Geology. — *On the Geology of Margarita, Cubagua and Coche (Venezuela).* By L. RUTTEN.

(Communicated at the meeting of June 29, 1940.)

Mr. P. WAGENAAR HUMMELINCK, of the Utrecht University, made in 1936 a voyage to the North Coast of Venezuela and to the islands North of Venezuela. His purpose was in the first place to make zoological collections; at the side of this he did also geological observations and collected rocks, which he put kindly at my disposal. The following is the result of the study of these rock-collections as far as regards the large island of Margarita and the small islands Cubagua and Coche.

The following data on these islands are to be found in the literature. DAUXION DE LAVAYSSE describes Margarita as being very dry and unfertil; the Macanao mountains are said to consist of micaschists (2). WALL (11) indicates the existence of his "Caribbean System" of metamorphic rocks and of younger sandstones of unknown age with a maximal dip of 35°; these sandstones crop out between Porlamar and Pampatar. W. SIEVERS (10) mentions, on the base of the diary and the collections of R. LUDWIG, the occurrence of gneiss-micaschists, graphite schists and phyllites, all considered as archaean rocks, of tertiary limestone in the neighbourhood of San Juan Griego, and of serpentine. C. MAURY (5), without giving details, says that there occur probably sediments of Midway-age on the island. R. A. LIDDLE (4), in his well-known book on Venezuela and Trinidad, is rather explicit on Margarita. He gives (p. 72) a N—S section, wherein he indicates: 1? Palaeozoic or Basal Cretaceous (schists and metamorphic limestone, shale and sandstone), 2. Basal Cretaceous? (partly altered limestone and sandstone capping mountains), 3. ?Lower Cretaceous (sandstone, shale and limestone), 6. granite (mica-hornblende granite, schistose at edges of mass., magnesite deposits at granite and schist contact). (1) and (2) are separated from (3) by a fault near Porlamar. LIDDLE's text (p. 73—74) is, unhappily, not in agreement with his section. In his section he calls the sandstone-shale formation of Porlamar "Lower Cretaceous", in his text "Upper Cretaceous". Moreover he states that it is impossible to differentiate the schistose rocks of the island into Precretaceous and Cretaceous, and he does not at all prove that part of the schists is of cretaceous age. He only says that he regards the marbles of the island as metamorphosed "El Cantil limestone", and that the "shiny mica schists which comprise the greater part of the island ..... are occasionally capped by a few meters of this marmolized limestone". HESS (3) mentions the occurrence of serpentines and says that in the

West Indies "the serpentines intrude Upper Cretaceous rocks for the most part" (p. 85). In recent time a special paper on Margarita has been published by P. I. AGUERREVERE (1); it is accompanied by a geological map. He states that metamorphic rocks (micaschists, gneiss, serpentine and crystalline limestone) are predominant; of these, the marbles are thought to be the youngest and of cretaceous age. A coarse granite intrudes the metamorphic rocks near Paraguachi; the existence of basic eruptive rocks is possible. A strongly folded formation, regarded as eocene, is found in the neighbourhood of Porlamar and Pampatar. A rock at the W.hill of the "Tetas de Maria Guevar" is considered to be a black lava; the description, however, is not very convincing: "una lava de color casi negro, excepto sus cristales de cuarzo que son blancos o sin color" (p. 402). Data about miocene and pliocene strata are very vague.

Cubagua and Coche are low islands (LIDDLE); SIEVERS supposes that Cubagua consists of archaean rocks; AGUERREVERE mentions from East Coche metamorphic rocks and variegated shales, capped by a ?pliocene conglomerate, containing pebbles of quartz and marble. These pebbles indicate that, formerly, Coche must have belonged to a greater land-area [1]).

The rocks of the three islands in the collection HUMMELINCK belong to:

1. The metamorphic basement of Margarita and Coche,
2. The Eocene of Margarita,
3. The young "capping" formations (?Pleistocene) of the three islands.

They will be discussed in this order. For localities, see the accompanying map.

Basement of Margarita. A. Gneisses. no. **5**, **6**, **7**, **8**, **10**, **13**, **25**, **36**, **194**, **195**, **240**, **371**, **372**, **373**, **375**. (No. **36** from an isolated rock-fragment; the others all outcropping). The gneisses have been found exclusively in the eastern part of the island; it must, however, been taken in mind that the W.part has been very poorly sampled. In the literature gneisses have been only mentioned by AGUERREVERE (1); microscopical descriptions are absolutely lacking.

The rocks **5** and **6** are sericite-albitegneisses [2]). Both contain porphyroblasts of albite (often with inclusions of sericite), and a mosaic of small quartzes and albites with some sericite, somewhat differentiated into layers. The twinning lamellae of the large albites are bent and sometimes broken. Both rocks have been exposed to crushing forces after their gneissification. The samples **36**, **371** and **375** are equally sericite- or muscovite-albitegneisses; **194** and **195** differ from the foregoing by strong

[1]) Some geological data on the three islands are to be found in the academical thesis of Mr. HUMMELINCK (3a, p. 16, 17, 45, 46, 47) which was published after the communication of this paper.

[2]) In the following I shall call "albite" the plagioclases with a refraction index of less than 1.540. These acid plagioclases, which are very common in the Margarita-rocks include albite s. str. and albite-oligoclase.

mylonitization. Quartz and albite have been crushed along more or less parallel zones, and the remaining larger crystals show strong undulatory extinction; **7** and **10** are analogous.

372 and **373** are albitegneisses with garnet; **372** contains moreover muscovite, chlorite, some biotite and tourmaline, **373** contains sericite and zoisite. **240** is a fine-grained, schistous albitegneiss with chlorite and zoisite.

Sample **8** has the habit of a coarse, schistose muscovitegneiss. It contains: a. some large, perthitic orthoclases, b. rather many large albites, partly with inclusions of sericite and idiomorphic epidote, c. small crystalls of (a) and (b) which probably originated — by crushing — from larger ones, d. large spots of strongly undulatory and cataclastic quartz, e. streaks with epidote, muscovite and some biotite, f. some large titanites, g. some fibrous sillimannite. Clearly, there is a large difference between this sample and the foregoing gneisses. Possibly this difference is related with the fact that no. **8** has been found at the same locality as a granitic rock.

No. **13** has a character of its own. The leucocratic minerals — quartz and albite — form a minority; the bulk of the finely schistous rock being composed of muscovite, epidote (mostly idiomorphic) and hornblende (in idiomorphic prisms; pleochroism yellow — greenblue). Accessories are rutile, chlorite, garnet and ore. This rock is from Puerto Manzanillo, where very basic rocks predominate.

We see that most of the gneisses are albite-gneisses with no great variation; only two samples are very different from the rest: the albite-orthoclase-gneiss no. 8 and the melanocratic albite-gneiss no. 13. Many rocks present signs of strong, crushing dynamometamorphosis posterior to the gneissification.

B. Micaschists. Samples: **2**, **45**, **54**, **55**, **56**, **59**, **69**, **70**, **72**, **73**, **74**, **75**, **79**, **80**, **81**, **82**, **97**, **187**, **192**, **193**, **235**, **236**, **244**, **247**, **248**, **251**, **370**, **374**, **377** (no. **72** and **244** from isolated rock fragments; the other ones from outcropping rock). The micaschists have been found at numerous localities throughout the island. They have formerly been mentioned by DAUXION DE LAVAYSSE (2), WALL (11), SIEVERS (10), LIDDLE (4) and AGUERREVERE (1); descriptions of the rocks are entirely lacking.

Most rocks are muscovite- and sericite-quartz-schists; biotite is extremely rare. Generally the schistosity is well developed in consequence of the concentration of mica and quartz in alternating layers. The quartzes are often interlocked. In many cases (f.i. **74**, **244**) the quartzes are cataclastic at their periphery, indicating that the rocks have suffered from crushing after their metamorphosis. Rarely, some plagioclases are found (**74**, **248**), the rocks passing then into gneissic micaschists. The following accessoria are found.

Chlorite occurs frequently (f.i. **2**, **45**, **75**, **192**, **248**); it may even be present in equal quantity as mica.

Many samples are rich in graphite (**2**, **45**, **72**, **82**, **97**, **187**, **235**, **247**,

251); they become very dark and even black, f.i. at the Tetas de Maria Guevar.

Garnet (**54**, **56**, **59**, **192**, **193**, **244**, **247**, **248**, **370**) is found frequently, mostly in isodiametric, xenomorphic grains with sieve-structure. All the garnet-containing rocks are relatively coarse.

Tourmaline (pleochroism: lightbrown — colourless) in idiomorphic prisms occurs in the samples **187**, **192**, **236**, **248**.

Rutile has been found in **79**, **248**, **251**; Zircon and Pyrite are common.

At the side of true micaschists there occur rarely quartzschists (**55**), whilst **97** is a quartz-graphite schist, in which the graphite has been concentrated in thin layers; the rock gives the impression of having originated from a chert.

There is one sample which deserves special description (**192**). It is a quartz-muscovite-schist with garnet and tourmaline, and with many crystals of a blue mineral with the following characteristics. Refraction high; pleochroism lightyellow-blue; one good cleavage; optical angle small and optical character positive, which can be stated in sections parallel to the cleavage; angle of extinction with regard to the cleavage maxim. 20°. The mineral is chloritoid, agreeing absolutely with chloritoids from Piemont, Wallis and Rhode Island.

C. Various Basic Schists. Samples: **37**, **38**, **39**, **40**, **41**, **49**, **50**, **51**, **52**, **92**. No data in the literature.

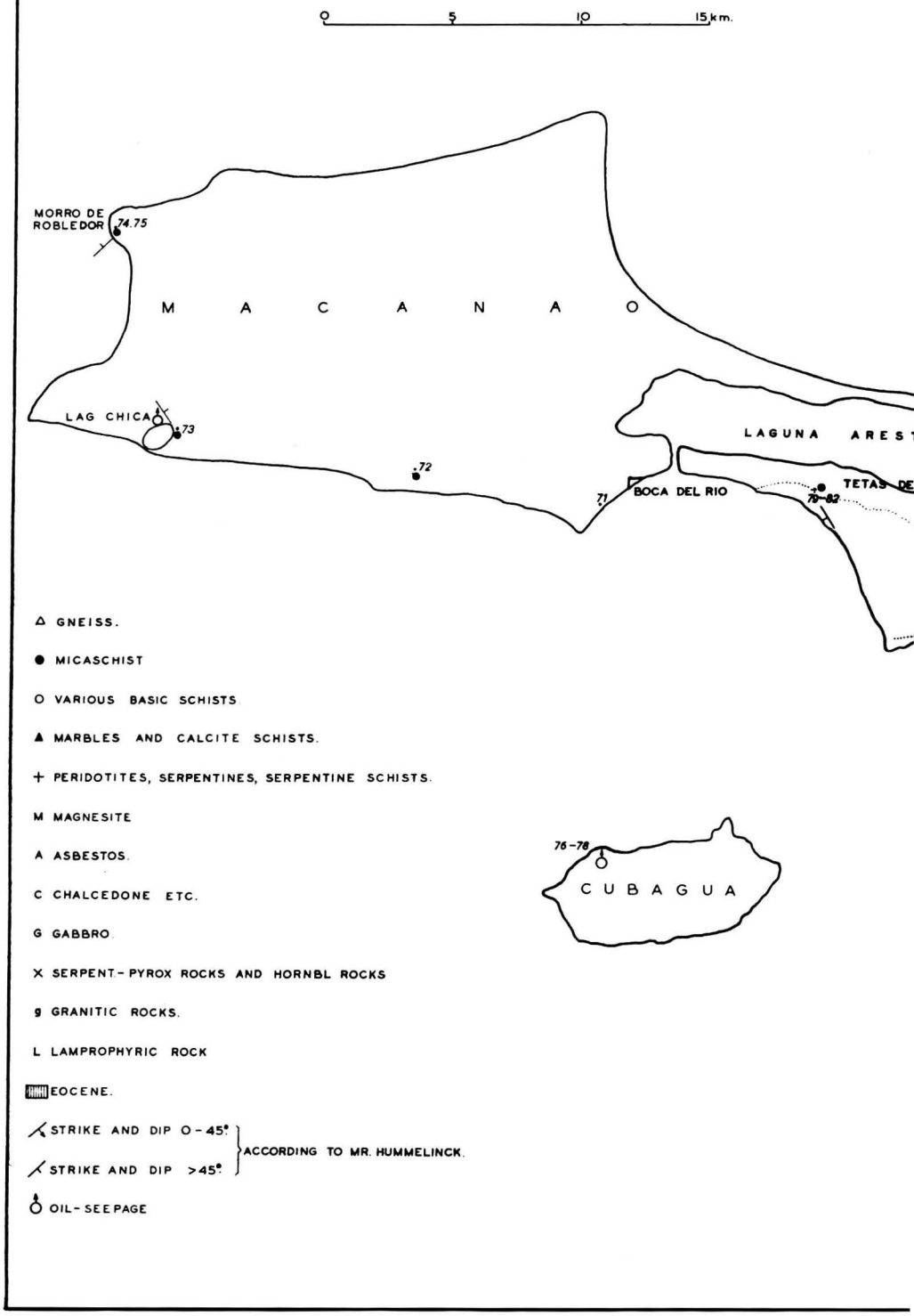
The samples **37**—**41** are all from Punta Ausente, where no other basement-rocks have been collected (**42**—**44** are subrecent limestones). No. **37** is an amphibole-eclogite with fine prisms of amphibole (yellow-greenblue), garnet (with inclusions of quartz), grains and idiomorphic crystals of epidote-zoisite, many plates of muscovite, grains of rutile, and with some quartz as matrix. No. **38** is a subschistose green rock with predominating hornblende and epidote, less muscovite, and with accessory quartz, chlorite and rutile; it is an amphibole-epidote-zoisite-rock. Nos. **39** and **40** are poorly schistose; they are composed of large, clear albites with many inclusions of blue-green hornblende and epidote-zoisite, and of large crystals of hornblende and epidote. Rutile is also present. The rocks are epidote-amphibole-albite-rocks. No. **41** has the same habit as the foregoing; it is, however, an epidote-muscovite-albite-rock. The samples **37**—**41** are very similar to inclusions, which are found in the serpentine-massives of Santa Clara province, Cuba (8a).

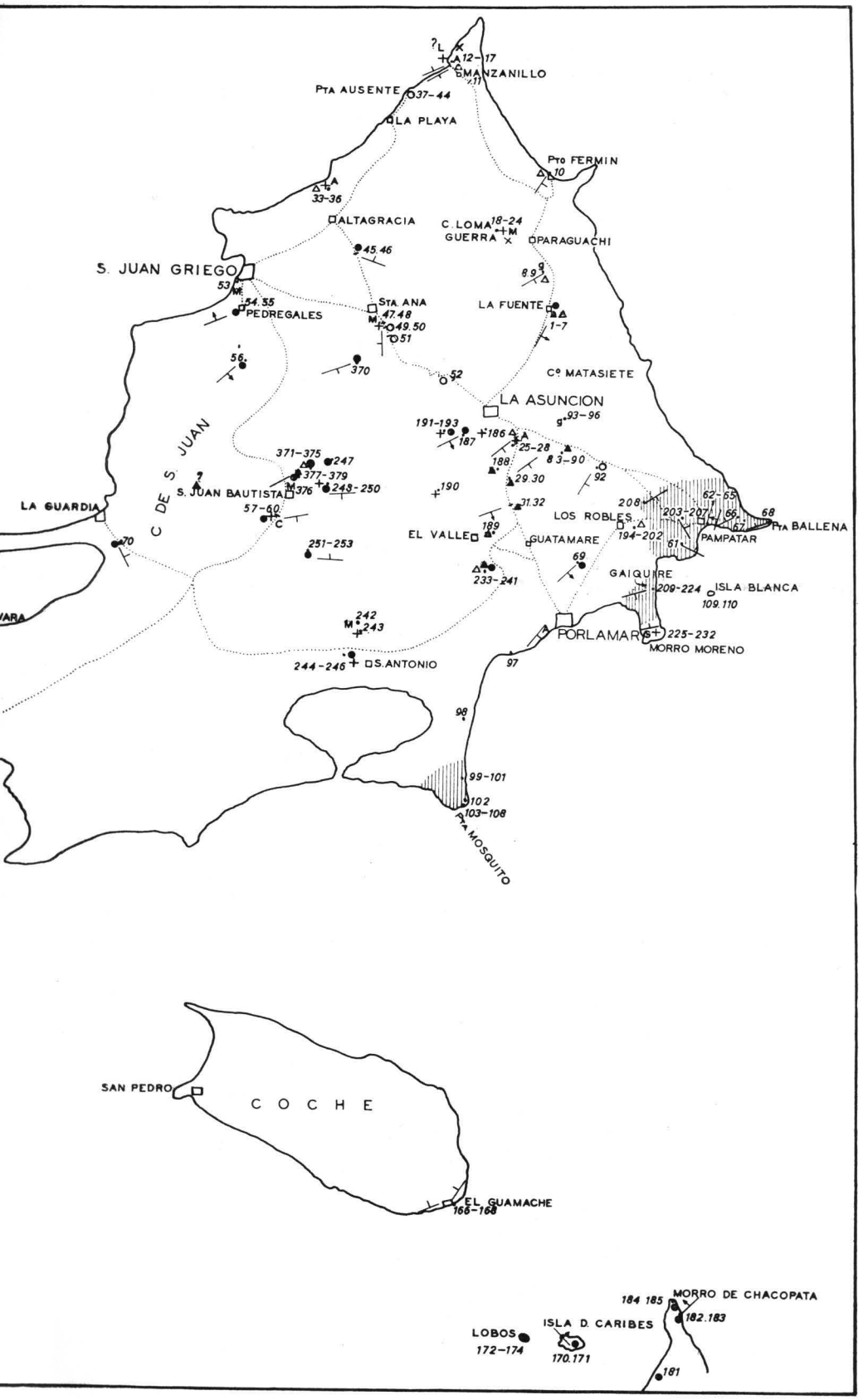
The samples **49**—**52** have been found on the road from Sta. Ana to La Asunción; they are fine-grained, schistose amphibolites, containing amphibole, albite and epidote-zoisite; in **51** and **52** there is, moreover, some mica.

The last sample (**92**) is an actinolite-schist with accessory zoisite and plagioclase.

An albite-chlorite-schist (**25**) may be regarded as an intermediate between the micaschists and the basic schists.

ISLAND MARGARITA




PTA AUSENTE
37-44
LA PLAYA
MANZANILLO
11
12-17
PTO FERMIN
10
33-36
ALTAGRACIA
C. LOMA
GUERRA
18-24
PARAGUACHI
45.46
S. JUAN GRIEGO
53
54.55
PEDREGALES
STA. ANA
47.48
49.50
51
LA FUENTE
1-7
8.9
56
370
52
Cº MATASIETE
LA ASUNCION
93-96
191-193
187
186
25-28
83-90
188
29.30
92
190
31.32
371-375
247
377-379
376
248-250
S. JUAN BAUTISTA
57-60
C DE S. JUAN
LA GUARDIA
70
251-253
189
EL VALLE
GUATAMARE
233-241
69
208
62-65
LOS ROBLES
203-207
66
68
PTA BALLENA
194-202
67
61
PAMPATAR
GAIQUIRE
209-224
ISLA BLANCA
109.110
242
243
244-246
S. ANTONIO
PORLAMAR
225-232
MORRO MORENO
97
98
99-101
102
103-108
PTA MOSQUITO
SAN PEDRO
COCHE
EL GUAMACHE
166-168
184 185
MORRO DE CHACOPATA
182.183
ISLA D. CARIBES
170.171
LOBOS
172-174
181

D. Crystalline Limestones.

Samples **1**, **3**, **4**, alternating with micaschists and gneiss, and, according to the field-notes of HUMMELINCK, also with quartzites.

Samples **188**, **29**, **30**, **31**, **32**, **189**, **83—90**, **233**, **234**, **237**, **241** apparently belong to a broad zone with ENE-strike and S-dip. According to the field-notes of HUMMELINCK the marbles are forming entire hills; at **31**, **32** schists, marbles and quartzites are alternating; at the locality **83—90** there is equally an alternation of marbles and schists; from **188** schists with strata of marble are mentioned; in the marble of **241** is a large cave (Cueba del Piache, 3a, p. 54).

Samples **378**, **379**, from large, isolated blocks. The people of San Juan told Mr. HUMMELINCK that much marble occurs in the Cerros de San Juan.

Evidently the marbles have been sampled in three districts: the area S. and E. of La Asunción, the surroundings of S. Juan Bautista, and the area around La Fuente [1]).

Crystalline limestones from Margarita have been mentioned by LIDDLE (4) and by AGUERREVERE (1). As is to be seen from the foregoing and on the map the marbles are often alternating with other metamorphic rocks, whilst the whole zone with crystalline limestone S. of La Asunción apparently lies between other schists. It is certainly not true that the marbles are "capping mountains" (LIDDLE), nor has it been proved that they are the youngest element of the basement-rocks (AGUERREVERE). As far as can be judged they form normal intercalations within the schist-series.

The rocks under consideration are sometimes without schistosity, white or grey-white (**29**, **30**, **84**, **85**, **87**, **88**, **90**, **189**, **233**, **234**, **237**, **241**, **378**, **379**) or they are schistose, sometimes hardly recognizable as calcite-schists, and with colours: white, green-white, grey, black-grey (**1**, **3**, **4**, **31**, **83**, **86**, **89**, **188**). In the first group calcite is always strongly predominating; in the second group the accessories may equal or even surpass the calcite. In some cases there are hardly any accessoria (**237**, **378**, **379**). Where present, the accessories are: quartz, albite, sericite-muscovite; more rarely epidote-zoisite, chlorite, biotite; very rarely tourmaline (**3**, **84**), garnet (**86**), titanite in grains (**4**), pyrite (**84**), and graphite-dust. Tourmaline and epidote may be idiomorphic; quartz occurs mostly as "drops"; it may, however, also occur in thin layers with interlocked crystals.

In the schistose samples the calcite-crystals are always elongated in the planes of the schistosity; in the true marbles they may be isodiametric.

As in the case of the gneisses and the micaschists, it can sometimes be observed that the marbles have suffered from crushing forces after their

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[1]) According to the map of AGUERREVERE marbles are to be found also in the W. part of the island.

crystallization, a cataclastic zone having developed between the large grains of calcite.

E. Peridotites, Serpentines, Asbestos, Gabbros, Magnesite etc.

Samples: Serpentinized peridotites **18**, **191**, **225**, **227**, **230**; Serpentines and Serpentine-schists, often with many accessories **16**, **20**, **21**, **26**, **28**, **33**, **34**, **48**, **58**, **60**, **186**, **190**, **229**, **232**, **243**, **246**, **249**, **250**; Magnesite **19**, **47**, **53**, **242**, **376**; Asbestos **14**, **15**, **27**, **35**; Serpentine-pyroxene-rock **17**, **22**, **23**; Hornblende-rock **24**; Gabbro **226**, **228**, **231**; Chalcedone etc. **57**.

According to the field-notes of Mr. HUMMELINCK the samples **14**—**17** have been collected in an old asbestos-mine; **18**—**24** proceed from the old magnesite-mine of Cerro Loma Guerra; **23**, **24**, **57**, **243**, **246** and **376** have been taken from isolated fragments of rock. I am not certain whether **53** has been really collected at the locality indicated on the map.

The localities are evenly distributed over the whole eastern part of the island; the western part has not furnished samples, possibly because it has been visited only very cursorily.

SIEVERS (10), AGUERREVERE (1) and HESS (3) mention the occurrence of serpentine on the island. LIDDLE (4) mentions the magnesites, which he regards as contact-products from the periphery of a granite-massif. This is certainly mistaken: the magnesites are found — as elsewhere in the world — in relation with peridotites or serpentines. There are no microscopical descriptions of this group of rocks in the literature.

Five samples are peridotites-in-serpentinization or serpentines, which clearly originated from peridotites. In (**18**) there is still much olivine, each grain with its net-work of serpentine. It is interesting that the original olivines, whose circumferences are recognizable by simultaneous extinction, *have very elongated forms,* which proves that the rock must have crystallized under the influence of thrust-powers. In **191** a considerable content of olivine remains; in this rock, the crystals were isodiametric. At the side of serpentine with net-structure there occur large plates of antigorite which show no trace of orientation. The forming of magnesite has already begun. Samples **225**, **227** and **230** are from the same locality and intimately related inter se. They are serpentines which, by their mash-structure, by the presence of chromite and of bastite (**230**), prove that they originated from peridotites. They contain abundant iron-ore; in 225 veins of opal are present.

As indicated above, the collection contains a large number of serpentines and serpentine-schists. Some of these will be mentioned separately. The rocks **16**, **20**, **21**, **33**, **34**, **48** are coarse antigorite-schists with accessory crystals of magnetite, which are sometimes limonitized. Nos. **26**, **28**, **58** are antigorite-chlorite-schists; **26** contains moreover talc; **58** shows a vein with chalcedone, quartz and opal. In these rocks occur crystalplates, consisting partly of antigorite, partly of chlorite: thus, these two minerals have the

faculty of growing in parallel superposition. No. **190** is an antigorite-jadeite-schist; the jadeite is partly so coarse that pyroxene-cleavage may be recognized, partly it is finely-fibrous, and recognizable only by the great angle of exinction. The antigorite-chlorite schist **186** contains equally some finely-fibrous jadeite. The samples **229, 232, 246, 249, 250** are ordinary serpentines and serpentine-schists; nos. **229** and **232** very probably originated from a peridotite. No. **60** is a serpentine with advanced formation of limonite and quartz.

Four somewhat abnormal rocks have been found in the northernmost part of the island. No. **17** is a poorly schistose, emerald-green rock. It consists for the greatest part of monoclinic pyroxene which may pass marginally into uralite; there is a matrix of serpentine and magnetite: it is a pyroxene-serpentine-rock. No. **22** is a serpentine-pyroxene-schist with "stream-lined" serpentine and less pyroxene. Still poorer in pyroxene is the serpentine-pyroxene-schist **23** which contains accesorily magnetite; the sections present some veins with opal. Quite another rock is **24** which consists almost entirely of large crystals of bluegreen hornblende with magnetite as an accessory. It has been found as an isolated rock-fragment and may originate from an intrusive dike.

The magnesites **19, 47, 53, 242, 376,** and the quartz-chalcedone-rock **57** belong to the weathering-products of the serpentines. The magnesites are dirty-white or light-green rocks, often somewhat concretionary. In one of the samples Dr. W. VAN TONGEREN determined the presence of 47 % magnesite. No. **47** presents still, at the side of magnesite, some antigorite. The sample **57** consists of quartz and chalcedone, with remains of serpentine-schist.

The asbestos-containing rocks of Margarita are certainly intimately related with the serpentines. At Manzanillo a beautiful tremolite-asbestos (**14**), an asbestos-schist with antigorite (**15**) and an antigorite-schist (**16**) have been sampled; at the locality **25—28** a chlorite-containing tremolite-asbestos has been found together with antigorite-chlorite-schists. The serpentine-schist **34** and the tremolite-asbestos **35** proceed equally from the same locality. In the field-notes of Mr. HUMMELINCK asbestos-schists have been mentioned from a point S. from Porlamar; there is no sample from this locality.

At the Morro Moreno three gabbroid rocks (**226, 228, 231**) have been sampled in intimate relation with serpentines. The rocks, which have suffered from strong pressure, are saussurite-gabbros.

F. Acid intrusive rocks. Samples: **9, 93, 94, 95, 96.** These rocks are very rare, and their character is not absolutely certain. LIDDLE (4), in his section, and AGUERREVERE (1) mention granitic rocks from Paraguachi, without giving details.

No. **9** is a white, non-schistose rock, containing large feldspars. The slide presents: 1. various large microclines with "quartz-drops", 2. some large orthoclase-perthites, 3. many large albites, frequently filled with

sericite. These three minerals may show traces of idiomorphism. At the side of them there is a fabric of quartz, acid plagioclase and microcline in smaller crystals; the intergrowth may be aplitic. The quartzes are strongly undulatory, at many points even strongly cataclastic and crushed along shear-planes. The rock seems to be a dynamomorphic aplite. It was found near Paraguachi, from where LIDDLE and AGUERREVERE mentioned their "granites".

Samples **93—96**. The rocks are poorly schistous. They show in the slides: 1. porphyritic albites with traces of idiomorphism, often strongly bent, broken and crushed at the margins, 2. quartz, partly in large crystals with undulatory extinction and with marginal crushing zones, partly also in totally crushed zones along shear planes, 3. sericite, epidote, zoisite and chlorite concentrated in small green streaks. The rocks are strongly dynamometamorphic albite-aplites.

G. Lamprophyric rocks. Sample 12 is possibly a strongly altered biotite – amphibole – lamprophyre.

Basement of Coche. AGUERREVERE has mentioned from the NE. part of Coche "una roca cristalina verdosa, probablemente metamorfica" (1, p. 400). HUMMELINCK has visited only the SE. part of the island, the area of Guamache, where he sampled three sericite-quartzites of the basement (**166**, **167**, **168**), covered by a young conglomerate.

General considerations on the Basement-Rocks of Margarita and Coche. Most of the rocks of the basement of Maragarita are para-schists. As such may be regarded all the mica-schists, most, if not all of the gneisses, and all the crystalline limestones and calcite-bearing schists. Intrusive rocks and ortho-schists are, of course, the aplites, the problematic lamprophyre, the gabbros, the peridotites and those serpentines which clearly have originated from peridotites. For the other serpentines and related rocks, and for the "various basic schists" it is impossible to say, whether they are ortho- or para-schists, although it is probable that many of them are ortho-rocks. Thus, we can distinguish in the basement of Margarita a series of older rocks, the para-schists, and a series of (somewhat) younger rocks, the (intrusive) ortho-rocks. The series of para-schists seems to be quite homogeneous and not to comprise rocks of different cycles: the different kinds of rock are clearly linked by transitional types. Gneiss, micaschist, calcite-bearing schists and quartzite (not sampled) are alternating at locality **1—7**; marbles, different schists and quartzites (not sampled) are intimately connected in the region S. of La Asunción. But also the ultrabasic schists, part of which must have ortho-character, seem to be related intimately with the foregoing. This holds good for the association gneiss-serpentines at P. Manzanillo and in the area S and SW from La Asunción. The only rock which does not fit well into the metamorphic complex is the graphite-

bearing quartzite no. **97** (?ex chert), S. of Porlamar, which might belong to a younger cycle.

Most of the rocks of the basement of Margarita are also known from the Caribbean Coast-Range of Venezuela. Gneisses and micaschists, comparable with those of Margarita, have been described from the roads La Guaira-Caracas and Puerto Cabello-Valencia (6). Mr. HUMMELINCK has collected samples at Esmeralda and Puerto Santo near Carupano, of which I mention: a micaschist with chlorite, a gneissic micaschist, an albite-gneiss and dynamometamorphic albitites. Rocks comparable with the marbles and the calcite-schists have been found along the road La Guaira-Caracas (6) and at Puerto Santo: coarse marbles without accessories, schistose marbles with graphite, quartz, albite, epidote and chlorite, and basic schists with calcite-layers. Serpentine-schists are equally known from the road La Guaira-Caracas, and from the mainland, S. of Margarita, where, at Manglillo, samples of a serpentine-talc-rock, of non-schistose, somewhat opalized antigorite-serpentine, of quartz-chalcedone-rock and of altered gabbro have been collected by Mr. HUMMELINCK.

I am not certain whether the few rocks from Coche, all sericite-quartzites, belong to the same cycle as the basement rocks of Margarita, where this type is practically absent. Only the southernmost sample from Margarita (97) is an (aberrant) graphite-quartzite. On the very small islands S. of Coche (Lobos, Isla de Caribes) and at Chacopata the same rocks as on Coche have been collected: sericite- and muscovite-quartzites (**170, 171, 173, 174, 181, 183, 184, 185**), whilst rocks of the "Margarita-type" (serpentines and micaschists) are found somewhat more to the S. at Manglillo. It is evident that the sericite-quartzites occupy a well-defined area, where other basementrocks seem to be lacking.

I am inclined to regard the quartzitic rocks of Coche and of Chacopata-Lobos as metamorphic Cretaceous and the other rocks of the metamorphic basement as older. The quartzites are not materially different from lower cretaceous sandstones in different parts of Venezuela (RUTTEN, 8, p. 345); the basement-rocks of Margarita, with their many basic intercalations (and/or intrusions) and their lack of what might be called "indicative cretaceous stratigraphy" (i.e. the existence of a sequence: sandstones-limestones-shales) would be older. It is certain that the basement rocks are all pre-eocene, as the non-metamorphic Eocene of Margarita contains pebbles of the basement rocks. If the age, contributed to gabbroid rocks of Lara by RUTTEN (7) and to serpentines of the Serranía del Interiór by SCHÜRMANN (9) is right, basic and ultrabasic rocks of different age must exist in North Venezuela and Margarita.

In E. Margarita Mr. HUMMELINCK has measured a considerable number of strikes and dips. A glance at the map shows that by far the most strikes are NE, the dips SE. From the field-notes it can be concluded that plication is frequently visible in the outcrops (f.i. Manzanillo, P. Ausente, Tetas de Maria Guevar, Morro de Robledor). Thus we may not regard

the SE-dipping beds as the SE-wing of a gigantic fold, *but certainly we have to do with isoclinal folds,* the details of which can, however, not been unravelled with the available data. It must be observed that the NE-strike which is the oldest visible tectonic direction in Margarita and Coche tends to cross the much younger direction which is indicated by the row of islands Aruba-Los Testigos (7). *It is, therefore, quite probable that the metamorphic basement continues unto unknown distances below the Caribbean Sea.*

In relation with the tectonic processes two facts must once more be mentioned: first that one of the peridotites has crystallized under the influence of thrusting forces, second that *almost all the rocks of the basement show signs of crushing metamorphosis, posterior to the crystallization metamorphosis and, of course, prior to the deposition of the Eocene*

Eocene of Margarita. Sediments in the region of Pampatar and Porlamar, already known to WALL (11), have been called Cretaceous by LIDDLE (4), Midway by MAURY (5) and Eocene by AGUERREVERE (1). Mr. HUMMELINCK has collected samples in Pampatar, Gaiquire and Punta Mosquito. The rocks are sandstones, greywacke-sandstones, shales, conglomerates and some limestone; the age is eocene. There is, however, a rather marked difference between the rocks of the three localities, and they will therefore be described separately.

The rocks of Pampatar and Punta Ballena (**61—68**) are grey or green, brown-weathering, platy, calcite-bearing sandstones and shales. Almost all of them contain Globigerina's and ?Radiolaria; no. **62** contains a fragment of a Lepidocyclina. The clastic minerals are: quartz, plagioclase, muscovite, biotite, serpentine and chloritic minerals. There are in the sandstones fragments of phyllite, quartzite, quartz-muscovite-schist, intergrowths of quartz and albite and cherts. The samples **203—208** proceed from the region W. of Pampatar. The calcite-bearing sandstones (**203, 206, 207**) contain very rare, smaller Foraminifera, quartz, plagioclase, muscovite, serpentine; **207** contains grains of schists and of porphyritic material. **204** is a marl, **208** a limestone without fossils. No. **205** is a conglomerate with a very interesting association of pebbles: black chert, many porphyritic fragments, plagiaplite and quartzepidote-rocks which are very similar to rocks, associated in Aruba with the quartzdiorites.

On Gaiquire, which is a small island within a lagoon N. of Morro Moreno Mr. HUMMELINCK collected the sandstones **211, 212, 213, 219** (with clastic: quartz, plagioclase, muscovite, serpentine, quartzite, chert, porphyrites and fine-grained schist) and the conglomerates **216** and **223** (with pebbles of porphyrites, cherts, quartzite and sericite-quartzite). The numbers **214, 217, 218, 220—222** and **224** are pebbles from the conglomerate; they are porphyrites, amygdaloidal porphyrites and cherts. Sample **215** is a dark limestone. Sample **210** is a conglomerate with Orbitoids, probably belonging to the genus Discocyclina.

The samples **99—108** proceed from Punta Mosquito. According to the fieldnotes of Mr. HUMMELINCK there occur here conglomerates with rapidly changing thickness, sandstones and limestone. At the coast fine, small anticlines are to be seen. The pebbles in the conglomerates are quartzite, schisty quartzite, black chert, true radiolarite, quartzdiorite and porphyrite. The fossils are Corallinaceae, Globigerinae, small Camerinidae. Lepidocyclinae and Discocyclinae. It was possible to isolate a lot of Orbitoids from a sample and to recognize the presence of Discocyclina georgiana Cushman and of Lepidocyclina trinitatis H. Douv., proving the eocene age of the deposit.

To the Eocene belong probably also the samples **109** and **110** from Isla Blanca, S. of Pampatar, being a phosphatized marl and a phosphatized sandy limestone with Globigerina.

The rocks of the Eocene are in the first place of interest by the clastic material which they contain. Part of it has been clearly derived from Margarita; many components must, however, proceed from elsewhere. The cherts and radiolarites which very probably are of cretaceous age, the porphyrites and the quartzdioritic rocks can not come from Margarita. The porphyrites and quartzdiorites may come from the North: we find similar rocks on Los Frailes and Los Testigos; the origin of the cherts is unknown.

The eocene rocks are rather strongly folded; in the area of Pampatar they seem to form a syncline; it is quite probable that they have been separated from the basement of Margarita — as indicated in LIDDLE's section (4) — by a fault.

The youngest "capping" deposits. It seems that the whole of Cubagua and a large part of Coche is covered by young marine, partly detritical deposits [1]). Their elevation above the sea to about 200 ft must have occurred in subrecent times. An elevated plateau with detritical, marine deposits covers a large part of Western Margarita; in the midst of it arises the mountaineous massive of Macanao (American Admiralty Chart 2035). According to the field-notes of HUMMELINCK 15—25 m of detritical deposits are to be seen to the West of Boca del Rio. He is of the opinion that, farther in the interior, this plateau rises to about 200 m; it is dissected by deep canyons. Slightly elevated marine deposits are found S. of the Laguna Arestinga, at the coast near San Juan Griego, at Punta Ausente and N. of Punta Mosquito. It is clear from the foregoing that different parts of Margarita have been elevated in subrecent time to different heights.

The petroleum seepages in Margarita and Cubagua. A rather impor-

[1]) A small collection of quaternary molluscs of Cubagua will be studied by Miss T. VAN BENTHEM JUTTING in Amsterdam; Prof. GERTH, of Amsterdam was so kind as to determine the following corals from the island: Millepora alcicornis (L), Orbicella acropora (L), Oculina diffusa (L), Siderastraea radians Pall.

tant seepage of oil must exist to the NW. of Laguna Chica in Western Margarita; Mr. HUMMELINCK got a bottle of the heavy brown oil, but did not visit the locality. From NW. Cubagua he collected some samples of sand, strongly impregnated with oil. We may presume that in the underground tertiary or cretaceous strata are to be found and that there exist important faults along which the oil has migrated to the surface. The presence of tertiary strata in the underground would be in accordance with the occurrence of Eocene on Margarita; the occurrence of cretaceous strata would not be strange, given the occurrence of clastic cretaceous material in the Magdalena Eocene. *The situation of the oil-bearing strata in the strike of the large oilbearing geosyncline of Lara-Falcon is quite natural.*

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Mr. HUMMELINCK's collections are in the Geological Institute of the University of Utrecht; details are to be found in the year-catalogue for 1940.