23. SURINAM

BY

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With geological map.

In the following a survey is given of what is known at present about the geology and petrology of Surinam. It must be understood that this outline cannot but be incomplete; in the first place because quantitatively our knowledge of Surinam is highly inadequate, and secondly because the same may be said concerning the insight into the geological relations between the different formations. Vast regions of Surinam have never been explored while besides in extensive areas exposures are very scarce.

Interest in Geology, Mining, Topography and the research in the province of General Natural Science have directly or indirectly contributed to our knowledge. In the past century our knowledge principally grew by purely geological exploration. In this period fall MARTIN's operations in our Colony (1884—1885). MARTIN has published fundamental facts about Surinam [1]). Besides MARTIN has given an impetus to important research performed by specialists [2]). After 1900 Mining-work came to the fore in connection with the Gold-industry; the topographical survey of the southern part of the Colony then also indirectly increased our stock of knowledge; of late years investigations have been multifarious.

The subsoil of Surinam is formed by a crystalline basal complex. This complex belongs to the pre-Paleozoic core of South America, largely exposed in the Guianas and along the Ocean, South of the Amazon basin.

The study of this basal complex is practically identical with that of the geology of Surinam. Besides this basal complex we know three later formations that occur much more infrequently:

1°. the basal complex is traversed by basic igneous rocks of later age; 2°. in the centre of the Colony we know a sandstone formation which has been little disturbed tectonically. It overlies the basal complex almost horizontally; 3°. the coastal area of Surinam is characterized by recent deposits of great thickness. Taking these components as our starting point we shall discuss the geology of Surinam, beginning with the basal complex.

[1]) Bibl. 11, 12 and 13.
[2]) Bibl. 10 and 20.

With regard to the crystalline basal complex we have to mention the researches of VOLTZ (1853—1855) [1]) along the rivers of the lowlands, of MARTIN (1885) [2]) along the Suriname river, of DU BOIS (1898—1901) [3]) who was especially engaged on the NE. part of the Colony between the Suriname river and the Marowyne, of VAN CAPPELLE in the Nickerie district (1900) [4]), of the Government Mining Exploration (1903—1908) [5]) which explored vast tracts between the Lawa and the Tapanahony and to the West of the Marowyne, and of ESSED along the Coppename (1926) [6]). A few explorers who occupied themselves with the adjoining Colonies, have given data about the border-districts of Surinam; viz. BROWN (1875) [7]), who published a report on the exposures in the Courantyne river, and VÉLAIN (1885) [8]), who gave data about the Marowyne river. Researches into the crystalline basal complex are of special value when they are supplemented by petrographical research. DU BOIS, himself, has worked out petrographically part of his material (1901) [9]), KLOOS that of MARTIN (1889) [10]) and BEEKMAN that of VAN CAPPELLE (1907) [11]).

A second category of data on the crystalline basal complex is formed by the samples collected on various occasions, without geological notes. It comprises especially the material collected by topographical expeditions. This loose sample-material was partly not investigated at all, partly provisionally [12]) or fully studied. The latter applies to the material of the Tumuchumac expedition investigated by GRUTTERINK (1908) [13]) and a collection from the Coppename described by BERGT (1902) [14]). Among the sample material we may also include the extensive collections of the Government Mining Exploration.

I myself had an opportunity to study the exposures in the Suriname river, Gran-rio, Lucie river, Curuni and Courantyne and in the Wilhelmina mountains (1926). Besides I had at my disposal the petrographic material gathered by all former explorations (1931) [15]).

In the basal complex we meet with a great variety of rocks. Two formations may be differentiated. First a formation of schists of prevailing sedimentary origin, para-schists. Secondly igneous rocks. This differentiation is not only a petrographical but also a geological one. Most of the schists, namely, may be assumed to be older than the igneous rocks.

The igneous rocks belong exclusively to the calc alkali series. Granites

[1]) vide Bibl. 11.
[2]) Bibl. 11.
[3]) Bibl. 4.
[4]) Bibl. 26.
[5]) Bibl. 14, 15 and 16.
[6]) Bibl. 7.
[7]) Bibl. 3.
[8]) Bibl. 27.
[9]) Bibl. 4.
[10]) Bibl. 10.
[11]) Bibl. 1.
[12]) Bibl. 6, 17, 18 and 21.
[13]) Bibl. 8.
[14]) Bibl. 2.
[15]) Bibl. 28.

and quartz mica diorites predominate. Granites are represented by biotite granites, biotite hornblende granites, and to a less degree by bi-mica granites, hornblende granites, aplitic granites, and granite-aplites. The first two types may be porphyritic, with coarse microcline phenocrysts. The granites vary considerably in the composition of the plagioclase: the first two granite types we mentioned very often contain oligoclase-andesine or oligoclase. It strikes us that as a rule the granites contain microcline and microperthite. Orthoclase has only been found locally (Nickerie basin).

Among the diorites acid, quartz-bearing members prevail by far. Quartz mica diorites and quartz mica hornblende diorites are represented in the largest number; besides these we also know quartz hornblende diorites and hornblende diorites. Among the quartz mica diorites an almost aplitic type poor in biotite is frequent.

The granites and diorites are petrographically united by transitions. Through decrease of potash feldspar the granites pass into quartz diorites, with intermediate types which might be called granodiorites. These intermediate forms are known between granites and diorites of different basicity, e. g. between biotite granite and quartz mica diorite, but just as well between granite rich in hornblende and quartz hornblende diorite, etc.

Locally the variation is still more marked. In the De Goeje mountains, for instance, we have gabbros of different mineral combinations: troktolites, olivine gabbros, norites, hornblende gabbros and normal gabbros. The latter gabbro type passes into quartz diorites with the intermediate form of quartz gabbros. They contain orthorhombic and monoclinic pyroxene and hornblende in varying combination. In their turn these diorites pass into quartz mica diorites and granites. Something like this we see in the Nickerie basin. But there the basic members of the transition-series are free from olivine.

Besides these mineralogical differences the Surinam igneous rocks show also considerable differences in structure and texture [1]). Ortho-gneisses are frequent. These rocks are characterized by the lack of crystallization-sequence of the colourless main minerals. We know ortho-gneisses with parallel texture, and likewise with granitic texture. So there is no connection between the lack of crystallization-sequence and the texture. In many rocks the gneiss-characteristics can only be established microscopically, which may lead to confusion in the field. Structurally all intermediate forms to rocks with normal crystallization-sequence, are present. The intermediate forms we know are gneissic granites, gneissic diorites, etc.

It is an important fact that mineralogically the ortho-gneisses are the equivalent of the above-named igneous rocks, even in details. Most numerous are granite-gneisses and diorite-gneisses namely quartz mica and quartz mica hornblende gneisses. The equivalent of the pyroxene-bearing quartz diorites we find in the pyroxene gneisses (Nickerie region). Pyroxene gneisses that are the equivalent of gabbros are rare.

The Surinam igneous rocks generally have an even texture. Banded

[1]) By "structure" we here mean the form and the size of the mineral grains. "Texture" refers to their stereometric grouping.

textures, variation of zones or lenses of various composition, and streaky texture are rare. Banded texture of some significance is known locally at the Suriname river. Parallel texture occurs rather frequently.

We suppose the gneiss-characteristics of most Surinam ortho-gneisses to be of primary nature. The arguments for our view may be found in my recent publication [1]). The term „primary nature'' does not apply to those ortho-gneisses, whose gneiss-characteristics were caused by cataclasm. Signs of pressure, namely, are very frequent in the Surinam igneous rocks. This phenomenon may become so intense that the primary structure and texture of the rocks is destroyed, and the rocks adopt a parallel texture, in which the minerals are partly rolled out, and partly greatly bent, or pulverized. Relics of primary structure show that normal igneous rocks as well as ortho-gneisses (with primary gneiss-characteristics) may have been the original material. Many granite- and diorite-gneisses have been formed in this way, also gneisses which are the equivalent of gabbros. The same applies to eye-gneisses.

We have one more group of ortho-gneisses whose ortho-gneiss characteristics are of secondary nature, viz. hornblende gneisses, garnet hornblende gneisses, etc. which are the re-crystallized equivalents of basic igneous rocks. Geologically speaking, however, these gneisses do not seem to have anything to do with the igneous rocks alluded to before. They are probably much older. Lower down we shall revert to them.

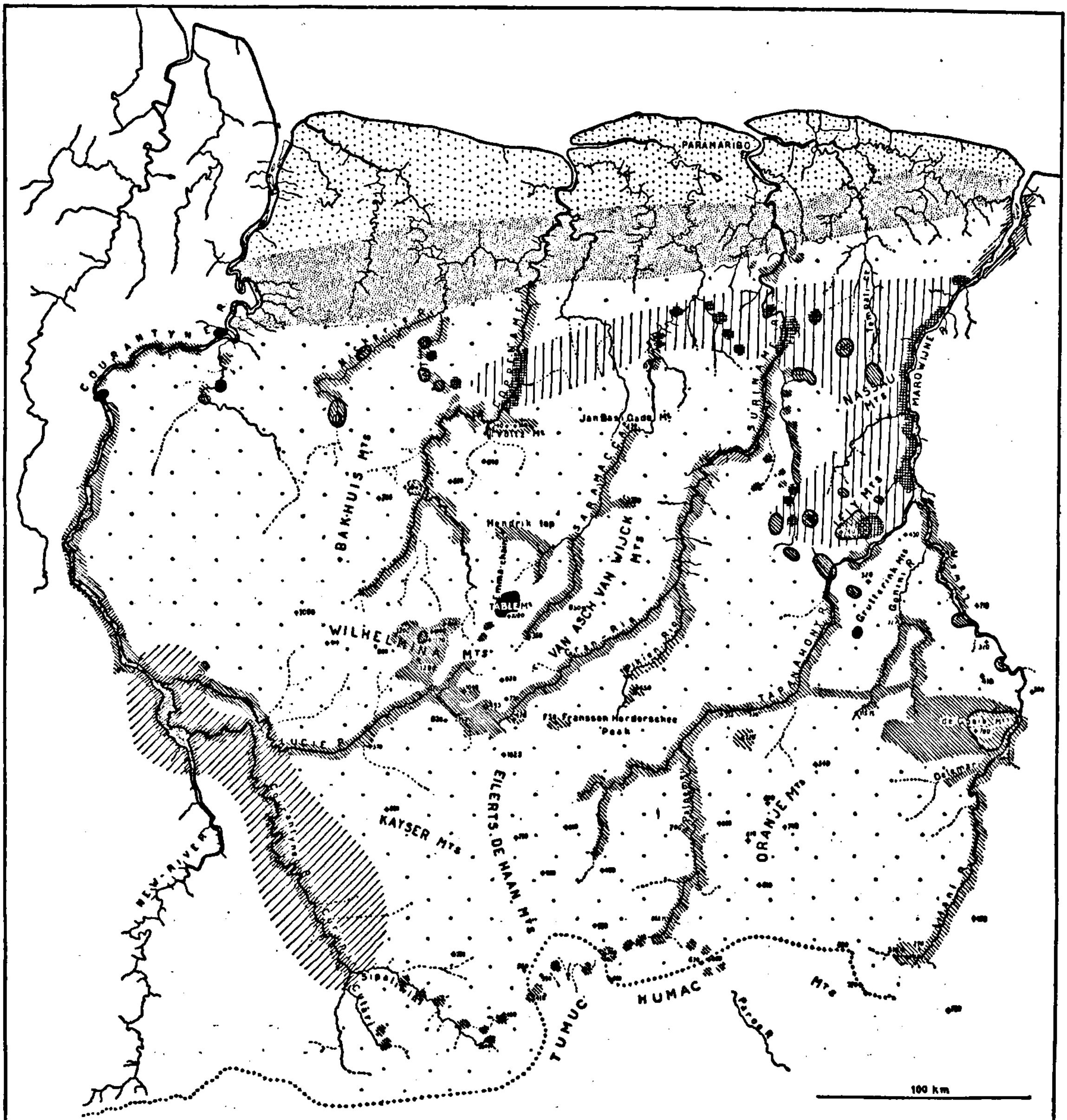
Venites have been found locally. Their genesis is doubtful.

About the geology and the cosanguinity of the Surinam igneous rocks we can impart the following. Chemically they furnish all together a normal differentiation-diagram of the calc alkali series. Only part of the basic rocks seem to show a distinct local character. The ortho-gneisses behave entirely like the normal igneous rocks.

The general distribution of the mineral orthite in the igneous rocks and gneisses throughout the Colony, and to a less degree also the occurrence of monazite, point to the fact that cerium, and possibly also other rare earths have been constant accessory components of the magmas. These facts speak for the differentiation of rocks coming from only one original magma.

Of most of the rock-types we enumerated, it is known that they are united by intermediate forms not only petrographically but also in the field. In many areas there are intermediate series of granites to diorites rich in quartz and locally to less acid diorites. These rocks are, therefore, different petrographical facies of the same magma. The composition of the rocks varies very irregularly in the field. Several extensive areas are occupied uniformly by biotite and biotite hornblende granites, in part porphyritic. In other areas, however, frequent alternations of acid and less acid rocks are to be seen, within some tens of metres and all united by intermediate forms. In the areas of uniform composition granitic texture prevails. In others frequent alternation of distinct and indistinct parallel texture may be observed. This variation in texture is especially developed in regions where variability in mineralogical composition is to

[1]) Bibl. 28.



VERSLUYS EN SCHERJON, UTRECHT.

GEOLOGICAL SKETCH-MAP OF SURINAM.

FLUVIO-MARINE DEPOSITS (PLEISTOCENE)

CONTINENTAL ALLUVIA IN THE LOWLANDS (PLEISTOCENE)

RORAIMA FORMATION

CHIEFLY GRANITO DIORITES; "a" IN ACCORDANCE WITH FIELD-OBSERVATIONS "b" IN ACCORDANCE WITH SUPPOSITIONS

a b

CHIEFLY GRANITE-AND DIORITE-GNEISSES; "a" IN ACCORDANCE WITH FIELD-OBSERVATIONS, "b" IN ACCORDANCE WITH SUPPOSITIONS

a b

CHIEFLY PARA-SCHISTS; "a" IN ACCORDANCE WITH FIELD OBSERVATIONS "b" IN ACCORDANCE WITH SUPPOSITIONS

a b

DIABASES, GABBROS, EPIDIORITES AND BASIC ORTHO-SCHISTS

(THESE ROCKS OCCUR VERY FREQUENTLY. THEY ARE PARTLY INDICATED) be noted, and may even exist in one and the same rock-group. A third complication is formed by the ortho-gneisses and gneissic rocks. They, too, may be very frequent in the areas of varying mineralogical composition. Within a few tens of metres the gneisses may pass into normal igneous rocks. However, we also know areas where ortho-gneisses predominate (Upper Courantyne, very likely also Lower Marowyne). From the above the important fact may be inferred that *the ortho-gneisses are of the same age as the granitodiorites.* All these facts together render it highly probable that vast regions in the Colony are part of enormous igneous masses, whose dimensions equal those of the largest batholiths known elsewhere. We believe that all the granitodiorites of the centre and the South-east of the Colony belong to one and the same coherent batholith.

We know some local complications. In the Nickerie region the basic and the acid rocks appear to traverse each other, partly in the shape of dykes, and all are supposed to be contemporaneous.

Dykes of small dimensions are frequent. They are granite-, and diorite-aplites, and pegmatites. There are also pegmatites rich in quartz, muscovite and tourmaline. They cut the granitodiorites, and ortho-gneisses. The lamprophyric dyke-rocks, represented by kersantites, odinites and malchites, are interesting from a petrographical point of view. In fine we want to make mention of local dykes of dioritic composition, which also cut the granitodiorites. The greater part or the total number of these rocks is to be considered as magma-differentiations of the granitodiorites in an acid or basic direction.

It is still an open question whether the vast regions of granitodioritic composition are of the same age. There are no indications pointing to differences in this respect. In this connection we must contravene the old hypothesis that the granites which compose the mountains in Surinam, are later than the rest of the basal complex. These granites are of the same composition as those that are exposed in the rivers. They are more resistant groups carved by erosion from a basis approximately of the same composition. It is assumed that all these rocks are of pre-Paleozoic age. The basal complex namely extends into the adjoining Amazon basin and is covered there by Paleozoic sediments beginning with those of the Silurian system.

Intense pressure may have formed secondary gneisses, as alluded to heretofore. Cataclasm has locally formed mylonites. In some localities in Surinam there were found the so-called pseudo-tachylytes (ultramylonites), those remarkable rocks, which have been recognized among other places in South Africa and on the Outer Hebrides as new formations because of intense pressure and mylonisation.

Finally we mention quartz porphyries among the igneous rocks of the basal complex. They have been met with in a number of localities in small quantities. They are sometimes accompanied by porphyroids. We are completely in the dark about their geology. Several highly metamorphic porphyroids may as well be called schists. It is doubtful whether the latter are geologically allied to the quartz porphyries or must be referred to the schist formation.

We now pass on to discuss the crystalline schists of the basal complex. A glance at the sketchmap shows us that quantitatively they are greatly in the minority with respect to the granitodiorites. In the schist region hatched vertically extensive schist complexes are present along the Marowyne, Suriname and the Coppename rivers. This hatched field illustrates *where schist are frequent*. However, also granitodiorites are found in it.

Quantitatively para-schists appear to be prevalent. The composition of the schists and their degree of recrystallization is variable. The para-schists are represented by strongly metamorphic sillimanite, cordierite, staurolite, garnet and mica-bearing gneisses and schists. Another schist series is less metamorphic. Often it still shows remnants of the primary, clastic structures. We shall specify them by the term graywacke formation. This formation comprises mica quartzites, crystalline graywackes, graywacke-quartzites, metamorphic conglomerates and conglomerate-schists, so that it is a true clastic formation. The mineral combination of the quartz, chlorite, sericite, albite, or calcite-bearing schists is very variable. These schists seldom exhibit remnants of clastic nature and apparently had fine, detritic matter for original material. A number of these schists appear to be metamorphic basic tuffs. Basic tuffs with distinct relics of primary structure (Schalsteine) are not frequent. Phyllites and clayslates are often met with; some are chloritoid-bearing. Quartzites of sedimentary origin show a great variety of accessoria. Of petrographical interest are kyanite, staurolite or chloritoid-bearing types. In the foregoing we have enumerated the principal para-schists. From this specification it follows that the metamorphic schists are of terrigenous-detritic origin. Crystalline limestones and in general such rocks as are derived from „chemical sediments'', we do not know in Surinam.

The ortho-schists appear to be principally the equivalent of basic igneous rocks (we have already made mention of some porphyroid-schists). They are amphibolites and hornblende gneisses, among which garnet, pyroxene and epidote-bearing types are frequent. Some of them come near to eclogites. Furthermore we have quartz hornblende schists, hornblende schists and hornblendites. The epidiorites which are widely distributed in the Colony, appear to be derived for the greater part from the later diabase- and gabbro intrusions to be discussed later on.

The geology of the para-, and ortho-schists we may discuss separately. It appears that the schists of the graywacke formation form two extensive complexes: on the Marowyne and on the Coppename river. A third important schist complex, on the Suriname river comprises chiefly quartz, chlorite, sericite, albite and calcite-bearing schists, phyllites and quartzites. The schist association of the latter region is also known in a number of other localities, where we cannot judge of the extent of the formation. The para-schists generally dip steeply. We know that in some regions they show surprisingly constant strike along great distances. The assumption is justified that we have to do with systems of strongly compressed folds.

We can only surmise the mutual connection between these schist complexes. It is remarkable that the graywacke formation and the quartz-, chlorite-, sericite-, albite schists etc., where they occur together, have the same chief tectonic direction. Moreover the members of the one schist group may occur in the other and the reverse. It is probable that these schist groups have belonged to one and the same sedimentation complex.

Sillimanite-, cordierite-, staurolite-, garnet- and mica schists we know in a number of places in the Colony, they cover, however, smaller areas than the schists discussed above. The geological relation between these schists and the preceding ones is not established yet. The intensely metamorphic schists may, from a petrographical point of view, very well be the equivalents of the less metamorphic schists.

Let it be observed in passing that the signs of cataclasm appearing in the granitodiorites, also occur in the coarsely crystalline para-schists.

Several groups of mountains and hills in the South-east of the Colony are composed of basic ortho-gneisses. These areas are taken up by amphibolites and hornblende gneisses, and apparently were originally masses of gabbros and diabases.

As was said before, it has been established for part of the strongly metamorphic schists that they are older than the granitodiorites (consequently also older than most of the ortho-gneisses). The granitodiorites break through these schists. Very likely they already found the latter in an intensely metamorphic state. The same sequence of age has been established for the crystalline graywackes. This formation owes its recrystallization chiefly to regional metamorphism. We are less certain of the respective ages of the quartz-, chlorite-, sericite-, albite schists, phyllites and clay slates, and the granitodiorites. A number of contact-metamorphic schists support the probability that the same age relation also holds good here; corroboration by observations in the fields is, however, greatly desirable. Concerning the basic ortho-gneiss massifs in the South-east of the Colony it may be assumed that they are older than the granitodiorites and gabbros. Whether these hornblende gneisses represent the igneous part of the schist formation is not known.

For briefness' sake we may speak of the *''schist formation''* in contradistinction to the igneous part of the basal complex. The schist formation must for the greater part be of pre-Paleozoic age considering what has been said above about the age of the granitodiorites. Fossils have never been found in the schists. In some of them, however, we find a rather large percentage of graphite.

Petrographically the basal complex in Surinam shows a great resemblance to the same complex in the Guiana Highlands generally (the Guiana Highlands comprise besides Surinam, British Guiana, Venezuelan Guiana, the northern border of the Amazon basin and French Guiana). The resemblance has special reference to the igneous part of the basal complex. A number of Surinam granitodiorite- and ortho-gneiss types are met with in the adjoining countries as well; they show the same local characteristics. It may be assumed that the same magmatical province is represented in all these countries.

It is remarkable that rock-types characteristic of the Guiana Highlands are not lacking in the basal complex of Eastern and Central Brazil and of the Argentine, judging from petrographic literature and from some material which I had an opportunity to study.

Diabases and gabbros, and epidiorites derived from them, are of later age than the basal complex. These rocks have a great distribution in the Colony, although they do not cover vast regions. In a large number of localities the granitodiorites, the ortho-gneisses and also the schists are intersected by dykes. We also know some masses. It is doubtful whether these rocks have also extended over the basal complex as sheets. Microscopically the dykes show diabase structure, while gabbro structure is developed in some broad dykes and in a few masses. It is common knowledge that these differences in structure are of little consequence, so that little value is attached here to the difference between diabase and gabbro.

Quartz diabases appear to be very common; KLOOS, as early as in 1889 [1]), drew attention to them. They contain granophyre of quartz and potash feldspar; the latter may show microcline structure. Through diminution of the granophyre percentage the rocks pass into normal diabases and gabbros. Olivine is frequent as an accessory component. Olivine diabases are rare, though. It is striking that olivine and free quartz may occur in the same rock. We have a few hypersthene diabases. Orthorhombic pyroxene occurs more frequently in the gabbros. The gabbros may also contain granophyre.

In many of these rocks pyroxene has been superseded by uralite (epidiorites). In the field it has been ascertained that geologically these rocks behave like the unchanged types. In other rocks the changes reach much farther. It is assumed that the metamorphism of the Surinam typical epidiorites cannot be owing to stress.

It is still an open question whether all diabases, gabbros and epidiorites belong to one single intrusion period. Contacts that might give an answer to this question are unknown in Surinam. In adjoining states (British Guiana and the State of Para in Brazil) we know diabases of Paleozoic and possibly also of Mesozoic age. With regard to a number of intensely metamorphic epidiorites in Surinam, inter alia epidote hornblende schists, it is doubtful whether they are geologically allied to the intrusive diabases and gabbros; they might just as well belong to the older schist formation.

We want to state emphatically that (older) gabbros, belonging to the basal complex should be distinguished from later gabbros and diabases. The former are petrographically related to the granitodiorites: they show local characteristics but no free potash feldspar, in contradistinction to those of the diabase-gabbro group.

Additionally we may observe that the diabase-gabbros show few signs of cataclasm, which on the contrary are frequent in the basal complex.

The Surinam diabases down to the smallest details agree with those of British Guiana described by HARRISON [2]). Points of similarity are also shown by the rocks of Rio de Janeiro and of Sao Paulo.

We are bound to mention for the sake of completeness that we know

[1]) Bibl. 10.
[2]) Bibl. 9.

some porphyrites (or andesites) from Surinam. Their relation to the intrusive diabases and to the basal complex we cannot establish.

The Roraima formation is superposed unconformably on the basal complex as a nearly horizontal cover. This formation consists of sandstones, conglomerates, and some insignificant porphyry tuffs. The thickness was locally determined at 650 m. at least. We know the formation in its typical shape only locally in the centre of the Colony. There it forms a table mountain, surrounded by an escarpment and a talus of boulders. The highest top is 1080 m. The foot is (on the S. West side) about 400 m. above sea-level. This table mountain occupies about 70 km². In the gently undulating hill-country this formation round the mountain is exposed over a distance of many kilometres, so that the extent of the sandstone base of the mountain is considerably larger. This mountain was discovered recently (1926). In the extreme West of the Colony (near the mouth of the Kabalebo river) some sandstone exposures are known to exist in the rivers. Following the example of MARTIN (1888) [1]) and BROWN (1875) [2]) they are classed with the Roraima formation. In my opinion this hypothesis requires further corroboration.

The sandstones and quartzites of the table mountain microscopically show much rounded grains of quartz, and also of plagioclase and microcline mostly with cementing of crystalline quartz, so that they come near to quartzites. The colour of the sandstones is brick-red, pale red and sometimes yellowish. Crossbedding is fairly common and also ripple marks were found. The finely grained sandstones pass into types of a coarser grain and into conglomerates. The latter cover the plateau. Of most frequent occurrence is a variegated conglomerate type rich in waterworn quartzite boulders, white quartzes, fragments of slates and jasper. Boulders of igneous rocks are rare.

The lithological composition of the formation is like that of the extensive Roraima formation in British Guiana. Intrusive sheets of diabases, however, are not known from Surinam. Neither in Surinam, nor elsewhere in the formation have fossils been found. The age is not known.

The latest deposits overlie the basal complex. They appear to be for the greater part of Pleistocene and Holocene age. They build up the coastal plain. This plain is narrowest in the East (along the Marowyne river), and broadest in the West (along the Courantyne river). In the West the first rock exposures appear at more than 100 km., in the East in the Marowyne at 30 km. from the Ocean. In the other rivers the first exposures are lying in an almost straight line connecting these two points (see sketchmap). The latest deposits in the interior are of comparatively inconsiderable thickness, whereas they attain to a great thickness in the coastal area (at Paramaribo at least 180 m, near the mouth of the Courantyne at least 300 m). However, nothing points to the fact that the deepest parts are of Tertiary age.

[1]) Bibl. 11 and 12.
[2]) Bibl. 3.

The latest deposits comprise fluvio-marine and continental deposits and laterites. The fluvio-marine deposits are found in a broad zone along the Ocean. The name fluvio-marine has been selected, because these sediments were deposited in the sea, and their material has been largely influenced by the rivers. They are havy clays, and sands partly mixed with shells. The latter are abundant in the sand- and shell-reefs, which run parallel to the coast (called „Schulp-ritsen'' in Surinam). The reefs were built up by the surf and are now to be seen stretching inland up to a distance of some tens of kilometres. The *mollusca* are the same as those which now live near the coast. The fluvio-marine clays have been chemically investigated by VAN BEMMELEN (1903, 1904, 1909) [1]), SACK (1906) [2]) and Miss VAN AMSTEL (1922) [3]).

The fluvio-marine deposits overlie continental alluvia. Their depth reaches to some tens of metres: in the Courantyne-basin to about 100 m. The material appears to be largely of local origin and not chiefly supplied by the equatorial current after having originally been carried out to sea by the Amazon river (as was assumed in former times). The following scheme of development of the coastland is adopted here:

1. Transgression of the sea over continental alluvia to the boundary of the fluvio-marine deposits. The cause of the transgression is left undecided.

2. Regression of the sea and increase of land, during which a slight uplift of the coastal area probably took place (judging from the present high position of the reefs). The regression possibly extended farther than the present coast-line.

3. Cessation of the formation of bays [4]) and of increase of land; some loss of land in the present time.

The continental alluvia adjoin the fluvio-marine deposits more inland. They cover a zone of gently undulating country and extend into the broad river valleys and plains in the interior. In this zone many savannahs are to be found. They are less frequent in the interior. The continental alluvia are composed of clays, partly very rich in kaolin, sands and gravels and sometimes also of vegetable matter. In some places we find cemented sands and gravels, which because of their hardness simulate older deposits.

The continental sands are little worn and are often coarse, in contradistinction to the sub-equigranular and well-rounded sands, which are so frequent in the fluvio-marine deposits. The accessory components, the heavy minerals, in both groups of sediments show differences indicative of the origin of the material. Vertical profiles through the continental alluvia show frequent alternation of the components named. The con-

[1]) Bibl. 23, 24 and 25.
[2]) Bibl. 19.
[3]) Bibl. 22.
[4]) „Haffs'' in German.

tinental alluvia are partly of local origin. and partly were carried a long way by the rivers.

The profiles of the thick continental deposits underlying the fluvio-marine for all we know do not show any essential differences in facies as compared with the deposits found nowadays in the interior.

The laterites overlie the hills and the mountainous country, unless they are found in a secondary locality. DUBOIS (1903) [1]) has contributed an excellent study on the Surinam laterites. Besides real laterites mottled soils are widely distributed. These soils are probably more silicic and do not contain free hydrated aluminium oxide, consequently they are not laterites sensu stricto. They are the soils known elsewhere in the tropics by the name of „Braunerden'', „Rotlehm'', „Red Loams'', etc.

We are better acquainted with the lateritic iron-ores and bauxites: the products of a far advanced state of lateritic weathering. The bauxites are in part oolitic. They pass into ferrous bauxites, and these again into lateritic iron ores. The bauxites cover flat-topped hills in the lowland, or cover flat-topped mountains in the interior. The bauxite profile is the same as that found elsewhere in the tropics, lying on kaolin. What the bedrock is from which the bauxites have been derived, is not known for certain. An investigation into the accessory components of the bauxites yields unexpected results. Staurolite namely occurs frequently in part of the bauxites, so that incidentally para-schists may have contributed to the original material of the bauxites.

The lateritic iron ores („Kakkerlakiston'' called in Surinam) are slaggy, compact or show oolitic structure. Lateritic iron-ores cover hills in the interior, their dimensions are often enormous, not only horizontally but also vertically. A number of observations point to the fact that in all probability these ores have been derived from basic or metamorphic basic, igneous rocks.

The formation of these enormous masses of laterite, which is still in progress nowadays, dates perhaps farther back than the Diluvial period. However there is no certainty whatever about this. The latest deposits overlie the foot of the bauxite hills in the lowland.

Now that all the formations have been discussed we have still to impart something about their influence upon the geomorphology.

As stated before, it is the granites that compose the mountains. The latter consist of groups of mountains and mountain-ridges showing a very irregular relief. Bare granite faces are often visible at the tops. Granite cupolas, typical monadnocks are frequent. They occur among the mountains but are also seen in the lowland (Voltz mountain etc.). In some places we know mountains that consist of gabbros and their allied rocks. We have already mentioned that the Roraima formation yields quite another type. Granites and acid diorites also partake in the upbuilding of the hilly country. This also holds good for schists of various composition, even for phylllites. The diabases form elongated ridges and cupolas.

[1]) Bibl. 5.

The mountainous country has the character of a very old landscape. The mountain groups are separated by extensive regions of the hilly country and strips of slightly undulating territory along the rivers. The base of the mountainous country lies in the interior only some hundreds of metres above the sea-level. The highest point of Surinam (in the centre of the Colony) to, only attains 1280 m. In the North the mountain system gradually slopes down into the lowlands.

Before concluding this short outline we are bound to say something about the probability of the distribution of the formations as marked on the sketchmap. Our data are principally derived from the exposures in the rivers. About half the stretches along the rivers have been explored by geologists. For the rest the geology has been marked on the basis of rock samples collected and handed in by non-geologists. The findspots of these samples are known however. The fields in the interior indicated by full signature, have been examined more or less in detail. Findspots bearing on loose samples and on fields of scanty distribution are marked by dots and patches on the map. Of the very numerous find-spots of the intrusive diabases and gabbros we have only been able to mark a few on the map, in connection with the scale.

The distribution of the rocks along the rivers, which was ascertained, together with the fact that geomorphology renders it highly probable that the mountains are of granitic composition, justifies the supposition that the subsoil of the Colony is for by far the greater part composed of acid igneous rocks. MARTIN [1]), as early as in 1888, arrived at this conclusion.

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