PORTLAND, NATURAL, AND PUZZOLAN CEMENTS.

CEMENT RESOURCES OF THE CUMBERLAND GAP DISTRICT, TENNESSEE-VIRGINIA.

By Edwin C. Eckel.

General statement.—In January, 1906, a short time was spent in the examination of the cement resources of the Cumberland Gap district. Here, in Claiborne County, Tenn., and Lee County, Va., heavy beds of nonmagnesian limestone and shales are exposed along the southeastern flank of Cumberland Mountain. Near Cumberland Gap these beds are particularly well located from a cement manufacturer's point of view, being accessible to two railroads and within 9 miles of the important Middlesboro coal district. These advantages seemed to justify careful examination of the area and the present brief report summarizes the writer's conclusions in regard to the matter. It is a pleasure to acknowledge the courtesies extended by the officials of the American Association, the Virginia Iron, Coal, and Coke Company, the Louisville and Nashville Railroad, and the Southern Railway. Mr. J. H. Bartlett, of the American Association, furnished detailed maps of the district and some analyses of the limestones and shales, and also, by request, had several sections measured and platted by his engineers. Further analyses of the limestones, shales, and iron ores of the district were obtained from the manager and chemist of the Middlesboro plant of the Virginia Iron, Coal, and Coke Company.

Geology of the district.—The rocks of the district include Silurian, Devonian, and Carboniferous formations, dipping mostly to the northwest at angles of 15° to 35°. The section exposed in the district, from above downward, may be generalized as follows:

Geologic section near Cumberland Gap.

	Thickness in feet.
Coal Measures: Shales and sandstones with coal beds.	
Lee conglomerate: Massive sandstone and conglomerate	1,000-1,100
Pennington shale: Greenish shales and thin sandstone	50- 150
Newman limestone: Heavy-bedded blue and gray limestone	250- 400
Grainger shale: Gray to greenish shales	50- 125
Chattanooga shale: Black carbonaceous shales	150- 300
Rockwood formation: Shales and sandstones, with beds of red hematite	400- 700

Areal distribution of the formations.—Of the formations above tabulated, the Coal Measures outcrop only in the area northwest of Cumberland Mountain. The crest and northwest flank of this mountain are formed by the massive beds of the Lee conglomerate. Underlying the conglomerate, near the top of the southeastern flank of the mountain, is a relatively thin bed of the Pennington shale. Below this, and usually forming the middle part of the slope, are heavy beds of Newman (Lower Carboniferous) limestone. The Grainger and Chattanooga shales outcrop on the lower slopes of the mountain and in the valley (Poor Valley) at its foot; while the Rockwood beds commonly make up the Poor Valley Ridge just southeast of this valley.

Available limestone.—The Newman (Lower Carboniferous) formation in this district is a series of heavy-bedded blue to gray limestones, the entire section showing a thickness of 250 to 400 feet. Cherty beds occur at several horizons in this limestone, but the mass of the rock is fairly pure and low enough in magnesia to furnish a satisfactory raw material for Portland cement manufacture.

Analyses of limestone near Cumberland Gap, Tennessee.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Silica (SiO_2)	1.40	1.86	5.05	4.20	2.00	2.80	1.32	4.12	0.74	5.78
Alumina (Al_2O_3) Iron oxide (Fe_2O_3)	1.00	.96	1.86	1.50	1.00	.90	1.23	.42	.24	.46
Lime carbonate ($CaCO_3$)	94.57	94.85	90.05	89.54	94.57	91.72	95.62	87.10	95.50	90.90
Magnesium carbonate ($MgCO_3$)	3.03	2.33	3.04	4.76	2.50	4.58	1.32	3.30	2.79	1.46
Sulphur trioxide (SO_3)	n. d.	n. d.	n. d.	n. d.	n. d.	n. d.	.51	n. d.	n. d.	n. d.
Water	......	......	......	......	......	.....	......	2.21	.44	1.28

1-6. Analyses by W. Rosenfeld, chemist Virginia Iron, Coal, and Coke Company.
7. Analysis by L. F. Barnes.
8-10. Analyses by J. Sanderson, chemist Watts Iron and Steel Company.

Available shales.—The shales required for cement can be obtained from four different geologic groups—the Coal Measures, the Pennington shales, the Grainger shales, or the Chattanooga shales. Each of these formations is well exposed in this vicinity. The latter three outcrop along the southeastern flank of Cumberland Mountain and the shales of the Coal Measures outcrop in the Middlesboro basin northwest of that ridge. The shales will be briefly described in geologic order.

The Chattanooga (Devonian) shale formation is in this district 150 to 400 feet thick. It consists of brittle black carbonaceous shales or slates, often containing small percentages of pyrite. Some beds, therefore, contain too much sulphur to be entirely satisfactory as cement material, but the mass of the formation is good enough so far as its sulphur content is concerned. These shales are rarely sandy, and their silica percentage often falls so low that the following ratio is obtained:

$$\frac{\text{Silica}}{\text{Alumina+iron oxide}}=2.25$$

While material with this silica-alumina ratio can be used in cement manufacture, the shales next to be considered would seem more satisfactory.

The Grainger formation, lying above the Chattanooga shales and below the limestone, varies from 50 to 125 feet in thickness. It is composed of gray to greenish shales, siliceous enough on analysis, but with no coarse sandy beds. For this reason this shale is probably the most satisfactory as a cement material.

Analysis of Grainger shale, Cumberland Gap, Tennessee.

Silica (SiO_2)	74.00
Alumina (Al_2O_3)	13.50
Iron oxide (Fe_2O_3)	3.40
Lime carbonate ($CaCO_3$)	2.01
Magnesium carbonate ($MgCO_3$)	1.53

The above analysis was made in 1904 by J. G. Harding, of Wellston, Ohio, on a sample of shale taken a few feet below the limestone in the Morrison quarry. It is obviously a very satisfactory shale for use in Portland cement manufacture, owing to its composition, giving the following ratio:

$$\frac{\text{Silica}}{\text{Alumina+iron oxide}}=\frac{74.00}{16.90}=4.38$$

The Pennington shale formation, which overlies the limestone, is here from 50 to 150 feet thick. It consists of beds of greenish shales, with alternating thin layers of sandstone.

While it is probable that by careful grinding this material could be utilized for cement manufacture, it is not regarded as being so satisfactory as the Grainger shales, which underlie the limestone formation.

In the Coal Measures of the Middlesboro district, immediately west of Cumberland Mountain, shale beds occur at many localities. At the Harkness Brick Works, 8 miles northwest of Cumberland Gap, some of these Carboniferous shales have been utilized. Analyses of these shales, by A. H. Phillips, follow:

Analyses of Carboniferous shales used at Harkness Brick Works.

	1.	2.
Silica (SiO_2)	61.14	56.21
Alumina (Al_2O_3)	19.35	27.00
Iron oxide (Fe_2O_3)	5.89	2.74
Lime (CaO)	.93	.13
Magnesia (MgO)	1.87	.77
Potash (K_2O)	3.07	3.46
Soda (Na_2O)	1.54	1.58
Carbon dioxide (CO_2) / Combined water	5.86	7.67

CEMENT RESOURCES OF WASHINGTON.

By Henry Landes.

GENERAL STATEMENT.

A decade ago the amount of cement used in the State of Washington was less than 25,000 barrels annually. In 1905, 264,982 barrels of cement were imported into the Puget Sound district. These came chiefly from Germany and Belgium. In addition, about 150,000 barrels of cement manufactured in California were shipped to Washington. The increasing demand for cement has led to many inquiries in regard to the possibilities of its manufacture in Washington, and it is the purpose of this article to describe very briefly the more important districts, so far as known, where the raw materials are found in sufficient quantities to make such an industry profitable.

Limestone, the principal ingredient necessary in the manufacture of cement, is found only in the northern counties of the State from Puget Sound to the Idaho boundary, that is, in San Juan, Whatcom, Skagit, Snohomish, King, Okanogan, Ferry, and Stevens counties. Clays occur much more widely than the limestones, but in this article only those will be referred to which lie conveniently near limestone deposits. A brief account of the clays of the State was given by the writer in Bulletin No. 260, pages 550–558. In regard to fuel, Washington is well supplied with coal suitable for use in cement manufacture. In the counties west of the Cascade Mountains coal may be had at a very reasonable cost wherever cement is likely to be manufactured. In the counties of the northeastern portion of the State it will be found that the freight charges on coal will be a serious hindrance in the manufacture of cement.

In a discussion of the cement possibilities of Washington it seems best to take up the matter by counties, from the coast eastward.

SAN JUAN COUNTY.

In San Juan County the only deposits of limestones and clays worth considering are at tide water on San Juan and Orcas islands. The principal deposits on San Juan Island are at Roche Harbor, and are the property of the Tacoma and Roche Harbor Lime Company. The largest lime works on the Pacific coast are located at this point. This lime has an established reputation because of its purity. The limestone has been rendered entirely crystalline by metamorphism, and any fossils which it may have contained have been destroyed. The limestone is one of a series of metamorphic rocks which have been greatly contorted and faulted and its geological age has not been accurately determined. It is without doubt older than the Cretaceous rocks which form the bulk of the small neighboring islands a few miles to the north.

At Roche Harbor the limestone occurs as two large ledges with a strike a little east of north. In outcrop they extend from north to south about one-half mile and from east to west about 1,000 feet. The height of the limestone above tide water averages 200 feet; its depth below the ocean level has not been determined. The fact that the limestone is much broken and that but little stripping is required makes it possible to quarry the stone and deliver it to the crusher at a minimum expense. The quarry at this place has been in operation since 1882 and the manufacture of lime amounts to about 300,000 barrels per year. The limestone varies but little in composition and is very uniform in character.

Adjacent to the limestones there are large deposits of glacial sediments which contain extensive beds of clays interstratified with sands. Some of the clay beds are known to be at least 40 feet in thickness and they have been so thoroughly washed as to be unusually free from gritty ingredients. In case the clays do not afford enough silica for use in cement manufacture it may be easily obtained from the quartzites and slates that are near at hand as members of the metamorphic series of which the limestone is a part.

A cement plant built at Roche Harbor could be so arranged that the limestone at least might be transported to the mills by a gravity system. The final product could also be transported in the same manner to warehouses on the wharf. The harbor here is well protected and the water is sufficiently deep for ocean-going vessels to enter and depart at any tide.

Analyses of limestone, clay, slate, and quartzite from Roche Harbor, Washington.

	Limestone.			Clay.		Slate.	Quartzite.	
	1.	2.	3.	4.	5.	6.	7.	8.
Silica	0.44	0.27	0.20	55.81	56.35	78.0	72.32	84.84
Iron and aluminum oxides	1.13	.21	.30	26.28	24.62	6.98	10.11	6.78
Calcium carbonate	98.21	99.06	98.57	4.34	3.66	6.45	7.75	3.63
Magnesium carbonate		.46	1.02	3.39	2.58	1.56	2.24	.80
Sulphur				Trace.	.31	Trace.	.07	Trace.
Alkalies				3.98	3.94	1.56	1.11	Trace.
Moisture				6.11	7.52	.30	.45	
Carbonic acid						5.15	5.01	3.41

No. 1, made in 1888, by Moss Bay Hematite and Iron Company (Limited), Workington, England.
No. 2, made in 1893, by Puget Sound Reduction Company, Everett, Wash.
No. 3, made in 1902, by C. F. McKenna, New York City.
Nos. 5 to 8, made by F. C. Newton, Seattle, Wash.

On the northwest shore of Orcas Island there are several outcrops of limestone very similar in character and occurrence to those described at Roche Harbor, but of smaller extent. At several points quicklime has been made from time to time and the conditions for cement making are favorable. The limestone ledges lie far enough above the level of the water to make a gravity method feasible, and this could be followed at all stages of cement making from the quarry to the warehouse on the wharf. The water is very deep and large vessels may come very close inshore. As at Roche Harbor the limestone is entirely crystalline, and with its neighboring metamorphic rocks has suffered extreme folding, faulting, and other dislocations. Along the adjacent shores, conveniently near the outcrops of limestone, there are shales and beds of clay affording materials suitable for cement manufacture. Below are some analyses of limestones, shales, and clays from this location on Orcas Island, made by A. H. Cederberg:

Analyses of limestone, shale, and clay from Orcas Island, Washington.

	Limestone.		Shale.		Clay.	
	1.	2.	3.	4.	5.	6.
Silica	1.61	1.14	62.8	39.80	57.3	53.2
Iron and aluminum oxides	.04		19.2	21.62	21.4	23.9
Calcium carbonate	97.45	97.23	10.2	29.10	5.1	6.3
Magnesium carbonate		.31	.9	2.91	3.1	4.1
Sulphur	Trace.	Trace.		.41	.5	.8
Alkalies, etc	.51	1.21	Undet.	2.15	2.1	2.9

WHATCOM COUNTY.

In the vicinity of Kendall, on the line of the Bellingham Bay and British Columbia Railway, there are a number of deposits of limestone and clay which afford the proper materials for cement manufacture. The outcrops of limestone immediately south of the railway do not indicate large bodies, but north of the railway, at a point about 3 miles from Kendall, is a large ledge of this rock presenting a vertical face or cliff which may be seen for a distance of 2 or 3 miles. The limestone is entirely crystalline and all traces of fossils have been eliminated. This limestone, as in the case of the San Juan limestones, is a part of an extensive metamorphic series which has been greatly folded and crushed. As a result of the breaking up of the original bed of limestone on the one hand and of extensive erosion on the other the rock occurs in fragments or pockets and not in one continuous body. The amount of limestone here could be determined readily by means of the diamond drill, and this should be done before a cement plant is installed.

A few miles west of the limestone deposits and along the railroad track there are beds of glacial clay. One of these beds was explored by drilling to a depth of 50 feet. The clay is advantageously located and may be loaded on cars for transportation at a very small cost.

Analyses of limestone, clay, and slate from Kendall, Wash.

	Limestone.		Clay.		Slate.	
	1.	2.	3.	4.	5.	6.
Silica	1.52	1.37	61.27	57.06	66.01	72.69
Iron and aluminum oxides	.35	.42	25.30	26.80	17.65	22.19
Calcium carbonate	97.48	98.72	2.96	10.62	8.01	2.16
Magnesium carbonate	1.26	.26	4.68	1.13	3.15	2.47
Alkalies				2.56		

Nos. 1 and 3 made by D. W. Riedle, Montavilla, Oreg.
Nos. 2, 4, 5, and 6 made by A. H. Cederberg.

SKAGIT COUNTY.

Large deposits of limestone and clay, lying side by side, occur on the east side of Baker River about three-fourths of a mile from its junction with Skagit River. This point is 40 miles from the mouth of the Skagit, a stream which is navigable at nearly all times of the year. Transportation is also afforded by the Seattle and Northern division of the Great Northern Railway.

These deposits of limestone and clay have been purchased by the Washington Portland Cement Company and a plant for the manufacture of cement is now under construction. It is expected that the plant will be in operation by May 1, 1906. Two 100-foot rotary kilns, 7½ feet in diameter, are being installed. Rotary driers and coolers with both ball and tube mills will be used. It is planned to use oil as a fuel both in drying and in calcining. A flume nearly 3 miles in length has been constructed from Baker River to the plant, giving a head of 57 feet, capable of generating 3,000 horsepower. It is planned to manufacture from 700 to 800 barrels of cement daily at the outset. The plant has been so arranged that it can easily be enlarged to a daily capacity of 3,000 barrels.

The limestone is crystalline in character and almost pure white in color. It belongs to an extensive metamorphic series the geological age of which is undetermined. Slate lies adjacent to the limestone and the two have a strike a little west of north. The ledge of limestone dips to the southwest at an angle of about 55°. The outcrop is traceable along the strike for 600 feet and shows a width of 207 feet in cross section. The actual amount of limestone at this place is difficult to make out, because when followed along the strike it passes under a thick layer of mantle rock.

The clay lies in horizontal beds in contact with the limestone and represents silt brought down by Baker and Skagit rivers. It is well stratified and finely assorted and rests upon beds of gravel. It is light blue in color and has an average depth of 165 feet. It is exposed along Baker River for a distance of 1,350 feet.

Analyses of limestone and clay from the property of the Washington Portland Cement Company, Baker, Wash.

	Limestone.		Clay.	
	1	2	3	4
Silica	0.80	3.41	58.75	55.90
Iron and aluminum oxides	.70	1.78	25.94	25.50
Calcium carbonate	98.14	92.50	4.66	4.90
Magnesium carbonate	.65	2.30	4.47	2.83
Sulphur				.51
Alkalies			1.48	3.91
Combined water			4.60	6.45

Nos. 1 and 3 made by Prof. C. W. Johnson, Seattle, Wash.
Nos. 2 and 4 made by F. C. Newton, Seattle, Wash.

SNOHOMISH COUNTY.

Limestone occurs in a number of places in the eastern half of Snohomish County, but only at a point 3 miles east of Granite Falls, on the Everett and Monte Cristo Railway, has the rock been quarried to any extent. The stone is crystalline and is a member of an extensive metamorphic series extending in a broad belt north and south. The adjacent rocks are chiefly slates and schists. A quarry has been opened by the side of the railway track and the stone is loaded directly onto the cars. The quarry has been in operation for several years and the principal sales of rock have been made to the smelter and paper mill at Everett. A limekiln having a capacity of 100 barrels per day is in operation. The property is owned by the Canyon Lime and Cement Company. Some investigations have been made as to the possibilities for a cement factory here, but no active work has yet been done.

The following analyses were made by A. H. Cederberg:

Analyses of limestone, calcareous slate, and clay near Granite Falls, Wash.

	Limestone.	Calcareous slate.	Clay.
Silica	0.2	22.1	61.6
Iron and aluminum oxides	1.4	10.6	25.4
Calcium carbonate	98.1	59.6	7.2
Magnesium carbonate	Trace.	1.8	2.3
Sulphur		Trace.	1.6
Alkalies		1.4	2.94

KING COUNTY.

The metamorphic series of rocks occurring in Whatcom, Skagit, and Snohomish counties is continued into King County. In the vicinity of Snoqualmie Pass and at several points along the line of the Great Northern Railway, notably in the region about Baring, outcrops of crystalline limestone have been found. Very little work has been done looking to the development of any of the deposits and there is little information at hand concerning them.

So far as clay is concerned King County is particularly favored. Clays of excellent quality occur abundantly in the western part of the county, chiefly in connection with the Tertiary coal measures. At Renton, Taylor, and Kummer thick beds of shale are found interstratified with seams of coal. At all these points clay is mined for use in the manufacture of ornamental and paving bricks, terra cotta, sewer pipe, etc. So far as known deposits are concerned, the limestones and clays are too widely separated to make the manufacture of cement a profitable industry in this county. Further prospecting may reveal the presence of desirable beds of clay within or adjacent to the limestone areas.

OKANOGAN COUNTY.

In the northern portion of Okanogan County crystalline limestone has been discovered at many points in conjunction with slate, metamorphic sandstone, and conglomerate. The largest limestone areas are to the west and northwest of Riverside, where there are conspicuous cliffs of this rock with an areal distribution of several square miles. On the eastern slope of Palmer Mountain there are several bold outcrops of light-gray limestone which is only partially crystalline. Because of the difficulties in the way of transportation and the sparseness of population nothing has been done toward utilizing the limestone of this county. It is safe to assume that the neighboring argillaceous rocks could be used with the limestone in the manufacture of cement whenever a sufficient demand arises for this product in this part of the State.

FERRY COUNTY.

The geological formations of Ferry County are mainly metamorphic rocks, represented by limestones, slates, and quartzites, with many granite intrusions. Here and there small areas of sandstones and shales indicate the existence of lakes in Tertiary times. The largest limestone area is in the form of a long narrow belt which extends north and south across the country and which lies at the western foot of the granite divide separating Columbia and Kettle rivers from the streams to the west. A few miles west of Republic there is a large outcrop of a bluish limestone which is very compact and hard. A limekiln is in operation here and a high grade of quicklime is manufactured. Very near the crystalline limestone, clay and impure limestone occur, which may be utilized in cement manufacture.

The following analyses were made by A. H. Cederberg:

Analyses of crystalline limestone, impure limestone, and clay from Ferry County, Wash.

	Crystalline limestone.	Impure limestone.	Clay.
Silica	1.1	18.9	60.13
Iron and aluminum oxides	Trace.	7.2	29.10
Calcium carbonate	98.6	66.1	8.98
Magnesium carbonate	Trace.	4.5	1.36
Sulphur		Trace.	.75
Alkalies		2.1	.29

STEVENS COUNTY.

Stevens County contains very large deposits of materials necessary for cement manufacture, the only drawback being the high cost of fuel, as the latter is subject to a long transportation charge. The rocks of the county are chiefly metamorphic in character, consisting mainly of limestone or marble, slate, and quartzite. These have been greatly disturbed by folding as well as by intrusions of granite, basalt, and other igneous rocks. The limestones are usually entirely crystalline and at several places yield marble of excellent quality. The fossils they may have contained have been wholly destroyed except in one known instance, near Springdale, where the semicrystalline limestone contains coral remains which indicate its Paleozoic, probably Carboniferous, age. While these rocks are ordinarily known as limestones, many of them are really dolomites, and careful field work must be done and many analyses made in order to locate the true limestones and determine their extent.

The only place in Stevens County where active steps have been taken toward the manufacture of cement is at Box Canyon, on Pend Oreille River. It is planned to transport the cement by steamer up the river 45 miles to Newport, where the Great Northern Railway is reached. At Box Canyon there are large deposits of pure limestone and beds of excellent clay, as well as layers of natural cement rock interstratified with the pure limestone. The Pacific Portland Cement Company has acquired 262 acres of land and has expended $20,000 in preliminary work. A dam has been made across Cedar Creek about 3 miles above its confluence with the Pend Oreille at Box Canyon, and by the use of a flume and a 28-inch steel penstock with Pelton wheel about 250 horsepower is obtained. The works now under construction will have a daily capacity of 200 barrels. Analyses of the limestone and clay at Box Canyon are as follows:

Analyses of limestone and clay from Box Canyon, Washington.

	Limestone.	Clay.
Silica	1.60	64.1
Aluminum and iron oxides	Trace.	22.30
Calcium carbonate	98.50	1.69
Magnesium carbonate	Trace.	Trace.

In the vicinity of Colville, on the Spokane Falls and Northern Railway, there are some occurrences of limestone free from magnesium carbonate in harmful amounts. One of these occurrences is at a point 15 miles northeast of Colville, where the Jefferson Marble, Mining, and Milling Company has opened a quarry and established marble works. The limestone outcrops cover a broad area with extensive beds of glacial clays conveniently near. The limestone or marble exhibits many varieties of colors, from clear white through yellow, brown, and dark blue to black. The stone is fine grained and compact. Analyses of two varieties of marble, made by Prof. S. Shedd, of Pullman, are as follows:

Analyses of white and pink marble from quarry 15 miles northeast of Colville, Wash.

	White marble.	Pink marble.
Silica	0.87	3.49
Iron	None.	.24
Alumina	None.	None.
Lime	55.16	51.54
Magnesia	.21	1.11
Carbon dioxide	43.77	42.46

The property of the Keystone Marble Company lies near the locality last described, at a point 8½ miles east of Bossburg, a station on the Spokane Falls and Northern Railway. The marble outcrops over a considerable area and presents ample conveniences for quarrying. The stone exhibits great diversity in color, but on the whole approaches a pure calcium carbonate. Interstratified with the beds of marble are slates and quartzites. Analyses of two varieties of marble, made by Prof. S. Shedd, of Pullman, are as follows:

Analyses of white and gray marble from quarry 8½ miles east of Bossburg, Wash.

	White marble.	Gray marble.
Silica	0.98	0.82
Iron	Trace.	Trace.
Alumina	....	....
Lime	53.96	54.81
Magnesia	1.25	0.70
Carbon dioxide	43.76	43.56

In the vicinity of Ryan, a small station on the Spokane Falls and Northern Railway, there are many outcrops of marble. The stone makes conspicuous bluffs on both sides of Columbia River and is in an advantageous position for economical quarrying. The marble is fine grained, is mostly of a light-gray color, and is unusually hard. An analysis of the Ryan marble, made by Prof. S. Shedd, of Pullman, is as follows:

Analysis of marble from Ryan, Wash.

Silica	1.00
Iron and alumina	None.
Lime	53.96
Magnesia	1.60
Carbon dioxide	43.27

Independent of the clay represented in the slates noted as occurring in proximity to the limestones, there are many places in Stevens County where clays exist in large amounts. Some of the clays are of glacial origin, while others represent residual clays derived from granites. As a type of the latter the clays in the vicinity of Clayton may be mentioned. The numerous drill holes that have been made here show that the clay beds cover several thousand acres. There can be little question that both limestones and clays may be had in close relationships and at points convenient for transportation, so that in time Stevens County may become an important producer of cement.

SURVEY PUBLICATIONS ON PORTLAND, NATURAL, AND PUZZOLAN CEMENTS.

The following list includes the principal publications on cement materials by the United States Geological Survey, or by members of its staff:

ADAMS, G. I., and others. Economic geology of the Iola quadrangle, Kansas. Bulletin No. 238. 80 pp. 1904.

BASSLER, R. S. Cement materials of the Valley of Virginia. In Bulletin No. 260, pp. 531-544. 1905.

CATLETT, C. Cement resources of the Valley of Virginia. In Bulletin No. 225, pp. 457-461. 1904.

CLAPP, F. G. Limestones of southwestern Pennsylvania. Bulletin No. 249. 52 pp. 1905.

CRIDER, A. F. Cement resources of northeast Mississippi. In Bulletin No. 260, pp. 510-521. 1905.

CUMMINGS, U. American rock cement. A series of annual articles on natural cements, appearing in the volumes of the Mineral Resources U. S. previous to that for 1901.

DURYEE, E. Cement investigations in Arizona. In Bulletin No. 213, pp. 372-380. 1903.

ECKEL, E. C. Slag cement in Alabama. In Mineral Resources U. S. for 1900, pp. 747-748. 1901.

——— The manufacture of slag cement. In Mineral Industry, vol. 10, pp. 84-95. 1902.

——— The classification of the crystalline cements. In Am. Geologist, vol. 29, pp. 146-154. 1902.

——— Portland-cement manufacture. In Municipal Engineering, vol. 24, pp. 335-336; vol. 25, pp. 1-3, 75-76, 147-150, 227-230, 405-406. 1903.

——— The materials and manufacture of Portland cement. In Senate Doc. No. 19, 58th Cong., 1st sess., pp. 2-11. 1903.

——— Cement-rock deposits of the Lehigh district. In Bulletin No. 225, pp. 448-450. 1904.

——— Cement materials and cement industries of the United States. Bulletin No. 243. 395 pp. 1905.

——— The American cement industry. In Bulletin No. 260, pp. 496-505. 1905.

——— Portland-cement resources of New York. In Bulletin No. 260, pp. 522-530. 1905.

ECKEL, E. C., and CRIDER, A. F. Geology and cement resources of the Tombigbee River district, Mississippi-Alabama. Senate Doc. No. 165, 58th Cong., 3d sess. 21 pp. 1905.

KIMBALL, L. L. Cement. A series of annual articles on the cement industry and the production of cement in the United States. In Mineral Resources U. S. for 1901, 1902, 1903, and 1904.

NEWBERRY, S. B. Portland cement. A series of annual articles on Portland cements, appearing in the various volumes of the Mineral Resources U. S. previous to that for 1901.

RUSSELL, I. C. The Portland-cement industry in Michigan. In Twenty-second Ann. Rept., pt. 3, pp. 629-686. 1902.

SMITH, E. A. The Portland-cement materials of central and southern Alabama. In Senate Doc. No. 19, 58th Cong., 1st sess., pp. 12-23. 1903.

——— Cement resources of Alabama. In Bulletin No. 225, pp. 424-447. 1904.

TAFF, J. A. Chalk of southwestern Arkansas, with notes on its adaptability to the manufacture of hydraulic cements. In Twenty-second Ann. Rept., pt. 3, pp. 687-742. 1902.