their average width from suture to suture. Ventral saddle very broadly rounded, lateral lobes broadly rounded, lateral saddles relatively narrow and prominent. Siphuncle central. The Bonaire specimens are close to *H. ulrichi*, however, the lateral saddles are more rounded in *H. ulrichi* and broadly rounded in the younger parts, and, as the Bonaire specimens are much smaller than *H. ulrichi*, it is just with the early stages of this species that they must be compared. *H. ulrichi* has become known of the Midway Eocene of Trinidad.

The Bonaire specimens also show some resemblance with *H. peruviana* Berry of the Eocene of Peru.

Age. Uppermost Cretaceous. Rincon formation.

Locality. W. of Rincon (W. Bonaire).

Gastropoda

Family Nerineidae Zitt.

Genus *Nerinea* Defr.

Nerinea sp. Fig. 144, 145.

The material consists of a weathered specimen and a fragment. Top, aperture and details of sculpture are obliterated. The shell is large sized, conic-cylindric. Whorls wide, height of whorls ca. 34 % of diameter of shell. The larger specimen, which has 5 whorls, has a length of 140 mm., largest diameter of 80 mm. Spiral angle 20—25 degrees. There is a single convex spiral ridge, ca. 30 % of height of whorl. Grooves between the ridges concave, with a faint indication of 2 spiral threads. Columella solid, ca. 30 % of diameter. There are 4 folds in the interior; 2 on the columella, the upper one obtuse conical, the lower one larger and higher; 1 on the outer lip, very obtuse; 1 on top of whorl, obtuse conical, somewhat larger than the upper fold of columella. On the basis of the whorl there are 2 or 3 slight undulations.

The shell of the larger specimen (not of the fragment) has a great many irregular cavities. On the surface these cavities give the impression of being the result of honeycombe weathering. but the cavities are inside as well. Some cavities are connected with the interior of the shell. I do not know whether such cavities have ever been found in the shell substance of gastropodes; I consider them as an individual abnormality.

The described species is different from any *Nerinea* that had become known up till now of the West Indies and of Central America and, as far as I can judge, of the N. part of S. America and the Cretaceous of W. Europe.

Age. Uppermost Cretaceous. Rincon formation.

Locality. W. of Rincon (W. Bonaire).

Family Volutidae Gray.

Genus *Volutolyria* Crosse.

Volutolyria musica L.

One ill-preserved specimen was found. It agrees in most features with the short forms of *V. musica*. On the inner lip it has 8 strong and 3 minor plaits, consequently 11 plaits in all. Generally the less attenuated forms of *V. musica* have 9 plaits, while 11 plaits are only found in more attenuated forms.

Length 50 mm.; largest width 33 mm.

Age. Quaternary.

Locality. S. of Kralendijk (Bonaire).

LAMELLIBRANCHIATA

Family Pholadomyidae Fischer.

Genus *Pholadomya* Sow.

Pholadomya trechmanni n. sp. Pl. I, fig. 22—24.

Test thick, oblong, inequilateral. Anterior end very short, posterior end much produced. Beaks touching, highly inflated, extremely far forward. Anterior side more or less truncated with rounded transitions to the right and left sides of the test. Posterior side gaping. Surface sculptured with concentric ribs, narrow and close anteriorly, becoming less conspicuous, wider and more distant posteriorly. Radial sculpture chiefly in middle portion of valves, very indistinct in anterior and posterior portion. It is much .less conspicuous than concentric sculpture and consists of coarse, broad, distant ribs, which pass obliquely from the umbo to the margin. Posterior dorsal area slightly concave, smooth.

The species has much resemblance with *P. alpina* Matheron. Though *P. alpina* is rather varying, however, I did not notice one form that agrees entirely with *P. trechmanni*. P. alpina is generally thicker, its posterior side is more gaping, its radial ribs are generally more conspicuous than the Bonaire species. *P. trechmanni* is generally more excentric anteriorly, its anterior surface is more truncate to all sides.

The species has been named in honour of Dr. C. T. TRECHMANN.

There are 12 specimens in the collection of which 8 are well enough preserved to be measured.

Length 35,5—41 mm.; Height ca. 18,5—25,5 mm.; Thickness (Th.) 16—21 mm.; $\frac{H}{L}$ ca 49—65 %; $\frac{Th}{L}$ 41—54 %.

Age. Upper Eocene.

Locality. SW. of Seroe Montagne (W. Bonaire).

BRACHIOPODA

ORDER TELOTREMATA

Family Terebratulidae Gray.

Genus *Terebratula* Muller 1776.

Terebratula martini n. sp. Fig. 146. Pl. I. fig. 25—28.

There are more than 50 specimens in the material, but the greater part of them is miserably preserved.

L. 17,4—36,8 mm.; W. ca. 9—32,5 mm.; Thickness (Th.) 9—24,1 mm; $\frac{W}{L}$ 87—ca. 98 %; $\frac{Th}{L}$ 52—69 %; transverse diameter of foramen 1,1—1,6 (?2) mm; $\frac{\text{transv. dm. for.}}{W}$ 4—7 %.

Shell suboval or suborbicular, smooth, striated by fine lines of growth, which become stronger and well marked towards the anterior margin. Ventral valve convex with a slight carination along its mesial portion from the beak to the anterior margin; near the anterior margin the valve is more or less compressed. Dorsal valve slightly more convex than ventral one, with an obscure, slightly raised mesial fold. Anterior commissure uniplicate. The shell is very finely striated radially (visible in Pl. I, fig. 25); the cardinal areas do not show the radial striae, but they have distinct concentric ones. Beak erect, almost suberect and pierced by a moderately large, circular foramen. In some specimens the foramen is subcircular, the transverse diameter being the largest. Hinge-teeth stout, projecting with blunt points. Cardinal process distinct, rather stout. Crural bases and crura well developed. Loop very simple, the transverse band strongly arched, crural processes inconspicuous. By the last mentioned character the species takes a separate position in the genus *Terebratula*. Also the fine radial striation is uncommon for the genus, but THOMSON mentions that it has been found in many representatives of the Terebratulinae, where it seems to be "an old-age feature" (lit. 69, p. 189).

The shape of *T. martini* resembles *T. carneoides* Guppy of the Eocene of Trinidad and St. Barts, but it is more orbicular and the curvature of the anterior commissure in *T. carneoides* is very gradually, while in *T. martini* it shows a sharp bending on both sides of the dorsal mesial fold.

The species has been named in honour of Prof. K. MARTIN.

Age. Upper Eocene.

Locality. SW. of Seroe Montagne (W. Bonaire).

ECHINOIDEA.

The material consists of more than 500 specimens, many of them in good state of conservation. Because I am of the opinion that absolute measures are of little value and that it are chiefly the proportions between the different measures that are essential, I have given proportions, as many as I thought necessary. I add some general remarks about the measuring and some abbreviations.

Average values of periproct and peristome are generally based on less measures than the other values; those of the petals and apex on less measures than those of length, width and height.

Peristome. The position of the peristome in species provided with a labrum was located by measuring the distance "labrum-anterior side". 1. because the labrum in ill preserved specimens is often well visible; 2. because the measure "labrum-anterior side" turned out to be better achievable than the measure "labrum-posterior side." In the other species the peristome was measured from anterior side of peristome-anterior side of test.

Periproct. The measure "periproct-posterior side" (in species with an inframarginal periproct) was taken from the posterior border of the periproct.

Petals were measured in real length, petaloid areas in horizontal projection (consequently the subtense was measured). Interporiferous areas were generally measured at widest part of petal.

In my descriptions I followed the classification given by LAMBERT & THIÉRY in their "Essai de nomenclature raisonnée des Echinides" (lit. 75).

Abbreviations.

L. length of test; W. width of test; H. height of test; $\frac{W}{L}\ \frac{\text{width of test}}{\text{length of test}}$; $\frac{H}{L}\ \frac{\text{height of test}}{\text{length of test}}$;
pet. area: petaloid area; l. I & V .length of petals I and V; w. I & V width of petals I and V; ia. I & V width of interporiferous area of petals I and V; $\frac{w}{l}$ I & V $\frac{\text{width of petals I and V}}{\text{length of petals I and V}}$; $\frac{\text{l. I \& V}}{L}\ \frac{\text{length of petals I and V}}{\text{length of test}}$; $\frac{ia}{w}$ I & V $\frac{\text{width of interporiferous area of petals I and V}}{\text{width of petals I and V}}$; the signification of the abbreviations l. II & IV, w. II & IV, ia II & IV, $\frac{w}{l}$ II & V, $\frac{\text{l. II \& IV}}{L}$, $\frac{ia}{w}$ II & V, l. III, w. III, ia. III, $\frac{w}{l}$ III, $\frac{\text{l. III}}{L}$, $\frac{ia}{w}$ III is comprehensible; apa. distance apex-anterior side; $\frac{apa}{L}\ \frac{\text{distance apex-anterior side}}{\text{length of test}}$; lps. length of peristome (measured parallel to longest diameter of test); wps. width of peristome (measured parallel to shortest, transverse diameter of test); psa. distance peristome-anterior side; $\frac{w}{l}$ps $\frac{\text{width of peristome}}{\text{length of peristome}}$; $\frac{lps}{L}\ \frac{\text{length of peristome}}{\text{length of test}}$; $\frac{psa}{L}\ \frac{\text{distance peristome-anterior side}}{\text{length of test}}$; lpp. length of periproct (measured parallel to a vertical plane through the longest diameter of test); wpp. width of periproct (measured parallel to transverse diameter of test); $\frac{w}{l}$ pp $\frac{\text{width of periproct}}{\text{length of periproct}}$; ppp. distance periproct-posterior side; $\frac{ppp}{L}\ \frac{\text{distance periproct-posterior side}}{\text{length of test}}$; av. average value.

SUBCLASS GNATHOSTOMATA.
ORDER ENDOCYSTA.
SUBORDER CIDAROIDA.

Family Cidaridae Gray 1825.

Genus *Cidaris* Rumph 1705.

Cidaris melitensis Forbes 1855.

1 or 2 specimens of this form as described and figured by COTTEAU from Anguilla (lit. 72) were found on Bonaire. JEANNET, however, is not sure that the species of COTTEAU agrees with that described by FORBES from Malta.

Diameter 14,2 mm.; height ca. 7,8 mm; $\frac{H.}{diam.}$ ca. 55 %.

w. of ambulacrum 2,5 mm.; w. of interambulacrum ca. 6,8 mm.; w. of ia 1 mm.; w. $\frac{amb.}{interamb.}$ ca. 37 %; $\frac{ia}{w.\ ambul.}$ 40 %; diameter of scrobicles 1,5 mm; diameter of tubercles ca. 0,3 mm.; $\frac{dm.\ scrob.}{dm.\ tub.}$ ca. 20 %.

There are 7—8 ambulacral plates to 1 interambulacral plate.

The Bonaire specimen shows some slight differences with the species of COTTEAU: 1. the proportion $\frac{H}{diam.}$ is smaller (59 % in COTTEAU's description); 2. the interporiferous areas are not depressed; 3. the interporiferous areas are narrower; the Bonaire specimen has 4 columns of tubercles, COTTEAU's figures give 6 columns, however, in his description he mentions 4 columns; 4. near the median suture of the interambulacra (zone miliaire) the Bonaire specimen has few scattered tubercles, quite near the median suture the surface is smooth; in this respect it agrees somewhat with *C. loveni*.

Age. Upper Eocene.

Locality. SW. of Seroe Montagne (W. Bonaire).

ORDER EXOCYSTA.
SUBORDER CLYPEASTROIDA.

Among my material a species occurs, which belongs to the suborder of the Clypeastroida and is nearest the family of the Eoscutidae. However, the species has a sunken peristome, while LAMBERT and THIÉRY give in lit. 75 for the Eoscutidae (p. 287): "... péristome à fleur de test ..." I therefore propose to change the characterization of the Eoscutidae by adding to "péristome à fleur de test": "ou enfoncé". Because the species has no septa and is moderately high, it is closest to the subfamily of the Echinocyamidae, this, however, being subglobular. This is only a minute difference and the Bonaire species can be brought to the Echinocyamidae when we add to "subglobuleux" in lit. 75: "ou déprimé".

We then get the characterizations as follow:

Family Eoscutidae Lamb. 1900.
Pas de rosette buccale, péristome à fleur de test ou enfoncé; cloisons simples ou nulles.
Subfamily Echinocyamidae Lamb. 1900.
Test subglobuleux ou déprimé; ni piliers, ni cloisons internes.

Genus *Bonaireaster* n. gen.

Test with subcircular or rounded pentagonal ambitus. Dorsal surface convex, flattened at the top, ventral surface depressed. Apex central or subcentral. Peristome subcircular to pentagonal, subcentral. Periproct subcircular, inframarginal, very near the posterior margin. Petals with unequal pores.

Bonaireaster rutteni n.g. n. sp. Genotype. Pl. I, fig. 1—8.
There have been found 298 specimens, a great many of them well preserved.

L. 10,9—35,4 mm.; av. L. 22,6 mm.; W. 10,8—33,8 mm.; av. W. 21,6 mm.; H. 5,9—17,8 mm.; av. H. 10,5 mm.; $\frac{W}{L}$ 90—100 %; av. $\frac{W}{L}$ 95 %; $\frac{H}{L}$ 37—59 %; av. $\frac{H}{L}$ 47 %; pet. area ca. 11,8 × 10,7—28 × 26 mm.; $\frac{\text{pet. area}}{L \times W}$ 42—74 %; av. $\frac{\text{pet. area}}{L \times W}$ 56 %; l. I & V 3—13,2 mm.; av. l. I & V 7,7 mm.; w. I & V 0,8—5 mm.; av.w. I & V 2,8 mm.; ia. I & V ca. 0,5—2 mm.; av. ia. I & V 1,1 mm.; $\frac{w}{l}$ I & V 26—50 %; av. $\frac{w}{l}$ I & V 37 %; $\frac{\text{l. I \& V}}{L}$ 23—42 %; av. $\frac{\text{l. I \& V}}{L}$ 33 %, $\frac{ia}{w}$ I & V 26—56 %; av. $\frac{ia}{w}$ I & V 38 %; l. II & IV 3,3 (2,3?)—12,5 mm.; av. l. II & IV 7,4 mm.; w. II & IV 0,7—4,8 mm.; av. w. II & IV 2,9 mm.; ia. II & IV 0,6(0,3?)—2 mm.; av. ia. II & IV 1,1 mm.; $\frac{w}{l}$ II & IV 29—55 %; av. $\frac{w}{l}$ II & IV 39 %; $\frac{\text{l. II \& IV}}{L}$ 23—43 %; av. $\frac{\text{l. II \& IV}}{L}$ 32 %; $\frac{ia}{w}$ II & IV 26—57 %; av. $\frac{ia.}{w}$ II & IV 39 %; l. III 4,5—16 mm. av. l. III 9,0 mm.; w. III c.a 1,5—5,5 mm.; av. w. III 3,1 mm.: ia. III 0,6(0,3?)—2(2,5?) mm.; av. ia. III 1,2 mm.; $\frac{w}{l}$ III 26—45 %; av. $\frac{w}{l}$ III 34 %; $\frac{\text{l. III}}{L}$ 31—51 %; av. $\frac{\text{l. III}}{L}$ 39 %; $\frac{ia}{w}$ III 26—54 %; av. $\frac{ia}{w}$ III 39 %; apa. 5,5—19 mm.; av. apa. 13,3 mm.; $\frac{apa}{L}$ 48—57 %; av. $\frac{apa}{L}$ 54 %; lps. 1,3—4,5 mm.; av. lps. 2,7 mm.; wps. 1,8—ca. 6 mm.; av. wps. 3,2 mm.; psa. 5—16 mm.; av. psa. 10,4 mm.; $\frac{w}{l}$ psa 88—ca. 160 %; av. $\frac{w}{l}$ psa 118 %; $\frac{lps}{L}$ 8—16 %; av. $\frac{lps}{L}$ 12 %; $\frac{psa}{L}$ 41—51 %; av. $\frac{psa}{L}$ 45 %; lpp. 0,7—ca. 2,5 mm.; av. lpp. 1,5 mm.; wpp. 0,9—2,5 mm.; av. wpp. 1,6 mm.; ppp. 0,5—3,4 mm.; av. ppp. 1,8 mm.; $\frac{w}{l}$ pp 95—ca. 146 %; av. $\frac{w}{l}$ pp 112 %; $\frac{ppp}{L}$ 2,5—13,9 %; av. $\frac{ppp}{L}$ 8 %.

Test as in genus, with the ventral surface depressed, subconcave or flat; in the latter case being somewhat depressed around the deep depression of the peristome. In many specimens the test shows slight sinuosities, being most pronounced at the ambitus. The depressions of these sinuosities correspond with the median suture of the interambulacra and with the adradial suture. The test is very thick. Apical system small, madreporic pores forming a compact button at the apex; 4 genital pores are arranged in a trapezium with the anterior pair approximated, all of the same size. Peristome central or slightly anterior to the midpoint. Periproct as in genus, subcircular, slightly wider than long. Ambulacral petals unequal, rather narrow, open at the ends, generally more or less costulate. Near the apex the pairs of pores of one petal are diverging, towards the margin becoming parallel or slightly converging. Ambulacra composed of simple primary plates, pores uniserial; the plates are low in the petals and ventrally from the petals as far as approximately halfway the ventral side where they become higher. Ambulacral pores unequal, the extern ones oblique, the intern ones rounded, the two members of a pair of pores connected by a groove, following the suture between two plates. Where the ambulacrum ceases to be petaloid, the pores become equal, rounded and disposed in oblique pairs, on the ventral side even becoming superposed. The whole surface of the test is studded with deep-set small tubercles of approximately uniform size, more crowded on the ventral side. The mamelons of the tubercles are set in such deep areolae that they hardly exceed the general level of the test. Interporiferous zones with 2, 3 or 4 columns of tubercles.

ARISTOTLE'S lantern and auricles. Preserved are pyramids, epiphyses and parts of teeth. The pyramids are relatively high; in a specimen measuring L: 23,7 mm.; W: 22,7 mm.; H: 10,2 mm., pyramid 5 measures w: 8 mm.; h: 6 mm.; pyramids 1 & 4 are smaller: w: 6 mm.; h: ca. 6 mm.; pyramids 2 & 3 are still smaller: w: 5 mm.; h: 5 mm. The two halfpyramids of 5 are equal, those of 1 & 4 are unequal, the posterior being the largest, the two halfpyramids of 2 & 3 are subequal. The foramen magnum is relatively deep, especially in pyramid 5, it is shallower in 1 & 4, still more shallow in 2 & 3; the interior distance of the small epiphyses is in the specimen mentioned above 2 mm. in pyramid 5, 1—1,5 mm. in pyr. 1 & 4, 1 mm. in pyr. 2 & 3. In the inner part of the lantern the wings of two halfpyramids approach each other very closely or even touch each other; in the latter case the tooth lies in a sort of conical tube with a small opening on the lower side. The teeth are nearly triangular with a broad keel.

The auricles are blunt processes, closely approaching interambulacrad.

The species has been named in honour of Prof. L. RUTTEN.

Age. Upper Eocene.

Localities. SW. of Seroe Montagne (W. Bonaire), SW. of Punta Blanco (W. Bonaire).

SUBCLASS ATELOSTOMATA.
ORDER II NODOSTOMATA.
SUBORDER PROCASSIDULOIDA.

Family Echinobrissidae Wright 1856.
Subfamily Haimeidae Lamb. 1931.
Tribe Echinogalerinae Lamb. 1918.

Genus *Amblypygus* Ag. 1840.

Amblypygus cf. merrilli Twitchell 1915.
Pl. II, fig. 4—6.

One specimen was found probably belonging to *A. merrilli* of TWITCHELL.

L. 55,6 mm.; W. 54,9 mm.; H. ca. 33,3 mm.; $\frac{W.}{L}$ 99 %; $\frac{H.}{L}$ ca. 60 %. l. I & V ca. 32 mm.; w. I & V 8,6 mm.; ia I & V 4,6 mm.; $\frac{w}{l}$ I & V ca. 27 %; $\frac{l.\ I\ \&\ V}{L}$ ca. 58 %; $\frac{ia}{w}$ I & V 54 %; l. II & IV ca. 31,5 mm; w. II & IV 8,5 mm.; ia. II & IV 4,5 mm.; $\frac{w}{l}$ II & IV ca. 27 %; $\frac{l.\ II\ \&\ IV}{L}$ ca. 57 %; $\frac{ia}{w}$ II & IV 53 %; l. III ca. 33,5 mm.; w. III 8,5 mm.; ia. III 4,5 mm.; $\frac{w}{l}$ III ca. 25 %; $\frac{l.\ III}{L}$ ca. 60 %; $\frac{ia.}{w}$ III 53 %; apa.ca. 28 mm.; $\frac{apa}{L}$ ca. 50 %; ps.?; psa. (measured from posterior margin) ca. 29 mm.; $\frac{psa}{L}$ ca. 52 %; lpp. ?2,3 mm.; wpp. ?1,9 mm.; $\frac{w}{l}$ pp. ?83 %.

Although the peristome is badly preserved, one can see that it is oblique. The Bonaire specimen differs from *A. merrilli* by the following characteristics: 1. nearly flush poriferous areas; 2. largest width of the petals lies higher than in *A. merrilli* (higher than halfway between apex and ambitus); 3. the extern pores are elongate; in *A. merrilli* all the pores are round; 4. the Bonaire specimen is higher: $\frac{H}{L}$ 60 %, *A. merrilli* $\frac{H}{L}$ 54 and 55 %. (CLARK & TWITCHELL, lit. 76).

According to LAMBERT and THIÉRY (lit. 75, p. 341) *A. americanus* can be a synonym of *A. merrilli*, "bien que plus renflée". I calculated the proportion $\frac{H}{L}$ for *A. americanus*, but found it to be smaller than for *A. merrilli*, viz. 45 %, 40 %, 36 %, 36 %.

Age. Upper Eocene.

Locality. SW. of Punta Blanco (W. Bonaire).

Tribe Oligopygynae Lamb. 1931.

Genus *Pauropygus* Arnold & Clark 1927.

Pauropygus ovum serpentis (Guppy 1866). Pl. I, fig. 7, 8.

Among my material there are 24 specimens of *P. ovum serpentis*, rather varying in their characteristics. Because I have only 24 specimens it has no sense to give average values.

L. 15,7—35 mm.; W. 13,4—31 mm.; H. 8,8—17,5 mm.; $\frac{W}{L}$ 78—89 %; $\frac{H}{L}$ 45—70 %; pet. area 15 × 11,9—31 × 27,5 mm.; $\frac{\text{pet. area}}{L \times W}$ 62—79 %; l. I & V ca. 4,7—14,7 mm.; w. I & V 2—5,5 mm.; ia. I & V ca. 1,1—2,3 mm.; $\frac{w}{l}$ I & V 28—47 %; $\frac{\text{l. I \& V}}{L}$ 28—42 %; $\frac{ia}{w}$ I & V 38—55 %; l. II & IV ca. 4,5—13,5 mm.; w. II & IV 2—6 mm.; ia. II & IV 1, 1—2,5 mm.; $\frac{w}{l}$ II & IV 35—50 %; $\frac{\text{l. II \& IV}}{L}$ 27—39 %; $\frac{ia.}{w}$ II & IV 38—60 %; l. III 6,5 (?5)—17 mm.; w. III 2—5,5 mm.; $\frac{w}{l}$ III 28(?25)—39 %; $\frac{\text{l. III}}{L}$ 35(?32)—49 %; $\frac{ia}{w}$ III 42—60 %; apa 7,8—ca. 19,5 mm.; $\frac{apa}{L}$ 50—58 %; lps. 2—ca. 3,3 mm.; wps. 2,5—3,4 mm.; psa. 6,5—ca. 12 (?15,5) mm.; $\frac{w}{l}$ ps. 103—138 %; $\frac{lps}{L}$ 10—14 %; $\frac{psa}{L}$ ca. 41—48 %; lpp. ca. 1,2—2,3 mm.; wpp. 1,5—2,5 mm.; $\frac{w}{l}$ pp. 107(?100)—136 %; ppp. 1,1—4 mm.; $\frac{ppp.}{L}$ 5—14 mm.

Some of the Bonaire specimens have flush petals, others do have costulate petals, but the poriferous areas are not depressed. It is a fact that these specimens do not agree in this respect with the species of GUPPY, but at the utmost the differences can be of varietal rank, because the specimens fall within the range of variation of *P. ovum serpentis*. Moreover, the great variabiblity of *P. ovum serpentis* is a well known fact: GUPPY, COTTEAU, JACKSON, SANCHEZ ROIG, ARNOLD & CLARK and LAMBERT have drawn the attention to it.

Age. Upper Eocene.

Localities. SW. of Seroe Montagne (W. Bonaire), SE. of Seroe Dochila (W. Bonaire), SW. of Punta Blanco (W. Bonaire).

Family Prospatangidae Lamb. 1905.
Subfamily Asterostomidae Pomel 1883.
Tribe Antillasterinae Lamb.

Genus *Antillaster* Lamb. 1909.

Antillaster bonairensis n. sp. Pl. II, fig. 1—3.

Only one, damaged specimen was found. Ambulacra III and IV are defective, as well as peristome and periproct.

L. 123,5 mm.; W. 98,5 mm.; H. 71,5 mm.; $\frac{W}{L}$ 80 %; $\frac{H}{L}$ 58 %; l. I & V ca. 90 mm. w. I & V 19,5 mm.; ia. I & V 11 m.; $\frac{w}{l}$ I & V ca. 22 %; $\frac{l.\ I\ \&\ V}{L}$ ca. 73 %; $\frac{ia}{w}$ I & V 56 %; l. II (&IV) ca. 69 mm.; w. II (&IV) 16 mm.; ia. II (& IV) 8 mm.; $\frac{w}{l}$ II (& IV) ca. 23 %; $\frac{l.\ II(\&\ IV)}{L}$ ca. 56 %; $\frac{ia}{w}$ II(& IV) 50 %; apa. ca. 35 mm.; $\frac{apa}{L}$ ca. 28 %; lpp. ?13,5 mm.; wpp. ?11 mm.; $\frac{w}{l}$ pp. ?81%.

Test very high, from the top, which is slightly anterior to the midpoint, the dorsal side is gently inclined towards the ambitus; ventral side nearly flat, slightly concave towards the peristome. Ambitus oval, smoothly rounded anteriorly, posteriorly the ambitus has the form of a Gothic arch, truncated by the large periproct, which lies in the level of the ambitus. Apical system excentric anteriorly, not coinciding with largest height of test. Periproct in and partly under the ambitus, oval with the longest diameter vertical. Peristome slightly sunken below the oral surface, excentric anteriorly. Petals I and V open, poriferous areas slightly diverging, somewhat narrowed at the tip, ending ca. 10 mm. above the ambitus. Angle between I and V small, ca. 30°. Petals II and IV open, poriferous areas first diverging till somewhat below halfway between base and tip, then converging, and ending nearer to the ambitus than petals I and V. Petals II and IV running almost in a vertical plane, neither anteriorly nor posteriorly. The extern pores of all the petals are elongate slits; some of the crests between each pair of pores are ornamented with 7 or 8 small tubercles, restricted to the extern part of the crest. The conservation of the specimen is not well enough to see if there were tubercles between all the pairs of pores. The poriferous areas are minutely depressed. Ambulacrum III not petaloid, very minutely depressed and provided with very small pores.

A. bonairensis is closest to *A. arnoldi* Arnold & Clark from Jamaica.

The differences are:

1. the apex of *A. bonairensis* is more excentric anteriorly; the proportion $\frac{apa}{L}$ for *A. arnoldi* is 41 %; 2. ambulacrum III is more depressed in *A. arnoldi*; 3. petals II and IV of *A. arnoldi* are running anteriorly: both poriferous areas of these petals are directed anteriorly; 4. the angle between petals I and V of *A. arnoldi* is larger (ca. 40°); 5. the extern pores of the petaloid ambulacra of *A. bonairensis* are more elongate; 6. periproct seems to lie higher in *A. arnoldi* than in *A. bonairensis*.

Age. Upper Eocene.
Locality. SW. of Seroe Montagne (W. Bonaire).

Subfamily Lovenidae Lambert 1905.
Tribe Brissoidesinae Lamb. 1920.

Genus *Brissoides* Klein 1734—78.
Section VI: *Rhabdobrissus* Cotteau 1889.

Brissoides (*Rhabdobrissus*) *aloysii* n. sp. Fig. 154, 155. Pl. I, fig. 18, pl. II, fig. 7—9.

The section *Rhabdobrissus* is distinguished by a subanal fasciole provided with "amorces de branches anales". Of the 8 specimens that were found only 2 show the *Rhabdobrissus-character*, the others being too much weathered. I suppose, however, that they all belong to the same species.

	1.	2.	3.	4.	5.	6.	7.	8.	
L.	49,7	45,8	39,8	36,8	22,3	54,1	?64	58	mm
W.	44	36,4	31,6	33,2	18,7	46	?51	45,9	mm
H.	22	24	ca. 22,5	19,9	13,3	ca. 28	32,5	ca. 30,4	mm
W./L	89	80	79	90	84	85	?79	79	%
H./L	44	52	ca. 57	54	60	ca. 52	?51	ca. 52	%
l. I & V	22,3	?20	18	ca. 18	ca. 11	ca. 25	ca. 30	—	mm
w. I & V	ca. 7	6,2	5	5	2,3	7	8	—	mm
ia. I & V	4	3,5	3	2,5	1,2	3,2	5,5	—	mm
w/l I & V	ca. 31	?31	28	ca. 28	ca. 21	ca. 28	ca. 27	—	%
l. I & V/L	45	?44	ca. 45	ca. 49	ca. 49	ca. 46	—	—	%
ia/w I & V	ca. 57	56	60	50	52	46	69	—	%
l. II&IV	21	?21	ca. 17,5	ca. 16	ca. 8	ca. 23	26	—	mm
w. II&IV	7,3	6	5,7	5	ca. 2,8	6,5	8,7	—	mm
ia. II&IV	ca. 4,3	3,3	3	3	ca. 1,5	4	6	—	mm
w/l II&IV	ca. 35	?29	ca. 33,	ca. 31	ca. 35	ca. 28	34	—	%
l. II&IV/L	42	?46	ca. 44	ca. 44	ca. 36	ca. 43	—	—	%
ia/w II&IV	ca. 59	55	53	60	ca. 54	62	69	—	%
apa.	ca. 21	?18,5	ca. 16	ca. 14,5	8	20,8	—	—	mm
apa./L	ca. 43	?40	ca. 40	ca. 39	36	38	—	—	%
lps.	—	?4	?5	?3,5	—	—	—	—	mm
wps.	—	?7,5	ca. 7,5	ca. 6	—	—	—	—	mm
psa.	?21	—	ca. 15	13	?6,5	—	—	ca. 18	mm
w/l ps.	—	?188	?150	?171	—	—	—	—	%
lps./L	—	?9	13	?10	—	—	—	—	%
psa./L	?42	—	ca. 38	35	?29	—	—	ca. 31	%
	2.	3.	3.	4.	5.	6.	7.	8.	
lpp.	8,5	—	ca. 7	6,5	—	—	—	?9	mm
wpp.	6	—	ca. 3,5	5,3	—	?6	—	5,5	mm
w/l pp.	71	—	ca. 50	82	—	—	—	?61	%

The general form resembles that of species like *B. antillarum*, *clevei* and *alatus*. Test depressed, ambitus oval, evenly rounded anteriorly, truncated by the hind side posteriorly, but with rounded corners. Largest width halfway or slightly anteriory. Dorsal side highest in interambulacrum 5, ventral side slightly convex towards the posterior margin, ending in an elevated point or ridge quite near the posterior margin; the ventral side is concave towards the peristome, sometimes the depression begins sideways of the plastron. Posterior margin vertical or inclined forwardly. Apical system excentric anteriorly, not coinciding with largest height of test. There are four genital pores, close together, all of the same size, arranged so as to form the angles of a trapezium. Peristome very excentric anteriorly, transverse, more or less depressed, with projecting labrum. Periproct at the top of the posterior margin, oval with the longest diameter vertical. Paired ambulacra unequal, with depressed poriferous areas. Pores of paired ambulacra rounded, united by a groove. Petals I and V forming a sharp angle, rather wide, at the tip closed or nearly closed. Poriferous areas evenly curved. Petals II and IV rather wide, running anteriorly, not quite closed at the tip. Poriferous areas evenly curved or the posterior poriferous area is nearly straight, bending anteriorly near the tip; in the latter case the anterior poriferous area is more strongly curved. Ambulacrum III not petaloid, depressed towards the median suture so as to form a superficial furrow from apex to peristome; in some specimens the furrow is hardly perceivable. In only one specimen (no. 1) the pores can be seen in two columns with the pores alternating. Pores small and rounded. These columns of pores have a length of ca. 8,5 mm.; the distance between the pores is 1,6 mm. There are two kinds of tubercles; larger, scrobiculated ones, situated on the dorsal side, encircled by the peripetal lous fasciole; on the ventral side situated chiefly inframarginally and on the posterior ambulacrum. The smaller ones are more crowded; they are smallest in the area encircled by the peripetalous fasciole.

The subanal fasciole is not sinuated, the branches of the anal fasciole are situated sideways of the periproct.

Till now there was only one species known belonging to the section *Rhabdobrissus*, viz. *B. jullieni* Cotteau, a living species from the coast of Guinea. The Bonaire species is very different from the recent species. The principal differences are: 1. the largest height of *B. jullieni* lies anteriorly of the apex (according to the description of COTTEAU; in the figure the difference in height anteriorly and posteriorly of the apex is not striking); 2. *B. jullieni* seems to be lower: the proportion $\frac{H}{L}$ is 39 %; 3. the petals are excavated in *B. jullieni*; 4. the interporiferous area of the petaloid ambulacra of *B. jullieni* are extremely narrow; COTTEAU says that the interporiferous area is sometimes entirely failing; 5. the pores are elongated in *B. jullieni*; 6. the periproct of *B. jullieni* is pear-shaped; 7. the branch of anal fasciole seems to be situated lower in *B. jullieni* than this is the case in *B. aloysii*; 8. the larger tubercles, as far as they are circumscribed by the peripetalous fasciole, are much larger and scarcer in *B. jullieni* than in the Bonaire species (lit. 73).

Apart from the *Rhabdobrissus*-character, the differences with *B. antillarum*, *clevei* and *alatus* are:

B. antillarum: 1. this species has the posterior margin inclined backwards, so that the periproct is visible in a dorsal view; 2. the apex is more excentric: the proportion $\frac{apa}{L}$ for *B. antillarum* is: 30, 31, 31, 31, 35 %; 3. the petals are more diverging in *B. aloysii*, resp. 55, ca. 49, 57 (damaged), 55, ca. 54, 56, 54, ?50 degrees; for *B. antillarum* it is ca. 36, 38, 40, 42 degrees.

B. clevei: 1. like *B. antillarum* the posterior margin is inclined backward.

B. alatus: 1. the apex is more excentric, the proportion $\frac{apa}{L}$ is 32, 33; 2. ARNOLD and CLARK mention "oral surface flat" and "peristome flush with oral surface"; none of the specimens of *B. aloysii* have an entirely flat oral surface and in most of the specimens the peristome is sunken.

This species has been named in honour of the negro-boy ALOYSIUS, whom we owe the discovery of the find-spot of echini SW. of Seroe Montagne.

Age. Upper Eocene.

Locality. SW. of Seroe Montagne (W. Bonaire), SW. of Punta Blanco (W. Bonaire).

Tribe Maretinae Lamb. 1905.

Genus *Maretia* Gray 1855.

Maretia sp. Pl. I, fig. 13—15.

Two specimens of a form belonging to the genus *Maretia* have been found; the preservation of the specimens, however, is very bad.

	L	W	H	$\frac{W}{L}$	$\frac{H}{L}$	l. I&V	w. I&V	ia. I&V
	(mm.)	(mm.)	(mm.)	(%)	(%)	(mm.)	(mm.)	(mm.)
1.	40,1	ca. 33	ca. 16,5	ca. 82	ca. 41	ca. 14	4	2
2.	?48,3	—	?18,4	—	?38	—	—	—

	$\frac{w}{l}$ I&V	$\frac{l.\ I\&V}{L}$	$\frac{ia.}{w}$ I&V	l. II&IV	w. II&IV	ia. II&IV	$\frac{w}{l}$ II&IV
	(%)	(%)	(%)	(mm.)	(mm.)	(mm.)	(%)
1.	ca. 29	ca. 35	50	13	3,8	ca. 1,7	29

	$\frac{l.\ II\&IV}{L}$	$\frac{ia.}{w}$ II&IV	apa.	$\frac{apa}{L}$	lps.	wps.	psa.	$\frac{w}{l}$ ps
	(%)	(%)	(mm.)	(%)	(mm.)	(mm.)	(mm.)	(%)
1.	32	ca. 46	ca. 16,5	ca. 41	4,2	ca. 6	15,5	ca. 143

	$\frac{lps.}{L}$	$\frac{psa.}{L}$
	(%)	(%)
1.	11	39

Ambulacrum III and periproct are not preserved in one specimen; of. no. 2 only L. and H. could be measured approximately.

Test depressed, almost flat, dorsal side slightly convex, from the raised antero-posterior midline sloping towards the rounded margin, ventral side almost flat with narrow, raised plastron, posteriorly ending in a very conspicuous point. Posterior margin truncated, with rounded corners. Peristome subcircular with truncated posterior margin. Labrum inconspicuous, elevated above surface of peristome, which is flush with the surface of the test. Periproct supra-marginal. Petals of the paired ambulacra narrow, flush with the surface. Pores united by a groove; the extern pores larger than the intern ones, slightly oval. Petals I and V forming a sharp angle (ca. 38°), petals II and IV directed anteriorly, forming an angle of ca. 110°. Near the apex the petals are rapidly widening, then gradually narrowing towards the tips, which are more or less open. On the dorsal side the interambulacra 1 and 4 are provided with large tubercles; on the ventral side large, scaly tubercles are found on the plastron and on the interambulacra. Smaller tubercles are found on the dorsal side between the large ones and on the margin. Both specimens have a "fasciole en écusson radié".

Age. Upper Eocene.

Locality. SW. of Seroe Montagne (W. Bonaire).

Family Brissidae Cotteau 1885.
Subfamily Periasteridae Lamb. 1920.
Tribe Prenasterinae Lamb. 1905.

Genus *Agassizia* Valenciennes 1846.

Agassizia conradi (Bouvé 1851).

Agassizia inflata Jackson 1922. Contr. Geol. and Paleont. West Indies. Publ. 306 Carn. Inst. Washington, p. 70, pl. 12, fig. 2—4.

The collected material consists of 80 specimens.

L. 12,9—27,2 mm.; av. L. 19,9 mm.; W. 10,9—22,7 mm.; av. W. 17,4 mm.; H. 9,5—19,4 mm.; av. H. 14,7 mm.; $\frac{W}{L}$ 82—95 %; av. $\frac{W}{L}$ 85 %; $\frac{H}{L}$ 69—83 %; av. $\frac{H}{L}$ 75 %; 1. I & V ca. 3 (?2)—ca. 5,5 mm.; av. 1. I & V 1—2,2 mm.; av.w. I & V 1,6 mm.; ia. I & V ca. 0,3(?0,1) —0,4(?0,5) mm.; av. ia. I & V 0,3 mm.; $\frac{w}{l}$ I & V 30—50 %; av. $\frac{w}{l}$ I &V 40 %; $\frac{\text{1. I \& V}}{L}$ 16—25(?27) %; av. $\frac{\text{1. I \& V}}{L}$ 20 %; $\frac{ia}{w}$ I & V ca. 14 (?7)—27 %; av. $\frac{ia}{w}$ I & V 19 %; 1. II & IV ca. 6 (?5)—ca. 13 mm.; av. 1. II & IV 9 mm.; w. II & IV 0,5—1,1 mm.; av. w. II & IV 0,8 mm; $\frac{w}{l}$ II & IV ca. 5—ca. 12 %; av. $\frac{w}{l}$ II & IV 9 %; $\frac{\text{1. II \& IV}}{L}$ ca. 34—ca. 52 %; av. $\frac{\text{1. II \& IV}}{L}$ 43 %; apa. 9—19 mm.; av. apa. 13 mm.; $\frac{apa}{L}$ 61(?58)—ca. 70 %; av. $\frac{apa}{L}$ 67 %; lps. 0,5—1,4 mm.; av. lps. 1,0 mm.; wps. 2,7—6 mm.; av. wps. 3,9 mm.; psa. ca 3—8 mm.; av. psa. 5,1 mm.; $\frac{w}{l}$ ps 286—700 %; av. $\frac{w}{l}$ ps 446 %; $\frac{lps}{L}$ 3—6 (?7) %; av. $\frac{lps}{L}$ 5 %; $\frac{psa}{L}$ ca. 21—31 %; av. $\frac{psa}{L}$ 26 %; lpp. ca. 1,3—4 mm.; av. lpp. 2,5 mm.; wpp. 2,5—ca. 3,7 mm.; av. wpp. 3,1 mm.; $\frac{w}{l}$ pp. ca. 108—175 (?190); av. $\frac{w}{l}$ pp. 127 %.

Beside the characteristics given by authors I will draw the attention to the following: the elevated swollen plastron, more elevated towards the peristome, and the conspicuous elevations of interambulacra 1 and 4 near the apex.

I have made *A. inflata* Jackson a synonym of *A. conradi* on the following considerations.

Clark and Twitchell say that *A. conradi* "is easily distinguished from other species of this genus by its more elevated upper surface, slightly conical at the apex, and its very excentric apex posteriorly. The sharp truncation of the posterior surface is very characteristic." (lit. 76).

The proportion $\frac{H}{L}$ for *A. inflata* is $\frac{17}{23}$ (Jackson). $\frac{8}{11}$, $\frac{22}{31,5}$ (Arnold & Clark), being resp. 74, 73 and 70 %. Consequently *A. inflata* falls within the range of variation of *A. conradi*: likewise *A. conradi* it has the "more elevated upper surface." And just like *A. conradi*, *A. inflata* is "slightly conical at the apex."

The apex of *A. inflata* is no more excentric than that of *A. conradi*; the proportion $\frac{apa}{L}$ for *inflata* is 64 %.

Jackson mentions concerning the posterior surface of *A. inflata*: "posterior face truncated, nearly vertical." I can not give exact data concerning the "truncation"; most of the Bonaire specimens have the truncated posterior surface inclined forwardly, but in some specimens it is nearly vertical. The figure given by Jackson of *A. inflata* (lit. 74, pl. 12, fig. 4), which must be a photograph of the specimen of Cotteau, given in drawings fig. 9 & 10, pl. 6, show distinctly a forwardly inclined posterior surface. The same can be seen in fig. 9, pl. 6 of COTTEAU, (lit. 72).

To this I can add that we find back all the typical characters of *A. conradi* in A. *inflata*: the wide, conical form, the anterior curvature of the apical disk to the ambitus, the swollen plastron, of which the elevation increases towards the peristome, the elevation of interambulacra 1 and 4 near the apex, the angle between ambulacra I and V.

Age. Upper Eocene.

Locality. SW. cf Seroe Montagne (W. Bonaire).

Agassizia sp., cf. *conradi* (Bouvé 1851).

L. ca. 35,5 mm.; W. ca. 30 mm.; H. ca. 23,2 mm.; $\frac{W}{L}$ ca. 85 %; $\frac{H.}{L}$ ca. 65 %; 1. I & V 7 mm.; w. I & V 2,7 mm.; ia I & V 0.5 mm.; $\frac{w}{l}$I & V 39 %; $\frac{\text{1. I \& V}}{L}$ ca. 20 %; $\frac{ia}{w}$I & V 19 % 1. II & IV ca. 21,5 mm.; w. II & IV 1,4 mm.; $\frac{w.}{l}$ II &IV ca. 7 %; $\frac{\text{1. II \& IV}}{L}$ ca. 61 %; apa. 26 mm.; $\frac{apa}{L}$ ca. 73 %.

The specimen is injured and weathered, peristome and periproct are not preserved. Probably it is a large specimen of *A. conradi*.

The specimen is lower than *A. conradi*: $\frac{H}{L}$ is ca 65 %; the smallest value that I found for *conradi* is 69 %. The petals II and IV are longer than in *A. conradi*: $\frac{\text{1. II \& IV}}{L}$ ca. 61 %, *A. conradi* to ca. 52 %. The apex is slightly more excentric, the proportion $\frac{apa}{L}$ being ca. 73 %.

The dorsal side is somewhat different from *A. conradi*: more evenly rounded, the elevation of the petals near the apex is less pronounced, the nod posteriorly of the apex towards interambulacrum 5 is less conspicuous.

Age. Upper Eocene.

Locality. SW. of Seroe Montagne (W. Bonaire).

Genus *Prenaster* Desor 1858.

Prenaster jeanneti n. sp. Fig. 156. Pl. I, fig. 9—12.

There are 103 specimens in the collection.

L. 11—52,5 mm.; av. L. 29 mm.; W. 9,9—45,2 mm.; av. W. 24 mm.; H. 8,4—ca. 36,9 mm.; av. H. 21 mm.; $\frac{W}{L}$ 80 (ca. 78?)—92 %; av. $\frac{W}{L}$ 85 %; $\frac{H.}{L}$ 68—80 %; av. $\frac{H.}{L}$ 74 %; 1. I & W 3,7—20,8 mm.; av. 1. I & V 13,1 mm.; w. I & V 0,6—2,5 mm.; av. w. I & V 1,8 mm.; ia. I & V 0,2—1 mm.; av. ia. I & V 0,6 mm.; $\frac{w}{l}$I & V 10—16 %; av. $\frac{w}{l}$12 %; $\frac{\text{1. I \& V}}{L}$ 34—51 %; av. $\frac{\text{1. I \& V}}{L}$ 45 %; $\frac{ia}{w}$I & V 28 (25?)—41 %; av. $\frac{ia}{w}$I & V 34 %; 1. II & IV ca. 3,5—19,5 mm.; av. 1. II & IV 11,6 mm.; w. II & IV 0,5—2,9 mm.; av. w. II & IV 1,8 mm.; ia. II & IV 0,4 (0,2?)—1,1 mm.; av. ia. II & IV 0,6 mm.; $\frac{w}{l}$ II & IV 10—ca. 16 %; av. w II & IV 14 %;

$\frac{\text{l. II \& IV}}{\text{L}}$ 32—48%; av. $\frac{\text{l. II \& IV}}{\text{L}}$ 40%; $\frac{\text{ia}}{\text{w}}$ II & IV 28 (22?)—42%; av. $\frac{\text{ia}}{\text{w}}$ II & IV 34%;

apa. ca. 2, 5—7 mm.; av. apa. 4,7 mm.; $\frac{\text{apa}}{\text{L}}$ ca. 11—24%; av. $\frac{\text{apa}}{\text{L}}$ 17%; lps. 0,9(0,5?) —

3,5 mm.; av. lps. 2,1 mm.; wps. ca. 2,1—9 mm.; av. wps. 5,4 mm.; psa. ca. 4—22 mm.;

av. psa. 11,9 mm.; $\frac{\text{w}}{\text{l}}$ps 167—370(420?)%; av. $\frac{\text{w}}{\text{l}}$ps 262%; $\frac{\text{lps}}{\text{L}}$ ca. 6—9(10?)%; av. $\frac{\text{lps}}{\text{L}}$ 7%;

$\frac{\text{psa}}{\text{L}}$ 34—52%; av. $\frac{\text{psa}}{\text{L}}$ 42%; lpp. 2,5—11,4 mm.; av. lpp. 5,8 mm.; wpp. 1,5—6,5 mm.;

av. w pp. 3,6 mm.; $\frac{\text{w}}{\text{l}}$pp 40—90%; av. $\frac{\text{w}}{\text{l}}$65%.

Test ovoid, high, rounded anteriorly, truncated posteriorly, so as to give the posterior margin a high and flat appearance, dorsal side very swollen, obliquely inclined anteriorly, slightly inclined posteriorly, largest height approximately halfway the length; ventral side slightly convex. Test very thin. Apical system extremely excentric anteriorly, supramarginal, consequently not corresponding with summit of test. Probably "apex ethmolyse" the 4 genital pores in specimens with well preserved apical system with a relative thick slightly elevated rim. Periproct at the top of the truncate posterior margin, elliptical with the longer axis vertically, very much longer than wide, above wider than below, getting to some degree the form of a deltoid with rounded corners. Peristome transverse, labiate, with projecting labrum, excentric anteriorly. Plastron amphisterne, wide, swollen, ornamented with scaly scrobiculated tubercles in regular close ranged, diverging series. Paired ambulacra unequal, anterior pair shorter, in connection with the pronounced anterior disposition of the apical system directed more or less posteriorly. Poriferous zones gradually widening away from the apex, at some distance running parallel. Petals open at the ends. Pores subequal, oval, the extern ones being a little longer than the intern ones; each pair of pores is placed in the form of a ,,circonflexe", the extern leg being a little longer. The unpaired ambulacrum III is not petaloid and has one straight pair of small pores. Ambulacra II and IV are rapidly descending to the ambitus, but do not reach it.

Outside the interambulacral plastron the granulation is not well preserved, probably the whole test was covered with small scrobiculated tubercles.

Fascioles. The marginal fasciole passes under the anus, with a sharp pointed bending towards the plastron, anteriorly passing along the ventral side at some distance of the peristome, with a gentle nod at the height of the ambitus. Exactly above this nod, consequently just above the ambitus separates the semiperipetalous fasciole first running parallel to ambulacra II and IV, then bending gently towards the tip of ambulacra I and V, traversing the interambulacrum 5 in an irregularly curved line.

According to Prof. JEANNET the species has some resemblance with *P. desori* Cott. and *P. montzensis* Lamb., but it has a more central peristome. *P. desori* has more depressed petals. By its flush petals and extremely excentric apex the species takes a separate place within the genus *Prenaster*.

I named this species in honour of Prof. A. JEANNET.

Age. Upper Eocene.

Localities. SW. of Seroe Montagne (W. Bonaire), SW. of Punta Blanco (W. Bonaire).

Tribe Schizasterinae Lamb. 1905.

Genus *Moira* Ag. 1872.

Moira sp. Pl. I, fig. 16, 17.

Only one, badly preserved specimen was found.

L. ca. 30 mm.; W. 25,1 mm.; H. 20,3 mm.; $\frac{H}{L}$ ca. 84 %; $\frac{W}{L}$ ca. 68 %; l. I & V [1]) 10 mm.; w. I & V 1,4 mm.; $\frac{w}{l}$ I&V 14 %; $\frac{\text{l. II \& IV}}{L}$ ca. 33% l. II&IV 15 mm.; w. II & IV ca. 1,2 mm.; $\frac{w}{l}$ II & IV ca. 8 %; $\frac{\text{l. II \& IV}}{L}$ ca. 50 %; apa 16,5 mm.; $\frac{apa}{L}$ ca. 55 %; width anterior furrow 2,5 mm.; $\frac{\text{w. ant. furrow}}{W}$ 10 %; depth anterior furrow ca. 1,2 mm.; $\frac{\text{depth ant. furrow}}{L}$ ca. 4 %.

Ventral side with peristome (which must have been excentric anteriorly) and posterior side with periproct are not preserved.

Test high, subcordiform, broadly rounded anteriorly, dorsal side sloping rather rapidly auteriorly and posteriorly to the low ambitus. Ventral side probably slightly convex. Posterior side narrow, ?truncated. Apex somewhat excentric posteriorly, with 4 genital pores, the anterior pair larger and more distantly. Periproct probably at the top of the posterior margin. Paired ambulacra very unequal, narrow, sunken in very deep excavations of the test. These excavations become wider below the general surface of the test. The poriferous areas lie halfway the bottom of the furrows. Anterior pair of ambulacra straight or nearly straight, descending towards the ambitus. Angle between petals II and IV ca. 90°. Posterior pair narrower and much shorter than anterior pair, slightly curved inwards. Angle between petals I and V ca. 30°. Unpaired ambulacrum not petaloid, provided with a deep furrow, the depth of which decreases towards the ambitus and is very shallow on the ventral side. One fasciole is preserved, the peripetalous, which very closely follows the petals. This fasciole is not flush with the surface of the test, but slightly sunken in the petalous excavations, so as to border these excavations. The granulation of the test is badly preserved; ventrally there are scaly tubercles, dorsally smaller tubercles.

The species shows some resemblance with *M. atropos* (Lmk. 1816). Differences are: 1. *M. atropos* is less elongate than the Bonaire species; the proportion $\frac{W}{L}$ is 93—100 %; 2. *M. atropos* is higher; the proportion $\frac{H}{L}$ is 74—85 %. The lowest value found for *M. atropos* 74 %), however, does not differ very much from the proportion found for the Bonaire species. It is almost certain that more extensive material will annul this difference. (The measures upon which the proportions are based are taken from *A. Agassiz*, lit. 70, p. 366); 3. the anterior pair of ambulacra of *M. atropos* is angular in outline with a part of the posterior edge of the apical part of the ambulacra projecting over the anterior edge; nothing of the triangular spaces between the apical parts of petals II and IV and the mid-line of *M. atropos* are to be seen in the Bonaire species; 4. the angle of petals I and V of *M. atropos* is larger, being ca. 65°.

Age. Upper Eocene.

Locality. SW. of Seroe Montagne (W. Bonaire).

Genus *Schizaster* Ag. 1836.

Schizaster sp.? cf. *subcylindricus* Cotteau 1875. Pl. I, fig. 20, 21.

The material contains 2 specimens that may belong to *S. subcylindricus* Cotteau.

	L.	W.	H.	$\frac{W.}{L}$	$\frac{H.}{L}$	l. I & V	w. I & V	ia. I&V
	(mm.)	(mm.)	(mm.)	(%)	(%)	(mm.)	(mm.)	(mm.)
1.	24.7	23,9	19	97	77	ca. 4	ca. 1,8	—
2.	23,8	23,1	18	97	76	3,5	1,7	ca. 0,6

[1]) Only the narrow and very deep furrows could be measured, not the petals itself.

	$\frac{w}{1}$ I & V	$\frac{\text{1. I \& V}}{L}$	$\frac{ia}{w}$ I & V	1. II&IV	w. II&IV	ia. II&IV	$\frac{w}{1}$ II&IV
	(%)	(%)	(%)	(mm.)	(mm.)	(mm.)	(%)
1.	ca. 45	ca. 16	—	ca. 10	2,8	0,9	ca. 28
2.	49	15	35	11	3	?0,7	27

	$\frac{\text{1. II \& IV}}{L}$	$\frac{ia}{w}$ II&IV	apa	$\frac{apa}{L}$	lps.	wps.	psa.
	(%)	(%)	(mm.)	(%)	(mm.)	(mm.)	(mm.)
1.	ca. 41	32	17	69	—	4,6	ca. 7,2
2.	46	?23	ca. 17	ca. 69	?2	4,5	ca. 6

	$\frac{w}{1}$ ps	$\frac{lps.}{L}$	$\frac{psa}{L}$	lpp.	wpp.	$\frac{w}{1}$ pp
	(%)	(%)	(%)	(mm.)	(mm.)	(%)
1.	—	—	ca. 28	?5	?4	?80
2.	?225	?8	ca. 25	3,7	2,3	62

The differences with *S. subcylindricus* are: 1. general form: *S. subcylindricus* is somewhat lower and longer; COTTEAU speaks of "forme allongée". The proportion $\frac{H}{L}$ of *S. subcylindricus* is 74 %, 72 %, 68 %; $\frac{W}{L}$ is 89 %, 93 %, 90 % (measurements from COTTEAU, lit. 72, and JACKSON, lit. 74). 2. In *S. subcylindricus* the furrow in ambulacrum III does not reach the ambitus; in one of the Bonaire specimens (no. 2) there is a distinct though very slight furrow at the ambitus. 3. the Bonaire specimens have an oval periproct with the longest diameter vertically. 4. the apex of the Bonaire specimens is slightly more excentric posteriorly; apa for *S. subcylindricus* 65 %, 62 %, 65 %, 64 % (measurements taken from the figures given by COTTEAU and JACKSON.

The Bonaire specimen no. 2 has the ambitus more angular than no. 1 and than *S. subcylindricus*.

Age. Upper Eocene.

Locality. SW of Seroe Montagne (W. Bonaire).

Schizaster gerthi n. sp. Fig. 157. Pl. I, fig. 19, pl. II, fig. 10—12.

Nineteen specimens were found; I shall only give the range of variation, no average values.

L. 20—ca. 49,5 mm.; W. 18—43 mm.; H. 14,2—32,7 mm.; $\frac{W}{L}$ ca. 87—93 %; $\frac{H}{L}$ ca. 65—78 %; 1. I & V ca. 3,5—11,5 mm.; w. I & V ca. 1,4—4 mm.; ia. I & V 0,8—1,2 mm.; $\frac{w}{1}$ I & V ca. 29—ca. 40 %; $\frac{\text{1. I \& V}}{L}$ ca. 18—27 %; $\frac{ia}{w}$ 28—33 %; 1. II & IV ca. 7—19 mm.; w. II & IV 2—5,8 mm.; ia. II & IV ca. 0,6—1,3 mm.; $\frac{w}{1}$ II & IV 25—ca. 35 %; $\frac{\text{1. II \& IV}}{L}$ ca. 35—ca. 42 %; $\frac{ia}{w}$ II & IV ca. 20—30 %; apa. 10,5—24(?27) mm.; $\frac{apa}{L}$ 48—ca. 56 %; lps. 1,5

—ca. 4,5 mm.; wps. ca. 3,8—9,5 mm.; psa. 6—ca. 13,5 mm.; $\frac{w}{l}$ ps 200—310 %; $\frac{lps}{L}$ 7—10 %; $\frac{psa}{L}$ 25— ca. 32 %; lpp. 3,5—8 mm.; wpp. 2,5—5,5 mm.; $\frac{w}{l}$ pp 52(?50)—71 %; width of anterior furrow ca. 2—5,2 mm.; $\frac{\text{w. ant. furrow}}{W}$ 11—15 %.

Test high, oblong, largest height approximately halfway between apex and posterior side. Largest width approximately halfway the length. Ventral side subconvex with slightly raised plastron. Posterior side high, narrow, truncated, vertical. Apical system subcentral (80 % of the proportions $\frac{apa}{L}$ are between 48 and 52 %). Peristome transverse, semicircular to kidney-shaped, flush with the surface, very excentric anteriorly. Periproct oval with the longest diameter vertical, at the top of the posterior side. Petals unequal, the anterior ones being much longer, very depressed. Petals I and V form a sharp angle, ca. 50—55°. Poriferous areas gently and equally curved. The interambulacrum 5 between I and V forms a prominent ridge in the midline, from apex to posterior margin. Petals II and IV form an angle of ca. 95—110°; posterior poriferous area almost straight, anterior one curved. Pores of paired ambulacra slightly oval. Ambulacrum III not markedly petaloid, forming a deep depression from apex to ventral side; depth of depression decreasing inframarginally. Pores of ambulacrum III situated sideways of bottom of depression. Large scaly tubercles are found on the interambulacral areas of the ventral side, attaining their largest diameter (ca. 1,2 mm. in a specimen 46,6 mm. of length) on interambulacrum 2 and 3. Smaller tubercles are on the dorsal side; on the margin the tubercles gradually diminish in size. There are 2 fascioles, a peripetalous one, closely following the petals, and a latero-subanal fasciole. The latter approximately separates halfway the posterior side of the petals II and IV from the peripetalous fasciole, runs with gentle slope towards the posterior margin and passes low under the periproct.

S. gerthi is related to *S. dumblei* Israelsky and *S. scherzeri* Gabb. *S. dumblei* is lower and has a posteriorly excentric apex and the posterior margin is not truncated as in *S. gerthi*. *S. scherzeri* has a posteriorly excentric apex and the angle between petals II and IV is decidedly smaller.

This species has been named in honour of Prof. H. Gerth.

Age. Upper Eocene.

Locality. SW. of Seroe Montagne (W. Bonaire).

GEOLOGICAL MAP AND SECTIONS.

The basis for the geological map furnished the topographical map 1:20.000. In the Washikemba formation only areas of chiefly diabase and diabase tuffs and intrusions have been marked separately. The other Washikemba rocks have been marked together (Washikemba formation: not differentiated). The boundaries of the tertiary limestones and of the areas with predominant diabase are only provisional: in these two cases more exact boundaries could not be given. The alluvial deposits in S. Bonaire are chiefly coral sands; their boundaries have for a great part been taken from the topographical map 1:20.000. (On that map they are marked as "drasland"). Dunes and shingle walls are given with the same signature; coral shingle is by far predominating.

Because of financial reasons the geological map has not been printed in colours; everyone who wants to get a better view of the distribution of the rocks on Bonaire can colour it with little trouble.

I must point to some inaccuracies in the sections. In the first place concerning the limits of the tertiary limestones towards the Washikemba formation and quaternary limestones in the underground. These limits could not be given with any certainty. The second inaccuracy concerns the Soebi Blanco conglomerate. There are some complications in the position of the layers (nearly vertical layers in some places S. of the Seroe Montagne). These complications are not marked in the section EF, because they are local phenomena. If there is more faulting in the conglomerate, it may be thicker or less thick than is marked in the section.

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PLATE I

Fig. 1—6	*Bonaireaster rutteni* n.g. n.sp., 1 & 2 dorsal surface, 3 & 4 ventral surface, 4 showing arrangement of plates, 5 profile, 6 interior view of ventral surface with auricles, and lantern of ARISTOTLE (1 & 3 dorsal side, 4 & 5 ventral side, 2 exterior side).
Fig. 7, 8	*Pauropygus ovum serpentis* (Guppy), 7 with costulate petals and not depressed poriferous areas, 8 with flush petals.
Fig. 9—12	*Prenaster jeanneti* n. sp., 9 dorsal surface, 10 ventral surface, 11 profile, 12 posterior surface.
Fig. 13—15	*Maretia sp.*, 13 dorsal surface, 14 ventral surface, 15 profile.
Fig. 16—17	*Moira sp.*, 16 dorsal surface, 17 profile.
Fig. 18	*Brissoides* (*Rhabdobrissus*) *aloysii* n. sp., posterior surface.
Fig. 19	*Schizaster gerthi* n. sp., ventral surface.
Fig. 20, 21	*Schizaster sp.*, ?cf. *subcylindricus* Cott., 20 dorsal surface, 21 profile.

Fig. 22—24	*Pholadomya trechmanni* n. sp., 22 profile, 23 dorsal surface, 24 anterior surface.
Fig. 25—28	*Terebratula martini* n. sp., 25 ventral surface, 26 dorsal surface, 27 profile, 28 anterior view.
Fig. 29	*Palaeopsammia sp.*
Fig. 30, 31	Coral belonging to the family of the Turbinolidae.
Fig. 32, 33	*Operculina bonairensis* n. sp.

PLATE II

Fig. 1—3	*Antillaster bonairensis* n. sp., 1 dorsal surface, 2 profile, 3 posterior surface.
Fig. 4—6	*Amblypygus* cf. *merrilli* Twitchell, 4 dorsal surface, 5 ventral surface, 6 profile.
Fig. 7—9	*Brissoides* (*Rhabdobrissus*) *aloysii* n. sp., 7 dorsal surface, 8 ventral surface, 9 profile.
Fig. 10—12	*Schizaster gerthi* n. sp., 10 dorsal surface, 11 profile, 12 posterior surface.
Fig. 13	*Hercoglossa sp.*, ?cf. *ulrichi* White, natural size.
Fig. 14	*Astrocoenia* cf. *portoricensis* Vaughan 1919, slightly reduced.
Fig. 15	*Stylophora sp.*, natural size.
Fig. 16	*Diploctenium sp.*, reduced.

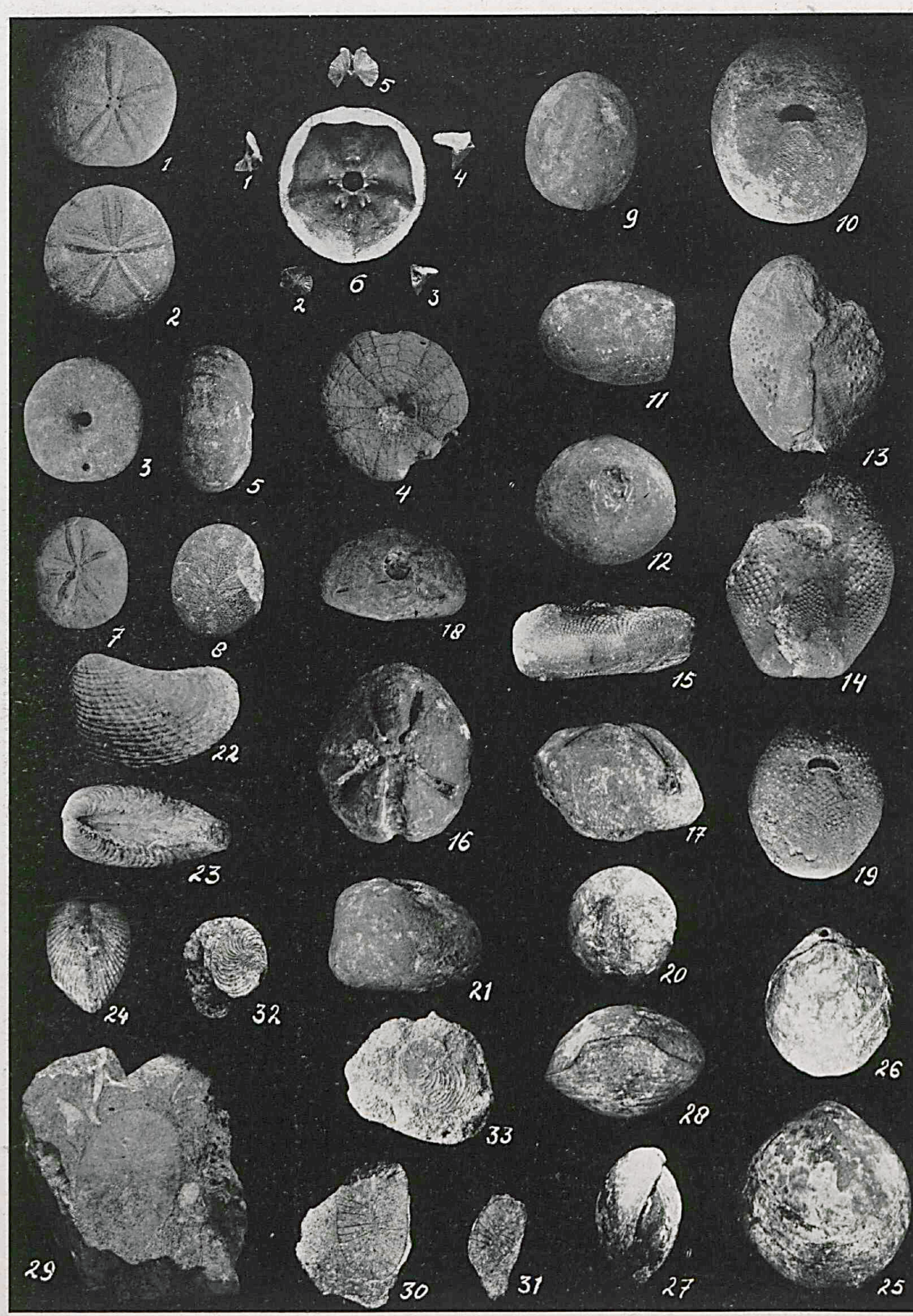

PLATE I.

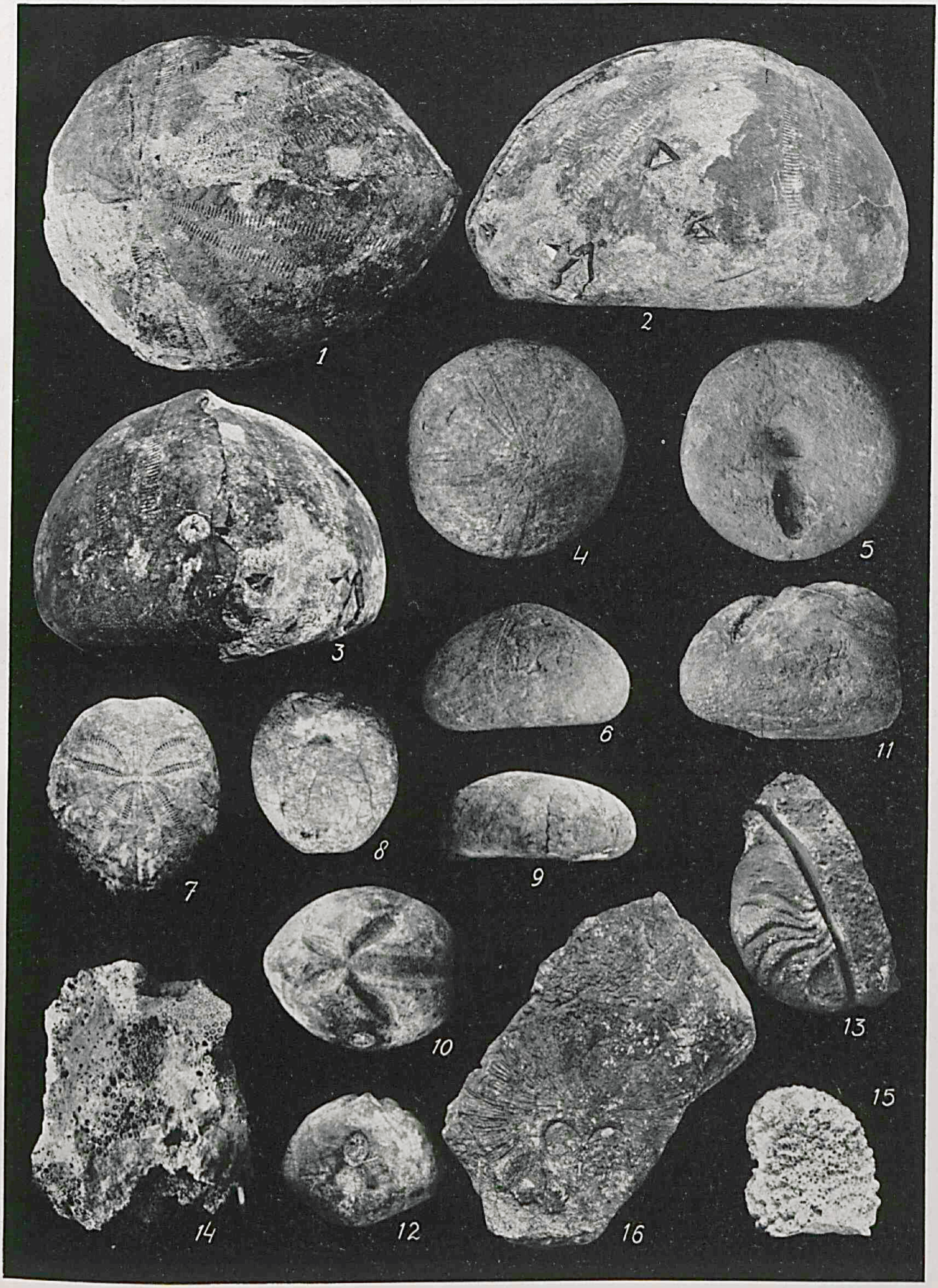

PLATE II.

STELLINGEN

I

Het ware wenschelijk de nomenclatuur van het gebit der Mammalia te gebruiken zooals voorgesteld wordt door Bolk in zijn z.g. concentratie-theorie.

II

A. H. Clark heeft verwantschap tusschen de Echinoidea en de Crinoidea meenen te vinden; de punten van overeenkomst zijn vermoedelijk voor een deel meer schijnbaar dan werkelijkheid.

III

Het is logischer de Orde der Bothriocidaroida als de primitiefste groep van Echiniden te beschouwen en de andere Orden van haar af te leiden, dan haar als een zijtak te beschouwen.

IV

De door Lameere en anderen aangenomen volgorde in de vorming der mesenteriën bij Tetracoralla tot en met het Edwardsia-stadium is alleen te vergelijken met die van de Hexacoralla, als men een afwijking aanneemt van de ontstaansregel tusschen mesenteriën en septa in de stadia, voorafgaande aan het Edwardsia-stadium.

V

Wood Jones heeft bewezen, dat Cocos Island zijn atol-vorm verkregen heeft zonder dat daling van het eiland heeft plaats gehad.

VI

Het ontstaan van kegel („Tuten")-structuren in gesteenten is een physisch-lithologisch probleem, d.w.z. eenerzijds afhankelijk van de facies van het gesteente, anderzijds van de physische toestand van het gesteente tijdens en na de sedimentatie.

De verklaring die R. Hermann voor het ontstaan van kegelstructuren heeft gegeven, kunnen we in groote trekken als juist aanvaarden; het is Hermann evenwel niet mogen gelukken een aannemelijke verklaring te geven voor alle details van de kegelstructuur.

VII

De verklaring die M. ROESLER gegeven heeft van de ijzerertsafzettingen in Oriente Province, Cuba, is het meest waarschijnlijk te achten.

VIII

De onderzoekingen van BRANCO in het Ries van Nördlingen hebben het zeer waarschijnlijk gemaakt, dat de aldaar gevonden verschijnselen niet het gevolg zijn van glaciatie.

IX

De daling van het Ries-gebied, volgende op de opheffing in het Mioceen, is niet bewezen. Voor de verklaring der feiten is het niet noodzakelijk, dat we deze daling aannemen.

X

Mocht men ooit algemeen tot het inzicht komen van de noodzakelijkheid van een wereldtaal, dan is het aan te bevelen als zoodanig ,,Anglic'' te kiezen en niet ,,Esperanto''.

BONAIRE.
GEOLOGICAL MAP AND SECTIONS.