

IGNEOUS ROCKS.

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GENERAL DISTRIBUTION.

Igneous rocks crop out in probably a little more than one-fifth of the total area of the Republic. The largest areas are in the Massif du Nord and in the ranges of the Southern Peninsula. Relatively few exposures are found in the central ranges and intervening plains. Most of the igneous rocks are older than the Tertiary sedimentary rocks and are now exposed principally on the eroded crests of anticlinal arches and in deep valleys where the sedimentary rocks have been removed. The areal distribution of the igneous rocks is shown on the geologic map (Pl. I.)

The igneous rocks are discussed under the heading of extrusive rocks, or those that have poured out on the surface of the earth, and of intrusive rocks, or those that have been injected into or have penetrated between other rocks and solidified without reaching the surface. As it is not always possible in the field, especially among the older rocks, to distinguish between extrusive and intrusive rocks, certain rocks of doubtful origin are either classified on textural and other features, or are discussed with other rocks of known origin that accompany them.

The geology of the igneous rocks is relatively complex. Notable differences are found both in the rocks and in the igneous history of the northern and southern parts of the country. The early igneous history of the central part of the country is obscured by the overlying Tertiary formations, but its later Tertiary history has some distinctive features. Both because of convenience in discussion and because of petrologic considerations, the igneous rocks of the Republic will be discussed under three geographical divisions:

1. The northern region (see Pl. XXVII), comprising Tortue Island, the North Plain, the Massif du Nord, the Northwest Peninsula, the northwestern part of the Montagnes Noires, the northern part of the Central Plain, and the northern extremity of the Artibonite Plain.

2. The central region, comprising the southern part of the Central Plain, the southeastern part of the Montagnes Noires, the southern part of the Artibonite Plain, the Montagnes du Trou d'Eau, and the Chaîne des Mateux.

3. The southern region, comprising the Massif de la Selle and the Massif de la Hotte.

The general boundaries of these regions are shown on the geologic map, although naturally they can not be sharply drawn. A summary of the igneous activity and of the tectonic history of these three regions is given in the following table:

Summary of the igneous activity and tectonic history.

Time subdivisions.	Northern region.	Central region.	Southern region.
Pliocene	Emergence	Emergence	Minor submergence and continuation of folding.
Upper Miocene ...	Emergence and folding. Intrusion of quartz diorite in Monts. de Terre-Neuve.	Emergence and intense folding.	Emergence and folding.
Lower and middle Miocene.	Marginal submergence. Marls and coralliferous limestones.	Nearly complete submergence. Minor eruptions of basalt, interbedded in marl.	Marginal submergence.
Upper Oligocene ..	Partial submergence followed by emergence.	Extensive submergence. Limestones. Eruption of nephelitic basalt. Partial emergence.	Emergence.
Middle Oligocene .	Partial submergence	Extensive submergence..	Local submergence.
Lower Oligocene ..	Emergence and folding..	Probable emergence	Emergence and folding.
Upper Eocene	Extensive submergence. Limestones.	Complete submergence. Limestones.	Complete submergence. Limestones.
Middle Eocene	Partial submergence	Emergence	Emergence.
Lower Eocene	Emergence and extensive erosion. (?) Minor eruptions of basalt, andesite, diabase, essexite. Exact age unknown.	Emergence and extensive erosion.	Emergence and extensive erosion.
Upper Cretaceous.	Batholithic intrusions of quartz diorite. Intense folding. Local submergence. Limestones.	Basalts and tuffs, probably of this age. Probably partial submergence.	Folding. Extensive fissure eruptions of basalt, partly submarine. Partial submergence. Limestones.
Lower or middle Cretaceous.	Partial submergence. Sandstones, shales, argillites, non-marine and marine.	Partial submergence. Argillaceous limestones and shales.
Jurassic	Emergence. Extensive volcanic activity. Eruption of andesites and dacites.	Emergence (?). No evidence of igneous activity.
Early Jurassic or Triassic (?).	Eruptions of basaltic lavas and minor intrusions of basic and ultrabasic rocks.		

OUTLINE OF THE IGNEOUS GEOLOGY.

Northern region.—The northern system of mountains in the Republic of Haiti, here called the Massif du Nord, is characterized by a core of large bodies of massive quartz diorite, probably of middle or late Cretaceous age. These granitic rocks intrude and metamorphose lavas of Mesozoic age and some older metamorphic sediments, possibly of Paleozoic age. The mountain ranges of the Northwest Peninsula also contain some bodies, of unknown size, of similar granitic intrusives.

Apparently the oldest Mesozoic lavas are basalts. Associated with them are some pyroxenites, peridotites, and diabasic intrusives, which are probably of nearly the same age. Near the quartz diorite batholith these older rocks have been subjected to contact metamorphism and are converted locally into amphibolites and serpentinous amphibolites or into amphibole, talc, and chloritic schists. The alteration of the pyroxenites and peridotites is somewhat in contrast to that of similar rocks in Cuba, where the formation of serpentine was the most common alteration. Most of the earlier basaltic rocks have suffered more or less metamorphism, and many are converted to "greenstones." Olivine-free and hypersthene basalts and porphyritic basalts rich in pyroxene and containing some olivine seem to be the more common types. The age of these basalts is possibly Jurassic or older.

The younger and more extensive Mesozoic lavas are chiefly andesites but include some dacites. They are found throughout nearly the length of the Massif du Nord and are remarkably uniform in composition and texture. The apparent lack of more diverse types of lava in association with the andesites and dacites is noteworthy. Where they have been intruded by the quartz diorite these lavas have been locally metamorphosed but not to the extent of the older basaltic rocks. The more common varieties seem to be pyroxene andesites, hornblende-augite andesites, and hornblende andesites; hypersthene andesites and hornblende-biotite andesites are less common. The quartz-bearing varieties of lava include pyroxene dacites, hornblende-augite dacites, and hornblende-biotite dacites. Some of the lavas that contain only a little quartz should possibly be classified as quartz-bearing pyroxene andesites. The eruption of the andesites and dacites in the central part of the Massif du Nord certainly took place prior to the deposition of certain sedimentary rocks that are considered Lower or Middle Cretaceous, but in the Montagnes Noires the lavas appear locally to have buried similar sediments. However, no lava flows have been found definitely interbedded in the Cretaceous (?) sedimentary rocks. Probably the eruptions occurred largely in the Jurassic period, but in some regions they extended at least into the lower Cretaceous, and minor undiscovered eruptions may be even later.

Basaltic lavas and intrusive rocks, some of them alkaline, have a rather local distribution in the western part and along the southwestern

border of the Massif du Nord. At several localities these rocks seem to be younger than the andesites, but their relation to the quartz diorite was not determined at any place. Calcareous sediments containing Foraminifera of unknown age are in places associated with these lavas and are locally engulfed or included in pillow lavas of this series. The varieties of rock include amygdaloidal basalts, olivine basalts and diabases, analcite andesites, analcite-olivine andesites, and essexite. Some of the rocks are much zeolitized. The more or less alkaline varieties are rather common and are widely distributed. The age of the eruptions may have been late Cretaceous or early Eocene, but the evidence warrants only very general conclusions.

The major igneous intrusion occurred in middle or late Cretaceous time and consisted of large bodies of quartz diorite of rather uniform composition. In the eastern part of the Massif du Nord, where it is extensively exposed, the quartz diorite contains hornblende and chlorite. In the Northwest Peninsula altered porphyritic facies of the intrusive rock locally contain mica. Some lamprophyric dikes and veins of quartz hornblendite cut the main body of the batholith.

Intrusions of minor stocks of quartz diorite, granodiorite, and associated porphyries occurred probably during the Miocene along the central arch of the Montagnes de Terre-Neuve. These rocks invaded the Mesozoic andesitic lavas and the overlying upper Eocene limestones. The intrusives where exposed are principally the fine-grained porphyries. There are also some associated dikes of porphyry and veins of pegmatite.

In a general way the igneous rocks of the northern part of the Republic are similar in many features to those of the Western Cordillera of South America and to those of the Pacific Coast ranges of North America. The prevalence of andesites and dacites among the volcanic rocks is a characteristic feature of the Western Cordillera of South America. An analysis of a pyroxene andesite from the Terre-Neuve region (p. 276) shows relatively higher silica and lower potassium oxide than the average andesite. The high percentage of quartz and the practical absence of orthoclase in the quartz diorite from the central part of the Massif du Nord is also particularly noteworthy. The Cretaceous quartz diorite of the Northwest Peninsula and the Miocene (?) intrusives of the Montagnes de Terre-Neuve are higher in potash feldspar than the principal body of quartz diorite. All the rocks are rather high in titanium.

Quartz and hornblende bearing granitic intrusives are widespread in the West Indies and are found in the islands of Cuba, Porto Rico, Vieques, St. Thomas, and St. Martin.¹ They are both pre-Cretaceous and post-Cretaceous in age.¹

Central region.—In the central ranges and plains of the Republic the pre-Tertiary igneous rocks are rarely exposed. Small patches of glassy

¹ Vaughan, T. W., unpublished notes.

hypersthene basalts are exposed along the central arch in the southeastern part of the Montagnes Noires. These lavas are older than upper Eocene. Small areas of early or pre-Tertiary igneous rocks are exposed in the central part of the Chaîne des Mateux.

Nephelite basalts are found at several localities in the Montagnes du Trou d'Eau. Flows and explosive eruptions of these lavas took place probably from isolated central vents. In composition the rocks are largely or entirely nephelite basalt. Some varieties contain haüynite or melilite and others are much zeolitized. Rocks of similar composition (p. 316) have been found in Grenada¹ and in Uvalde County, Texas.² The nephelite basalts northeast of Thomazeau are of middle or upper Oligocene age; basalts near Saut d'Eau are post-middle Oligocene and may be younger than the others, but their relations to the Miocene beds of the Artibonite Valley are not known. In the Dominican Republic limburgite, probably of Pleistocene age, has been found.³

Minor amounts of basaltic lavas and débris are interbedded in the Miocene sedimentary rocks on the western flank of the Chaîne des Mateux and in the southwestern part of the Montagnes du Trou d'Eau.

Southern region.—The principal igneous rocks found in the mountain ranges comprising the Southern Peninsula of Haiti are basaltic lavas. These lavas are exposed in the central arch of the mountains or in deep valleys cut in the Tertiary limestones. The lavas have buried older limestones and argillaceous rocks, probably partly of Cretaceous age, and together with these comprise a basement on which the Tertiary limestones lie. Probably only a part of the original extent of the eruptions is included by the present outline of the Southern Peninsula. The eruptions were doubtless for the most part of the fissure type, as pyroclastic débris is found only locally. Ordinary basalts are the most common variety of lava, but olivine basalts, spilitic basalts, diabase porphyries, and augite andesites are also found. Some of the lavas are amygdular and many have pillow structure. Large amounts of tuff and agglomerate are exposed in the northwestern part of the Massif de la Selle. An analysis of an ordinary basalt from the Massif de la Selle (p. 325) shows that the lava is unusually high in calcium oxide and rather high in titanium. One of the noteworthy features of the analysis is the very high ferrous iron, showing that the lavas were probably fluid.⁴ The eruptions doubtless occurred in Upper Cretaceous time, as the lavas have buried argillaceous limestones that are considered Lower or Middle Cretaceous, and pillow lavas have locally buried or intruded unconsolidated calcareous deposits that are

¹ Harrison, J. B., *Rocks and soils of Grenada and Carriacou*, p. 10, London, 1896.

² Osann, A., *Melilite-nephelite basalt and nepheline basanite from Southern Texas*: *Jour. Geol.*, vol. 1, pp. 341-346, 1913. Vaughan, T. W., and Cross, W., *U. S. Geol. Survey Geol. Atlas, Uvalde Folio (No. 64)*, pp. 3-5, 1900.

³ Condit, D. D., and Ross, C. P., *Dominican Rep. Geol. Survey Mem.*, vol. 1, p. 203, 1921.

⁴ Washington, H. S., *Deccan traps and other plateau basalts*: *Geol. Soc. America Bull.*, vol. 33, pp. 765-804, 1922.

supposed to be Upper Cretaceous (pp. 96-97). The lavas lie unconformably beneath upper Eocene limestones.

Hypersthene and hornblende andesites are found near Baradères in the Southern Peninsula. They comprise only a small group of rocks, and their relations to the basalts are unknown. They are probably, like the basalts, of late Cretaceous age.

NORTHERN REGION.

EXTRUSIVE ROCKS.

GENERAL FEATURES AND DISTRIBUTION.

The extrusive rocks of the northern region are principally lavas. Although they include some interbedded breccias and tuffs, no thick deposits of such rocks were seen except in the western part of the Northwest Peninsula, where some tuffaceous and agglomeratic rocks of unknown thickness underlie limestone of supposed upper Eocene age. A large part of the detrital volcanic rocks have probably been reworked and deposited in water. The lavas form the larger part of the igneous rocks in the northern region and in general range in composition from basalts to dacites, but may include more basic or more acidic rocks.

The thickness of the extrusive series is unknown but is probably variable in different parts of the region, and at some places is undoubtedly very great. No reliable estimate of the thickness is possible at present, as the basement on which the lavas rest has not been definitely recognized in outcrops. In the western part of the Massif du Nord the thickness probably is more than 1,000 meters. The original thickness of the series may have considerably exceeded 1,000 meters in some places, as in addition to their erosion in the present cycle these rocks underwent erosion during long periods in both Cretaceous and early Eocene time, parts of the later volcanic accumulations probably having been removed during each period. In some regions a part of the series has also been engulfed in a Cretaceous batholithic intrusion of quartz diorite.

In the eastern part of the Massif du Nord the volcanics flank the intrusive quartz diorite along its entire southern boundary, and a band of metamorphic volcanic rocks extends along the north side from Grande-Rivière du Nord eastward to Les Perches. East of Les Perches they were largely engulfed in the quartz diorite, although small patches are still preserved and in places crop out through the alluvial deposits of the North Plain. (See Fig. 18, *A* and *B*, p. 311.) In the western part of the Massif du Nord, west of the Grande Rivière du Nord, the volcanic rocks comprise 80 to 90 per cent or more of the exposed igneous rocks. A small area of volcanic rocks is found at the border of the Central Plain north of Hinche. Northwest of the plain, near St.-Michel de l'Atalaye and Ennery, small patches of the underlying lavas are exposed in the areas of Eocene limestones.