STONE.

By William C. Day.

INTRODUCTION.

The replies to inquiries addressed to the individual quarrymen of the United States have been exceptionally complete and full, and it is upon the information thus gained at first hand by direct correspondence with the producers that all important conclusions in the report are based. Unusual promptness in replying has also been shown. Some quarrymen have even sent in the usual reports unsolicited, thus showing a gratifying spirit of cooperation in the difficult task of publishing promptly the data secured. The importance of prompt replies can not be overestimated in work of this kind, and it is hoped that in future the few producers who need second, and sometimes even third, reminders, will, in the interest of prompt publication, make an effort to avoid unnecessary delay in mailing their returns.

ACKNOWLEDGMENTS.

While the individual returns from quarrymen constitute the most important source of information used in this report, the following technical journals have been consulted, and the value of information obtained from them is hereby acknowledged: Stone, of Chicago; The Monumental News, of Chicago; The Granite Cutters' Journal, of Baltimore; The Stone Trade News, of Concord, New Hampshire; The Mining Industry and Review, of Denver, Colorado; The American Slate Trade Journal, of Bangor, Pennsylvania, and The Journal of the Franklin Institute, of Philadelphia.

In addition to these there are many other technical papers which have been of occasional assistance. Special acknowledgments for use of publications in the above and other journals are made in the proper places in this report.

VALUE OF STONE PRODUCED IN 1896 AND 1897.

The following table shows the value of the different kinds of stone produced in the United States during the years 1896 and 1897:

Value of different kinds of stone produced in the United States during the years 1896 and 1897.

Kind.	1896.	1897.
Granite	$7,944,994	$8,905,075
Marble	2,859,136	3,870,584
Slate	2,746,205	3,524,614
Sandstone	4,023,199	4,065,445
Limestone	13,022,637	14,822,661
Bluestone	a 750,000	a 900,000
Total	31,346,171	36,088,379

a Estimated.

This table shows that the production of all the various kinds of stone has undergone a substantial increase. The reason for this is unquestionably that the financial conditions in general have improved, and a return toward prosperity is emphatically indicated. This improvement is not characteristic of all producing regions alike, since in some of them the wave has not as yet made its appearance; but, as in times of panic or depression, some industries feel the effects some time after they have been disastrous in others, these are also likely to be behind when recovery is again inaugurated.

VALUE OF STONE PRODUCT IN 1897, BY STATES.

The following table shows the value of the various kinds of stone produced in 1897, by States:

Value of various kinds of stone produced in 1897, by States.

State.	Granite.	Sandstone.	Slate.	Marble.	Limestone.	Total.
Alabama		$3,000			$221,811	$224,811
Arizona		15,000			11,522	26,522
Arkansas		3,161			44,222	47,383
California	$167,518	4,035	$7,000	$48,690	308,925	536,168
Colorado	44,284	60,847		99,600	79,256	283,987
Connecticut	616,215	364,604			178,410	1,159,229
Delaware	272,469					272,469
Florida					18,889	18,889
Georgia	436,000			598,076	32,000	1,066,076
Idaho	1,900			5,000	15,538	22,438
Illinois		14,250			1,483,157	1,497,407

Value of various kinds of stone produced in 1897, by States—Continued.

State.	Granite.	Sandstone.	Slate.	Marble.	Limestone.	Total.
Indiana	....	$35,561	....	....	$2,012,608	$2,048,169
Iowa	....	14,771	....	....	480,572	495,343
Kansas	....	20,953	....	....	208,889	229,842
Kentucky	....	40,000	....	....	40,815	80,815
Louisiana	....	8,000	....	....	....	8,000
Maine	$1,115,327	....	$201,117	....	742,877	2,059,321
Maryland	247,948	....	53,939	$130,000	199,365	631,252
Massachusetts	1,736,069	194,684	....	79,721	126,508	2,136,982
Michigan	....	171,127	....	....	215,177	386,304
Minnesota	92,412	158,057	1,500	....	236,397	488,366
Missouri	97,857	57,583	....	....	1,018,202	1,173,642
Montana	....	25,644	....	....	37,300	62,944
Nebraska	....	....	....	....	42,359	42,359
Nevada	3,050	....	....	....	....	3,050
New Hampshire	641,691	....	....	....	....	641,691
New Jersey	561,782	190,976	775	....	141,646	895,179
New York	422,216	544,514	53,799	354,631	1,697,780	3,072,940
North Carolina	59,236	11,500	....	....	....	70,736
Ohio	....	1,600,058	....	....	1,486,550	3,086,608
Oregon	1,125	....	....	....	....	1,125
Pennsylvania	349,947	380,813	2,365,299	62,683	2,327,870	5,486,612
Rhode Island	629,564	....	....	....	11,555	641,119
South Carolina	37,820	....	....	....	30,000	67,820
South Dakota	68,961	....	....	....	3,895	72,856
Tennessee	....	....	....	441,954	113,774	555,728
Texas	3,500	30,030	....	....	57,258	90,788
Utah	3,854	7,907	....	....	9,250	21,011
Vermont	1,074,300	....	695,815	2,050,229	165,657	3,986,001
Virginia	88,096	....	145,370	....	192,972	426,438
Washington	5,800	16,187	....	....	126,877	148,864
West Virginia	....	47,288	....	....	61,546	108,834
Wisconsin	126,134	33,620	....	....	641,232	800,986
Wyoming	....	11,275	....	....	....	11,275
Total	8,905,075	4,065,445	3,524,614	3,870,584	14,822,661	35,188,379
Bluestone *a*	....	....	....	....	....	900,000
Grand total	....	....	....	....	....	36,088,379

a Estimated.

GRANITE.

The following table shows the value of the granite output by States:

Value of granite product, by States, in 1897.

State.	Value.	State.	Value.
California	$167,518	New York	$422,216
Colorado	44,284	North Carolina	59,236
Connecticut	616,215	Oregon	1,125
Delaware	272,469	Pennsylvania	349,947
Georgia	436,000	Rhode Island	629,564
Idaho	1,900	South Carolina	37,820
Maine	1,115,327	South Dakota	68,961
Maryland	247,948	Texas	3,500
Massachusetts	1,736,069	Utah	3,854
Minnesota	92,412	Vermont	1,074,300
Missouri	97,857	Virginia	88,096
Nevada	3,050	Washington	5,800
New Hampshire	641,691	Wisconsin	126,134
New Jersey	561,782	Total	8,905,075

The table of granite production by States shows a gain in total output for the year 1897 of $960,081 over 1896. This advance is greater than was generally expected at the beginning of the year. Increase is characteristic of nearly all of the productive States, but is particularly striking in the case of Vermont, which has reached the highest figure ever attained in that State. This is due to activity at Barre. Quite large gains also are evident for Georgia, New Hampshire, New Jersey, New York, and Pennsylvania.

The table on the next page shows the purposes for which the granite was sold by the quarrymen. The column headed "Rough" shows how much stone was sold in rough condition without any special squaring up or dressing. The purposes which such stone ultimately served is a matter of question, as it was disposed of by the quarrymen to builders, monument and tombstone cutters, and to others for uses which could not be ascertained from the quarrymen. In spite of the difficulty thus indicated, however, the table will probably be found of interest in showing, for example, just how far the quarrymen go in preparing their product for immediate consumption without the intervention of others.

Value of granite, by States and uses, in 1897.

State.	Rough.	Building purposes.	Monumental and cemetery purposes.	Paving.	Road-making or macadamizing.	Other purposes.	Total.
California	$39,351	$35,508	$37,525	$32,264	$22,000	$870	$167,518
Colorado	7,825	34,175	2,284	....	....	....	44,284
Connecticut	248,955	148,414	94,271	76,760	34,460	*a* 13,355	616,215
Delaware	246,751	16,171	....	7,073	....	*a* 2,474	272,469
Georgia	40,288	56,366	15,083	295,005	2,318	*a* 26,940	436,000
Idaho	1,900	....	....	....	....	....	1,900
Maine	228,663	505,826	56,576	172,637	....	*b* 151,625	1,115,327
Maryland	146,213	52,048	2,700	3,328	41,999	1,660	247,948
Massachusetts	539,163	678,616	229,346	243,750	4,900	*c* 40,294	1,736,069
Minnesota	16,826	52,668	22,918	....	....	....	92,412
Missouri	25,428	3,222	4,181	47,646	17,380	....	97,857
Nevada	1,300	750	1,000	....	....	....	3,050
New Hampshire	161,190	217,486	214,803	26,177	....	*d* 22,035	641,691
New Jersey	700	28,501	1,060	24,006	477,515	*e* 30,000	561,782
New York	12,140	131,626	10,450	26,900	241,100	....	422,216
North Carolina	25,032	32,794	1,250	....	....	160	59,236
Oregon	1,125	....	....	....	....	....	1,125
Pennsylvania	64,638	30,316	....	11,708	110,065	*f* 133,220	349,947
Rhode Island	42,706	209,355	316,585	51,646	3,000	*g* 6,272	629,564
South Carolina	20,692	....	12,376	4,643	109	....	37,820
South Dakota	11,131	11,000	5,300	40,030	1,500	....	68,961
Texas	2,500	....	1,000	....	....	....	3,500
Utah	558	400	2,896	....	....	....	3,854
Vermont	430,121	283,167	341,034	16,770	3,208	....	1,074,300
Virginia	25,234	28,827	13,788	20,247	....	....	88,096
Washington	3,600	1,200	....	1,000	....	....	5,800
Wisconsin	19,001	7,200	28,076	38,827	32,313	717	126,134
Total	2,363,031	2,565,636	1,414,502	1,140,417	991,867	429,622	8,905,075

a All used for curbing.
b $80,000 dressed for bridge work and $71,625 for curbing.
c $25,126 for curbing.
d $15,525 for curbing.
e For bridge work.
f $130,020 for bridge work.
g $5,150 for curbing.

The following table shows the output of paving blocks in the years 1896 and 1897. A decrease is evident; the paving block industry is suffering from competition with various kinds of smoother and less noise-producing materials, such as asphalt and brick:

Value of granite paving blocks made in 1896 and 1897, by States.

State.	1896.	1897.
California	$73, 390	$32, 264
Connecticut	32, 592	76, 760
Delaware	17, 074	7, 073
Georgia	94, 390	295, 005
Maine	344, 101	172, 637
Maryland	33, 933	3, 328
Massachusetts	324, 784	243, 750
Missouri	27, 911	47, 646
New Hampshire	26, 353	26, 177
New Jersey	14, 847	24, 006
New York	24, 389	26, 900
North Carolina	1, 554	
Oregon	210	
Pennsylvania	65, 580	11, 708
Rhode Island	50, 851	51, 646
South Carolina	4, 644	4, 643
South Dakota	28, 326	40, 030
Vermont	30, 990	16, 770
Virginia	10, 129	20, 247
Washington		1, 000
Wisconsin	25, 688	38, 827
Total	1, 231, 736	1, 140, 417

VALUE OF THE GRANITE PRODUCT, BY STATES, FROM 1890 TO 1897.

The following table gives the value of the granite output, by States, for the years 1890 to 1897:

State.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.
Arkansas	(a)	$65, 000	$40, 000	....	$28, 100	....	....	....
California	$1, 329, 018	1, 300, 000	1, 000, 000	$531, 322	307, 000	$348, 806	$215, 883	$167, 518
Colorado	314, 673	300, 000	100, 000	77, 182	49, 302	35, 000	36, 517	44, 284
Connecticut	1, 061, 202	1, 167, 000	700, 000	652, 459	504, 390	779, 361	794, 325	616, 215
Delaware	211, 194	210, 000	250, 000	215, 964	173, 805	73, 138	67, 775	272, 469
Georgia	752, 481	790, 000	700 000	476, 387	511, 804	508, 481	274, 734	436, 000
Idaho	....	....	....	....	....	14, 560	3, 037	1, 900
Maine	2, 225, 839	2, 200, 000	2, 300, 000	1, 274, 954	1, 551, 036	1, 400, 000	1, 195, 491	1, 115, 327
Maryland	447, 189	450, 000	450, 000	260, 855	308, 966	276, 020	251, 108	247, 948
Massachusetts	2, 503, 503	2, 600, 000	2, 200, 000	1, 631, 201	1, 994, 830	1, 918, 894	1, 656, 973	1, 736, 069
Minnesota	356, 782	....	360, 000	270, 296	153, 936	148, 596	155, 297	92, 412
Missouri	500, 642	400, 000	325, 000	38[illegible], 803	98, 757	128, 987	107, 710	97, 857
Montana	(a)	51, 000	36, 000	1, 000	5, 800	....	....	....
Nevada	(a)	....	....	3, 000	1, 600	3, 200	1, 250	3, 050
New Hampshire	727, 531	750, 000	725, 000	442, 424	724, 702	480, 000	497, 966	641, 691
New Jersey	425, 673	400, 000	400, 000	373, 147	310, 965	151, 343	204, 323	561, 782
New York	222, 773	225, 000	200, 000	181, 449	140, 618	68, 474	161, 167	422, 216
North Carolina	146, 627	....	150, 000	122, 707	108, 993	75, 000	40, 017	59, 236
Oregon	44, 150	3, 000	6, 000	11, 255	4, 993	1, 728	2, 449	1, 125
Pennsylvania	623, 252	575, 000	550, 000	206, 493	600, 000	300, 000	159, 317	349, 947
Rhode Island	931, 216	750, 000	600, 000	509, 799	1, 211, 439	968, 473	746, 277	629, 564
South Carolina	47, 614	50, 000	60, 000	95, 443	45, 899	22, 083	55, 320	37, 820
South Dakota	304, 673	100, 000	50, 000	27, 828	8, 806	33, 279	199, 977	68, 961
Texas	22, 550	75, 000	50, 000	38, 991	....	....	....	3, 500
Utah	8, 700	....	15, 000	590	....	....	886	3, 854
Vermont	581, 870	700, 000	675, 000	778, 459	893, 956	1, 007, 718	895, 516	1, 074, 200
Virginia	332, 548	300, 000	300, 000	103, 703	123, 361	70, 426	95, 040	88, 096
Washington	(a)	....	....	....	....	....	....	5, 800
Wisconsin	266, 095	406, 000	400, 000	133, 220	166, 098	80, 761	126, 639	126, 134
Total	14, 464, 095	13, 867, 000	12, 642, 000	8, 808, 934	10, 029, 156	8, 894, 328	7, 944, 994	8, 905, 075

a Granite valued at $78,000 was produced in Arkansas, Montana, Nevada, and Washington together, and this amount is included in the total.

THE GRANITE INDUSTRY IN INDIVIDUAL STATES.

CALIFORNIA.

The output of granite in 1897 amounted in value to $167,518. The figure for 1896 was $215,883, so that there has been a large decline in production. Comparatively few paving blocks were made in 1897, since the overproduction of a few years previous was ample to supply the demand. Some blocks were sold below cost. Many of these had been lying by the railroad sidings ready for shipment for several years. Much of the stone used for paving and macadamizing is basalt.

The following is a statement of results obtained at the Watertown Arsenal on granite from the Rocky Point Granite Works at Exeter, Tulare County:

Tests of granite from Exeter, Tulare County, California.

[Shearing test.]

Number.	Shearing dimensions.	Shearing area.	Transverse fracture developed.	Shearing strength.	
				Total.	Per square inch.
	Inches.	*Square inches.*	*Pounds.*	*Pounds.*	*Pounds.*
302	4.04 × 6 × 2	48.48	42,500	117,300	2,419

Analysis of granite from Exeter, California.

	Per cent.
Silica, SiO_2	75.35
Oxide of iron, Fe_2O_3	3.94
Oxide of aluminum, Al_2O_3	13.69
Oxide of calcium, CaO	2.97
Oxide of magnesium, MgO	.06
Oxide of sodium, Na_2O	1.14
Oxide of potassium, K_2O	2.85
Total	100.00

Transverse test of Exeter (California) granite.

[Ends supported 20 inches apart, loaded at the middle.]

Number.	Description.	Dimensions.		Ultimate strength.	
		Breadth.	Depth.	Total.	Modulus of rupture.
		Inches.	*Inches.*	*Pounds.*	*Pounds.*
432	Light colored .	4.03	6.07	9,170	1,853

Coefficient of expansion = 0.00000461 per inch.

The following is a statement of mechanical tests made at the Watertown Arsenal by Maj. J. W. Reilly on the granite quarried by the Rocklin Granite Company.

Tests of granite from Rocklin, California.

[Tests by compression, granite cubes, pyramidal fractures.]

No. of test.	Marks.	Dimensions.			Sectional area.	First crack.	Ultimate strength.	
		Height.	Compressed surface.				Total.	Per sq. inch.
		Inches.	*Inches.*	*Inches.*	*Sq. inches.*	*Pounds.*	*Pounds.*	*Pounds.*
9819	No. 1	3.96	3.96	3.96	15.68	332,000	342,100	21,817
9820	No. 2	3.94	3.97	3.96	15.72	329,000	340,900	21,686
9821	No. 3	3.96	3.96	3.97	15.72	271,000	311,400	19,809

COLORADO.

The value of granite produced in 1897 was $44,284. This is a slight increase over 1896.

CONNECTICUT.

Production fell off from a valuation of $794,325 in 1896 to $616,215 in 1897. This decline was due to the fact that very much less breakwater stone was quarried for Government use in 1897 than in the preceding year. But for the decline in this item production would have increased, as business was better in a number of the producing localities in the State.

The following data relative to granite quarried by Mr. Henry Gardiner, at Millstone, are submitted. The tests were made by General Gillmore in 1875.

Crushing strength determined with 2-inch cubes. Total strength, 75,000 pounds. This is equal to 18,750 pounds per square inch. Specific gravity, 2.706.

The following tests of crushing strength of granite quarried by the Booth Brothers and Hurricane Isle Granite Company at its quarries at Waterford, Connecticut, were made by Mr. Ira H. Woolson, E. M., of Columbia University, New York City:

Crushing strength of granite from Waterford, Connecticut.

[Two-inch cubes tested.]

Number.	Size.	Area.	First crack.	Crushed at.	Maximum per square inch.
	Inches.	*Sq. inches.*	*Pounds.*	*Pounds.*	*Pounds.*
1575	2.1 high × 2.00 × 1.98	3.96	65,000	93,100	23,510
1576	2.008 high × 2.03 × 2.01 ...	4.08	92,000	97,600	23,921

The following analysis of the same granite was made by Messrs. Ricketts and Banks, of New York City:

Analysis of granite from Waterford, Connecticut.

	Per cent.
Silica, SiO_2	68.11
Alumina, Al_2O_3	14.28
Ferrous oxide, FeO	2.63
Lime, CaO	1.86
Magnesia, MgO	.68
Sulphur	.34
Oxide of potassium, K_2O	5.46
Oxide of sodium, Na_2O	6.57
Total	99.93

DELAWARE.

A large increase in production was realized in 1897, in this State; that is, from $67,775, in 1896, to $272,469, in 1897. This is very easily explained for the reason that a large quantity of breakwater stone for Government use was quarried in 1897.

The following tests and analysis were made by Messrs. Booth, Garrett, and Blair, of Philadelphia, on the gneiss quarried by the Brandywine Granite Company, of Wilmington, Delaware:

Analysis and tests of granite from Wilmington, Delaware.

	Per cent.
Loss on ignition, i. e., organic matter and moisture	0.30
Silica, SiO_2	67.98
Alumina, Al_2O_3	16.14
Ferrous oxide, FeO	4.39
Lime, CaO	5.89
Magnesia, MgO	.53
Oxide of sodium, Na_2O	4.32
Oxide of potassium, K_2O	.45
Total	100.00

Specific gravity = 2.77.

Crushing test: On natural bed No. 1, 2 by 2 inches equals 4 square inches, at 100,300 pounds, equals 25,075 pounds per square inch. Across natural bed No. 2, 2 by 2 inches equals 4 square inches, at 99,000 pounds, equals 24,750 pounds per square inch.

Average: 24,913 pounds per square inch.

Absorption of water: Weight after drying twenty-four hours at 212° F., 1.20 pounds. Weight after immersing twenty-four hours in distilled water, 1.20 pounds. Water absorbed, 0.0 pounds or 0.0 per cent.

GEORGIA.

Production increased from $274,734 in 1896 to $436,000 in 1897. Conditions were quite substantially improved.

A crushing strength test made at the Washington (D. C.) Navy-Yard on six 2-inch cubes of granite quarried by Mr. John Bradley at Lithonia, Georgia, gave a mean of 85,467 pounds, or 21,367 pounds to the square inch.

IDAHO.

Very little was accomplished in granite production during the year.

MAINE.

A slight decrease in production characterized the year 1897; the total value of output in 1896 was $1,195,491; in 1897, $1,115,327. Some of the individual reports indicate better prospects for 1898.

The following analysis of the granite quarried by the Blue Hill Granite Company, of Blue Hill, Hancock County, Maine, was made by Mr. Henry J. Williams, chemist, of Boston, Massachusetts.

Analysis of Blue Hill, Maine, granite.

	Per cent.
Water, H_2O	0.27
Silica, SiO_2	74.64
Ferric oxide, Fe_2O_3	1.56
Alumina, Al_2O_3	14.90
Lime, CaO	.39
Magnesia, MgO	Trace.
Potassium oxide, K_2O	6.88
Sodium oxide, Na_2O	.41
Total	99.05

On the basis of this chemical analysis the chemist estimates the mineralogical composition as follows:

Composition of granite from Blue Hill, Maine.

	Per cent.
Mica	35
Feldspar	10
Quartz	55
Total	100

The following tests of granite quarried by Messrs. S. L. Treat & Son at their quarries at Millbridge, Maine, were made at the Watertown Arsenal under the direction of Maj. J. W. Reilly:

Tests of granite from Millbridge, Maine.

COMPRESSIVE ELASTIC PROPERTIES.

[Sectional area, 4."12 × 6."09 = 25.09 square inches. Gauged length, 20".]

Applied loads.		In gauged length.		Remarks.
Total.	Per square inch.	Compression.	Set.	
Pounds.	*Pounds.*	*Inch.*	*Inch.*	
2, 509	100	0.	0.	Initial load.
25, 090	1, 000	.0023		
50, 180	2, 000	.0047		
75, 270	3, 000	.0069		
100, 360	4, 000	.0089		
125, 450	5, 000	.0108		
100, 360	4, 000	.0089		
75, 270	3, 000	.0069		Modulus of elasticity E = 9, 800, 000.
50, 180	2, 000	.0050		
25, 090	1, 000	.0030		
2, 509	100		.0008	
25, 090	1, 000	.0027		
50, 180	2, 000	.0045		
75, 270	3, 000	.0067	....	
100, 360	4, 000	.0088	....	
125, 450	5, 000	.0108	....	
100, 360	4, 000	.0089	....	
75, 270	3, 000	.0069	....	
50, 180	2, 000	.0049	....	
25, 090	1, 000	.0030	....	
2, 509	100	....	.0008	

Tests of granite from Millbridge, Maine—Continued.

LATERAL EXPANSION.

Gauged length, 5.5″.

Applied loads.		In gauged length.		Remarks.
Total.	Per square inch.	Compression.	Set.	
Pounds.	*Pounds.*	*Inch.*	*Inch.*	
2,509	100	0.	0.	Initial load.
125,450	5,000	.0005	....	
2,509	100	....	.0001	Ratio of lateral expansion to longitudinal compression, 1 to 6.8.
125,450	5,000	.0005	....	
2,509	100	....	.0001	

This specimen used in transverse test No. 391.

SHEARING TEST.

[Light-colored stone.]

No. of test.	Shearing dimensions.	Shearing area.	Transverse fracture developed on tension side.	Shearing strength.		Surfaces sheared.
				Total.	Per square inch.	
	Inches.	*Sq. in.*	*Pounds.*	*Pounds.*	*Pounds.*	
309	4.02×5.99×2	48.16	43,800	135,800	2,820	One.

TRANSVERSE TESTS.

[Ends supported 20″ apart; loaded over length of 1″ at middle.]

No. of test.	Dimensions.		Ultimate strength.		Remarks.
	Breadth.	Depth.	Total.	Modulus of rupture R.	
	Inches.	*Inches.*	*Pounds.*	*Pounds.*	
391	4.12	6.09	10,540	2,069	
424	4.13	6.08	10,320	2,027	Had been previously exposed to hot and cold water baths during observations made on the coefficient of expansion by heat.

Coefficient of expansion .00000400 between 32° and 212° F.

The following tests of granite quarried by the Maine and New Hampshire Granite Company at their quarries at North Jay, Maine, were made at the Watertown Arsenal under the direction of Maj. F. W. Parker:

Test by compression of red granite from North Jay, Maine.

Test number.	Height.	Dimension compressed surface.		Sectional area.	First crack.	Ultimate total.	Strength per square inch.
	Inches.	*Inches.*	*Inches.*	*Sq. inches.*	*Pounds.*	*Pounds.*	*Pounds.*
4541	3.02	3.00	3.00	9.00	196,800	201,300	22,367

Pyramidal fracture.

Test of white granite from North Jay, Maine.

[Compressed surface faced with plaster of paris.]

Sectional area, 6.18 inches × 6.00 inches = 37.08 square inches.
First crack at 583,000 pounds = 15,722 pounds per square inch.
Ultimate strength, 604,800 pounds = 16,310 pounds per square inch.
Pyramidal fracture.

The following report on the same granite was made by Prof. J. E. Wolff, of Cambridge, Massachusetts:

REPORT ON STONE FROM NORTH JAY, MAINE.

The analysis of this stone is based on two pieces $4 \times 2 \times 1\frac{1}{4}$ inches, of which one was used for chemical analysis, the other for the preparation of thin slices.

The rock as seen by the eye is an even-grained, white granite composed of white feldspar, quartz, plates of black mica (biotite), and white mica (muscovite), with a very rare small grain of red garnet. It has a perfectly even, massive structure without any visible line of structure or weakness. The scientific name of the rock is biotite-muscovite-granite.

Thin transparent slices of the rock were prepared and studied under the microscope, by which even the smallest impurities can be detected and the constituent minerals determined and the degree of freshness, absence or presence of cracks, etc., can be seen.

The following minerals compose the rock:

Composition of rock from North Jay, Maine.

Potash feldspar (orthoclase).
Potash feldspar (microcline).
Soda (lime) feldspar (plagioclase).
Dark mica (biotite).
Light mica (muscovite).
Quartz.

Garnet and some small accessory minerals always present in granite. All these minerals are entirely fresh, and even the feldspar, which in many good granites is clouded or whitish, owing to partial decomposition, is here entirely clear. The biotite is fresh and so is the garnet. There is hardly any magnetite in the rock and no carbonate and no pyrite, so far as could be seen. The grains are free from fractures which could possibly allow the moisture and frost to enter the rock and cause disintegration. A careful search was made for pyrite in the piece of rock and in the thin slice, but it was not found. The following analysis of the rock has been made by Mr. E. T. Rogers:

Analysis of granite from North Jay, Maine.

	Per cent.
Silica, SiO_2	71.54
Titanic oxide, TiO_2, and iron peroxide, Fe_2O_3	.84
Alumina, Al_2O_3	14.24
Ferric oxide, Fe_2O_3	.74
Ferrous oxide, FeO	1.18
Lime, CaO	.98
Magnesia, MgO	.34
Soda, Na_2O	3.39
Potash, K_2O	4.73
Water (at red heat)	.61
Sulphur, S	Trace.
Carbon dioxide, Co_2	Trace.
Total	98.59

This is the proper proportion for an average fresh granite of this mineral composition, showing a per cent of ferric iron below the average and of water below the average. As the water in granite is principally due to the decay of the feldspar and is an index of this decay, this low per cent bears out the previous statement as to the freshness of the feldspar. The ferric iron is an index to the amount of magnetic iron oxide present in the rock, and shows a very small amount. As this sometimes produces spots in time, its absence is very desirable. The trace of sulphur may be due to pyrites, but it has not been possible to detect any, and if present it must be of little importance. The cause of decay in this class of granites lies generally in the feldspar or in minute fissures penetrating the minerals. Easily soluble substances like carbonate of lime are bad, and grains of pyrites cause iron stains.

So far as this kind of an examination can go, this rock is exceptionally free from visible defects, and the microscopic and chemical analyses confirm this.

MARYLAND.

The output in 1897 differs very little from that in the preceding year. The figures for the two years were $251,108 for 1896, and $247,948 for 1897. Although there was a slight decrease, producers speak much more cheerfully than in 1896.

MASSACHUSETTS.

This State is now, and always has been, the leading State of the country in granite production. Production increased from $1,656,973 in 1896 to $1,736,069 in 1897.

The decline in the production of paving blocks, which has been going on all over the country during the past few years, has been keenly felt in Massachusetts. This decline is due in some degree to hard times, but it is becoming evident that much of it is also due to competition with other paving materials, particularly brick and asphalt. These latter materials are preferred where traffic is not too heavy because of less noise and less expense in cleaning.

On the whole, conditions are decidedly better in Massachusetts now than they were a few years ago, and prospects for the future are much more encouraging, although it may take a year or two yet to get back to the status of 1891.

The following test of crushing strength was made at the Watertown Arsenal under the direction of Maj. F. H. Parker. The stone tested was Milford pink granite, quarried by Messrs. Norcross Brothers from their quarries at Milford, Massachusetts:

Test by compression of one 6-inch cube of Milford granite.

[Compressed surfaces faced with plaster of paris to secure even bearings.]

Test number.	Dimensions.			Sectional area.	Ultimate strength.	
	Length.	Compressed surface.			Total.	Per square inch.
	Inches.	*Inches.*	*Inches.*	*Sq. inches.*	*Pounds.*	*Pounds.*
2596	5.98	5.83	5.96	34.75	725,700	20,883

Snapping sounds and pieces flew off at 546,000 pounds. Slight explosive sound at 674,500 pounds. Burst into small fragments and sand at the maximum load, accompanied by a loud report. One principal fragment was pyramidal shaped, with sharp apex.

The following analysis of the same stone was made at the School of Mines. Columbia University, New York City, by Prof. C. F. Chandler:

Analysis of Milford pink granite.

	Per cent.
Silica, SiO_2	76.07
Alumina, Al_2O_3	12.67
Ferric oxide, Fe_2O_3	2.00
Oxide of manganese	.03
Lime, CaO	.85
Magnesia, MgO	.10
Potash, K_2O	4.71
Soda, Na_2O	3.37
Total	99.80

MINNESOTA.

Production declined from $155,297 in 1896 to $92,412 in 1897.

While less activity is indicated by these figures, it is also true that in the early part of the present year (1898) prospects are more encouraging, as is indicated by the much more cheerful tone of the replies from producers.

MISSOURI.

The value of the product in 1896 was $107,710; in 1897 the corresponding figure was $97,857. A slight decline is evident, but, as in other States, the early part of 1898 shows an improved outlook.

The granite quarried by the Syenite Granite Company, of Granitevile, Missouri, was tested at Washington University, St. Louis, by Prof. J. B. Johnson, with the following results:

Tests of granite from Graniteville, Missouri.

Number of test.	Size of specimens.	Crushed at—	Crushing strength per square inch.
	Square inches.	*Pounds.*	*Pounds.*
1	3.85	93,100	24,181
2	3.78	95,700	25,317

NEW HAMPSHIRE.

The value of the output in 1896 was $497,966, and in 1897 $641,691.

At Concord and West Concord production was somewhat less active than the year before, but indications there and elsewhere were for improvement in 1898. Concord granite is of thoroughly established reputation, particularly for cut and hammered work.

The granite of Milford, New Hampshire, is highly regarded among granite producers, and its reputation for monumental work seems to be steadily increasing. Indeed, it may also be said that within the past two years this granite has become quite prominent as an admirable stone throughout New England.

NEW JERSEY.

Most of the stone classed here with granite is trap rock and is used for road purposes. Production increased from a valuation of $204,323 in 1896 to $561,782 in 1897. The stone is enormously strong as a rule, and is well adapted for road purposes.

The writer recently tested the trap rock quarried by Messrs. Hatfield & Chamberlain at their quarries at Scotchplains, New Jersey, and found a crushing strength of 35,000 pounds to the square inch.

NEW YORK.

The granite output of this State increased from a valuation of $161,167 in 1896 to $422,216 in 1897. This is a large increase, and is due to the greater activity in the production of trap rock for road purposes.

NORTH CAROLINA.

Production increased from a valuation of $40,017 in 1896 to $59,236 in 1897. All producers report better conditions in 1897. There is much fine granite susceptible of easy quarrying at a number of localities in the State.

PENNSYLVANIA.

The value of the output was $159,317 in 1896 and $349,947 in 1897. Business has been better in general. Some of the increase is accounted for by increased production of trap rock for road making, in which there has been greater activity.

The following is a report by Hermann Fleck, Ph. D., of the University of Pennsylvania, on Birdsboro trap rock, quarried by the John T. Dyer Company, of Norristown, Pennsylvania:

Analysis of Birdsboro trap rock.

	Per cent.
Silica, SiO_2	46.87
Alumina, Al_2O_3	13.36
Ferrous oxide, FeO	2.71
Ferric oxide, Fe_2O_3	9.79
Calcium oxide, CaO	14.70
Magnesium oxide, MgO	4.35
Sodium oxide Na_2O	4.64
Potassium oxide, K_2O	2.01
Titanium oxide, TiO_2	1.98
Total	100.41

The results obtained go hand in hand with those gotten by microscopic examination, which may be summed up as follows: The mineral constituents are plagioclase, pyroxene, and hornblende, with magnetite or magnetic iron to the extent of 4.56 per cent as an accessory constituent. Pyroxene and hornblende predominate.

The rock is, therefore, to be classed as dolorite, valued as one of the best for ballast, roadbed, macadamizing, and paving purposes, excellent examples being found in the so-called French Creek granite and the Palisades of the Hudson, which find a widespread use.

The mineral constituents present impart desirable qualities for a good wearing and durable rock.

Plagioclase and pyroxene add the required hardness on the one hand, while on the other hand hornblende vastly increases the toughness and durability, together making it an excellent material for roadbed and ballast or Belgian block, where these qualities are required.

In addition I may add that such a rock will stand the heaviest traffic without breaking down or splintering. Moreover, it is but slowly attacked by the disintegrating action of frost and thaw, rain, etc., weathering slowly, and then only on the surface, retaining its original hardness throughout the body of the rock.

RHODE ISLAND.

The value of the product in 1896 was $746,277; in 1897 the figure was $629,564. There has thus been some decline, but there is unquestionably a better outlook for 1898, judging from operations so far. Most of the granite quarried in Rhode Island is monumental stock taken from quarries at Westerly and Niantic. Quarrying for building purposes has been taken up more vigorously than heretofore at Westerly, and a large quantity of stone has been quarried for such use.

SOUTH CAROLINA.

The value of the product in 1896 was $55,320; in 1897 the figure was $37,820. Conditions for 1898 are improved.

SOUTH DAKOTA.

Production declined from $199,977 in 1896 to $68,961 in 1897. Some of this product is the Sioux Falls quartzite, a stone of great hardness, strength, and durability. Considerable of the output goes for paving blocks, which have been used to some extent in Chicago.

UTAH.

Very little granite was quarried in Utah, either in 1896 or 1897.

VERMONT.

Production increased from $895,516 in 1896 to $1,074,300 in 1897. Two-thirds of the product came from the Barre region, where, in spite of hard times, production has been active and the stone has been shipped over a large area of the United States.

The following report on the "dark" and "medium" granite quarried by Messrs. Wells, Lamson & Co. at their quarries at Barre, Vermont, was recently made by the writer in the analytical and testing laboratory of Swarthmore College, Swarthmore, Pennsylvania.

REPORT ON DARK AND MEDIUM GRANITE FROM WELLS, LAMSON & CO.'S QUARRIES AT BARRE, VERMONT.

Chemical analysis of dark granite.

	Per cent.
Silica, SiO_2	69.56
Ferric oxide, Fe_2O_3	2.65
Alumina, Al_2O_3	15.38
Manganese	Trace.
Lime, CaO	1.76
Magnesia, MgO	Trace.
Sodium oxide, Na_2O	5.38
Potassium oxide, K_2O	4.31
Loss on ignition, CO_2, and moisture	1.02
Total	100.06

A microscopic examination of this granite was made by Mr. Whitman Cross, of the United States Geological Survey, and his report thereon is as follows:

Messrs. Wells, Lamson & Co.'s dark granite is a fine, even-grained, typical granite containing two micas (biotite, muscovite), sometimes called granite proper. The constituents of importance are quartz, orthoclase, microcline, biotite, and muscovite. The first three occur in wholly irregular grains interlocking in a very complex manner. The micas are in small leaves between and penetrating the other minerals to some extent. Muscovite apparently occurs in two forms, one corresponding to the biotite as seemingly primary and in small flakes in the orthoclase, and clearly a secondary mineral.

Accessory constituents are oligoclase, albite (?), titanite (sphene), and apatite.

There is an almost total absence of magnetite or other iron ore.

Biotite is slightly changed to green, and probably yields chlorite in some samples. The orthoclase gives way to an aggregate of fine muscovite leaves, also varying much in different samples, no doubt.

Both quartz and biotite show that the rock has endured considerable pressure, the former by the "undulatory extinction" it exhibits, and the biotite by the curved and bent lamellæ. The pressure did not extend to a crushing of the grains or any banded structure.

In the feldspars is some calcite filling small cracks. On the basis of this examination I should estimate it at quartz 30 to 35 per cent, orthoclase 30, microcline 20 to 25 per cent. Much of the iron is present in the ferrous or unoxidized condition.

Determinations of specific gravity.

DARK GRANITE.

	Grams.
Weight of granite	8.8061
Weight of water displaced	3.2956
Specific gravity found	2.672
Temperature of water, 22° C.	

MEDIUM GRANITE.

Weight of granite	32.95715
Weight of water displaced	12.37680
Specific gravity found	2.662
Temperature of water, 20° C.	

Determinations of absorption capacity.

DARK GRANITE.

	Grams.
Weight of granite after heating in air at 110° C. for six hours	49.9625
Weight of granite after boiling in water for three hours and wiping dry	50.0230
	.0605
Weight after heating again at 110° C. for six hours	49.9328
Per cent of water absorbed, 0.121.	

MEDIUM GRANITE.

Weight of granite after heating in air at 110° C. for six hours	64.1723
Weight of granite after boiling in water for three hours and wiping dry	64.2549
	.0826
Weight after heating again at 110° C. for six hours	64.1534
Per cent of water absorbed, 0.129.	

Determinations of crushing strength of "dark" and "medium" Barre granite from Messrs. Wells, Lamson & Co., using the standard Tinius Olsen testing machine, of Philadelphia.

DARK GRANITE.

[Crushing strain applied perpendicular to rift.]

No.	Size.	Area.	Broke at—	Crushing strength per square inch.
	Inches.	*Sq. inches.*	*Pounds.*	*Pounds.*
1	2 high × 2 × 2.02......	4.04	71,870	17,790
2	2 high × 2.03 × 2.07 ...	4.20	70,220	16,719
	[Crushing strain applied parallel to rift.]			
3	2 high × 2.06 × 2.04 ...	4.20	83,820	19,957

MEDIUM GRANITE.

[Crushing strain applied perpendicular to rift.]

No.	Size.	Area.	Broke at—	Crushing strength per square inch.
1	2 high × 2 × 2.02......	4.04	72,140	17,856
2	2 high × 2.02 × 2.04....	4.12	61,670	14,968
	[Crushing strain applied parallel to rift.]			
3	2 high × 2 × 2.03	4.06	64,170	15,805

While the foregoing results speak plainly for themselves to the effect that the "dark" and the "medium" granite quarried by Messrs. Wells, Lamson & Co., at their quarries at Barre, Vermont, are unquestionably commendable for the customary uses of granite, it may be well to call attention to certain features of these results which are worthy of special mention. The analysis shows a low percentage of iron, rendering liability to stain a minimum, a high percentage of silica, and the usual percentages of other constituents found in true granites.

The crushing strength of the "dark" granite is high, much above the average for true granite, and somewhat higher on the average than that of the "medium."

An examination of the stone at the quarries by the writer shows it to be unusually free from knots and streaks or irregularities in structure of any kind.

The absorption capacities of both "dark" and "medium," while showing a slight difference in favor of the "dark," are both so low as to amount to virtually nothing when possible disintegration from freezing of absorbed moisture is considered. In this connection it must be remembered that in the absorption tests the stone is so treated as to absorb the maximum quantity of water, i. e., the conditions of the test are far more severe than any natural conditions to which the stone is ever likely to be exposed.

Most of the Barre producers report a very encouraging outlook for 1898.

VIRGINIA.

The value of the granite output declined from $95,040 in 1896 to $88,096 in 1897.

A number of the Virginia quarries produce fine stock, but as yet there has been no recovery from the effects of the financial depression of the last few years.

The following chemical analysis and tests of the granite quarried by the Petersburg Granite Quarrying Company at their quarries at Petersburg, Virginia, were made by Messrs. Hunt and Clapp, at their Pittsburg testing laboratory:

Analysis of granite from Petersburg, Virginia.

	Per cent.
Silica, SiO_2	64.12
Alumina, Al_2O_3	20.91
Oxide of iron, Fe_2O_3	2.96
Lime, CaO	1.98
Magnesia, MgO	.66
Sodium oxide, Na_2O	4.57
Potassium oxide, K_2O	4.82
Total	100.02

Constituent minerals of granite from Petersburg, Virginia.

	Per cent.
Mica	15
Feldspar	60
Quartz	25
Total	100

Test of 2-inch cube of granite from quarries at Petersburg, Virginia.

Original dimensions, 2 inches square.
Original area, 4 square inches.
Ultimate load, 100,400 pounds.
Crushing strength, 25,100 pounds per square inch.

WISCONSIN.

Production in this State has remained practically the same as in 1896, when the output was valued at $126,639.

An analysis of the granite quarried by the Milwaukee Monument Company, at their quarries in Waushara County, was made by Mr. A. S. Mitchell, chemist, of Milwaukee, giving results as follows:

Analysis of granite from Waushara County, Wisconsin.

	Per cent.
Silica, SiO_2	76.62
Alumina, Al_2O_3	13.02
Ferric oxide, Fe_2O_3	1.01
Lime, CaO	.51
Magnesia, MgO	.05
Oxide of sodium, Na_2O	2.24
Oxide of potassium, K_2O	6.38
Total	99.83

NOTES ON GRANITE IN NEW ENGLAND.

During the summer of 1897 the writer had opportunity to visit some, though for lack of time not all, of the leading granite-producing regions of New England. These notes are intended to give some of the results of observations made. In the order of the value of the granite produced, the New England States rank as follows: Massachusetts, Maine, Vermont, New Hampshire, Rhode Island, Connecticut. These States produce annually from 65 to 70 per cent of the total output of the United States. The products of some of these quarry regions have a national reputation and are shipped to all parts of the United States.

The leading position of the New England States in respect to granite production is due to a combination of circumstances and facts, among which may be mentioned the age of this region of the country, the fact that granite is found in great variety and abundance, and finally the fact that many of the quarries are favorably located for cheap transportation of the products by water to the various points of consumption. Such advantages of location on the water are the possession of quarries in Maine, some in Massachusetts, Connecticut, and elsewhere, but they are of less importance now than formerly. At present much of the most valuable monumental granite is, from necessity or choice, shipped from the points of production by rail.

MASSACHUSETTS.

This State has always been the leader in magnitude of output. The principal producing localities are Cape Ann (including Rockport, Pigeon Cove, Lanesville, and Bay View) and Quincy (including West Quincy). These two regions produced in value somewhat more than half the total output of the State, and are about equally productive;

but the uses to which the output is devoted are radically different, in that the Quincy granite is strictly a monumental stone, of national reputation, while Cape Ann granite is primarily a building stone, which can be rapidly quarried and in any desired size of blocks. Other important centers of production in the State are Milford, Monson, Fitchburg, and New Bedford. In addition to these are numerous scattered localities at which valuable stone is produced, but in smaller amounts.

Quincy.—So well is Quincy known as a granite region that it almost seems needless to say anything more. Every stonecutting yard of any importance in all large cities continually has Quincy granite monuments and gravestones displayed for sale or in process of completion to fill orders specifying that stone.

Mineralogically, the stone consists chiefly of quartz, hornblende, and feldspar. There is a high percentage of quartz, and to this is largely due the extreme hardness of the stone. The distinguishing features of Quincy granite, which have given it the high reputation it bears, are its hardness, the durability of the high polish which may be developed, and the contrast between the polished and the hammered surface. This latter feature is more pronounced in the so-called dark Quincy granite than in the light, and for this reason the former commands a higher price.

According to Gillmore the crushing strength of Quincy granite is 17,750 pounds to the square inch; its specific gravity is 2.669. The following analysis was made by Mr. E. R. Angell, chemist of New Hampshire State Board of Health:

Analysis of Quincy granite.

	Per cent.
Silica, SiO_2	75.14
Alumina, Al_2O_3	15.57
Ferrous oxide, FeO	2.49
Lime, CaO	1.85
Potash, K_2O	.54
Soda, Na_2O	4.41
Total	100.00

The qualities of the granite are such as to render it so desirable for monumental work that it is inexpedient to devote the best of it to any other use, and very little determined effort is made by producers to extend its application to building purposes, for which it is also admirably adapted.

Granite for monumental use must be carefully selected, and there is consequently considerable waste of material, which would serve excellently for building, but the producers seem to make but little effort to dispose of stone for this purpose, although not a little finds its way into retaining walls and bridges erected by railway corporations along their lines. Occasionally, also, the granite is used in large and pretentious buildings, but not to the extent to which the qualities of the stone would seem to justify.

Many of the producers at Quincy have been engaged in quarrying for monumental work only for many years, and considerable conservatism as to business policy is the not unnatural result.

Quarrying for monumental stock and for building material are two quite different operations, and if one of these is emphasized at all the other is apt to receive but little, if any, attention. To operate a quarry producing both kinds of stock at the same time, and withal to develop the quarry with due regard to future operations, is a difficult matter, and requires, moreover, a liberal working capital. This is, in many cases, lacking. There is at Quincy a strong temptation to quarry for to-day only. A fine piece of monumental stone is visible in a certain part of the quarry; it can be sold for cash as soon as taken out; it is therefore removed as quickly as possible, and in many cases without such thought for the morrow as will make future operations economical.

Refuse stone is frequently freely and generously given to paving-block cutters, who cut it into paving blocks and sell them on their own account. Knots, streaks, and "mud holes" must be carefully avoided in a conscientious selection of stock for monumental work; but these defects, except the third, would be of but little moment in stone devoted to a wide range of building purposes.

In former years the production of paving blocks was actively carried on, but as many quarrymen put it, the paving-block industry has "gone to the dogs," owing to the competition of other kinds of paving material. While paving blocks are still being made to a slight extent there is very little profit in the business, the maker of the block being able to realize little more than $1 per day for what is very hard manual labor. Paving cutters in the past few years, owing to difficulty in securing other kinds of work, have been obliged to cut blocks for small return or do nothing at all.

The methods of quarrying at Quincy are to blast with lewis holes and then cut into blocks by plug and feather. Sometimes, but not often, channeling is resorted to, but the hardness of the stone is such as to make this very expensive. In channeling, holes are drilled with a steam drill, an inch apart, and then the partitions between the holes are broken down with the channel bar.

Quincy granite is at present used chiefly in the Eastern and Middle States, less being sold in the West than formerly. This is accounted for in two ways; in the first place but few, if any, Quincy salesmen are sent to the West, and Eastern granites that are more easily quarried, and hence cheaper, are largely monopolizing western trade.

Cape Ann.—As already stated, this region includes Rockport and vicinity, Pigeon Cove, Bayview, and Lanesville.

Methods of quarrying and handling stone here offer a strong contrast to the conditions at Quincy, for the reason that monumental work is ignored at Cape Ann, and building stone is the product sought. The stone is decidedly less valuable per cubic foot, and the amounts disposed of and the methods of working must compensate for this. Everything must be done on a large scale, and explosives must be used much more freely than would be permissible in quarries where smaller amounts of more valuable stone for monumental work are sought.

In every way Cape Ann seems to be suited to the production of building stone. In the first place, it is on the coast, and all stone is shipped by water on ships that can come almost to the edge of the quarries. In the second place, the granite is enormously abundant and well adapted to heavy building work, in that it can be taken out in large blocks by expeditious methods of quarrying. In the third place, the construction of an extensive and much-needed breakwater by the United States Government enables quarrymen to dispose of all grout at prices which help them to keep quarry property well cleaned up at less expense than is required at other less favorably located quarries.

The stone is a hornblende-biotite granite, medium to coarse in texture, gray in color, massive, and with both horizontal and vertical joints. It takes a good, durable polish, but, being a light-colored stone, the contrast between hammered and polished surfaces is not so strong as in some of the granites having an established reputation as monumental stones. Very little if any effort is made to push the stone as a monumental material, but the quarrymen seem as a rule to be content with the large possibilities of building, and quarries are equipped for operations on the scale necessary for extensive building contracts and the heaviest foundation work. An important contract recently on hand was the foundation work on the new terminal railway station in Boston, now in course of construction. A few years ago the production of paving blocks constituted an important item in the business of Cape Ann quarrymen, but, as at other localities, this is now suffering from depression and can no longer be regarded as cutting much of a figure in the total output of the quarries. The stone is well adapted for paving, and during the years when paving blocks were in active demand in large cities a product of considerable magnitude was turned out.

The breakwater in course of construction will eventually make a fine harbor at Pigeon Cove, while at present the lack of it is rather a menace to vessels at anchor, or even at the wharves. The dimensions of the completed breakwater will be 50 feet wide at the bottom, 30 feet at the top, 18 feet above high water, and 2¼ miles long. About 800,000 tons of stone have already been put in place. About 6,000,000 tons in all will be required for the completion of the work. The good effects of what has already been done are said to be unmistakably manifest in lessening the violence of the water in the area partially inclosed.

If the work were vigorously pushed it is said that it could be completed in about fifteen years. About $150,000 is annually appropriated for the breakwater work. Stones varying in weight from 50 pounds to 6 tons are used. Dumping scows of special construction are employed, and a whole load is dumped at once by means of ingenious devices adapted to the needs of this particular breakwater.

Care is needed to prevent what is termed the "wandering" of stones in sinking through the water. This is liable to take place if the entire load is not dumped in one mass.

Another use to which considerable stone has been devoted is its employment in concrete in the construction of Government fortifications.

The methods of quarrying are in general similar to those of other regions, but are all carried out on a large scale. Powder is quite freely, but carefully, used. Good railway facilities for transportation to the docks are provided.

A few large concerns do most of the business, which seems to be economically and judiciously conducted.

Some of the Cape Ann granite is iron stained, and on casual inspection might be taken for sap. However, it is not such, but a very tough, durable stone, which is well adapted for use in paving blocks or retaining walls. There is, of course, as at all quarries, plenty of sap, but it is not identical with the iron-stained rock to which reference has just been made. Sap is not only stained from exposure, but shows signs of weakness and disintegration which render it unfit for construction work.

Cape Ann granite is quite free from knots or streaks, is very hard, splits well, occurs in enormous masses, and can be quarried in large blocks. Its special field is heavy work—massive foundations and bridges. The stone is so abundant that blasting may be resorted to freely in cases which at other localities would be treated by slower processes. Blasting may sometimes sacrifice material, but good stone is so abundant that, on the whole, blasting is more economical.

CONNECTICUT.

The most important granite quarries in Connecticut are on or near Long Island Sound.

Groton.—At Groton, just across the river from New London, are a few granite quarries producing only monumental stock. The stone is fine-grained, hard, and well adapted to this use. The valuable stock is in some of the quarries overlain by a large mass of rock, marked by numerous black dikes very much curved and folded and separated from the true granite by a sharp line of division. Under the sheet of granite is another thick mass of bastard rock. Quarrying is done on a small scale only, and is somewhat expensive owing to the large amount of stripping that has to be done. At Center Groton, 5 miles or more from Groton, is another isolated quarry capable of producing fine monumental stock in large quantity if capital were invested in sufficient amount. A long haul by wagon is necessary, and this is quite a drawback. Investment of more capital is imperative before anything considerable can be done at this point.

Waterford.—A large quarry at this point is operated by Messrs. Booth Brothers. The stone is fine-grained biotite granite, of gray color. Operations are quite extensive, both monumental and building stone being produced. The stone is of fine quality, and preparations for even greater activity were being made, as the quality of the stone is such as to amply justify extensive work as soon as production again assumes normal proportions. Work here has been prosecuted actively for the past five years, although in times past quarrying has been done on a smaller scale than at present.

The cutting, carving, and polishing plant is extensive, and at the time of the visit of the writer was being still further enlarged by the erection of a shed 220 feet long, intended to accommodate 100 men in the work of cutting and polishing.

Millstone.—Here is a large quarry, known as Henry Gardiner's quarry. This was originally opened in 1830. Even as far back as one hundred and fifty years ago millstones were quarried for use in the old-fashioned windmills, the ruins of which are in many cases still to be seen near Newport and elsewhere. The quarry is well equipped with modern machinery, and is also provided with a private railroad connecting with the New York, New Haven and Hartford Railroad at Millstone Station. When polished, the color of the stone is rather dark, and this shows a good contrast to the hammered surface, which is light in comparison. The stone is used chiefly for monumental work, although building stone is also quarried. Paving blocks in time past have been turned out in large quantities, but at present but few blocks are made, owing to the reduced demand for such paving material in large cities.

A stone crusher was in operation to furnish crushed stone for the Government fortifications at Dutch Island and elsewhere. Shipping facilities, both by land and water, are exceptionally good.

Stony Creek.—At this place are a few quarries producing a highly feldspathic, coarse-grained, pink stone, well adapted to building purposes. Pink granite is at present quite popular among builders, and the attractive feature of this granite is its color. Contracts for stone for some large buildings, such as the New York Life Insurance building, at the corner of Broadway and Leonard streets, New York City, were on hand during the past year. Preparations for a large increase in output were under way at the time of my visit.

Sachem Head.—At Sachem Head quarrying operations of very different character from those usually adopted are carried out on a large scale, for the single purpose of obtaining stone for breakwaters. A bluff 1,500 feet long has been exposed. From this the stone is removed by the most violent explosives, while in addition any and every way of dislodging stone cheaply is freely applied. Having been loosened out, regardless of size and shape, the stone is loaded on cars which carry it to scows and barges at the wharf a few hundred feet away and it is then transported to the breakwater now in course of construction at Point Judith. The plant for handling and transporting stone is very complete, and altogether represents the investment of nearly $500,000. The firm operating here, Messrs. Hughes Bros. & Bangs, makes a specialty of breakwater and canal work, and, in addition to extensive contracts for breakwaters, are also engaged in supplying limestone at Buffalo for use in the Erie Canal. The workmen are all Italians.

Leete Island.—On this island a highly feldspathic pink gneiss is quarried for heavy construction and bridge work. It was used in the foundation of the Statue of Liberty, in New York Harbor.

This stone has an excellent reputation for the purposes to which it is generally applied. It takes a good polish, and, from the wavy lines that were well shown in a polished slab which was exhibited, would look well in interior decoration in buildings.

Meriden.—At Meriden are quarries of trap rock, which is used only for railroad ballast and highway construction. The stone is fed into crushers and sold for ballast or macadam. Roads around Meriden, where the stone has been used, testify to the excellence of this stone for such use. Not only is the stone of remarkable strength and toughness, but as it slowly pulverizes the dust cements together at every wetting, making a surface of extreme smoothness. The stone seems to be the ideal road material. At one place the stone occurring on the mountain side is in small fragments, which are raked down and transported to the crushers. This operation can hardly be called quarrying. From the solid masses in the quarry the rock is blasted by violent explosives, which are intended to shatter the stone as much as possible, thus reducing the work of the crushers. An improvement in stone crushers consists of the use of manganese steel, which in the form of a pestle rotates eccentrically in a hopper. This form of crusher lasts much longer than ordinary steel-jaw crushers, which have been generally used.

Ansonia.—Near this place are a few small quarries producing gneiss well adapted for street curbing, for which purpose much of the stone is used. The stone splits exceptionally well.

RHODE ISLAND.

This State has been distinguished as standing in first place for the value of monumental work produced. The most important quarries for monumental granite are at Westerly and Niantic. At some of the quarries only monumental stone is produced, but at others building stone also is sold in very large quantities.

Westerly and Niantic.—The monumental stock from these places is distinguished commercially as blue and white, the former being more valuable on account of the better contrast between polished and hammered surfaces. The stone is a biotite granite, of a crushing strength of 17,750 pounds to the square inch. Its value for monumental work is due to its fine grain, uniformity, and the fact that it may be safely carved to a fine edge, which it will hold without danger of chipping. In short, it is exceptionally well adapted to elaborate carving on blocks of great size. Many notable statues and monuments have been made of this stone, and its reputation has been established by years of experience.

Care in selecting stone has to be exercised, as streaks and knots occur. Some of these do not reveal themselves until polishing or carving brings them into view. As the producers are conscientious in letting only good stock leave the yards, there is occasionally financial loss, due to the necessity for condemning a piece of work after considerable labor of an expensive kind has been done.

Some of the quarrymen are opposed to selling stock in the rough, but prefer to dispose of only finished products, as they can thus better protect the high reputation of the stone.

The largest block ever quarried here was 55 by 10 by 5 feet. Facilities for quarrying, cutting, polishing, and carving are of a high order at a number of the Westerly quarries. The latest improvements in all directions are tested promptly, and, if found satisfactory, adopted. At one of the Westerly granite works considerable granite is sawed, with good results as to character of work and economy. Sawing granite is a comparatively new process, and it can not be said to have yet come into anything like general use, but it is favorably regarded by a number who have tried it.

Since the financial depression began a few years ago, the use of Westerly granite for building purposes has increased, and a number of large contracts have been filled or are now on hand. Some of the older quarries are now quite deep, and, although some very fine stone is taken out at considerable depth, the expense of quarrying is somewhat increased. Some of the producers, therefore, have found it necessary to extend their quarries laterally in order to obtain a larger volume of stone sufficient to accommodate building contracts as well as monumental work.

At no place in the United States is finer or more artistic work in carving and sculpture done than at Westerly. In monumental work Westerly granite has marked advantages over many others, but in building work it has no such advantages, and hence must be sold for building at prices which will allow it to compete with granites quarried for building only.

Granite is quarried at Centerdale, Pascoag, Narragansett, Newport, Coventry Center, Greenville, and a few other localities, but the amounts are small as compared with those produced at Westerly and Niantic.

Centerdale.—The stone produced at Centerdale is adapted to street work or rough building. The general tone of color is light, with a greenish tinge. The feldspar is faint pink in color. Quarrying operations are on a small scale.

Greenville.—At this point a hard, durable granite, suitable for building or street work, is produced. The stone contains a biotite here and there, giving a spotted appearance. The chief minerals are quartz and feldspar. The stone is used in Providence and Pawtucket for curbing and foundation work. It is also an excellent stone for engine beds. The stone looks well in rock-faced work. It is easily quarried, but has to be hauled 5 miles to railroad.

Pascoag.—The stone quarried at this place is a biotite gneiss, which splits very well. It is used for bridge work, curbing, and paving in Providence.

VERMONT.

Barre.—Over two-thirds of the granite output of Vermont comes from quarries at or near Barre, and is known as Barre granite. Special interest, therefore, attaches to this region. The stone is distinguished commercially as "light, medium, and dark," these terms applying, of course, to the color. The dark Barre is the most valuable, on account of the stronger contrast between the polished and hammered surfaces, and also on account of superiority in other respects. The light granite occurs in rather regular sheets, while the dark granite presents a very different mode of occurrence, the sheets being more irregular, so that a "dark" granite quarry looks more like a bowlder quarry than a sheet quarry. In quarrying the light granite considerable channeling is done. While such work is expensive, the rock is valuable and uniform enough to justify the extra pains. The dark granite is worked very differently from the light, in that more blasting is done, but without serious damage to the stone, particularly where the Knox system of blasting is used. In the light granite the frequent sticking of the drills gives evidence of considerable pressure in the granite. This is also borne out by microscopical examination, which proves the existence of strong pressure. Barre granite is remarkably free from flaws, such as white-horse and dark-horse knots, and streaks of all kinds. While blemishes are occasionally met, they are so infrequent that it is an easy matter to throw out such material without much loss.

The stone is easily and cheaply quarried as compared with that at some other places producing monumental stock.

The granite is what might be called "granite proper," consisting of quartz, orthoclase, microcline, biotite, and muscovite. The quarries are all on a hill or mountain, and the quarried stone is transported either by rail or by wagon to the town of Barre, a few miles distant. The granite industry at Barre has been built up within the past eighteen years, during which time progress has been steady and satisfactory. The features which have contributed markedly to this success are the favorable situation of the quarries for transportation to the railroad, the ease of quarrying, the uniformity of the granite, and its freedom from knots, streaks, etc. While granite of equally fine quality for monumental work is produced at other places, the quarries at Barre yield a stock which is so uniform that the amount which has to be rejected and thrown on the dump is less. Lower prices for Barre stock are probably, therefore, just as remunerative to the quarryman as the higher prices which have to be charged in other places on account of a greater percentage of waste or the fact that the quarries have reached an inconvenient and expensive depth. The producers at Barre show considerable enterprise in advertising their products and in getting them before the public through the agency of traveling salesmen and in other ways.

Facilities for cutting, carving, polishing, and finishing in every way are abundant and thoroughly up to date, and even in the hard times that have characterized the past few years the Barre producers have more than held their own.

There was considerable talk at Barre in the fall of 1897 relative to the formation of a syndicate which should unite the whole region under one management. This, however, has not resulted in accomplishing anything as yet.

NEW HAMPSHIRE.

The granite industry of New Hampshire is old and well established. The most important localities from the standpoint of value are Concord and West Concord, Milford, Suncook, and Fitzwilliam. Stone is also quarried at a number of other localities.

Concord and West Concord.—The quarries at Concord and West Concord are the most productive. Rattlesnake Hill, near Concord, is the source of most of the stone. The granite is used to a larger extent for building than for monumental purposes. This stone was used in the Library of Congress building at Washington, and has met with general approbation in its use for that purpose. For cut and hammered work in buildings there are few if any granites that surpass Concord stone.

The introduction of more working capital and the provision of better transportation facilities from Rattlesnake Hill to the town are quite evidently needed, and would do about all that is required to make the industry flourish to a degree far beyond what is possible under existing conditions.

The stone, being light in color, has to be carefully selected so as to be free from flaws. This, however, can quite easily be done, as there is a great abundance of entirely satisfactory stone.

The stone is a muscovite-biotite-granite, fine grained, and occurs in sheets. Quarrying is comparatively easy. Very little if any staining results from exposure in buildings.

MARBLE.

The following table shows the value of the output of marble in the United States for the year 1897, by States:

Value of marble product in 1897, by States.

State.	Value.	State.	Value.
California	$48, 690	New York	$354, 631
Colorado	99, 600	Pennsylvania	62, 683
Georgia	598, 076	Tennessee	441, 954
Idaho	5, 000	Vermont	2, 050, 229
Maryland	130, 000	Total	3, 870, 584
Massachusetts	79, 721		

An increase of $1,011,448 over the figure for 1896 has been realized. This is due largely to greater activity in Vermont, although a notable increase is also evident for California, while Colorado appears for the first time with an output of $99,600.

The figures for 1897 are the highest ever reached in the history of marble production in the United States.

Since much of the marble quarried is devoted to monumental or cemetery work and interior decoration, and is therefore something of a luxury, the increase in output for 1897 may be regarded as quite significant of return toward general prosperity.

The following table shows the various uses to which the marble quarried in 1896 and 1897 was put:

Distribution and value of output in 1896 and 1897 among various uses.

	1896.	1897.
Sold by producers in rough state	$583, 690	$477, 856
Sold for outside building	1, 036, 163	1, 074, 646
Ornamental purposes	65, 365	9, 010
Cemetery work (monuments and tombstones)	813, 146	1, 547, 469
Interior decoration in buildings	329, 804	576, 983
Other scattering uses	30, 968	184, 620
Total	2, 859, 136	3, 870, 584

The following table shows the purposes for which the marble of the various productive States was sold by the quarrymen in 1896 and 1897:

Value of the marble product, by uses and States, in 1896 and 1897.

State.	Rough.	Building.	Ornamental.	Cemetery.	Interior.	Other.	Total.
1896.							
California	$4,000	....	....	....	....	....	$4,000
Georgia	171,644	$258,886	....	$98,200	$63,650	$25,000	617,380
Idaho	1,500	....	....	4,000	....	....	5,500
Iowa	23,460	10,080	$6,200	....	....	....	39,740
Maryland	....	109,000	....	....	1,000	....	110,000
Massachusetts	14,763	56,641	....	8,000	3,000	1,500	83,904
New York	69,072	365,737	....	41,682	4,471	3,198	484,160
Pennsylvania	3,022	28,500	....	....	....	....	31,522
Tennessee	190,103	....	....	....	190,000	1,270	381,373
Vermont	106,126	207,319	59,165	661,264	67,683	....	1,101,557
Total	583,690	1,036,163	65,365	813,146	329,804	30,968	2,859,136
1897.							
California	8,280	2,625	4,960	3,015	27,310	2,500	48,690
Colorado	....	....	....	....	82,000	17,600	99,600
Georgia	198,198	145,875	....	157,803	71,200	25,000	598,076
Idaho	....	....	....	4,500	500	....	5,000
Maryland	....	130,000	....	....	....	....	130,000
Massachusetts	1,026	58,608	306	2,300	16,481	1,000	79,721
New York	11,066	274,626	....	61,631	5,308	2,000	354,631
Pennsylvania	....	56,000	....	6,683	....	....	62,683
Tennessee	147,679	4,000	....	15,625	259,025	15,625	441,954
Vermont	111,607	402,912	3,744	1,295,912	115,159	120,895	2,050,229
Total	477,856	1,074,646	9,010	1,547,469	576,983	184,620	3,870,584

The following table gives the production of marble, by States, for the years 1890 to 1897, both inclusive:

Value of marble, by States, from 1890 to 1897.

State.	1890.	1891.	1892.	1893.
California	$87,030	$100,000	$115,000	$10,000
Georgia	196,250	275,000	280,000	261,666
Idaho	....	....	....	4,500
Maryland	139,816	100,000	105,000	130,000
Massachusetts	....	....	100,000	....
New York	354,197	390,000	380,000	206,926
Pennsylvania	....	45,000	50,000	27,000
Tennessee	419,467	400,000	350,000	150,000
Vermont	2,169,560	2,200,000	2,275,000	1,621,000
Scattering	121,850	100,000	50,000	....
Total	3,488,170	3,610,000	3,705,000	2,411,092

Value of marble, by States, from 1890 to 1897—Continued.

State.	1894.	1895.	1896.	1897.
California	$13,420	$22,000	$4,000	$48,690
Colorado				99,600
Georgia	724,385	689,229	617,380	598,076
Idaho	3,000	2,250	5,500	5,000
Iowa		13,750	39,740	
Maryland	175,000	145,000	110,000	130,000
Massachusetts		2,000	83,904	79,721
New York	501,585	207,828	484,160	354,631
Pennsylvania	50,000	59,787	31,522	62,683
Tennessee	231,796	362,277	381,373	441,954
Vermont	1,500,399	1,321,598	1,101,557	2,050,229
Total	3,199,585	2,825,719	2,859,136	3,870,584

THE MARBLE INDUSTRY IN INDIVIDUAL STATES.

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

CALIFORNIA.

A notable increase marks the past year, namely, from $4,000 in 1896 to $48,690 in 1897.

The following data as to the composition and properties of the marble of Colton, San Bernardino County, were obtained by Prof. E. W. Hilgard, of the University of California:

Composition of Colton marble.

	Per cent.
Carbonate of calcium	92.9
Carbonate of magnesium	4.5
Black minerals	2.6
Total	100.0

The black minerals consist of biotite and pyrolusite. The minerals coloring the marble are very refractory to the action of the air and will produce no spotting under ordinary conditions. The stone is therefore a very durable one under any conditions in which marble is likely to be placed, whether in rough ashlar work or with polished face.

Prof. Frank Soule, of the University of California, found the crushing strength to be 9,350 pounds to the square inch.

Of the marble quarried by the Carrara Marble Company, at their quarries in Amador County, Prof. E. W. Hilgard is quoted as follows:

I find the marble of the Carrara quarry, of Amador County, Cal., most remarkably uniform and free from flaws; partly pure white and partly pleasingly shaded with bluish and black veins. I find it to contain only four-tenths of 1 per cent of minerals other than carbonate of lime. Few marbles are found so pure and charmingly veined. It contains a very small proportion of magnesia, a large percentage of which is a characteristic in all other California marbles. The marble of the Carrara quarry will stand exposure to the weather and scarcely ever become stained, as other marble will.

The following information in regard to marble at Healdsburg, Sonoma County, near San Francisco, quarried by the Healdsburg Marble Company, is submitted by the quarrying company. Mr. George Madeira, mining engineer and geologist, made the scientific observations:

The marbles crop along the summit of a high ridge or mountain. Barometrical readings show an elevation of 1,640 feet above sea level, and 1,400 feet above the level of a creek flowing at base of the mountain. The croppings vary in width from 200 to 600 feet.

The marbles, carbonates of lime, silicates of magnesia, etc., consist of banded green breccia, brown breccia or Potomic marble, and veined serpentine of every hue and color. The reticulation or veining is of white, green, brown, red, and yellow alternating. The base of the stone is formed of patches or zones of yellow, brown, dove, blue, red, etc., the golden and green veined marbles being very handsome. The deposit, which is composed of tilted, stratified serpentine, stands at an angle of 70 degrees, pitching north, crops on the top of the ridge, and runs south for a distance of 1,500 feet, where it passes under the overlying strata. The dike, ledge, or deposit comes up through the Miocene or bituminous slates, which are seen in situ lower down the slopes of the hill on the south (coast) side.

For a distance of 600 feet along the deposit the marbles alternate. At the south end of this 600 feet the marbles suddenly shoot up above the surface of the terrace on the east side to a height of 65 feet, standing directly at right angles to the trend of the lode. This high wall of Potomic and white marble has prevented the higher ridge backing it from being worn away by the action of the elements, and, in a great measure, covers the deposits southward. The croppings and detached pieces of "float" thickly strewing the hill slope indicate that the deposit continues on and into the lands of the South claim. In the South claim, beside the marbles supposed to underlie the surface croppings, chrome iron ore is found as "float" all over the surface, and at one point a deposit of 75 or 100 tons crops above the surface. Blocks of marble of any desired shape can be obtained from these extensive deposits. There is, in fact, a mountain of marble.

The deposits are situated 11 miles from a railroad station. The main country road is within 1 mile of the deposits, and this length of road will have to be constructed, at a cost of about \$700. There is another railroad depot about 7 miles from the place, and in this direction there would be 1½ miles of road to make, costing probably \$1,100. Another railroad point can be reached by constructing a road 4½ miles long, at a cost from \$3,000 to \$5,000. This road would run all downhill; on this line of road, about 2 miles from the deposits, there could be erected workshops, etc., for finishing up the marbles, as there is abundant water power all the year round. There is no machinery yet on the property, and but little has been done in the way of development, though the prospects so far are excellent. The 1 mile of the road could be made in three weeks.

In weight the marbles average about 14 cubic feet to the ton of 2,000 pounds. The green or peacock marbles sell for much higher figure than the serpentine. Capital is needed to develop the property, and the product could be mined and shipped to San Francisco, and thence to Eastern States, South America, Australia, the Orient, etc.

No systematic developments have yet been made, but in several places along the side of the lode the marbles have been cut into, showing the character of the rock. A few inches below the surface croppings the rock is found to be quite solid and free from blemish, particularly the serpentine marbles. Of the green, greater depth will be required to secure large slabs, or columns, than the present superficial development. At one point a tunnel has been driven into the solid serpentine 27 feet along the south side of a band of green onyx marble 6 feet thick, which has not been cut into. In this tunnel the rock became more and more compact with increasing depth below the surface.

Prof. F. W. Crosby is quoted as follows in regard to the verd antique of San Bernardino County:

The marble belt crops from 10 to 20 feet above the surface, and is from 100 to 300 feet in width. It is composed of a series of ledges from 4 to 6 feet thick. In some instances, on top, these ledges show a thin line of division, but at no great depth they will be found to be practically solid from wall to wall. * * * Blocks can now be obtained containing from 100 to 125 cubic feet without seam or flaw. * * * The marble at the surface of most quarries is worthless, but pieces chipped from the topmost crags of these giant croppings that have been exposed to the elements for countless ages show no traces of decay. On the contrary, the beautiful tints and delicate veins and shading are so perfect as to almost defy any improvement in the character of the stone by deeper workings. It is to be expected, however, as depth is attained, the marble will become a little softer and the colors grow deeper and brighter. * * *

The marble is a verd antique of fine texture, free from faults or imperfections, and susceptible of a very high polish. It embraces all shades of color and tints producible from the commingling of black, white, green, yellow, brown, pale blue, and soft creamy pink. * * *

It is evident that the marble dike extends to a great depth. It seems like a veritable rib of the earth. To all intents and purposes, the quantity of marble is practically inexhaustible.

Capital is at present needed to develop these quarries.

COLORADO.

This State appears in the table for the first time as a marble producer, although attention has been in former reports repeatedly called to the fact of the existence of fine marble in the State. The output for 1897 was valued at $99,600, and it is said by the producers that about the same quantity was also produced in 1896, but no returns to that effect were received in time for publication in the report of 1896.

Mr. Henry Wood, analytical chemist, found the following results in an analysis of the marble from Beulah, Colorado:

Analysis of marble from Beulah, Colorado.

	Per cent.
Carbonate of lime, $CaCO_3$	98.00
Magnesia, MgO	.05
Iron (probably Fe_2O_3)	.04
Silica, SiO_2	.06
Total	98.15

For further data concerning Colorado marble former reports should be consulted.

GEORGIA.

The value of the output in 1896 was $617,380; in 1897 the corresponding figure was $598,076. Since August, 1897, business has been increasing. An exhaustive consideration of the Georgia marble has been given in a former report.

IDAHO.

Five thousand dollars' worth of marble was produced in 1897. It was used for cemetery work and interior decoration.

MARYLAND.

The output increased from $110,000 in 1896 to $130,000 in 1897. The product is largely used for building purposes.

MASSACHUSETTS.

The value of the output differed but slightly from that in 1896.

NEW YORK.

The output fell from $484,160 in 1896 to $354,631 in 1897. In 1896 there was an unusually large product from Tuckahoe, which accounts for the difference in the figures.

The following analysis of marble quarried by the Snowflake Marble Company at their quarries at Pleasantville, Westchester County, New York, was made by Prof. C. F. Chandler, of Columbia University, New York:

Analysis of marble from Pleasantville, New York.

	Per cent.
Calcium carbonate, $CaCO_3$	54.12
Magnesium carbonate, $MgCO_3$	45.04
Ferric oxide, Fe_2O_3	.11
Alumina, Al_2O_3	.07
Silica, SiO_2	.10
Total	99.44

The following analysis and tests of marble quarried by the South Dover Marble Company, of South Dover, Dutchess County, New York, were made by Messrs. Ricketts and Banks, of New York City:

Analysis of marble from South Dover, New York.

	Per cent.
Silica, SiO_2	0.70
Ferric oxide, Fe_2O_3	.25
Alumina, Al_2O_3	.37
Lime, CaO	30.63
Magnesia, MgO	20.25
Oxide of sodium, Na_2O	.12
Oxide of potassium, K_2O	.46
Undetermined and loss	.56
Carbonic acid, CO_2	46.66
Total	100.00

Tests of marble from South Dover, New York.

[Specific gravity, 2.86.]

Porosity: A piece of the marble weighing 143.173 grams and having a volume of 50.05 cubic centimeters absorbs 0.267 grams of water after having been placed therein twenty-four hours.

The following crushing-strength tests were made by Mr. Ira H. Woolsen, M. E., of the engineering department of the School of Mines, Columbia University, New York City:

Crushing-strength tests of marble from South Dover, New York.

[Material, white marble.]

	Test No.		
	1355.	1356.	1357.
How tested	Bed.	Bed.	Bed.
Shape of test piece	Cube.	Cube.	Cube.
Dimensions:			
Length or height, in inches	1.995	1.985	1.986
Diameter or breadth, in inches	2.01	2.02	2.04
Original:			
Thickness, in inches	2.01	2.00	2.00
Area, in square inches	4.04	4.04	4.08
Elastic limit	Slightly.	----------	----------
First crack	67,800	48,800	77,400
Stress (in pounds):			
Maximum	76,100	70,300	85,200
Compression:			
Maximum per square inch	18,836	17,401	20,882
Average, 19,039 pounds to the square inch.			

PENNSYLVANIA.

The output increased in value from $31,522 in 1896 to $62,683 in 1897.

The product of the Avondale Marble Company is now well introduced to the building public, and has been under scrutiny for several years. The stone is well adapted for building, in point of strength as well as beauty.

The following mineralogical analysis was made at the Michigan Mining School:

Mineralogical analysis of marble from Avondale, Pennsylvania.

	Per cent.
Calcite	53.19
Magnesite	39.17
Quartz, mica, etc	1.64
Total	100.00

The crushing strength was found to be 22,505 pounds to the square inch by the School of Mines of Columbia University, New York City.

It shows very low absorption of moisture.

The Avondale quarries have been equipped with the most modern machinery for quarrying marble, including a powerful derrick capable of handling 100 tons. Another interesting feature is the erection of a mill to be run by electricity. This is now in course of construction.

A peculiarity of this marble deposit is that true granite is quarried from an opening not over 150 feet from the marble opening.

The development of the Avondale quarries is watched with much interest by quarrymen generally on account of the unique features presented and on account of the thoroughly modern methods of conducting the enterprise.

Quarries have recently been opened at Annville, near Swatara, Dauphin County, Pennsylvania, by Mr. J. H. Black. The product is known as Keystone marble. It is to be used for building, interior decoration, and cemetery work.

The following analysis and tests of this marble were made by Prof. G. G. Pond, of the chemical department of State College, Pennsylvania:

Analysis and tests of marble from Annville, Pennsylvania.

	Per cent.
Carbonate of calcium	95.10
Carbonate of magnesium	3.96
Silica	1.07
Oxide of iron	.23
Alumina	.14
Phosphorus	.00
Organic matter	Slight tr.
Total	100.50
Specific gravity	2.67
Crushing test, pounds per square inch	12,210

TENNESSEE.

The value of the output in 1896 was $381,373; in 1897, $441,954; so that an increase is evident. Producers report encouraging prospects for 1898. The output goes largely for purposes of interior decoration, although considerable that is sold by the quarrymen as rough is used in buildings. The so-called "Knox pink" is well suited for outside building.

A full description of the Tennessee marble has already been given in the reports for 1894, 1895, and 1896.

UTAH.

The marble quarried by the Hobble Creek Marble Company was described in the report for 1896. Operations preliminary to quarrying have been carried on during the past year, and an output may be looked for in the near future.

VERMONT.

The output of Vermont underwent a notable increase in 1897, namely, from $1,101,557 in 1896 to $2,050,229 in 1897. More than half of the product of the United States came from Vermont. Most of it was used for cemetery purposes, although some of the quarries now produce building stone on quite a large scale, which appears to be increasing.

Full descriptions of the Vermont quarries have been given in former reports, together with analyses and tests of the marble in some cases.

WEST VIRGINIA.

Although no output from this State has yet been secured, operations looking to that end have been gotten under way by the Pocahontas

Marble Company, of Academy, Pocahontas County, where marble of apparently very desirable properties has been found. It has been examined by experts. The following report by Mr. George C. Underhill shows the nature of the material and its mode of occurrence:

A careful study of the outcroppings indicate, first, that there are several miles of fossiliferous marble strata, perhaps 5 or 6, exposed to plain view much of the distance and nowhere covered by more than a few feet of débris. The vein is at least 40 feet thick and lies nearly horizontal at all points, coursing through and through the low range of hills wherein it is located. There is no possible way to determine the full depth of the stratum except by core drill or uncovering the exposure to a greater depth than has been attempted, or by actual excavation; nor does it matter much whether it be proved to be of greater depth than is shown by outcroppings, for there is more marble already in sight than has ever been used during all the ages, and this statement is in no sense extravagant or overdrawn. An excavation 2,000 feet square and 40 feet deep would produce 80,000,000 cubic feet of merchantable marble--assuming that one-half the excavations be débris—and I seriously doubt whether that enormous gross total has yet been produced, for while the world's production now aggregates perhaps 4,000,000 cubic feet annually, it is only of late that even 1,000,000 was used, and it is probable that 100,000 feet would cover the production of fifty years ago, and proportionately less as we go back. Thus it will be seen that with an area of several miles square available it is not very important to know accurately whether the depth be 40 or 140 feet, especially as a 40-foot stratum can be economically worked.

In quality this marble may be divided into two general grades, one ranging from the richest red to the deepest maroon color, the other dove colored, richly marked with white mottling and dark veins. Perhaps the most important query is as to the condition of this vast mass, for many deposits that are otherwise desirable are so unsound and broken by eruption and upheaving forces as to be rendered worthless.

A word as to the method of its presentation above the adjacent country side will make plain that no great strain could have obtained. The contour of the immediate country surrounding Marble Mountain, taken in connection with the position of all the exposed rocks, makes it sure that the hills in question were forced up from their original level, the level where deposition took place, without tilting or contortion, just as though some force should operate directly under a given piece of level meadow land so as to lift it hundreds or thousands of feet above its natural surroundings, thus making an elevated table-land or mesa, the top being undisturbed and level as before.

I have never seen like conditions except at Dorset, Vermont, where a large bed of low-grade marble and noncrystallized limestone was forced up in a like manner, and where more than half a century's work on an extensive scale shows a practically sound and unbroken mass of marble except in a few spots where it is locally injured, as in case of the "blue ledge" and its immediate vicinity.

The red and maroon marble referred to are counterparts almost of marble found in Hawkins County, Tennessee, and at Swanton, Vermont, both valuable and much sought after. Many years ago the balusters and columns inside the Capitol building at Washington were produced, at great expense, near Rogersville, in the former State, and are standing advertisements for this beautiful material.

The dove-gray varieties have no known counterpart, in this country at least, except in Colorado, where there is a somewhat similar vein. This marble is at once chaste and rich, and would find a ready market wherever beauty is appreciated. Commercially the future of Marble Mountain is largely dependent on a railway outlet, but as a valuable marble field is a great freight producer; and in view of the recent discoveries of coal near by it is not possible that the building of a railway will be long delayed. Moreover, it is almost a wonder that a rich farming district like that bordering the Greenbrier River for the 40 miles or more north from the Chesapeake and Ohio Railroad at Ronceverte should have been so long overlooked by railroad men.

I may add that I was shown one of the finest pieces of black marble that I have ever seen and a fine sample of agate onyx, both of which would aid in making a railroad pay through this valley.

Finally, let me say that under favorable conditions large returns are made from the production of marble, and I feel confident that when it is fully understood that there are large quantities of freight some railway company to the north or south will reach out for it, and the rest will naturally follow.

SLATE.

CONDITION OF TRADE.

The slate industry has been in a comparatively flourishing condition, judging from the increase in value of output from $2,746,205 in 1896 to $3,524,614 in 1897.

This increase is seen, from the following table, to be due to unusual activity in the production of roofing slate, the number of squares of which has, for the first time in the history of slate quarrying in the United States, reached over 1,000,000 squares. The two most productive States, Pennsylvania and Vermont, have, of course, contributed most to this increase, which is due to the export trade and not to increased domestic consumption. Exportations have not been confined to these States alone, but have characterized the trade of others as well.

Tests of slate produced in this country have been made abroad, and the verdict in some cases, if not, perhaps, in all, has been gratifying to American producers.

The average price per square at the quarry of all slate produced has reached the lowest point, namely, $3.09 per square. This, however, is only 2 cents below the average for 1894. It is not unlikely that there will be a slight rise next year. When the demand for slate in this country returns to the conditions of 1891 or 1892 the industry ought to be in a flourishing condition, if the foreign trade is still retained, and there is no reason whatever for believing that such will not be the case.

The export trade began something more than a year ago, and the causes which led to it were fully considered in the report for 1896.

The strike among the workmen of the large slate quarries in Wales has at last, after months of rather bitter feeling, been settled to the satisfaction of employers and employees. This labor difficulty was one of the causes which led to the exportation of American slate, which was needed abroad to supply what had previously been largely forthcoming from the Welsh quarries. Of course the question naturally arises as to whether United States producers can hold the foreign trade they have gained now that the Welsh quarries are again productive.

It is generally believed among American slate producers that this trade can be retained, as the American slate is, on the whole, looked upon with favor abroad and much enterprise has been shown in efforts to popularize our product.

The terms of settlement of the Welsh strike are, according to the American Slate Trade Journal, as follows:

1. (*a*) The grievances of any employee, crew, or class shall be submitted by him or them in the first instance to the local manager. If dissatisfied with the decision of the local manager, then the said grievances shall be submitted to the chief manager, either personally or by deputation, appointed in such manner as the workmen may deem advisable, but to consist of not more than five employees selected from the same class as the person or persons aggrieved, who must be included in the deputation.

(*b*) Grievances in which the employees generally are interested, or which they may adopt on behalf of an employee, crew, or class who have submitted their grievances under the preceding clause and are dissatisfied, can again be submitted to the chief manager by a deputation consisting of not more than six employees, appointed in such manner as the workmen may deem advisable.

(*c*) Finally, in a similar manner in all cases of importance an appeal may be made to Lord Penrhyn, either by the individual or by a deputation, against the decision of the chief manager. The grounds of such appeal shall in all cases be first submitted to his lordship in writing.

2. Suitable monthly bargains will be given without delay as soon as the management finds it practicable.

3. The letting of the contracts to be left in the hands of the management, who engage all persons employed thereon and see that each employee receives his just ratio of wage.

4. Previous to the cessation of work the average wage paid to the quarrymen was 5s. 6d. per day, other piecework classes being in proportion (viz, badrockmen 4s. 7d. and laborers 3s. 7d.). When work is resumed this same basis will be continued so long as trade permits.

5. All the employees who desire work in the Penrhyn quarry will be readmitted in a body as far as it is practicable and the remainder as soon as work can be arranged for them, reasonable time being allowed to those who may now be employed at a distance.

The best evidence that foreign exportation of slate may be regarded as a permanently established practice is that the American Slate Mart and Wharf Company, Limited, of London, England, capital £100,000 ($500,000), was incorporated on September 13, 1897. The object of this company is "to establish, foster, and develop the American slate trade in Great Britain and on the continent of Europe, in all its branches, by the importation of slates from the United States," etc. Mr. William S. Iles, of London, is the head of the new concern, and with him are associated a number of well-known English capitalists. Mr. Samuel Keat, of Pen Argyl, Pennsylvania, is a stockholder and also the sole representative of the company in this country.

A notable improvement in slate quarrying has asserted itself in the comparatively recent adoption of the channeling machine in removing large masses of slate from the quarry. This machine replaces explosives. Blasting, no matter how carefully done, shatters the rock to such an extent that a great deal of otherwise good material is turned into rubbish, resulting in the course of a year in the loss of thousands of dollars. The channeler cuts the rock out so nicely that every part can be used for slate, and the quarry is always clear of rubbish.

PRODUCTION.

The following table shows the output of roofing and milled slate in 1897:

Value of slate product in 1897, by States.

State.	Roofing slate.		Other purposes, value.	Total value.
	Squares.	Value.		
California	1,000	$7,000		$7,000
Maine	38,367	161,262	$39,855	201,117
Maryland	11,592	53,049	890	53,939
Minnesota	400	1,000	500	1,500
New Jersey	250	775		775
New York	9,197	52,799	1,000	53,799
Pennsylvania	657,692	2,034,958	330,341	2,365,299
Vermont	244,575	656,114	39,701	695,815
Virginia	38,375	130,495	14,875	145,370
Total	1,001,448	3,097,452	427,162	3,524,614

The following table shows the average value of roofing slate per square since 1890:

Average annual price per square of roofing slate for the entire country.

1890	$3.34	1894	$3.11
1891	3.49	1895	3.23
1892	3.56	1896	3.36
1893	3.55	1897	3.09

The following table shows the value of the production of slate, by States, during the years 1890 to 1897, inclusive:

Value of slate, by States, from 1890 to 1897.

State.	1890.			
	Roofing slate.	Value.	Other purposes than roofing; value.	Total value.
	Squares.			
California	3,104	$18,089	....	$18,089
Georgia	3,050	14,850	$480	15,330
Maine	41,000	201,500	18,000	219,500
Maryland	23,099	105,745	4,263	110,008
New Jersey	2,700	9,675	1,250	10,925
New York	16,767	81,726	44,877	126,603
Pennsylvania	476,038	1,641,003	370,723	2,011,726
Vermont	236,350	596,997	245,016	842,013
Virginia	30,457	113,079	....	113,079
Other States *a*	3,060	15,240	....	15,240
Total	835,625	2,797,904	684,609	3,482,513

State.	1891.			
	Roofing slate.	Value.	Other purposes than roofing; value.	Total value.
	Squares.			
Arkansas	120	$480	....	$480
California	4,000	24,000	....	24,000
Georgia	3,000	13,500	....	13,500
Maine	50,000	250,000	....	250,000
Maryland	25,166	123,425	$2,000	125,425
New Jersey	2,500	10,000	....	10,000
New York	17,000	136,000	40,000	176,000
Pennsylvania	507,824	1,741,836	401,069	2,142,905
Vermont	247,643	698,350	257,267	955,617
Virginia	36,059	127,819	....	127,819
Total	893,312	3,125,410	700,336	3,825,746

a Includes Arkansas, Michigan, and Utah.

Value of slate, by States, from 1890 to 1897—Continued.

State.	1892.			
	Roofing slate.	Value.	Other purposes than roofing; value.	Total value.
	Squares.			
California	3,500	$21,000	....	$21,000
Georgia	2,500	10,625	....	10,625
Maine	50,000	250,000	....	250,000
Maryland	24,000	114,000	$2,500	116,500
New Jersey	3,000	12,000	....	12,000
New York	20,000	160,000	50,000	210,000
Pennsylvania	550,000	1,925,000	408,000	2,333,000
Vermont	260,000	754,000	260,000	1,014,000
Virginia	40,000	150,000	....	150,000
Total	953,000	3,396,625	720,500	4,117,125

State.	1893.			
	Roofing slate.	Value.	Other purposes than roofing; value.	Total value.
	Squares.			
Georgia	2,500	$11,250	....	$11,250
Maine	18,184	124,200	$15,000	139,200
Maryland	7,422	37,884	....	37,884
New Jersey	900	3,653	....	3,653
New York	69,640	204,776	206	204,982
Pennsylvania	364,051	1,314,451	157,824	1,472,275
Utah	75	450	400	850
Vermont	132,061	407,538	128,194	535,732
Virginia	27,106	104,847	12,500	117,347
Total	621,939	2,209,049	314,124	2,523,173

Value of slate, by States, from 1890 to 1897—Continued.

State.	1894.			
	Roofing slate.	Value.	Other purposes than roofing; value.	Total value.
	Squares.			
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

State.	1895.			
	Roofing slate.	Value.	Other purposes than roofing; value.	Total value.
	Squares.			
California	1,500	$10,500	....	$10,500
Georgia	2,500	10,675	....	10,675
Maine	23,774	118,791	$21,363	140,154
Maryland	13,188	59,157	1,200	60,357
New Jersey	200	700	....	700
New York	13,624	90,150	1,725	91,875
Pennsylvania	426,687	1,437,697	210,054	1,647,751
Vermont	221,359	531,482	93,849	625,331
Virginia	27,095	92,357	19,000	111,357
Total	729,927	2,351,509	347,191	2,698,700

Value of slate, by States, from 1890 to 1897—Continued.

State.	1896.			
	Roofing slate.	Value.	Other purposes than roofing; value.	Total value.
	Squares.			
Georgia	4,597	$20,388	....	$20,388
Maine	23,078	99,831	$24,255	124,086
Maryland	15,557	70,194	1,948	72,142
Massachusetts	....	....	1,200	1,200
New Jersey	200	700	....	700
New York	16,002	78,612	3,880	82,492
Pennsylvania	431,324	1,391,539	334,779	1,726,318
Tennessee	160	640	780	1,420
Vermont	155,523	509,681	99,915	609,596
Virginia	26,863	92,163	15,700	107,863
Total	673,304	2,263,748	482,457	2,746,205

State.	1897.			
	Roofing slate.	Value.	Other purposes than roofing; value.	Total value.
	Squares.			
California	1,000	$7,000	....	$7,000
Maine	38,367	161,262	$39,855	201,117
Maryland	11,592	53,049	890	53,939
Minnesota	400	1,000	500	1,500
New Jersey	250	775	....	775
New York	9,197	52,799	1,000	53,799
Pennsylvania	657,692	2,034,958	330,341	2,365,299
Vermont	244,575	656,114	39,701	695,815
Virginia	38,375	130,495	14,875	145,370
Total	1,001,448	3,097,452	427,162	3,524,614

THE SLATE INDUSTRY IN INDIVIDUAL STATES.

CALIFORNIA.

Slate was produced in Eldorado County to the amount of $7,000. It has an excellent color, dark blue, and is said to be durable; in fact, there seems to be no question as to the quality of the material for roofing purposes, to which use only has the slate yet been applied.

MAINE.

In Maine production increased from a valuation of $124,086 in 1896 to $201,117 in 1897. Some of the quarries were required to increase working force very materially to fill orders.

The following table gives the results of an analysis of roofing slate quarried by the Monson Slate Company at their quarries at Monson, Maine. The analysis was made by Mr. L. M. Norton, of the Massachusetts Institute of Technology, at Boston.

Analysis of Monson (Maine) slate.

	Per cent.
Loss on ignition, including organic matter	3.88
Silica, SiO_2	56.42
Alumina, Al_2O_3	24.14
Ferrous oxide, FeO	4.46
Lime, CaO	.52
Magnesia, MgO	2.28
Oxide of potassium, K_2O	5.53
Oxide of sodium, Na_2O	3.15
Total	100.38

The following data relative to slate quarried by the East Brownville Slate Company at their quarries at Brownville, Maine, were obtained by Prof. W. O. Crosby, of the Massachusetts Institute of Technology, at Boston:

Two 1-inch cubes were crushed on bed; that is, the pressure was applied in a direction perpendicular to the cleavage. The first cube crushed under a load of 29,420 pounds, while the second yielded at 29,120 pounds. In other words, the average crushing strength of this slate, perpendicular to the cleavage, is 29,270 pounds to the square inch. It is thus much stronger than ordinary building stones, which usually range from 5,000 to 20,000 pounds; in fact, the strength is equaled by very few stones and surpassed by almost none. One cube was crushed on edge; that is, the pressure was applied parallel with the cleavage. It yielded at 16,750 pounds, a higher result than is afforded by most kinds of slate on bed. Two slabs were submitted to transverse or breaking strains; they were of uniform size, 6 inches wide, 1 inch thick, and 11 inches long between the supports. They were laid horizontally upon the supports and the load applied at the middle, bearing upon the entire width of the slab. The first slab, which had been purposely selected because it was visibly imperfect in structure, broke under a load of 2,540 pounds, while the second slab, which clearly shows the normal quality of the slate, required 3,550 pounds to break it.

MARYLAND.

In 1896 the total value of the output was $72,142; in 1897, $53,939; so that there was a slight decline. The outlook for 1898 is said to be improved.

In the report for 1896 results of tests of Maryland Peach Bottom slate were given in detail.

MASSACHUSETTS.

A small quantity of slate was quarried during the year, but apparently not used for the purposes to which slate is usually applied.

MINNESOTA.

A little slate quarrying was done in 1897, but the industry in this State has not yet become permanently established, although there seems to be no reason why it should not.

NEW JERSEY.

A little work was done in New Jersey at Lafayette, where there are a few quarries belonging to the continuation of the Pennsylvania slate belt.

NEW YORK.

The slate of this State is almost entirely red slate, produced in the quarries of Washington County, not far from the Vermont State line. Production declined slightly in 1897.

PENNSYLVANIA.

The output of slate in Pennsylvania in 1896 was valued at $1,726,318; in 1897, at $2,365,299—a very remarkable increase. This is largely due to a continuation of the export trade, which commenced in 1896. Domestic trade was not largely increased over 1896.

The following analysis of slate quarried by the East Bangor Consolidated Slate Company, of East Bangor, Pennsylvania, was made by Mr. Henry Leffman, of Philadelphia:

Analysis of slate from Bangor, Pennsylvania.

	Per cent.
Silica, SiO_2	68.620
Iron oxide	4.200
Alumina, Al_2O_3	12.680
Calcium Carbonate, $CaCO_3$	2.337
Magnesium	3.759
Alkalies	3.730
Moisture and combustible matter	4.470
Total	99.796
Summary:	
Silicates	89.160
Carbonates	6.096
Moisture and cumbustible matter	4.470

The following article is an abstract of a paper by Professor Mansfield Merriam, of Lehigh University, originally published in Vol. XXVII of the Transactions of the American Society of Civil Engineers:

THE STRENGTH AND WEATHERING QUALITIES OF OLD BANGOR ROOFING SLATES.

The roofing slates here described and investigated are those from the quarries of the Old Bangor Slate Company, situated at Bangor, Pennsylvania. The Old Bangor quarry is about 3 miles from the Blue Mountain, and thus at the bottom of the upper or softer slate beds. This quarry is very much the largest in the Bangor region, a great part of its product being manufactured into roofing slates, which, by general reputation, stand high in quality.

The manner of working this quarry is in benches whose surfaces are parallel with the plane of cleavage. As the benches are worked downward, the top is constantly being stripped off in order to allow new ones to be started, and thus the horizontal extent of the quarry is continually increased, its maximum depth remaining at about 125 feet below the original surface of the ground. This method of working in benches is peculiar to this particular quarry, and can be pursued only when the uncovered area is very large. There are five of these benches, each being about 15 feet in height and from 30 to 40 feet in width.

This is the oldest quarry in the Bangor region, having been opened in 1866, and the horizontal uncovered area is now about 500 by 1,000 feet.

Roofing slates.—In the manufacture of roofing slates everything is done by hand except dressing the edges. The blocks delivered at the shanties are first split into thicknesses of about 2 inches. These are piled up in a shanty beside a workman called a splitter, who, with a wooden mallet and a long, thin chisel, divides each into halves, and continues the process until they are reduced to the required thickness of about three-sixteenths of an inch. He then cuts out pieces in approximate sizes, and these are taken by an assistant and squared off into regular shape and size on a dressing machine. The rock requires to be kept damp from the time it is first exposed until it is split into the final sizes, otherwise the cleavage becomes difficult.

Roofing slates are made in numerous sizes, from 14 by 24 inches down to 6 by 12 inches, the longer dimension being that which is placed parallel with the rafters of the roof. In all roofing which is properly done, a triple lap of 3 inches is allowed; thus, for a 24-inch slate 10½ inches are exposed, 10½ inches are covered by the slate above it, and 3 inches are covered by two slates above it. The amount of slate required to cover a space 10 by 10 feet in this manner is called a square, which is the unit by which they are sold. For slates 12 by 24 inches it takes 114 to make a square; for those 8 by 16 inches, 277 makes a square, and so on.

The normal product of roofing slates is called No. 1 stock, and this is entirely free from ribbons. In addition to the first quality there is a small proportion of the product manufactured into No. 1 Ribbon and No. 2 Ribbon, the former containing ribbons near one end only, so that when laid on the roof the exposed parts are free from them. The color of the slate produced in the quarries of the Old Bangor Slate Company is a permanent dark blue. The color of the ribbons, however, is nearly black. This is due to the sulphide of iron which they contain.

The investigations of the properties of slate which are found on record are few, and these are almost entirely by chemical analysis. Silica and alumina are supposed to give strength and toughness, the carbonates of lime and magnesia are liable to be acted upon and washed out by the rain, and the compounds of iron and sulphur are known to promote disintegration under the action of smoke and acid fumes. Something as to quality can therefore be judged by the comparison of chemical analyses, but the information thus obtained is so slight as to have little weight with an engineer, particularly when he considers that the mineralogists inform us that the rocks of the same identical chemical composition may have quite different properties on account of different lithological structure. A chemical test of iron or steel affords but little information to the engineer concerning its physical properties, and he demands that quantitative results concerning its toughness and strength must be known. So it should be with stones and slates.

Method of investigation.—It was purposed in investigating these roofing slates to experiment as closely as possible upon those properties which are called into service in resisting the stresses to which they are subject, and upon those qualities which either assist or resist the disintegrating action of the atmosphere and weather. The strength and toughness of slate are important elements in preventing breakage in transportation and handling, as well as in resisting the effect of hail or of stones maliciously thrown upon the roof. They are also brought effectively into play by the powerful stresses produced by the freezing of water around and under the edges. Porosity, on the other hand, is not a desirable property, for the more water the slate absorbs the greater the disintegrating action when it freezes and thaws. Density is a quality of value, for, in accordance with a fundamental principle of the science of the resistance of materials, the greater the specific gravity of one of several similar substances, the greater is its strength. Hardness may or may not be a desirable quality according as it is related to density or to brittleness. Lastly, corrodibility, or the capacity of being disintegrated by the chemical action of smoke and of fumes from manufactories, is certainly not desired in roofing slates.

A scientific investigation was undertaken to determine these qualities in the Old Bangor slates. In order to do this, such tests were selected as seemed likely to be both precise and simple, and of such a character that quantitative results concerning each of the above properties could be determined. These results will be given below for a number of specimens, and they will be discussed and compared with the view of ascertaining the relation between the different properties. Lastly, by the help of chemical analyses, the relation of the physical qualities to the presence or absence of certain elements is to be studied.

The pieces tested were 12 inches wide by 24 inches long, and varied in thickness from three-sixteenths to one-fourth of an inch. They were all free from ribbons and were presumably of the best product of the Old Bangor quarries. There were twelve specimens, marked 1, 2, 3, 4, etc. These numbers were kept upon the specimens and their fragments throughout the different tests, thus enabling the different properties to be compared for each individual specimen. The general appearance of the slates was very similar.

Strength.—The transverse or flexural strength of the slates was selected for experiment because of the ease and accuracy with which the tests can be made, and also because such stresses are brought upon it in actual use rather than those of pure tension or compression. The pieces were supported in a horizontal position upon wooden knife edges 22 inches apart, and then loads were placed upon another knife edge halfway between the supports. The load was applied by means of sand running out of an orifice in a box at the uniform rate of 70 pounds per minute, and by the help of an electric attachment the flow of sand was stopped at the instant of rupture. The slates were always placed upon the supports so that the beveled edges were on the lower side. As the load was increased the deflection of the slate could be observed upon a scale and the ultimate deflection was recorded.

The strength of a beam or plate broken in this manner is indicated by the modulus of rupture, which is the computed horizontal rupturing stress on the upper and lower fibers, and is intermediate in value between the ultimate tensile and compressive strength. Let W be the load in pounds which causes rupture when applied at the middle, let l be the distance between the supports in inches, b the breadth and d the thickness of the plate in inches. These being carefully found by observation, the formula

$$S = \frac{3Wl}{2bd^2}$$

furnishes the means of computing the modulus of rupture S, whose value is then in pounds per square inch.

In the following table are given the values of the modulus of rupture for each of the twelve specimens. In four cases this value is the average of two tests, the second one being made upon pieces 10 inches long which were cut from the larger broken specimens. The figures for these duplicate tests will be interesting as showing the slight range in the results, and thus establishing the accuracy and value of this method of investigation. They give the following values for the modulus of rupture in pounds per square inch, and the average of these is stated in the table, while for the other specimens tests were made upon the larger sizes only:

Average modulus of rupture, in pounds per square inch, of Old Bangor roofing slate.

Mark of specimen.	B3	B7	B9	B11
S for large slate	9, 750	8, 420	10, 195	8, 100
S for small slate..................	9, 720	8, 450	10, 235	8, 140

The mean value of the modulus of rupture of all the specimens is seen to be 9,810 pounds per square inch.

The following table shows tests of Old Bangor slates:

Tests of Old Bangor slates.

Mark of the specimens.	Strength.	Toughness.	Density.	Softness.	Porosity.	Corrodibility.
	Modulus of rupture per square inch.	Ultimate deflection on supports 22 inches apart.	Specific gravity.	Amount abraded by 50 turns of a small grindstone.	Water absorbed in 24 hours.	Weight lost in 63 hours in acid solution.
	Pounds.	*Inch.*		*Grains.*	*Per cent.*	*Per cent.*
1........	11, 550	0. 32	2. 816	151	0. 131	0. 410
2........	11, 540	. 38	2. 807	140	. 170	....
3........	9, 740	. 31	2. 795	76	. 099	. 439
4........	8, 650	. 31	2. 784	119	. 127	. 481
5........	7, 280	. 25	2. 779	86	. 204	....
6........	9, 220	. 31	2. 759	130	. 174	. 374
7........	8, 440	. 27	2. 776	119	. 167	....
8........	11, 570	. 40	2. 769	130	. 123	. 551
9........	10, 215	. 32	2. 782	173	. 123	. 464
10........	10, 900	. 37	2. 767	86	. 169	....
11........	8, 120	. 23	2. 769	140	. 099	. 404
12........	10, 490	. 32	2. 754	184	. 152	....
Means..	9, 810	. 312	2. 780	128	. 145	. 446

Toughness.—The ultimate deflections of the pieces broken under transverse stress furnish an indication of their toughness, in the same manner that the ultimate elongation of a metallic specimen under tensile strain is an index of toughness and extensibility. The greater the ultimate deflection of a bar, the less is its brittleness, and the greater its toughness, other things being equal. All the specimens of slate were so elastic that the deflection of the middle part, where the load was applied, could easily be noted on a scale by the eye, with an error rarely exceeding one thirty-second of an inch. The test can, therefore, be readily made with the simplest apparatus. The results for the individual specimens are seen in the table, all of which were found from the pieces laid upon supports 22 inches apart. The mean values of the ultimate deflection are 0.312 inch.

The toughness of the slate can also be inferred from the manner of rupture of the specimens. It was observed in general that all the specimens ruptured in different planes on the upper and lower surfaces, so that, in fact, it often split or sheared into two thinner sheets, which were then pulled apart from each other. The structure of the Old Bangor slate, therefore, is laminated and very fibrous, and hence tough and strong.

Specific gravity.—The density was next determined for each specimen by weighing it first in air and then in water, from which data the specific gravity was computed. The results given in the table show the mean density to be 2.780.

Softness or capacity for abrasion.—The hardness of the slates was next tested by subjecting them to abrasion upon a grindstone, whose thickness was 1½ inches and diameter 7 inches. A piece of slate about 4 by 4 inches was accurately weighed, and then held against the grindstone by a lever, which exerted a constant pressure of 10 pounds upon it while the grindstone was turned fifty times. The piece was then weighed again, and the difference of the two weights gives the amount ground off. The results thus obtained indicate the hardness, or rather the softness, for the greater the abrasion the softer is the material. The table which gives these results for each specimen shows the mean values to be 128 grains. For a roofing material hardness is not necessarily a valuable quality, and it will appear later in this discussion that the softer slate has the higher strength and weathering qualities.

Porosity.—The well-known test for porosity is to determine the percentage of water absorbed by the specimens under similar conditions. In the absence of standard rules regarding the shape and size of the specimen, its degree of dryness, or time of immersion, the following procedure was adopted: A piece of slate from each specimen was cut to a size about 3 by 4 inches, the edges being left rough and irregular. These were dried for twenty-four hours in an oven at a temperature of 135° F. After cooling to the normal temperature of the room, they were weighed on delicate scales and then immersed in water for twenty-four hours, when they were taken out and weighed again. The difference of these weights, divided by the first weight, gives the percentage of water absorbed by a specimen. The table exhibits the results thus obtained, and it is seen that the mean percentage of the samples is 0.145.

Corrosion by acids.—In order to imitate the action of smoke and of sulphurous fumes of manufactories, the following test was used: A solution of hydrochloric and sulphuric acids was prepared, consisting by weight of 98 parts of water, 1 part of hydrochloric and 1 part of sulphuric acid. In this pieces of slate about 3 by 4 inches in size were immersed for certain periods of time, having first been carefully weighed. After being taken out of the solution they were dried for two hours in the normal air of the laboratory and were again weighed. Thus the loss of weight due to the corrosive action of the acids was ascertained. The results were then transformed into percentages of the original weight, which give an absolute measure of the corrosion. Two specimens of slate were kept for twenty-four hours in the solution, and gave the following percentages of loss of weight:

Corrosion of Old Bangor slate in acid.

	Per cent.
B5	0.297
B7	0.235
Mean	0.266

Two specimens of slate were kept for eighty-seven hours in the acid solution, and there were found the following percentages of loss of weight:

Corrosion of Old Bangor slate in acid.

	Per cent.
B2	0.633
B12	0.696
Mean	0.665

Most of the specimens, however, remained in the acid for a period of sixty-three hours, and from these the percentages of loss of weight were obtained which are given in the table. After the tests the surfaces of the pieces showed but slight traces of acid action, notwithstanding the loss of weight.

These results plainly indicate that the corrosion or disintegration rapidly increased with the time. The sum of these means for twenty-four hours, sixty-three hours, and eighty-seven hours is 1.377 per cent for the specimens, which may, perhaps, be taken as the final value for comparison.

Discussion of the tests.—The above physical tests were mostly made under the writer's direction by Mr. J. P. Brooks, instructor in civil engineering in Lehigh University. Great care was taken to so conduct them that the numerical results would be strictly comparable.

The recapitulation of the mean results of these tests will be useful at the outset of the discussion. These mean values have, according to the principles of the method of least squares, about 12 times the weight of a single determination, and should hence be expected to furnish a tolerably reliable indication concerning the properties under investigation. They are given in the table below, and it is at once seen that the different qualities are connected by definite relations, the strongest slate being the toughest and softest, as also the least porous and corrodible.

Mean results of physical tests.

Property.	Measured by—	Slates.
Strength	Modulus of rupture, in pounds per square inch.	9, 810
Toughness	Ultimate deflection, in inches, on supports 22 inches apart.	0. 313
Density	Specific gravity	2. 780
Softness..........	Weight, in grains, abraded on grindstone under the stated conditions.	128
Porosity	Per cent of water absorbed in 24 hours when thoroughly dried.	0. 145
Corrodibility.....	Per cent of weight lost in acid solution in 63 hours.	0. 446

The conclusion is hence apparent that the greater the strength, the greater, also, is the softness or capacity for abrasion. This result was unexpected, and can not, of course, be laid down as a general rule applicable to building stones, or even to slates which differ greatly in structure. The capacity for abrasion here seems allied to toughness, or it denotes the lack of brittleness; but this relation certainly is not a general one, although it is true of the roofing slates here discussed, and also of others which the writer has investigated. The testimony of the quarrymen, moreover, as far as he has been able to obtain it, seems to verify the conclusion that in this slate region softness, strength, and toughness are qualities closely connected.

Similar comparisons may be made between strength and toughness, strength and corrodibility, and porosity and corrodibility. The conclusion is irresistible that these qualities are so connected that one may be taken as an approximate index of the others; and, after carefully considering the whole field, the writer does not hesitate to decide that the test for transverse strength is the one which is the most satisfactory for roofing slates, if only one test is to be made. It is one that can be made quickly and without expensive apparatus. The modulus of rupture is an absolute quantity independent of the size of the specimen, and it gives to the engineer a more definite idea of the quality of materials than do the figures indicating other properties. In making this test it will usually be easy to measure the deflections and thus obtain the means for comparing the toughness as well as the strength.

While the test for porosity is a valuable one, it is necessary that the specimens should be brought to the same degree of dryness by heating them for an entire day; and as the amount of water absorbed is only about one-fifth of 1 per cent, the weighing must be done with care. The test for corrodibility is also a good one, but precise weighing is also necessary. The tests for abrasion on a grindstone and for specific gravity appear lowest of all in practical value, and their use can not, in general, be recommended, the former being liable to be misinterpreted, and the latter not being sharply related, in this case at least, to the strength and weathering qualities.

Chemical analyses.—Although the interpretation of chemical analyses is, at best, imperfect and unsatisfactory, it was not thought advisable to entirely neglect them in this investigation. The physical properties being known, they may perhaps be in some measure accounted for by the chemical composition. Hence an analysis was made of a specimen of slate by Dr. Frederick Fox, instructor in chemistry in Lehigh University. The expense of chemical work is so great that an analysis of each specimen could not be undertaken, and accordingly B3 was selected as being an average sample in strength and weathering qualities. The complete analysis of the slates was not undertaken, this being a long and expensive operation, but such elements were determined as would probably afford indications, first, of its valuable qualities, and, secondly, of its injurious constituents. The following is the report of the chemical analysis:

Analysis of slate from Bangor, Pennsylvania.

	Per cent.
Silica (SiO_2)	56.97
Oxides of iron and aluminum (Fe_2O_3 Al_2O_3)	26.05
Carbonic acid (CO_2) and organic matter	7.14
Oxide of calcium (CaO), or lime	4.38
Oxide of magnesium (MgO)	2.69
Sulphur (S)	0.46
Oxides of sodium and potassium (by difference)	2.31
Manganese	Trace.
Total	100.00

The above are the substances actually determined in the chemical work. They do not, however, exist in these forms in the slate itself. Slate consists principally of silicates of iron and aluminum, with smaller proportions of silicates of sodium and potassium, together with carbonates of lime and magnesium and sulphide of iron as impurities. In the analysis the silicates are broken up into silica and oxides, and these separately determined. So the carbonate of lime is broken up into carbonic acid and oxide of calcium, and the latter determined.

Now, the valuable constituents of slate are the silicates of iron and aluminum, or the clay, this being inert and incorrodible. The percentage of this is easily computed from the chemical analyses to be as follows, which indicates the "Old Bangor" to be a very superior slate:

Silicates of iron and aluminum found in Old Bangor slate.

	Per cent.
Silicates of iron and aluminum	83.02

The injurious constituents in slate are the carbonates of lime and magnesia and the sulphide of iron, or iron pyrites. The carbonates are easily attacked and dissolved by water which has been rendered slightly acid by smoke, and the pyrites is apt to cause disintegration. The chemical analyses furnish the means of computing the carbonates, and the amount of pyrites is probably closely proportioned to that of the sulphur. The percentage of sulphur, however, is so small that its influence is probably slight. The computed percentages of carbonates are:

Carbonates found in Old Bangor slate.

	Per cent.
Carbonate of lime	7.82
Carbonate of magnesia	5.65
Total carbonates	13.47

Conclusions.—The above investigation seems to indicate the following conclusions regarding the roofing slates from the quarries of the Old Bangor Slate Company:

1. These roofing slates weigh about 173 pounds per cubic foot, and the best qualities have a modulus of rupture of from 7,000 to 10,000 pounds per square inch.

2. The stronger the slate, the greater is its toughness and softness and the less is its porosity and corrodibility.

3. Softness, or liability to abrasion, does not indicate inferior roofing slate; but, on the contrary, it is an indication of strength and good weathering qualities.

4. The strongest slate stands highest in weathering qualities, so that a flexural test affords an excellent index of all its properties, particularly if the ultimate deflection and the manner of rupture be noted.

5. The strongest and best slate has the highest percentage of silicates of iron and aluminum, accompanied by moderate amounts of carbonates of lime and magnesia.

6. Chemical analyses give only imperfect conclusions regarding the weathering qualities of slate, and they do not satisfactorily explain the physical properties.

7. Architects and engineers who write specifications for roofing slate will probably obtain a more satisfactory quality if they insert requirements for a flexural test to be made on several specimens picked at random out of each lot.

8. Although the field of this investigation is probably not sufficiently extended to fully warrant the recommendation, it is suggested that such specifications should require roofing slates to have a modulus of rupture, as determined by the flexural test, greater than 7,000 pounds per square inch.

VERMONT.

The output increased from a valuation of $609,596 in 1896 to $695,815 in 1897.

Export trade was a very important element in the business of Vermont, as also in Pennsylvania, during 1897.

VIRGINIA.

The product in 1896 was valued at $107,863, in 1897 at $145,370. An increase is evident, and export trade is largely accountable for this, as in Vermont and Pennsylvania.

The following is an analysis of slate quarried by Messrs. Jno. R. Williams & Co. at their quarries at Arvonia, Virginia, by Henry Froehling, Ph. D.: .

Analysis of slate from Arvonia, Virginia.

	Per cent.
Silica, SiO_2	60.65
Alumina, Al_2O_3	16.87
Ferri-oxide, Fe_2O_3	7.79
Manganese	Trace.
Lime, CaO	1.91
Magnesia, MgO	2.39
Carbon dioxide, CO_2	Trace.
Sulphur, S	.69
Potash, K_2O	3.80
Soda, Na_2O	2.18
Water and organic matter	3.63
Total	99.91

The sample dried at 212° F.

SANDSTONE.

PRODUCTION.

The following table shows the output of sandstone in the United States for the year 1897:

Sandstone production in 1897, by States.

State.	Value.	State.	Value.
Alabama	$3,000	Missouri	$57,583
Arizona	15,000	Montana	25,644
Arkansas	3,161	New Jersey	190,976
California	4,035	New York	544,514
Colorado	60,847	North Carolina	11,500
Connecticut	364,604	Ohio	1,600,058
Illinois	14,250	Pennsylvania	380,813
Indiana	35,561	Texas	30,030
Iowa	14,771	Utah	7,907
Kansas	20,953	Washington	16,187
Kentucky	40,000	West Virginia	47,288
Louisiana	8,000	Wisconsin	33,620
Massachusetts	194,684	Wyoming	11,275
Michigan	171,127	Total	4,065,445
Minnesota	158,057		

The following table gives the value of the sandstone output, by States, for the years 1890 to 1897:

Value of sandstone, by States, from 1890 to 1897.

State.	1890.	1891.	1892.	1893.
Alabama	$43,965	$30,000	$32,000	$5,400
Arizona	9,146	1,000	35,000	46,400
Arkansas	25,074	20,000	18,000	3,292
California	175,598	100,000	50,000	26,314
Colorado	1,224,098	750,000	550,000	126,077
Connecticut	920,061	750,000	650,000	570,346
Florida	(a)			
Georgia	(a)		2,000	
Idaho	2,490		3,000	2,005
Illinois	17,896	10,000	7,500	16,859
Indiana	43,983	90,000	80,000	20,000
Iowa	80,251	50,000	25,000	18,347
Kansas	149,289	80,000	70,000	24,761
Kentucky	117,940	80,000	65,000	18,000
Maryland	10,605	10,000	5,000	360
Massachusetts	649,097	400,000	400,000	223,348
Michigan	246,570	275,000	500,000	75,547
Minnesota	131,979	290,000	175,000	80,296
Missouri	155,557	100,000	125,000	75,701
Montana	31,648	35,000	35,000	42,300
Nevada	(a)			
New Hampshire	3,750			
New Jersey	597,309	400,000	350,000	267,514
New Mexico	186,804	50,000	20,000	4,922
New York	702,419	500,000	450,000	415,318
North Carolina	12,000	15,000		
Ohio	3,046,656	3,200,000	3,300,000	2,201,932
Oregon	8,424		35,000	
Pennsylvania	1,609,159	750,000	650,000	622,552
Rhode Island	(a)			
South Dakota	93,570	25,000	20,000	36,165
Tennessee	2,722			
Texas	14,651	6,000	48,000	77,675
Utah	48,306	36,000	40,000	136,462
Vermont	(a)			
Virginia	11,500	10,000		3,830
Washington	75,936	75,000	75,000	15,000
West Virginia	140,687	90,000	85,000	46,135
Wisconsin	183,958	417,000	400,000	92,193
Wyoming	16,760	25,000	15,000	100
Total	10,816,057	8,700,000	8,315,500	5,295,151

(a) Sandstone valued at $25,199 was produced by Rhode Island, Nevada, Vermont, Florida, and Georgia together, and this sum is included in the total.

Value of sandstone, by States, from 1890 to 1897—Continued.

State.	1894.	1895.	1896.	1897.
Alabama	$18, 100	$31, 930	$48, 000	$3, 000
Arizona	....	20, 000	10, 000	15, 000
Arkansas	2, 365	13, 228	1, 400	3, 161
California	10, 087	11, 933	7, 267	4, 035
Colorado	69, 105	63, 237	58, 989	60, 847
Connecticut	322, 934	397, 853	426, 029	364, 604
Georgia	11, 300	....	1, 250	....
Idaho	10, 529	6, 900	16, 060	....
Illinois	10, 732	6, 558	15, 061	14, 250
Indiana	22, 120	60, 000	32, 847	35, 561
Iowa	11, 639	5, 575	12, 351	14, 771
Kansas	30, 265	93, 394	18, 804	20, 953
Kentucky	27, 868	25, 000	....	40, 000
Louisiana	....	....	....	8, 000
Maryland	3, 450	16, 836	10, 713	....
Massachusetts	160, 231	339, 487	304, 361	194, 684
Michigan	34, 066	159, 075	111, 321	171, 127
Minnesota	8, 415	74, 700	202, 900	158, 057
Missouri	131, 687	100, 000	51, 144	57, 583
Montana	16, 500	31, 069	3, 250	25, 644
New Jersey	217, 941	111, 823	126, 534	190, 976
New Mexico	300	2, 700	....	....
New York	450, 992	415, 644	223, 175	544, 514
North Carolina	....	3, 500	13, 250	11, 500
Ohio	1, 777, 034	1, 449, 659	1, 679, 265	1, 600, 058
Pennsylvania	349, 787	500, 000	446, 926	380, 813
South Dakota	9, 000	26, 100	37, 077	....
Tennessee	....	....	4, 100	....
Texas	62, 350	97, 336	36, 000	30, 030
Utah	15, 428	5, 000	7, 860	7, 907
Virginia	2, 258	....	....	....
Washington	6, 611	14, 777	11, 090	16, 187
West Virginia	63, 865	40, 000	21, 693	47, 288
Wisconsin	94, 888	78, 000	65, 017	33, 620
Wyoming	4, 000	10, 000	16, 465	11, 275
Total	3, 955, 847	4, 211, 314	4, 023, 199	4, 065, 445

Inspection of this table shows that the output has increased slightly over 1896, for which year the value was $4,023,199, while for 1897 it was $4,065,445.

THE SANDSTONE INDUSTRY IN THE VARIOUS STATES.

ALABAMA.

But little sandstone quarrying was done in 1897, but indications are more encouraging for 1898.

ARIZONA.

Production amounted to $15,000, a slight increase over 1896. A full description of the Flagstaff quarries was given in the report for 1896. This stone is making a good impression and has already been employed in the construction of a number of large buildings.

ARKANSAS.

But little was done in 1897; a number of quarries were shut down for the year or a large part of it.

CALIFORNIA.

Production was small in amount for 1897.

The following report regarding the sandstone quarried by the Farwell Stone Company, at their quarries at Niles, Alameda County, was made by Prof. E. W. Hilgard, of the University of California:

> I find it to be a sandstone consisting in the main of grains of quartz partly angular, partly rounded, scattering grains of black mica (biotite), and a few scattering grains of calcite and feldspar. These minerals are cemented together mainly by zeolitic cement, together with a purely siliceous one. The minerals of which this rock is composed are highly refractory to weathering and none of them are liable to change of color. None of the rock submitted contains any iron pyrites which might discolor or disintegrate it. The cementing substance resembles closely that of concrete made with hydraulic cement, and is therefore more liable to harden than to soften from exposure to the weather. From the chemical standpoint therefore I consider the rock a very durable one.

COLORADO.

The value of the output in 1896 was $58,989; in 1897, $60,847. Indications for the future are better on the whole than for several years past.

CONNECTICUT.

The value of output in 1896 was $426,029; the figure for 1897 was $364,604. There has evidently been a decline, but prospects for 1898 are said to be better. Most of the sandstone comes from the neighborhood of Portland, Cromwell, and just across the river from Middletown. A full and exhaustive statement of tests and analyses of the Portland sandstone quarried by the Brainerd, Shaler & Hall Quarry Company and the Middlesex Quarry Company was made in the report for 1896.

The stone quarried at East Haven is a rather unique sandstone, being composed of granitic constituents and requiring methods of quarrying resembling those applied to granite rather than ordinary sandstone. It is a hard, durable stone, used freely in New Haven and vicinity in buildings and in bridge work. A church at East Haven built of this material over a hundred years ago is apparently unimpaired to-day.

The sandstone industry of Connecticut has long been one of general interest because of the popularity of the Portland sandstone for use in fronts of pretentious buildings, notably residences in New York, Boston, Philadelphia, and other large Eastern cities. For quite a long period of years this stone was in favor among the wealthy classes, and was generally regarded as the correct thing for fronts, and as an unmistakable indication of the financial and social standing of the occupant of the brownstone front.

At present there is some reaction in the leading cities in favor of lighter colored and less somber-looking stone, but in spite of this the Portland stone is still in demand in connection with light-colored material, as it forms, when so used, an agreeable contrast, bringing out in relief the light and dark stone to the advantage of both, and producing a general effect which is an improvement upon either stone by itself. It is conceded by builders generally that Portland stone should invariably be laid "on the bed" in buildings and not "on edge," if the maximum durability is to be secured. Experience has shown a decided difference in the weathering qualities of this sandstone, according to the manner of laying the stone on bed or edge. The producers of the stone themselves insist that this distinction should be observed, in justice to the stone, as well as to the builder and owner of the edifice.

The quarries at Portland and vicinity are worked upon a large scale, and by firms possessing ample capital and extensive plant. There is a very large percentage of waste material handled at these quarries, and much care is exercised in selecting the best material only for use in building. This fact necessitates handling enormous quantities of stone, and to do this economically the best and most modern devices for lifting and shifting large masses must be used, so that liberal capital must be invested or the work becomes too expensive to pay. The Brainerd, Shaler & Hall Quarry Company represents the consolidation of a number of concerns with extensive capital. The Middlesex Quarry Company is another important concern. Private railways, powerful derricks, and what is probably the largest traveler in the country, if not in the world, are to be found here.

A slaty-looking material, known to the quarrymen as "shell," is abundant and must be avoided; the same material occurs in the sandstone at East Long Meadow, Massachusetts.

The method of quarrying is simple, and adapted to the production of large blocks at a minimum of expense. Large blocks are loosened out by the Knox system of blasting, and then men working together in gangs pry the blocks out so that a chain may be hooked around them, by which they are hoisted from the quarry by derricks. The teams of oxen formerly used for hauling stone have almost entirely disappeared, their work now being done by steam. The stone is shipped largely in the rough. The work of squaring blocks is done by dealers using saws and chilled iron as the abrasive material, although a few diamond saws are also in use. Rubbing is accomplished by lowering the stone upon a revolving iron disk, upon which sand and water are continually fed.

ILLINOIS.

The production of sandstone was about the same in point of value for the last two years. Comparatively little sandstone is produced. Most of the quarries of the State produce limestone, and, as may be seen from the limestone report, the output is very large.

INDIANA.

Sandstone quarrying in Indiana is, as compared with the limestone industry of the State, of much less importance. The value of the sandstone output in 1897 was $35,561, a slight increase over 1896.

IOWA.

Limestone quarrying in this State constitutes the chief part of the stone industry of the State, sandstone production being comparatively small. The value of the sandstone product in 1897 was $14,771. Most of the quarries of the State are small, but there is a large number of them.

KANSAS.

The output from a number of comparatively small quarries in 1897 amounted to $20,953, slightly more than in 1896.

KENTUCKY.

Sandstone valued at $40,000 was produced in 1897.

The following is an analysis of the bluestone quarried by Mr. John M. Mueller at his quarries in Rockcastle County, by Mr. W. M. Mew, analytical chemist:

Analysis of sandstone from Rockcastle County, Kentucky.

	Per cent.
Silica, SiO_2	91.075
Oxide of iron and alumina, $F_2O_3+Al_2O_3$	4.920
Lime, CaO	1.187
Water	2.361
Total	99.543

The stone absorbs 3 per cent of water.

The same stone was tested at the Watertown Arsena. by Capt. Ira MacNutt, with the following results:

Tests of sandstone from Rockcastle County, Kentucky.

Test No.	Marks.	How tested.	Dimensions.			Sectional area.	Ultimate strength.	
			Height.	Compressed surface.			Total.	Per sq. in.
			Inches.	*Inches.*	*Inches.*	*Sq. inches.*	*Pounds.*	*Pounds.*
5485	Upper ledge.	On bed..	2.01	2.00	2.02	4.04	61,250	15,160
5486	......do	On edge.	2.03	2.00	2.02	4.04	49,320	12,208
5487	Lower ledge.	On bed..	2.03	2.01	2.01	4.04	61,050	15,111
5488	......do	On edge.	2.03	2.00	2.00	4.00	49,900	12,475

Crack appeared in No. 5486 at 47,500 pounds.
Crack appeared in No. 5488 at 43,000 pounds.
Fractures all pyramidal.

LOUISIANA.

A small quantity of sandstone was quarried for riprap in jetty construction.

MASSACHUSETTS.

There was a decided falling off in sandstone production, namely, from $304,361 in 1896 to $194,684 in 1897. The most important quarries are those of East Long Meadow, the output of which is well and favorably known as the result of years of experience in building.

The following is a statement of tests made on the sandstone quarried by Messrs James & Marra at their quarries at East Long Meadow, by Maj. J. W. Reilly at the Watertown Arsenal:

Tests of sandstone from East Long Meadow, Massachusetts.

[Compressed surfaces faced with plaster of paris.]

No. of test.	Marks.	Dimensions.			Sectional area.	First crack.	Ultimate strength.	
		Height.	Compressed surface.				Total.	Per square inch.
		Inches.	*Inches.*	*Inches.*	*Sq. in.*	*Pounds.*	*Pounds.*	*Pounds.*
9425	Kibbe red stone...........	4.97	4.95	4.98	24.65	299,000	301,100	12,215
9426	Long Meadow brown stone.	4.89	5.03	4.92	24.75	304,800	305,150	12,330

The following tests and analyses of sandstone from the three quarries, Worcester, Kibbe, and Maynard, operated by Messrs. Norcross Brothers at East Long Meadow, Massachusetts, were submitted by this firm. The physical tests were made by Lieut. Col. F. H. Parker at the Watertown Arsenal, and are as follows:

Tests by compression of two 6-inch cubes of sandstone from Worcester quarry.

[The specimens were tested between flat steel platforms. Their bed surfaces were faced with a thin (.02") coating of plaster of paris to secure even bearings in the testing machine.]

No. of test.	Dimensions.			Sectional area.	Ultimate strength.	
	Length.	Bed surface.			Total.	Per square inch.
	Inches.	*Inches.*	*Inches.*	*Square inches.*	*Pounds.*	*Pounds.*
4 96	6.16	6.03	6.02	36.30	420,900	11,595
4097	6.13	6.02	6.01	36.18	371,800	10,276

A single pyramid was developed by the fracture of these specimens, the bed surfaces forming the bases of the pyramids.

The following analysis of sandstone from the same quarry, Worcester, was made by L. P. Kinnicutt, Ph. D., at the laboratory of the Worcester Polytechnic Institute:

Analysis of sandstone from Norcross Brothers' Worcester quarry.

	Per cent.
Silica, SiO_2	88.89
Alumina, Al_2O_3	5.95
Iron oxide, F_2O_3	1.79
Manganese dioxide, MnO_2	0.41
Lime, CaO	0.27
Potassa and soda, K_2O+Na_2O	0.86
Carbonic acid, water, and loss	1.83
Total	100.00

Tests by compression of two 6-inch cubes of red sandstone from Messrs. Norcross Brothers' Kibbe quarry.

[The specimens were tested between flat steel platforms. Their bed surfaces were faced with a thin (0.02") coating of plaster of paris to secure even bearings in the testing machine.]

Number of test.	Dimensions.			Sectional area.	Ultimate strength.	
	Length.	Bed surface.			Total.	Per square inch.
	Inches.	*Inches.*	*Inches.*	*Square inches.*	*Pounds.*	*Pounds.*
3337	6.00	5.97	6.00	35.82	452,000	12,619
3338	6.02	5.97	5.98	35.70	459,600	12,874

Cracks appeared in cube No. 3337 under 451,000 pounds pressure. A single pyramid was developed by the fracture of this specimen. Cracks appeared in cube No. 3338 under 435,000 pounds pressure, the specimen developing a double pyramidal fracture, the bed surfaces forming the bases of the pyramids.

The following analysis of sandstone from Kibbe quarry was made by Prof. C. F. Chandler, of school of mines, Columbia University, New York:

Analysis of sandstone from Norcross Brothers' Kibbe quarry.

	Per cent.
Silica, SiO_2	81.38
Alumina, Al_2O_3	9.44
Oxide of iron, Fe_2O_3	3.54
Lime, CaO	.76
Oxide of manganese	.11
Magnesia, MgO	.28
Carbonic acid, water, and loss	4.49
Total	100.00

Tests by compression of two 6-inch cubes of sandstone from Messrs. Norcross Brothers' Maynard quarry.

[The specimens were tested between flat steel platforms. Their bed surfaces were faced with a thin (0.02") coating of plaster of paris to secure even bearings in the testing machine.]

Dimensions.			Sectional area.	Ultimate strength.	
Length.	Bed surface.			Total.	Per square inch.
Inches.	*Inches.*	*Inches.*	*Square inches.*	*Pounds.*	*Pounds.*
6.16	6.03	6.02	36.30	371,100	10,223

A single pyramid was developed by the fracture of these specimens, the bed surfaces forming the bases of the pyramids.

The following analysis of Maynard quarry sandstone was made by L. P. Kinnicutt, Ph. D.:

Analysis of sandstone from Norcross Brothers' Maynard quarry.

	Per cent.
Silica, SiO_2	79.38
Iron oxide, Fe_2O_3	2.43
Alumina, Al_2O_3	8.75
Lime, CaO	2.57
Soda and potassa, Na_2O and K_2O	4.08
Carbonic acid and water loss	2.79
Total	100.00

MICHIGAN.

The value of the output increased from \$111,321 in 1896 to \$171,127 in 1897. The sandstone of Michigan is coming more and more into use over a considerable area of the United States.

The following physical tests of stone quarried by the Kerber-Jacobs Redstone Company were made by Maj. J. W. Reilly at Watertown Arsenal:

Tests of Michigan sandstone.

Test number.	Dimensions.			Sectional area.	First crack.	Ultimate strength.	
	Height.	Compressed surface.				Total.	Per square inch.
	Inches.	*Inches.*	*Inches.*	*Sq. inches.*	*Pounds.*	*Pounds.*	*Pounds.*
7823..	2.00	2.03	2.03	4.12	24,800	24,800	6,019
7824..	2.00	2.04	2.02	4.12	21,700	21,820	5,296
7825..	2.00	2.01	2.02	4.06	27,510	27,510	6,776
7826..	2.00	2.01	2.00	4.02	27,440	27,440	6,826
7827..	1.99	2.03	2.02	4.10	24,550	24,550	5,988
7828..	2.00	2.02	2.02	4.08	24,980	24,980	6,123

Pyramidal fractures.

MINNESOTA.

Production fell from a valuation of \$202,900 in 1896 to \$158,057 in 1897.

The following is an analysis of the sandstone known as Kettle River sandstone, quarried by the Minnesota Sandstone Company at their quarries at Sandstone, Minnesota, by Prof. N. H. Winchell:

Analysis of sandstone from Sandstone, Minn.

	Per cent.
Water	0.00
Silica, SiO_2	98.69
Alumina, Al_2O_3	1.06
Iron oxide	Slight trace.
Calcium oxide, CaO	.42
Magnesium oxide, MgO	.01
Sodium oxide, Na_2O	.17
Total	100.35

The following test of crushing strength was made at one of the United States arsenals:

Crushing-strength test of sandstone quarried by Minnesota Sandstone Company.

[Four inch cubes.]

No.	Total pressure.	Pressure per square inch.
	Pounds.	*Pounds.*
1	204,100	12,295
2	109,900	12,799

MISSOURI.

The value of the output in 1896 was $51,144; in 1897, $57,583. When the general business interests of the country have again reached normal conditions production will probably increase.

NEW JERSEY.

The value of the output in 1896 was $126,534; that of the product in 1897 was $190,976. An increase in output is evident, and the industry seems to be on a more substantial basis than for several years.

NEW YORK.

The sandstone industry in New York State is of special interest on account of the fine quality of the stone taken from a number of its prominent quarries. The stone is well known to builders and experts. The output of 1896 was valued at $223,175, while that of 1897 amounted in value to $544,514.

The increase in output is due in some degree to the use of stone in repairs and changes in the Erie Canal.

The following is an analysis of the sandstone quarried by Mr. L. W. Hotchkiss at his quarries at Lewiston, Niagara County, made by Messrs. Stillwell and Gladdig, chemists, of New York City:

Analysis of sandstone from Lewiston, Niagara County, New York.

	Per cent.
Silica, SiO_2	98.6
Oxide of iron, Fe_2O_3	0.6
Total	99.2

The following test of the stone quarried by the Genesee Valley Blue Stone Company at their quarries at Portage, New York, was made at the Watertown Arsenal by Maj. F. H. Parker:

Tests of stone from Portage, New York.

[Compression faces dressed, sides rough.]

Specimen did not have parallel compression faces; and required 0.08-inch packing under one corner to secure even bearings in testing machines.

Sectional area, 5.04 square inches.

At 502,000 pounds stone began to crack at one corner. Gradual opening of cracks along two edges after passing the above load.

Ultimate strength, 711,100 pounds = 14,110 pounds per square inch.

Burst suddenly into fragments under the maximum load. One principal piece pyramidal shaped.

The following tests of bluestone quarried by the Warsaw Bluestone Company at their quarries at Warsaw, New York, were made by Lieut. Col. D. W. Flagler at the Watertown Arsenal:

Tests of bluestone from Warsaw, New York.

[Stones tested on bed.]

Test No.	Weight.			Dimensions.			Sectional area.	First crack.	Ultimate strength.	
	Total.		Per cubic foot.	Height.	Compressed surface.				Total.	Per square inch.
	Lbs.	*Oz.*	*Pounds.*	*Inches.*	*Inches.*	*Inches.*	*Sq. in.*	*Pounds.*	*Pounds.*	*Pounds.*
6648	11	7½	158.2	5.01	5.00	5.00	25.00	499,200	499,200	19,968
6649	11	6	157.3	5.00	5.00	5.00	25.00	476,900	476,900	19,076
6650	11	7½	157.3	5.01	5.02	5.01	25.15	478,400	478,400	19,022

Pyramidal fractures; stones burst into fragments when the maximum load was reached.

NORTH CAROLINA.

The output of sandstone in 1897 was valued at $11,500. This is slightly below the value of the product of 1896.

OHIO.

The sandstone industry in Ohio is a large and important one. The value of the output in 1892 was $3,300,000; since that year, however, owing to the general depression in business, this high figure has not again been reached. The value of the output in 1897 was $1,600,058.

The stone is used for a wide range of purposes, including building, flagging, curbing, grindstones, whetstones, etc.

The following is the statement of an analysis of the sandstone quarried by Messrs. Reynolds Brothers, at their quarries at Freeport, Ohio, by Mr. Charles D. Rawling, chemist, of Wheeling, West Virginia:

Analysis of Freeport, Ohio, sandstone.

	Per cent.
Dried at 100° C.	
Silica, SiO_2	95.17
Alumina, Al_2O_3	.73
Ferric oxide, Fe_2O_3	2.53
Lime, CaO	.36
Magnesia, MgO	Trace.
Loss on ignition	1.17
Total	99.96
Water absorbed	6.08

The following tests of sandstone quarried by Mr. F. C. Neeb at his quarries at Lancaster, Fairfield County, were made by Mr. M. J. Becker, chief engineer of the Pittsburg, Cincinnati, Chicago and St. Louis Railroad:

Six inch cubes were tested.

Tests of sandstone from Lancaster, Ohio.

No. of test.	Dimensions.			Sectional area.	Ultimate strength.	
	Height.	Compressed surface.			Total.	Per square inch.
	Inches.	*Inches.*	*Inches.*	*Sq. in.*	*Pounds.*	*Pounds.*
1	5.9	6	5.9	35.4	210,600	5,950
2	5.8	5.85	5.85	34.22	231,400	6,762

The following analyses of the same stone were made by Mr. Hugo Blanck, chemist, of Pittsburg, Pennsylvania:

Analyses of sandstone from Lancaster, Ohio.

	Yellow (No. I).	Pale (No. II).
	Per cent.	*Per cent.*
Silica, SiO_2	96.822	97.762
Alumina, Al_2O_3	.505	.731
Oxide of iron	.670	.510
Lime, CaO	.040	.122
Magnesia, MgO	.005	.003
Water, H_2O	1.281	.511
Total	99.323	99.639

OREGON.

This State produced sandstone to the value of \$35,000 in 1892, but since that time little has been done. The value of the output in 1897 was very small.

The following is a statement of the results of analysis and physical test of sandstone quarried by the Victor Sandstone Company at their quarries at Chitwood, Lincoln County, by Maj. J. W. Reilly at the Watertown Arsenal:

Analysis of Chitwood (Oregon) sandstone.

	Per cent.
Silica, SiO_2	72.45
Oxide of iron	10.80
Alumina, Al_2O_3	12.60
Lime, CaO	4.10
Magnesia, MgO	Trace.
Total	99.95

Compression test.

Sectional area, 4.03×4.20×6.07=24.46 square inches.
First crack at 145,000 pounds.
Ultimate strength, 153,700=6,284 pounds per square inch; pyramidal fracture.

PENNSYLVANIA.

The value of the sandstone output in 1896 was \$446,926; the corresponding figure for 1897 was \$380,813. A full account of the sandstone of Pennsylvania was published in the report for 1896.

The following is an analysis of sandstone quarried by Mr. Webster Keasey at his quarries at Rough Run, Pennsylvania, by Mr. James O. Handy, chemist, of Pittsburg, Pennsylvania:

Analysis of Rough Run sandstone.

	Per cent.
Silica, SiO_2	97.96
Alumina, Al_2O_3	1.15
Ferric oxide, Fe_2O_3	.11
Water and organic matter	.54
Alkalies	.24
Total	100.00

The following analysis of stone quarried by the Edge Hill Mica Schist Company, of Edge Hill, Pennsylvania, was made by the chemical department of the Pennsylvania Steel Company, of Steelton, Pennsylvania:

Analysis of sandstone from Edge Hill, Pennsylvania.

	Per cent.
Silica, SiO_2	89.00
Alumina, Cl_2O_3	6.83
Ferric oxide, Fe_2O_3	2.21
Lime, CaO	0.07
Magnesia, MgO	0.16
Alkalies (oxides of sodium and potassium)	1.73
Total	100.00

SOUTH DAKOTA.

Very little sandstone was quarried during 1897.

The following tests of sandstone quarried by the Baker Quarry Company, at their quarries at Rapid City, were made by Mr. William F. M. Goss, at Purdue University:

Tests of sandstone from Rapid City, South Dakota.

Kind of stone.	Area.	Total crushing strength.	Strength per square inch.
	Sq. in.	*Pounds.*	*Pounds.*
Gray	4.42	50,618	11,452
White	4.40	31,030	7,052
Red	4.14	25,320	6,116
Buff	4.34	39,220	9,037
Variegated	4.14	36,855	8,902
Brown	4.43	25,825	5,829

TENNESSEE.

Almost nothing was done in sandstone quarrying during the past year.

TEXAS.

The value of the sandstone output of 1897 was about the same as in 1896; for 1897 the value was $30,030.

UTAH.

A small output was secured during the year. The following tests of crushing strength were made at the testing laboratory of the University of Illinois.

Tests of sandstone from Utah.

[Two-inch cubes tested.]

Kind of stone.	Area.	Total stress.	Crushing strength per square inch.
	Sq. in.	*Pounds.*	*Pounds.*
Gray	4	16,800	4,200
Red	4	34,550	8,638

VIRGINIA.

Very little sandstone was quarried in 1897.

WASHINGTON.

Production increased from $11,090 in 1896 to $16,187 in 1897.

The following tests of sandstone, known as Bellingham Bay stone, from quaries known as Chuckanut quarries, operated by Mr. Henry Roeder, of Chuckanut, Washington, were made by Maj. J. W. Reilly, of Watertown Arsenal:

Tests of sandstone from Chuckanut, Washington.

[Compressed surfaces faced with plaster of paris to secure even bearings in the testing machine.]

Test No.	Dimensions.			Sectional area.	First crack.	Untimate strength.	
	Height.	Compressed surface.				Total.	Per sq. in.
	Inches.	*Inches.*	*Inches.*	*Sq. in.*	*Pounds.*	*Pounds.*	*Pounds.*
7178	3.99	4.22	4.20	17.72	179,000	182,100	10,276
7179	4.09	4.13	4.20	17.35	183,000	221,900	12,790
7180	4.20	4.21	4.23	17.81	192,000	197,700	10,780

WEST VIRGINIA.

Production increased from a valuation of $24,693 in 1896 to $47,288 in 1897. Business is generally reported as improving throughout the State.

WISCONSIN.

The value of the output in 1896 was $65,017; in 1897, $33,620.

The following analysis of the sandstone quarried by the Prentice Brownstone Company at their quarries at Ashland, Wisconsin, was made by Prof. C. F. Chandler, of Columbia University, New York City:

Analysis of sandstone quarried by Prentice Brownstone Company, Ashland, Wisconsin.

	Per cent.
Silica, SiO_2	91.40
Ferric oxide, Fe_2O_3	2.00
Alumina, Al_2O_3	3.53
Lime, CaO	.25
Magnesia, MgO	None.
Potash, K_2O	2.36
Soda, Na_2O	.14
Sulphur	None.
Carbon dioxide, CO_2	None.
Moisture	.05
Total	99.73

WYOMING.

Production fell off from $16,465 in 1896 to $11,275 in 1897.

The crushing strength of Rawlins gray sandstone is reported from a Government test to be 10,833 pounds to the square inch.

LIMESTONE.

PRODUCTION.

The following table shows the production of limestone in the United States in 1897. The total valuation, $14,822,661, exceeds that of 1896 by $1,800,024. This is a very substantial gain, but in view of the increase which has marked the production of other kinds of stone it is not at all surprising and is a very satisfactory indication of returning prosperity in stone production:

Production of limestone in 1897, by States.

State.	Lime.	Building and roadmaking.	Flux.	Total.
Alabama	$157,842	$25,752	$38,217	$221,811
Arizona	11,522			11,522
Arkansas	30,890	13,332		44,222
California	277,104	17,894	13,927	308,925
Colorado	11,970	2,971	64,315	79,256
Connecticut	177,702		708	178,410
Florida	16,636	2,253		18,889
Georgia	27,000		5,000	32,000

Production of limestone in 1897, by States—Continued.

State.	Lime.	Building and roadmaking.	Flux.	Total.
Idaho	$12,760	$2,778		$15,538
Illinois	228,220	1,213,291	$41,646	1,483,157
Indiana	173,750	1,716,461	122,397	2,012,608
Iowa	104,163	376,409		480,572
Kansas	8,971	199,918		208,889
Kentucky	6,583	27,943	6,289	40,815
Maine	742,877			742,877
Maryland	182,441	16,924		199,365
Massachusetts	113,809	11,726	973	126,508
Michigan	145,280	67,534	2,363	215,177
Minnesota	61,187	175,210		236,397
Missouri	404,885	605,445	7,872	1,018,202
Montana	12,750		24,550	37,300
Nebraska	400	21,446	20,513	42,359
New Jersey	108,195	2,170	31,281	141,646
New York	555,050	1,074,214	68,516	1,697,780
Ohio	877,167	462,209	147,174	1,486,550
Pennsylvania	1,038,723	580,383	708,764	2,327,870
Rhode Island	11,555			11,555
South Carolina	30,000			30,000
South Dakota	1,895	2,000		3,895
Tennessee	76,037	35,609	2,128	113,774
Texas	21,862	14,816	20,580	57,258
Utah	3,877	116	5,257	9,250
Vermont	164,960	697		165,657
Virginia	101,424	27,852	63,696	192,972
Washington	122,317		4,560	126,877
West Virginia	57,328	3,183	1,035	61,546
Wisconsin	311,355	328,759	1,118	641,232
Total	6,390,487	7,029,295	1,402,879	14,822,661

The following table shows the value of limestone, by States, since 1890:

Value of limestone, by States, from 1890 to 1897.

State.	1890.	1891.	1892.	1893.
Alabama	$324, 814	$300, 000	$325, 000	$205, 000
Arizona	(a)	....	....	15, 000
Arkansas	18, 360	20, 000	18, 000	7, 611
California	516, 780	400, 000	400, 000	288, 626
Colorado	138, 091	90, 000	100, 000	60, 000
Connecticut	131, 697	100, 000	95, 000	155, 000
Florida	(a)	....	....	35, 000
Georgia	(a)	....	....	34, 500
Idaho	28, 545	....	5, 000	1, 000
Illinois	2, 190, 607	2, 030, 000	3, 185, 000	2, 305, 000
Indiana	1, 889, 336	2, 100, 000	1, 800, 000	1, 474, 695
Iowa	530, 863	400, 000	705, 000	547, 000
Kansas	478, 822	300, 000	310, 000	175, 173
Kentucky	303, 314	250, 000	275, 000	203, 000
Maine	1, 523, 499	1, 200, 000	1, 600, 000	1, 175, 000
Maryland	164, 860	150, 000	200, 000	....
Massachusetts	119, 978	100, 000	200, 000	156, 528
Michigan	85, 952	75, 000	95, 000	53, 282
Minnesota	613, 247	600, 000	600, 000	208, 088
Missouri	1, 859, 960	1, 400, 000	1, 400, 000	861, 563
Montana	24, 964	....	6, 000	4, 100
Nebraska	207, 019	175, 000	180, 000	158, 927
New Jersey	129, 662	100, 000	180, 000	149, 416
New Mexico	3, 862	2, 000	5, 000	....
New York	1, 708, 830	1, 200, 000	1, 200, 000	1, 103, 529
Ohio	1, 514, 934	1, 250, 000	2, 025, 000	1, 848, 063
Oregon	(a)	....	....	15, 100
Pennsylvania	2, 655, 477	2, 100, 000	1, 900, 000	1, 552, 336
Rhode Island	27, 625	25, 000	30, 000	24, 800
South Carolina	14, 520	50, 000	50, 000	22, 070
South Dakota	(a)	....	....	100
Tennessee	73, 028	70, 000	20, 000	126, 089
Texas	217, 835	175, 000	180, 000	28, 100
Utah	27, 568	....	8, 000	17, 446
Vermont	195, 066	175, 000	200, 000	151, 067
Virginia	159, 023	170, 000	185, 000	82, 685
Washington	231, 287	25, 000	100, 000	139, 862
West Virginia	93, 856	85, 000	85, 000	19, 184
Wisconsin	813, 963	675, 000	675, 000	543, 283
Wyoming	(a)	....	....	....
Total	19, 095, 179	15, 792, 000	18, 342, 000	13, 947, 223

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

Value of limestone, by States, from 1890 to 1897—Continued.

State.	1894.	1895.	1896.	1897.
Alabama	$210, 269	$222, 424	$180, 921	$221, 811
Arizona	19, 810	24, 159	18, 470	11, 522
Arkansas	38, 228	47, 376	30, 708	44, 222
California	288, 900	322, 211	143, 865	308, 925
Colorado	132, 170	116, 355	65, 063	79, 256
Connecticut	204, 414	154, 333	138, 945	178, 410
Florida	30, 639	10, 550	16, 982	18, 889
Georgia	32, 000	12, 000	29, 081	32, 000
Idaho	5, 315	7, 829	5, 662	15, 538
Illinois	2, 555, 952	1, 687, 662	1, 261, 359	1, 483, 157
Indiana	1, 203, 108	1, 658, 976	1, 658, 499	2, 012, 608
Iowa	616, 630	449, 501	410, 037	480, 572
Kansas	241, 039	316, 688	158, 112	208, 889
Kentucky	113, 934	154, 130	135, 967	40, 815
Maine	810, 089	700, 000	608, 077	742, 877
Maryland	350, 000	200, 000	264, 278	199, 365
Massachusetts	195, 982	75, 000	118, 622	126, 508
Michigan	336, 287	424, 589	109, 427	215, 177
Minnesota	291, 263	218, 733	228, 992	236, 397
Missouri	578, 802	897, 318	802, 968	1, 018, 202
Montana	92, 970	95, 121	83, 927	37, 300
Nebraska	8, 228	7, 376	10, 655	42, 359
New Jersey	193, 523	150, 000	134, 213	141, 646
New Mexico	4, 910	3, 375	....	....
New York	1, 378, 851	1, 043, 182	1, 591, 966	1, 697, 780
Ohio	1, 733, 477	1, 568, 713	1, 399, 412	1, 486, 550
Oregon	....	970	1, 600	....
Pennsylvania	2, 625, 562	3, 055, 913	2, 104, 774	2, 327, 870
Rhode Island	20, 433	....	11, 589	11, 555
South Carolina	25, 100	....	26, 000	30, 000
South Dakota	3, 663	4, 000	3, 126	3, 895
Tennessee	188, 664	156, 898	157, 176	113, 774
Texas	41, 526	62, 526	77, 252	57, 258
Utah	23, 696	22, 503	9, 358	9, 250
Vermont	408, 810	300, 000	147, 138	165, 657
Virginia	284, 517	268, 892	182, 640	192, 972
Washington	59, 148	75, 910	83, 742	126, 877
West Virginia	43, 773	42, 892	59, 113	61, 546
Wisconsin	798, 406	750, 000	552, 921	641, 232
Wyoming	....	650	....	....
Total	16, 190, 118	15, 308, 755	13, 022, 637	14, 822, 661

THE LIMESTONE INDUSTRY IN INDIVIDUAL STATES.

The following is a consideration of the limestone industry in the various productive States:

ALABAMA.

Production increased from a value of $180,921 in 1896 to $221,811 in 1897. The increase was due to a greater production of lime and of flux for blast furnaces. The amount used for building and road making declined.

The following analysis of lime made from limestone quarried by the Longview Lime Works at their quarries at Longview, Alabama, was made by Mr. William C. Stubbs, Director of the Louisiana Sugar Experiment Station, of New Orleans:

Analysis of lime from Longview, Alabama.

	Per cent.
Insoluble matter	0.18
Lime, CaO	98.44
Magnesia, MgO	.98
Peroxide of iron } Alumina }	.26
Carbonic acid, Co_2	.32
Total	100.18

Dr. W. B. Phillips, chemist, of Birmingham, Alabama, reports that the limestone quarried by Mr. A. P. Birch, of Blount Springs, contains 99.10 per cent of calcium carbonate and less than 0.5 per cent of silica, the remainder being oxides of iron and alumina.

Mr. Alfred D. Brainerd, chemist, of Birmingham, Alabama, made the following analysis of lime from stone quarried by the Standard Lime Company at their quarries at Fort Payne, Alabama:

Analysis of lime from Fort Payne, Alabama.

	Per cent.
Lime, CaO	96.1128
Silica, SiO_2	1.6900
Magnesia, MgO	.1058
Phosphorus	.0554
Phosphoric acid, P_2O_5	.0126
Sulphur	.0192
Sulphuric acid, SO_3	.0048
Binoxide manganese	Trace.
Undetermined and water	1.9994
Total	100.0000

The following table represents the analyses of a number of Alabama limestones:

Analyses of limestone quarried in Alabama.

Name of firm quarrying stone.	Location of quarry.		Name and address of analyst.	Substances determined.									Total.
	Town.	County.		Calcium carbonate, $CaCO_3$.	Magnesium carbonate, $MgCO_3$.	Oxides of iron and aluminum.	Siliceous matter insoluble in acids.	Calcium oxide, CaO.	Magnesium oxide, MgO.	Silica, SiO_2.	Carbon dioxide, CO_2.	Ferric oxide, Fe_2O_3.	
				Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Anniston Lime Works Co.	Anniston..	Etowah	Wm. Makemson, Anniston, Ala.	98.76	Trace	0.36	......	......	......	0.74	......	......	99.86
Longview Lime Works (No. 1).	Longview.	Shelby	Eugene A. Smith, State geologist.	99.11	0.75	0.13	0.39	......	......	......	......	......	100.38
Longview Lime Works (No. 2).	.....do	.....do	.....do	99.16	0.75	Trace	0.15	......	......	......	......	......	100.06
Longview Lime Works (lime).	.....do	.....do	A. L. Metz, chemist Louisiana State Board of Health.	1.55	0.56	0.21	0.37	97.30	......	......	......	......	99.99
Franklin Quarry Co.	Russellville.	Franklin	J. C. Foster...........	97.00	1.40	0.70	......	......	......	0.90	......	......	100.00
T. L. Fossick & Co.	Sheffield ..	.....do	Chemist of Watertown Arsenal, Nov. 20, 1895.	......	......	......	......	54.20	1.23	0.50	42.61	1.45	99.99
Shelby Iron Co...	Shelby	Shelby	C. F. Chandler, of New York.	98.91	0.58	0.63	......	......	......	0.10	......	......	100.22

ARIZONA.

There was a slight falling off in production in 1897, but it is hardly significant, as the industry in this State is as yet small at best.

ARKANSAS.

Production increased from $30,708 in 1896 to $44,222 in 1897.

The following analysis of the stone quarried by Mr. Mark Liles, at his quarries at Beaver, was made at the Navy Department at Washington, D. C.:

Analysis of limestone from Beaver, Arkansas.

	Per cent.
Silica, SiO_2	8.66
Oxides of iron and aluminum	4.77
Calcium carbonate, $CaCO_3$	48.48
Magnesium carbonate, $MgCO_3$	33.58
Calcium sulphate, $CaSO_4$	.42
Water alkalies, etc	4.09
Total	100.00

The following analysis of stone quarried by the Crescent White Lime Works, at their quarries at Johnson, was made by Prof. G. L. Teller, of the Arkansas Industrial Institute, at Fayetteville:

Analysis of limestone from Johnson, Arkansas.

	Per cent.
Material insoluble in acid	0.39
Oxides of iron and aluminum	.17
Calcium carbonate, $CaCO_3$	99.34
Moisture	.10
Total	100.00

The crushing strength was found to be 15,500 pounds to the square inch, by Professor Martin, of the same institution.

CALIFORNIA.

A decided increase in output marks 1897 as compared with 1896 in California. The value of the product in the former year was $143,865; in 1897 it was $308,925. Stone production all over the State has very materially improved during the past year.

COLORADO.

The value of the output in 1896 was $65,063; the figure for 1897 was $79,256. A slight increase is evident.

CONNECTICUT.

Production increased from a valuation of $138,945 in 1896 to $178,410 in 1897. Practically all the product was burned into lime, of which the above figures represent the value.

The following is an analysis of limestone quarried by Messrs. Canfield Brothers, of East Canaan, made at the Connecticut Agricultural Experiment Station:

Analysis of limestone from East Canaan, Connecticut.

	Per cent.
Matter insoluble in acid	0.48
Oxides of iron and aluminum	.20
Lime, CaO	31.31
Magnesia, MgO	21.03
Carbon dioxide, CO_2	46.98
Total	100.00

FLORIDA.

This State produced very little or no stone of any kind except coquina until a few years ago. In 1896 the value of the limestone output was $16,982; in 1897 $18,889.

GEORGIA.

Production increased somewhat in 1897, the value for this year being $32,000. The following analyses of limestone quarried by the A. C. Ladd Lime Works at their quarries at Bartow, and of the lime made from it, were made by Mr. N. P. Pratt, formerly State Mineralogist:

Analysis of lime from Bartow, Georgia.

	Per cent.
Lime, CaO	34.070
Magnesia, MgO	55.736
Alumina and iron oxide	1.236
Silica, SiO_2	7.252
Moisture	1.622
Total	99.916

Analysis of limestone from Bartow, Georgia.

	Per cent.
Calcium carbonate, $CaCO_3$	56.02
Magnesium carbonate, $MgCO_3$	38.43
Alumina and iron oxide	1.50
Silica, SiO_2	1.94
Moisture	0.00
Total	97.89

IDAHO.

Production increased from a valuation of $5,662 in 1896 to $15,538 in 1897.

ILLINOIS.

The limestone industry in Illinois has always been a large and important one. A few years ago the State stood first in output of limestone for building, but in 1896 and 1897 Indiana has taken first place. Most of the limestone produced in Illinois goes for building purposes. Full accounts of the quarrying operations at the Lemont and Joliet quarries have been given in former reports. The value of the product in 1897 was $1,483,157; in 1896 the corresponding figure was $1,261,359.

The following is a partial analysis of the stone quarried by the Kankakee Stone and Lime Company at their quarries at Kankakee, made by Mr. C. S. Robinson, chemist of Illinois Steel Company:

Analysis of limestone from Kankakee, Illinois.

	Per cent.
Silica, SiO_2	3.00
Oxides of iron and aluminum	2.50
Calcium oxide, CaO	30.45
Magnesium oxide, MgO	20.50
Phosphorus	.006

The following data in regard to the same stone were secured by Prof. C. W. Rolfe, of the Illinois State University, at Champaign:

Weight per cubic foot, 165.75 pounds; specific gravity, 2.65; crushing strength, 13,544 pounds to the square inch.

The following analysis of the limestone quarried by the Chicago Union Lime Works Company at their quarries in the limits of the city of Chicago was made by Mr. J. Blodget Britton, of the Ironmasters' Laboratory, of Warrenton, Virginia:

Analysis of Illinois limestone.

	Per cent.
Calcium carbonate, $CaCo_3$	52.76
Magnesium carbonate, $MgCo_3$	45.04
Oxides of iron and aluminum	1.48
Insoluble matter	.21
Water and loss	.51
Total	100.00

INDIANA.

The value of the limestone output in Indiana reached the highest figure since 1891, when it was very little more than that for the past year, for which the value was $2,012,608. Of course the Bedford oölitic limestone contributes the bulk of this output. The oölitic stone of Bedford was fully described, together with a consideration of methods of quarrying, occurrence, etc., in the report of 1896 by Messrs. T. C. Hopkins and C. E. Siebenthal. The latter gentleman has also contributed further information, which is presented further on in this report.

The crushing strength of the stone quarried by the Hollensbee Stone Company at their quarry at Westport, Indiana, was determined by General Q. A. Gillmore, U. S. A., and found to be 16,875 pounds per square inch.

A test was also made by General Gillmore of stone quarried by the Greensburg Limestone Company, at their quarry at Greensburg, Indiana, by which the average crushing strength of two 2-inch cubes was found to be 16,875 pounds per square inch.

Tests made by Mr. W. S. Blatchley, Indiana State geologist, of limestone from the quarries of the Acme Bedford Stone Company, at Clear Creek, Indiana, showed a crushing strength of specimen on natural bed of 11,770 pounds per square inch, and a crushing strength of specimen on edge of 10,119 pounds per square inch.

An analysis of this stone will be found in the following table of analyses of Indiana limestones.

Analyses of limestone quarried in Indiana.

Name of firm quarrying stone.	Location of quarry.		Name and address of analyst.	Substances determined.																		
	Town.	County.		Calcium carbonate, $CaCO_3$.	Magnesium carbonate, $MgCO_3$.	Oxides of iron and aluminum.	Silica, SiO_2.	Ferric oxide, Fe_2O_3.	Aluminum oxide, Al_2O_3.	Calcium oxide, CaO.	Magnesium oxide, MgO.	Moisture and loss at 212° F.	Carbon dioxide, CO_2.	Loss and undetermined.	Siliceous matter insoluble in acids.	Ferrous oxide, FeO.	Sulphuric anhydride, SO_3.	Sulphur, S.	Oxides of potassium and sodium.	Sodium oxide, Na_2O.	Manganese oxide.	Total.
				P. c.	*P. c.*	*P. c.*	*P. c.*	*P. c.*	*P. c.*	*P. c.*	*P. c.*	*P. c.*	*P. c.*	*P. c.*	*P. c.*	*P. c.*	*P. c.*	*P. c.*	*P. c.*	*P. c.*	*P. c.*	*P. c.*
Acme Bedford Stone Co.	Clear Creek.	Monroe	W. S. Blatchley, State geologist.	97.39	0.78	0.13									0.84					0.10	Trace	99.24
Bedford Quarries Co.	Bedford	Lawrence	F. W. Clarke, chief chemist United States Geological Survey.	97.20			1.69	0.49			0.37	0.19										100
Bedford Portland Cement Co. (No. 1).	do	do	Prof. A. W. Smith, Case School of Applied Science, Cleveland, Ohio.				0.89	0.12	0.38	54.48	0.36		43.40			0.13						99.76
Bedford Portland Cement Co. (No. 2).	do	do	do				0.87	0.13	0.34	54.68	0.32		43.44									99.78
Baltes Land, Stone and Oil Co. (top rock).	Montpelier	Blackford	S. S. Gorby, State geologist.			4.70	2.75			42.92	3.88	0.95	41.20	2.81			0.79					100
Baltes Land, Stone and Oil Co. (intermediate rock).	do	do	do			5.25	2.68			42.55	4.40	1.25	39.10	3.68			1.09					100
Baltes Land, Stone and Oil Co. (bottom rock).	do	do	do			5.17	2.43			43.01	4.18	1.60	41.55	1.78			0.88					100
Huntington White Lime Co.	Huntington.	Huntington.	G. M. Lovette, Indianapolis, Ind.			4.70	2.75			42.92	4.41	0.95	41.20	1.82			1.25					100
Defenbaugh & Smith (No. 1)	Kokomo	Howard	Grasselli Chemical Co.	98.66			0.24	Trace.	0.43		Trace.											99.33

Defenbaugh & Smith (No. 2).	.....do	.....do	.....do	97.05	.....	.....	1.62	0.16	0.60	.....	0.36	.....	.....	.....	.....	.....	.....	Trace.	.....	.....	.....	99.79
J. A. Derbyshire.	Laurel......	Franklin ...	Prof. W. A. Noyes, Rose Polytechnic Institute, Terre Haute, Ind.	43.67	20.60	11.01	21.51	.....	.....	.....	.....	1.39	.....	.....	.....	.....	.....	.....	1.55	.....	.....	99.73
Romona Oolitic Stone Co.	Romona	Owen........	.....do	.....	.....	0.18	.....	.....	.....	54.82	0.31	.....	43.49	.....	1.26	.....	.....	.....	.....	.....	.....	100.06
Peru Stone and Lime Co.	Peru........	Miami	J. N. Hurtz, Indianapolis, Ind.	52.90	38.94	.....	4.05	1.20	1.25	.....	.....	2.63	.....	.....	.....	.....	.....	.....	.....	.....	.....	100.97
S. Casparis	Kenneth....	Cass........	S. S. Gorby, State geologist.	93.48	.....	2.07	1.33	.....	.....	.....	1.16	1.57	.....	0.39	.....	.....	.....	.....	.....	.....	.....	100

THE BEDFORD OÖLITIC LIMESTONE.

By C. E. Siebenthal.

Occurrence.—The Bedford limestone occurs as a massive stratum, varying from a few feet to nearly 100 feet in thickness, intercalated near the middle of the Lower Carboniferous limestone of Indiana. Its labyrinthine outcrop has been traced in detail through an extent of over 60 miles through Owen, Monroe, and Lawrence counties. To the south of this area extensive deposits of good stone are known to occur in Washington, Harrison, and Crawford counties, and though the exact limits of these deposits remain to be traced the stone is undoubtedly continuous southward from Lawrence County to the Ohio River. The stratum is massive, often without an interruption from top to bottom, and the size of the blocks which may be quarried is limited only by the capacity of the quarry machinery and transportation facilities.

Physical character.—The Bedford limestone is essentially a freestone in that it works nearly equally well in all directions. This fact is due to its semiorganic, semiclastic nature. In places its true oölitic character shows its organic origin, while in others the oölites are entirely wanting and the local cross bedding and granular structure betray its clastic origin. The size of the grains varies in different parts of the oölitic area and in different horizons at any one locality. Scattered over the whole oölitic area are local developments of the limestone in which the granules are very small, with remarkable uniformity and homogeneity. This constitutes the so-called "No 1 stone," which just now has the call of the market. The coarser varieties, though quite as durable and easily worked, and as handsome when erected, are comparatively neglected.

Color.—The original color of the oölitic stone in all cases varied from a light to a rather deep blue. On the outcrops and along the vertical clay seams, where the stone has been exposed to the leaching action of terrestrial water impregnated with organic acids, the stone has been changed to a buff. The bluer the stone was originally the more pronounced the buff after leaching. The lighter varieties of the unbleached stone can scarcely be told from the bleached stone of the same variety. It is a peculiar fact that the freshly quarried blue stone does not bleach on exposure to the air, but turns a deeper blue—that is to say, the outer surface does, but beneath this thin coat the stone has a pronounced reddish cast as far down as it has been affected. It is for this reason that buildings built of the blue stone do not become buff in course of time, as would be expected.

Both the "buff" and the "blue" stone are marketed, though the mixed buff and blue is almost a dead loss. At present the demand is strongest for the former color. A few years ago the preference was for the blue stone, and in a few years is likely to be so again. While the buff stone is necessarily confined to that zone which has been subjected to the leaching action of terrestrial water and is thus limited in quantity, the blue stone, on the contrary, extends back as far as the ledge reaches, and the accessible amount is limited only by excessive stripping. It may be remarked in passing that heavy stripping, or rather rock stripping, has been found to be not so disadvantageous as was formerly supposed. The expense of stripping in all cases must be distributed between the channel cuts of salable stone below, and the more channel cuts of such stone the larger the profit on each. Rock stripping means that the expense is to be borne by the full thickness of the oölitic stratum. Furthermore, a rock stripping generally acts as a roof, keeping the oölitic stone below free from percolating waters and thus diminishing the loss from mixed stone and from clay seams.

It is to be presumed that the blue stone, not having been subject to leaching and weathering, is the stronger and more durable stone, but no tests have been made which bear on the question other than the tests of actual experience in buildings, and the facts in regard to such are not sufficient to warrant a conclusion.

Crushing strength.—Formerly great crushing strength was the first desideratum in a building stone, but in these days of steel skeleton construction a more moderate crushing strength is required and more stress is laid on pleasing color, ease of working, and homogeneity of texture. Many compression tests have been made upon the Bedford limestone, in both the green and seasoned states, and with sawed and tool-dressed specimens. The results vary widely, as might be expected. A series of tests recently made under uniform conditions gave an average of 7,000 pounds per square inch for 2-inch sawed cubes, with a maximum of 13,200 pounds. It is a well known fact that the crushing strength increases with increase in the size of the specimen tested. The large masonary blocks are able to stand a much greater pressure per square inch than the 2-inch cubes used in making the tests. The result of the tests shows a very ample margin over what the stone is called upon to bear in the lower masonary courses of the tallest buildings.

Refractoriness.—A series of experiments on 1-inch cubes were made to determine the fire resisting qualities of the Bedford limestone. Heated to 1,000° F. and plunged in cold water, the cubes were not affected. Heated to 1,200° F. and plunged in cold water, the cube crumbled slightly along the lower edges. Heated to 1,500° F. and cooled in air, the cubes retained their forms intact but were calcined in a marked degree. This shows that the stone will withstand the effects of fire up to the point of calcination.

Chemical composition.—The Bedford limestone is a nearly absolutely pure limestone of remarkably uniform composition. Lime carbonate constitutes on the average 97 per cent of the whole, varying in different samples from 95 per cent to 98 per cent. It thus equals in point of purity the French Caen limestone, and surpasses the English Portland oölitic limestone, the former of which contains 97.60 per cent of lime carbonate and the latter 95.16 per cent. It is excelled in purity by the purest marbles only.

Durability.—Since no structure built of Bedford stone is known of greater age than 60 years, we must estimate its durability from the well-known durability of pure limestone and the ability of the Bedford stone to withstand sudden extremes of heat and cold as shown by the fire tests above.

The effects of weathering exhibited by buildings 60 years of age are inconsiderable.

THE QUARRY DISTRICTS.

The quarries of the oölitic belt naturally group themselves into the following districts: Romona, Owen County; Stinesville, Ellettsville, Bloomington, and Sanders, Monroe County; and Bluff Ridge, Dark Hollow, and Bedford, Lawrence County.

Romona district.—This, the most northerly of the quarry districts, is in Owen County at Romona Station, on the Indianapolis and Vincennes division of the Pittsburg, Cincinnati and Chicago Railroad.

First and last a number of quarries have been in operation here, though at present but 3 are equipped with machinery, and but 1 was in operation in 1897.

The equipment in this district is as follows: 10 channelers, 7 saw gangs, 3 planes, 1 lathe, and the necessary travelers, derricks, steam drills, etc.

Stinesville district.—The first quarries to be operated on a business-like scale in the oölitic limestone belt were on Big Creek, 1 mile west of Stinesville. These were opened in 1854 by the firm of Biddle, Watts & Co., of Pittsburg, Pennsylvania A quarry is still in operation on the site of the old quarry. Ten quarries have been opened in this district, of which 7 are now equipped with machinery, though but 2 were in operation in 1897. The equipment of the district is 18 channelers, 21 saw gangs, 3 planers, 2 lathes, etc.

Ellettsville district.—This also was one of the early regions to be developed. In all, 9 quarries have been opened, of which 3 were still in operation in 1897. The equipment consists of 3 channelers and 16 saw gangs.

Bloomington district.—The quarries of the district are located in Hunter Valley, which lies 2 miles northeast of the city of Bloomington. The region has been only recently developed, the first quarry being opened in 1890. Nine quarries have been opened, of which 7 were still in operation in 1897. The equipment shows 28 channelers and 22 saw gangs.

Sanders district.—This district includes the quarries in the vicinity of Sanders station, on the Chicago, Indianapolis & Louisville Railway (Monon route), and has been developed since 1888. Eight quarries have been opened, in all of which, with one exception, the machinery is still in place, though but 4 were in operation in 1897. The equipment is 20 channelers, 10 saw gangs, etc.

Buff Ridge district.—This district lies about the village of Oolitic, Lawrence County. It is the most productive district of the oölitic area, producing in 1897 nearly one-half of the entire output of Bedford oölitic stone. Out of 10 quarries which have been opened, 7 are still in operation, though but 5 were active in 1897. The equipment is as follows: 50 channelers, 20 saw gangs, 6 planes, and 1 lathe.

Dark Hollow district.—This was one of the first districts to be opened up in a large way and has contributed very largely to establish the reputation of the Bedford stone. In all, 6 quarries have been opened, of which 3 were in operation in 1897. The equipment consists of 15 channelers, 6 saw gangs, drills, etc.

Bedford and vicinity.—The remainder of the quarries in Lawrence County are grouped more or less closely about Bedford. Sixteen quarries have been opened in this region, of which 10 are still in operation, though but 3 were active in 1897. The equipment consists of 20 channelers, 44 saw gangs, 7 planers, and 7 lathes.

PRICES.

At the beginning of the industrial depression in 1893 the price of Bedford stone was 20 cents per cubic foot in scabbled blocks, free on board cars at the quarry. This price was maintained by general agreement until 1895, since which time prices have fallen nearly one-half. The price of mill blocks to-day runs from 10 cents to 20 cents per cubic foot, with the larger amount of sales much nearer the former figure than the latter. The price for the season just past seems to have recovered to a certain extent, as an inspection of the figures below will show that, while the production has fallen off slightly from 1896, the value of the same shows a gain on that of the former year. A noticeable feature of the year just past has been the remodeling and enlarging of stone sawmills and the erection of new ones. Almost one-half of the product for the year was worked up in home mills. This may account in part for the apparent advance in price noted above.

Production and value of Bedford oölitic limestone from 1894 to 1897, inclusive.

	Quantity.	Value.
1894.	*Cubic feet.*	
Monroe and Owen counties	2,176,246	$576,962
Lawrence County	2,404,172	577,284
Total	4,580,418	1,154,246
1895.		
Monroe and Owen counties	2,337,716	751,792
Lawrence County	3,030,591	771,468
Total	5,368,307	1,523,260

Production and value of Bedford oölitic limestone from 1894 to 1897, inclusive—Cont'd.

	Quantity.	Value.
1896.	*Cubic feet.*	
Monroe and Owen counties	2,016,926	$483,749
Lawrence County	3,438,656	725,883
Total	5,455,582	1,209,632
1897.		
Monroe and Owen counties	1,792,586	502,748
Lawrence County	3,590,303	841,410
Total	5,382,889	1,344,158

IOWA.

The value of the limestone output in 1896 was $410,037; in 1897 the corresponding figure was $480,572. The quarries of Iowa are in general small, but the aggregate makes an industry of considerable magnitude.

KANSAS.

Better conditions have prevailed in the stone business of this State in 1897, as the value of the output increased from $158,112 in 1896 to $208,889 in 1897. Most of the producers speak in much more cheerful vein than for some years past.

KENTUCKY.

Business was not so good in 1897, for which year the output was valued at $40,815, considerably less than for 1896. However, during the latter part of the past year indications were decidedly better.

MAINE.

A few years ago, and notably in 1892, the production of limestone at Rockland and vicinity was an industry of much greater magnitude than at present. The decline has been simply on account of hard times, and judging from gains made during the past year the old status will be regained before long. The output for the State in 1896 was valued at $608,077, and for 1897 at $742,877. Practically all of the value represents the lime made at and near Rockland, which has made a national reputation for the quality and abundance of pure limestone there found.

The following analysis of limestone quarried by Mr. George W. Bachelder at his quarries at Union, Maine, was made by Mr. F. C. Robinson, of Brunswick, Maine:

Analysis of limestone from Union, Maine.

	Per cent.
Calcium carbonate, $CaCO_3$	95.20
Magnesium carbonate, $MgCO_3$	1.00
Silica, SiO_2	1.00
Water	2.70
Iron	Trace.
Total	99.90

The following analysis of limestone quarried by the McLoon and Stover Lime Company at their quarries at Warren, Maine, was made by Mr. S. P. Sharples, State Assayer, Boston, Massachusetts:

Analysis of limestone from Warren, Maine.

	Per cent.
Moisture	0.40
Silica, SiO_2	0.95
Magnesium carbonate, $MgCO_3$	45.13
Calcium carbonate, $CaCO_3$	53.52
Total	100.00

MARYLAND.

In Maryland, as in a few other States, the limestone industry seems to be lagging behind somewhat in the return to prosperity, as the value of the product of 1896 exceeds that of 1897; but conditions in the early part of 1898 were undoubtedly better, judging from the statements made by some of the leading producers. A large amount of oyster-shell lime is made in Maryland, and this competes with the limestone quarrying.

The following analysis of the limestone quarried by Mr. George M. Busbey at his quarry at Cavetown, Maryland, was made by Messrs. Lehman and Glaser, of Baltimore, Maryland:

Analysis of limestone from Cavetown, Maryland.

	Per cent.
Silica, SiO_2	0.47
Lime, CaO	55.51
Loss on ignition	44.02
Total	100.00

MASSACHUSETTS.

The value of the product in 1896 was $118,622; in 1897, $126,508. A slight gain is evident. The most abundant stone in Massachusetts is granite, and limestone quarrying has never been prominent.

The following analysis of lime made from limestone quarried by Messrs. Hutchinson Brothers, at their quarry at New Lenox, Massachusetts, was made by Mr. W. M. Habirshaw, chemist, New York State Agricultural Society:

Analysis of limestone from New Lenox, Massachusetts.

	Per cent.
Lime, CaO	95.66
Magnesia, MgO	.76
Oxide of iron and aluminum	.17
Silica, SiO_2	1.14
Loss on ignition	3.00
Total	100.73

MICHIGAN.

The value of the output in 1896 was $109,427; in 1897, $215,177, or nearly twice the figure for the former year. Business was in every way better than in 1896. Most of the product is burned into lime.

MINNESOTA.

There was an increase from $228,992 in 1896 to $236,397 in 1897, a difference not large enough, however, to have much significance.

MISSOURI.

The limestone industry of Missouri is one of considerable importance. While the value of the output is still considerably below that of 1890, it is an increase over the figure for 1896, for which year the output was valued at $802,968; while in 1897 the valuation was $1,018,202. The product is about equally divided between building and burning into lime.

The following is a table of analyses of various Missouri limestones:

Analyses of limestone quarried in Missouri.

Name of firm quarrying stone.	Location of quarry.		Name and address of analyst.	Substances determined.	
	Town.	County.		Calcium carbonate, $CaCO_3$.	Magnesium carbonate, $MgCO_3$.
				P. ct.	*P. ct.*
Marble Head Lime Co	Springfield	Greene	R. Chauvenet & Bro., St. Louis, Mo.	99.46	....
Hannibal Lime Co	Hannibal	Marion	do	98.80	....
Star Lime Co	do	Ralls	do	99.64	0.21
Glencoe Lime and Cement Co	Glencoe	St. Louis	do	98.36	....
Ashgrove White Lime Association.	Ashgrove	Greene	Chas. W. Eoff	99.82	....

Name of firm quarrying stone.	Substances determined.									
	Oxides of iron and aluminum.	Iron oxide.	Aluminum oxide, Al_2O_3.	Silica, SiO_2.	Magnesium oxide, MgO.	Siliceous matter insoluble in acids.	Manganese oxide.	Phosphorus anhydride, P_2O_5.	Sulphuric anhydride, SO_3.	Total.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Marble Head Lime Co	......	0.21	......	0.33	....	......	......	......	......	100.00
Hannibal Lime Co	0.40	......	......	0.08	0.02	......	......	......	......	99.30
Star Lime Co	......	......	......	....	....	0.15	......	......	......	100.00
Glencoe Lime and Cement Co.	0.68	......	......	....	0.26	0.70	......	......	......	100.00
Ashgrove White Lime Association.	......	0.01	0.05	0.12	Trace.	......	Trace.	None.	Trace	100.00

MONTANA.

Production fell off from a valuation of $83,927 in 1896 to $37,300 in 1897. Prosperity has not yet made its appearance in this State, judging from the expressions of producers and the fact that nearly all report a diminished output.

NEBRASKA.

Limestone quarrying has never amounted to much in this State, but a large advance was made in 1897, when the product was valued at $42,359, about four times the figure for 1896.

NEW JERSEY.

In 1896 a valuation of $134,213, and in 1897 that of $141,646, show that better conditions have prevailed during the past year.

The following analysis of limestone quarried by the estate of E. Weise, at Vernon, New Jersey, was made by Mr. H. B. Weaver, chemist:

Analysis of limestone from Vernon, New Jersey.

	Per cent.
Calcium carbonate, $CaCO_3$	52.450
Magnesium carbonate, $MgCO_3$	43.250
Iron oxide	1.340
Alumina, Al_2O_3	.545
Phosphorus, P	.035
Silica, SiO_2	2.280
Total	99.900

NEW YORK.

This State produces in greater or less quantity every kind of stone known to the trade. Its limestone output increased from a value of $1,591,966 in 1896 to $1,697,780 in 1897. About two-thirds of the product is used for building and road making, while the remainder is nearly all burnt into lime.

The following is a table of analyses of New York limestones:

Analyses of limestone quarried in New York.

Name of firm quarrying stone.	Location.		Name and address of analyst.	Substances determined.															
	Town.	County.		Calcium carbonate, $CaCO_3$.	Magnesium carbonate, $MgCO_3$.	Oxides of iron and aluminum.	Siliceous matter insoluble in acids.	Calcium oxide, CaO.	Magnesium oxide, MgO.	Carbon dioxide, CO_2.	Aluminum oxide, Al_2O_3.	Ferric oxide, Fe_2O_3.	Sulphur, S.	Phosphoric anhydride, P_2O_5.	Phosphorus, P.	Sulphuric anhydride, SO_3.	Undetermined matter and loss.	Silica, SiO_2.	Total.
				P.c.	*P.c.*	*P.c.*	*P.c.*	*P.c.*	*P.c.*	*P.c.*	*P.c.*	*P.c.*	*P.c.*	*P.c.*	*P.c.*	*P.c.*	*P.c.*	*P.c.*	*P.c.*
D. C. Hewitt (upper stratum).	Amsterdam.	Montgomery	J. M. Sherrerd, chemist, Troy Steel and Iron Co.	......	....	3.00	....	52.78	None.	.....	....	....	....	......	....	......	a42.97	1.25	100.00
D. C. Hewitt (intermediate stratum).	.....do	.....do	.....do	......	....	1.08	....	52.46	None.	.....	....	....	....	......	....	......	a42.64	3.82	100.00
D. C. Hewitt (lower stratum).	.....do	.....do	.....do	......	....	2.76	....	52.12	None.	.....	....	....	....	......	....	......	a39.44	5.68	100.00
D. R. & H. Fogelsonger.	Williamsville.	Erie	Hugo Carlson, chemist, Johnson County, Johnstown, Pa.	96.54	1.90	0.64	....	......	......	.....	....	....	0.10	......	0.01	......	......	1.17	99.46
Howes Cave Association.	Howes Cave	Schoharie...	Prof. Chas. A. Chaeffer, president Iowa State University.	97.24	1.39	0.73	....	......	......	.....	....	....	....	None.	....	Trace.	......	1.27	100.63
Ossining Lime Co....	Ossining....	Westchester	Ledoux Chemical Laboratory.	....	....	0.23	0.20	30.04	22.28	47.14	....	....	....	......	....	......	......	....	99.89
ANALYSES OF LIME MADE FROM LIMESTONE QUARRIED IN NEW YORK.																			
Robinson and Ferris	Mechanicsville.	Washington	M. L. Griffin, Mechanicsville, N. Y.	......	....	....	....	97.64	0.80	.....	1.01	0.25	....	......	....	......	......	0.23	99.66
E. B. Alvord & Co....	Jamesville..	Onondaga ..	F. E. Englehardt, Ph. D., Syracuse, N. Y.	......	....	2.03	1.88	91.93	3.06	.....	....	....	....	......	....	0.73	......	....	99.63
Chazy Marble Lime Co	Chazy	Clinton	Enrique Touceda, Troy, N. Y.	......	....	....	....	97.08	1.40	.....	0.14	0.12	....	......	....	......	......	0.79	99.53

a Chiefly carbon dioxide, CO_2.

OHIO.

The stone output of Ohio is divided between sandstone and limestone, both of which are quarried in large amounts. The value of the limestone product in 1896 was $1,399,412; in 1897, $1,486,550. The product is used for lime burning to the extent of nearly two-thirds, while something like one-third is divided between building, road making, and blast-furnace flux.

The following is a table of analyses of Ohio limestones:

Analyses of limestone quarried in Ohio.

Name of firm quarrying stone.	Location of quarry.		Name and address of analyst.	Substances determined.							Total.
	Town.	County.		Calcium carbonate, $CaCO_3$.	Magnesium carbonate, $MgCO_3$.	Oxides of iron and aluminum.	Siliceous matter insoluble in acids.	Phosphoric anhydride, P_2O_5.	Phosphorus, P.	Silica, SiO_2.	
				Per cent.	*Per cent.*	*Per ct.*	*Per cent.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per cent.*
Snowflake Lime Co......	Bowling Green.	Wood	Edward Orton, State Geologist.	53.88	44.91	0.40	0.30	......	......	......	99.49
M. Daum & Son.........	Carey	Wyandot....	.....do	56.40	41.99	0.31	0.48	......	......	......	99.18
T. J. Price & Co	Columbus ...	Franklin....	.....do	94.80	1.21	0.80	3.20	......	......	......	100.01
D. P. Lloyd & Co	Fostoria	Wood	.....do	52.00	45.26	2.70	Trace.	......	......	......	99.96
N. E. Gregg & Co	Genoa.......	Ottawa	.....do	54.30	45.14	0.16	0.23	......	......	......	99.83
Casparis Stone Co	Cold Springs	Clark	Ellis Lovejoy, Columbus, Ohio.	54.05	44.94	0.23	0.49	......	......	......	99.71
Casparis Stone Co	Columbus ...	Franklin	Cleveland Rolling Mills chemist.	93.21	4.70	1.74	....	......	......	......	99.65
Norris & Christian Lime and Stone Co.	Marion......	Marion......	.....do	86.22	9.27	2.30	2.86	......	0.11	......	100.76
N. B. Eddy.............	Luckey	Wood	G. A. Kirchmaier, Toledo, Ohio.	54.10	44.90	0.36	....	......	......	0.45	99.81
Duncan & Bussard	Williston ...	Ottawa	.....do	53.90	44.82	0.21	....	0.001	......	0.21	99.141
Ohlemacher Lime Co	Sandusky ...	Erie	Edward Orton..........	89.08	8.34	0.35	1.51	......	......	......	99.28
J. Kingham	Rockyridge .	Ottawa	.....do	54.10	44.27	0.29	0.87	......	......	......	99.53
Sugar Ridge Lime and Stone Co.	Sugarridge..	Wood	.....do	55.23	43.12	0.69	0.84	......	......	......	99.88

PENNSYLVANIA.

Numerous comparatively small producers of limestone in this State aggregate annually a large output. This, in 1896, was valued at $2,104,774, and in 1897 at $2,327,870. A little less than half of the product was burned into lime, which is extensively used as a fertilizer, while the remainder was divided between blast-furnace flux, building, and road making. The amount devoted to blast-furnace flux increased quite decidedly in 1897.

The following is a table of analyses of Pennsylvania limestones:

Analyses of limestone quarried in Pennsylvania.

Name of firm quarrying stone.	Location of quarry.		Name and address of analyst.	Calcium carbonate, $CaCO_3$.	Magnesium carbonate, $MgCO_3$.	Oxides of iron and aluminium.	Calcium oxide, CaO.	Magnesium oxide, MgO.	Ferric oxide, Fe_2O_3.	Aluminium oxide, Al_2O_3.	Siliceous matter insoluble in acids.	Silica, SiO_2.	Loss on ignition.	Phosphoric anhydride, P_2O_5.	Potassium oxide, K_2O.	Phosphorus, P.	Sulphur, S.	Total.
	Town.	County.																
				P. ct.	*P. ct.*	*P. c.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. c.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. c.*	*P. c.*	*P. ct.*	*P. ct.*	*Per ct.*
Carbon Limestone Co	Youngstown	Lawrence	S. W. McKeown	96.43	0.40	1.60						1.50				0.02	0.08	100.03
Steary & Co.	Wrightsville	York	A. S. McCreath, Harrisburg, Pa.	54.26	44.51	.66						.56						99.99
R. McCoy Lime Co.	Bridgeport	Montgomery	Chas. I. Reader	55.70	41.97	.72						1.58						99.97
Chickies Iron Co.	Chickies	Lancaster	Chickies Iron Co. chemist	51.00	48.49					0.31		.36						100.16
James Copeland	Downingtown.	Chester	Jas. H. Eastewick, Germantown, Pa.	54.15	45.20				0.37									99.72
Abraham K. Stauffer.	Esterly	Berks	Chas. T. Davies	55.58	39.21	1.22					3.89							99.90
Wm. H. Gelbach	Fairfield	Adams	Franklin Menger, Ph. D.	85.23	2.78	1.50						10.90	0.19					100.00
Geo. W. Musselman	do	do	do	86.91	3.11				.60			8.85		0.12	0.38			99.97
Geo. W. Bachman	Freemansburg.	Northampton.	Irwin A. Bachman, Ph. D., Allentown, Pa.	89.09	5.16				.32	1.61		2.18						98.36
J. King McLanahan, jr.	Frankstown	Blair	Chemist of Shoenberger Steel Co.			1.00	54.90	None.				1.06	43.80					100.76
Wm. B. Rambo (quarry No. 1).	Norristown	Montgomery	Booth, Garrett & Blair, Philadelphia, Pa.	53.49	45.76				.45		.20							99.90
Wm. B. Rambo (quarry No. 2).	do	do	do	54.04	45.51				.20		.25							100.00
Jas. B. Smith (No. 1).	Reedsville	Mifflin	R. Kent, Burnham, Pa.	95.75	2.03	1.36						1.69				.002		100.832
Jas. B. Smith (No. 2).	do	do	do	96.24	2.86	.61						.33				.002		100.042
Jno. C. Fisher	Richland Station	Lebanon	A. S. McCreath, Harrisburg, Pa.	99.02	.67	.19						.07				.003		99.953
Listie Mining Co	Listie	Somerset	Chemist of W. Dewees Wood Co., McKeesport, Pa.	92.12	2.35	2.00					3.53					.02		100.02
Winfield Mineral Co.	West Winfield.	Butler	Chemist of Pennsylvania Salt Mfg. Co., Natrona, Pa.	95.10	1.12	1.00					2.78							100.00
ANALYSES OF LIME MADE FROM LIMESTONE QUARRIED IN PENNSYLVANIA.																		
Jno. Yeager	Dalmatia	Northumberland.	Dr. Wm. Frear, State Chemist.			6.80	81.38	1.34			2.43		7.05	0.35	0.65			100.00
R. McCoy Lime Co.	Bridgeport	Montgomery	Chas. I. Reader			1.35	58.33	37.37				2.95						100.00

RHODE ISLAND.

Very little limestone is produced in this State. It is all used for burning into lime.

SOUTH CAROLINA.

Thirty thousand dollars' worth of lime was manufactured from limestone quarried in the State during 1897. This output is slightly greater than that of 1896.

SOUTH DAKOTA.

Only about $4,000 worth of stone, used mainly for building, was quarried in 1897.

TENNESSEE.

The limestone product in 1897 was valued at $113,774. This figure is somewhat less than the value for 1896. Most of this represents the value of lime made.

TEXAS.

Production of limestone and lime fell off somewhat in 1897, when the product was valued at $57,258. The product is about equally divided between lime and blast-furnace flux.

The following analysis of limestone quarried by Mr. D. R. Boone, at his quarry at Oglesby, Texas, was made by Prof. H. H. Harrington, of the Agricultural and Mechanical College and Experiment Station, of Texas:

Analysis of lime from Oglesby, Texas.

	Per cent.
Silicious matter	1.09
Organic matter	.52
Iron oxide	.35
Calcium oxide, CaO	54.02
Magnesium oxide, MgO	.12
Sulphur trioxide, SO_3	.17
Carbon dioxide, CO_2	43.96
Total	100.23

UTAH.

About $10,000 worth of lime and limestone for flux was yielded in 1897. The output has never been large.

VERMONT.

Production increased from $147,138 in 1896 to $165,657 in 1897. All of the product is burned into lime.

The following analysis was made by Mr. S. P. Sharples, State Assayer for Massachusetts, of limestone quarried by Mr. L. H. Felton at his quarry at High Gate Springs, Vermont:

Analysis of limestone from High Gate Springs, Vermont.

	Per cent.
Calcium oxide, CaO	55.83
Magnesium oxide, MgO	Trace.
Oxides of iron and aluminum	.10
Silica, SiO_2	.40
Carbon dioxide, CO_2	43.65
Total	99.98

The following analysis was made by Prof. F. C. Robinson, of Bowdoin College, Brunswick, Maine, of lime made from limestone quarried by Mr. W. B. Fonda at his quarry at St. Albans, Vermont:

Analysis of lime from St. Albans, Vermont.

	Per cent.
Calcium oxide, CaO	99.23
Insoluble matter	.14
Alumina, Al_2O_3	Trace.
Iron	Trace.
Magnesium oxide, MgO	.60
Total	99.97

The following analysis was also made by Prof. F. C. Robinson of lime quarried and burned by Mr. John P. Rich at his quarry at Swanton, Vermont:

Analysis of lime from Swanton, Vermont.

	Per cent.
Calcium oxide, CaO	99.29
Magnesium oxide, MgO	.46
Ferrous oxide, FeO	.12
Silica, SiO_2	.10
Aluminum	Trace.
Manganese	Trace.
Total	99.97

VIRGINIA.

The value of the output in 1896 was $182,640; in 1897, $192,972. Most of the product is burned into lime.

The following analysis was made by Dr. Henry Froehling, Richmond, Virginia, of limestone quarried by the Moore Lime Company at their quarry at Eagle Rock, Virginia:

Analysis of limestone from Eagle Rock, Virginia.

	Per cent.
Calcium carbonate, $CaCO_3$	98.71
Magnesium carbonate, $MgCO_3$	.65
Oxides of iron and aluminum	.31
Silica, SiO_2	.25
Total	99.92

WASHINGTON.

Production increased from $83,742 in 1896 to $126,877 in 1897. Practically all of this value represents lime made.

WEST VIRGINIA.

Production in 1896 was valued at $59,113; the figure for 1897 was $61,546.

The following analysis was made by Mr. J. Blodget Britton, of Philadelphia, Pennsylvania, of limestone quarried by Mr. D. Y. Huddleston at his quarry at Snow Flake, Greenbrier County, West Virginia:

Analysis of limestone from Snow Flake, West Virginia.

	Per cent.
Calcium carbonate, $CaCO_3$	96.46
Magnesium carbonate, $MgCO_3$	1.11
Organic matter, loss on ignition	Trace.
Insoluble siliceous matter	.97
Sulphur	None.
Aluminum oxide, Al_2O_3	1.46
Phosphorus	None.
Total	100.00

WISCONSIN.

The limestone industry of this State is an important one and likely to become still more so as Western population increases. Most of the limestone quarried is converted into lime, which bears an excellent reputation to a greater than merely local extent.

The following analysis was made by Mr. George N. Prentiss, Milwaukee, Wisconsin, of limestone quarried by Messrs. Blair and Larson at their quarries at Lannon, Wisconsin:

Analysis of limestone from Lannon, Wisconsin.

	Per cent.
Calcium carbonate, $CaCO_3$	52.29
Magnesium carbonate, $MgCO_3$	42.27
Oxides of iron and aluminum	1.68
Silica, SiO_2	3.96
Total	100.20

The following analysis was made by Mr. Gustave Bode, Milwaukee, Wisconsin, of limestone quarried by the Ormsby Lime Company at their quarry at Brillion, Wisconsin:

Analysis of limestone from Brillion, Wisconsin.

	Per cent.
Calcium carbonate, $CaCO_3$	55.09
Magnesium carbonate, $MgCO_3$	43.96
Silica, SiO_2	.59
Aluminum oxide, Al_2O_3	.36
Total	100.00