STONE.[1]

By William C. Day.

VALUE OF VARIOUS KINDS OF STONE PRODUCED IN 1893 AND 1894.

The following table shows the production of the various kinds of stone in the United States in the years 1893 and 1894:

Value of different kinds of stone produced in the United States during the years 1893 and 1894.

Kinds.	1893.	1894.
Granite	$8,808,934	$10,029,156
Marble	2,411,092	3,199,585
Slate	2,523,173	2,790,324
Sandstone	5,195,151	3,945,847
Limestone	13,947,223	16,512,904
Bluestone	*a*1,000,000	*a*900,000
Total	33,885,573	37,377,816

a Estimated.

An inspection of this table shows a gain of $3,492,243 for the year 1894 for all the kinds of stone considered. Production of granite, marble, slate, and limestone has increased, while a falling off is evident in the cases of sandstone and bluestone.

The gain in granite output is due to the increased business of quite a small number of important producers, chiefly in New England. Many small producers have not, however, enjoyed prosperity; in not a few instances, indeed, quite the reverse has been true, even to the extent of a complete shutting down of all operations on the part of some, owing to the depression which has been felt by all commercial enterprises during the past two years.

The increase in marble output is due to increased activity in Georgia and New York.

[1] To Mr. William A. Raborg, of the United States Geological Survey, I am especially indebted for the intelligence and unremitting zeal with which he has cooperated in the difficult work of securing and tabulating the statistics of this report.

It is almost unnecessary to state that the statistical data of this report are obtained by direct individual correspondence with the stone producers of the United States. To the thousands of quarrymen who have courteously and promptly replied to the inquiries addressed to them in connection with this and former reports, my grateful acknowledgments are due. The feeling of cooperation shown by quarrymen in contributing to the value of the report by their replies, and the interest which they have always shown in the published results, make the duty of distributing among them copies of this article a gratifying one.

In the preparation of this report I have been aided by a number of the technological articles and items which have appeared from time to time in the journal "Stone," and which are elsewhere individually credited, and also by the courteous cooperation of the editor of that journal in calling the attention of stone producers to the importance of replying promptly and fully to the inquiries addressed to them.

In the consideration of the constituent minerals of the granitic rocks, I have followed, in general, the classifications adopted in the Tenth Census Report on the Building Stones of the United States.

The slate industry during the past year has been recovering lost ground to some extent, but the activity shown in 1894 is very noticeably less than that which has characterized the early part of the present year, 1895.

For reasons given further on in connection with the sandstone article, the production of sandstone has fallen off very decidedly.

Limestone shows a very marked increase, but this may be accounted for in part by the exceptionally thorough and searching canvass of the limestone producers which has been made in compiling the statistical data for 1894.

The figure for bluestone is an estimate, but is made on satisfactory evidence of a general character and is probably quite close to the truth in showing, as it does, a falling off in valuation. Prices for bluestone have been declining for sometime past.

VALUE OF STONE PRODUCED IN 1894, BY STATES.

The following table shows the values of the different kinds of stone produced in 1894, by States:

Value of various kinds of stone produced in 1894, by States.

States.	Granite.	Sandstone.	Slate.	Marble.	Limestone.	Total.
Alabama		$18,100			$210,269	$228,369
Arizona					19,810	19,810
Arkansas	$28,100	2,365			38,228	68,693
California	307,000	10,087	$5,850	$13,420	288,900	625,257
Colorado	49,302	69,105			132,170	250,577
Connecticut	504,390	322,934			204,414	1,031,738
Delaware	173,805					173,805
Florida					30,639	30,639
Georgia	511,804	11,300	22,500	724,385	32,000	1,301,989
Idaho		10,529		3,000	5,315	18,844
Illinois		10,732			2,555,952	2,566,684
Indiana		22,120			1,203,108	1,225,228
Iowa		11,639			616,630	628,269
Kansas		30,265			241,039	271,304
Kentucky		27,868			113,934	141,802
Maine	1,551,036		146,838		810,089	2,507,963
Maryland	308,966	3,450	153,068	175,000	672,786	1,313,270
Massachusetts	1,994,830	150,231			195,982	2,341,043
Michigan		34,066			336,287	370,353
Minnesota	153,936	8,415			291,263	453,614
Missouri	98,757	131,687			578,802	809,246
Montana	5,800	16,500			92,970	115,270
Nebraska					8,228	8,228
Nevada	1,600					1,600
New Hampshire	724,702					724,702
New Jersey	310,965	217,941	1,050		193,523	723,479
New Mexico		300			4,910	5,210
New York	140,618	450,992	44,542	501,585	1,378,851	2,516,588
North Carolina	108,993					108,993
Ohio		1,777,034			1,733,477	3,510,511
Oregon	4,993					4,993
Pennsylvania	600,000	349,787	1,620,158	50,000	2,625,562	5,245,507
Rhode Island	1,211,439				20,433	1,231,872
South Carolina	45,899				25,100	70,999
South Dakota	8,806	9,000			3,663	21,469
Tennessee				231,796	188,664	420,460
Texas		62,350			41,526	103,876
Utah		15,428			23,696	39,124
Vermont	893,956		658,167	1,500,399	408,810	3,461,332
Virginia	123,361	2,258	138,151		284,547	548,317
Washington	166,098	6,611			59,148	231,857
West Virginia		63,865			43,773	107,638
Wisconsin		94,888			798,406	893,294
Wyoming		4,000				4,000
Total	10,029,156	3,945,847	2,790,324	3,199,585	16,512,904	*a* 37,377,816

a Includes $900,000, the value of production of bluestone.

THE GRANITE INDUSTRY.

THE TERM "GRANITE" AS USED IN THIS REPORT.

The term "granite," as it is used in this report, might more properly, from the strictly scientific standpoint, be replaced by the designation "crystalline siliceous rocks." Since, however, the report is of interest chiefly as a statistical production, and is intended to give to those interested in the commercial aspects of the subject information bearing upon not only the true granites, but also upon those rocks whose general properties and industrial applications are the same as those of true granites, it has been thought wiser to use the term "granite" as it is understood by quarrymen. Most of the material included under this head is really true granite, but some of it is granite only in the commercial sense of the term. The tables giving the values of granite output in the various States of the country show, therefore, no distinction between true granites, syenites, trap rocks, gneisses, and crystalline schists.

COMPONENTS OF GRANITE.

The essential components of the true granites are quartz and feldspar. Quite a number of other minerals are, however, to be found in the granites, and these have been classified by Mr. G. P. Merrill, in the Tenth Census report on stone, as follows:

Essential.

Quartz.
Feldspar.
- Orthoclase.
- Microcline.
- Albite.
- Oligoclase.
- Labradorite.

Characterizing accessories.

Mica.
- Muscovite.
- Biotite.
- Phlogopite.
- Lepidolite

Hornblende.
Pyroxene.
Epidote.
Chlorite.
Tourmaline.
Acmite.

Microscopic accessories.

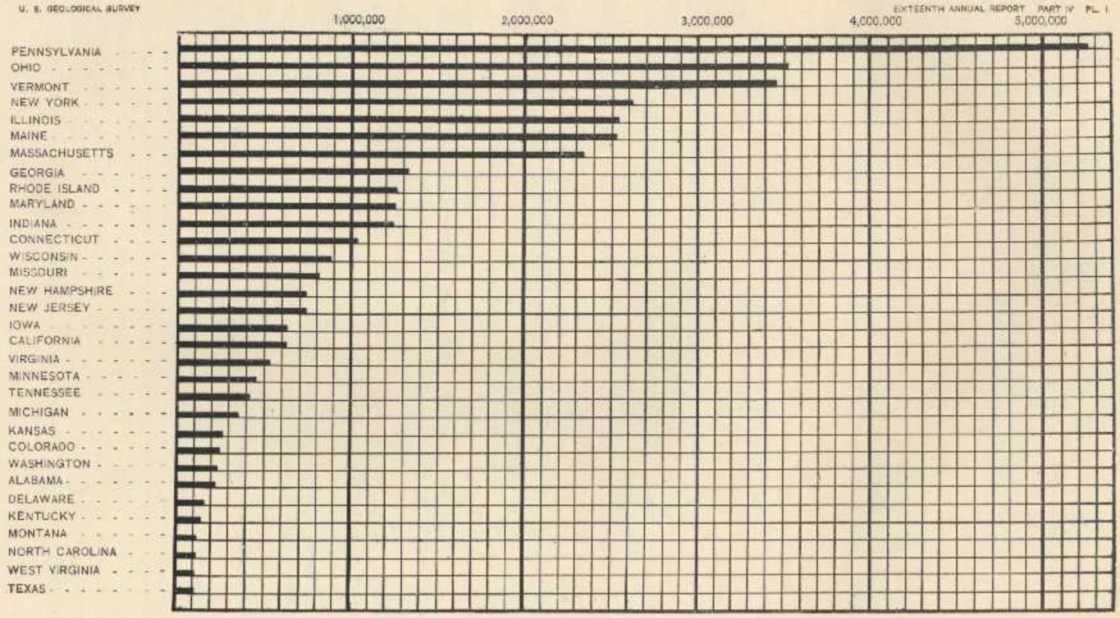
Sphene.
Zircon.
Garnet.
Danalite.
Rutile.
Apatite.
Pyrite.
Pyrrhotite.
Magnetite.
Hematite.
Titanic iron.

Decomposition products.

Chlorite.
Epidote.
Uralite.
Kaolin.
Iron oxides.
Calcite.
Muscovite.

Inclosures in cavities.

Water.
Carbon dioxide.
Sodium chloride.
Potassium chloride.



VALUE OF THE DIFFERENT KINDS OF STONE PRODUCED IN THE VARIOUS STATES DURING THE YEAR 1894.
(In millions of dollars.)

The following statements relative to the minerals to be found in granites is a condensed abstract of matter contained in the Tenth Census report on stone, referred to above:

Of the two essential minerals, quartz and feldspar, the former is invariable in composition; but in the form of the particles and in appearance it is quite variable. As is evident from the enumeration of the various kinds of feldspar already given, there is much latitude for differences in granites, due to the feldspathic constituent. According to the kinds of feldspar present, the granite shows a number of variations in color, which may due to the color of the feldspar itself or to its transparent or semitransparent character, and its consequent effect upon light. Red and pink granites owe their color to the feldspars contained in them; dark effects in granite are sometimes caused by the absorption of light effected by transparent crystals of feldspar. While the hardness of quartz is always much the same, that of the feldspars is subject to considerable variation in its resistance to the stonecutter's tools.

The variation in the amounts and the kinds of accessory ingredients is great, and these determine very largely the character of the stone as to its resistance to disintegrating agencies, its strength, its color, and its susceptibility to ornamentation or polish. Of these accessories mica is the most common. White muscovite gives a light effect to the stone, but if it appears in the form of black biotite the granite is dark in general tone. Much interest attaches to mica as a granitic constituent, for, while its color effect may be very attractive, it does not polish so well as the other constituents, nor does it retain polish so well, frequently becoming dull on exposure. In stone for polishing the manner of occurrence of the mica particles is of importance as well as their amount. Numerous fine particles are less objectionable, if scattered promsicuously, than are occasionally occurring larger crystals.

Mica is frequently replaced wholly or in part by the minerals hornblende and pyroxene. Both minerals are frequently present in the same rock. Hornblende is more desirable than mica as a constituent of granite, having cleavage in two planes instead of one, as in mica, and polishing much more easily. Pyroxene is more brittle than hornblende, and is therefore liable to break out in polishing, leaving little pits which mar the surface. The presence of pyroxene in granite is sometimes a source of much vexation to the quarryman and stonecutter. Of the three minerals, mica, hornblende, and pyroxene, the second is, all things considered, the most desirable as a constituent of granite.

CLASSIFICATION OF UNITED STATES GRANITES.

According to the Tenth Census report on stone, the granites quarried throughout the United States may be classed as follows:

Muscovite granite, biotite granite, muscovite-biotite granite, hornblende granite, hornblende-biotite granite, epidote granite, granitel (or granite without any accessory). Lines of distinction between these varieties are by no means sharply drawn, one kind gradually merging into another in many cases.

Muscovite granite.—This variety is always light in color, from the nearly colorless character of the muscovite. Comparatively little is quarried in the United States. A highly important example is that produced at Barre, Vt.

Biotite granite.—The biotite granites are the most widespread of all the varieties named above. In color they vary from light to very dark, according to the amount of mica present and the color of the feldspar. Many of the red granites belong to this class, the red color being due to red feldspar. The granites of this class are, as a rule, tough and hard. Good examples are the granites from Dix Island, Maine, Westerly, R. I., and Richmond, Va.

Muscovite-biotite granite.—As the name implies, this granite stands between the two already considered. The essential constituents are quartz, orthoclase, muscovite, and biotite. The Concord, N. H., granite is a good example of this variety; similar to it is the stone from quarries at Allenstown, Sunapee, and Rumney.

Hornblende granite.—In addition to the hornblende contained in this granite as the characterizing accessory, black mica is in nearly all cases likewise to be found. Biotite is found as a microscopic constituent in many hornblende granites, and the name "hornblende granite" is, therefore, restricted to those in which no biotite is visible to the naked eye. Granite belonging to this class is quarried at Peabody, Mass., and also at Mount Desert, Me.

Hornblende-biotite granite.—Some of the most beautiful of our granites belong to this class, notably so-called black granite from St. George, Me., and some of that quarried at Cape Ann, Massachusetts, and at Sauk Rapids, Minn. The essential constituents are quartz, orthoclase, hornblende, and biotite. These granites are susceptible of fine and lasting polish.

Epidote granite.—The granites of this class in the United States are rare, an example being that quarried at Dedham, Mass. The rock works easily and takes a good polish.

Syenite.—The absence of quartz in a granite, or its presence only to the extent of forming an accessory constituent, determines its classification as a syenite. Fine syenites are known to occur, but they have not been extensively quarried.

Gneiss.—Stratification determines the classification of granite as gneiss. Its cleavage enables it to be quarried in the form of slabs suitable for curbing and similar uses in which slabs are desirable. The stratification is largely determined by the uniformity in the direction of the flat cleavage planes of the mica present in it. The terms "bastard granite" and "stratified granite" are commonly used in reference to gneiss. The only essential difference between granite and gneiss being in the matter of stratification in the latter, there is good reason for the use of the single term "granite" as applied to gneiss.

Mica schist.—The minerals present in this rock are essentially quartz and mica. It differs from gneiss in its lack of feldspar. This variety is easily quarried, and is well adapted to foundation construction and bridge work, but it is not in general favor for fine superstructures.

Diabase.—This term includes rocks commonly called trap rock and black granite. The essential minerals are augite and triclinic feldspar. Microscopic accessories are magnetite, titanic iron, and frequently apatite and black mica. These rocks are eruptive and occur in dikes. Examples of this variety are the products of quarries at Weehawken, N. J., and other localities in the same State, and in Pennsylvania and Virginia.

Basalt.—This rock differs from diabase in being of finer texture and of more recent origin. In California this rock is extensively employed in the manufacture of paving blocks.

Porphyry.—In this rock the constituent minerals, essentially quartz and orthoclase feldspar, are exceedingly minute, making the rock compact and close-grained. They are of eruptive origin and occur in dikes, like trap rocks. They show considerable variation in color, are almost indestructible, and take a fine polish. They are cut with difficulty and their hardness and lack of stratification constitute serious obstacles in quarrying. In this connection the reader is reminded of the interesting rediscovery of the ancient Egyptian quarries of porphyry described in the Report on Mineral Resources for 1893. Steps have been taken toward the reworking of these long-abandoned quarries by Messrs. Farmer and Brindley, of London. Quartz-porphyry is found at Fairfield, Pa.. and at Stone Mountain, Missouri.

GEOGRAPHICAL DISTRIBUTION OF THE VARIOUS CLASSES OF GRANITE.

The following list, from the writer's report on granite for the Eleventh Census, gives a general idea of the geographical distribution of granite, and indicates most of the particular kinds that have been or are now being quarried in the various localities mentioned:

ARKANSAS.

Hornblende-biotite granite	Pulaski County.
Elæolite syenite	Garland County.

CALIFORNIA.

Biotite granite	Placer County.
Hornblende-biotite granite	Placer and Sacramento counties.
Hornblende granite	Placer County.
Quartz diorite	Placer County.
Basalt	Solano, Sonoma, and Alameda counties.
Andesite	Shasta County.
Andesitic tufa	Solano County.
Quartz porphyry	San Bernardino County.
Basaltic tufa	Tehama County.

COLORADO.

Biotite granite	Clear Creek and Jefferson counties.
Muscovite gneiss	Clear Creek County.
Diorite	Chaffee County.
Rhyolite	Chaffee and Conejos counties.
Rhyolitic tufa	Douglas County.
Basalt	Jefferson County.

CONNECTICUT.

Biotite granite	Litchfield, New Haven, New London, and Fairfield counties.
Muscovite-biotite granite	Litchfield County.
Muscovite-biotite gneiss	Litchfield County.
Biotite gneiss	Litchfield, New Haven, New London, Windham, Tolland, and Hartford counties.
Hornblende-biotite gneiss	Middlesex and Fairfield counties.
Diabase	New Haven County.

DELAWARE.

Augite-hornblende gneiss	Newcastle County.

GEORGIA.

Muscovite granite	Dekalb County.
Hornblende-biotite gneiss	Fulton County.

MAINE.

Biotite granite	Knox, York, Washington, Lincoln, Waldo, Oxford, Kennebec, and Hancock counties.
Biotite gneiss	Lincoln, Franklin, and Androscoggin counties.
Muscovite-biotite granite	Kennebec, Waldo, and Franklin counties.
Hornblende-biotite granite	Penobscot and Knox counties.
Hornblende granite	Hancock County.
Olivine diabase	Washington County.
Diabase	Washington and Knox counties.

MARYLAND.

Biotite granite	Baltimore, Howard, and Montgomery counties.
Biotite gneiss	Cecil and Baltimore counties.
Gabbro	Baltimore County.

MASSACHUSETTS.

Hornblende granite	Norfolk and Essex counties.
Hornblende-biotite granite	Essex County.
Epidote granite	Norfolk County.
Biotite granite	Norfolk, Middlesex, Bristol, Worcester, and Plymouth counties.
Biotite-muscovite granite	Worcester and Berkshire counties.
Biotite gneiss	Franklin County.
Muscovite gneiss	Middlesex, Essex, Worcester, and Hampden counties.
Diabase	Middlesex and Hampden counties.
Melaphyre	Suffolk County.

MINNESOTA.

Hornblende granite	Sherburne, Benton, and Lake counties.
Hornblende-mica granite	Benton County.
Quartz porphyry	Lake and St. Louis counties.
Diabase	St. Louis County.
Olivine diabase	Chisago County.
Gabbro	St. Louis County.

MISSOURI.

Hornblende-biotite granite	Iron and St. François counties.
Granite	Iron County.
Olivine diabase	Iron County.

MONTANA.

Hornblende-mica granite	Lewis and Clarke County.

NEVADA.

Hornblende andesite	Washoe County.

NEW HAMPSHIRE.

Biotite-muscovite granite	Merrimack, Cheshire, Hillsboro, Grafton, Sullivan, and Strafford counties.
Biotite granite	Cheshire, Hillsboro, Grafton, and Rockingham counties.
Hornblende-biotite granite	Carroll County.
Muscovite-biotite gneiss	Cheshire and Hillsboro counties.
Biotite-epidote gneiss	Grafton County.

NEW JERSEY.

Biotite gneiss	Passaic County.
Hornblende granite	Morris County.
Diabase	Hudson County.

NEW YORK.

Biotite granite	Putnam County.
Hornblende-mica granite	Jefferson County.
Norite	Essex County.
Biotite gneiss	Westchester and Rockland counties.

NORTH CAROLINA.

Biotite granite	Warren, Franklin, Gaston, Granville, Alamance, Davidson, Mecklenburg, Iredell, Forsyth, Guilford, Richmond, and Anson counties.
Muscovite granite	Warren County.
Granite	Rowan and Orange counties.
Biotite-muscovite granite	Rowan County.
Hornblende-biotite granite	Mecklenburg County.
Biotite gneiss	Cleveland, McDowell, Caldwell, Wilson, Stokes, Iredell, Wake, and Guilford counties.
Hornblende gneiss	Burke County.

OREGON.

Granite	Jackson and Columbia counties.
Diabase	Linn County.
Basalt	Clackamas and Columbia counties.
Andesite	Multnomah County.

PENNSYLVANIA.

Biotite gneiss	Philadelphia and Delaware counties.
Muscovite gneiss	Philadelphia and Berks counties.
Biotite-muscovite gneiss	Delaware County.
Diabase	Adams, York, Berks, and Lancaster counties.
Diorite	Berks County.
Hornblende gneiss	Philadelphia County.

RHODE ISLAND.

Biotite granite	Washington, Kent, and Providence counties.
Granite	Washington County.
Biotite gneiss	Providence County.
Hornblende gneiss	Providence County.

SOUTH CAROLINA.

Biotite granite	Fairfield, Charleston, Aiken, Lexington, Richland, Edgefield, and Newberry counties.
Hornblende-biotite granite	Fairfield County.

SOUTH DAKOTA.

Granite	Minnehaha County.

TEXAS.

Biotite granite	Burnet County.
Diorite	El Paso County.

UTAH.

Hornblende-biotite granite	Salt Lake and Weber counties.

VERMONT.

Biotite granite	Washington and Essex counties.
Muscovite granite	Windsor County.
Biotite-muscovite granite	Caledonia County.
Gabbro.	

VIRGINIA.

Biotite granite	Dinwiddie, Chesterfield, and Henrico counties.
Muscovite granite	Spottsylvania County.
Biotite gneiss	Campbell County.
Biotite schist	Fauquier County.
Diabase	Loudoun and Fauquier counties.

WASHINGTON.

Granite	Stevens County.

WISCONSIN.

Granite	Marquette County.
Hornblende granite	Marathon County.
Quartz porphyry	Green Lake County.
Biotite gneiss	Jackson County.

The following list gives the same data as contained in the preceding one, except that the arrangement is by kinds of granite instead of by States:

Hornblende-biotite granite.—Pulaski County, Ark.; Placer and Sacramento counties, Cal.; Penobscot and Knox counties, Me.; Essex County, Mass.; Iron and St. François counties, Mo.; Carroll County, N. H.; Mecklenburg County, N. C.; Fairfield County, S. C.; Salt Lake and Weber counties, Utah.

Elæolite syenite.—Garland County, Ark.

Quartz diorite.—Placer County, Cal.

Basalt.—Solano, Sonoma, and Alameda counties, Cal.; Jefferson County, Colo.; Clackamas and Columbia counties, Oreg.

Biotite granite.—Placer County, Cal.; Clear Creek and Jefferson counties, Colo.; Litchfield, New Haven, New London, and Fairfield counties, Conn.; Knox, York, Washington, Lincoln, Waldo, Oxford, Kennebec, and Hancock counties, Me.; Baltimore, Howard, and Montgomery counties, Md.; Norfolk, Middlesex, Bristol, Worcester, and Plymouth counties, Mass.; Cheshire, Hillsboro, Grafton, and Rockingham counties, N. H.; Putnam County, N. Y.; Warren, Franklin, Gaston, Granville, Alamance, Davidson, Mecklenburg, Iredell, Forsyth, Guilford, Richmond, and Anson counties, N. C.; Washington, Kent, and Providence counties, R. I.; Fairfield, Charleston, Aiken, Lexington, Richland, Edgefield, and Newberry counties, S. C.; Burnet County, Tex.; Washington and Essex counties, Vt.; Dinwiddie, Chesterfield, and Henrico counties, Va.

Andesite.—Shasta County, Cal.; Multnomah County, Oreg.

Andesitic tufa.—Solano County, Cal.

Quartz porphyry.—San Bernardino County, Cal.; Lake and St. Louis counties, Minn.; Green Lake County, Wis.

Basaltic tufa.—Tehama County, Cal.

Diorite.—Chaffee County, Colo.; Berks County, Pa.; El Paso County, Tex.

Rhyolite.—Chaffee and Conejos counties, Colo.

Rhyolitic tufa.—Douglas County, Colo.

Muscovite-biotite granite.—Litchfield County, Conn.; Kennebec, Waldo, and Franklin counties, Me.

Muscovite-biotite gneiss.—Litchfield County, Conn.; Cheshire and Hillsboro counties, N. H.

Biotite gneiss.—Litchfield, New Haven, New London, Windham, Tolland, and Hartford counties, Conn.; Lincoln, Franklin, and Androscoggin counties, Me.; Cecil and Baltimore counties, Md.; Franklin County, Mass.; Passaic County, N. J.; Westchester and Rockland counties, N. Y.; Cleveland, McDowell, Caldwell, Wilson, Stokes, Iredell, Wake, and Guilford counties, N. C.; Philadelphia and Delaware counties, Pa.; Providence County, R. I.; Campbell County, Va.; Jackson County, Wis.

Hornblende-biotite gneiss.—Middlesex and Fairfield counties, Conn.; Fulton County, Ga.

Diabase.—New Haven County, Conn.; Washington and Knox counties, Me.; Middlesex and Hampden counties, Mass.; St. Louis County, Minn.; Hudson County, N. J.; Linn County, Oreg.; Adams, York, Berks, and Lancaster counties, Pa.; Loudoun and Fauquier counties, Va.

Augite-hornblende gneiss.—Newcastle County, Del.

Muscovite granite.—Dekalb County, Ga.; Warren County, N. C.; Windsor County, Vt.; Spottsylvania County, Va.

Hornblende granite.—Placer County, Cal.; Hancock County, Me.; Norfolk and Essex counties, Mass.; Sherburne, Benton, and Lake counties, Minn.; Morris County, N. J.; Marathon County, Wis.

Olivine diabase.—Washington County, Me.; Chisago County, Minn.; Iron County, Mo.

Gabbro.—Baltimore County, Md.; St. Louis County, Minn.; Vermont.

Epidote granite.—Norfolk County, Mass.

Biotite-muscovite granite.—Worcester and Berkshire counties, Mass.; Merrimack, Cheshire, Hillsboro, Grafton, Sullivan, and Strafford counties, N. H.

Biotite-muscovite granite.—Rowan County, N. C.; Caledonia County, Vt.

Muscovite gneiss.—Clear Creek County, Colo.; Middlesex, Essex, Worcester, and Hampden counties, Mass.; Philadelphia and Berks counties, Pa.

Melaphyre.—Suffolk County, Mass.

Hornblende-mica granite.—Benton County, Minn.; Lewis and Clarke County, Mont.; Jefferson County, N. Y.

Granite.—Iron County, Mo.; Rowan and Orange counties, N. C.; Jackson and Columbia counties, Oreg.; Washington County, R. I.; Minnehaha County, S. Dak.; Stevens County, Wash.; Marquette County, Wis.

Hornblende andesite.—Washoe County, Nev.

Biotite-epidote gneiss.—Grafton County, N. H.

Norite.—Essex County, N. Y.

Hornblende gneiss.—Burke County, N. C.; Philadelphia County, Pa.; Providence County, R. I.

Biotite-muscovite gneiss.—Delaware County, Pa.

Biotite schist.—Fauquier County, Va.

METHODS OF QUARRYING, CUTTING, AND POLISHING GRANITE.

The following account of methods of quarrying, cutting, and polishing granite in the United States[1] is taken from the Eleventh Census report, for which it was prepared from field notes taken, under the writer's direction, by Mr. Walter B. Smith:

METHODS OF QUARRYING GRANITE.

STRUCTURE OF GRANITE IN PLACE.

The successful and economical working of granite quarries depends upon an intelligent application of a knowledge of the structure of the rock and its natural divisions in the mass, as well as upon improved methods, tools, and machinery for quarrying. The topographical location of the quarry and its relation to facilities for transportation are important factors that affect the productiveness and greatly modify the actual cost of operations in a given place.

In regions of great dynamic movement, such as most granite localities possess, very large rock masses without seams or fissures do not occur; but these fractures, extending as they do in certain definite directions to each other in the mass, form systems of inchoate joints, which divide it into roughly rectangular and rhombic forms, thus rendering valuable assistance to the quarryman. It is probable that the fissures were caused by pressure operating in certain directions during the origin or uplifting of the rock, and it is even possible for it to have been sufficient to change the molecular arrangement of the component minerals. Even those granites which are apparently normal, and which

[1] Methods of quarrying granite in foreign countries have been well described by H. Lundbohm, of Sweden, in the article on stone in the Report on Mineral Resources for 1893.

reveal no traces of stratification or parallel arrangement of mica or hornblende, are found by quarrymen and stonecutters to split more easily and with a smoother surface in one or more directions than in others. An unequal pressure operating on the mass would have caused certain directions or lines of weakness and account for this, or it may have produced the apparent rearrangement of the feldspar crystals, as found in a few of the granites.

In northern New England particularly most of the fissures, as revealed by quarry openings, are slightly curved, parallel partings conforming in general to the direction of the slope upon which the quarry may be located. They produce a sheeted arrangement of the rock, which bends in ridges or curves in hilltops like anticlinal or quaquaversal folds of sedimentary strata. In addition to these divisional planes there occur one or more systems of vertical joints, the joints of each system running approximately parallel to each other, though the systems cross at varying angles.

It is interesting to note that the direction of easiest cleavage, called by quarrymen the "rift," is parallel to the most numerous natural fractures, and that at right angles to this another direction of cleavage, called the "grain," is parallel to the system having the next greatest number of joints. When the rift of the rock in place is horizontal, or more nearly horizontal than perpendicular, it is customarily called the "lift." The grain, although important, is not generally an eminent feature, and its direction may remain unknown even for a long time after the quarry is opened. These systems of fracture, and the unequal ease of splitting in different directions, are points generally well understood and advantageously used by experienced granite workers.

OPENING THE QUARRY.

Granite quarries are nearly always started in natural outcroppings of the ledge, but as they are entirely open workings, and necessarily cover large areas, considerable development work is needed at first and from time to time, as the quarry is enlarged, in stripping or clearing away the timber and soil and in removing the weathered portions or cap rock. It sometimes happens, especially in the northeastern region, that a ledge is found showing sound granite at the top, ready for quarrying, having been ground smooth by glacier movement and left bare of soil; but usually long exposed outcroppings have a softer outer portion, called "sap," resulting chiefly from the partial decomposition of the feldspar. This also occurs to a less extent along the seams and fissures, and where the rock contains iron the sap is stained by its oxidation to a brownish or reddish color. The sap may be merely a thin coating, scarcely discernible, or it may be that the rock is rendered unsound for 30 feet or more in depth, as is the case with a certain coarse-grained granite occurring in the Rocky Mountains. The observation of such points in the field will serve as indications of the probable durability of the stone and the stability of its color.

BLASTING.

Owing to great diversity in the structure of the rocks classed here as granite, the operations of quarrying necessarily vary considerably, even in different openings of the same region. The object desired is, however, the same in all, namely, the removal of large rectangular blocks with the least outlay of time and labor compatible with keeping the quarry in good working shape and avoiding waste. Ordinarily, to break the rock into sizes which can be handled, blasting is necessary. In doing this the object is to direct the force of the powder so that it may break the rock in the desired direction without shattering either the piece removed or the standing rock, but it can be successful only when it is detached at the ends and bottom and has a chance to move out in front. As the rift in the rock in the majority of quarries approaches the horizontal the first breaks are obviously made either with or across the grain. The method most generally used for doing this is called "lewising," from the shape of the blast hole. A lewis hole is made by drilling close together holes about an inch and a half in diameter and in breaking down the partition between them by means of a flat steel bar, called a "set." This wide hole determines the direction of the required fracture. A "complex" lewis hole is the combination of three ordinary drill holes; a "compound" one, of four; but the latter is seldom used, for if a very long break is to be made a series of lewis holes is drilled at considerable distances apart, and after being charged are fired simultaneously by means of an electric battery.

Another process occasionally used in a few quarries is as follows: A single round hole having been drilled, the explosive is put in, and on top of it an inverted iron wedge, placed between two half-rounds, is carefully lowered; then the tamping is proceeded with in the usual way. When the powder is exploded, the wedge, which is driven forcibly up between the half-rounds, breaks the rock in a direction corresponding to its thin end. One of the worst results of this procedure is that considerable rock near the top of the hole is apt to be huffed or flaked up.

Within a few years past, the Knox system of blasting rock has been introduced and successfully used with general satisfaction in many of the larger quarries. The results obtained are those which were sought for by lewising, but the process is safer, quicker, takes less powder, and, as it never shatters the rock, not only gives good, sound blocks as the product of the blast, but also leaves the standing rock with a perfectly sound, clean face for future operations. A round hole is first drilled to the required depth, and into this is driven a reamer, which produces V-shaped grooves at opposite sides to the entire depth of the hole. The charge is then inserted, and the tamping is done in the usual manner, except that instead of driving the tamping down upon the top of the charge an air space or cushion is reserved between the charge of powder and the tamping and as far above the charge as possible. The explosive has therefore the greatest possible chance for expansion before actually breaking the rock, the tamping being put down only to a sufficient depth to insure firmness of position. The result of this method is that the force of the explosive is directed in the line of the grooves, and no shattering of the rock occurs if it be solid, such as is common in ordinary blasting operations, and, as a consequence, quarrymen are enabled to get out stone of rectangular shape without waste or loss of valuable rock.

Very large blasts or mines are sometimes fired in quarrying granite. A shaft is sunk to the required depth, and from it drifts are run in various directions. These chambers, or drifts, are then charged with explosives and fired. In 1887, at Granite Bend, Missouri, stone enough was broken with one blast to supply the demands of a firm for fifty years. The shaft, which was 85 feet deep, had chambers running in several directions from the bottom, and was charged with 32,700 pounds of black powder.

The explosive used for breaking out dimension stone is black blasting powder, as its action is somewhat slower than that of the various forms of nitroglycerin, and there is consequently less danger of shattering the rock or of weakening it by starting incipient fractures, that may not be detected until it is in place in a building; but for breaking up poor stone, or for getting out rock regardless of size or form, giant powder is frequently employed.

In a quarry having rather thin sheets and numerous vertical joints very good splits may be made with wedges driven between half-rounds (plug and feather) into small holes drilled a few inches apart along a prescribed line, every few feet a deeper hole of a somewhat larger dimension being drilled to guide the fracture; but this process is chiefly used for subdividing the blocks after they have been loosened by powder and for initial splits in quarries where the drift is vertical.

Drills driven either by steam or compressed air are in use for making blast holes in all the principal quarries. The drill is connected with the piston, which is supported by a portable iron tripod, carrying the necessary appliances for regulating its movements. A flexible pipe conveys the motive power in the form of compressed air or steam.

In smaller quarries these holes are drilled by the "jumper" drill, a long, flat-edged steel bar, which a man holds and turns as it rebounds slightly after each of the swinging blows dealt it by heavy sledges.

Steam channeling machines, common in large marble and sandstone quarries, are used on granite by a few quarriers chiefly for making end cuts in stone of exceptional structure, but only to a limited extent, since the great hardness of granite renders the process very slow and expensive.

The large blocks loosened by blasting are broken and split into sizes of the required approximate dimensions by the plug and feather method.

The holes, which are of small diameter, generally not more than three-fourths of an inch, and a few inches only in depth, are made by a drill and hand hammer. Into each hole is inserted two half-rounds or "feathers," tapering pieces of iron, flat on one side and rounded on the other, between which is placed a steel plug or wedge. The wedges are then driven in with a sledge till the strain is sufficient to split the rock.

METHODS OF CUTTING, POLISHING, AND ORNAMENTING GRANITE.

Only a small percentage of granite in rough blocks as it leaves the quarry proper is available for use in this form. Most of it has to be cut to the desired dimensions and brought to the degree of finish required for the special purposes for which it is to be used. Very large blocks and stone designed for uses not requiring fine finish are often worked in the open air, but most quarries have cutting sheds erected near the openings, in which the blocks are worked into their intended form. These sheds vary from merely a rough covering of boards to extensive buildings.

To produce good results great skill is needed by the stonecutter in the manipulation of his tools, and considerable artistic ability is required for the finer kinds of work. From the rough work of simply splitting a block or rudely spalling an ashlar face to the artistic working of highly embellished and complicated statuary carving, a knowledge of the rift and grain is important, as it indicates where heavy blows may be struck and where lighter ones are required.

Owing to the great obduracy of this stone, and the fact that the different minerals composing it vary greatly in hardness, the chief work of shaping it is still performed by hand, probably by much the same process that was used by Egyptian stonecutters more than three thousand years ago. Improvements and inventions have, however, been made from time to time in hand tools, and extensive machinery is now in use for producing certain forms and kinds of finish.

Recent improvements.—The most important improvements of the last decade include the more extended adoption of lathes for turning and polishing columns, urns, etc., and new devices in power machinery for plain polishing. Greater economy and speed are now obtained by the general use of chilled iron globules and crushed steel as abrasive materials and of the pneumatic tool for the ornamentation of surfaces.

Implements for cutting.—The implements used by stonecutters to produce common forms and ordinary finish are as follows:

Chisel.—Various forms and sizes are employed in cutting border drafts, moldings, letters, and ornamental work.

Point.—A piece of steel bar drawn out to a pyramidal end; used for "roughing out" surfaces and removing "bunches."

Hand drills, wedges, and half-rounds.—Used for splitting out blocks.

Hand hammer.—Used in one hand for driving chisels, points, and drills, which are held and guided by the other.

Spalling hammer.—A heavy square-cornered sledge, used for roughly reducing a block by breaking off large chips or spalls from the edges, thus bringing it closer to its intended form.

Pean hammer.—Shaped like a double-edged wedge, with a handle running parallel with the edges; used to remove irregularities by striking squarely upon a surface and wedging or bruising off small chips.

Bush hammer.—Made of rectangular steel plates brought to an edge, bolted together, and attached to a long handle; used in the same manner as the pean hammer, but produces a smoother surface, the degree of smoothness depending upon the number of steel plates in the particular hammer used. These hammers, which are all of the same thickness, are called 4-cut, 5-cut, 6-cut, 8-cut, 10-cut, and 12-cut, according to the number of plates used in their construction.

The size, shape, and finish of a stone depend upon the particular place it is to occupy in a building and the style of architecture. Fronts or walls are laid up in various kinds of ranges, usually designated as coursed range, broken range, broken ashlar, random range, and rubble work. The kind of finish given the face of the stone is called either bush hammered, pean hammered, pointed work, or rock face. These may or may not have a border draft chiseled around their margins. Other kinds of finish are chiseled moldings and carved or polished faces.

The usual process followed by stonecutters in shaping blocks may be generalized as follows: The block, having been split out to about the right size by the plug and feather method, is brought to a plane surface on one side, which is accomplished by knocking off overhanging edges and projections with the spalling hammer or spalling tool. Drafts or ledges are then chiseled along two opposite edges. One draft being completed, the workman lays upon it a wooden strip or rule having parallel edges. A second rule is then sunk in the draft made on the opposite side until the two drafts are in the same plane, which is determined by sighting across the upper edges of the rules. The whole face is then worked down to this plane with the tools necessary for the required fineness of finish, a straightedge being applied from time to time as the work progresses. The point is used for removing rougher projections. This is followed by the pean hammer, and, if a smoother surface is required, it is made by bush hammering, the hammer having the fewest number of plates being used first. The required size of the face being marked out upon this surface, the position of a second face may be determined by chiseling drafts across the ends of an adjacent surface, using for the purpose either a square or a bevel, depending upon the angle it is desired to make with the first face. The projecting rock between the drafts having been removed in the manner used in forming the first surface, a third face may be projected. A winding surface is formed by using in one draft a rule or strip having its edges not parallel, the amount of divergence depending upon the amount of warp required. This rule is sunk till its upper edge is even with the upper edge of the strip, having parallel edges placed upon the opposite edge of the stone.

A cylindrical surface is worked by using curved rules in one direction, and is not as hard a matter as might at first seem. Much difficulty is, however, encountered in laying out and working spiral, conical, and spherical surfaces, as it is first necessary to form plane and cylindrical faces on which to apply the necessary bevels and templets.

GRANITE FOR BUILDING PURPOSES.

By reference to the table giving the output of granite according to purposes, it will be seen that more stone was used for building than for any other purpose. A great amount of labor by the stonecutter is necessary to fit it for its destined place, but much of this work consists in merely squaring up or subdividing the large blocks as hauled from the quarry opening. Much more work is needed on the stone to be used for fronts, trimmings, and certain portions of superstructures, while for special parts, such as polished columns and ornate keystones and capitals, the greatest skill and longest time are required. The general processes of finer finish will, however, be mentioned further on in connection with cemetery, monumental, and decorative purposes, although all stone designed for superstructures, whether rough or finely wrought, has been tabulated under the heading "Building purposes."

GRANITE FOR STREET WORK.

PAVING BLOCKS.

Experience has demonstrated that the best and most enduring streets for heavy traffic in large cities are those paved with stone blocks of proper material and size laid upon a specially prepared bed. The very hard and tough rocks frequently used, though capable of withstanding a maximum amount of wear, soon become smooth and glazed under traffic, and are therefore inferior to a stone which, wearing roughly, affords a better foothold for horses. Many of the granitic rocks possess the right degree of hardness and brittleness, and are largely used for this purpose. This industry has increased largely since 1880, the number of granite blocks made in 1889 in the various States aggregating nearly 62,000,000.

Streets paved with the large-sized block used at first were found to be more difficult to keep in repair, worse for horses, and rougher on vehicles than pavements made of the smaller blocks now in general use. There is no uniform standard of size, as specifications of the various cities call for different sizes, but the variations are not great, and blocks 3½ to 4½ inches wide, 6 to 7 inches deep, and 8 to 12 inches long are generally preferred. In New York City, Brooklyn, and Philadelphia blocks a trifle longer are more commonly used, while in many of the Western and Southern cities the length does not exceed 10 inches. New Orleans, owing to the peculiar nature of its streets, takes blocks much larger.

The manufacture of paving blocks, though an important adjunct of the granite business, varies nevertheless for obvious reasons in many of its details from the ordinary methods of granite cutting. The high skill and fine workmanship of the stone mason are not needed, but a quickness in seeing and taking advantage of the directions of cleavage, as well as a deftness in handling the necessary tools, is requisite.

Specifications call for blocks so quarried or dressed as to present substantially rectangular faces with practically straight edges. The corresponding dimensions of opposite faces must not vary more than one-half inch, and the surface must be free from bunches, depressions, and inequalities exceeding one-half inch.

The tools used for making blocks are knapping hammers, opening hammers, hand hammers, reels, chisels, and, for initial splits, drills, wedges, and half-rounds. When the block maker quarries his own stock it is called "motion work," and the same process is used as in quarrying stone for other purposes, except that, as large blocks are not required, most of it can be done with plug and feather.

Slabs, having been split out in the usual manner to sizes that may be easily turned over and handled by one man, are subdivided into pieces corresponding approximately to the dimensions of the required blocks. This is done by striking repeated blows upon the rock along the line of the desired break with heavy knapping and opening hammers. When a break is to be made crosswise the grain, it is frequently necessary to chisel a light groove across one face, and commonly across the adjacent sides, to guide the fracture produced by striking on the opposite surface with the opening hammer. Good splits can, however, be made along either the rift or grain by the skillful use of the opening hammer alone. Blocks broken out in the manner described are trimmed and finished with the reel, which is a hand hammer having a long, flat, steel head attached to a short handle. Block breakers become very expert in the use of this instrument, and, without making any measurements, turn out in a surprisingly short time a large number of blocks. In Maine, which is far ahead of any other State in the number of blocks made, the entire product of many quarries is used for this exclusive purpose. This is also the case in California, which comes second, though the blocks are manufactured chiefly from the surface "bowlders" or detached masses of basalt so common in Sonoma County. Other quarries, however, in various parts of the country utilize only the "grout," small or irregular shaped pieces, for making paving blocks, and haul the stock to the breakers, who work in sheds; but the greatest number of blocks are made on the spot where the rock is quarried, the workmen being protected during the hottest months by a temporarily spread canvas fly.

Blocks are counted as they are thrown into the cart, which is usually needed to haul them to the shipping point. Several paving-block quarries in Maine are situated on steep mountain slopes so near water communication that blocks may be slid in long board chutes from the quarry directly into the hold of the vessel used for their transportation.

Paving breakers seldom work by the day, but are paid a certain sum per thousand for making the blocks, the price paid in 1889 ranging from $22 to $30, according to the size of block made, kind of stone used, locality, and whether the tools were furnished and the blocks quarried by their employers. Workmen using their own tools are commonly paid $1 more per thousand for the blocks made, and when they quarry the stock they use, from $2 to $5 per thousand is allowed in addition.

CURBING AND BASIN HEADS.

Next in importance to the manufacture of paving blocks, in the division of granite for street work, is the production of long granite slabs for curbstone. Granite having a free rift is preferred for this purpose on account of its better working qualities. The dimensions of ordinary curbstones are from 6 to 12 feet long, 6 to 8 inches thick, and about 2 feet deep. The top edge is made full and square and neatly bush hammered; the face is also bush hammered down about a foot from the top. The ends are dressed smooth, so as to make close joints, and the back of the stone, which is placed next to the sidewalk, is also dressed a few inches from the top.

OTHER USES.

Other applications of granite to street work are for flagstone, for cross walks laid at the intersection of streets, and for gutter stone, but these are dressed, when required, in the usual manner, and need no special comment here.

Granite is largely used for making macadam and telford roads and concrete and artificial stone pavements, though it is seldom quarried expressly for this purpose, but made of spalls, grout, and waste from other quarries. The pieces are broken with sledges where coarse stones are needed, or run through power rock breakers when a finer subdivision is required.

GRANITE FOR CEMETERY, MONUMENTAL, AND DECORATIVE PURPOSES.

A considerable portion of the stone for these uses, especially for small-sized monuments, tombstones, and grave markers, is shipped from the quarries in rough blocks, which are suitably shaped and finished by masons working in town shops or stone yards. Large monuments and large polished blocks for buildings, columns, pilasters, and statuary are generally worked at quarry sheds, polishing mills, or shops not far distant.

There has been a decided increase in the use of polished granite for cemetery purposes since the introduction of machinery for its polishing, which has greatly decreased the price for this kind of finish. For these, as well as for all purposes where a polished surface is desired, as bottom courses in buildings, columns, pilasters, wainscoting, etc., the red, pink, dark-gray, and black varieties are in high favor, since they have a richer look and present a much greater contrast between a hammered or chiseled surface and a polished one; but for granite statuary and ornately carved building blocks, and for all purposes where it is desirable to present fine detail, it is necessary that the granite be of a light color, fine grained, and easily worked to secure the best results.

POLISHED GRANITE.

The varieties of granite susceptible of the highest and most enduring polish are those containing the largest percentages of the hard minerals, quartz and feldspar, quartz being especially important. Hornblende, however, takes a fairly good polish, and contributes largely to the coloring of most dark granites. Pyroxene of the type occurring in the Quincy granites is rather bad, since, owing to its brittleness, it cracks out more or less and leaves small pits in the finished face. Much mica, especially in large plates, is objectionable, as it will not polish, but remains dull and lusterless except where the direction of its cleavage planes happen to coincide with the face of the stone.

After being prepared by bush hammering, the block is transported to the shop or mill to receive further smoothing and its final finish. The surface to be worked upon is brought to a horizontal position and ground smooth with an abrasive material mixed with water and moved about by a revolving iron or steel disk perforated with holes or made of concentric rings. This disk, which is 12 or 14 inches across, is revolved by an upright shaft, to the bottom of which it is fastened, and the power is communicated through a main shaft running overhead. Joints in the upright or counter shaft and its peculiar attachment to the main shaft allow its lower end to be swung over a considerable area, thus permitting the workman who guides it to move it over a surface of stone many times larger than the disk itself.

The abrasive material now almost exclusively used for grinding granite is either chilled-iron globules, steel emery, or crushed steel. A coarse grade is used at first, then a finer kind, and for the last grinding fine emery is often used. Polishing is done in much the same way as grinding, except that a felt-covered disk is used in place of an iron one, and putty powder mixed with a little water, instead of coarser grinding materials. Before the final polish, however, the surface is usually given a dull gloss or "skin coat" by the disk and water alone. A polish is sometimes produced by the use of oxalic acid instead of putty powder, but the polish thus made is less durable. Moldings are ground and polished by means of blocks fitting the grooves dragged back and forth either by power or hand.

Granite for columns, balusters, round posts, and urns is now worked chiefly in lathes, which, for the heaviest work, are made large enough to handle blocks 25 feet long and 5 feet in diameter. Instead of being turned to the desired size by sharp cutting instruments, as in ordinary machines for turning wood and metal, granite is turned or ground away by the wedge-like action of rather thick steel disks, rotated by the pressure of the stone as it slowly turns in the lathe. The disks, which are 6 to 8 inches in diameter, are set at quite an angle to the stone, and move with an automatic carriage along the lathe bed. Large lathes have four disks, two on each side, and a column may be reduced some 2 inches in diameter the whole length of the stone by one lateral movement of the carriages along the bed. The first lathes for turning granite cut only cylindrical or conical columns, but an improved form is so made that templets or patterns may be inserted to guide the carriages, and columns having any desired swell may be as readily turned. For fine grinding and polishing the granite is transferred to another lathe, where the only machinery used is to produce a simple turning or revolution of the stone against iron blocks carrying the necessary grinding or polishing materials.

Blocks are prepared for lathe work by being roughed out with a point, and by having holes chiseled in their squared ends for the reception of the lathe dog and centers. This principal of cutting granite by means of disks revolved by contact with the stone has been also applied to the dressing of plain surfaces, the stone worked upon being mounted upon a traveling carriage and made to pass under a series of disks mounted in a stationary upright frame.

Tracery and lettering for polished granite are usually first drawn upon paper which is firmly pasted to the surface and the design chiseled through to the requisite depth in the rock.

CARVED GRANITE.

Statues, capitals, keystones, and, in general, all highly ornamental designs, are worked out with chisels from detail drawings or plaster casts. It is necessarily a slow process, owing to the hardness of the rock, and the cost of such work is consequently great. The MacCoy pneumatic tool, however, which has been recently patented and successfully applied to this purpose, gives promise of superseding much of the tediousness of the hand process. This instrument is connected to a flexible pipe, supplying the compressed air or steam by which it is driven, and works at a remarkably high rate of speed. It may be moved to any part of a surface, and works with a celerity unapproached by other means.

The use of granite for sculpture is steadily increasing, particularly for outdoor statuary. The white fine-grained muscovite-biotite granite found at Hallowell, Manchester, and Augusta, in Maine, is particularly well adapted for this purpose. Statues made of the Hallowell granite are to be found in nearly every State, though possibly the stone is not superior to varieties found in other localities.

VALUE OF THE GRANITE PRODUCT, BY STATES.

The following table shows the value of the granite product, by States, for the year 1894:

Value of granite product in 1894, by States.

States.	Value.
Arkansas	$28,100
California	307,000
Colorado	49,302
Connecticut	504,390
Delaware	173,805
Georgia	511,804
Maine	1,551,036
Maryland	308,966
Massachusetts	1,994,830
Minnesota	153,936
Missouri	98,757
Montana	5,800
Nevada	1,600
New Hampshire	724,702
New Jersey	310,965
New York	140,618
North Carolina	108,993
Oregon	4,993
Pennsylvania	600,000
Rhode Island	1,211,439
South Carolina	45,899
South Dakota	8,806
Vermont	893,956
Virginia	123,361
Wisconsin	166,098
Total	10,029,156

The foregoing table shows a gain of $1,220,222 in the value of the product as compared with that of 1893. This gain was made in the following States, named in alphabetical order: Georgia, Maine, Maryland, Massachusetts, New Hampshire, Pennsylvania, Rhode Island, Vermont, Virginia, and Wisconsin. By far the most of the gain was made in Rhode Island alone, this State showing an advance of $701,640. It is thus apparent that for most of the States there has been a falling off in the total output. As was true for 1893, the financial depression is accountable for this state of affairs.

VALUE OF GRANITE PAVING BLOCKS MADE IN 1894, BY STATES.

In a number of the New England States there was an increased tendency toward the manufacture of paving blocks rather than the production of stone for building or other purposes. The following table shows the value of the granite paving-block industry in the various productive States:

Value of granite paving blocks made in 1894, by States.

States.	Value.	States.	Value.
California	$31,000	North Carolina	$197
Connecticut	32,100	Pennsylvania	258,777
Delaware	80,000	Rhode Island	115,000
Georgia	225,910	South Carolina	9,085
Maine	710,836	Vermont	32,711
Maryland	18,885	Virginia	42,000
Massachusetts	593,726	Wisconsin	20,450
New Hampshire	24,000		
New Jersey	60,000	Total	2,254,587

The following table gives the value of the granite output, by States, for the years 1890 to 1894:

Value of granite, by States, from 1890 to 1894.

States.	1890.	1891.	1892.	1893.	1894.
Arkansas	(a)	$65,000	$40,000	....	$28,100
California	$1,329,018	1,300,000	1,000,000	$531,322	307,000
Colorado	314,673	300,000	100,000	77,182	49,302
Connecticut	1,061,202	1,167,000	700,000	652,459	504,390
Delaware	211,194	210,000	250,000	215,964	173,805
Georgia	752,481	790,000	700,000	476,387	511,804
Maine	2,225,839	2,200,000	2,300,000	1,274,954	1,551,036
Maryland	447,489	450,000	450,000	260,855	308,966
Massachusetts	2,503,503	2,600,000	2,206,000	1,631,204	1,994,830
Minnesota	356,782	....	360,000	270,296	153,936
Missouri	500,642	400,000	325,000	388,803	98,757
Montana	(a)	51,000	36,000	1,000	5,800
Nevada	(a)	....	....	3,000	1,600
New Hampshire	727,531	750,000	725,000	442,424	724,792
New Jersey	425,673	400,000	400,000	373,147	310,965
New York	222,773	225,000	200,000	181,449	140,618
North Carolina	146,627	....	150,000	122,707	108,993
Oregon	44,150	3,000	6,000	11,255	4,993
Pennsylvania	623,252	575,000	550,000	206,493	600,000
Rhode Island	931,216	750,000	600,000	509,799	1,211,439
South Carolina	47,614	50,000	60,000	95,443	45,899
South Dakota	304,673	100,000	50,000	27,828	8,806
Texas	22,550	75,000	50,000	38,991	....
Utah	8,700	....	15,000	590	....
Vermont	581,870	700,000	675,000	778,459	893,956
Virginia	332,548	300,000	300,000	103,703	123,361
Washington	(a)	....	....	....	....
Wisconsin	266,095	406,000	400,000	133,220	166,098
Total	14,464,095	13,867,000	12,627,000	8,808,934	10,029,156

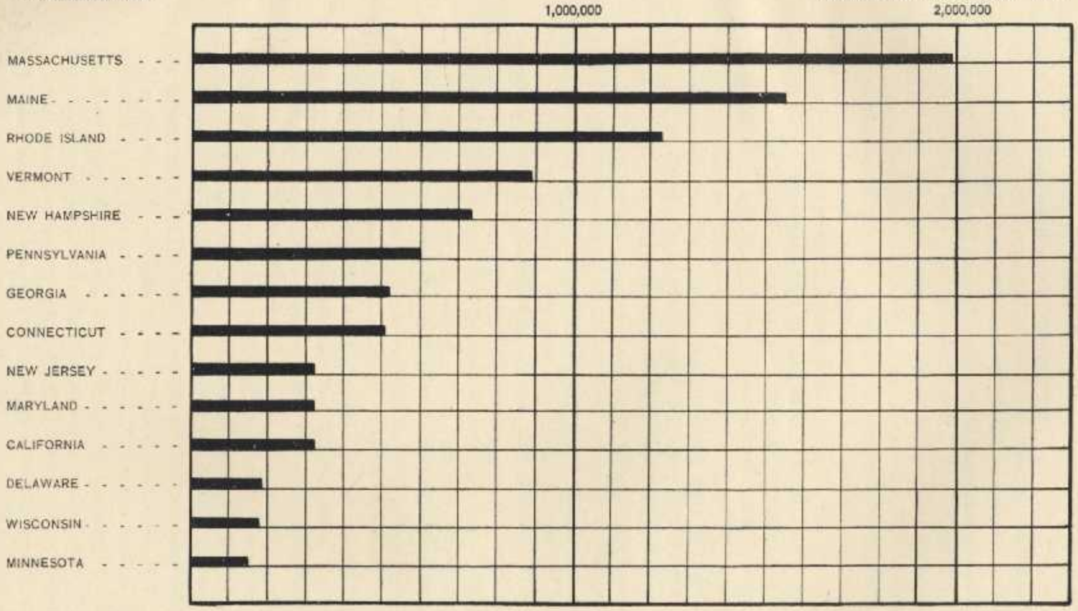
a Granite valued at $76,000 was produced in Arkansas, Montana, Nevada, and Washington together, and this amount is included in the total.

GRANITE INDUSTRY IN THE VARIOUS STATES.

Arkansas.—The value of the product in 1894 amounted to $28,100, while in 1893 very little, if anything, was accomplished in granite quarrying. The entire output comes from Pulaski County. Indications for 1895 are encouraging.

California.—The granite industry in this State for the last few years, but particularly for 1893 and 1894, has been at a low ebb. The value of the product for 1894 is $307,000, but included in this figure is an estimate as to the value of the output from the State prison quarries, which forms an important item of the total. Placer County is credited with an output valued at $103,443, Sonoma County $34,568, San Bernardino County $30,450, while smaller amounts were taken from quarries in Tulare, Sacramento, Madera, Fresno, Solano, Alameda, Riverside, and Marin counties. Almost every communication received from producers in this State emphatically reveals decline in the industry, due, it is believed, entirely to the financial depression. Many quarries discontinued work entirely, while others shut down for a part of the year or worked with reduced force of men.

Colorado.—The output for 1894 is valued at $49,302. Most of the stone was taken from quarries in Jefferson County, while smaller amounts



VALUE OF GRANITE PRODUCED IN THE VARIOUS STATES DURING THE YEAR 1894.
(In millions of dollars.)

came from Douglas, Gunnison, and Clear Creek counties. A little work was done in Chaffee, Larimer, and Boulder counties. A number of quarries discontinued operations entirely.

Connecticut.—The product for 1894 was valued at $504,390, while the corresponding figure for 1893 was $652,459. A decrease in product is evident. The general tone of replies from quarrymen indicates a falling off as compared with the preceding year. The productive counties in order of magnitude of output are New Haven, New London, Fairfield, Windham, Middlesex, Hartford, and Litchfield. The first two counties produced most of the entire output. Judging from a number of important contracts that have been awarded to Connecticut producers, 1895 will make a much better showing than the past year.

Delaware.—The value of the output in 1894, $173,805, is below that of 1893. All of the productive quarries are in Newcastle County.

Georgia.—As will be seen from the report on "marble," this State has very materially advanced in its marble output. The same can be said of the granite product, which has increased from $476,387 in 1893, to $511,804 in 1894. Of this amount $225,910 is the value of paving blocks. There is every reason to believe that with a revival in business there will be a still greater increase in the granite industry in this State. By far the most of the output comes from Dekalb County, in which are the important producing centers, Lithonia and Stone Mountain. Other productive counties are Hancock, Henry, Bibb, Elbert, Spalding, Rockdale, Jones, Oglethorpe, and Newton. The last seven of these counties produce very little as compared with the others.

Maine.—This State stands second among the granite-producing States in the value of its output. This has increased from $1,274,954 in 1893 to $1,551,036 in 1894. While the manufacture of paving blocks for use in the largest cities along the Atlantic coast has always been an important feature of the granite industry in Maine, it has become somewhat more so during the past year. In the census year 1889, the value of the paving-block product was 37 per cent of the whole, but in the year just past it was 45.8 per cent. The most productive counties are Hancock, Knox, Franklin, Waldo, Washington, Kennebec, and York; smaller amounts are quarried in Lincoln, Somerset, Penobscot, Androscoggin, and Oxford. Many small quarries have been temporarily abandoned, while others have been sold out to larger concerns. An improvement in the industry in this State is looked for during 1895.

Maryland.—The output in this State increased from a value of $260,855 in 1893 to $308,966 in 1894. The worst part of the year was the first half, after which, in the case of a number of concerns, business improved somewhat and became even better than the latter part of 1893. Indications are quite decided toward improvement in 1895.

Massachusetts.—This State seems to have prospered exceptionally well during 1894, considering the hard times. The value of the output increased from $1,631,204 in 1893 to $1,994,830 in 1894, and the State maintains first position among the granite-producing States of the country. Many complaints of financial depression are to be heard, of course, and in times of prosperity the output would have been much larger. Lower prices than in 1893 have been generally prevalent. The most productive counties in order of importance are Essex, Worcester, Norfolk, Middlesex, Bristol, and Hampden; small quantities were produced in Franklin and Hampshire counties.

As is true of other New England States, more attention than usual was devoted to the production of paving blocks, for which the demand was good, but lower prices prevailed than were received in 1893.

Minnesota.—The value of the output in 1894 was $153,936; the corresponding figure for 1893 was $270,296. The decrease is accounted for in the usual manner—hard times, resulting in the shutting down of operations entirely or operating with reduced force. The output comes from the following counties: Bigstone, Stearns, Sherburne, Pipestone, Rock, and Nicollet.

Missouri.—A falling off from $388,803 to $98,757 in 1894 marks the granite industry in this State. A few prominent concerns practically suspended operations, and their comparative inactivity accounts for the decrease. Indications for 1895 are much better. The productive counties of this State are Iron, Wayne, St. François, and Madison.

Montana.—Very little in the way of granite quarrying has ever been done in this State. A little quarrying was done in Lewis and Clarke County.

New Hampshire.—In this State a decided gain in output was made, namely, from $442,424 in 1893 to $724,702. A number of quite important contracts have been fulfilled during the year. Among most of the producers there is considerable complaint of dull trade, but in spite of the financial depression, business seems to have been markedly better on the whole than in 1893. The most productive counties are Carroll, Cheshire, Hillsboro, Merrimack, and Strafford; smaller amounts were taken from quarries in Grafton, Sullivan, and Rockingham counties. Quite a number of new firms have commenced business during the year. The outlook for 1895 is much better.

New Jersey.—Quarrying in New Jersey seems to have suffered from the prevailing business depression. The product fell off in value from $373,147 in 1893 to $310,965 in 1894. Considerable of the product is really trap rock, which, for reasons already given, is included with granite. Indications for 1895 are promising. The productive counties are Somerset, Hudson, Essex, Sussex, Passaic, Mercer, and Hunterdon. Small amounts were quarried also in Union and Morris counties.

New York.—This State has never yielded very large quantities of granite, although good stone is to be found there. The product of 1893 was valued at $181,449, while that of 1894 amounted to $140,618. The productive counties are Essex, Richmond, Orange, and Westchester.

North Carolina.—Although the value of the granite product in this State declined from $122,707 in 1893 to $108,993 in 1894, considering the comparative newness of the industry in the State its condition may be regarded as very satisfactory in view of the hard times. The productive counties were Gaston, Iredell, Rowan, Surry, and Wake.

Oregon.—Small quantities of granite were produced in Clackamas, Columbia, and Multnomah counties.

Pennsylvania.—A more thorough canvass of the granite producers in this State is in part accountable for the large reported increase from $206,493 in 1893 to $600,000 in 1894. The value of the stone devoted to paving purposes in 1894 amounted to $258,777, or nearly one-half of the total. Although there is no exceptionally fine granite in the State, there is an abundance of stone that serves ordinary uses very well, and it is steadily produced. The productive counties are Bucks, Chester, Allegheny, Delaware, Montgomery, Somerset, Adams, and Northampton.

Rhode Island.—The increase in the output of granite in Rhode Island over the preceding year, 1893, is nothing less than phenomenal. In 1889, the census year, the output was valued at $931,216; in 1893 at $509,799; and in 1894, at $1,211,439. A number of quite serious strikes have occurred among the Rhode Island quarries and works within the last three years, and it may be that contracts have been delayed on that account until the past year. In spite of the prosperity which appears to prevail, complaints of financial depression are to be heard in Rhode Island as in all other States. The smaller producers have been particularly affected and in some cases have had to shut down their operations. The bulk of the business is now in the hands of a small number of concerns.

The granite quarries and works located at Westerly, Washington County, have long been celebrated for the very fine ornamental stock produced. Most elaborately ornamented monuments and statues are turned out in great number. The plants for finishing and polishing are exceedingly well equipped, all the latest improvements in quarry tools being freely used. The stone is particularly well adapted for successful ornamentation and fine finish, and this accounts largely for the prominence of this branch of the granite industry in the State. In fine carving a pneumatic tool, striking exceedingly rapid blows and operated by heavy air pressure, is becoming popular among granite cutters. The rapidity with which fine work can be executed is very much increased by the use of this tool. Its value in connection with granite as well as with ornamental marble has already been satisfactorily demonstrated.

Rhode Island stands first among the States of the Union for its output of ornamental and monumental stock.

South Carolina.—The financial stringency made itself felt in South Carolina to the extent of reducing the output from a valuation of $95,443 in 1893 to $45,899 in 1894. The productive counties are Fairfield, Edgefield, and Richland.

Vermont.—In spite of dullness in business generally, the value of the output in Vermont has increased to the extent shown by the values $778,459 for 1893 and $893,956 for 1894. The productive counties are Washington, Windham, Orange, and Caledonia; small amounts have been quarried also in Chittenden, Orleans, and Windsor counties.

Among the most important developments of the last decade are those which have been made at Barre. At this point there is an enormous supply of granite of the finest quality, such that the product is well adapted not only to all the ordinary uses to which granite is put, but also for the finest kinds of monumental and decorative work, to which it is quite largely applied. The methods of quarrying are modern. In one of the quarries in this locality the Knox system of blasting is in very successful use. The application of this recent method of blasting granite is quite limited, and is not received with favor by a great many of the large producers of granite in this and other States. The objections to the system as applied to granite are probably, however, due more to the results of single, and in some cases unsuccessful, experiments than to long-continued and fair trials of it.

Virginia.—The output in Virginia in 1894 amounted in value to $123,361, while in 1893 the corresponding figure was $103,703. There has thus been a gain which though not large is very satisfactory when the falling off in many other States is considered. The productive counties are Chesterfield, Amherst, Henrico, Alexandria, Campbell, and Dinwiddie.

A number of the quarries in the vicinity of Richmond have been operated successfully for a number of years. The plants are comparatively well equipped, and while operations might be conducted upon a considerably larger scale they may be said to be prosperous. The stone from most of these quarries is of good quality and is generally well received.

Wisconsin.—The value of the granite output in 1893 amounted to $133,220, while in the year 1894 it reached $166,098. The output comes from Green Lake, Marinette, and Marquette counties. The granite industry in this State is comparatively new, but it bids fair to increase steadily under normal financial conditions.

THE MARBLE INDUSTRY.

Stone of one kind or another, suitable for building or other industrial use, is most abundantly distributed throughout the United States. One is apt therefore to look upon the operations of quarrying as practicable in almost any locality, and consequently to regard the industry of stone production as practically universal. This view is not far from correct when only the coarser kinds of stone are considered. Marble, however, is found in comparatively few localities, since only here and there have the metamorphosing influences of heat and pressure transformed the widely distributed limestone deposits into marble. Quarrying operations in the case of marble are still further restricted by the fact that by no means all marble is of sufficiently good quality to justify its production for the purposes to which marble as an ornamental product is applied. Marble must fulfill certain definite conditions as to strength, color, crystalline condition, freedom from flaws, etc., and, furthermore, must be fairly easy of access, before quarrying operations can be undertaken with a fair prospect of financial success.

Not only are marble and limestone very different in physical structure and purity, but the uses to which they are put are strongly contrasted, so that, even though closely related from the chemical standpoint, in that they are both carbonates of calcium or of calcium and magnesium together, they have in a commercial sense almost nothing in common, except in so far as waste marble replaces ordinary limestone for such uses as burning into lime, road ballast, or blast-furnace flux. In this report, therefore, ordinary limestone and marble are separately considered in so far as the uses to which they are applied are radically different.

VALUE OF THE MARBLE PRODUCT, BY STATES.

The following table shows the value of the marble output, by States, for the year 1894. Inspection of this table shows that only a small number of States produce marble, while from the report on limestone it is evident that a large number of our States yield ordinary limestone in abundance:

Value of marble production, by States, for the year 1894.

States.	Value.	States.	Value.
California	$13,420	Pennsylvania	$50,000
Georgia	724,385	Tennessee	231,796
Idaho	3,000	Vermont	1,500,399
Maryland	175,000		
New York	501,585	Total	3,199,585

From the foregoing table it appears that the product from Vermont, valued at $1,500,399, amounts to 47.6 per cent of the total. In the census year 1889, Vermont produced 62 per cent of the total. Large gains in production have been made during the past year in Georgia and New York. The total product in 1893 was valued at $2,411,092, so that for the marble industry as a whole there has been a gain of $788,493 in value of output for the entire country.

The following table shows the value, by States, of the marble produced during the years 1890 to 1894, inclusive:

Value of marble, by States, from 1890 to 1894.

States.	1890.	1891.	1892.	1893.	1894.
California	$87, 030	$100, 000	$115, 000	$10, 000	$13, 420
Georgia	196, 250	275, 000	280, 000	261, 666	724, 385
Idaho	....	....	....	4, 500	3, 000
Maryland	139, 816	100, 000	165, 000	130, 000	175, 000
Massachusetts	....	....	100, 000	....	....
New York	354, 197	390, 000	380, 000	206, 926	501, 585
Pennsylvania	....	45, 000	50, 000	27, 000	50, 000
Tennessee	419, 467	400, 000	350, 000	150, 000	231, 796
Vermont	2. 169, 560	2. 200, 000	2, 275, 000	1, 621, 000	1, 500, 399
Scattering	121, 850	100, 000	50, 000	....	....
Total	3. 488, 170	3. 610, 000	3, 765, 000	2, 411, 092	3, 199, 585

MARBLE INDUSTRY IN THE VARIOUS STATES.

The following is a consideration of the marble industry in the individual productive States:

California.—Although the output in this State increased in value from $10,000 in 1893 to $13,420 in 1894, the marble branch of the stone industry is not at present in a flourishing state, and owing to the depressed financial condition, operations have been much curtailed. It is believed, however, that with general improvement in business will come a prosperous revival of the quarrying operations throughout the State. The counties which at one time or another have produced marble are San Bernardino, Amador, Inyo, and San Luis Obispo. Most of the output has come from the first-named county.

Georgia.—The advances made in marble quarrying in Georgia during the past year are very remarkable. The value of the output in 1893 was $261,666, and in 1894, $724,385. The entire output came from Pickens County.

According to Bulletin No. 1 of the Geological Survey of Georgia, under direction of Mr. W. S. Yeates, entitled "A Preliminary Report on the Marbles of Georgia," by S. W. McCallie, assistant geologist, the quarrying of marble in this State dates back to 1840, when operations on a very small scale were undertaken near Tate. Very little was accomplished, however, until the organization of the Georgia Marble Company in 1884, with a capital of $1,500,000. There are now four flourishing firms in Pickens County, while another, operating in Cherokee County, will begin in 1895.

The marbles of Georgia follow a general line running in a northerly direction from Fannin County on the north, through Gilmer and Pickens counties, to Cherokee County on the south. "The Marietta and North Georgia Railroad runs parallel to the marble belt throughout its entire length, and at no point is the outcropping located more than 2 or 3 miles from this road." All the quarries at present operating are near the town of Tate, Pickens County.

The product of the quarries operated by the Georgia Marble Company varies somewhat in color. The Kennesaw quarry yields a limited quantity of white marble, the crystals of which are large and glistening, but very compactly united; and in addition there is a white marble clouded with light spots and lines of blue. The Cherokee quarry produces white and bluish-gray stock, both clouded with dark-blue spots. From the Creole quarries a marble having a white ground and exceedingly dark-blue mottlings is taken. This is used for monumental work and exterior decoration. A great variety of different shades of marble is to be found in the Etowah quarry, the principal colors being pink, salmon, rose, and dark green. These, with their combinations, produce very rich effects and are suitable for work in which high color and richness are desired. It finds its chief application in wainscoting, mantels, table tops, counters, panels, etc.

The following analysis was made by Mr. John C. Jackson, of Chicago:

Analysis of Georgia marble.

	Per cent.
Calcium carbonate	97.32
Magnesium carbonate	1.60
Silica	.62
Iron protoxide	.26
Alumina	.25
Total	100.05

The following tests by compression of the strength of three cubes of Georgia marble, made in 1886 by Capt. Marcus W. Lyon, United States Army, with the testing machine at Watertown Arsenal, Mass., serve to indicate the great crushing strength of this marble:

Mechanical tests of Georgia marble.

Test No.	Marks.	Dimensions.		Sectional area.	Ultimate strength.	
		Height.	Compressed surface.		Total pounds.	Pounds per square inch.
				Sq. inch.		
4337	Cherokee	6''.04	6''.01 by 6''.00	36.06	395,800	10,976
4338	Creole	6''.03	6''.00 = 5''.99	36.94	434,100	12,078
4339	Etowah	6''.03	6''.03 = 6''.01	36.12	384,400	10 642

The structure of the marbles from the various quarries is essentially the same, the difference being in color only. The nonabsorbent properties are indicated by the following experiments made by Prof. J. B. Johnson, of St. Louis, Mo.:

A 3-inch cube was soaked in water twenty-four hours and weighed. It was then dried over a steam coil at a temperature of about 215° F. for twenty-four hours and again weighed. The difference in the weight divided by the weight when dry showed that it had absorbed water to an amount expressed by six-hundredths of 1 per cent. The nonabsorbent qualities thus revealed enable the stone to withstand disintegration.

The following data are taken from the bulletin of the Georgia Geological Survey, already referred to:

Crushing tests of Georgia marble.(*a*)

Name.	Quarry.	Compressed surface in inches.	Position.	Actual crushing load in pounds.	Compressive strength per square inch in pounds.	Reduced to correspond to pressure per sq. in. on 2-in. cubes[b], in lbs. per sq. inch.	Specific gravity.	Weight per cubic foot in pounds.
Kennesaw:								
No. 1	Kennesaw	.99 x .99	Bed	*e*10, 000	10, 204	12, 244		
No. 2	do	1.00 x 1.00	do	*d*11, 400	11, 400	13, 680	2. 717	169. 8
No. 3	do	1.00 x 1.00	do	*e*10, 672	10, 672	12, 806		
Creole:								
No. 1	Georgia	1.00 x 1.00	do	*e*13, 900	13, 900	16, 680		
No. 2	do	1.00 x 1.00	do	*e*13, 100	13, 100	15, 700	2. 763	172. 6
No. 3	do	1.00 x 1.00	do	13, 200	13, 200	15, 840		
Etowah:								
No. 1	do	1.00 x 1.00	do	13, 200	13, 200	15, 840		
No. 2	do	.99 x .99	do	12, 000	12, 244	14, 692	2. 707	169. 1
No. 3	do	.99 x .98	do	12, 300	12, 540	15, 048		
Southern:								
No. 1	Southern	.99 x 1.00	do	11, 300	11, 414	13, 696		
No. 2	do	.99 x 1.00	do	10, 900	11, 010	13, 212	2. 734	171. 8
No. 3	do	.98 x 1.00	do	10, 800	11, 020	13, 224		

a The survey is under obligations to Prof. Charles Ferris of the engineering department of the University of Tennessee, for valuable aid rendered in making the crushing and absorption tests.

b Gen. Q. A. Gillmer, in his report on the compressive strength of building stones of the United States, Appendix II, Annual Report of the Chief of Engineers for 1875, determined a general formula for converting the crushing strength of different cubes into each other. In applying this formula for 1 and 2 inch cubes, it is found that the crushing weight of the smaller cube should be increased by approximately one-fifth of itself in order to compare correctly the strength of the two cubes.

c Cracked on edge before bursting.

d Burst suddenly.

e Burst with explosion.

The following artificial weathering tests were made on unpolished cubes of Nos. 1, 3, and 6 and a polished cube of No. 1. They were suspended for several days in an atmosphere of hydrochloric, sulphurous, and carbonic acids:

Artificial weathering tests made on polished and unpolished Georgia marble.

	Original weight.	Final weight.	Loss.
	Grams.	*Grams.*	*Grams.*
No. 1. Polished	45. 0868	44. 9337	. 1531
No. 1. Unpolished	45. 9492	45. 7793	. 1699
No. 3. Unpolished	44. 2569	44. 1240	. 1329
No. 6. Unpolished	42. 1369	41. 9943	. 1426

It is noticeable that the unpolished cube of No. 1 was dissolved with considerable more readiness than the polished.

Chemical analyses of Georgia marble.

Marbles.	Calcium oxide.	Magnesium oxide.	Ferric oxide and alumina.	Insoluble siliceous matter.	Loss on ignition.	Total.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
No. 1	54.06	.90	.10	2.12	42.86	100.04
No. 2	32.73	19.37	.35	.73	46.58	99.76
No. 3	55.00	1.12	.15	.35	44.16	100.76
No. 4	31.53	21.30	.24	.10	47.26	100.43
No. 5	31.61	21.06	.78	1.01	46.49	100.95
No 6	54.41	.75	.32	1.62	43.13	100.23
No. 7	54.67	1.01	.42	.76	43.49	100.35
No. 8	52.77	.82	3.28	1.43	41.85	100.15
No. 9	24.07	17.24	.43	21.76	37.08	100.58
No. 10	30.42	19.86	.91	4.23	(*a*)	(*a*)
No. 11	31.89	19.64	.74	1.73	(*a*)	(*a*)

a Undetermined.

No. 1. A coarsely crystalline white marble, from the Cherokee quarry (Georgia Marble Company), Pickens County.
No. 2. A white fine-grained marble from J. P. Harrison's quarry, 2 miles east of Jasper.
No. 3. A coarse-grained black and white mottled marble, "Creole," of the Georgia quarries.
No. 4. A fine-grained gray marble, from the Dickey property.
No. 5. A fine-grained bluish-gray marble, from the Holt property.
No. 6. A coarse-grained flesh-colored marble, "Etowah," of the Georgia quarries.
No. 7. A coarse-grained gray marble, from the Eslinger farm.
No. 8. A coarse-grained brown marble, from the Haskins farm.
No. 9. A fine-grained light-gray marble, from the White property.
No. 10. A fine-grained black marble, from Six Mile Station.
No. 11. A fine-grained white marble, from Fannin County.

Maryland.—The value of the marble output in this State in 1894 was $175,000; in 1893, $130,000. The industry in Maryland is limited to a number of points near Baltimore on the line of the Northern Central Railroad and all in Baltimore County. The industry has been established for many years and is in a prosperous condition.

The product is used to some extent for cemetery work, and also largely for building purposes, particularly in Baltimore, where it enters into the construction of a number of the finest structures. It has also been used in Philadelphia and in the extension of the National Capitol. The Beaver Dam Marble Company is the most important firm, and has a well-equipped plant, including the modern improvements for quarrying and sawing. The most practical test which has been made of the strength of this marble was its use as material for the Washington Monument in Washington, the highest stone structure in the world.

New York.—A very striking advance in production was made in New York during 1894, namely, from a valuation of $206,926 in 1893 to $501,585 in 1894. The increase was due to very largely increased operations at Tuckahoe. The productive counties are St. Lawrence, Westchester, Columbia, and Warren.

The color of the St. Lawrence County marble varies from white to dark blue and green and mixtures of these shades, producing in these cases a mottled appearance. The marble is adapted to monumental and building purposes, but the greater part of the product of 1889 was used for the latter purpose. This stone, while too coarsely crystalline for fine carving, scroll work, or tracing, forms a fine contrast with the polished surface. It weighs 174 pounds to the cubic foot, and has a crushing strength of 12,000 pounds to the inch.

The product from Pleasantville is called, from its appearance, "snowflake marble," and is a dolomite, as is evident from the following analysis made at Columbia College:

Analysis of "snowflake" marble (dolomite) from Pleasantville, N. Y.

	Per cent.
Calcium carbonate	54.62
Magnesium carbonate	45.04
Iron carbonate	.16
Alumina	.07
Silica	.10
Total	99.99

This marble is especially adapted for use in the preparation of carbonic acid. Its weight per cubic foot is 180 pounds. The Tuckahoe marble was used for building, macadamizing roads, and for the preparation of soda water. Like the Pleasantville marble, it is a dolomite.

The product of Warren County, which comes from Glens Falls and its vicinity, consists of black marble, which is generally used for tiling and to some extent for other kinds of interior decoration, soda-water fountains, clock frames, etc. The stone is quite hard, and is quarried by light blasting, and some of it, owing to the looseness of the beds, can be removed by ordinary tools; the rougher stone is extensively burned into lime.

At Hudson, in Columbia County, and at Catskill, across the river in Greene County, are quarries of what is known as "shell marble," largely made up of fossil remains. The stone is so irregular that quarrying is largely done by blasting. It is of a dull, brownish color, and presents a beautiful appearance in finished surfaces; but owing to its character it can not now receive the fine finish given to other more perfectly metamorphosed marbles.

The product from the Tuckahoe quarries is now largely used for building, and a still further increase in production is looked for during the year 1895.

Oregon.—In Douglas County several thousand dollars' worth of marble was produced in 1894, most of the material being used for cemetery purposes. The Variety Marble Company, of Roseburg, is the principal producer. More extensive operations are predicted for 1895.

Tennessee.—The marble output of Tennessee increased from a valuation of $150,000 in 1893, to $231,796 in 1894. The industry has unquestionably suffered from the hard times, although evidently less in 1894 than in 1893. It comes mainly from Knox, Loudon, and Hawkins counties, although a small amount is produced in Hamblen, Blount, and Jefferson counties. The marble region is thus seen to be in the eastern part of the State, running in a northeasterly direction from Loudon

County at the south to Hawkins County at the northeast. The total value of the marble produced in 1880 was $173,600. The marble industry in this State is in a reasonably flourishing condition.

The marble in Tennessee is in general easily quarried, and this fact has caused a number of property owners in the past to undertake quarrying operations on a small scale. The methods of quarrying are generally somewhat crude, and only a few channelers and other improvements in quarry machinery are in use.

Six marble-producing concerns have within a few years united, forming a combination known as the Tennessee Producers' Marble Company, the object of which is to maintain prices and carry on business more economically.

Tennessee marble presents much variety of color, and its great beauty is well known. It is especially well adapted for purposes of interior decoration in buildings and for furniture tops, but the amount devoted to the latter purpose is much less than it was a few years ago.

The processes of metamorphosis have in much of this marble stopped short of the obliteration of fossil remains, the outlines of which are very plainly marked and present a pleasing variety in the surface of the polished slab. The colors run from a very light pink through various shades to a chocolate brown and a mixed brown, white, and pink.

The product of Hawkins County is highly esteemed, and its price is almost twice that of the product of Knox or Loudon County. As shown by the numerous outcrops of marble in this State, it disintegrates somewhat under the influence of atmospheric agencies, but this does not detract from its adaptability for interior decoration, to which it is largely applied.

Some of the finishing mills in the State are well equipped and operated in a thoroughly modern way. The average cost per cubic foot of producing the marble output of Tennessee in 1889 was 85.1 cents. Of this amount 80.8 per cent was paid for labor involved in taking marble from the quarry and putting it into the shape in which it was sold. Cost of transportation by wagon and railroad from the quarry to the mill is in many cases quite a serious item of expense.

Vermont.—The value of the marble output in 1893 was $1,621,000; the year 1894 shows a falling off to $1,500,399. This decrease is entirely due to the prevailing financial depression, and with the return of prosperous times the growth of the industry will proceed as steadily as it has done in the past.

The producing counties are, in the order of their importance, Rutland, Bennington, Franklin, and Addison. These counties are all in the western part of the State, and, interrupted only by Chittenden County, extend from the Dorset quarries in the southwest corner to the Champlain marbles at Swanton, in the extreme northern part. The quarries now operated are found in or near the towns of Manchester, Dorset, East Dorset, Wallingford, Rutland, West Rutland, Proctor, Pittsford, Brandon, Fair Haven, Middlebury, North Ferrisburg, and Swanton. Abandoned quarries are found all along the railroad line from Dorset to Middlebury. Most of the quarries are near railroad lines, but in some cases it is necessary to haul by wagon to the nearest railroad station. The longest distance of such transportation is 7 miles.

The marble lies in irregular beds, extending north and south, and having a slight dip toward the west, but at West Rutland the angle is very much increased, amounting to 80°, and the marble is worked to a depth of 300 feet. In most cases the upper layers are of little value, and the marble can only be used for purposes requiring rough stone, regardless of composition. Ten or twelve feet of surface rock must be thrown away before sound material is reached.

There is considerable variety in the color as well as in the texture of the stone. The pure white marble is rare, occurring in layers of very limited extent. Most of the stone is of a bluish-gray tone, and presents a mottled or clouded appearance, resulting from a more or less intimate mixture of blue and white. In some cases the blue is so predominant that the marble is known as "blue marble," and in cases where the blue is particularly pronounced it is called "extra dark blue." The pure white statuary marble is generally found at considerable depth. There is, however, no decided regularity in the relative arrangement of the different colors. The following analyses made at Yale University for the Columbian Marble Company may be regarded as representative of the marbles of the colors named:

Analyses of marble from Proctor, Vt.

DARK-COLORED MARBLE.

	Per cent.
Calcium carbonate	98.370
Magnesium carbonate	.790
Iron carbonate	.034
Oxides of manganese and aluminum	.005
Matter insoluble in acids	.630
Organic matter	.080
Total	99.909

LIGHT-COLORED MARBLE.

	Per cent.
Calcium carbonate	96.300
Magnesium carbonate	3.060
Iron carbonate	.053
Matter insoluble in acids	.630
Organic matter	.004
Total	100.047

The stone weighs on an average 170 pounds to the cubic foot, although it sometimes reaches 180 pounds.

METHODS OF QUARRYING AND MANUFACTURING MARBLE.

The following description of methods of quarrying and manufacturing is taken from the writer's report on marble for the Eleventh Census:

QUARRYING.

The method of quarrying is essentially the same in most marble quarries. With fine marble, blasting seems to be entirely out of the question, because of injury to the stone, which has been amply proved by past experiments in Italy. This injury has not always been apparent in freshly quarried stone, but has been revealed years after by disintegration. It has already been stated that the marble at Swanton, Vt., and at a few quarries in other States, is quarried by the Knox system of blasting; but the product is not used for purposes which would be injuriously affected by blasting, and, furthermore, the character of the stone in such cases admits of the application of this method. Experiments in blasting marble have also been recently tried in California, but the results have not yet been made public. A spot for opening a quarry is selected with the greatest care. If the surface indications are not sufficient to determine the quality of the underlying marble, it becomes necessary to drill a hole to a greater or less depth into the body of the stone. This is accomplished by means of an ordinary diamond drill for prospecting; that is, a hollow tool cutting a circle and leaving a core, which is taken out when a proper depth is reached. Lengths of 10 or 12 feet are thus frequently taken out without flaws. If the core presents satisfactory indications, the surface material is stripped by blasting, so as to make an opening for the quarry. Derricks are then placed in position, and channelers, drills, and gadders commence operating upon the comparatively level floor secured by the operations of stripping. A channeler then cuts two grooves or channels across the grain of the stone the width of the channeler apart (about 5 feet). The stone thus separated from the rest is called the key course. This is cut across at intervals to the same depth as the long channels, namely, the thickness of the bed operated upon. The key course is thus cut into blocks, which are held to the fixed marble only on the under side. To separate the blocks from the quarry, two different processes are in use. According to one of these, a block, called the "key block," is blasted out, destroying it, but also separating it at the bottom, thus giving space for operating upon the adjacent block to be taken out entire and in sound condition. Instead of blasting, the key block may be loosened at the bottom by means of wedges driven into the channels at one side and one end. A ring fastened into the center of the block forms a means of attachment to the derrick, which then lifts it from the floor. In the latter method more time is consumed, but the key block is saved. After the key block is removed, space sufficient for the introduction of the gadder is secured. The gadder, similar to the drill, bores horizontal holes 6 inches apart into the adjacent block at the bottom. Iron wedges, known as "gadding pins," are then driven into the holes, thus separating the block at the bottom. In order to avoid breaking a block at the edges the pins are a foot or more in length. When the key course has been removed, several courses parallel to it are channeled out and removed in a similar manner. The channelers require two men, a runner and his helper, and will cut 75 channel feet per day to a depth of about 5 feet.

The drills operate by striking rapid blows, and the diamond borer cuts by revolving, the cutting edge consisting of diamonds set into the end. The underlying marble is cut into successive floors, as in the case described, thus gradually sinking below the surface, until, as in the Rutland and Proctor quarries, depths of 200 to 300 feet have been reached. Steam is commonly employed in running the quarry machinery, but in some cases compressed air is used, and hoisting is done by derricks. The usual size of blocks taken out is 4 feet by 4 feet 6 inches by 6 feet 6 inches, but for special purposes considerably larger blocks are frequently removed.

MANUFACTURING.

If the marble quarried as above is to be sold in sawed or in finished condition the blocks are transported to the mills, where they are sawed into slabs of various thicknesses. The saws consist of strips of steel fastened to an oscillating frame. The cutting material is sand, which, mixed with water, continually flows over the block and into the cuts made by the saws, and is fed upon the block either by hand or automatically. In the automatic process of feeding the sand is first delivered from a hopper into a well conveniently located in the mill; from this the mixture of water and sand is pumped through a main pipe connected with various branches, which delivers the contents upon the blocks of stone.

After sawing, the blocks or slabs are placed upon a rubbing bed, consisting of a circular iron disk revolving horizontally and continually supplied with the same mixture of sand and water used in sawing. A rather smooth but dull surface is thus secured, and the stone is then ready for decorative work or for carving and polishing.

The polishing of large surfaces is accomplished by means of a buffer, which consists of a rapidly revolving wheel covered with flannel and charged with a so-called putty powder, and frequently with a mixture of putty and oxalic acid. This wheel is capable of a universal horizontal movement while revolving, so that it may reach all parts of the slab. Much of the polishing in Vermont mills is necessarily done by hand on account of the delicate nature of the work, owing to the intricacies of surface resulting from carving. In Tennessee mills, where large plain slabs for wainscoting and partitions are polished, the practice of machine polishing is much more general.

The light carving, or "skin work," as it is called, is largely done in the old-fashioned way, with mallet and hand-cutting tool; but a recently patented pneumatic tool, delivering a large number of light blows per second, is now being introduced. This is held in the hand and moved along the outline to be cut into the stone. Its work is very rapid, and it appears to be gaining in favor. It is used not only for the softer kinds of stone, but also for granite.

In the preparation of stone for architectural designs, such as moldings, cornices, etc., planers similar to iron planers are used. Monumental urns and turned architectural work are produced by means of lathes, which are used both for cutting and polishing the various forms.

THE SLATE INDUSTRY.

Clay slate consists of siliceous clay which has been hardened and otherwise changed by metamorphosing influences, such as heat, pressure, and in some cases oxidation.

Quite a variety of minerals, generally in an exceedingly fine state of division, have been found in varying proportions throughout the kaolin mass which constitutes the great bulk of the rock. Among such minerals may be mentioned quartz, feldspar, mica, tourmaline, organic material, and hydrated oxide of iron. Carbonaceous matter accounts for the black color of slate from quarries in Maine and Pennsylvania. In the red, purple, and green slates of Vermont and New York, carbonaceous material is wanting; the process of oxidation which converted compounds of iron into the ferric condition, thus giving the various shades of red and purple, may also have destroyed the carbonaceous material characteristic of black slate.

USES TO WHICH SLATE IS PUT.

The property of slate which renders it useful as a roofing material is its cleavage, in virtue of which it may be readily split into thin sheets of suitable area. The great bulk of all the slate quarries in the United States goes for roofing, but the number of other uses to which slate is put is already large and is continually increasing. Such uses are the following:

Slate is used locally in a comparatively rough state for sidewalks, curbstones, hitching posts, underpinning, cellar walls, and door steps. As a manufactured article, after going through the mill, it is offered for the following purposes: Billiard-table beds, mantels, fireboards, register frames, radiator tops, steps and risers, platforms, tiles, wainscoting, moldings, thresholds, window sills, lintels, brackets, laundry tubs, washbowl tops, cisterns, sinks, urinals, refrigerators, blackboards, mangers, curriers' slabs, imposing stones, grave boxes, grave covers, headstones, grave markers, vault doors, water tables, belting courses, counter tops, brewers' vats, greenhouse shelves, chimney tops, switch boards, and panels for electric work. In the marbleizing process it is susceptible of considerable ornamentation, which makes it more desirable still for many of the above uses and also extends the list of its uses as follows: Table tops, stand tops, card receivers, soda-water fountains, checkerboards, door plates, signs, and paper weights.

METHODS OF QUARRYING SLATE.

Slate quarrying having been for hundreds of years an exceedingly important industry in Wales, it naturally happens that the industry in this country is largely carried on under the direction and superintendence of Welsh quarrymen who have learned the art by years of experience in their native land. Owing to the peculiarities of the slate itself, methods of quarrying applicable to other kinds of stone are not suitable to the production of slate. A successful slate quarryman has almost invariably learned his art by years of experience under competent and skilled supervision in quarries operated upon a liberal scale. While in this work general principles are recognized and applied, no rule-of-thumb methods of application will suffice, but the operator must be in possession of such trained judgment as will enable him to meet continually changing conditions both in the nature of the slate and in its environment. What might have been otherwise a fine and profitable quarry may readily be spoiled by the exercise of poor judgment in the initial steps of opening the quarry. A large amount of débris must be disposed of in connection with slate quarrying and the proper disposition of this, so as not to interfere with future developments, is frequently a matter involving careful consideration and good judgment. That serious mistakes may be made even by skilled workmen is testified to by the large number of abandoned quarries in Vermont and Pennsylvania which indicate unsuccessful operations.

Blasting is liberally resorted to in slate quarrying, and in this part of the art there is much room for the exercise of good judgment, so as to take advantage of the position of the rock as determined by the cleavage grain and natural joints, and to direct the blast so that just the desired effects may be produced. To an on-looker the skill of a quarryman in producing already planned for and predicted effects is sometimes quite wonderful.

Aside from this mental work and judgment involved in the successful development of a quarry, the mechanical operations are comparatively simple, and there is room for the employment of a considerable amount of unskilled labor. In some of the largest quarries of Pennsylvania Italians are freely employed in stripping and similar work. The tools used are of simple character. In the production of roofing slates the operations of manufacture, which consist in splitting and trimming to the proper thickness and size, are carried on at the edge of the quarry by men who are trained and skilled in this specialty and are known as "splitters." Their work involves a thorough knowledge of slate as to its cleavage, and in many cases the most successful workmen have followed the calling from boyhood up, having started as assistant to some one else in this work. Frequently a father brings up his sons in the same line of work, and in some cases this practice has been followed through a number of generations.

MANUFACTURE OF MILLED STOCK.

A long enumeration of the articles other than roofing slate into which slate is manufactured has already been given. In the mills devoted to this work there has been much opportunity for the exercise of mechanical ingenuity in inventing labor-saving devices and in adapting slate to new uses. While the Welsh enjoy quite a monopoly of the skilled work in quarrying and in making roofing slate, their particular skill is much less in demand in the mill itself, where all other articles of slate are produced. In the production of milled stock improvements have been rapidly made and American inventiveness has made itself felt. Much of the work involved in the production of milled stock consists in the making of slabs having smooth surfaces. Slate will not take a polish, but it may be made quite smooth by planing and rubbing with sand and emery. The planers are similar to those used for planing iron. At some localities in Pennsylvania the slate is so hard that it has to be cut with black diamond saws. In the manufacture of billiard table tops much care must be exercised to secure perfectly smooth and level surfaces, and for this purpose slate has no superior.

Slate is well adapted for ornamental purposes after it has gone through the process of marbleizing. Quite a variety of stones and wood are thus imitated in a very successful manner. The following is a list of different kinds of stone which are thus imitated: Gray granite, Mexican onyx, fossil limestone, Devonshire marble, Tennessee marble, Circassian, Egyptian, and Pyrenees marble; and in fact all the better-known varieties of variegated marble; also blue agate, red granite, red serpentine, the various kinds of woods, and petrified wood of California. As the industry progresses the number of different kinds of imitation increases. The slab to be marbleized is first rubbed by hand with fine sand, using a wooden block covered with cloth. The marbleizing process is done in two ways. The marble having fine veins and lines running through it like Spanish marbles, is colored on a "float," as it is called; that is to say, a large vat of water is sprinkled with the different oil paints required. The effect desired on the stone is thus produced on the surface of the water, and is then transferred to the slab by simply immersing the slab and leaving the representation on it. The other method is by hand, brushes, sponges, and feathers being used to smear on the paint. In this process water colors are used.

At this stage the slab is baked overnight, the temperature of the oven or kiln varying from 175° F. to 225° F. After this first baking the slab is varnished and the baking is then repeated. Next it is scoured with ground pumice dust, varnished, and baked again. If any gilding is to be done it is done at this stage, after the slab comes out of the kiln for the third time. The next stage consists in rubbing with very fine pumice stone and a felt bock, after which it is baked for the last time. Rubbing with rotten stone follows, and the final polish is put on by rubbing with the palm of the hand.

SLATE PRODUCT AND ITS VALUE, BY STATES.

The following table of production for the year 1894 shows the number of squares of roofing slate, its value, the value of milled stock, and the total value of slate for all purposes:

Value of slate production in 1894, by States.

States.	Roofing.		Other purposes, value.	Total value.
	Squares.	Value.		
California	900	$5, 850	....	$5, 850
Georgia	5, 000	22, 500	....	22, 500
Maine	24, 690	123, 937	$22, 901	146, 838
Maryland	39, 460	150, 568	2, 500	153, 068
New Jersey	375	1, 050	....	1, 050
New York	7, 955	42, 092	2, 450	44, 542
Pennsylvania	411, 550	1, 380, 430	239, 728	1, 620, 158
Vermont	214, 337	455, 860	202, 307	658, 167
Virginia	33, 955	118, 851	19, 300	138, 151
Total	738, 222	2, 301, 138	489, 186	2, 790, 324

The following table shows the value of the production of slate, by States, during the years 1890 to 1894, inclusive:

Value of slate, by States, from 1890 to 1894.

States.	1890.				1891.			
	Roofing.	Value.	Other purposes than roofing, value.	Total value.	Roofing slate.	Value.	Other purposes than roofing, value.	Total value.
	Squares.				*Squares.*			
Arkansas	....	....	....	....	120	$480	....	$480
California	3, 104	$18, 089	....	$18, 089	4, 000	24, 000	....	24, 000
Georgia	3, 050	14, 850	$480	15, 330	3, 000	13, 500	....	13, 500
Maine	41, 000	201, 500	18, 000	219, 500	50, 000	250, 000	....	250, 000
Maryland	23, 099	105, 745	4, 263	110, 008	25, 166	123, 425	$2, 000	125, 000
New Jersey	2, 700	9, 675	1, 250	10, 925	2, 500	10, 000	....	10, 000
New York	16, 767	81, 726	44, 877	126, 603	17, 000	136, 000	40, 000	176, 000
Pennsylvania	476, 038	1, 641, 003	370, 723	2, 011, 726	507, 824	1, 741, 836	401, 000	2, 143, 905
Utah	....	....	....	....	....	....	....	....
Vermont	236, 350	596, 997	245, 016	842, 013	247, 643	698, 350	257, 267	955, 617
Virginia	30, 457	113, 079	....	113, 079	36, 059	127, 819	....	127, 819
Other States(*a*)	3, 060	15, 240	....	15, 240	....	....	....	....
Total	835, 625	2, 797, 904	684, 609	3, 482, 513	893, 312	3, 120, 410	700, 336	3, 825, 746

Value of slate, by States, from 1890 to 1894—Continued.

States.	1892.				1893.			
	Roofing slate.	Value.	Other purposes than roofing, value.	Total value.	Roofing slate.	Value.	Other purposes than roofing, value.	Total value.
	Squares.				*Squares.*			
Arkansas	....	....	....	....	....	....	....	....
California	3,500	$21,000	....	$21,000	....	....	....	....
Georgia	2,500	10,625	....	10,625	2,500	$11,250	....	$11,250
Maine	50,000	250,000	....	250,000	18,184	124,200	$15,000	139,200
Maryland	24,000	114,000	$2,500	116,500	7,422	37,884	....	37,884
New Jersey	3,000	12,000	....	12,000	900	3,653	....	3,653
New York	20,000	160,000	50,000	210,000	69,640	204,776	206	204,982
Pennsylvania	550,000	1,925,000	408,000	2,333,000	364,051	1,314,451	157,824	1,472,275
Utah	....	....	....	....	75	450	400	850
Vermont	260,000	754,000	260,000	1,014,000	132,061	407,538	128,194	535,732
Virginia	40,000	150,000	....	150,000	27,106	104,847	12,500	117,347
Total	953,000	3,396,625	720,500	4,117,125	621,939	2,209,049	314,124	2,523,173

States.	1894.			
	Roofing slate.	Value.	Other purposes than roofing, value.	Total value.
	Squares.			
Arkansas	....	....	....	....
California	900	$5,850	....	$5,850
Georgia	5,000	22,500	....	22,500
Maine	24,690	123,937	$22,901	146,838
Maryland	39,460	150,568	2,500	153,068
New Jersey	375	1,050	....	1,050
New York	7,955	42,092	2,450	44,542
Pennsylvania	411,550	1,380,430	239,728	1,620,158
Utah	....	....	....	....
Vermont	214,337	455,860	202,307	658,167
Virginia	33,955	118,851	19,300	138,151
Total	738,222	2,301,138	489,186	2,790,324

(*a*) Includes Arkansas, Michigan, and Utah.

An inspection of this table shows that during the past year slate has been produced in nine States. During the census year 1890 twelve States yielded slate. The financial depression has had the effect of shutting down operations in a number of States in which the industry had not yet secured a firm foothold.

SLATE INDUSTRY IN THE VARIOUS STATES.

California.—As is the case with other kinds of stone, quarrying of slate in this State has not enjoyed great prosperity during the past year. The entire output comes from Eldorado County and was entirely devoted to roofing.

Georgia.—The slate industry in Georgia undoubtedly has a future, although operations have not been very extensive in the past. Demand for slate as a roofing material in the South has not been a keen one, but it is difficult to understand why it should not become so in view of the extending use of slate for roofing in other portions of the country.

Although slate is known to occur at a number of localities in the South, the quarries at Rock Mart are the only ones at present equipped to supply any considerable demand.

Maine.—Slate production in Maine increased from a total valuation of $139,200 in 1893 to $146,838 in 1894. Of the total value in the latter year, $123,937 represents the value of 24,690 squares of roofing slate, while the remainder, $22,901, is the value of milled stock, the production of which is on the increase. The entire output comes from quarries in Piscataquis County.

Maryland.—The slate region of this State is a continuation of the York County slate belt. The Maryland quarries are all in the northern part of Harford County, near the State line. The quarries of these two counties constitute what is known as the Peach Bottom slate region. This region is discussed more fully in connection with Pennsylvania slate statistics. The Maryland product is almost entirely used for roofing purposes, 7,422 squares having been produced in 1893 and 39,460 in 1894. These products were valued at $37,884 and $150,568, respectively.

New Jersey.—The slate quarries of this State are an extension of the Pennsylvania slate belt, and only a little quarrying is annually done. The quarries are in Sussex and Warren counties.

New York.—The slate quarries of this State are all in Washington County, near the line separating New York and Vermont. The New York quarries produce slate of a cherry-red color, which is the only slate of its kind in the world. The price for this slate is much higher than for any other slate in the country. No red slate is quarried on the Vermont side of the line. In 1894 the product amounted to 7,955 squares, valued at $42,092. Many of the quarrymen operating in Vermont reside in New York State.

In the report for 1893 the value of the output of slate in New York was placed at too high a figure, on account of an error arising from the difficulty in identifying quarries near the State line as belonging to one State or the other. The figures for 1894 are exact, having been verified by Mr. George W. Harris, formerly a resident of Fair Haven, Vt., who is familiar with the Vermont and New York slate region.

Pennsylvania.—As is evident from the table of production, this State produces more than half of the entire slate output of the country. The product of 1894 was valued at $1,620,158. Of this amount $1,380,430 is the value of 411,550 squares of roofing slate, while the remainder is the value of milled stock.

The following description of the State quarrying regions of Pennsylvania is taken from the writer's report in Mineral Resources for 1889–90:

While there is a great variety in the colors of the slate produced in Vermont, a similar statement does not apply to Pennsylvania, the product of which is entirely black, although a very fine distinction is locally made between black and a sort of bluish-black.

The actively quarried slate belt of Pennsylvania really begins in Sussex County, in the northeastern part of New Jersey, where, at Lafayette and Newton, there are slate quarries in operation, and also in Warren County, at Polkville. The Pennsylvania portion of this slate belt begins at the Delaware Water Gap, in the northeastern part of Northampton County, and extends through Northampton, Lehigh, and Berks counties in a southwesterly direction. There is then a break filled up by Lebanon and Lancaster counties to the southwest, but in the southern part of York County operations in what is known as the Peach Bottom region reappear. Passing from the Delaware Water Gap in a southwesterly direction, the most important producing localities are as follows: Slateford, Mount Bethel, East Bangor, Pen Argyl, Wind Gap, Belfast, Edelman, Chapman Quarries, Treichlers, Danielsville, Walnutport, Slatington, Tripoli, Lynnport, Steinsville, and finally, in York County, a portion of what is known as the Peach Bottom region, which is for the most part in the northern part of Harford County, Md. The most important localities in York County are West Bangor and Delta, which may be regarded as the principal points for the entire Peach Bottom region. The slate of Pennsylvania is frequently divided, more for commercial reasons than anything else, into the following regions: The Bangor region, the Lehigh, the Northampton Hard Vein, the Pen Argyl, and the Peach Bottom regions. The Bangor region is entirely within Northampton County, and is the most important. It includes quarries at Bangor, East Bangor, Mount Bethel, and Slateford; the Lehigh region includes Lehigh County entire, also a few quarries in Berks and Carbon counties, and also a small number of quarries in Northampton County, on the side of the Lehigh River, opposite Slatington; the Pen Argyl region embraces quarries at Pen Argyl and Wind Gap, in Northampton County. The Northampton Hard Vein region is especially distinguished on account of the extreme hardness of the slate as compared with that produced in other regions of the State. It includes the following localities: Chapman Quarries, Belfast, Edelman, Seemsville, and Treichlers, all in Northampton County. The Peach Bottom region includes four quarries in York County, Pa., and five in Harford County, Md.

One of the chief difficulties met with in quarrying the so-called "soft" slate of Pennsylvania is the occurrence of what are known as "ribbons." These ribbons are composed of foreign material and are exceedingly hard and interfere not a little with the smooth and economical quarrying of the slate. These ribbons are entirely wanting in the Peach Bottom slate, and this makes a great difference in the case of quarrying in favor of the product of the Peach Bottom region. The slate produced at Chapman Quarries and other localities quarrying the same kind of slate that is produced at this locality is so extremely hard that although it can be split with about the same readiness as the soft slate, it has to be sawed with diamond saws. This hardness is naturally an advantage to the slate, rendering it durable and nonabsorptive. For flagging purposes it is extremely well adapted, chiefly on account of its hardness. The most important product into which this hard vein slate is made is roofing slate, although it finds considerable application for billiard tables, imposing stones, blackboards, cisterns, lintels, window sills, copings, ridgepoles, stairsteps, and floor tiles. For paving purposes it has given great satisfaction.

The largest quarry in the State, and probably in the country, is the old Bangor quarry at Bangor. The dimensions of this quarry are 1,100 feet long, 350 feet wide, with an average depth of 175 feet. Operations are conducted on a very large scale here in every respect, two locomotive engines and a large number of cars being kept during a part of the year almost constantly employed in stripping and transporting the surface material to the dump.

Slate quarrying not only in Pennsylvania, but in all other States producing slate, is carried on almost entirely by the Welsh, in so far as skilled labor is concerned. This is of course due to the fact that operations of quarrying slate have been better studied in the enormous slate quarries of Wales than in any other part of the world, and naturally labor skilled in slate quarrying comes from that country. For ordinary labor, such as stripping, Italians supply most of the demand. A large school-slate factory is in active operation at Bangor. In this factory the operations are carried on almost entirely by machinery, which is so perfect in its working that the manual labor required in attending to it is largely monopolized by children of both sexes. Similar statements may be made of large and prosperous school-slate factories in operation in Slatington and Walnutport. In the manufacture of roofing slate, boys are quite freely employed in the work of trimming the slates after they have been split to the proper thickness and approximate size. This practice enables the Welsh to keep the skilled work largely in their own hands, as they bring up their sons to learn the business after them, beginning with the light work of trimming, and as they grow older and stronger extending their work to the heavier operations.

Vermont.—The slate output of this State comes entirely from quarries in Rutland County. The industry has suffered quite noticeably from the financial depression which has characterized the years 1893 and 1894. The total value of the output of 1893 was placed at $535,732. As explained in connection with the consideration of slate statistics in New York State, the above figures for 1893 in Vermont are somewhat too low, as returns from some Vermont quarries operated by residents of New York State were erroneously returned as belonging to the latter. The value of the product in 1894 for Vermont has been very exactly ascertained to be $658,167. Of this amount, $455,860 represents the value of 214,337 squares of roofing slate, while the remainder is the value of milled stock.

The area in which slate is actually produced at present is confined to a narrow strip in Washington County, N. Y., and a somewhat wider one lying next to it in Rutland County, Vt. It extends from Castleton, Vt., on the north, to Salem, N. Y., on the south, a distance of 35 or 40 miles, and has a maximum width of 6 miles, but the average is not more than a mile and a half. Scattered over this territory there are about forty-nine quarries in Vermont, and abandoned quarries, or those which for one cause or another are at present idle, number many more. The first commercial use to be made of the slate of this region was between thirty and forty years ago, when Messrs. Alanson and Ira Allen began on a small scale the manufacture of school slates from the stone obtained at Scotch Hills, 2 miles north of the village of Fair Haven. This quarry is still in operation. The industry has now reached large proportions, the number of quarries keeping pace with the demand for the stone, and this is steadily increasing as new purposes are found for its application.

According to Mr. George W. Harris an outcropping of black slate has been observed near Benson, Rutland County. No actual developments have been made, but tested samples give promising indications both as to texture and color.

The slate differs somewhat in its physical properties, such as hard, ness, homogeneity, and cleavage, but the greatest variation is to be found in its color, no other place in the world showing so many colors in an area of equal size. Most of the commercial names under which the slate is sold are descriptive of the color of each kind, and are as follows: Sea green, unfading green, uniform green, bright green, red-bright red, cherry red, purple, purple variegated, variegated, and mottled.

The line dividing Vermont and New York also marks the division of two important varieties of slate. The true sea-green is found only in the former State, while the red is entirely confined to the latter, some of the quarries producing the respective kinds being, however, but a few hundred yards apart. The sea-green slate is manufactured almost entirely into roofing slates, more than three times as many squares being made from it as from all other varieties combined. It is quarried very extensively in the villages of Pawlet and Poultney. The selling price per square is lower than for any other prominent kind quarried in the region, and the greater output results both from its predominance in the localities mentioned and from the ease with which it is worked, the split being remarkably pronounced. When first quarried its color is a pleasant grayish-green, but after being exposed to the weather it gradually fades and changes in a very unequal manner, certain sheets turning brown, others light gray, while some remain practically unchanged. A roof covered with it presents, after a year or two, a peculiar spotted appearance. It is, however, a good wearing slate, and the objection to its color is the principal one against it.

As already stated, no red slate is produced in Vermont, while the red-slate quarries of New York, just across the dividing line, are the only ones in the world producing red slate.

Virginia.—The slate industry of Virginia is developing in a satisfactory manner, and although the general business depression has affected the industry during the past two years, progress has been made both in an increase of output in 1894 as compared with 1893, and in the further perfection of mills for the manufacture of products other than roofing slate. The value of the output in 1893 was $117,347, representing the value of 27,106 squares of roofing slate and $12,500 worth of milled stock. In 1894 the total value of the output was $138,151, of which $19,300 represented the value of milled stock and the remainder that of 33,955 squares of roofing slate. Most of the product comes from Buckingham County, while the rest is quarried in Amherst and Albemarle counties.

HISTORICAL DATA.

According to Mr. George W. Harris, of Fair Haven, Vt., the quarrying of slate began with the operations at the Cilgwyn quarries in Wales. From these was taken the slate used in roofing some of the oldest castles in that country. Some of these structures are said to have been in existence prior to the Norman conquest. Excavations made in one of the ancient churchyards of Wales revealed a headstone erected over the grave of Sir William Brereton, who, according to the inscription, died in the year 1651. A headstone in a graveyard at Plymouth, Mass., bears the date February 23, 1672. This slab and others were brought to this country as ballast in ships from the earliest Welsh quarries.

The first use to which Vermont slate appears to have been put was the manufacture of school slates by Deacon Ranney and Colonel Allen, of Fair Haven, Vt. In 1847 the production of roofing slate began, only 200 squares being manufactured the first year. In 1855 the same locality yielded 45,000 squares of roofing slate.

THE SANDSTONE INDUSTRY.

NATURE AND VARIETIES OF SANDSTONE.

The constituent granules of sandstone have resulted from the disintegration of the older rocks under the influences of dynamic action, erosion, and weathering. The sedimentary deposition of these granules from suspension in water, supplemented by the cementing effect of other substances, aided by pressure, has given rise to what is known as sandstone. The hardest essential component of the older rocks is quartz, which is naturally therefore the most abundant granule-forming material, and while other minerals are to be found in sandstone most of the sandstones are almost entirely made up of quartz. Feldspar and mica are to be found in some sandstones, but the constitution of this rock on the whole is much simpler and more uniform than is the case with granitic and volcanic rocks.

The size of the constituent granules in sandstone is quite variable, and thus it is customary to distinguish between fine and coarse grained stone.

The nature of the material which binds the granules together is an important consideration, since it determines largely the strength, durability, and beauty of the stone, and consequently its commercial value. It is scarcely necessary to observe that no matter how hard the granules of a sandstone may be, if they are not firmly bound together the rock as a whole may be easily crushed and disintegrated. The commonly occurring cementing materials are oxides of iron, argillaceous material, calcium carbonate, and silica, the latter in a different physical condition from that which constitutes the quartz granules themselves.

Argillaceous sandstone is that in which the cementing material is clay; such stone is apt to be weak and easily crushed, unless it happens that the original clay has been changed and hardened by metamorphic action.

The cementing material of calcareous sandstone is calcium carbonate, which, owing to its susceptibility to decomposition under the influence of an acid atmosphere, is not so desirable as some other materials.

Ferruginous sandstone is that in which the cement consists of one or another of the oxides of iron, or mixtures of them. These oxides of iron are to be found in many of the best sandstones. In addition to their cementing qualities they are also responsible for the color of the stone when this is pink, red, brown, or some shade intermediate between them. Sandstones in which but little or no ferric oxide is present usually show a light color, due to the absence of iron compounds altogether or to their presence only in the ferrous or unoxidized condition. Light-colored stone frequently becomes darker in color upon exposure to the air, on account of the oxidation of ferrous compounds (oxide or carbonate) or iron pyrites to ferric oxide.

When the cementing material is silica, which is chemically the same thing as quartz, the stone consists entirely of silica. Such stone is extremely hard and durable, but difficult to work. It is not subject to change in color, which is light gray or bluish gray. When such stone occurs in thin layers it is easily quarried in sheets or slabs, in which form it is used extensively for curbing and flagging in our largest cities, and is known commercially as bluestone. Siliceous sandstone grades into what is known as quartzite, which has been hardened by heat and pressure.

COMPOSITION OF SANDSTONE AS SHOWN BY ANALYSES OF SAMPLES FROM VARIOUS LOCALITIES.

The following table of analyses of sandstone from a number of localities will serve to indicate its general composition:

Analyses of sandstone.

No.	Kinds of stone.	Locality.	Silica.	Alumina.	Iron oxides.	Manganese oxide.	Lime.	Magnesia.	Potash.	Soda.	Carbonic acid, water, and loss.
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1	Manyard	East Longmeadow, Mass.	79.38	8.75	2.43	......	2.57	......	4.08 (potash and soda)		2.79
2	Worcester	....do	88.89	5.95	1.79	.41	.27	......	.86 (potash and soda)		1.83
3	Kibbie quartz	....do	81.38	9.44	3.54	.11	.76	.28	......	......	4.49
4	Brownstone	Portland, Conn.	69.94	13.15	2.48	.70	3.09	Trace	3.30	5.43	1.01
5	Sandstone	Stony Point, Mich.	84.57	5.90	6.48	......	......	.68	Undetermined.		1.92
6	Quartzite	Pipestone, Minn	84.52	12.33	2.12	......	.31	Trace	.11	.34	2.31
7	Buff	Amherst, Ohio	97.00	......	1.00	......	1.15	......	.64 (potash and soda)		.21
8	Berea	Berea, Ohio	96.90	......	1.68	......	.55	......	.55 (potash and soda)		.32
9	Euclid bluestone.	Euclid County, Ohio.	95.00	2.50	1.00	......	......	......	......	......	1.50
10	Columbia	Columbia, Ohio	96.50	......	......	......	1.00	......	.50 (potash and soda)		2.00
11	Red	Laurel Run, Pa.	94.00	Trace	1.90	......	1.10	1.00	......	......	1.92
12	Elyria	Grafton, Ohio	87.66	1.72	3.52	......	.17	.20	......	......	2.03
13	Sandstone	Fond du Lac, Minn.	78.24	10.88	3.83	......	.95	1.60	1.67	.06	......

AUTHORITIES FOR ANALYSES.—Nos. 1 and 2, Leonard P. Kinnicutt, Ph. D.; No. 3, C. F. Chambers, Ph. D.; No. 4, F. W. Taylor; No. 5, F. W. Clarke, United States Geological Survey, Bulletin No. 27; No. 6, Geology of Minnesota, vol. 1; No. 7, J. H. Salesbury; No. 8, John Eisenmann; No. 11, A. A. Breniman; No. 12, F. F. Jewett; No. 13, N. H. Winchell, Geology of Minnesota, vol. 1.

USES TO WHICH SANDSTONE IS PUT.

The following is a list showing the various uses to which the sandstone of the country is put:

FOUNDATIONS, SUPERSTRUCTURES, AND TRIMMINGS.

Solid fronts.	Buttresses.	Capping.	Ashlar.
Foundations.	Window sills.	Belting or belt courses.	Forts.
Cellar walls.	Lintels.	Rubble.	Dimensions.
Underpinning.	Kiln stone.		Sills.
Steps.			

STREET WORK.

Paving blocks.	Basin heads or catch-basin covers.	Road making: Macadam.	Sledged stone.
Curbing.	Stepping stones.	Road making: Telford.	Crushed stone.
Flagging.		Road making: Concrete.	

ABRASIVE PURPOSES.

Grindstones.	Whetstones.	Shoe rubbers.	Oilstones.

BRIDGE, DAM, AND RAILROAD WORK.

Bridges.	Breakwater.	Rails.	Bank stone.
Culverts.	Jetties.	Ballast.	Parapets.
Aqueducts.	Piers.	Approaches.	Docks.
Dams.	Buttresses.	Towers.	Bridge covering.
Wharf stone.	Capstone.		

MISCELLANEOUS.

Grout.	Lining for blast furnaces.	Watering troughs.	Glass furnaces.
Hitching posts.	Rolling-mill furnaces.	Fluxing.	Core sand for foundries.
Fence wall.	Adamantine plaster.	Ganister.	Random stock.
Sand for glass.	Millstones.	Fire brick, silica brick.	
Sand for plaster and cement.	Cemetery work.	Lining for steel converters.	
Furnace hearths.			

VALUE OF THE SANDSTONE PRODUCT, BY STATES.

The following table shows, by States, the value of the sandstone produced during the calendar year 1894:

Value of sandstone production in 1894, by States.

States.	Value.	States.	Value.
Alabama	$18,100	Missouri	$131,687
Arkansas	2,365	Montana	16,500
California	10,087	New Jersey	217,941
Colorado	69,105	New Mexico	300
Connecticut	322,934	New York	450,992
Georgia	11,300	Ohio	1,777,034
Idaho	10,529	Pennsylvania	349,787
Illinois	10,732	South Dakota	9,000
Indiana	22,120	Texas	62,350
Iowa	11,639	Utah	15,428
Kansas	30,265	Virginia	2,258
Kentucky	27,868	Washington	6,611
Maryland	3,450	West Virginia	63,865
Massachusetts	150,231	Wisconsin	94,888
Michigan	34,066	Wyoming	4,000
Minnesota	8,415		
		Total	3,945,847

Inspection of the foregoing table, which reveals a total value of $3,945,847, and a comparison with the total for the year 1893, shows a falling off in production of $1,249,304. This decrease is greater than for any other kind of stone. This is what would naturally be expected, in view of the fact that sandstone is more exclusively used for building purposes than any other variety of stone. Thus, granite is quite largely employed as paving material in the form of Belgian blocks, and for monumental and cemetery purposes; limestone, also, besides its use as building material, is used for road making, burning into lime, and for blast-furnace flux purposes, requiring large quantities of stone. In the census year 1889, 23 per cent of the limestone, 43 per cent of the granite, and 65 per cent of the sandstone were the proportions of each used for building purposes. Hence it is, that building operations being restricted on account of hard times, the sandstone industry suffered more than the others. A surprisingly large number of sandstone quarries shut down operations entirely on account of the lack of demand, while, without any exception, the largest producers report a serious falling off in output, sometimes amounting to 50 per cent of the value of the output in 1893.

The following table shows the production of sandstone, by States, for the years 1890 to 1894:

Value of sandstone, by States, from 1890 to 1894.

States.	1890.	1891.	1892.	1893.	1894.
Alabama	$43,965	$30,000	$32,000	$5,400	$18,100
Arizona	9,146	1,000	35,000	46,400	....
Arkansas	25,074	20,000	18,000	3,292	2,365
California	175,598	100,000	50,000	26,314	10,087
Colorado	1,224,098	750,000	550,000	126,077	69,105
Connecticut	920,061	750,000	650,000	570,346	322,934
Florida	(a)	....	....	....	....
Georgia	(a)	....	2,000	....	11,309
Idaho	2,490	....	3,000	2,005	10,529
Illinois	17,896	10,000	7,500	16,859	10,732
Indiana	43,983	90,000	80,000	20,000	22,120
Iowa	80,251	50,000	25,000	18,347	11,639
Kansas	149,289	80,000	70,000	24,761	30,265
Kentucky	117,940	80,000	65,000	18,000	27,868
Maryland	10,665	10,000	5,000	360	3,450
Massachusetts	649,097	400,000	400,000	223,348	150,231
Michigan	246,570	275,000	500,000	75,547	34,066
Minnesota	131,979	290,000	175,000	80,296	8,415
Missouri	155,557	100,000	125,000	75,701	131,687
Montana	31,648	35,000	35,000	42,300	16,500
Nevada	(a)	....	....	....	....
New Hampshire	3,750	....	....	....	....
New Jersey	597,309	400,000	350,000	267,514	217,941
New Mexico	186,804	50,000	20,000	4,922	300
New York	702,419	500,000	450,000	415,318	450,992
North Carolina	12,000	15,000	....	....	....
Ohio	3,046,656	3,200,000	3,300,000	2,201,932	1,777,034
Oregon	8,424	....	35,000	....	....
Pennsylvania	1,609,159	750,000	650,000	622,552	349,787
Rhode Island	(a)	....	....	....	....
South Dakota	93,570	25,000	20,000	36,165	9,000
Tennessee	2,722	....	....	....	....
Texas	14,651	6,000	48,000	77,675	62,350
Utah	48,306	36,000	40,000	136,462	15,428
Vermont	(a)	....	....	....	....
Virginia	11,500	40,000	....	3,830	2,258
Washington	75,936	75,000	75,000	15,000	6,611
West Virginia	140,687	90,000	85,000	46,135	63,865
Wisconsin	183,958	417,000	400,000	92,193	94,888
Wyoming	16,760	25,000	15,000	100	4,000
Total	14,464,095	8,700,000	8,265,500	5,195,151	3,945,847

a Sandstone valued at $26,199 was produced by Rhode Island, Nevada, Vermont, Florida, and Georgia together, and this sum is included in the total.

SANDSTONE INDUSTRY IN THE VARIOUS STATES.

Alabama.—Sandstone has been produced from quarries in Jefferson, Colbert, and St. Clair counties. Production in 1894 has been much restricted, but indications for improvement in 1895 are well defined and unmistakable.

Arkansas.—But very little sandstone is quarried in Arkansas, although it has been produced on a limited scale in four different counties, namely, Johnson, Sebastian, Conway, and Miller.

California.—In sandstone production, as in that of all other kinds of stone, the year 1894 has been an exceedingly dull one in this State. Production in 1894 was so limited as to be hardly worth noting. In former years sandstone has been produced in the following counties, named in order of importance: Santa Clara, Amador, Ventura, San Bernardino, Yolo, Solano, and Napa.

Colorado.—Production of sandstone in Colorado a few years ago had assumed quite large proportions, and in 1889 the value of the output was found to be $1,224,098. During 1894 the industry almost came to a standstill, many operators quitting the business entirely, while others barely existed in their struggles with slack demand, low prices, and slow collections. The counties which have yielded sandstone are, in order of importance: Boulder, El Paso, Larimer, Eagle, Jefferson, Las Animas, Fremont, Park, Huerfano, and Montezuma.

Connecticut.—Practically the entire output of sandstone in this State comes from the well-known quarries at Portland, Middletown, and Cromwell, in Middlesex County. The product of these localities has long been in favor in the most important cities of the East. While production is in amount well below that of a few years since, the industry is in a stable condition, with promise of decidedly better results in 1895.

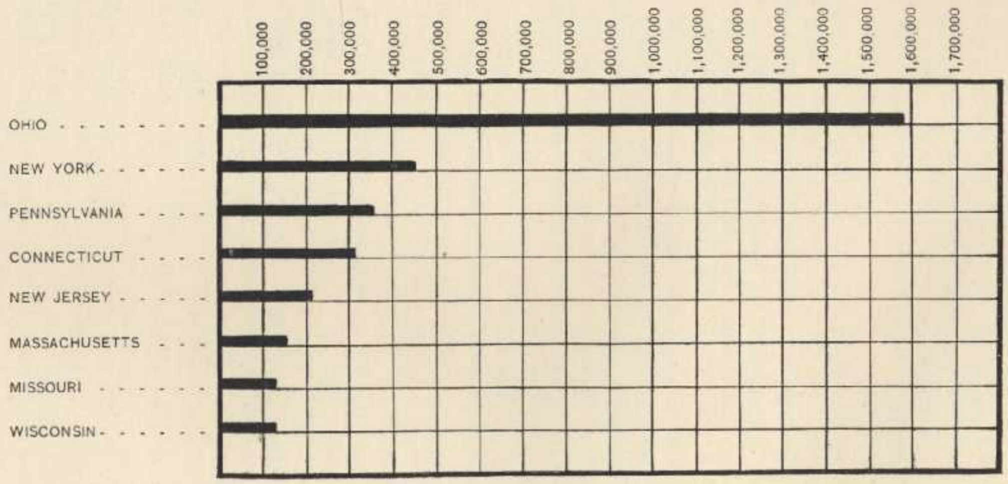
Georgia.—While a small quantity of sandstone was produced in 1894, this branch of the stone industry in Georgia has never amounted to a great deal. Much more enterprise has been shown in the development of its valuable resources in granite, marble, and slate.

Idaho.—The output of sandstone in Idaho exceeded that of the census year, but the industry does not yet cut much of a figure. The product is confined to Ada County.

Illinois.—This State, while very prominent for its limestone output, has not as yet done much in the way of quarrying sandstone, although operations have been carried on in Henry, Fulton, Whiteside, Union, Knox, Lee, and Clay counties.

Indiana.—Indiana is widely known for oolitic limestone rather than for other varieties. Sandstone is produced to a limited extent in the following counties: Warren, Fountain, Orange, and Putnam.

The sandstone of Orange County deserves especial mention on account of its value for abrasive purposes. This stone is said to need no oil to soften it, but is used with water alone, and it appears to be very



VALUE OF SANDSTONE PRODUCED IN THE VARIOUS STATES DURING THE YEAR 1894.

popular for the purpose of sharpening tools. It has been very highly recommended for razor hones and for sharpening axes and knives. It is found chiefly in the western part of Orange County, and appears to be produced in no other county of the State. Much of it is shipped in the rough to various points in New York to be sawed.

Iowa.—Sandstone production has been at quite a low ebb in 1894, although it has never been of much importance to the State. Marion and Hardin counties have been the most important, though small amounts have been quarried in Cerro Gordo, Clayton, Lee, Jasper, Washington, and Scott counties.

Kansas.—Sandstone is found in all parts of this State, but the most productive portions are in the southern and southeastern counties. Bourbon, Phillips, and Rawlins counties are the most productive, although quarries have been operated in Crawford, Woodson, Clark, Wilson, Kingman, Harper, and Comanche counties.

But little was done in 1894.

Kentucky.—Although sandstone has been quarried in seven counties of the State, almost nothing was done in 1894. Productive counties are Rowan, Muhlenberg, Lewis, Bell, Crittenden, Rockcastle, and Ohio.

Maryland.—The annual production of sandstone in this State has never been large, although some of the stone is fine in quality. This statement applies particularly to stone quarried in Montgomery County, on the Potomac River, 20 miles from Washington. It was known originally as Seneca red sandstone. It has been used in quite a large number of buildings in the city of Washington, notably the Smithsonian Institution. From all the evidence which has been submitted it appears to be one of the best red sandstones in the country. Many of the strong and unqualified indorsements of this stone appear as the favorable result of an investigation of a committee of Congress appointed to investigate the use of this stone in the construction of the State, War, and Navy Department building in Washington.

Massachusetts.—While the granite interests of Massachusetts have held their own during the financial depression, sandstone production has fallen off decidedly. The productive counties are Hampden, Suffolk, Norfolk, and Hampshire. The first named yields most of the product.

Michigan.—This State has produced some fine grades of sandstone, which are favorably received by builders over quite a wide area of the country. Leading producers report poor business for the past year, but there is no doubt that indications for 1895 are much more favorable. Productive counties are chiefly Houghton and Marquette.

Minnesota.—Production fell off markedly in 1894. Productive counties are Pine, Pipestone, St. Louis, Houston, Rock, and Scott.

The developments which have been made in Pipestone County in what is commercially known as "Pipestone red jasper" are of particular interest. This is a metamorphic quartzite rock of intense hardness, varying in color from cherry to lavender or violet. Its extreme hardness is another important characteristic. The following analysis was made by Dr. C. T. Jackson:

Analysis of red pipestone from Pipestone County, Minn.

	Per cent.
Water	8.4
Silica	48.2
Alumina	28.2
Magnesia	6
Peroxide of iron	5
Oxide of manganese	.6
Carbonate of lime	2.6
Loss	1
Total	100.0

The following tests of this stone have been made:

Tests of Minnesota red pipestone.

Crushing strength	lbs. per sq. in.	23,000
Specific gravity		2.8
Weight per cubic foot	lbs.	170.6

On account of its color and desirable properties which tend to make the stone durable, it is quite popular as a building material, and has already been used in the construction of a large number of important buildings.

Missouri.—Sandstone quarrying was very much depressed throughout the year. In spite of hard times, however, the falling off was not nearly so pronounced as in many other States. The value of the product in 1889 was $155,557, and in 1894, $131,687. The most important counties are Johnson, St. Clair, and Cape Girardeau; others less productive are Carroll, Barton, Saline, Franklin, Vernon, Holt, Lewis, Buchanan, and Henry.

Montana.—A small amount of sandstone was quarried during the year. The productive counties are Deer Lodge, Cascade, Custer, and Yellowstone.

New Jersey.—The sandstone industry of New Jersey is one of considerable magnitude, having amounted in 1889 to a valuation of $597,309. The decrease to $217,941 in 1894 appears to be entirely attributable to the general low condition of trade.

New York.—The sandstones of this State are quite various in color and in fineness of texture; some of them have won lasting reputations for adaptability to building purposes. Production languished in 1894, amounting in value to $450,992, while in 1889, the corresponding figure was $702,419.

The best known sandstone is the Potsdam red sandstone. It has an enviable reputation for durability and for ability to withstand the effects of sudden heating and cooling.

The leading countries producing sandstone are Orleans and St. Lawrence; others are Niagara, Oswego, Oneida, Jefferson, Chenango, Monroe, Allegany, Greene, Rockland, Washington, Tioga, Steuben, Schuyler, Franklin, Wyoming, Essex, Chautauqua, Otsego, and Cattaraugus.

In addition to the production of sandstone in New York, a large quantity of what is commercially known as "bluestone" is quarried. Bluestone is the name given to the variety of sandstone which consists almost entirely of granules of silica cemented together by silica. The identity of this stone with sandstone is not generally recognized among the bluestone producers; in fact, many of them seem almost indignant if it is called sandstone. The bluestone industry is entirely distinct from what is herein given as the sandstone industry. Owing to the hardness and durability of bluestone, as well as the manner in which it occurs in the earth, it is well adapted to purposes of street paving, such as flagging and curbing, and most of it is devoted to these uses. A certain amount of the stone is quarried from regularly organized quarries, with a definitely invested capital and plant and good facilities for quarrying, but a large amount is produced irregularly and spasmodically by men who invest no capital and have no definite organization as producers of stone. Their operations are conducted as follows: Provided with a very simple equipment of the most ordinary quarry tools, they dislodge the stone found on land belonging to other persons and transport it to a number of shipping points, selling it there to dealers who make a business of collecting the stone in this manner and shipping it to places where it is used. The dealers pay the individuals who quarry the stone an amount which simply compensates them for their time and labor, while the owner of the property receives a certain definite percentage from the dealer for the amount of stone thus taken from his land. During the year 1889, and a number of years previous, some of the dealers at various points in New York State constituted the members of the Union Bluestone Company, with headquarters in New York City. Each member of this company was entitled to furnish a certain percentage of the total amount sold by this company in a given year. The dealers may, therefore, be regarded in a certain sense as producers. The land on which this stone is quarried is, generally speaking, of little value for anything but the bluestone contained n it. Originally the stone was quarried for flagging only, but more recently it has been applied to quite a long list of purposes, such as rubble masonry, retaining walls, and bridge stone, curbing, gutters, step stones flooring, vault covers, bases of tombstones, porch and hitching posts, house trimmings, such as platforms, steps, door and window sills, lintels, and caps.

The stone is known commercially by a number of names, which designate approximately the region from which it is taken. Among the names in common use may be mentioned the following: Hudson River bluestone, Hudson River flagging, North River bluestone, North

River flagging, Pennsylvania bluestone, Wyoming Valley bluestone, Delaware River bluestone, Delaware flags, bluestone flagging, and bluestone.

The value of the bluestone produced in New York in 1889 was $1,303,321. This product came from 142 quarries, in addition to numerous minor quarries or holes from which the product was taken by laborers, as has already been described. The productive counties are seen in the following list: Ulster, $662,324; Delaware, $150,866; Chenango, $93,100; Sullivan, $87,930; Wyoming, $50,260; Schenectady, $47,906; Orange, 33,405; Albany, $23,285, and smaller amounts from Otsego, Jefferson, Tompkins, Schoharie, Steuben, Seneca, Greene, Chemung, Broome, Saratoga, Oneida, Rockland, Franklin, Washington, and Yates. The Union Bluestone Company, as organized in 1889, has dissolved.

No canvass of the bluestone producers has been made since 1889, when the census figures, which were collected with great care by personal visitation of all producing localities, gave the values and distribution above stated. It is safe, however, to estimate the output for 1894 at $900,000, as production has fallen off in value since 1889.

The following article, originally published in "Stone" for July, 1893, is of interest as showing the peculiarities of bluestone quarrying:

The quarrying of bluestone probably requires as much skill, if not more, than any other kind of stone, a fact often overlooked, and a potent factor in the success or failure of a quarryman. It seems to be the general impression among a great many users, and perhaps a few of the producers, of this most useful and durable stone that a man need only find a deposit of salable quality of bluestone, with no more than the usual proportion of top to bed, and with the usual shipping facilities, and success is assured, but for any one who has been closely connected with this especially interesting business it is easy to find the reason why a quarry has not paid. The causes are usually radical, and one of the first flaws, after ascertaining that the quarry contains stone in fair quantity, will be found by looking into the system of quarrying, wherein usually inheres the drawback to the prosperity of the quarry.

The peculiar formation of bluestone, and the fact that it is found in comparatively small deposits, make the use of machinery impracticable, a quarry in Chenango County, N. Y., probably being the only one which uses any of the modern machinery or blasting devices in quarrying, such as the Knox system in use at this place. Some few of the other large quarries, perhaps, are using the Knox system in blasting their top rock, and quite a number are equipped with steam drills, but it is safe to say that 90 per cent of all the bluestone is quarried by hand wedges and sledges. Flagging is a large percentage of the kind produced, and runs from one-fourth inch thick up. The beds usually produce the thinner stone on top, running heavier as the bed is worked down. Nearly every quarry has its own peculiar formation. Quarries within 400 or 500 yards of each other frequently differ greatly as to quality and formation. As a rule the best quarrymen have worked in the quarries from the time they have been able to do anything, and as that is usually pretty early in life, many of them have gained such knowledge of the work that they know to a certainty how the stone will work as soon as they see the bed, without raising a lift. It is only after long work at quarrying that a man becomes expert. In raising the flag it is very necessary that they come up in as large pieces as possible, that the cutters may get the larger-sized stone most in demand and for which the best prices are obtained. A good quarryman will handle a lift with utmost skill, driving the wedges just enough to give it the proper strain to free itself from the bed of stone, and yet not so to strain it that it will break under the stonecutter's tool, or perhaps before it is raised. There are no general rules or directions to follow; only knowledge and skill obtained by long and close attention to the work are of any service.

Ohio.—This State stands in first place among all the States of the Union for its output of sandstone. The value of the product in 1894 is $1,777,034. The financial depression during the past two years has been severely felt by the sandstone producers of the State. In 1890 the total value amounted to $3,046,656. The productive counties, in order of importance, are as follows: Cuyahoga, Lorain, Stark, Scioto, Washington, Huron, Fairfield, Summit, Trumbull, Morrow, Wayne, Muskingum; and smaller amounts from Crawford, Richland, Holmes, Harrison, Tuscarawas, Belmont, Jefferson, Mahoning, Erie, Delaware, Franklin, Lucas, Meigs, Montgomery, Ross, Licking, Guernsey, Columbiana, Perry, Portage, Wood, Ashland, Pike, and Lawrence. By far the most of the stone comes from Cuyahoga and Lorain counties, in the northern part of the State.

Some of the sandstone quarries of Cuyahoga and Lorain counties are operated in a most thorough, complete, and economical manner; the latest appliances are in use, and for smoothness of working very few quarries in the country can compare with them. The use of the Knox system of blasting in the quarries of this State is attended with great success. The stone is of such a thoroughly homogeneous character that the result of a blast by the Knox system is simply to move, slightly, large masses of stone without spalling or weakening them in any manner. One could almost stand upon the mass of rock while being blasted out without danger of personal injury.

The uses to which Ohio sandstone is put are as follows: About one-sixth is consumed for abrasive purposes, for which the stone has a very high reputation. It supplies most of the demand in the United States for grindstones, etc. Somewhat more than one-half is used for building. About one-seventh is devoted to street work; while the remainder is consumed in bridge, dam, and railroad construction.

Pennsylvania.—The value of the product in 1894 was $349,787. A great many quarries ceased operations entirely during the past year, demand being very light and prices lower than heretofore. The following are the productive counties, in order of importance: Beaver, Dauphin, Lawrence, Allegheny, Westmoreland, Montgomery, Lackawanna, Fayette, Luzerne, and Somerset; and smaller amounts from Huntingdon, Bucks, Chester, Tioga, Philadelphia, Lancaster, Indiana, Berks, Blair, Lehigh, Erie, Lebanon, Clearfield, Lycoming, Venango, Jefferson, Cambria, Warren, Elk, Crawford, Armstrong, Clarion, McKean, Delaware, Greene, and Susquehanna.

South Dakota.—The total output reached a valuation of only $9,000. The industry is a new one in this State, but there is reason to believe that it will develop considerably in the course of the next decade.

Texas.—The value of the output was $62,350, which is quite an increase over the product of a few years ago. The output comes from quarries in Washington, Parker, Grimes, Llano, Brown, Collin, and Wise counties.

Utah.—The value of the output of 1894 was $15,428. The productive counties are Utah, Summit, Emery, and Boxelder.

Virginia.—The production of sandstone in Virginia has thus far been very limited. Campbell and Prince William counties have yielded most of the product.

Washington.—Although very fine sandstone is known to occur on the shores of Lake Whatcom, but very little has yet been done in the way of development. The product of 1894 is valued at $6,611.

West Virginia.—In this State there are large quantities of sandstone admirably adapted for use in heavy foundation work, and particularly bridge work. Productive counties are Kanawha, Wood, Summers, Ohio, Marion, Lewis, Preston, Ritchie, Harrison, McDowell, and Taylor. The value of the output in 1894 was $63,865.

Wisconsin.—This State produced $94,888 worth of sandstone in 1894. This amount differs but little from that of 1893. Productive counties are Bayfield, Pierce, Douglas, Ashland, Dunn; small amounts have been taken from the following: Sauk, Lafayette, Monroe, Portage, Jackson, La Crosse, Trempealeau, Dane, and Grant.

Wyoming.—Quarrying in this State is in its infancy, although there appear to be many possibilities well worth investigation when the demand for sandstone is such as to justify it. Stone has been produced in Laramie, Albany, Converse, Carbon, and Sweetwater counties.

THE LIMESTONE INDUSTRY.

NATURE, ORIGIN, AND USES OF LIMESTONE.

The name "limestone" implies stone from which lime is made. Strictly speaking, therefore, it should apply only to the carbonate of calcium, which, by ignition, is converted into lime. In practice, however, the name covers quite a variety of materials which contain carbonate of calcium, but in very different degrees. When limestone presents itself in crystalline condition, so as to be susceptible of fine polish and delicate ornamentation, it is known as marble. Marble is specially treated in an earlier portion of this report, inasmuch as its beauty of texture and fine crystalline condition make it applicable to uses for which the noncrystalline variety of limestone can not serve.

Calcium carbonate is frequently associated with magnesium carbonate in varying proportions. When the proportion of the latter is small the stone is called magnesian limestone, but when the proportion becomes 54.35 parts of calcium carbonate to 45.65 parts of magnesium carbonate it receives the name of "dolomite," which, if crystalline, may constitute a marble, but if noncrystalline is classed with the ordinary limestones. The term "ordinary limestone" is commonly used to include all the grades and degrees of limestone except marble, and it is of "ordinary limestone" with this meaning that this report treats.

The limestones are mainly, though probably not entirely, of organic origin, resulting from the deposition and aggregation of shells, corals, etc.; but at the time of deposition other materials, such as clay, sand, iron oxides, iron pyrites, mica, etc., may have been included, thus producing a large number of grades, which are frequently distinguished by names which imply the presence of the most characteristic impurity. Siliceous, argillaceous, and micaceous limestones are names in common use. Usually the presence of these impurities is an objection to the stone for almost all the great variety of uses to which limestone is applied.

The detailed uses to which ordinary limestone is put are numerous, and some of them are of vast importance, because they can not be met by any other kind of stone. Some of the uses to which limestone is put bring it into competition with the granites and sandstone, such as building of all kinds, road making, and structural purposes generally. In its application to lime burning and blast-furnace flux, limestone stands alone, and, as will be seen from the table of production, large quantities are devoted to these purposes.

VALUE OF LIMESTONE PRODUCT, BY STATES.

Owing to the widespread distribution of limestone throughout the United States and the number and varied character of the uses to which it is put, the collection of accurate statistics becomes a much more difficult problem than is encountered in the same undertaking with any other kind of stone. In view of the difficulties which present themselves in connection with statistics of limestone, an entire revision of the directory was made, and as a result the original list of names of producers was decidedly lengthened. While the original list contained the names of all important operators, a great many additional names of less important producers were secured. The method which was found most effective in obtaining knowledge of new names consisted in addressing to postmasters of all offices located in limestone producing counties of the country a double postal card, which enabled them to return to this Bureau names of all persons in their vicinity who quarry limestone for any purpose whatsoever. The results which followed our subsequent request for information addressed to limestone producers are most gratifying, since there was every reason to believe that the returns relating to value of output were so full and complete as to amount to an actual census.

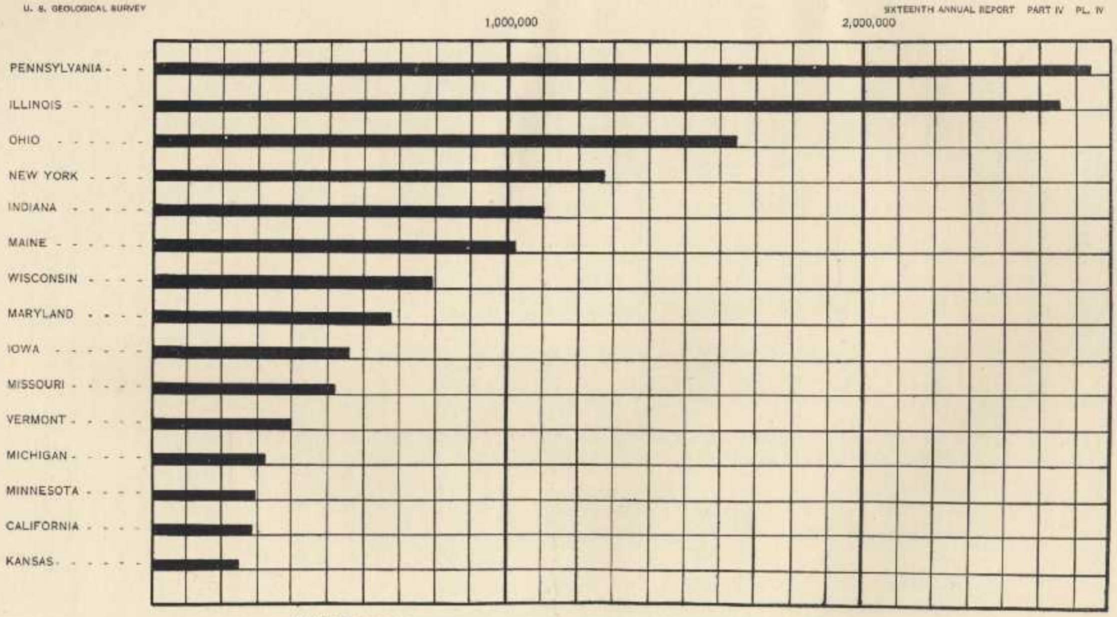
The following table shows the value of lime made, the value of stone used for building and road making, the value of stone used for blast-furnace flux, and the total value for all purposes together:

Value of limestone production in 1894, with uses to which the stone was applied.

States.	Lime.	Building and road making.	Flux.	Total.
Alabama	$171,344	$30,925	$8,000	$210,269
Arizona	15,710	44,100		19,810
Arkansas	34,360	3,868		38,228
California	273,250	15,650		288,900
Colorado	24,413	35,077	72,680	132,170
Connecticut	204,414			204,414
Florida	16,419	14,220		30,639
Georgia	32,000			32,000
Idaho	5,315			5,315
Illinois	387,973	2,167,979		2,555,952
Indiana	307,545	895,563		1,203,108
Iowa	237,066	379,564		616,630
Kansas	12,065	228,974		241,039
Kentucky	17,815	96,119		113,934
Maine	810,089			810,089
Maryland	628,979	43,807		672,786
Massachusetts	173,065	22,917		195,982
Michigan	44,656	291,631		336,287
Minnesota	78,499	212,764		291,263
Missouri	167,133	411,669		578,802
Montana	42,850	36,165	13,955	92,970
Nebraska	700	7,528		8,228
New Jersey	177,197	8,190	8,136	193,523
New Mexico	690	4,220		4,910
New York	660,503	709,962	8,386	1,378,851
Ohio	930,705	752,772	50,000	1,733,477
Pennsylvania	1,743,947	547,990	333,625	2,625,562
Rhode Island	20,433			20,433
South Carolina	25,000	100		25,100
South Dakota	2,013	1,650		3,663
Tennessee	102,921	85,743		188,664
Texas	13,308	28,218		41,526
Utah	11,665	10,031	2,000	23,696
Vermont	407,730	1,080		408,810
Virginia	151,915	109,172	23,460	284,547
Washington	57,148	2,000		59,148
West Virginia	34,801	8,972		43,773
Wisconsin	584,971	213,435		798,406
Total	8,610,607	7,382,055	520,242	16,512,904

It is evident from an inspection of the totals that the value of the lime output for the entire country is $8,610,607, or somewhat more than one-half the total value of the total output of limestone for all purposes. Somewhat less than half has been devoted to building and road making, while the remainder has been used for fluxing purposes. For the last-named uses the amount consumed has in the last year been smaller than usual on account of the depression which has existed in the manufacture of iron.

A comparison of the figures for 1894 with those of the census year 1890 shows a decline from $19,095,179 to $16,512,904. This, however, is not surprising in view of the exceptional financial depression.



VALUE OF LIMESTONE PRODUCED IN THE UNITED STATES DURING THE YEAR 1894.
(In millions of dollars.)

The following table shows the value of the limestone output by States for the years 1890 to 1894, inclusive:

Value of limestone, by States, from 1890 to 1894.

States.	1890.	1891.	1892.	1893.	1894.
Alabama	$324,814	$300,000	$325,000	$205,000	$210,269
Arizona	(a)			15,000	19,810
Arkansas	18,360	20,000	18,000	7,611	38,228
California	516,780	400,000	400,000	288,626	288,900
Colorado	138,091	90,000	100,000	60,000	132,170
Connecticut	131,697	100,000	95,000	155,000	204,414
Florida	(a)			35,000	30,639
Georgia	(a)			34,500	32,000
Idaho	28,545		5,000	1,000	5,315
Illinois	2,190,607	2,030,000	3,185,000	2,305,000	2,555,952
Indiana	1,889,336	2,100,000	1,800,000	1,474,695	1,203,108
Iowa	530,863	400,000	705,000	547,000	616,630
Kansas	478,822	300,000	310,000	175,173	241,039
Kentucky	303,314	250,000	275,000	203,000	113,934
Maine	1,523,499	1,200,000	1,600,000	1,175,000	810,089
Maryland	164,860	150,000	200,000		672,786
Massachusetts	119,978	100,000	200,000	156,528	195,982
Michigan	85,952	75,000	95,000	53,282	336,287
Minnesota	613,247	600,000	600,000	208,088	291,263
Missouri	1,859,960	1,400,000	1,400,000	861,563	578,802
Montana	24,964		6,000	4,100	92,970
Nebraska	207,019	175,000	180,000	158,927	8,228
New Jersey	129,662	100,000	180,000	149,416	193,523
New Mexico	3,862	2,000	5,000		4,910
New York	1,708,830	1,200,000	1,200,000	1,103,529	1,378,851
Ohio	1,514,934	1,250,000	2,025,000	1,848,063	1,733,477
Oregon	(a)			15,100	
Pennsylvania	2,655,477	2,100,000	1,900,000	1,552,336	2,625,562
Rhode Island	27,625	25,000	30,000	24,800	20,433
South Carolina	14,520	50,000	50,000	22,070	25,100
South Dakota	(a)			100	3,663
Tennessee	73,028	70,000	20,000	126,089	188,664
Texas	217,835	175,000	180,000	28,100	41,526
Utah	27,568		8,000	17,446	23,696
Vermont	195,066	175,000	200,000	151,067	408,810
Virginia	159,623	170,000	185,000	82,685	284,547
Washington	231,287	25,000	100,000	139,862	59,148
West Virginia	93,856	85,000	85,000	19,184	43,773
Wisconsin	813,963	675,000	675,000	543,283	798,406
Wyoming	(a)				
Total	19,095,179	8,700,000	18,392,000	13,920,223	16,512,904

a Limestone, valued at $77,935, was produced in Oregon, Georgia, Florida, Arizona, South Dakota, and Wyoming. This value is included in the total.

LIMESTONE INDUSTRY IN THE VARIOUS STATES.

Alabama.—The total value of the output in 1894 is $210,269, including the value of lime, amounting to $171,344. The product comes from the following counties: Shelby, Colbert, Lee, Blount, Franklin, Dekalb, Etowah, and Jefferson.

Arizona.—The production of limestone in this State is a comparatively new development and the product amounts to but little as yet, namely, for 1894, $19,810, of which $15,710 is the value of lime made. The producing counties are Yavapai and Maricopa.

Arkansas.—The total value of the output in 1894 was $38,228, of which the value of lime made was $34,360. The productive counties are Washington, Independence, Carroll, and Benton. The State has never produced a large quantity of lime or limestone.

In northern Arkansas, according to the geological survey made under the direction of Mr. John C. Branner, State geologist, there are six distinct beds of limestone. Each of these six beds will furnish good building material. The upper bed in places will furnish marble, although the greater part of it has little commercial value. The third bed in the series furnishes an excellent building stone at almost every outcrop, and it is found throughout nearly all the northern counties. It corresponds quite closely with the Indiana oolitic limestone, being in the same geological horizon, and resembling it in structure, except that it is more crystalline and takes a finer polish than the Bedford (Indiana) stone. It is more crystalline, less oolitic, and more fossiliferous in the western than in the eastern part of the bed. It has been quarried at Batesville, Independence County, for building stone and burning into lime. The fourth bed in the series, belonging to the Trenton period, occupies the same geological position as the Tennessee marble, which it resembles in structure and appearance. It has been traced and carefully mapped through Independence, Izard, Stone, Searcy, Marion, and parts of Newton and Boone counties. It is known to exist also in Madison and Carroll counties, and possibly extends as far west as the State line or beyond. Only small quantities have been quarried, for local use in monuments and mantels. It varies in color through light gray, pink, red, variegated, and mottled. The fifth bed is found in great quantities in Independence, Izard, Stone, and Searcy counties. It is a fair building material, and produces good lime. Some lithographic stone has been obtained from it.

California.—The value of the limestone output, $288,900, in 1894 is largely the value of lime produced; i. e., $273,250. The productive counties, in order of importance, are Santa Cruz, San Bernardino, Kern, Riverside, and San Benito; small amounts have been quarried also in Eldorado, Santa Clara, San Diego, and Placer counties.

Colorado.—The total value of the output in 1894 was $132,170. Of this value $72,680 represents the quantity used for fluxing purposes, while the remainder was about evenly divided between building and lime making. Productive counties are Pitkin, Jefferson, La Plata, Boulder, Fremont, Pueblo, Larimer, and Chaffee.

Connecticut.—The total value of the output in 1894 was $204,414. The entire output is converted into lime. In spite of considerable complaint about hard times, business was better in 1894 than in 1893, as shown by a gain of $49,414. The product comes entirely from Litchfield and Fairfield counties.

Florida.—Production of stone of any kind in this State is limited to the past few years. The value of the limestone output in 1894 was $30,639, and its use was divided about equally between the building of jetties and burning into lime.

Georgia.—Catoosa County yielded lime valued at $32,000. Ordinarily, quite a considerable amount is used for fluxing in blast furnaces, but much less was used for this purpose in 1894 than formerly.

Idaho.—A little limestone was converted into $5,315 worth of lime in Kootenai, Bingham, Alturas, and Fremont counties.

Illinois.—The limestone interests of this State are very large and important. The total value of the output in 1894 was $2,555,952. Of this amount $2,167,979 worth was used for building purposes. More than half of the product comes from Cook and Will counties, while the rest is distributed among the following counties: Adams, Jersey, Madison, Hardin, Kane, Pike, Kankakee, Hancock, St. Clair, Winnebago, Rock Island, Henderson, Dupage, Randolph, Union, Whiteside, Monroe, Ogle, Stephenson, Kendall, Jo Daviess, McHenry, Greene, and Lasalle.

The following description of the Lemont and Joliet stone is taken from the writer's report in Mineral Resources for 1889–90:

The operations in Cook and Will counties, on account of their magnitude, the general excellence of the stone produced, and the ease of quarrying and working out, deserve special mention. The region embraced by these two counties is known generally as the Joliet region. It includes territory from about 5 miles south of the city of Joliet to about 10 to 12 miles north, taking in the towns of Lockport and Lemont and running along the valley of the Illinois River. Most of the quarries are situated on the banks of either the river or the canal. The stone exists in layers at the surface, varying from 1 inch to 3 inches in thickness, and growing in thickness with the increasing depth, until at about 25 feet it is found of a thickness varying from 15 to 20 inches. It is, however, rarely quarried below the 25-foot level, owing to the expense of getting it out and dressing it, since at that depth it is much harder, although the quality of the stone is superior to that in the upper levels. At the depth of 25 feet the inflow of water materially adds to the expense of quarrying. The stone found at or near the surface is almost valueless and is almost entirely thrown away in stripping the quarry. The next two-fifths furnish stone of sufficiently good quality to be used for riprap, rubble, sidewalks, and curbing. The last two-fifths contain the best stone, namely, that used for building. It is generally of a bluish-gray color. The exposed stone is of a yellowish color, from the effects of the exposure to the atmosphere. It is also true that most of the Joliet stone turns more or less yellow upon exposure. The beds are divided vertically by seams occurring at somewhat irregular intervals of from 12 to 50 feet, and continue with quite smooth faces for long distances, and also by a second set of seams running nearly at right angles with the first, but continuous only between main joints, and occurring at very irregular intervals. This structure renders the rock very easily quarried and obtainable in blocks of almost any required lateral dimensions. The stone is easily worked into required shapes, and takes a fine, smooth finish, and is susceptible of being readily planed. This forms a very rapid and cheap method of finishing flagging stones and preparing such as are to receive a smooth finish on the polishing bed. Enormous quantities of flagging stone are taken out, most of which goes into Chicago; but business with other cities is decidedly on the increase. The finest varieties are readily produced in forms which are capable of being turned out by lathes.

The following is an analysis of Cook County limestone:

Analysis of Cook County, Ill., limestone.

	Per cent.
Silica	26.08
Alumina and oxide of iron	6.57
Carbonate of lime	46.90
Carbonate of magnesia	14.19
Water	6.26
Total	100.00

The crushing strength of this stone is 16,017 pounds to the square inch; specific gravity, 2.512. The stone obtained in the vicinity of the towns of Sterling, Morrison, Fulton, Cordova, and Port Huron is largely burned into lime. This is true of much of the stone all along the Mississippi River. The best grades of Alton stone become whiter upon exposure to the air, and some of it that has stood in buildings for twenty to twenty-five years has become almost perfectly white. The quarry at the Chester (Illinois) State prison is an immense bluff about 200 feet in height. It has been worked for only the past two or three years and is now turning out fine stone. All work is done by the convicts.

Indiana.—Owing to the production of what is known as Bedford oolitic limestone, this State is widely known as the most important in the Union in its output of limestone for fine building and ornamental purposes. The total value of the output of limestone of all kinds for the year 1894 is $1,203,108. Three-fourths of this amount is the value of stone used for building, while the remainder represents the value of lime made. The productive counties are as follows, in order of their relative magnitude: Lawrence, Huntington, Monroe, Decatur, Washington, Ripley, Owen, Clark, Franklin, Putnam, Wabash, and smaller amounts from Shelby, Grant, Carroll, Cass, Delaware, Howard, Blackford, Madison, Harrison, Jennings, Adams, Floyd, Wells, Crawford, Jay, Fayette, Miami, Randolph, Vanderburg, Wayne, and White.

The most productive portions of the State are the southern and southeastern. The limestone of the State may, for convenience, be divided into three general classes: First, the oolitic limestone, otherwise known as cave limestone, from the numerous caverns which are to be found scattered through it; second, the harder and much more crystalline variety; and third, the rock which occurs in thin strata and which is well adapted for purposes of flagging, etc. The oolitic limestone extends in a southeastern direction from Greencastle, in Putnam County. This stone is commonly known in trade as Indiana stone, or Bedford stone. It is well known over a wide area in the United States, and is an exceedingly popular building stone not only in cities of the West, but in Eastern cities as well. It has been most extensively quarried at Stinesville, Ellettsville, and Bloomington, Monroe County, and at Bedford, in Lawrence County; but owing to the increased demand for this stone, new quarries are being opened and extensively worked at frequent intervals along the line of the Louisville, New Albany, and Chicago Railroad from Gosport to Bedford, and these give promise of rich and practically inexhaustible supplies. This stone is almost exclusively used for building purposes, and it is the great production of this stone which enables Indiana to take second place among the States producing limestone for building purposes, Illinois standing in the first place. The stone is characterized by its oolitic character, and is comparatively soft when first removed from the quarry, but hardens on exposure to air. The deposit varies from a few feet to a great many in thickness, and it is practically free from fissures. Solid walls 40 to 50 feet in depth, without a seam or fault of any kind from top to bottom, have already been revealed. It is easily quarried in blocks of any size required, being cut from the solid mass by means of channelers. It is soft enough to be readily sawed, ordinary steel blades, with sand as the abrasive material, being used for sawing. Occasionally diamond saws are used with fine results. For most part the stone is fine-grained, but contains also layers of coarser material in which shells are easily recognized with the unaided eye. Operations in all quarries producing this kind of stone are conducted on the largest scale and the machinery employed is usually of the very best.

The harder, more crystalline stone is found in the eastern and southeastern parts of the State, principally in Decatur County, in the southeastern part. The quarries in general are rather small, there being twenty of them in Decatur County alone. Some of the quarries are operated on a large scale. On account of its hardness this stone can not be sawed. It is used quite largely for building purposes. In the northern and northeastern portions of the State the stone is used somewhat for building and street purposes, and in Huntington County it is largely burned into lime. The great center of the lime industry is at Huntington. The most important concern producing lime at this point is the Western Lime Company. The product has a widespread reputation for use in building. On account of the flagging nature of the stone in the more northern portions of the State, it is often quarried simply by aid of a pick and bar. This is more especially true in regard to the northeastern sections of the State. In the northern, northeastern, and eastern portions of Indiana are a great many small quarries. A number of them seem to be capable of more extended operations, but the lack of railroad facilities from the quarries to the main lines of travel exerts a retarding influence. The stone quarried at Greensburg, in Decatur County, is decidedly crystalline, and is susceptible of a high polish. The thin-bedded stone in the upper portions of these quarries is used to some extent for flagging.

The development of the oolitic or Bedford stone is largely the result of operations conducted within a comparatively few years. In a small way it has been quarried and used for twenty-five years or more, but it is within the last twelve years that the stone has been recognized and appreciated by the larger cities of the East and West. It occupies at present a very prominent position among the best building stones of the country.

Iowa.—The total value of the limestone output in 1894 was \$616,630. As is evident from the following list of productive counties, the stone is widely distributed. There are as yet few large operators, but a large number of firms producing in each case upon a comparatively limited scale. The counties yielding the product are Jackson, Dubuque, Cedar, Marshall, Jones, Scott, Lee, Clinton, and smaller amounts from Des Moines, Madison, Decatur, Cerro Gordo, Dallas, Wapello, Linn, Muscatine, Blackhawk, Mahaska, Washington, Benton, Clayton, Pocahontas, Montgomery, Tama, Floyd, Adams, Mitchell, Humboldt, Johnson, Jefferson, Clarke, Van Buren, Howard, Taylor, Keokuk, Pottawattamie, Louisa, Webster, Allamakee, Story, and Buchanan.

The following notes on Iowa building stones, by Mr. H. Foster Bain, of the Iowa State Geological Survey, are of much interest, particularly as indicating future possibilities in the stone industry of the State. Although these notes are not entirely confined to the consideration of limestone, so much of the matter relates to it that it has been thought best to insert them in the space devoted to Iowa limestone rather than in any other connection.

NOTES ON IOWA BUILDING STONES.

BY H. FOSTER BAIN.

The work of the present Geological Survey of Iowa has not as yet extended over the main stone-producing counties of the State, so that only very fragmentary notes on the stone industry are at present possible. The stone marketed from this State is almost exclusively limestone. The Sioux quartzite, occurring in Lyon County, has never been worked, except to furnish a few display and test blocks. Excellent quarry sites, however, occur over a number of square miles, and there is an ample supply of quartzite within the State for the support of a large industry. The sandstones occurring are in the main too incoherent to be of much value. Important exceptions, however, occur, among which may be mentioned the Red Rock sandstone of the coal measures occurring in Marion County. The quarries here have been idle for a few years, but it is expected that work will be resumed shortly. Similar beds occurring near Monroe, in Jasper County, have also been opened up, and it is expected that the active work of development will begin this spring.

Within the year considerable attention has been attracted to the "marble" beds along the Cedar and Iowa rivers. Extensive exposures near Iowa Falls are reported, and arrangements are being made to open them up. The Charles City beds, which are the only ones at present supplying stone to the market, belong to the Devonian, and represent the portion which has usually been called the Hamilton. The rock is a coralline limestone, and occurs in layers 8 to 30 inches thick, with a total thickness, so far as known, of about 20 feet. It is a trifle harder than Italian marble, and is reasonably free from the checks and seams so common in colored marbles. There is a great variety of colors displayed, the groundwork being mostly buff, gray, blue, or drab. Inlaid in this are masses of coral, from 1 to 20 inches in diameter, exhibiting very delicate coloring and tracing. A mantel made of this material received honorable mention at the Columbian Exposition. The stone has been on the market for several years. The quarries and mills have recently passed into other hands, and the business will be enlarged. Samples of the stone found near Iowa Falls show it to be similar to that at Charles City.

Linn County.—The chief quarries in this county are in the Upper Silurian limestones near Stone City, Waukee, and Mount Vernon. The stone is exceedingly uniform and is in color a warm-gray or pleasing cream tint. It is so homogeneous as to be readily carved and easily worked, being quite soft when first taken from the quarry. The bedding planes are so constant, smooth, and parallel as to require very little dressing. It is dolomitic, and contains very little impurity. These facts, together with the fineness and evenness of grain, presenting uneven expansion, make it one of the most durable of the limestones. In the Mount Vernon Cemetery, tombstones bearing dates as early as 1845 show little decay, though various marbles in the same cemetery show the usual loss of polish, checking, and cracks, indicating the progress of disintegration.

In the Crescent quarry near Stone City there is a total face of 60 feet of available stone, the courses running from 1 foot to 8 feet 4 inches in thickness, and including layers available for dimension, bridge, and rubble work. At Mount Vernon a switch has recently been built to the quarries and an expensive quarry plant, including steel derricks, channelers, and planers, has been put in. Borings here show a thickness of at least 50 feet of available stone below the base of the present quarry.

In addition to the larger quarries operated in the Mount Vernon beds, which are the western continuation of the well-known Anamosa limestone, there are a number of smaller openings in the various other formations exposed in the county. The Devonian does not in this county afford such good stone as elsewhere, and can hardly compete as a building stone with the Silurian stone just described. The Otis beds, however, yield abundant supplies of macadam, and are quarried for that purpose at Cedar Rapids. The Coggan beds (of the Silurian) have been used with good results in bridge work.

Van Buren County.—The rocks exposed in this county belong entirely to the Carboniferous, both the Coal Measures and the Mississippian being present. The quarry rock is taken from the latter. Both limestone and sandstone are obtained; the former from both the Keokuk and St. Louis stages, and the latter from the lower portion of the St. Louis. About 8 years ago a considerable quantity of stone was quarried from the Keokuk beds near Bentonsport and used for bridge work and riprap. In the winter of 1893 and 1894 about 1,000 yards were taken out and used to protect the piers of the bridge at that point. Magnesian limestone from the St. Louis has been quarried and used for dam work along the Des Moines River, and was used to some extent at the time the State capitol was built. There are, however, no quarries which support more than a local trade. In the upper divisions of the St. Louis, white limestone of good quality, running in courses of 12 to 15 inches in thickness, is obtained at a number of points. The "Chequest marble," a compact, dove-colored, fossiliferous limestone, susceptible of a good degree of polish, and which has been used to some extent for ornamental work, is found near Keosauqua. A block of this stone may be seen in the Washington Monument at Washington.

Mahaska County.—The quarry industry of this county is not great, a fact due in part to the poor quality of the stone exposed, and in part to the great amount of capital absorbed by the coal interests, together with the active competition of the clay interests. At present only a few quarries are open, they being worked for local trade. The limestone of the St. Louis stage is exposed along the major streams, and is opened up near New Sharon, Union Mills, Fremont, Peoria, Given, and on Spring Creek, northeast of Oskaloosa. It yields a fine-grained, ash-gray to buff stone, breaking with a sharp conchoidal fracture and running in courses of from 6 to 24 inches. This stone is used for foundations, well curbing, and similar purposes, bringing from \$2 to \$3 per perch. Only about 900 to 1,000 perch are quarried each year. The Coal Measures contain several heavy standstones which are not as yet used. At Raven Cliff, on the Des Moines River, there is an excellent face of this stone extending along an old arm of this river nearly 2 miles. The bed is over 90 feet thick, and shows single precipitous faces of more than 50 feet. The stone is clear and homogeneous, of pleasing color, and apparently of good strength. There is a railway within about two miles.

Keokuk County.—All the formations exposed within this county yield more or less quarry rock. By far the greater portion, however, comes from the St. Louis limestone. The Coal Measures here, as in the neighboring regions, contain more or less sandstone, but with the exception of the heavy beds south of Delta, which have been used a little for the construction of a dam and as foundation stone, this formation is not productive. The St. Louis contains the usual thin-bedded, fine-grained, ash-gray limestones, and has been quarried for local purposes at a number of points near What Cheer, Delta, Sigourney, Hedrick, and Richland. Near Atwood the

Chicago, Rock Island and Pacific Railway operated a quarry for some time, mainly for ballast. The greater portion of the rock is too irregular to admit of quarrying on a large scale. The lower magnesian portion of the St. Louis occurs, and yields some stone of good quality. By far the best rock in the county occurs below the St. Louis in the Augusta beds. This is a coarse, subcrystalline stone, in buff, blue, and white ledges. It is encrinital, and takes a fair degree of polish. It is readily accessible along Rock Creek near Ollie, where a switch from the Iowa Central Railway leads to the quarries. The stone is not now shipped, but arrangements are being made to reopen the property.

Washington County.—This county yields stone from all three of the major members of the Mississippian series. The principal quarries are located near Brighton, and supply stone from the St. Louis. The ledges quarried belong to the upper beds of this stage, and run in courses from 8 inches to 7 feet. The heavier and lower ledges are not now taken out, as they are badly water-coursed. The stone marketed is used for bridge and rubble stone, as well as paving flags. It is of excellent quality, but the number of ledges which are suitable for quarrying is limited. Northwest of Washington is a small group of quarries on Crooked Creek. The stone belongs to the Augusta formation. It is a coarse encrinital limestone, of great durability and of very pleasing tints. Quite an important local trade is sustained. Stone from equivalent ledges is quarried a little in the northern part of the county, near Dayton and south of Riverside. An impure magnesian limestone belonging to the Kinderhook occurs along English River and its branches, and is quarried locally. It is apparently very soft and worthless, but is really much more durable than might be supposed from its appearance.

Lee County.—The limestone of the Lower Carboniferous and the sandstones of the Coal Measures are exposed throughout Lee County, and are quarried at many points. The Burlington, Keokuk, and St. Louis beds yield the greater amount of stone. The Coal Measures yield at several points a soft, more or less ferruginous, coarse-grained sandstone, which is used but little. The Burlington beds are made up largely of a coarse encrinital lime rock, varying in color from brown to white. It is very durable, easily quarried, and readily dressed. The Keokuk limestone is, as a rule, a compact, rather hard, often subcrystalline rock, of an ashen or bluish color. Its fracture is even, approaching conchoidal. The quarry rock of the upper part of the Keokuk, sometimes called the Warsaw, is chiefly a magnesian limestone containing some sand and pebbles. It is quarried at Sonora on the east side of the Mississippi, and is known locally as the Sonora sandstone. It occurs in a massive layer 6 to 12 feet in thickness, is bluish or brownish when first taken out, but after exposure turns to buff or light brown. It has been quite extensively used at Keokuk, and has proven very durable. The St. Louis limestone is a fine-grained, compact limestone, of blue to gray color, breaking with a marked conchoidal fracture, and resembling lithographic stone in appearance.

The principal quarry industry of the county is centered around Keokuk, where there are a number of large and well-worked openings, mainly in the Keokuk beds. Quarries are found along the Mississippi, from Keokuk to Montrose, and along the Des Moines, from Croton to Sand Prairie. A number of smaller openings are located on Sugar Creek near Pilot Grove and Franklin.

Des Moines County.—This county affords quarry rock from the same beds as Lee County, and in addition a certain amount of stone is taken from the Kinderhook. The latter contains a thin bed of oolite, which is readily accessible and easily worked. It will not, however, stand well in exposed positions, and is of small value. By far the larger number of quarries in the county draw their supply from the Upper Burlington beds. These beds underlie about one-fourth of the county, and stretch out in a broad belt parallel to the Mississippi River. The rock is massive and compact, and varies in color from a pure white to shades of gray and buff. It is of excellent quality.

The quarries are located near Burlington, on Flint River and Knotty Creek, along the Mississippi, at Cascade and Patterson, and near Augusta, on Long Creek and Skunk River. A considerable expansion in the quarry industry of the county may be expected.

Allamakee County.—This county is one of the few counties of Iowa which are not covered by heavy drift deposits. There are accordingly a large number of exposures and excellent quarry sites, though the rough topography of the county has made railroad building expensive, and transportation facilities are accordingly limited. The beds exposed represent the St. Croix stage of the Cambrian, and the Oneota, St. Peter, Trenton, and Galena stages of the Ordivican. They all yield more or less good quarry stone. The St. Croix beds are quarried a little at Lansing, at a level about 100 to 125 feet above the river. The rock taken out here comes from immediately below the calcareous shale layers, which, in Minnesota, have been called the St. Lawrence limestone. It is a sandstone in which the grains of silica are cemented with calcium carbonate. The beds are exposed at numerous points along the Oneota Valley, but the St. Croix yields comparatively little stone. The Oneota limestone yields quarry rock from several horizons. At New Albin, Lansing, Harpers Ferry, and other points along the Mississippi, a fine-grained, even, and regularly bedded dolomite, in layers varying from 3 to 36 inches, is quarried. The workable beds have an aggregate thickness of about 30 feet. In the northwestern part of the county the beds are finer grained, more compact, and furnish a stone which for fine masonry is not excelled by any stone in the Mississippi Valley. Smooth-surfaced slabs, 10 or 15 feet in length and almost equal width, may be seen at numerous points. The stone stands weathering influences excellently. The beds of the Oneota above this horizon, while yielding some good stone, rarely afford the opportunity for extensive development.

The St. Peter sandstone is usually a bed of unconsolidated sand. At a few points only the particles have been cemented by siliceous or ferruginous cement, so as to be available for building stone. The Trenton limestone, while in part of excellent character, is not in this county sufficiently regular in character to supply more than local demands. A thick-bedded, yellowish limestone, resembling dolomite in appearance, and belonging to this formation, is quarried in the head of Paint Creek, near Waukon. About 75 feet above the base of the beds a thin-bedded, fine-grained, dark-gray to slate-colored stone has been quarried in the same vicinity. It does not, however, stand the weather so well as other stone in the county, and requires the handling of considerable rubbish. The Galena limestone is not quarried in Allamakee County, though it supplies a good quality of stone in the neighboring portion of Clayton County.

Rock taking a high polish and affording suitable material for ornamental purposes is taken from the Trenton. It is a compact limestone, made up of fragments of brachiopods and bryozoans, cemented with what was originally a fine calcareous mud. All the pores and interstices of the original rock and of the fossils have become filled with calcite, and very good effects may be obtained by its use.

Kansas.—The value of the product in 1894 was $241,039. Most of this was used in building and road making. The following are the productive counties: Cowley, Leavenworth, Marshall, Chase, Ripley, Butler, Lyon, Wyandotte, and smaller amounts from Marion, Atchison, Wabaunsee, Shawnee, Washington, Johnson, Russell, Dickinson, Franklin, Morris, Elk, Brown, Douglas, Republic, Pottawatomie, Coffey, Anderson, Jefferson, Ness, Montgomery, Jackson, Harper, Sumner, Ellsworth, and Osage. The stone is pretty well distributed over the eastern portion of the State. Most of it, however, comes from the vicinity of Atchison, Leavenworth, Topeka, and Fort Scott.

Tests and analyses of Kansas building stones.

LIMESTONE.

Counties.	Formations.	Crushing strength.	Weight per cubic foot.	Specific gravity.	Ratio of absorption.	Analyses.						Remarks.
						Insoluble matter.	Oxides of iron and alumina.	Calcium carbonate.	Magnesium carbonate.	Sulphates.	Moisture.	
		Pounds.	*Pounds.*			*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
Johnson		10,279	165.4	2.65	.01	8	1.35	90	.12	.02		From Ottawa; average from 3 blocks
Allen						1.53	1.75	94.12	2.72			From Humboldt.
Leavenworth		7,863	168.5	2.70	.02	5.91	2.47	89.88	1.11	.38		From Lansing; average from 5 blocks.
Do.		15,961	169.1	2.71	.004	6.20	3.31	88.17	1.88	.28	.04	From Lansing.
Cowley	Permian		165.4	2.65	.045	13.60	2.55	76.16	7.63			From Arkansas City; fine-grained and homogeneous; no appearance of fossils.
Do.	do	4,555	157.3	2.52	.07	4.25	.85	94.06	.62			From Winfield.
Marion	do		167	2.67	.07	5.18	3.15	53.16	38.33			From Marion; this stone appears to have nearly the composition of dolomite. It is fine-grained, takes a smooth surface, and is gray in color.
Do.	Carboniferous	5,824	169.8	2.72	.01	6.85	1.91	59.21	30.09	.95	.90	From Marion.
Do.	Permian	8,136	167.6	2.68	.05	13.51	1.65	61.64	22.72			From Marion; produced by I. Kuhn & Co.; dark gray; not perfectly homogeneous, occasional spots.
Do.	do	13,711	170.7	2.73	.04	6.75	1.59	51.05	40.51			Produced by I. Kuhn & Co.; average from 4 blocks, 5 miles northeast of Marion.
Do.	do	12,364	168.2	2.69	.03	5.51	1.24	91.50	1.62			
Clay	do	10,291	170.4	2.73	.05	9.50	6.40	60.04	24.72			From Clay Center; average from 3 blocks.
Butler	do	2,727	162.9	2.61	.01	5.04	.96	93.32	1.06			From Eldorado.
Douglas	Carboniferous	11,830	167.6	2.68	.007	3.53	1.07	94.18	1.16			Crushing strength is the average from 5 blocks; from Lawrence.
Franklin		2,940	162	2.59	.03	1.18	3.09	92.71	2.64			From Greeley.
Leavenworth		8,223	170.4	2.73	.01	12.97	3.06	78.46	1.16	2.32		From Lansing.
Marshall		4,216	158.8	2.54	.06	13.89	4.29	80.10	1	.39		From Beattie; average from 5 blocks.
Do.		9,810	163.2	2.61	.03	8.75	2.37	84.80	2.80	.78	.25	Do.
Do.	Carboniferous	6,543	163.5	2.62	.05	14.01	1.34	80.31	3.87			From Beattie; average from 4 blocks.
Riley	Permian	3,272	159.1	2.55	.07							From Monterey; quarried by Ulrich Bros.
Wabaunsee			166.3	2.67	.01	6.22	1.74	89.68	1.99			From Alma.
Do.	Carboniferous	7,646	161.3	2.58	.05	9.12	.70	88.55	1.25			From Alma; quarried by A. Zechser.
Do.		2,891	154.4	2.49	.06	10.37	2.49	84.53	2.35			Crushing strength is the average from 5 blocks.
Chase	Carboniferous	7,907	162.9	2.61	.04	7.30	1.05	90	1.60	.03		From Strong City; average from 6 blocks.
Do.		6,860	161.6	2.59	.04	8.57	3.62	84.72	1.75	.90		From Cottonwood Falls; quarried by Bittiger Bros.; crushing strength, average from 4 blocks.

Cowley		12,567	164.5	2.63	.01	3.34	1.69	93.98	.94			From Cambridge; quarried by H. Heddeman; average from 5 blocks.
Do	Carboniferous	3,649	153.5	2.46	.08							From Cambridge; average from 5 blocks.
Lincoln	Benton Cretaceous											No data; known as Lincoln marble, but is hardly a marble, not being sufficiently crystalline.
Hodgeman						5.06	2.08	91.30	.87	(b)	.44	From Jetmore.
Hamilton	Benton Cretaceous					4.81	3.07	90.63	.84	do	.08	From Coolidge.
Norton	Loup Fork Tertiary	4,277	156.3	2.51	.06	8.29	a.90	89	2			From Norton; crushing strength, average from 4 blocks.
Cherokee	Subcarboniferous	9,520	166	2.66	.003	8	.69	97.32	.80			From Galena.
Allen			167.3	2.68	.02	2.75	5.91	91.02	.14			Iola Marble Company.
Do		7,683	166	2.66	.02	2.63	1.76	94.10	1.54			Average crushing strength from 5 blocks.
Montgomery		7,731	169.8	2.72	.006	16.15	1.91	79.25	1.80			From Independence.
Barber		10,349	163.5	2.62	.01	1.85	1.95	94.62	1.40			Average from 6 blocks.
Franklin		12,809	167.3	2.68	.008	1.18	2.38	94.77	1.07			From Lane; quarried by Hanway.
Do		{14,415 / 16,609}	169.8	2.72	.005	3.82	a.77	94.21	1.30			Do.
Do		10,469	167.9	2.69	.009	3.94	1.20	93.61	1.20			Do.
Do		12,354	167.9	2.69	.006	4.79	1.18	93.30	1.26			Do.
Anderson	Carboniferous	14,647	168.2	2.69	.004	4.30	.81	92.76	.95	.23	.43	From Garnett.
Do		4,390	154.2	2.47	.04	.61	a1.51	97.32	.32	.43		Do.
Jackson		11,005	163.5	2.62	.02	10.93	2.02	83.99	2.66	.14		Quarried by A. W. Charles.
Woodson		14,145	168.2	2.69	.007	6.80	2.60	88.03	2.04	.21		From Yates Center.
Elk		10,162	166.2	2.66	.008	.66	2.13	93.49	3.04	.36		From Moline.
Leavenworth		5,515	160.4	2.57	.02	17.49	4.09	69.07	3.06	.37		From Soldiers' Home.
Wabaunsee		5,273	156.3	2.50	.06	3.27	2.61	92.50	1.62			From McFarland; average from 5 blocks.
Micami		2,036	128.2	2.50	.06	1.50	.95	96.50	.74			From Fontana.
Do		13,802	165.4	2.65	.004	1.35	1.32	96.09	1			From Fontana; crushing strength, average from 4 blocks.
Do		4,625	145.4	2.33	.04	2.44	.82	95.57	.80			From Fontana; crushing strength, average from 5 blocks.
Jefferson		8,767	169.8	2.72	.005	6.98	1.04	90.01	1.66			From Winchester.
Nemaha		6,757	161.6	2.59	.05	11.97	3.59	81.98	1.20	.55	.29	From Sabetha.
Leavenworth		12,266	161.1	2.71	.01							From Lansing; crushing strength, average from 5 blocks.
Brown		4,721	164.5	2.63	.06	11.83	5.53	81.91	1.56	.05		From Horton; owners, Frey Bros.; crushing strength, average from 5 blocks.
Douglas		10,339	166.6	2.67	.01	2.29	1.79	95.02	.79			From Lawrence; crushing strength average from 5 blocks.
Do		11,038	166.6	2.67	.01	8.02	2.05	88.54	1.29			From Lawrence.
Allen		17,160	168.8	2.70	.008	1.99	1.21	95.20	1.10			From Humboldt; crushing strength, average from 3 blocks.
Do		11,267	166	2.66	.02	3.79	1.07	93.20	1.01	.20		From Humboldt; crushing strength, average from 5 blocks.

a Iron in ferrous state.   b Not determined.

All of these limestones are fossiliferous in appearance. The surface appears to polish very well. Fossil outlines are very distinct in most of them. The prevailing color of the samples is a sort of gray, occasionally brownish. The polished surface of certain bluish-gray specimens is quite dark. The polish of some of these stones is very good indeed.

The foregoing table is made from the collection of limestone specimens at the World's Columbian Exposition; the determinations having been made by Dr. S. W. Williston, of Lawrence, Kans.

Kentucky.—Limestone to the value of $113,934 was quarried in Kentucky in 1894. The productive counties are Warren, Jefferson, Kenton, Fayette, Pendleton, Lyon, Jessamine, Menifee, Logan, Montgomery, Caldwell, Crittenden, Boyd, Marion, Hardin, Washington, Carter, and Trigg.

The product of Warren is deserving of special notice because of its peculiarities and its value as a building stone. This stone is known commercially as Bowling Green oolite. It is quite different from the oolitic stone of Indiana, inasmuch as it belongs to another limestone group, the constituent globules being large and distinct, whereas in most of the Indiana stone they are minute. It is quite similar to the Portland oolite of Ireland. The following analyses of Bowling Green and Portland oolite show the similarity between the two:

Composition of Bowling Green, Ky., limestone compared with Portland, Ireland, limestone.

	Bowling Green.	Portland.
	Per cent.	*Per cent.*
Carbonate of lime	95.31	95.16
Carbonate of magnesia	1.12	1.20
Silica	1.42	1.20
Water and loss	1.76	1.94
Iron and alumina	.39	.50
Total	100.00	100.00

The quarries are of large extent and are well equipped with channeling machines, derricks, etc. A mill with twelve gangs of saws finishes the stone. Blocks of almost any size can be furnished. These quarries were first opened in 1833, but until recently they were operated in the most primitive manner, and while the product has been used chiefly in the South, efforts are now being made to introduce the stone to the building trade of the Northern States. Among the cities in which it has been most used are Louisville, Memphis, Nashville, and Bowling Green; to some extent also in Chicago. The stone is soft and easily worked, and, like the Indiana stone, hardens on exposure to the atmosphere. Carvings made upon the stone stand exposure to the air very well. Its color, under the influence of sunlight, tends to become continually lighter. Its crushing strength is such as to enable it to resist a pressure of 3,000 pounds to the square inch. When heated to redness on the surface and plunged into cold water it revealed no crack, even upon examination with a magnifying glass, and in some cases on being reheated for a second and third time and plunged into water, still failed to present indications of cracking. According to present indications the extended application of the stone in the northern and eastern portions of the country seems highly probable.

Maine.—All of the limestone quarried in Maine is converted into lime. The value of the lime output in 1894 was $810, 089. This figure is lower than it has been for several years previous. Many complaints relative to business depression were made by the lime producers. The product comes mainly from Knox County, but smaller quantities are produced in Waldo and Penobscot counties.

The stone is almost inexhaustible in quantity and is admirably adapted to the purpose for which it is used. Operations of quarrying consist simply in blasting by means of dynamite, which breaks the stone up at once into sizes suitable for use in the kilns. It is then hoisted out by means of improved cables and machinery and sent directly to the limekilns, which are favorably situated for transportation by water. The stone is partially crystalline, but very coarse-grained. Fine crystals of calcite are very numerous, and gypsum also occurs. The operations at the quarries near Rockland are all below the surface of the ground. The fuel used in the kilns is entirely wood, which is imported from Canada. The stone produced for burning into lime is not measured as such, but is measured only by the quantity of lime produced from it, so that in speaking of the amount of stone quarried the producers name the amount of lime obtained from it, and the unit of measurement is a bushel or barrel of lime. The lime produced at Rockland is of fine character and is the standard lime of New York City, to which it is shipped in enormous quantities. Boston also forms an important market for the product.

Maryland.—The result of an exceptionally complete canvass of the limestone-producing sections of this State have revealed a much greater activity in limestone and lime production than has heretofore been supposed to exist. Frederick County yields two-thirds of the entire output; the rest comes from Baltimore, Allegany, Washington, Carroll, and Howard counties. The value of the product in 1894 was $672,786, almost all of which is the value of lime made.

Massachusetts.—The value of the product in 1894 was $195,982. Most of the stone is converted into lime. The output comes from Berkshire County.

Michigan.—The value of the output in 1894 was $336,287. The productive counties are Monroe, Huron, Wayne, Charlevoix, and Alpena. Most of the product was used for building and road making. The industry has grown quite markedly since 1889.

Minnesota.—The great bulk of the limestone output of Minnesota comes from quarries in the southeastern part of the State, where the cities of St. Paul and Minneapolis form important outlets. The value of the product in 1894 was $291,263. The productive counties are Lesueur, Hennepin, Blue Earth, Ramsey, Goodhue, Winona, Wabasha, Rice, Dodge, Houston, Brown, Fillmore, Olmsted, and Scott. The product is used largely for building and street work.

Missouri.—The value of the limestone and lime output in 1894 was $578,802. The corresponding figure for 1890 was $1,859,960. There has thus been a very decided falling off in production. The productive counties are St. Louis, Jackson, Marion, Greene, Buchanan, Dade, Pike, Jasper, Perry, Clark, Mercer, Lawrence, Callaway, and smaller amounts in Jefferson, Lewis, Wright, Cape Girardeau, Livingston, Andrew, St. Charles, Macon, Clay, Pettis, Cole, Linn, Caldwell, Sullivan, Randolph, Ray, Harrison, Monroe, Saline, Boone, Henry, Dekalb, Webster, and Nodaway. By far the most important county producing limestone is St. Louis County. Many quarries in and around the city of St. Louis are operated. The stone is used for purposes of heavy construction, such as bridge and railroad masonry, building, paving, macadam, riprap, and the manufacture of lime. It is of excellent quality and shows great strength. In some of the quarries steam drills are in use, but in most of them the old methods are adhered to. The manufacture of a superior quality of lime in St. Louis has grown to be a large industry. Most of the kilns are located just outside of the city limits. They are well equipped and numerous. The product is almost entirely used in St. Louis.

Analysis of Marion County, Mo., limestone.

[By Regis Chauvenet & Bro.]

	Per cent.
Silica	.08
Alumina and oxide of iron	.40
Magnesia	.02
Carbonate of lime	98.80
Total	99.30

These chemists state that this is the purest sample of limestone they have ever analyzed, leaving nothing to be desired for whiteness and purity.

Montana.—The value of the product in 1894 was $92,970, about equally divided between building and lime burning. The product comes from Jefferson, Cascade, Deerlodge, and Park counties.

Nebraska.—The limestone industry in this State was at a very low ebb in 1894, the product being valued at only $8,228.

New Jersey.—The value of the total output in 1894 was $193,523. Most of this amount represents the value of lime made. The productive counties are, in order of importance, Sussex, Hunterdon, Warren, Morris, and Somerset.

New Mexico.—The output in this Territory is so small as to call for no special comment.

New York.—The total value of the limestone output for 1894 was $1,378,851, divided equally between building and road making and lime. The productive counties are Onondaga, Westchester, Warren, Rockland, Washington, Madison, Schoharie, Ulster, Herkimer, Erie, Dutchess, Clinton, Albany, Fulton, Monroe, Columbia, Genesee, Niagara, Orange, Saratoga, St. Lawrence, Wayne, Rensselaer, Cayuga, Lewis, Montgomery, Orleans, Jefferson, Oneida, Seneca, Yates, Essex, and Greene.

Ohio.—The total value of the limestone product for 1894 was $1,733,477, about equally divided between lime and building and road making. The industry has long been an important one to the State, and the quarries are distributed over a large area embraced by the following counties: Ottawa, Sandusky, Stark, Erie, Clark, Miami, Montgomery, Wood, Franklin, Seneca, Lucas, Preble, Hamilton, Allen, Hancock, Highland, Greene, Hardin, Lawrence, Wyandot, Butler, Delaware, Muskingum, Scioto, Shelby, Van Wert, Logan, Guernsey, Jackson, Putnam, Clermont, Crawford, and Clinton.

Pennsylvania.—Production of limestone in this State is active; in fact, the value of the output for 1894 exceeds that of any other State in the Union. Four important uses, namely, building, lime, road making, and blast-furnace flux, unite in placing this State at the head of the list in consumption of limestone. The total value for all purposes in 1894 was $2,625,562. The value of the lime produced was $1,743,947; stone used for building and road making, $547,990; flux, $333,625. In addition to some very large producers, there is a large number of small producers of lime, whose output in toto amounts to a very considerable figure. The productive counties are Chester, Montgomery, Lawrence, Northampton, Bedford, Lancaster, Berks, Lehigh, Union, Blair, Dauphin, Lebanon, Northumberland, Lycoming, York, Westmoreland, Adams, Franklin, Bucks, Somerset, Mifflin, Butler, Armstrong, Huntingdon, Columbia, Cumberland, Monroe, Montour, Warren, Schuylkill, Beaver, Mercer, Washington, Allegheny, and Clarion.

Rhode Island.—The limestone production in this State amounted to $20,433, all of which was the value of lime produced in Providence County.

South Carolina.—Lime to the value of $25,000 was produced from limestone in Spartanburg County during the year 1894.

South Dakota.—The limestone industry in this State does not as yet amount to a great deal. A small quantity was produced in Custer County during the year 1894.

Tennessee.—The limestone industry in Tennessee has increased quite notably since the year 1889, when the output was valued at $73,028. In 1894 the total output reached a value of $188,664. Somewhat more than one-half of this represents the value of lime made; the remainder was devcted to building and road making. The productive counties, in order of their importance, are Davidson, Houston, Dickson, Franklin, Colbert, Hamilton, James, Montgomery, Maury, and Hickman.

Texas.—There appears to have been quite a falling off in the limestone industry of Texas. The total value of the output was only $41,526.

Most of this went for building and road making. The productive counties are Coryell, El Paso, Bell, Williamson, Travis, Hood, Grayson, Hamilton, Lampasas, and Mills.

Utah.—In Salt Lake and Sanpete counties $23,696 worth of limestone was produced in 1894. This was equally divided between lime and building purposes.

Vermont.—The value of the total output in 1894 was $408,810. This was almost entirely converted into lime, which was valued at $407,730. The product was taken from quarries in Addison, Franklin, Windham, Chittenden, and Windsor counties.

Virginia.—The production of limestone in this State has increased quite noticeably in the last few years. The value of the output in 1894 was $284,547. A comparatively small quantity was used for blast-furnace flux, while the remainder was equally divided between lime and building and road making. The most important counties are Botetourt, Warren, Alleghany, and Shenandoah. Very much smaller quantities were produced in Loudoun, Roanoke, Montgomery, Washington, Augusta, Frederick, Pulaski, Giles, Rockingham, and Tazewell counties.

Washington.—Three counties in this State yielded, in 1894, an output valued at $59,148. This was almost entirely converted into lime. The productive counties were San Juan, Stevens, and Whitman.

West Virginia.—From Berkeley, Jefferson, Greenbrier, Monroe, and Tucker counties, a product valued at $43,773 was quarried. Most of it was converted into lime.

Wisconsin.—The limestone industry in Wisconsin has become one of considerable importance. The output in 1894 was valued at a total of $798,406. Of this amount $584,971 represents the value of lime made. The remainder was consumed for building and road making. The productive counties are as follows: Calumet, Fond du Lac, Manitowoc, Dodge, Jefferson, Milwaukee, Ozaukee, Brown, Iowa, Door, Monroe, Outagamie, Racine, La Crosse, Dane, Grant, Green, Kewaunee, Columbia, Buffalo, Oconto, Waukesha, Washington, Rock, Sheboygan, Walworth, Trempealeau, St. Croix, Shawano, and Waupaca.