"Granites and Gneisses"

Including Granites of the various States and Territories, starting on pp. 411 (circa 1886)

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Note: The U.S. states covered in the granite and gneisses section include: California, Colorado, Connecticut, Delaware, Georgia, Maine, Maryland, Massachusetts, Minnesota, Missouri, Montana, New Hampshire, New York, New Jersey, Pennsylvania, Rhode Island, Tennessee, South Carolina, Texas, Utah Territory, Vermont, Wyoming, Virginia, and Wisconsin.)

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E.—THE GRANITES AND GNEISSES.

(1) COMPOSITION AND ORIGIN.

By the term "granite" is understood a crystalline granular mixture of the minerals quartz, orthoclase, and plagioclase, which, in varying proportions, make up the chief bulk of the rock. Besides these, there is nearly always present one or more of the minerals biotite, muscovite, or hornblende, and more rarely augite, chlorite, tourmaline, graphite, and hematite. By the aid of the microscope may frequently be detected other accessory minerals such as apatite, epidote, zircon, magnetite, menaccanite, and microcline. These last, although of scientific interest, are of little practical importance.

Microscopic study of properly prepared thin sections of granite have shown that there are at least two varieties of feldspar and that they are radically different. The one is orthoclase, which is usually the predominating constituent, while the other is a triclinic variety, usually albite or oligoclase, called for convenience *plagioclase* when the exact variety can not be definitely ascertained. It is easily distinguished from the orthoclase by its beautiful banded structure as seen in polarized light. A third variety, identical in chemical composition with orthoclase, but crystallizing in the triclinic system, is also frequently present. This is microcline. Under the microscope it shows a peculiar basket-work structure, due to the nearly rectangular intersection of its laminæ produced by twin formation.

The quartz does not occur in the form of crystals, but rather in that of angular crystalline grains. It appears always fresh and glassy, but on microscopic examination is found to contain numerous inclosures, such as rutile needles and little prisms of apatite. A most interesting fact is the presence of minute cavities within the quartz, usually filled wholly or in part with a liquid, though sometimes empty. This liquid is commonly water containing various salts, as the chloride of sodium or potassium, which at times separates out in the form of minute crystals. Carbonic acid is frequently present, giving rise to a minute bubble like that of a spirit-level, and which moves from side to side of its small chamber as though endowed with life. So minute are these cavities that it has been estimated from one to ten thousand millions could be contained in a single cubic inch of space.*

Granites are massive rocks, occurring most frequently associated with the older and lower rocks of the earth's crust, sometimes interstratified with metamorphic rocks or forming the central portion of mountain chains. They are not in all cases, as was once supposed, the oldest of

* Judd on Volcanoes, p. 64.

rocks, but occur frequently in eruptive masses or bosses, invading rocks of all ages up to late Mesozoic or Tertiary times.*

They are very abundant throughout the Eastern and Northern United States and the Rocky Mountain region.

The average specific gravity of granite is 2.66, which is equal to a weight of 166½ pounds per cubic foot, or practically 2 tons per cubic yard. According to Professor Ansted† granites ordinarily contain about 0.8 per cent. of water, and are capable of absorbing some 0.2 per cent. more. In other words, a cubic yard would in its ordinary state contain 3.5 gallons of water. The crushing strength of granite is quite variable, but usually lies between 15,000 and 20,000 pounds per square inch, as will be seen by reference to the tables. The average chemical composition is as follows:

	Per cent.
Silica	72.00
Alumina	15.07
Iron peroxide	2.22
Magnesia	5.00
Lime	2.00
Potash	4.12
Soda	2.9
Loss by ignition	1.19

(2) VARIETIES OF GRANITE.

In classifying granites the varietal distinction is based upon the prevailing accessory minerals. The more common varieties are muscovite granite, biotite granite, muscovite-biotite granite, hornblende granite and hornblende-biotite granite; more rarely occur augite, epidote, tourmaline, cordierite, and chlorite granites. The variety without any accessory minerals is sometimes called *granitell*. *Protogine* is the name given to granites like those of Mount Blanc, which have talc or chlorite as the characterizing accessory. Pegmatite or graphic granite is a vein rock containing scarcely any mica, but consisting almost altogether of quartz and orthoclase. It owes its peculiar structure to the crystallization of these two ingredients in long parallel and imperfect prisms so that a cross-section shows peculiar triangular and polygonal figures comparable to the letters of the ancient Greek or Phœnician alphabets.

By far the larger proportion of the granites at present quarried in the United States have mica, either muscovite or biotite, as the characterizing accessory, and hence can be spoken of as mica granites. The amount of mica present is of considerable economic importance. It does not polish as easily as do quartz and feldspar, owing to its softness,

* Professor Whitney considers the eruptive granites of the Sierra Nevada to be Jurassic. Zirkel divides the granites described in the reports of the 40th parallel survey into three groups: (1) Those of Jurassic age; (2) those of Paleozoic age; and (3) those of Archæan age. The granites of the Eastern United States, on the other hand, are considered by geologists almost without exception as Archæan.

† Hull, Building and Ornamental Stones, p. 30.

and the presence of a large amount therefore renders the rock difficult to polish, and when polished it does not retain its luster so long as do the other minerals, its surface soon becoming dull by exposure. Its presence in large amounts is therefore deleterious to stones which are intended for exterior polished work. The condition in which the mica occurs is also an important factor. A large amount of it scattered in very fine flakes throughout the mass of the rock influences its value as a polished stone less than does the presence of large and thick crystals scattered through the rock in smaller number. The method of the arrangement of the mica is an important item; if scattered at haphazard, and lying in all directions among the quartz and feldspar crystals, the rock will work nearly as well in one direction as another. If it is scattered through the rock in such a way that its laminæ are arranged in one definite plane, it imparts a stratified appearance to the rock, causing it to split more readily in the direction of this lamination than across it. When this stratified appearance becomes strongly marked the rock is called a gneiss. Since, then, the distinction between granite and gneiss is simply one of structure, and as the two rocks are used to a considerable extent for the same purposes, they will be treated of together in the following pages.

If hornblende is the characterizing accessory, the rocks are usually without distinct lamination, as this mineral commonly exists in a granular form. Hornblende is subject to as wide variations of composition as is mica, but its white and very light colored varieties do not usually occur in our granites. Hornblende cleaves parallel to two planes, which make angles of 124° with each other, and in this respect is distinguished from black mica, which has but one cleavage. Its folia are also inelastic.

Hornblende takes an easier and more durable polish than mica and its presence is preferable on this account. Pyroxene as a characterizing accessory in granite is more common than has ordinarily been supposed. Indeed all rocks which contain pyroxene abundantly have usually been confounded with hornblende granites. The distinction between these two minerals is important from an economic stand-point, as hornblende possesses a much better cleavage than pyroxene, while the pyroxene is much more brittle than the hornblende, and cracks out with greater ease while working. The cracking out of little pieces from the black ingredient of the Quincy granites has been frequently noticed, and is due to the circumstance that this granite is not the hornblende-granite it has usually been supposed to be. Hornblende is very tough, but the Quincy granite contains a peculiar variety of pyroxene which is so brittle that it is difficult to produce a large surface which does not show some little pits, due to the breaking out of a portion of the black grains of pyroxene. Although pyroxene and hornblende may be identical in composition, they are frequently associated together in the same rock; a fact which is very evident when thin sections are examined

with the microscope, though they are indistinguishable to the naked eye. Those granites which contain hornblende also frequently contain mica, but it is noticeable under such circumstances that the mica is always the dark variety, and an example of a granite which contains both hornblende and muscovite is unknown.* Although epidote is a very common constituent of our granites in the form of microscopic crystals, the cases in which it occurs as chief accessory are quite rare. So far as observed it is always of a green color, and when present in any quantity is readily noticeable on this account alone. The pink granite of Dedham, Mass., is the most marked example of epidotic granite now quarried, though in several other cases, as the biotite-epidote gneiss of Lebanon, N. H., the mineral is frequently present in such quantities as to appear in greenish blotches on a polished surface. Tourmaline granites occur only in veins, and, so far as is known to the writer, never in sufficient abundance to warrant the opening of quarries to work them exclusively.

In texture the granites vary from extremely fine and homogeneous rocks to those in which the individual crystals are several inches in length. Porphyritic structure is common, and is produced by the development of larger crystals of orthoclase in the finer groundmass of quartz and feldspar. The color of granites is dependent largely upon the abundance and kind of accessory minerals and the color of the prevailing feldspar. Ordinarily the muscovite granites are very light gray in color, the biotite and hornblende granites light to dark gray, or sometimes almost black on a polished surface, as is the case with the hornblende-biotite granite of Saint George, Me. In the red and pink granites the color is due to the red or pink orthoclase, which is the prevailing constituent.

(3) USES OF GRANITE.

Since the earliest times granite has been used by all civilized nations for monumental and other purposes where great strength or durability was required. But while the enduring properties of the rocks have caused them to be eagerly sought, their great hardness and consequent poor working qualities have caused them to be used in works of the more simple and massive kind, where but little carving and dressing were necessary. In past ages the cheapness of life and labor in great part counter-balanced these difficulties, and hence are found works of most elaborate design executed in this refractory material; works which with the present high valuation set upon labor could never be executed but with the aid of greatly-improved machinery and methods of workmanship. The ancient Egyptians, to whom human life and labor were matters of minor importance, have left a profusion of temples, obelisks, and pyramids, whose surfaces are often carved and polished in the finest and most delicate manner, although constructed of material so obdurate

* Hawes Lith. of New Hampshire.

and unchangeable that in some cases even the marks of the tool remain upon it to the present day. A specimen of red granite now in the Museum, and formerly a portion of one of these obelisks, still shows the original carving made upon it upwards of three thousand years ago.

There is probably no country on the globe in which so large a proportion of its stone buildings are of granitic rock as the United States. This fact is due rather to the ready accessibility of the rock in those portions that were earliest settled than to any very decided preference on the part of the builder. The United States Government has of late shown a decided preference for granite in the construction of its public buildings, and has often had it transported many hundreds of miles, at a cost that never would have been undertaken by private capitalists. One item that tends to increase the cost of our granite, and other stone buildings as well, to a seemingly needless extent is the fact that American tastes seem yet incapable of appreciating any but smoothly-dressed or carved stone in a wall. This fact is, it seems to the writer, greatly to be regretted, since, with the majority of stones, better and more majestic effects can be produced by rock-faced and rubble-work than in any other manner, and at a much less cost.

Probably the most elaborate granite buildings now in the United States are the State, War, and Navy Department Buildings in Washington and the new capitol at Albany, N. Y.

(4) GRANITES OF THE VARIOUS STATES AND TERRITORIES.

California.—It is stated* that the first stone house erected in San Francisco was built of stone brought from China, and at the present day the granites most employed are brought from Scotland and the Eastern United States. However this may be, it is obvious that this condition of affairs need not long continue to exist, since granites of good quality occur in inexhaustible quantity in the near vicinity. As early as 1853 a granite quarry was opened in Sacramento County, and since then others have been opened and systematically worked in Penryn and Rocklin in Placer County. The Penryn works are some 28 miles east from Sacramento on the line of the Central Pacific Railroad. The first quarries were opened in 1864 and are now said to cover some 680 acres at Penryn and Rocklin,† the latter point being some 6 or 8 miles distant from the former in a westerly direction.

The rock varies in color from light to dark gray, one variety, which contains both hornblende and biotite, being almost black on a polished surface. They are as a rule fine grained, and take a good polish. Blocks more than 100 feet long, 50 feet wide, and 10 feet thick have been quarried out and afterwards broken up.‡

The buildings mentioned below have been constructed wholly or in

*Building Stone and Quarry Industry, Report Tenth Census, Vol. x, p. 2.

†The Rocklin stone is rather a quartz diorite than a true granite.

‡Mineral Resources of the United States, 1883, p. 455.

part of these granites: United States Mint, new City Hall, new Stock Exchange, the Real Estate Associates' building, and several private residences, and many monuments; all in San Francisco.

A fine-grained very light-gray granite of excellent appearance is found on the line of the California Southern Railroad between Los Angeles and Cucamonga, and is beginning to be used in Los Angeles. In texture it is as fine as the finest Westerly, R. I., or Manchester, Va., stone, and of a uniform light gray color. A coarser stone, carrying abundant hornblende and black mica, is found also at Sawpit Cañon, in the same county. It works readily, but contains too much hornblende, and also too many small crystals of sphene, to be of value for fine monumental work.

Colorado.—Granites are at present but little worked in Colorado, although the State contains great quantities of this material. A coarse red granite has been quarried to some extent from bowlders at Platte Cañon, Jefferson County, but the rock is poor in color and possesses but little tenacity. Fine gray granite of good quality occurs at Georgetown and Lawson, in Clear Creek County, and there are inexhaustible quantities of equally good material all through the mountains, but which are not quarried owing to the cost of transportation. A full series of them is in the Museum collection.

Connecticut.—"Extensive quarries of granite and gneiss are located at various points in this State, especially near Thomaston and Roxbury, in Litchfield County, on Long Island Sound, Fairfield County, near Ansonia, Bradford, and Stony Creek, New Haven County, Haddam, Middlesex County, and near Lyme, Mantic, Groton, and Mason's Island, New London County. The Connecticut granites and gneisses are usually fine-grained and light gray in color, and the appearance is usually so characteristic as to distinguished them from other granites of the Atlantic States."*

The most of these stones are, however, quarried only for local use, and but few find their way into markets outside of the State. A beautiful light gray muscovite-biotite granite is quarried at Thomaston and Reynolds Bridge, which for evenness of grain and clearness of color can not be excelled. The stone from Roxbury is a trifle darker, but though of fine and even grain and acquiring a good polish, is used only for curbings, foundations, and pavings. The Ansonia rock is a very fine-grained muscovite-biotite gneiss, and has been used for general building purposes in New Haven and Bridgeport. The Leetes Island and Stoney Creek rocks are of a pink color, the first mentioned being sometimes very coarsely porphyritic. A turned column of the Leetes Island rock in the Museum shows large pink orthoclase crystals 2 inches or more in length embedded in the finer gray groundmass of the rock. A beautiful and very coarsely crystalline red granite occurs near Lyme, but for some unexplained reason the stone is not in the market. It has

*Report Tenth Census, Vol. x, p. 127.

been used to some extent in Newport, R. I., and some of the material may be seen in the Chaney Memorial Church at this place. Contrary to the general rule in red granites, the feldspars of this rock are not opaque, but quite clear and transparent, and in point of beauty the rock far excels the celebrated Scotch granites from Peterhead. The Haddam, Greenwich, and Bridgeport gneisses are all hornblendic, very dark gray, and split readily in the direction of their lamination; their uses are strictly local.

Delaware.—This State produces scarcely anything in the way of granite rocks. A few quarries of a dark gray gneiss are worked near Wilmington, and are used for general building purposes in this city. One church and several private dwellings have been constructed of this stone, which belongs to the class known as *augite-hornblende* gneiss, since it contains both of these minerals in about equal proportions.

Georgia.—Although this State is known to contain inexhaustible quantities of building stones of the finest quality, but little systematic quarrying is done, and none of the rocks have more than a local reputation. A fine grade of muscovite granite, light gray in color, occurs at Stone Mountain, near Atlanta, and also a dark gray hornblendic gneiss. A hornblendic granite resembling that of Quincy, Mass., is said to occur in Oglethorpe County, though the author has never seen any of the material.

Maine.—The large extent of coast-line of the State of Maine, composed of granitic rocks of a kind suitable for building purposes, renders possible the shipment and transportation of the quarried rock at rates much lower than would otherwise be attainable, the quarries being frequently situated so near the water's edge that little, if any, handling is necessary prior to loading upon the vessel. This favorble circumstance, together with the excellent quality of the rock obtainable, led to the early opening of very numerous quarries both on the mainland and the adjacent islands, and hence at the present time are found Maine granites in very general use in nearly every city of importance in the country, even as far west as California, frequently to the almost entire exclusion of perhaps equally good material close at hand.

According to the returns furnished by the special agents in the employ of the building-stone department of the Tenth Census, there were during the census year some eighty-three quarries of various kinds of building stone in the State, situated chiefly either immediately on the coast or within easy reach of tide-water.

Of these eighty-three quarries seventy-four were of granite or gneiss. The different varieties of these stones produced may be classed under the following heads: Biotite granite, biotite-muscovite granite, hornblende granite, hornblende-biotite granite, biotite gneiss, and biotite-muscovite gneiss.

BIOTITE GRANITE.—The great majority of the Maine granites are of this kind. They vary usually from light to dark gray in color, though

pinkish and red varieties are quarried in a few instances. At Red Beach, near Calais, and at Jonesborough there is quarried a pink or reddish rock, very compact and hard, which from a simple examination with the unaided eye is seen to be composed of pink or cream-colored feldspars, smoky quartz, and a few small shreds of mica. An examination of a thin section with the microscope does not greatly increase the number of constituent minerals. The mica, which is usually of a greenish color, is very evenly disseminated throughout the rock and in very small shreds, bearing numerous inclosures of magnetite. A few small apatite crystals are as usual present, but are visible only with a microscope.

The evenness of the grain of these rocks, and the occurrence of the mica only in small amount and in minute flakes are matters of great practical importance, since they allow the production of a more perfect surface and lasting polish than would otherwise be possible. The texture of the rock is much finer than the red Scotch granite, and the color a more delicate pink. They are, in fact, the most beautiful of any of our pink or red granites now in the market, and are used very extensively for monuments, ornamental work, and general building purposes. The largest blocks ever taken out from these quarries was 7 by 7 feet and 2 feet thick. It is said, however, that blocks 30 by 15 by 2½ feet could be obtained if desired. The principal markets of the stone are Boston, Providence, New York City, Baltimore, Philadelphia, Buffalo, Cincinnati, Cleveland, and Columbus, Ohio, Springfield and Chicago, Ill., Milwaukee, Saint Louis, Charleston, S. C., Washington, D. C., and San Francisco, Cal.

At West Sullivan, in Hancock County, a light gray, sometimes slightly pinkish, granite of medium texture is extensively quarried for paving blocks and general building purposes. The stone corresponds closely with that quarried in the town of Franklin. A slightly pinkish granite of coarse texture is also quarried at Somerville, on Mt. Desert Island. This stone was used in the construction of the Brooklyn approaches to the East River bridge and in the arches and foundations of the new bridges in Back Bay Park, Boston. Blocks 150 by 50 by 18 feet have been loosened in the quarry. "The position of these quarries is peculiarly good for shipping, as they lie near the head of Somer Sound, along a narrow and very deep fiord, running several miles inland from the southwest harbor, between the mountains. One of the quarries is situated on the side of a hill and at the water's edge. The sheets of stone are very thick in some cases, one being 18 feet in thickness."

In the vicinity of East Blue Hill, in this same county, are quarried some of the most beautiful gray granites at present in the market. The rock varies from fine, even-grained gray or slightly pinkish to coarsely porphyritic. A foot cube of this granite in the National Museum is composed of a fine even-grained gray groundmass, carrying very many snow-white crystals of orthoclase an inch or more in length. This is

one of the most beautiful gray granites for monumental work with which the author is acquainted. Blocks 90 by 80 by 6 feet have been moved out in some of these quarries. Specimens of this granite tested at the Centennial Exposition at Philadelphia in 1876 showed a crushing strength of 22,000 pounds per square inch. In the quarries the stone lies in sheets from 3 to 10 feet in thickness. The principal markets are Philadelphia, New York, Chicago, Harrisburg, and Washington, D. C.

Two varieties of granite are quarried at Mount Waldo, in the town of Frankfort. Both are light-gray rocks, frequently porphyritic through large white orthoclase crystals. Both varieties are of the same mineral composition, the difference being simply one of texture, one being quite coarse and somewhat porphyritic, while the other is much finer and of more even texture. As would naturally be expected, the finer grade is the better and more durable rock, the coarser variety being more liable to crumble. The mica occurs in large flakes, which the microscope shows to be frequently pierced by small crystals of apatite. A part of the mica is greenish in color and contains a few small grains of epidote. An occasional flake of white mica was noticed in this rock, and there is present the usual sprinkling of magnetite granules, together with an occasional cube of pyrite. Quarries were opened at Mt. Waldo in 1853, and single blocks 80 by 40 by 20 feet have been taken out and afterward cut up. It is estimated that blocks 150 by 50 by 12 feet could be obtained if desired. The rock has been used largely in the building of forts on the coast of Maine, but is also used for all purposes, both ornamental and otherwise, to which granite is usually applied, and has been shipped as far South as Mobile and New Orleans. It is a beautiful stone when polished. The principal quarry is situated on Mt. Waldo, overlooking the Penobscot River, at an elevation of some 320 feet above high tide.

The quarries at Vinalhaven, in Penobscot Bay, are the most extensive of any at present in operation in this country. Quarries were first opened here about 1850, and the present annual product is upwards of 200,000 cubic feet, valued at some $110,000. Upwards of six hundred men are regularly employed at the works, though the number has at times risen as high as one thousand five hundred. The capabilities of the quarries can be best illustrated by stating that during a visit of the writer to these quarries in the summer of 1883 he was shown the remains of a huge block of granite 300 feet long, 20 feet wide, and varying from 6 to 10 feet in thickness, that had been loosened from the quarry in a single piece and afterward broken up. The largest block ever quarried and dressed was the General Wool monument, now in Troy, N. Y., which measured, when finished, 60 feet in height by 5½ feet square at the base, or only 6 feet 7 inches shorter than the Egyptian obelisk now in Central Park, New York.

In texture the Vinalhaven rock is rather coarse and the general color gray, although the prevailing feldspar is sometimes of a light flesh-

color. Besides biotite, the rock contains small amounts of hornblende and microscopic apatite and zircon crystals.* It takes a good and lasting polish, and is well adapted for all manner of ornamental work and general building purposes. The stone has been used so extensively all over the country, that to cite special cases seems superfluous.

A granite closely resembling that of Vinalhaven is extensively quarried at Hurricane Island, some 3 miles distant, in a southwesterly direction, and is used for similar purposes. The structure of the stone here differs in different parts of the quarry. In one portion it lies in comparatively thin sheets, while in another there occur immense masses of solid rock, extending downward for 50 feet without perceptible jointing. A block of 80 tons has been moved, and a mass 80 by 40 by 25 feet was loosened in the quarry. Natural blocks 500 feet long, 20 feet wide, and 50 feet deep occur.

The celebrated quarries on Dix Island, in Knox County, from whence was obtained the granite for the United States Treasury building at Washington, including the monolithic columns, 31½ high by 3 feet in diameter, are at the present writing (1885) abandoned. Nearly the whole island has been quarried over and large bluffs entirely removed. The rock is rich in quartz, and therefore quite hard, but is a good and safe working stone. It has been very extensively used in New York City, Philadelphia, and Washington, D. C.

To give a special description of each and all the quarries of biotite granite to be found upon the coast would extend this work far beyond the prescribed limits. A complete list of them is to be found in the Museum catalogue.

MUSCOVITE BIOTITE GRANITES.—The granite of Augusta and Hallowell has long been justly celebrated for its beauty and fine working qualities. It is a fine, light-gray rock, the uniformity of whose texture is often broken by the presence of large white crystals of microcline, which inclose small, rounded grains of quartz. Biotite and muscovite occur in abundance, and in about equal proportions, but in small flakes, the muscovite appearing as small, silvery-white glistening particles on a broken surface of the rock. Under the microscope three feldspars are readily distinguished—orthoclase in imperfect crystals and irregular grains, an abundance of plagioclase, and microcline in large plates filled with cavities and inclosures of muscovite and quartz. In the thin sections the quartz inclosures are usually circular in outline and are pierced in every direction by minute thread-like crystals of rutile, in polarized light showing up in strong contrast with the beautiful basket-work structure of the inclosing microcline. All the feldspars are quite fresh and pure. A few apatite crystals are present, together with occa-

* In Hitchcock's "Report on the Geology and Natural History of Maine," 1862, p. 265, the Vinalhaven rock is referred to as a "peculiarly fine-grained syenite of good color," etc. In none of the specimens received at the Museum from this locality, however, does hornblende play more than a secondary part, and in the majority of cases does not appear at all. Hence all are classed as biotite-granites.

(photo caption) "Granite Quarry, Hallowell, Maine. Drawn from a photograph."

sional garnets, which in thin sections are always destitute of crystalline form, appearing as rounded or oval nearly colorless bodies traversed by many irregular lines of fracture. They are quite free from impurities, though occasionally containing inclosures of biotite. As is usual in muscovite-bearing rocks but little magnetite is present; in two cases only grains of pyrite were noticed.

This is one of the best working of the Maine granites, and is used very extensively, not only for building and monuments, but is carved into statues, like marble. The rock is properly a gneiss, but showing no signs of stratification in the hand specimen is classed here as a granite. As illustrative of the great extent of the quarries, it is stated that blocks 200 feet in length, by 40 feet in width and 8 feet in thickness, can be broken out in a single piece if so desired. There is no gap between the sheets, and little or no pyrite to cause discoloration. The sheets, as is usually the case, increase in thickness downward, being about 1 foot thick at the surface and 10 feet thick at the bottom of the present openings, which are from 50 to 60 feet deep. (See Plate VIII.)

This stone is in such demand for statuary and monumental work that an Italian designer who served his apprenticeship in Roman studios is employed constantly by the company. Many of the workmen are also said to be Italians who worked on marble in Italy, but have learned to cut granite since their arrival in Hallowell. Among the prominent structures and monuments constructed, wholly or in part, of this stone, are the new capitol, Albany, N. Y.; Bank of Northern Liberties, Philadelphia; State capitol, Augusta, Me.; Emory Block, Portland, Me.; Odd Fellows' Memorial Hall, Equitable Building, and part of the old Quincy Market, Boston; Ludlow-street jail, the Tribune building, and the old Tombs prison, New York City; the statues of the Pilgrim's Monument at Plymouth, Mass.; soldier's and sailor's monuments at Marblehead, Mass.; Portsmouth, Ohio; Augusta, Boothbay, and Gardiner, Me.; Odd Fellows' monument, Mount Hope, Boston; Washington Artillery monument and Hernandez tomb, New Orleans, etc. The statues on the Pilgrim's Monument are said to be the largest granite figures in existence. The standing figure is 38 feet in height, while the four in sitting posture are each 15 feet in height.

HORNBLENDE GRANITE.—This is rather a rare building-stone in Maine, though extensively quarried in other States. Its production is at present confined to Otter Creek, Mount Desert, where a coarse red rock is quarried, which on a superficial examination somewhat resembles the biotite granites of Calais and Jonesborough, though lacking the cream-colored feldspar and consequent speckled appearance characteristic of these rocks. Orthoclase predominates over all other constituents, and is deep-red in color.

This rock is very compact and hard, but works well and takes an excellent surface and polish. It is of finer texture than the Scotch-red granites, and bears a closer resemblance to red granite of the Bay of

Fundy than to any other at present in the collection. If the specimen received at the Museum is a fair sample of the rock at the quarry, it is certainly a most excellent stone, though its otherwise uniform texture is often interrupted by the presence of oval or rounded black patches or knots, caused by segregations of mica, hornblende, and other iron-rich minerals. This is, however, a defect not uncommon in many of the Maine granites.*

Maryland.—The most noted quarries in this State are situated in Baltimore County, near Woodstock. The rock is a biotite granite, varying from light to dark gray in color, and of about medium texture. It is used extensively for general building purposes and for monumental work in Baltimore, Washington, and some of the Western States. At Mount Royal and opposite Ellicott City fine-grained dark-gray gneiss is quite extensively quarried for general building purposes, curbstones, etc. A part of this rock is beautifully porphyritic through large feldspars an inch or more in length.

A dark-gray gneiss, which is the principal stone used in Baltimore for rough work, is quarried in the immediate vicinity of the city.

At Port Deposit, in Cecil County, a gray biotite gneiss is extensively quarried, and is used chiefly for bridge building, docks, harbor improvement, and general building work. It has been used in the construction of Haverford College, Md., St. Dominick's Church, Washington, and several churches in the immediate vicinity. Other locations where good quality of granite is exposed, but not quarried to any extent, are Gwynn's Falls, in Baltimore County, and 3 miles east of Rockville, in Montgomery County.

All of the Maryland granites and gneiss at present quarried have biotite as their chief accessory, are of a gray color and of medium fineness of grain. They appear, however, better adapted for general building than for ornamental work.

Massachusetts.—As Massachusetts was the earliest settled of the New England States it is but natural that here the systematic quarrying of granite should first be undertaken. As already noted,† granite from the bowlders on the Quincy Common, and from Chelmsford began to be used in and about Boston as early as 1737, but it was not until the early part of the present century that its use became at all general. Indeed it may be said that it was not until the opening of the quarries at Quincy in 1825 that the granite industry assumed any importance. From this time the use of the stone for general building purposes increased in a marked degree, and the history of granite quarrying in the United States may properly begin with this date.

This early opening of quarries at Quincy was due largely to the demand for stone at Charlestown for building the Bunker Hill monument.

* See On the Black Patches in Maine Granite, Proc. Nat. Mus., 1883, p. 137; also, On the Collection of Maine Building Stone in the National Museum, Proc. Nat. Mus., 1883, p. 165.

† Ante p. 286.

but the attention of capitalists being thereby called to the extent of the granite ledges in this vicinity other works were soon established, and at the present time the two towns of Quincy and West Quincy contain upwards of thirty quarries. Altogether these produce not less than 700,000 cubic feet annually, and give employment to upwards of eight hundred men.

The Quincy granites are as a rule dark blue-gray in color, coarse grained, and hard. A pinkish variety is quarried to a slight extent. They are all hornblende granites, and their general appearance so characteristic that once seen they are always easily recognizable wherever met with. As already mentioned these rocks contain besides hornblende a very brittle variety of pyroxene, which makes the production of a perfect surface somewhat difficult. Nevertheless, they are very extensively used both for rough and finished work. The United States custom-houses at Boston, Mass., Providence, R. I., Mobile, Ala., Savannah, Ga., New Orleans, La., and San Francisco, Cal., are of this stone, as are also the new Masonic Temple and Ridgeway Library building, in Philadelphia. In Boston alone there are one hundred and sixty-two buildings constructed wholly or in part of this material. Its suitability for interior decorative work can not be better shown than by reference to the polished stairways and pilasters in the new city buildings at Philadelphia.

Other very extensive quarries of hornblende-granite are located at Cape Ann, in the town of Gloucester, where it is stated * that quarrying was commenced as early as 1824 by a Mr. Bates, of Quincy. The largest quarries in the State, and, with the exception of those at Vinalhaven, Me., the largest works now in operation in the United States, are situated at this place. Like that of Quincy the rock is hornblendic, though frequently considerable black mica is present.† The texture is coarse and the color greenish, owing to the orthoclase it contains. Some varieties are, however, simply gray. It is a hard, tough rock, eminently durable, and well suited for all manner of general building and ornamental work. The stone has been used in the construction of the post-office and several churches and private buildings in Boston, and the Butler house on Capitol Hill at Washington.

Other hornblendic granites, somewhat similar in appearance, are quarried at Rockport, Peabody, Wyoma, Lynn, and Lynnfield, all of which are represented in the Museum collection. The Rockport stone is the most important of these, and has been quarried since 1830. In color and texture it is indistinguishable from much of the Gloucester stone, but, if anything, is of a more decided greenish hue. In the quarries it is extremely massive, and blocks 100 feet long by 50 feet wide and 16

* History of Gloucester, Cape Ann, by J. J. Babson, p. 577.

† The black mica of the Gloucester and Rockport granites has been shown by Professors Dana and Cooke to be lepidomelane or annite. (Text book of Mineralogy, p. 313).

feet thick have been loosened from the bed in a single piece, while it is estimated a block 200 feet long 50 feet wide and 20 feet thick could be obtained if desired. The principal markets are New York, Boston, New Orleans, and Cuba.

Biotite granites.—Several important quarries of coarse biotite granite are worked in this State, but their product is mostly used in the near vicinity. Light pink varieties admirably adapted for rock-faced work occur at Brockton, Milford, and North Easton. The Milford stone, though not extensively quarried, is particularly effective when used in this manner, as is well illustrated in the new city hall at Albany, N. Y., and also in the new railway station at Auburndale, Mass. At Framingham, Leominster, Fitchburgh, Clinton, Fall River, and Freetown are also quarries of coarse gray but apparently strong and durable granites of this class.

Epidote granite.—This is a rare variety of granite in this country, the quarries at Dedham producing all that is now upon the market. The stone is fine-grained and of a light pink color. Besides epidote, which is visible to the naked eye as small greenish specks, it contains numerous flecks of chlorite, resulting from the alteration of a black mica. The stone works readily and gives very pleasing effects either in polished or rock-face work. It is of this stone that was constructed the new Trinity Church in Boston, and which is considered by good authorities to be, from an architectural standpoint, the finest building in America.

Gneiss.—A fine-grained very light gray, sometimes pinkish, muscovite gneiss of excellent quality has been quarried more or less for the past thirty-five years near the town of Westford. Other quarries of gneiss are at West Andover, Lawrence, Lowell, Ayer, several towns in Worcester County, at Becket, Northfield, and Monson, as will be noted in the tables.

Being in most cases distinctly stratified, these gneisses are not adapted to so wide a range of application as the massive granites, but at the same time the ease with which in many cases they can be quarried makes them particularly valuable for foundations, bridge abutments, curbing, paving, and rock-faced building. At the Monson quarries, for instance, the rock is divided by a series of joints, approximately parallel to the surface of the hill on which the quarries are situated, into immense lenticular sheets from 6 inches to 10 feet in thicknes. By taking advantage of these natural facilities a block was split out in 1869 which measured 354 feet in length by 11 feet in width and 4 feet in thickness. An analysis of the Monson stone from the Flynt quarry is given in the tables.

As a general rule it may be stated that while the granites and gneisses of Massachusetts are good and safeworking stones they are coarse and in no way remarkable for their beauty. In the matter of color and texture they bear a striking contrast to the fine and even grained stones of her sister States, Connecticut and Rhode Island.

Minnesota.—According to Professor Winchell more than half the State of Minnesota is underlaid by that general class of rocks—the crystalline—to which granite belongs. In the northern part of the State there are large exposures of very fine light-colored granites, but being beyond the limits of settlements and roads those in the southern and western part, in the country bordering along the Mississippi and Minnesota Rivers, are of more especial interest and importance. These last have been somewhat quarried and the materials can be seen in some of the principal buildings in various parts of the State, as well as in cities beyond the State limits. The first quarry in these rocks in Minnesota was that now owned by Breen & Young, at East Saint Cloud, Sherburne County.

This was opened in 1868, and the stone first taken out was used in the corners, steps, and trimmings of the United States custom-house and post-office in Saint Paul. Three kinds of stone were taken out and used indiscriminately, and all of them may be seen in the building first erected. The variety now more generally used is of a gray color and uniform texture. The crystalline grains are rather fine, so that the texture is close. The color, however, is sometimes disturbed by the appearance of greenish spots of the size of butternuts or even as large as 6 inches in diameter, caused by segregations of a green chlorite. "About one-third of the whole rock is made up of quartz, and two-thirds of the remainder of orthoclase. About one-half the remainder is hornblende and the residue is divided between the other minerals, the chlorite predominating." An occasional grain of a triclinic feldspar is present together with magnetite and pyrite in minute crystals.†

"The red granite from East Saint Cloud is not very different from the foregoing, but the feldspar is mainly flesh red and all the grains are coarser." It also has a higher per cent. of silica, a fact that has been discovered practically by the owners, who had given up the general use of it because of it being more costly to work. "* * * In the winter of 1874–5 a block weighing ten tons was taken out of the red-granite quarry, about 3 miles west of Saint Cloud, for a monument base. * * * It was very fine, and greatly resembled the Scotch granite in color, grain, and polish. At the point where this was taken out the granite rises about 20 feet above the general surface and spreads over more than an acre. A similar red granite occurs at Watab (in Benton County), and has furnished several handsome monuments." A light-gray granite also occurs here.*

At Sauk Rapids, in the same county, there is found a fine-grained gray granite closely resembling the gray variety from East Saint Cloud.

* See Geol. and Natural Hist. Survey of Minnesota, Vol. I, pages 142–148.

† These rocks are designated in Professor Winchell's report above referred to as "Syenites." According to the system of classification now generally adopted, they are rather hornblendic or hornblende-biotite granites, as designated by the author in the census report, p. 90. The name *syenite*, as already noted, is applied to a quartzless rock (see pp. 308 and 430).

It has been quite generally used, and is one of the best-known granites in the State.

Missouri.—Although there are inexhaustible quantities of granite in the northern part of Iron and Madison Counties and the southern portion of Saint Francois, there are but few quarries of the material systematically worked.

At Graniteville, Iron County, and in Syenite, Saint Francois County, there occurs a coarse red granite, quite poor in mica, which is now extensively quarried for the Saint Louis and Chicago markets. It is somewhat lighter in color than the well known Scotch granite, but is admirably suited for massive structural purposes, as is well illustrated in the lower stories of the fine business blocks erected during the season of 1886 on Adams street, between Fifth avenue and Franklin, and on the corner of Adams and La Salle streets, in Chicago. The enormous blocks of rock-faced granite and large polished columns of this stone as here displayed* would indicate that this is destined to be one of the leading granites of this portion of the country. It admits of a high lustrous polish and is coming into use for monumental work.

Montana.—There is a plenty of good granite within the limits of the Territory, but for lack of a market scarcely any quarrying is at present carried on.

A cube of a fine-grained light-gray biotite granite was received at the National Museum from Lewis and Clark Counties, but so far as the writer is aware the quarry has never been worked to any extent. A coarse hornblende-mica granite of a greenish-gray color and somewhat resembling the celebrated Quincy and Gloucester (Massachusetts) stone forms the country rock in the region of the celebrated silver and copper mines of Butte, and is beginning to be used for purposes of heavy foundation and general building. So far as the writer was able to judge, from the short time he was on the ground, the rock is of excellent quality, but needs to be selected with care, as certain portions, those in proximity to the ore veins, are abundantly charged with pyrite, which oxidizes readily on exposure.

New Hampshire.—Although New Hampshire is popularly known as the "Granite State," in value of total product of the material it anks but fifth in the list of New England States, being preceded by Maine, Massachusetts, Connecticut, and Rhode Island. However this may be there are but few of our building stone that have a wider reputation than the fine light-gray muscovite-biotite granites from quarries near Concord.

* The window-sills in the first of the above-mentioned buildings are rough blocks of granite, each 3 feet square by 17 feet 4 inches long, and weighing about 10 tons each. The polished columns of the building corner of Adams and La Salle streets are ten in number, each 18 feet high by 4½ feet in diameter, and weighing not far from 18 tons. The largest single block of polished granite yet produced at these works is the Allen monument, in Saint Louis, which is 42 feet in height by 4½ feet square at the base. The weight is about 45 tons.

These rocks have been quarried for many years and very extensively used for all manner of constructive purposes. The following list includes some of the more important buildings and monuments made wholly or in part from this material: Charter Oak Insurance Building, Hartford, Conn.; soldiers' monument, at Manchester, N. H.; monument to the discoverer of anesthetics; the Germania Savings Bank; Equitable Life Insurance; Masonic Temple; Massachusetts State prison, and some seventy-five other buildings in Boston, and Booth's Theater in New York.

According to Professor Hitchcock, the more important quarries are situated on what is known as Rattlesnake Hill, an elevation some 600 feet above the level of the Merrimac River, and which consists almost entirely of granite rocks. Other granites of this class occur and are quarried at Allentown, Sunapee, and Peterborough, and are used for similar purposes, though they are not widely known outside of New England. Gray biotite granites of good quality are quarried at Mason, Fitzwilliam, Rumney, Hanover, Portsmouth, and other towns, as noticed in the tables.

The Peterborough, Mason, and Fitzwilliam are exported to some extent to the neighboring States, but the others mentioned are used in the near vicinity.

The New Hampshire granites are nearly without exception of fine and even grain and well adapted for all kinds of work. The Concord rock is practically identical both in general appearance and mineral composition with that of Hallowell, Maine, already described.

New York.—This State, although rich in marbles, limestones, and sandstones, produces little of general interest in the way of granite rock. A coarse, gray biotite gneiss is quarried at Hastings-upon-Hudson, in Westchester County; a somewhat darker hornblendic gneiss at Cold Spring, in Putnam County; and a coarse red hornblendic granite at Clayton, in Jefferson County.

The gneisses are quarried chiefly for the rough work of foundations in the vicinity. The red granite from Grindstone Island (Clayton post-office) is a beautiful stone and takes a fine polish. The sample forwarded to the National Museum, however, contains particles of iron pyrite, which unfit it for monumental work. The present product of the quarry is made into paving blocks and monuments, principally for Chicago, Ill., and Montreal, Canada, though two beautiful columns of it are to be seen in the new capitol building at Albany, N. Y.

New Jersey.—Aside from a single quarry of greenish-gray gneiss at Dover, Morris County, in this State, no granitic or gneissic rocks are anywhere regularly worked within the State limits. But "Gneissic rocks are found in a few localities in thick beds and so jointed that large and regular blocks can be quarried out at a comparatively small cost. Of the quarries that have been opened and worked to any extent that at Dover alone is kept steadily in operation. It furnishes a large

amount of stone annually for railroad construction along the line of the Delaware, Lackawanna and Western Railroad. The same rock occurs along the New York, Ontario, and Western Railroad from Pompton to Franklin, and at several points its outcrops have been opened for stone. The Sussex and Central Railroad lines also cross the rock. A large quarry was opened a few years ago near Franklin, on the mountain east of the village, but the place, though promising, was soon abandoned. The stone was adapted for heavy work. The transportation appeared to be too expensive for it to compete with stone coming by water routes."*

Pennsylvania.—Although ranking as second in importance in the list of stone-producing States, Pennsylvania furnishes very little in the way of granitic rock, and absolutely nothing in this line of more than local interest. "The southern gneissic district, described in the geological reports of Pennsylvania as ranging from the Delaware River at Trenton to the Susquehanna, south of the State line and lying south of the limestone valley of Montgomery, is the district in which are located nearly all the quarries of gneiss in the State, and those furnishing most of the material are in the vicinity of Philadelphia." The rock, which is for the most part a dark-gray hornblende gneiss, is quarried at Rittenhousetown, Twenty-first ward, and Germantown, Twenty-second ward, and Jenkinstown, in Montgomery County, and is used principally for the rough work of foundations in the near vicinity. In Chester, Delaware County, the gneiss bears mica in place of hornblende and is, as a rule, lighter in color. The quarries are in close proximity to the Delaware River, which affords an easy method of transportation to Philadelphia, the principal market. This stone is also used almost wholly for foundations, though in some cases it has been used as rock-faced work in the fronts of private dwellings, with rather a pleasing effect.

Rhode Island.—The granites of this State are nearly all fine-grained light gray or pink biotite granites, the principal quarries of which are situated some 2 miles east from Westerly, in Washington County. The rock is of fine and even texture and of excellent quality, and is much used for monumental work and general building. Other quarries of biotite granite occur at Smithfield, West Greenwich, Newport, and Niantic. A greenish, fine gray, hornblendic gneiss is quarried at Diamond Hill, in Providence County. Aside from the Westerly rock the most of this material is for local market only.

Tennessee.—At the present time scarcely anything in the line of granitic rock is quarried in this State, and owing to the limited areas occupied by granite ledges it is more than doubtful if the granite quarrying ever assumes any great importance. Small outcrops of granite, gneiss, or mica schist occur in the extreme eastern and southern parts of Polk, Monroe, Cocke, Washington, Carter, and Johnson Counties, in the eastern part of the State, but even these are not in all cases suitable for

* Ann. Rep. of State Geologist of New Jersey, 1886, pp. 41–42.

any but the roughest work. The Museum collections contain an extremely coarse greenish epidotic granite, with large red porphyritic crystals of orthoclase, from Bench Mountain, in Cocke County, which might perhaps be worked if there were a market.

South Carolina.—Although no granites from this State are to be found in our principal markets, it by no means follows that there is any deficiency in the supply. The collection now in the Museum shows, on the contrary, that excellent stones of this class occur in various localities.

Near Winnsborough, in Fairfield County, quarries have recently been opened which furnish fine-grained gray biotite granite fully equal to any in the market. The quarries, as we are informed by the owner, Mr. W. Woodward, cover some 70 acres of bowlders and two large ledges, one 11 acres in extent and the other 6. The stone works readily and acquires an excellent polish. A pinkish granite also occurs in this same county. Other granites in this State, of which we have seen specimens, but concerning which we have but little accurate information, occur near Columbia, Richland County; and in Newberry, Lexington, Edgefield, and Aiken Counties. The Columbia stone is of a light-gray color, apparently of excellent quality. It was used in the construction of the State house in that city, and is stated to be very durable.*

Texas.—Red granites, both coarse and fine, occur in Burnet County, in this State, though at present neither are quarried to any extent. Both varieties carry biotite as the chief accessory mineral. The coarser variety corresponds closely with the coarse red granite from Platte Cañon, Colo. Their colors are dull and they seem better adapted for rough building than for monumental work.

Utah Territory.—A coarse, light-gray granite occurs in inexhaustible quantities in Little Cottonwood Cañon, not far from Salt Lake City. So far the stone has been quarried only from bowlders that have been rolled down the cañon, and the parent ledge remains untouched. This stone has been used in the construction of the new Mormon temple at Salt Lake City.

Vermont.—This State furnishes but little in the way of granitic rocks, from the fact that few of her quarries produce material not found elsewhere in New England, where there are better and cheaper facilities for transportation. Quarries of biotite granite of fine grain and a gray color are, however, worked at Barre, Brunswick, Morgan, Ryegate, and Woodbury. A very light, almost white, muscovite granite is also quarried at Bethel. The most of these rocks are for local use only, though that from Brunswick is said to be carried to some extent into the neighboring cities in New York State.

Wyoming.—"The only building stone which is quarried in Wyoming is at Sherman, the highest point of the Northern Pacific Railroad. At this point—the summit of the Black Hills—the road cuts through a heavy

* South Carolina, Resources, Population, etc., 1883, p. 609.

body of red granite similar to the Scotch, but with much larger crystals." This stone has been used to some extent in San Francisco and Sacramento, but is hard to work, owing to its coarseness and lack of tenacity.*

Virginia.—The granites of this State are, as a rule, fine-grained, biotite-bearing rocks, and of a light-gray color. They correspond in a remarkable degree with the granites of New England, more so than those of any Southern or Western State. The principal quarries, thus far developed are in Chesterfield and Henrico Counties on the James River, and within easy reach of the Richmond market.

The quarry of the Richmond Granite Company, on the Richmond and Alleghany Railroad, near Richmond, produces a massive gray granite used for general building purposes, paving stone, and monumental work, and which is shipped more or less to all the States and cities south of New England and as far west as Nebraska. Much of the material is dressed at the quarry, polishing works being located on the ground.

The Old Dominion Granite Company and the Westham Granite Company, in Chesterfield County, produce a very similar stone, the principal markets of which are in Richmond, Washington, Norfolk, Lynchburgh, and Philadelphia. Other important quarries are in the Tuckahoe district, Henrico County, and Namozine district, Dinwiddie County. Stone from the last-named locality was used in the construction of the post-office and custom-house at Petersburgh, Va. The most important building yet constructed of the Virginia granites is the State, War, and Navy building in Washington, which is probably the most elaborate granite structure in the country. Near Fredericksburgh is found a fine light-gray muscovite-biotite granite closely resembling those of Hallowell, Me., and Concord, N. H., but it is not at present quarried to any extent.

Wisconsin.—The extensive outcrops of granite rock in this State have been scarcely at all worked up to the present time, owing to the lack of transportation facilities. At the present writing the most important quarries are at Montello, Marquette County, and Wausau, Marathon County. The Montello rock is very fine grained, compact, and of a dull pink color. Quarries were first opened here to furnish paving stones for the Chicago market, but the stone has since been used to a considerable extent for general building and monumental work.

According to Prof. T. C. Chamberlain† the great Laurentian area of the northern part of the State is occupied largely by granite and gneiss, among which are some of exceptional excellence. Granite rocks of greater or less excellence crop out along the upper reaches and tributaries of the Menominee, the Peshtigo, the Oconto, the Wolf, the Wisconsin, the Yellow, the Black, the Chippewa, the Flambeau, the Bad, and the Montreal Rivers. These are now being brought within the reach of cheap transportation, and should be utilized to the mutual benefit of those who work and those who use.

* Report Tenth Census, Vol. X, p. 278. † Geology of Wisconsin, Vol. I, p. 66.