

with pinkish to reddish-brown patches of garnet. In thin section the rock is seen to be composed essentially of quartz, chlorite, biotite, magnetite, and garnet. The quartz comprises about 70 to 75 per cent of the volume and has a characteristic mortar structure, produced by granulation of the borders of the grains. The chlorite and brown biotite comprise 15 to 20 per cent of the rock and together with the finely crushed quartz occupy the spaces between the larger grains of quartz. Considerable magnetite and some rounded patches of garnet are scattered through the rock. The garnet has a slight reddish tinge and apparently has replaced the chlorite, mica, and quartz between the larger grains of quartz. The rock may have been formed by the metamorphism of an impure sandstone. It shows evidence of intense dynamic and thermal metamorphism of a character not observed as the result of deformation caused by intrusions of igneous rock in Cretaceous and later times.

Exposures of these older rocks were found on Tortue Island beneath limestone that is probably of upper Oligocene age. There the metamorphic rocks consist principally of much sheared limestones that have been completely recrystallized and in some places partly replaced by chlorite, epidote, and quartz. The limestone is exposed in a sea cliff a short distance east of the landing at La Vallée, on the south coast. It is a hard bluish-gray rock and contains a network of seams of calcite. About 150 meters east of the landing greenish limestone containing chlorite and stringers of quartz crops out in a sea cliff. Bluish schistose limestone underlies this rock. The beds are contorted and wrinkled. The schistosity planes in general strike N. 80° W. and dip 20° NE. Similar rocks crop out in the huge amphitheater inland from La Vallée, where the cover of upper Oligocene limestone has been stripped by erosion, but along trails their exposures are weathered. Float of a granitic rock, which presumably intrudes the schistose limestone, was seen on the trail to Source Lavier. Schistose rocks were also seen northwest of Pointe des Oiseaux, where the trail from La Vallée descends to the coast. The schistose limestone resembles similar rock on the south slope of Samaná Peninsula, Dominican Republic.¹

No exposures of schists considered to be older than Cretaceous were found in the southern part of the Republic, but float consisting of mica and quartz schists like those from the northern part of the Republic was seen on the western part of the Léogane Plain. This material probably comes from an unexplored part of the mountains south or southwest of the plain.

CRETACEOUS SYSTEM.

Rocks that can be positively identified from fossil evidence as Cretaceous are confined to the Upper Cretaceous series. They consist principally of limestone and were found in only a few small patches in the

¹ A geological reconnaissance of the Dominican Republic: Dominican Rep. Geol. Survey Mem., vol. 1, pp. 53, 83, 182-183, 1921.

arrondissements of Cap-Haïtien and Grande-Rivière du Nord. Detailed examination of the Republic doubtless would disclose other similar patches, but the area covered by such rocks is probably very small.

Rocks that are tentatively referred to the Lower Cretaceous system on stratigraphic, structural, or lithologic grounds underlie rather large areas, chiefly in the Massif du Nord. Lithologically most of these rocks in the northern part of the Republic are grouped under the term argillite, although at places they show wide variation from this type. Rocks in the southern part of the Republic that are considered of the same age on indefinite grounds generally consist of metamorphosed limestone. It is not at all certain that all these rocks called Lower Cretaceous are of the same age. All of them are older than Tertiary, but some may be even older than Cretaceous.

The Upper Cretaceous rocks probably rest unconformably on the rocks of supposed Lower Cretaceous age, but the actual contact was not examined. They contain small pebbles of the older igneous rocks. The Lower Cretaceous rocks in the northern part of the Republic appear to have been deposited on a basement composed mainly of volcanic rocks, of which they contain recognizable pebbles at some places. The relations of the argillite and volcanic rocks are considered elsewhere. (See p. 273.)

The fossils show that the Upper Cretaceous rocks are marine. (See list, p. 98.) The lithology and the absence of marine fossils in much of the Lower Cretaceous series of the northern part of the Republic indicate that they are marginal deposits, laid down in part on flood plains. These rocks are nearly everywhere thinly and evenly bedded, and in many places they show mud cracks and contain fragments of lignite. Some impure limestones, calcareous sandstones, and argillites in this series contain small Foraminifera, indicating that they were deposited in shallow marine waters. Most if not all of the limestone of supposed Lower Cretaceous age in the southern part of the Republic is marine.

Both series of Cretaceous rocks doubtless were once much more extensive, but erosion prior to upper Eocene time removed the greater part of them. The solubility of the limestones facilitated their rapid removal. The argillite, even though now in some places much indurated, is not ordinarily very hard and generally remains only where it has been preserved in the troughs of faulted or folded areas.

Detailed descriptions of the Cretaceous rocks as observed at different localities are given below.

LOWER CRETACEOUS SERIES.

DESCRIPTION BY REGIONS.

MASSIF DU NORD.

Plaisance Valley.—That part of the valley of Les Trois Rivières above Pilate is known as Plaisance Valley. All this rolling valley between the bordering mountains seems to be underlain by argillite. On the north bank

of Les Trois Rivières at the bridge near Plaisance an excellent exposure shows a thickness of about 40 meters of beds that strike north and dip 40° E. The beds are 2 to 5 centimeters in thickness and very regular. They consist of indurated dark-brown fine-grained sandstone or sandy slaty shale. Many of the weathered blocks contain peculiar ridges that suggest fossils, but that are apparently fillings of mud cracks.

About 300 meters southwest of the bridge on the road to Ennery brown to gray beds resembling those just described but more clayey and containing no visible sand grains are exposed in a roadside cut. An analysis of a sample of material from this exposure is given on page 502, under the discussion of possible raw materials for cement. Silica in the moisture-free sample forms about 56 per cent and calcium and magnesium carbonates only about 17 per cent of the total.

A number of other exposures of this series are found along the road farther southeast. The rocks differ chiefly in color, which varies from ashy gray to deep purple. At all the exposures the beds are steeply tilted.

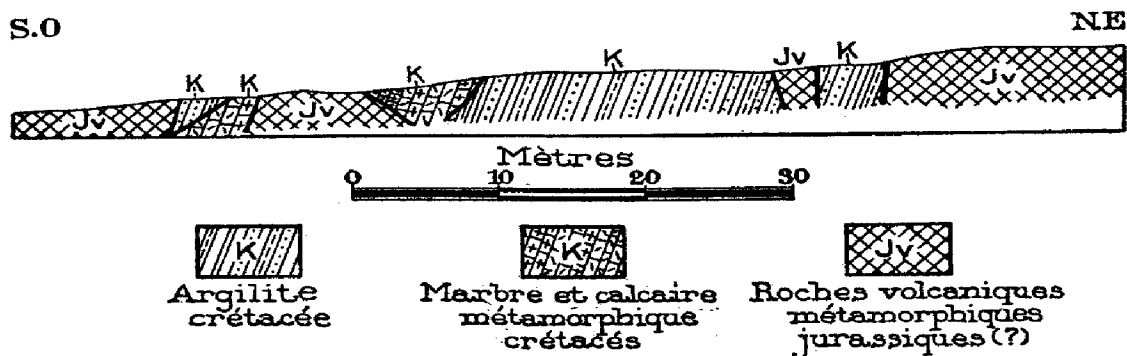


FIGURE 4.—Generalized section showing fault zone at contact of argillite and volcanic rocks as exposed in roadside ditch at Plaisance.

Rather different rocks, probably of the same series, are exposed at the foot of Mont Puilboreau in a roadside cut about 100 meters long. The thickness of beds exposed is apparently 60 to 75 meters. The beds dip steeply to the southwest, into the mountain. They consist in part of dark-gray metamorphosed cherty limestone, which is partly crystalline. Interbedded with the limestone is at least an equal amount of shale, indurated and at places slaty and showing ridges due to hardened fillings of mud cracks. The contact of these rocks with the igneous rocks to the south is probably marked by a fault.

At the north side of Plaisance Valley, just at the north edge of the town of Plaisance, the contact of the rocks of the valley with the volcanic rocks of Plaisance Mountain is well exposed in a ditch beside the road. The rocks exposed are purple argillite, metamorphic cherty limestone (which is partly changed to marble and which ranges in color from brown to white), and reddish volcanic rock. The three rocks are intermixed along a zone of step faults as shown in Figure 4.

Similar argillite and other clastic rocks are exposed in the Plaisance Valley between Plaisance and Pilate. They consist principally of dark chocolate-brown thin-bedded argillite and thicker beds of harder sandstone. The argillite breaks into small blocks that have conchoidal surfaces. The general strike of these beds is northwest and they dip to the northeast and southwest at various angles.

Les Trois Rivières between Gros-Morne and Pilate.—Farther west the same series of rocks is exposed on Les Trois Rivières along the trail from Gros-Morne to Pilate. They crop out on both banks of the river above the second crossing toward Pilate. Their outcrop is a narrow northwestward-trending band between volcanic rocks on the west and middle Eocene limestone (Plaisance limestone) on the east. At this place the rocks consist of dark thin-bedded calcareous argillite. About 200 meters above the second crossing, on the right bank, a bed of limestone changed to white marble containing greenish streaks is interbedded with the argillite. At most of the exposures the beds strike northwestward and dip steeply southwestward. An exposure on the left bank about 1 kilometer above the second crossing shows that the beds are crumpled. (See Pl. VIII, A.) The contacts with both the volcanic rocks and the limestone are probably along faults.

Near Dondon.—Argillite and other rocks of the same series probably underlie nearly all the mountain-walled valley at Dondon, but over most of its area they are covered by alluvium. Good exposures are found in the trail between Dondon and Grande-Rivière du Nord at the north end of the valley, about 3 kilometers north of Dondon. The rock consists partly of brown or purple calcareous argillite and partly of similar but whiter rock, in fairly thin beds. Interbedded in the fine-grained argillite are one or two conglomeratic beds, about half a meter thick, which contain cobbles of igneous rock, some as much as 25 centimeters in diameter. The matrix of these beds consists in part of angular fragments of dacitic lava, quartz, and plagioclase in a calcareous cement containing a few small undetermined Foraminifera. Smaller lenses of sandy material not more than a few centimeters in thickness contain angular fragments of plagioclase, quartz, and volcanic rocks in an impure calcareous matrix containing numerous small undetermined Foraminifera.

Between this place and Carrefour Ménard, the nearest station on the railway between Cap-Haïtien and Grande-Rivière du Nord, there are numerous exposures of the argillite along the trail that follows a deep ravine leading down to the Grande Rivière du Nord. Most of the rock is thin-bedded fine-grained brown sandstone, which contains abundant fragments of lignitized wood. Some of the rock grades into impure limestone, which is brown and partly recrystallized. At some places it is a coarse conglomerate, composed of fragments of the underlying igneous rocks that are exposed at some places in the ravine. The rock everywhere is complexly folded and has been considerably metamorphosed.



A. CRETACEOUS (?) CALCAREOUS ARGILLITE ON LES TROIS RIVIÈRES
BETWEEN GROS-MORNE AND PILATE.



B. PILLOW LAVA AND LIMESTONE OF SUPPOSED UPPER CRETACEOUS
AGE ON THE NORTH SIDE OF THE ASILE VALLEY.

Northwest of this locality, on the trail leading from Milot to Christophe's Citadelle, on the northeast slope of the ridge called Bonnet-à-P'Evêque, exposures of purple argillite are common between altitudes of 300 and 650 meters above sea level. The rock is intricately folded and at places has a slaty cleavage.

Near Cerca-la-Source.—The largest area of Lower Cretaceous argillite is in the eastern part of the Massif du Nord, embracing the southern part of the arrondissement of Vallière. This area is probably continuous under the cover of Tertiary limestones with the area near Dondon and with that in Plaisance Valley. Near the Dominican border the area covered by these rocks is about 11 kilometers wide, but the width is less toward the northwest. Its length is about 60 kilometers.

These rocks are well exposed in bluffs on the right bank of Rivière l'Océan 100 meters below the crossing of the trail from Thomassique to Cerca-la-Source. At this place they consist of thin-bedded variegated argillite and thicker beds of greenish sandy material. The colors of the argillite are somber shades of chocolate-brown, olive-green, purple and brick-red. The argillite weathers into small blocks that have conchoidal surfaces. In the bluffs the beds have slumped, but ledges in the stream show that they strike northwestward and dip 40°–80° NE. or SW. or even stand vertically.

The greenish sandy beds consist of angular to subangular grains and crystals of plagioclase, grains of quartz, and flakes of brown mica. Grains of magnetite, a few prisms of apatite, and a very few grains of epidote and zircon are present. The brown mica is partly altered to greenish micaceous and chloritic material, which has partly replaced the plagioclase and quartz, giving the sandstone its greenish color and acting as a cement. The plagioclase is also partly replaced by calcite, sericite, or brownish products of the alteration of the mica. There is abundant calcite in the rock, but owing to alteration and recrystallization it is impossible to determine whether this mineral was an original constituent of the sandstone.

The brown shaly rock carries small fragments of plagioclase and quartz in a matrix of finer material containing an iron-stained calcareous and chloritic cement. The shale contains thin seams of coarser gritty material.

The argillite lies at the surface northeastward from Cerca-la-Source to the foot of the north slope of the ridge south of Lamielle, where the underlying pyroxene andesite crops out. The soil formed by the argillite is very thin, and the rock is well exposed at many places along the trail. On weathered surfaces it is dark brown or dark gray, and contains angular to subangular fragments of quartz and a few fragments of altered plagioclase, as well as flakes of white mica and grains of magnetite. The cement is largely calcareous, but there is considerable secondary chloritic material. Beds of gray calcareous sandstone, which weather brownish, contain angular to subangular fragments of quartz, a few fragments of

plagioclase largely altered to sericite or kaolinite, and a few grains of magnetite. The grains are embedded in a calcareous matrix, which constitutes a large part of the rock.

Some of the rock has an incipient cleavage almost at right angles to the bedding. The beds undoubtedly are intricately crumpled, as in the shallow exposures along the trail they dip northeastward and southwestward at steep angles, the direction of dip changing within short distances. On the south slope of the first ridge northeast of Cerca-la-Source a network of branching quartz veins about 10 meters wide cuts the argillite. The white quartz débris from the veins makes a conspicuous band that is visible on the next two spurs to the northwest. In this distance the veins are offset twice by faults.

Morne du Cap.—In the Morne du Cap near Cap-Haïtien there are numerous small patches of a formation which, although rather different from anything else in the Republic, apparently should be classed with the Lower Cretaceous rocks. This formation consists mainly of very dark chert and of brown or yellow indurated mudstone and siltstone, considerably more metamorphosed than the Eocene rocks. Moreover, it is overlain unconformably by upper Eocene limestone. It probably rests unconformably on a basement of igneous rocks that are mainly of volcanic origin. This formation in its relation to the water supply of Cap-Haïtien is described on page 581.

The formation is typically developed at the shore and in bluff slopes just above the shore near Carenage, the most northerly section of the city, and on Morne Calvaire, perhaps 200 meters to the southwest. It consists partly of brown or yellow siltstone, claystone, or fine sandstone, partly of dense black or blue chert, all in generally rather thin beds that average perhaps 8 to 15 centimeters in thickness. The chert at some places forms solid beds or constitutes a whole series of beds several meters in thickness, but at other places it forms nodules or concretionary masses. The claystones at places appear to grade into very impure limestone. The whole formation is much shattered and breaks into minute polygonal blocks, which at many places form a talus over weathered slopes. Such material is successfully used as top dressing for roads in the city. (See p. 497.)

Thin sections show that some of the chert probably is in part of radiolarian origin, as Radiolaria can be recognized. It also contains some Foraminifera, but the rock is so greatly metamorphosed that the proportion of the two kinds of organisms is not easily determinable. In many features the rock resembles some of the Franciscan chert of California.

Beds of coarser, distinctly detrital material and even of coarse conglomerate appear at places, the conglomerate probably being near the base of the formation. At Carenage the bluffs of blue chert above the shore are underlain by sandstone and conglomerate, which crop out on

the beach. This conglomeratic material contains much-weathered fragments of dark igneous rocks and also rounded masses of chert, apparently concretionary. Farther northeast the conglomerate appears to be underlain by much-weathered greenish volcanic rock. The following section was measured in a ravine about 200 meters north of the end of the street in Carenage. The beds strike N. 10° E. and dip 30° NW.

Section of Lower Cretaceous beds near Cap-Haïtien.

	Meters.
Thin beds of yellowish sandstone and interbedded chert.....	41
Same as above, but thicker beds, cherty nodules.....	36
Thick beds of blue chert.....	8
Soft gray sandstone containing a bed of blue chert about 25 centimeters thick	5
Greenish weathered igneous rock.....	2
Beach.	—
Thickness of Cretaceous beds exposed.....	92

On either side of the east gate to Morne Calvaire there is a bluff, 5 to 10 meters in height and nearly 100 meters in total length, in which the formation is well exposed. The rocks are chiefly cherty beds and brown siltstone. The siltstone has blue-black or brown iron stains on fractured surfaces. In this exposure there is one peculiar bed about 2.5 meters thick, apparently a fine conglomerate composed mainly of fragments of greenish igneous rock but partly of small pebbles of chert resembling the underlying cherts. However, the conglomerate appears to be perfectly interbedded in the series, and whether it denotes an unconformity is doubtful. Other exposures of a similar bed of conglomerate were noted at several places in the Ravine de la Belle Hôtesse.

Many other small exposures of the formation were noted, particularly around the shore of the cape north and west of Cap-Haïtien. Those near the town are shown in some detail in Figure 37 (p. 579) in connection with the description of the water supply.

The structure of the formation is complex. Everywhere it is sharply folded, and in good exposures many faults are visible. In the bluff east of Morne Calvaire the beds dip into the hill, but at the north end of the bluff there is part of a small anticlinal fold, much resembling a fan, in which minor faults are seen. Just south of the steps leading up to the gate there is a normal fault, which shows an offset of about a meter in the thick bed of conglomerate described above. A nearly vertical normal fault is exposed near the gate south of the city on the road to Port-au-Prince, where road metal has been dug off the hillside. The contact of the cherty formation with the porphyritic igneous rock is marked by a fault, which has an apparent displacement of at least 20 or 30 meters.

MONTAGNES NOIRES.

About 4 kilometers southwest of St.-Michel de l'Atalaye, on the trail through Section Paul to Dessalines, stretches a broad interior valley called Savane la Cidra, which lies back of the first range of the Montagnes Noires at the border of the Central Plain. This valley contains numerous exposures of a thin-bedded slaty argillite. The rock is gray or brown tinged at places with tints of blue or green. Part of the series consists of a black slaty limestone, which contains small undetermined Foraminifera. This rock weathers yellowish white. The beds are considerably folded.

In contact with this argillite appears a gray or green altered hornblende andesite. Both the argillite and the andesite have been metamorphosed by an intrusion of dacite porphyry. The argillite is partly replaced by epidote, chlorite, and quartz and contains cubes of pyrite.

SOUTHERN PENINSULA.

Rocks of doubtful age that are known to be older than the oldest Tertiary rocks were examined at several localities in the Southern Peninsula. They are tentatively classed with the rocks of supposed Lower Cretaceous age in the northern part of the Republic.

Arrondissement of Jacmel.—In the area of basalt north of Jacmel there are several exposures of schistose limestones which apparently have been engulfed by the basaltic eruptions. An exposure of this limestone was found north of Coteaux on the trail from Jacmel to Léogane, about 500 meters north of the southern boundary of the basalt. The limestone is brown and dense and is much sheared but contains eyes of uncrushed limestone. In thin section the limestone is seen to be only partly recrystallized and contains small undetermined Foraminifera. The schistosity strikes N. 60° W. and dips 80° S.

Another thin zone of metamorphic limestone was seen just south of Corail-Brache on the same trail.

North of the divide along Ravine la Rououne, the western branch of the Rivière des Citronniers, there are exposures of light-brownish much sheared metamorphic limestone. The beds strike N. 80° W. and dip 50° S.

These metamorphic limestones appear to be overlain by the basalts, although the contacts generally were concealed.

Near Petit-Goave.—About 4 kilometers southeast of Petit-Goave, on a trail leading up the mountain slope, there are large exposures of a gray to grayish-brown impure metamorphic limestone, but the extent of the beds was not determined. The rock is in regular and rather thin beds, and some beds have a conchoidal fracture. The grayish-brown limestone contains *Globigerina*, *Textularia*, and other small Foraminifera. It probably is overlain by upper Eocene limestone, but the contact was not seen.

Arrondissement of Aquin.—About 2 kilometers west of the little village and chapel of Changier, at the highest point on the trail between

l'Asile and Cavaillon, some small exposures of a reddish schistose limestone were noted. The area covered is small, and the relations of this rock to the surrounding rocks are not known, but it is undoubtedly older than the prevailing upper Eocene limestone and is tentatively referred to the Cretaceous. Such highly metamorphosed sediments are not common in the Cretaceous but probably form local masses in less metamorphosed rock, as at Camp Perrin.

Arrondissement of Cayes.—Rocks which on rather indefinite grounds are tentatively assigned to the Lower Cretaceous were found at a number of other places in the Southern Peninsula. The principal area is north of the lowland near Camp Perrin, which is underlain by the lignite-bearing Miocene beds described on pages 236, 483. Here the rock is a thin-bedded, very cherty, generally chocolate-brown limestone, but some beds are whiter. Some beds are recrystallized and contain many closely spaced fractures, which are filled with coarsely crystalline calcite. About 2 kilometers north of the diversion dam of Canal d'Avezac the limestone appears to contain large zones of schist, which is probably derived from impure limestone by metamorphism. The beds are crumpled into close folds, the strike changing greatly within a few meters, but the prevailing strike is approximately east. No fossils were found in this limestone, but the degree of metamorphism indicates that it is at least as old as Cretaceous. It was seen in place only along La Ravine du Sud, beginning at a locality about a kilometer north of the diversion dam. Float of a similar rock is very abundant in the lowland, indicating that it is extensive in the mountains to the north. Float of similar brown metamorphosed limestone, which was noted at Port-à-Piment and elsewhere along the south coast, possibly indicates an extensive area of such rocks in the unexplored interior of the Montagnes de la Hotte.

Arrondissement of Tiburon.—Somewhat similar brown limestone was found along the trail near the north coast of Tiburon Bay. Basalt seems to overlie the limestone, but this relation was not definitely established. If the limestone really underlies the basalt the limestone probably is Cretaceous; if not, it probably is a phase of the upper Eocene limestone, which appears to cap the high ranges north of Tiburon.

UPPER CRETACEOUS SERIES.

DESCRIPTION BY REGIONS.

MASSIF DU NORD.

Near the Citadelle of Christophe.—A good exposure of limestone of undoubted Upper Cretaceous age was found on the trail between Dondon and the Citadelle of Christophe, about half a kilometer south of the junction of the trail with a trail leading from Milot to the Citadelle. The locality is on the mountain side, approximately east of the Citadelle, at an altitude of about 600 meters above sea level. (See Fig. 29, p. 462.)

The extent of the exposure is undetermined, but probably it is not more than 100 to 300 meters in diameter. The rock consists of white limestone, apparently massive and partly broken down by solution into a mass of large boulders. In the calcareous matrix there are a few small fragments, probably of volcanic rock. The whole limestone mass is richly fossiliferous. It contains some undetermined Foraminifera, but the conspicuous fossils are large, mostly fragmentary rudistid mollusks. (See list, p. 98, stations 9880 and 9746.)¹ Some single specimens on weathered exposures are more than a meter in length, but it is difficult to extract them from the tough rock. The limestone is virtually a reef rock formed by these mollusks.

The relations of this limestone to the underlying rocks were not determined. Two exposures of a thick-bedded tilted conglomerate found near by probably should be referred to the upper Eocene basal conglomerate. (See p. 111.)

Near La Tannerie.—Upper Cretaceous limestone was found near the railway station called La Tannerie, a few kilometers north of Grande-Rivière du Nord, at the northern border of the mountains. The limestone at this place forms the first low mountain ridge bordering the North Plain. It is exposed just north of La Tannerie, in a railway cut about 75 meters long and 7 meters in maximum height. The rock at the south end of the exposure consists mainly of dark-blue metamorphosed limestone containing prominent veins of crystalline calcite. At the north end the limestone is mixed with a considerable amount of purple argillite and dark-brown sandstone, evidently belonging to the Lower Cretaceous series as developed near Dondon. (See p. 88.) The whole mass is intricately faulted and badly crushed, and the intermixture of argillite and limestone is probably due to the faulting.

On the ridge west of this cut the limestone is exposed for several hundred meters. It is rather thick-bedded, the beds ranging from 20 to 40 centimeters in thickness. The strike is somewhat south of west and the dip vertical or very steep to the north. The rock is brown on weathered surfaces and is etched and furrowed by peculiar ridges. The broken interior is dense and dark blue. The rock contains small scattered fragments of igneous rock. No fossils show on the interior, but weathered surfaces contain undetermined Foraminifera and numerous fragments of rudistids (see list, p. 98, station 9881), which appear to be indigenous to the calcareous matrix.

To the south the limestone is in contact with quartz porphyry. Near La Tannerie the contact is along a ravine and is covered by detrital material, but westward it rises up the northern slope leading down to the ravine and curves gradually southward. Although the relations were not definitely

¹ The numbers given designate stations at which collections were made by members of the U. S. Geological Survey. The collections are deposited in the U. S. National Museum.

determined the contact is believed to be marked by a fault. Along the contact there is a zone, 2 or 3 meters wide, of altered green igneous rock.

Directly east of La Tannerie, on the mountain slopes east of the Grande-Rivière du Nord, there are small outcrops that appear from a distance to be limestone, probably the same as that at La Tannerie.

Morne Grand-Gille.—Morne Grand-Gille is an isolated hill in the North Plain about 3 kilometers northeast of La Tannerie. It stands just north of the road connecting Milot and Limonade and just east of the Grande Rivière du Nord. This hill is capped by dark limestone. Float found along the road at the foot of the hill indicates that the rock is the same as that at La Tannerie. A collection of float fossils made here was lost.

MONTAGNES DE TERRE-NEUVE.

At an altitude of about 800 meters above sea level, on the west slope of Morne Guimbi, float limestone containing small indeterminable gastropods and an *Anomia*-like bivalve was collected. This rock may be of Upper Cretaceous age, although at the same locality float containing upper Eocene Foraminifera (see list opposite p. 144, station 9816) was obtained.

MASSIF DE LA SELLE.

In the southern part of the Republic impure limestone and tuffaceous rocks, apparently interbedded in basalt, are considered Upper Cretaceous, although the evidence is rather meager. Some of these rocks contain fresh tuffaceous material and also marine fossils. The volcanic material must either have been blown into the sea during eruptions or was quickly washed from the land surface during floods. Other thinly laminated rocks that contain no marine fossils probably were laid down on flood plains.

Such rocks were seen at many places in the basalt areas of the Massif de la Selle. In the western part of the Commune of Marigot, along the trail leading from the coast to Étang Bossier, a brownish-gray shaly limestone was found in the area of basalt at a locality about a kilometer south of the lake. It contains small pieces of thick shell that have the fine fibrous texture characteristic of *Inoceramus*. A dark impure limestone containing finely laminated bands crops out on the same trail about half a kilometer closer to the lake. This rock contains fish vertebrae and carbonized plant fragments.

Rocks of the same age were seen at several places in the large basalt area around Furey. They consist of black laminated calcareous tuff, sandy tuff, and banded chert. The black laminated tuff contains scattered fresh angular fragments of augite and fragments and crystals of plagioclase. Thin seams in the tuff consist largely of crystals of plagioclase and fragments of augite. The matrix is calcareous and contains *Globigerina*, *Textularia*, and other small Foraminifera, some of which have been replaced by hematite. The matrix is stained brown by iron oxides and other impurities.

Similar rocks crop out on the south slope of the mountains along the trail from Jacmel to Carrefour. Dark banded calcareous tuff and impure limestone are exposed on Rivière Gosseline, at the south end of the basalt gorge between the locality marked by the contact with upper Eocene limestone and Carrefour Andral, where the trail leaves Rivière Gosseline and ascends Rivière Mabial. These rocks are crumpled at the place where the trail crosses from the right to the left side of the river. Along the same trail near the crest of the mountains, at an altitude of 1,050 meters above sea level, on the south slope, a bed of black tuffaceous limestone stands vertically in a cut along the trail.

Numerous exposures of dark shaly limestone or tuffs were seen in the area occupied by basalt along the trail from Corail-Brache to the head of the valley of Rivière des Citronniers, on the eastern route from Jacmel to the Léogane Plain. Most of the rock exposed appeared to be in thin beds interbedded in the basalts. As these exposures were near the center of the basalt band it is probable that they are in the lower part of the basalt series.

At all these localities the exposures of these rocks are very narrow across the strike, and the beds seem to lie between basalt. They have a remarkably uniform northwesterly strike, indicating that they belong to the same series as the basalt. They apparently lie near the base of this series. At all the exposures examined the beds dip steeply, usually to the southwest, indicating that the rocks are folded, although the folding is not apparent from exposures of the basalt.

MASSIF DE LA HOTTE.

Limestone that is probably of Upper Cretaceous age was found near the Grande Rivière de Nippes north of the Asile Valley, along the trail between l'Asile and Anse-à-Veau. In this region the Grande Rivière de Nippes occupies a narrow gorge cut mainly in basalt. About 3 kilometers from l'Asile the river bends sharply eastward, and the trail also turns eastward along the north bank of the river. At this turn a ledge of brown limestone, apparently interbedded with the basalt, is exposed. It strikes about N. 75° W. and dips 35° NE.

Perhaps 300 meters east of the turn in the trail and river the trail parts from the river, ascends a steep mountain side, and crosses a divide in basalt at an altitude of about 300 meters above sea level. At an elevation of 50 meters south of the crest of this divide there is an exposure of brown limestone, which strikes east and dips 55° N. beneath basalt. The trail for several meters follows a sharp V-shaped ditch along the contact.

A little lower on the hillside an exposure shows basalt containing fragments of limestone of irregular size and shape. The limestone is dark gray and partly recrystallized. Plate VIII, *B*, a view of this exposure, shows that ellipsoidal masses of basalt fit into cusp-shaped edges of pieces of

limestone. The head of the hammer shown in the view rests on one of the ellipsoidal masses of basalt. These features suggest pillow structure and that the basalt flowed under water where calcareous muds were being deposited, the calcareous mud filling the open spaces between the pillows of basalt.

At all these exposures the limestone contains undetermined calcareous algae, and at the exposure near the crest of the hill it contains small indeterminable gastropods. It is of marine origin and apparently was laid down when the basalt was being poured out. The masses of limestone that are included in the basalt contain small fragments of igneous rock clouded with iron oxides.

In the level savanna south of the first range of mountains south of Anse-à-Veau, along the same trail, there is a small ledge of brownish-yellow limestone which protrudes through the basalt that floors the valley. The rock is entirely recrystallized. It may or may not be the same as the rocks described in the preceding paragraphs.

Another exposure of brownish-yellow limestone was found 5 or 6 kilometers east of Baradères on the trail to Anse-à-Veau. It is just east of the crest of the third ridge east of Baradères. Basalt appears to overlies the limestone, which is poorly exposed. The limestone contains the coral *Actinacis* ? (station 9639).

In the northern part of the arrondissement of Nippes there is probably much limestone overlain by or interbedded with basalt, but some of it may be older than Upper Cretaceous.

FOSSILS.

The only fossils of undoubted Upper Cretaceous age come from the limestone in the arrondissements of Cap-Haïtien and of Grande-Rivière du Nord. Rudistid mollusks form huge reefs in this rock at some localities, particularly on the mountain side east of the Citadelle of Christophe. They are similar to some of the peculiar rudistids described by Whitfield¹ from Jamaica. Similar mollusks have been found in the Dominican Republic, Cuba, and St. Croix, indicating that this fauna is characteristic of the Upper Cretaceous of the West Indies. Although the evidence is rather meager, Dr. T. W. Stanton, of the United States Geological Survey, who examined the collections from the Republic of Haiti, believes that the fauna indicates a rather late Upper Cretaceous age.

Stations—Upper Cretaceous.

9881 (B 300 F). Arrondissement of Cap-Haïtien, mountain slope just west of La Tannerie, a station on railroad from Cap-Haïtien to Grande-Rivière du Nord, about 10 kilometers northwest of Grande-Rivière du Nord. J. S. Brown, collector. March 11, 1921.

¹ Whitfield, R. P., Descriptions of species of Rudistae from the Cretaceous rocks of Jamaica, W. L., collected and presented by Mr. F. C. Nicholas: Am. Mus. Nat. Hist. Bull., vol. 9, pp. 185-196, pls. 6-22, 1897.

9880 (B 296 F). Arrondissement of Grande-Rivière du Nord, trail from Dondon to Citadelle of Christophe, about halfway up mountain, about 3 kilometers east of Citadelle and 10 kilometers north of Dondon; altitude, 620 meters above sea level. J. S. Brown, collector. March 8, 1921.

9746 (B 317 F). Arrondissement of Grande-Rivière du Nord, same locality as 9880. W. P. Woodring and J. S. Brown, collectors. March 21, 1921.

Upper Cretaceous fossils from limestone of Massif du Nord.^a

Species.	Massif du Nord.		
	Cap-Haïtien.	Grande-Rivière.	
	9881	9880	9746
Undetermined coral	×
Mollusca:			
Pelecypoda:			
Radiolites nicholasi Whitfield.....	×
Radiolites sp. cf. R. cancellatus Whitfield.....	×	×
Radiolites sp.	×
Genus ?, Caprinidae.....	×	×

^aIn the lists of fossils the names in the first enclosed heading (for example, Massif du Nord) indicate geographic divisions; those in the second heading (for example, Cap-Haïtien) indicate arrondissements. The numbers at the heads of the columns are those of the stations in the preceding list.

Stations—probably Upper Cretaceous.

9663 (W 67 F). Arrondissement of Jacmel, trail from Cayes de Jacmel to Étang Bossier, about a kilometer south of Étang Bossier; altitude, 200 meters above sea level. W. P. Woodring, collector. November 2, 1920.

9639 (B 113 F). Arrondissement of Nippes, trail from Baradères to Anse-à-Veau, third ridge east of Baradères. J. S. Brown, collector. November 22, 1920.

Upper Cretaceous (?) fossils from arrondissements of Jacmel and Nippes.

Coral:	Station.
Actinacis ? sp.....	9639
Mollusca:	
Pelecypoda:	
Inoceramus sp. indet.....	9963

TERTIARY SYSTEM.

Sedimentary rocks of Tertiary age are the most extensive surface rocks in the Republic, covering probably three-quarters of its area. Middle and upper Eocene, middle and upper Oligocene, lower and middle Miocene, and Pliocene deposits were seen during the reconnaissance. Rocks of lower Eocene age have not yet been recognized anywhere in the West Indies proper. The deposits that are considered middle Eocene in this report are the first deposits of that age recognized in the West Indies proper