LIME, MAGNESITE, ETC.

LIMESTONE AND DOLOMITE IN THE BIRMINGHAM DISTRICT, ALABAMA.

By Charles Butts.

INTRODUCTION.

Both limestone and dolomite are important from an economic standpoint in the Birmingham district. Limestone is used for lime and cement, and both limestone and dolomite are extensively utilized as flux in iron smelting. Indeed, this fluxing material is one of the three essential factors in the great industrial development of the Birmingham district, coal and iron, of course, being the other two. Along Birmingham Valley, from Bessemer to Trussville, ore, coal, and flux are to be had within a distance of 5 to 10 miles from each other, and it is due to the proximity of these three indispensable materials that profitable iron making from the comparatively low-grade ores of this region is possible. This paper is based on work done in the field by Chester W. Washburne, William F. Prouty, E. F. Burchard, E. M. Dawson, jr., and the writer. Other published reports have been freely drawn on for information, for which due acknowledgment is made in the proper place.

In this area there are three distinct limestone formations and one dolomite formation. These are the Bangor limestone, the Chickamauga ("Trenton") limestone, the Knox dolomite, and the Conasauga limestone, the highest being named first.

BANGOR LIMESTONE.

The Bangor limestone is of Carboniferous age and is named from Bangor, Ala., where it has been quarried. It is generally a semicrystalline, rather light-gray limestone, varying from a few feet to 300 feet or more in thickness.

This limestone outcrops along both sides of Blount Valley, from Reid station to Bangor and farther north, where it forms a considerable part of the valley walls, extending up nearly to the bottom of the sandstone that caps the sand ridges or mountains overlooking the valley. It dips into the hills at angles of 5° to 15°.

The limestone is thus favorably situated for quarrying, and it has been worked on a considerable scale at Blount Springs and Bangor. One quarry between these two places, belonging to W. F. Harrell, is now in operation. This quarry is an open working and the face is almost 80 feet high, extending nearly to the top of the outcrop on the escarpment. The following is a section of the rock quarried:

Section of Bangor limestone at Harrell quarry.

	Feet.
Gray semicrystalline limestone	28
Dark semicrystalline limestone	12
Gray semicrystalline limestone	40

The limestone beds are separated by thin partings of carbonaceous shale. Limestone from this quarry is used for flux in the furnaces at Birmingham and Bessemer.

Other quarries have been operated along the outcrop, both at Bangor and Blount Springs. The one at Blount Springs was operated by the Sloss-Sheffield Steel Company. The composition of the limestone from this quarry, which includes a thickness of 100 feet or more, is as follows:

Average of eight analyses of Bangor limestone from Blount Springs quarry. [a]

Silica (SiO_2)	1. 05
Iron oxide and alumina ($Fe_2O_3+Al_2O_3$)	. 82
Lime carbonate ($CaCO_3$)	96. 74
Magnesium carbonate ($MgCO_3$)	. 71
	99. 32

The Bangor limestone outcrops along the west side of Murphree Valley, and around the southern point of Blount Mountain, whence its outcrop extends along the valley of Canoe Creek to the neighborhood of Springville and beyond. At Dale is the quarry of the Republic Iron and Steel Company, of which the following is an approximate section:

Section of Bangor limestone at Dale quarry.

	Feet.
Limestone	20
Red shale	5
Green shale	5
Gray crystalline limestone	25
Dark limestone	30
White limestone	5
Shale	1
Clay	2
Gray limestone	60
	153

[a] Analyzed by Henry McCalley, J. L. Beeson, and J. R. Harris. Eckel, E. C., Cement materials and industry of the United States: Bull. U. S. Geol. Survey No. 243, 1905, p. 68.

In this quarry nearly the full face of the outcrop on the valley wall is quarried, the stone being used for flux. The beds dip into the hill at an angle of 15°. The limestone has been extensively quarried along this outcrop for some distance north of Dale, though all the workings except that at Dale have been abandoned. These abandoned workings suggest that the quarrymen continued operations to a point where it became necessary to remove too much cover and then moved to a new location. Below are analyses of the limestone in this locality:

Analyses of Bangor limestone from Compton quarry, north of Dale.[a]

	1.	2.	3.
Silica (SiO_2)	2.05	4.45	2.80
Iron oxide and alumina (Fe_2O_3+Al_2O_3)	.76	3.30	.70
Lime carbonate ($CaCO_3$)	89.64	86.35	94.59
Magnesium carbonate ($MgCO_3$)	8.15	....	....

[a] Eckel, E. C., loc. cit.

1. Average sample of 150 feet of rock used as flux. J. L. Beeson, analyst.
2 and 3. Stockhouse samples. W. B. Phillips, analyst.

These analyses show considerably more silica and magnesia in the limestone in this locality than at Blount Springs. Analysis No. 2, however, is the only one that shows an injurious amount of silica with a corresponding low percentage of lime carbonate.

The limestone outcropping around the south end of Blount Mountain and on Canoe Creek has never been utilized. The formation is exposed high up on the west face of the mountain east of Village Springs, where it must reach a thickness of 300 feet. The outcrop along the west side of Birmingham Valley has been traced southward to Sayreton Gap, near North Birmingham. The limestone thins toward the south, being at Boyles Gap 50 to 100 feet thick and at Sayreton Gap only a few feet. South of Sayreton Gap it has not been identified. In Shades Valley but little can be discovered of this limestone. The top of the formation outcrops just south of Trussville, where it has been quarried. Between Trussville and Argo is another small showing. Limestone is reported in wells at Trussville at a depth of 12 feet. Along Shades Valley south of Irondale only chert and shale were observed in outcrop, and although thin beds and lenses of limestone are known to occur in the generally sandy material of this part of the valley, the deposits can have no economic importance. A considerable thickness of chert shows along the valley south of Trussville, and it is probable that the Bangor limestone has been more or less replaced by shale and other siliceous matter along this belt, a change that becomes complete farther to the southeast in the Cahaba Valley, east of Leeds, where the limestone is practically absent, having been entirely replaced by shale.

CHICKAMAUGA ("TRENTON") LIMESTONE.

The Chickamauga limestone is of Ordovician or lower Silurian age. Its stratigraphic position is below the Rockwood (Clinton) formation, which carries the red ores of the region, and above the Knox chert. In Birmingham Valley this limestone outcrops along the west escarpment of Red Mountain almost the entire distance from a point south of Bessemer nearly to Springville and thence southward along the east side of Red Mountain nearly to Trussville. There are several gaps in this outcrop that are probably due to faults, but perhaps in some places to nondeposition of the limestone. One of these is on the west side of Red Mountain, 1 mile south of Saddlers Gap; another extends northward from Clay for 2 miles, and another about 3 miles in length is northeast of Ayres. The limestone appears to be absent along the west side of the Cahaba trough from a point 1 mile south of Argo northeastward to the boundary of the Birmingham quadrangle. It outcrops along the west side of Birmingham Valley and makes the east face of West Red Mountain from the vicinity of Cunningham Gap to Dale and thence, along the same belt, extends up Murphree Valley to Chepultepec and beyond. South of Cunningham Gap the outcrop thins gradually and finally disappears about 2 miles to the south, being cut off diagonally by a fault. Along the east side of Murphree Valley it is cut out by a fault as far south as Village Springs. Around the south end of Blount Mountain it outcrops in a broad belt extending from Village Springs to Springville and thence northward parallel to the east side of Blount Mountain. A belt of Chickamauga limestone also extends down the east side of East Red Mountain from Canoe Creek nearly to Trussville.

Along all the outcrops described above the limestone is generally rather thin bedded and light or dark gray in color. In places, as at Dale and west of Swansea, there is a thick-bedded buff limestone near the base, and at the south end of Blount Mountain purple-mottled layers occur through the lower 25 feet or more. Crystalline limestone also occurs in the formation. The Chickamauga limestone appears to run from 300 to 700 feet in thickness except where affected by faults, as described above. Its thickness at Gate City is about 300 feet, on Blackburn Fork, west of Swansea, 500 feet, at Chepultepec 600 to 800 feet, and on Butler Mountain, at the south end of Blount Mountain, 700 to 800 feet. The limestone dips into the hills on either side of the valleys, generally at angles of 15° to 20°, though higher dips may occur locally. In some localities, as in the region of Butler and Foster mountains, it lies nearly flat.

The Chickamauga limestone outcrops along Cahaba Valley in a belt about 1 mile wide. In fact the valley has been eroded in the limestone, which is less resistant than the rocks on either side. Leeds is situated near the center of this valley, the limestone showing on all sides. The limestone in Cahaba Valley is generally dark gray and it is much thicker bedded, especially in the lower part, than along Birmingham Valley. Its thickness is difficult to determine accurately on account of probable irregularities of dip, but it may be as much as 1,000 feet. Its dip in the vicinity of Leeds is 15° to 20° SE., and about 4 miles south of Leeds dips of 50° E. were noted.

The Chickamauga limestone has been quarried at Gate City by the Sloss Iron Company for use as flux, but it is no longer used in this region for that purpose to any extent. The subjoined analyses show the composition of the limestone at this quarry:

Analyses of Chickamauga limestone at Gate City quarry.[a]

	1.	2.
Silica (SiO_2)	5.70	3.30
Iron oxide (Fe_2O_3)	1.87	2.14
Lime carbonate ($CaCO_3$)	91.16	91.33

[a] Eckel, E. C., loc. cit.

1. Average sample from crusher. Henry McCalley, analyst.
2. Average of four samples. J. W. Miller, analyst.

The high percentage of silica shown by these analyses probably indicates the reason why the use of this limestone as flux has been discontinued. Much purer rock can be obtained in the region, as is shown on page 253.

This limestone is used for lime near Chepultepec, in Murphree Valley, by the Cheney Marble and White Lime Company. The quarry is situated on the east face of West Red Mountain, where the situation is favorable for working the rock. Below is a section of the limestone exposed in this quarry:

Section of Chickamauga limestone at Chepultepec quarry.

	Feet.
Dark-gray crystalline limestone	40
Darker crystalline limestone	20
Blue limestone	5
Gray limestone	2
Blue limestone	5
Shaly, impure limestone	6
Dark amorphous (lithographic?) limestone	2
Gray limestone	10
	90

The gray limestone at the top is the chief source of material for lime. At the time the works were visited (September, 1905) two kilns were in operation, each producing 100 barrels of lime daily.

At Leeds, in Cahaba Valley, a large plant has been built which will use the Chickamauga limestone, quarried near the works, for cement manufacture. The limestone here is thick bedded and dips 15° to 20° E. As it outcrops but little above drainage level, quarrying operations will be more difficult and expensive than in a quarry entirely above drainage. So far as its known composition indicates, this limestone is everywhere suitable for cement manufacture.

The most favorable locality for quarrying the limestone in this region, with regard to natural conditions, is at the south end of Blount Mountain, where it lies nearly flat and forms high hills such as Foster and Butler mountains. From 500 to 700 feet of limestone is here available, entirely above drainage and exposed on all sides. This locality could be easily reached from the Louisville and Nashville Railroad by a spur 3 miles long, leaving the main track 2 miles north of Mount Pinson and extending up Dry Creek to Foster Mountain.

KNOX DOLOMITE.

The lower 500 to 600 feet of the Knox dolomite, which is free from the chert characterizing the upper 2,500 feet of the formation, is largely used as flux in the furnaces of the district. This chert-free dolomite is limited below by the thin-bedded, bluish to dark-gray Cambrian limestone known as the Conasauga limestone.

The dolomite outcrops along the east side of Opossum Valley, being quarried by the Tennessee Republic Company at Thomas and by the Sloss Iron Company at North Birmingham. The outcrop in Opossum Valley continues as a narrow belt up the west side of Birmingham Valley to Mount Pinson. Along the east side of Birmingham Valley the outcrop extends in a narrow belt to a point within 1 mile of Chalkville. Besides the quarries mentioned above, the Spencer quarry of the Lacy-Buek Iron Company at Lardona and that of the Tennessee Republic Company at Ketona, as well as the old quarry at Dolcito, are located along the western belt. The eastern and western belts of outcrop are connected between North Birmingham and East Birmingham, where the dolomite lies nearly flat and makes a wide outcrop separating the chert ridge in Birmingham, known as Cemetery Ridge, from the chert ridge extending northeastward from East Birmingham to Blount Mountain. There is an outcrop of the dolomite in Murphree Valley extending along the east side of Gravelly Ridge from Chepultepec to Remlap. It is well exposed on Blackburn Fork west of Swansea, as a bluff about 100 feet high. The dolomite is also known to occur along the east side of the Cahaba trough, at the west base of Pine Mountain, where, on account of its vertical attitude, its outcrop is narrow, though it probably extends for 10 miles diagonally across the southeast corner of the Birmingham quadrangle.

The dolomite is generally gray in color and more or less crystalline in texture. As shown by the accompanying analyses, it is nearly free from silica, though thin plates of chert or silica in some other form are said to occur in the rock at various points. At the top it begins to show more or less abundant chert inclusions, such as nodules, stringers, and thin irregular sheets. This transition may be observed in the vicinity of the abandoned Dolcito quarry, where the overlying cherty phase of the Knox is fairly well exposed. The rock is in most places thick bedded. In weathering much of the surface becomes granular, simulating closely the appearance of a coarse-grained sandstone. As stated above, the thickness of this dolomite seems to be about 500 feet. It was measured in Opossum Valley, west of Birmingham, and along the section from the Spencer quarry through Lardona, where the top and bottom can be determined within reasonably close limits. There may be considerable variation from this thickness, however, in different parts of the region. The dip along the western belt, where the quarries mentioned above are located, is from 10° to 15° E.

From this dolomite is obtained all the flux quarried in the Birmingham quadrangle except that obtained from the Bangor limestone. At the quarries of the Tennessee Republic Company at Ketona, and of the Sloss Iron Company at North Birmingham, this rock is a nearly pure calcium and magnesian carbonate, as shown by the following analyses:

Analyses of dolomite from Ketona and North Birmingham quarries.

	1.	2.
Silica (SiO_2)	1.31	0.70
Alumina (Al_2O_3)	.96	.63
Lime carbonate ($CaCO_3$)	55.80	56.41
Magnesium carbonate ($MgCO_3$)	42.47	43.00

1. Average of four analyses of average sample from Ketona quarry, August to October, 1903. Analyses furnished by Tennessee Republic Company.
2. Average of ten analyses of carload lots from North Birmingham quarry, August, 1903, to June, 1905. Analyses furnished by Sloss Iron Company.

These analyses indicate that the lime and magnesia in this rock are nearly in the proportions of the mineral dolomite and that it is properly called dolomite. W. B. Phillips[a] has made a number of silica determinations from the dolomite in the vicinity of Dolcito. At the south end of the Dolcito quarry, which had a face of 17 feet at the time of sampling, samples taken from every foot of the face showed a range of 0.48 to 0.88 per cent of silica, with an average of 0.64 per cent. At the northeast end of the same quarry, presumably from the same beds as at the southwest end, though not so stated, the silica, in samples taken in the same way, ranged from 0.48 to 4.58 per cent, with an average of 1.69 per cent. This shows a considerable variation within a short distance. Two miles northeast of Dolcito, on Fivemile Creek, 29 samples taken at intervals from top to bottom of

[a] Geol. Survey Alabama, Rept. on Valley Regions, pt. 2, 1897, pp. 323-326.

116 feet of dolomite gave silica ranging from 0.96 to 7.28 per cent, with an average of 3.26 per cent. This shows a still greater increase in silica content to the northeast. The writer suspects that in the latter case the samples were obtained at a horizon above the true chert-free dolomite, which north of Dolcito is apparently confined to the flat land along the valley and does not show in outcrop to any extent.

On account of the fact that the dolomite outcrops along the valley bottoms but little above drainage the conditions for quarrying are not very favorable, inasmuch as it is necessary to keep the quarries dry by constant pumping and the rock has to be raised from considerable depth. It is especially difficult to keep the quarries dry in heavy and prolonged rains, and at times work has to be suspended on account of flooding.

The most favorable conditions for quarrying exist in Murphree Valley between Remlap and Chepultepec, where the dolomite outcrops well up on the east side of Gravelly Ridge, and though the rock dips to the west at a considerable angle large bodies could be quarried in such a way as to be self-draining; moreover, the expense involved in raising the rock from a deep quarry on level ground would be entirely avoided.

The suitability of this dolomite for flux has been amply demonstrated by its use in the furnaces of the region for the last ten years, and no comments on that phase of the matter need be made here. The results obtained in actual use throughout this period prove that the dolomite is in every respect equal to the best limestone to be had in the region for fluxing purposes. One company reports its exclusive use in smelting iron for the manufacture of steel by the basic process. The abundance of the rock in proximity to the furnaces is another condition favoring its use.

CONASAUGA LIMESTONE.

The Conasauga limestone is a thin-bedded bluish to gray rock, immediately underlying the Knox dolomite. It is the lowest and oldest rock formation exposed in the region under consideration. The limestone is interbedded with more or less shale. It is known in the region as the Flatwoods formation, because it underlies the flat, badly drained lands of the valleys. Thus it underlies Opossum Valley, as at North Birmingham, for two-thirds of its width; and east of Cemetery Ridge it has an outcrop more than a mile in width in the central part of the city of Birmingham, where its ledges can be seen here and there in the streets. Most of the limestone seen outcropping in Opossum Valley between Village Creek and the Louisville and Nashville Railroad is Conasauga. This outcrop wedges out a mile south of Wylam, and to the north it gradually tapers to a point and disappears beneath the dolomite about 1 mile north of Greene station, on the Louisville and Nashville Railroad. The outcrop east of Cemetery Ridge extends northward as a narrow belt through East Lake, running to a point and disappearing beneath the dolomite one-half mile west of Hoffman. In Murphree Valley a belt of this limestone half a mile wide extends from Remlap to Chepultepec.

The Conasauga limestone can be readily distinguished from the overlying dolomite by the following differences: The limestone is blue or dark gray, without granular texture, and effervesces freely when treated with cold dilute acid; the dolomite is generally light gray with distinct granular texture and effervesces in cold dilute acid very feebly or not at all.

It is probable that the Conasauga formation in this region is not all limestone, but is composed of alternating layers of limestone and shale.

The Conasauga limestone is separated from the younger rocks on the west by a fault which has brought it into contact successively with all the overlying formations as high as the coal measures. The beds generally dip at a high angle. It seems probable that they are affected by minor folding or wrinkling to a considerable extent. Such wrinkling can be seen along the road from Dolcito to Tarrant Gap, and it probably occurs elsewhere as well. On account of such irregularities in the dip no reliable estimate of the thicknesss of the Conasauga limestone can be made. It seems hardly probable, however, that it is less than 1,000 feet, and it may be much greater. No use has been made of this limestone so far as known to the writer.

Below is an average analysis, by William E. Janes, of two samples from an old quarry near Wheeling, northeast of Bessemer. It was kindly furnished by Mr. A. Lodge, of the Woodward Iron Company:

Average analysis of Conasauga limestone from Wheeling quarry.

Silica (SiO_2)	1.20
Iron oxide and alumina ($Fe_2O_3+Al_2O_3$)	.49
Lime carbonate ($CaCO_3$)	89.03
Magnesium carbonate ($MgCO_3$)	8.04
Sulphur dioxide (SO_2)	.115

This rock is suitable for flux and for lime, but it contains too much magnesia for cement making. It would, however, manifestly be unsafe to draw any conclusions as to the general composition of this limestone from these two analyses.

The outcrop of the formation is always on low ground, little above drainage, and the dips are high, so that conditions for quarrying are very unfavorable. Since there is abundant material in the region of as good or even better quality and better situated for quarrying, there is little likelihood that this limestone will be utilized to any extent.

SAND-LIME BRICKMAKING NEAR BIRMINGHAM, ALA.

By Charles Butts.

The manufacture of sand-lime brick is rapidly approaching the proportions of an important industry in the United States, as it has been in Germany for the last ten or fifteen years. In the following brief discussion of the subject no effort is made to go into detail.

A sand-lime brick is essentially a mass of sand cemented by hydrous lime silicates. The sand may be either loose sand or pulverized sandstone. Sand and quicklime are thoroughly mixed in the proportion of 5 to 10 pounds of lime to 100 pounds of sand. The lime may be slaked to a putty or to a powder; or it may be ground dry and mixed with the sand, enough water being added to slake the lime. In any case the mixture should contain enough water to be plastic. The brick are molded and placed in a steam drying cylinder where they remain from seven to ten hours under a pressure of 115 to 160 pounds to the square inch, at a temperature of 170° to 185° C. It is believed by the advocates of sand-lime brick that this treatment results in the formation of lime silicates or lime hydrosilicate, by which the sand grains are firmly cemented together, making a brick of great strength. These brick can easily be made with a crushing strength of over 4,000 pounds per square inch and a tensile strength of over 200 pounds per square inch. The crushing strength and elasticity exceed that of some sandstones. The brick withstand severe freezing and thawing tests, as well as fire tests. With pure sand the color is white, but by the addition of various proportions of manganese or graphite, pink or gray brick can be made. It is claimed that these brick will make very rigid structures and that they are in every way safe and satisfactory building material. Both common and front brick are made. Their chief merits seem to be their white color and their somewhat lower cost of manufacture than that of clay or shale brick used for building fronts and for ornamental purposes.

The sand used for brick should be comparatively free from clay and feldspar, neither of which probably should exceed 10 per cent and even a smaller amount may be desirable. The best results appear to be obtained from the use of high calcium, hot or fat lime, that is, lime made from limestone containing 85 to 100 per cent of calcium carbonate. Some magnesium carbonate may be present.

According to Peppel[a] the cost of production in this country, not including interest, depreciation, repairs, etc., varies from $3 to $4 per thousand and the selling prices vary, according to the locality, from $8 to $15 per thousand.

A few notes are appended concerning the plant near Sayreton, Ala., a village just north of Birmingham. This plant is owned and operated by the Birmingham Sand-lime Brick and Stone Manufacturing Company. The sand used here is derived from the sandstone outcropping along the crest of Sand Mountain. This sandstone lies near the base of the "Coal Measures." Its composition is shown by the following analysis:

Analysis of sandstone from Sand Mountain, Alabama.

Metallic iron (Fe)	0.50
Silica (SiO_2)	92.80
Alumina (Al_2O_3)	2.69
Lime (CaO)	.33
Magnesia (MgO)	.50
Moisture	.62

The sand from the pulverized rock is mixed by the Schwarz process with lime in the proportion of 70 pounds of lime to a cubic yard of sand with the addition of enough water to make the mass plastic. The material is then pressed dry and run into cylindrical driers, where the brick remain eight hours under a pressure of 160 pounds of steam. The brick are white and hard and have a crushing strength of 4,507 pounds per square inch. The daily capacity of the plant is 20,000 brick. The product is sold in Alabama, Georgia, and Mississippi, and there is a large local demand.

An unlimited supply of sandstone from the formation supplying the sand at Sayreton is to be had along Sand Mountain, Black Jack Ridge, and Shades Mountain, and also on Oak Mountain, east of Leeds. Sand from a lower Carboniferous sandstone lying between the Fort Payne chert and the Bangor limestone, which has an extensive outcrop in the region, would also be suitable for brickmaking, since it is nearly pure quartz sand. The quarry between Gate City and Irondale, from which glass sand has been taken, is in this sandstone. It makes Little Sand Mountain southwest of Trussville and the dikelike outcrop from Tarrant Gap to Mount Pinson, known as Rocky Row. It is conspicuous in Blount Valley. At Blount Springs it makes the sharp ridge just east of the hotel. It is possible that many of the sandstone strata in the coal measures would afford sand

[a] Peppel S. V., Bull. Geol. Survey Ohio No. 5, 1905, p. 78.

suitable for brick, since they appear to be made up mostly of quartz grains. There is an unlimited source of lime in the Bangor and Chickamauga limestones, described in the paper in this volume entitled "Limestone and dolomite in the Birmingham district, Alabama" (pp. 247–255).

For those who wish more detailed information on the subject the following references are given, taken mainly from Eckel's book, the first in the list:

ECKEL, E. C., Cements, Limes, and Plasters, 1905, pp. 130–147.

——— Lime and sand-lime brick: Mineral Resources U. S. for 1905, pp. 1003–1006.

GOWDY, J. K., Sand bricks in France: U. S. Consular Reports, No. 1547, January, 1903.

KITCHELL, W., Lime-brick manufacture: Second Ann. Rept. New Jersey Geol. Survey, 1856, pp. 107–108.

MARSTON, A., Tests of sand-lime and sand-cement brick and concrete building blocks: Eng. News, vol. 51, 1904, pp. 387–389.

MASON, F. H., Calcareous brick and stone manufacture in Germany: Daily U. S. Consular Reports, No. 1765, October 3, 1903.

OWEN, W., Patent lime and sand block: Jour. Soc. Chem. Industry, vol. 19, 1899, p. 147.

PEPPEL, S. V., The manufacture and properties of artificial sandstone: Trans. Am. Ceramic Soc., vol. 4, 1903; Eng. News, vol. 49, 1903, pp. 70–73.

——— Further contributions to the manufacture of artificial sandstone or sand brick: Trans. Am. Ceramic Soc., vol. 5, 1903.

——— Sand-lime brick industry: Mineral Resources U. S. for 1903, pp. 866–882.

——— The manufacture of artificial sandstone or sand-lime brick: Bull. Geol. Survey of Ohio, 4th ser., No. 5, 1905.

This is probably the most complete original treatise on the subject published in this country. It brings the subject down to January 1, 1905.

ROCHMANOW, ——, Basic fire-proof bricks: Thonindustrie Zeitung, vol. 27, p. 108; abstract in Jour. Soc. Chem. Industry, vol. 22, 1903, p. 421.

SCHWARZ, ——, Sand bricks. Abstract in Jour. Soc. Chem. Industry, vol. 21, 1902, pp. 1183–1184.

WOLFF, L. C., Bricks of lime and sand: Thonindustrie Zeitung, vol. 23, pp. 854–859; abstract in Jour. Soc. Chem. Industry, vol. 19, 1899, p. 48.

ANON., The Schwarz drying and mixing machine for manufacturing lime-sand brick: Eng. News, vol. 49, 1903, p. 179.

SURVEY PUBLICATIONS ON LIME AND MAGNESIA.

In addition to the papers listed below, which deal principally with lime, magnesite, etc., further references on limestones will be found in the lists given on pages 245–246 and 360 under the heads "Cements" and "Building stone," respectively.

BASTIN, E. S. The lime industry of Knox County, Maine. In Bulletin No. 285, pp. 393–400. 1906.

HESS, F. L. Some magnesite deposits of California. In Bulletin No. 285, pp. 385–392. 1906.

RIES, H. The limestone quarries of eastern New York, western Vermont, Massachusetts, and Connecticut. In Seventeenth Ann. Rept., pt. 3, pp. 795–811. 1896.

STOSE, G. W. Pure limestone in Berkeley County, W. Va. In Bulletin No. 225, pp. 516–517. 1904.

YALE, C. G. Magnesite deposits in California. In Mineral Resources U. S. for 1903, pp. 1131–1135. 1904.