STRUCTURAL MATERIALS, ETC.

THE ABERDEEN GRANITE QUARRY NEAR GUNNISON, COLORADO.

By J. Fred. Hunter.

INTRODUCTION.

During the summer of 1912, in the course of the mapping of the geology and, in particular, the granites and gneisses of the Uncompahgre quadrangle, Colorado, the writer had occasion to make a hasty examination of the Aberdeen granite quarry, which lies about three-quarters of a mile east of the quadrangle. Although there are many granite quarries and much granite available for building stone within short distances of the larger towns of Colorado, gray granite is by no means so common as other varieties. This fact adds interest to the occurrence here described.

The Aberdeen granite quarry is located in Gunnison County, on South Beaver Creek, about 4 miles from the point where that stream empties into Gunnison River. It is 11 miles from the town of Gunnison and about 5½ miles from a siding on the Denver & Rio Grande Railroad, from which the stone has been shipped in recent years.

The quarry is owned jointly by F. G. Zugelder, of Gunnison, Peter F. Bossie, and Gettis & Seerie, of Denver. The quarry site was patented in 1890 as placer claims, and includes in all 120 acres, in secs. 4 and 5, T. 48 N., R. 1 W.

HISTORY.

From Mr. Fred Zugelder, of Gunnison, the following brief account of the history of the quarry was obtained.

The quarry was first worked in July, 1889, when Gettis & Seerie began taking out stone for the State capitol at Denver. From this time until 1892 they worked an average of 60 men and took out about 280,000 cubic feet of stone. This was by far the largest and longest operation that the quarry has known. The granite was loaded at the quarry, there being at that time a spur up South Beaver Creek. The stone had to be transferred, however, from the narrow-gage to the standard-gage cars at Salida.

Since this period of activity the quarry has been worked only sporadically. From 1892 until 1895 a small amount of monumental stock was quarried. During 1905 stone was quarried for the steps of the State capitol. In 1908 Mr. Zugelder took out 3,500 cubic feet, and in 1911–12 Mr. Bossie quarried about 3,000 cubic feet for the State Museum building in Denver. The last work was done in July, 1912, and the quarry is now idle. In all nearly 290,000 cubic feet of stone has been quarried.

GEOLOGIC RELATIONS.

The quarry granite is part of a broad dikelike mass intruding pre-Cambrian gneiss. This body is one of many similar masses of varying sizes and shapes intruding the pre-Cambrian metamorphic rocks approximately parallel to their schistosity, which strikes N. 50–60° W. in this vicinity. The bodies of this type of granite are very numerous in a zone running northwestward through the northeast corner of the Uncompahgre quadrangle. They are characteristically lacking in persistency, and grade laterally as well as longitudinally from granite with numerous inclusions of gneiss to gneiss highly injected with granite. The granite has been injected into the highly foliated gneiss along the planes of schistosity in all manner of ways and in bodies of all shapes and sizes. However, no very large single bodies were observed in the region studied, to the northwest of the quarry. Indeed, the largest body so far seen is the one in which the quarry is located.

This mass is in places over a quarter of a mile wide and can be followed for nearly 2 miles in a N. 50° W. direction from the quarry. How far it extends to the southeast is not known. In many places northwest of the quarry the granite of this band includes considerable gneiss. This condition makes it extremely difficult to find large enough bodies for quarrying and has influenced the location of the Aberdeen quarry at so great a distance from the railroad.

THE GRANITE.

PETROGRAPHIC CHARACTER.

The rock is a soda-rich granite and is known in the trade as gray granite. It approaches a quartz diorite in composition. The thick sprinkling of black biotite through the clear transparent quartz and white, more opaque feldspar, gives the general gray appearance. The rock is entirely crystalline, of medium grain and even texture. The individual crystals average from 2 to 3 millimeters in diameter, few being larger than 7 millimeters.

In thin section the rock is seen to be allotriomorphic—that is, almost all the individual minerals which compose it are without definite crystal outline and have irregular boundaries. The texture is that usual to a granite, and the individual minerals, although varying somewhat in size, show all intermediate gradations from the smallest to the largest.

The essential mineral constituents, in descending order of abundance, are plagioclase of the composition of oligoclase, quartz biotite, and potash feldspar (microcline and orthoclase). The potash feldspar is very subordinate, comprising less than 5 per cent of the rock. The accessory minerals are magnetite, apatite, epidote, calcite, and titanite.

An estimate of the mineral percentages of the rock by the Rosiwal method gave the following results: Quartz, 36; feldspar, 51; biotite, 12; accessory minerals, 1.

PHYSICAL CHARACTER.

The granite is hard and compact and is said to work easily. It takes a good polish, becoming slightly darker than on fracture surfaces. It is said to be good for bush-hammer work and has been used for monumental stone. For the latter purpose, and particularly for inscriptions, the color, susceptibility to polish, and contrast between cut or hammered and polished surfaces, are properties of chief economic importance. Merrill[1] has explained the cause of these contrasts very satisfactorily:

> The impact of the hammer breaks up the granules on the immediate surface, so that the light falling upon it is reflected, instead of absorbed, and the resultant effect upon the eye is that of whiteness. The darker color of a polished surface is due merely to the fact that, through careful grinding, all these irregularities and reflecting surfaces are removed, the light penetrating the stone is absorbed, and the effect upon the eye is that of a more or less complete absence of light, or darkness. Obviously, then, the more transparent the feldspars and the greater the abundance of dark minerals, the greater will be the contrast between hammered and polished surfaces. This is a matter worthy of consideration in cases where it is wished, as in a monument, to have a polished die, surrounded by a margin of hammered work to give contrast.

The abundance of black mineral and the transparency of the quartz and plagioclase feldspar in the granite are very significant in this connection.

The granite has a decided rift (running approximately N. 60° W. in the mass), along which it slabs easily. Physical tests of the granite were made by E. C. Rhody, a student in the college of engineering of the University of Colorado, with the following results:

Compressive strength.................pounds per square inch..	14, 340
Modulus of rupture.................................do....	2, 465
Proper specific gravity..	2. 71
Apparent specific gravity......................................	2. 70
Ratio of absorption............................per cent..	. 17
Porosity...do....	. 46
Weight per cubic foot...........................pounds..	169

[1] Merrill, G. P., The physical, chemical, and economic properties of building stones: Maryland Geol. Survey, vol. 2, 1898, p. 64.

In outcrops the granite shows considerable weathering near the surface. In this process it becomes rougher, the quartz and feldspar standing out more prominently, and the rock takes on a brownish and more somber tone. There are, as a rule, innumerable cracks and minor joints where the rock has been long exposed to surface weathering. These, however, are superficial and apparently do not extend more than a short distance from the surface. The face of the quarry shows fresh, unaltered rock with few joints or cracks. Quarried rock which has lain out in the weather for several years shows no sign of staining or disintegration. The granite of the State capitol at Denver, which came from this quarry, is said to show no evidence of weathering after 20 years' exposure to the weather.

CONDITIONS AND DEVELOPMENT.

The Aberdeen quarry is situated along the north and east sides of South Beaver Creek at an elevation of about 8,000 feet above sea level. The workings, which are of the sidehill type, extend for several hundred yards along the creek. There is no overburden and the creek here has steep, canyonlike slopes so that it has been necessary only to remove the talus from the foot of the cliffs and a small amount of weathered surface rock to get into a face of fresh, unaltered granite. At the upper end of the quarry, where the workings have been carried on most extensively, the face is 50 feet high for a distance of 100 feet. From this space most of the rock has been taken, although a much larger working face would be available if needed. This face shows massive rock with but little jointing, so that blocks of almost any size can be obtained. There is an irregular jointing nearly parallel to the face of the quarry. A single well-marked joint plane runs diagonally across the face of the quarry, dipping 45° E. The rock at the face is fresh and clean, with no sign of staining.

Conditions of quarrying are favorable, in that the bottom of the quarry is far enough above the bed of the stream to be well drained and at the same time afford a ready means of loading. The quarry equipment has been largely dismantled. At present there remain a derrick, a boiler and boiler house, some track, several large frame houses, and a few cabins. The railroad along the creek has been torn up.

ORNAMENTAL MARBLE NEAR BARSTOW, CALIFORNIA.

By Robert W. Pack.

INTRODUCTION.

In December, 1912, while engaged in a reconnaissance of a portion of the Mohave Desert north of Barstow, Cal., the writer saw specimens of very attractive ornamental marble which had been obtained at a recently discovered deposit in the mountains south of town, and through the kindness of Messrs. E. T. Hillis and P. M. Le Sage, owners of the claims on which the marble occurs, he was able to spend a couple of hours on the property. The following notes are based on the hasty and necessarily superficial examination this brief time permitted.

Barstow is a settlement of about 800 or 900 persons in western San Bernardino County, Cal. It is situated on Mohave River, in the central part of the Mohave Desert, approximately 140 miles east of Los Angeles by rail. Two railroads pass through it, the San Pedro, Los Angeles & Salt Lake Railroad and the Atchison, Topeka & Santa Fe Railway, Barstow being the junction of the San Francisco and Los Angeles lines of the latter road.

The marble deposit occurs in the northern part of a mountain group which lies between the San Bernardino Range on the south and Mohave River on the north. This group, which is known as the Granite Mountains, comprises a number of rugged, almost treeless ridges which rise abruptly from the desert floor, and which have no definite system of orientation or arrangement, being really a collection of more or less isolated peaks and ridges. The marble is found on the north flank of one of these ridges, locally known as Stoddard Peak Ridge. It is about 15 miles due south of Barstow, in an unsurveyed part of T. 7 N., R. 2 W., San Bernardino base and meridian. A good but rather circuitous road some 22 miles in length extends from Barstow to a point within about a mile of the deposit. The closest railroad point is Cottonwood siding, on the road to Los Angeles, which is said to be about 14 miles distant by road. Stoddard Well, 6 or 8 miles from the deposit on the road to Barstow, furnishes the only water in this vicinity.

CHARACTER AND AGE OF THE ROCKS.

As their name implies, the Granite Mountains are formed largely of granitoid rocks. These rocks are associated with various schists, gneisses, quartzites, crystalline limestones, and some less altered sedimentary and igneous rocks. Metamorphic and igneous rocks of this general type are widely distributed over southeastern California and the neighboring parts of Nevada and Arizona, but as yet those occurring in the central part of the Mohave Desert have received scant study, and very little is known as to their age or their correlation with the rocks occurring in better-known regions. About 70 miles north of Barstow, in the Funeral and Kingston ranges, Paleozoic rocks of various kinds rest upon nonfossiliferous rocks that are believed to be pre-Cambrian.[1] In the southeastern part of the desert, 100 miles to the east, Cambrian rocks rest upon an earlier granite.[2] In the San Bernardino Range to the south various metamorphic rocks of unknown age are intruded by igneous rocks.[3] Altered sedimentary rocks that are believed, on the evidence of a few poorly preserved fossils, to be Carboniferous, as well as some probably older schists and granites, occur in the Randsburg region, some 30 miles northwest of Barstow.[4]

The only attempt to correlate the metamorphic and igneous rocks in the Granite Mountains with similar rocks in better known regions is that made by Hershey,[5] who briefly describes certain metamorphosed sedimentary rocks south of Barstow along the Los Angeles line of the Santa Fe Railway, and correlates them with Lower Cambrian rocks in the White Mountains of Inyo County described by Walcott. This correlation is based entirely on the general similarity in the degree of metamorphism and mode of occurrence of the rocks at the two places and can not be considered as definitely established.

THE MARBLE.

Occurrence.—The marble occurs on the east flank of a spur ridge which extends toward the north almost at right angles to the trend of Stoddard Peak Ridge. The deposit consists of a number of beds of brecciated mottled green and white marble which vary in thickness from a few inches up to 10 or 12 feet and possibly even to 20 feet. Interstratified in alternate layers with the beds of marble are

[1] Gilbert, G. K., U. S. Geog. Surveys W. 100th Mer., vol. 3, 1875, pp. 33, 179, 181. Campbell, M. R., Reconnaissance of the borax deposits of Death Valley and Mohave Desert: Bull. U. S. Geol. Survey No. 200, 1902, p. 14. Spurr, J. E., Descriptive geology of Nevada south of the fortieth parallel and adjacent portions of California: Bull. U. S. Geol. Survey No. 208, 1903, pp. 187-200.

[2] Darton, N. H., Discovery of Cambrian rocks in southeastern California: Jour. Geology, vol. 15, 1907, pp. 470-475.

[3] Mendenhall, W. C., unpublished notes.

[4] Hess, F. L., Gold mining in the Randsburg quadrangle, California: Bull. U. S. Geol. Survey No. 430, 1910, pp. 23-47.

[5] Hershey, O. H., Some crystalline rocks of southern California: Am. Geologist, vol. 29, 1902, pp. 286, 287.

hard siliceous detrital rocks which vary in color from light yellow-green to greenish black. These siliceous rocks were evidently originally arkose sandstones or shale, but they have been altered and under the microscope show a slightly schistose structure and an abundance of greenish sericite. Both the marble and the interstratified siliceous rocks form prominent ragged outcrops which are traceable for more than 2,500 feet. Where best developed the marble occurs through a stratigraphic thickness of 200 feet or more. The beds strike approximately north and south along the spur ridge and dip westward into it. Near the center of the spur, where a small cut has been opened, the dip is approximately 20°, but in general it is probably somewhat higher. At the base of the succession of alternating beds of brecciated marble and altered detrital rocks is a bed of gray crystalline limestone a few feet thick. This bed, although considerably fractured, does not exhibit the brecciation characteristic of the marble nor does it show the slightest trace of greenish color.

Character and composition.—The marble is essentially a brecciated white crystalline limestone recemented by a greenish calcareous cement. The brecciated fragments are angular and vary in size, some of them being as much as 6 or 8 inches in length. Some of the fragments, particularly the larger ones, retain their original white color and form a sharp contrast to the inclosing greenish matrix. Most of them, however, are at least partly colored, commonly having an outer greenish rim. Many of the smaller fragments are stained throughout and assume a greenish color similar to that of the matrix, but lighter in tone. Many of the unstained fragments are finely crystalline, dense, and of a dead-white color; others are more coarsely crystalline and appear semitranslucent on a polished surface. In general effect the marble is mottled green, black, and white, but this appearance varies greatly, owing to the irregular size and staining of the brecciated fragments, to their irregular spacing, and to differences in the tone of the cementing material. The finely brecciated material is usually a mottled light yellow-green, olive-green, and black, with a few small fragments of unstained lime, and is probably the most handsome. In places, owing to a parallel arrangement of the longer axes of the brecciated fragments, the marble has a somewhat banded appearance. Small crystals of pyrite, barely visible to the unaided eye, occur in scattered bunches or small stringers. So far as observed the marble is free from veins or bands of silica. It is reported to cut easily and takes a very fair polish.

Under the microscope the marble is seen to be entirely recrystallized. The principal impurity is a feebly double-refracting mineral, probably either chlorite or serpentine, which occurs in abundant minute particles in the colored portions of the stone. Tremolite is also present, but in far less amount.

The following analyses were made by George Steiger, of the United States Geological Survey. The first represents a sample of the more finely brecciated marble in which the original white fragments as well as the matrix have a greenish color. The second represents a sample of the unbrecciated gray limestone which occurs below the marble.

Analyses of limestones from beds near Barstow, Cal.

	1	2		1	2
SiO_2	21.63	2.02	H_2O-	0.17	0.02
Al_2O_3	3.86	1.48	H_2O+	6.07	.51
Fe_2O_3	.80	None.	TiO_2	.26	None.
FeO	1.13	.30	CO_2	20.35	42.41
MgO	19.17	7.56	P_2O_5	.05	None.
CaO	26.18	45.89	Cr_2O_3	None.	None.
Na_2O	None.	.02			
K_2O	None.	.23		99.67	100.44

Originally the beds of greenish marble were probably grayish limestone, somewhat similar to that now exposed at the base of the section. These beds were brecciated and recemented by a calcareous cement obtained from percolating solutions which contained, besides the lime, considerable amounts of magnesia and silica, probably derived from the interstratified arkosic beds. The magnesia shown in the analysis of the greenish marble probably occurs in part as dolomite in the brecciated fragments. The remainder is mainly in the matrix in combination with the silica in the form of chlorite or serpentine.

Weathering.—The marble shows very little decomposition from weathering. Usually the rock is affected to a depth of only a fraction of an inch, and when it is chipped fresh unweathered stone appears. The brecciated fragments weather somewhat more easily than the matrix, and the outcrops have a very pitted appearance. Many of the fragments have a thin dark coating formed largely of chlorite or serpentine, which weathers out, leaving deeply impressed grooves between the fragments and the inclosing matrix.

Jointing.—The marble is rather extensively jointed, and the surface outcrops show very few unbroken blocks more than 3 feet in diameter. The joints, as nearly as may be judged from the surface exposures, have no systematic distribution or arrangement. No regularity which might be of service in the extraction of the stone was observed. Many of the joints unquestionably disappear at moderate depth, and although the seam may continue it is filled and recemented by lime. This is well shown in a small cut driven about 20 feet into the hill near the center of the deposit, where several large blocks, one measuring roughly 6 by 7 by 9 feet, apparently free from flaws, were obtained. Besides the jointing of this type several small cross faults have offset the beds, in places bringing the marble into juxtaposition along the strike with the interstratified siliceous detrital rock. Such a cross fault forms the south wall of the small cut mentioned above.

Utilization.—The deposit is practically undeveloped. The surface showings are promising and are worthy of careful exploratory work. In the central and northern parts of the deposit the beds of marble appear to be several feet thick, and good-sized blocks can probably be extracted, but toward the south the marble and the siliceous rock occur in alternate beds only a few inches thick. The feature that will interfere most seriously with the exploitation of the deposit is the fracturing. As has been pointed out, there seems to be no regularity in the jointing that would aid in the extraction of the material. Many of the joints evidently disappear a few feet below the surface, but others are probably more persistent, and along some there has been movement resulting in an offsetting of the beds. It will take careful detailed work, including both an examination of the outcrops and systematic core drilling or excavating, to determine just how seriously the marble is fractured and how large blocks may be obtained. The marble dips at a fairly low angle into the hill, and considerable dead work will always be necessary. One point very much in its favor is that the marble is an ornamental stone of unique and pleasing appearance, and in consequence a relatively small block would be commercially valuable.

OTHER DEPOSITS OF LIMESTONE.

Other deposits of limestone occur in this vicinity, but so far as known they do not show the brecciation characteristic of the greenish marble. About half a mile north of the marble deposit is a high, long ridge almost barren of vegetation, trending approximately east and west. The crest of this ridge is determined by a thick bed of gray limestone which may easily be followed by the eye. This outcrop was not visited, but according to Mr. Le Sage it is composed of gray limestone exactly like that found at the base of the section in which the marble occurs. He also reports that the limestone is traceable for over three-quarters of a mile and that it is in contact with granitic rocks, none of the altered detrital rocks similar to those bedded with the marble being present.

About 2 miles southwest of the deposit of brecciated marble, in, it is said, sec. 28, T. 7 N., R. 2 W., is an old excavation known as the Gem quarry, the Kimball mine, or the Verde Antique Marble quarry.

This quarry is briefly described in a State bulletin.[1] It was opened 15 years or more ago and has been worked for short periods at several different times. Owing to the fractured condition of the stone and the impossibility of extracting blocks of reasonable size, it was finally abandoned and has now been idle for several years. Specimens of the rock now in the National Museum were examined. It is a mottled or wavy serpentinous limestone, usually light yellowish green in color and unbrecciated, and is entirely different from the green brecciated marble here described.

[1] The structural and industrial materials of California: Bull. California State Min. Bur. No. 38, 1906, pp. 147–148.

CLAY IN NORTHEASTERN MONTANA.

By C. M. Bauer.

Field work.—During July and August, 1912, several townships in the vicinity of Plentywood, Mont., were geologically examined, principally for the purpose of determining the quality and thickness of the lignite beds of that area. While this work was being done interest was directed to a white bedded deposit that had been used locally for plaster and mortar. Visits to several pits from which the material had been excavated seemed to indicate that it was a fair-grade clay. Samples were collected from several places near Redstone and the locations of prospects were determined. The accompanying map (Pl. VIII) gives these locations and shows the approximate position of the outcrop.

Geology.—The clay bed is a part of the Fort Union formation and is therefore of Tertiary age. This formation consists of stratified materials, principally shale, clay, and sandstone, with local thin lenses of limestone and beds of lignite. The strata in this field have a southeasterly dip of about 19 feet to the mile.

Extent and character of the bed.—The known extent of the bed is about 18 miles east and west and about 8 miles north and south, but it probably has a much wider distribution.

On a high hill about a mile southwest of Redstone and a quarter of a mile west of the Bergh lignite mine is an outcrop of the clay bed. In this place (locality No. 1 of the accompanying map) it is 8 feet thick and has gray shale above and below. It is massive and homogeneous through the entire thickness. As the quality here is representative of that in the western half of the field a sample was collected and sent to A. V. Bleininger, of the United States Bureau of Standards, for examination. The report on this sample may be found below under the heading "Properties of the clay." West of this point the clay bed has been eroded generally.

In sec. 2, T. 35 N., R. 52 E., is a pit (locality No. 2) from which clay has been taken for local use. At this locality the bed is 4 feet thick and very similar in quality to that at locality No. 1. At locality

No. 3, in sec. 1 of the same township, the following section of the bed was measured:

Section at locality No. 3, sec. 1, T. 35 N., R. 52 E.

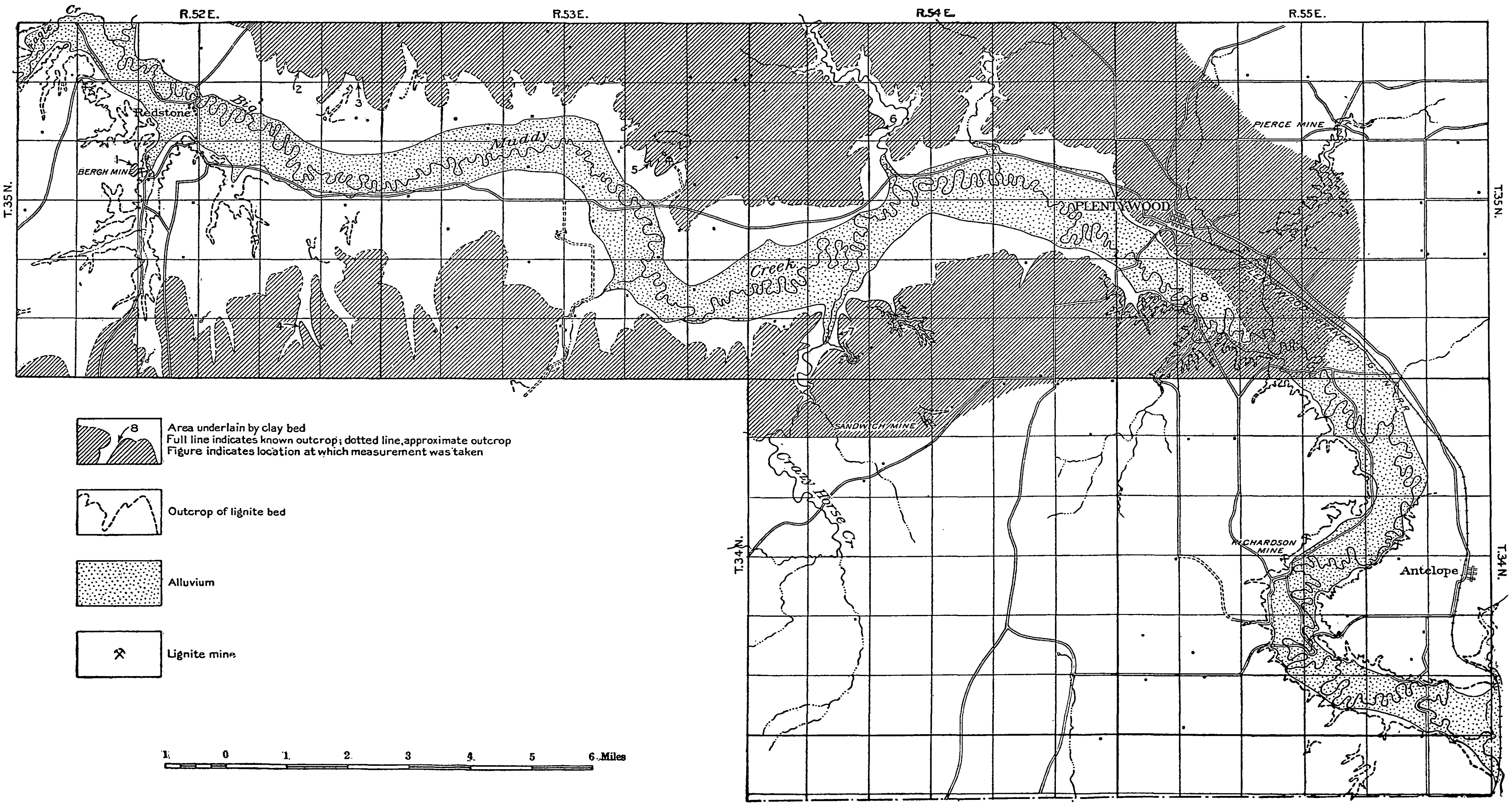
	Ft.	in.
Sandstone.		
Limestone, siliceous	2	6
Clay, blue and yellow, alternating layers	5	
Shale, gray	4	
Shale, yellow, arenaceous		10
Clay, white, hard	1	10
Shale, yellow		10
Clay, white, hard	4	2
Shale, brown.		

Locality No. 4, in sec. 35, T. 35 N., R. 52 E., is on the outcrop of the bed, but no measurement was obtained here. In the Chalky Buttes, in sec. 14, T. 35 N., R. 53 E., this bed is sandy and separated into several layers by thick partings of sandstone, and the weathering of the clay gives a general white appearance to the neighboring beds.

The bed also outcrops along Plentywood Creek in T. 35 N., R. 54 E., and at locality No. 6 it is 2 feet 10 inches thick but contains a large percentage of sand. On Dick Mann's ranch, along Crazy Horse Creek, the bed is 4 feet 3 inches thick and of fair quality. At locality No. 7 it is only 30 feet above the water in the creek. Another measurement was obtained on the same stratum about a mile south of Plentywood, T. 35 N., R. 55 E. At this point, however, it is 16 feet 8 inches thick and is composed almost entirely of white sandstone. Some of the material from this place was examined and seemed to be chiefly grains of quartz and muscovite. A few hundred yards east of this point, where the road crosses Big Muddy Creek, the dip of the stratum takes it below the level of the flood plain.

Origin of the clay.—The origin of this clay can be attributed to sedimentation in a quiet body of water during the Fort Union epoch. The white color is probably due primarily to subsequent bleaching by waters laden with organic acids which leached through the bed and carried away the more soluble constituents. However, lixiviation was not completed and the whiteness is intensified by the presence of a small amount of lime. Beds of white clay have been noted in the Cypress Hills and along White Mud River in Canada by R. G. McConnell,[1] who states that "The clays and sands have been bleached almost pure white by the action of vegetable débris. * * * Exposures in the distance look like great snow banks. The clays and sands graduate almost imperceptibly one into the other and seldom remain pure for any distance."

[1] McConnell, R. G., Rept. Canada Geol. Survey, 1885, Northwest Territory, p. 28c.



MAP SHOWING LOCATION OF CLAY BED NEAR PLENTYWOOD, MONT.

Properties of the clay.—The character and quality of the clay, as reported by the United States Bureau of Standards, are as follows:

The sample received consisted of lumps of hard clay, gray in color. The clay was ground in a mortar, screened through a 20-mesh sieve, and tempered with water. Small briquets were molded by hand, dried, and burned. The clay developed good plasticity and bonding power and the drying behavior was satisfactory, the dried briquets possessing high tensile strength. The linear drying shrinkage of the clay was 8 per cent.

Briquets of the clay were burned in a natural-gas-fired kiln to different temperature and the following noted:

Temperature.	Color.	Hardness.	Water absorption.
° C.			*Per cent.*
950	Buff	Soft	13.1
1,010	Buff	Soft	13.3
1,070	Buff	Soft	11.8
1,130	Buff	Steel hard	7.5
1,190	Gray	Steel hard	.9
1,250	Gray	Steel hard	.4

The softening point of the clay in an electric furnace was found to correspond to that of standard pyrometric cone 20 (approximately 1,530° C.).

From the above preliminary examination we would say that the material has properties similar to those of a No. 3 fire clay. The temperature at which the clay softens is not sufficiently high to permit its use in the manufacture of refractories. The sample submitted was not large enough to observe the behavior of the plastic clay in flowing through the die of an auger machine. The indications are, however, that the material would be satisfactory in this respect.

The clay appears to be a promising one for the manufacture of common and face brick and possibly drain tile and fireproofing.

The buff color developed by burning would not permit its use in the manufacture of whiteware pottery. However, the clay has properties similar to those used in the manufacture of stoneware.

The clay contains no injurious impurities except in the area south of Plentywood, where it grades into sandstone. It is believed that the quartz sand which is mingled with it in this area could readily be separated by washing and settling. The outcrop of the bed is near the Big Muddy flat, where water can readily be obtained. Wells 25 to 35 feet deep have an abundant flow of water.

Development and utilization.—The development and utilization of this bed have been meager. It has been used locally for plaster and mortar in building walls and chimneys, but it is not a satisfactory material when used in this way. It becomes fairly hard, however, when dried or baked in the sun, but unless it is fired it is readily affected by water. It is believed that the clay could best be used in the manufacture of brick. Crockery and tile could also be made from it, and by the addition of small quantities of iron or other metallic oxides a variety of colors might be obtained.

The outcrop and distribution so far as known are shown on the accompanying map. Owing to the white color of the bed the outcrops are readily detected. In the western part of the area it is exposed on the high hills, but toward the east, because of the eastward dip of the strata, their altitude diminishes, and at a point about a mile south of Plentywood the clay bed disappears beneath the flat of Big Muddy Creek. The overlying bed is a gray shale from 2 to 15 feet in thickness. Perhaps the most desirable spot for mining is in sec. 17, T. 35 N., R. 52 E., where the overburden does not exceed 20 feet. The presence of lignite in the area will aid greatly in the exploitation of the bed and the manufacture of clay products. The outcrop and distribution of the lignite beds of this region are shown on the map. Near the point just mentioned is a lignite mine operated by Olaf Bergh. The lignite bed at the mine is 5 feet 5 inches thick and of fair quality and could be used for firing.

Transportation.—A branch of the Great Northern Railway has recently been extended from Bainville to Plentywood. This opens the way for shipment to many western markets, and though the local demand for the clay products may not be great, the association of lignite and clay, together with the advantages of location and transportation, may make the deposit valuable to the prospective manufacturer.

SURVEY PUBLICATIONS ON BUILDING STONE AND ROAD METAL.

The following list comprises the more important recent publications on building stone and road metal by the United States Geological Survey. These publications, except those to which a price is affixed, can be obtained free by applying to the Director, United States Geological Survey, Washington, D. C. The priced publications may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C. The annual volumes on Mineral Resources of the United States contain not only statistics of stone production, but occasional discussions of available stone resources in various parts of the country. Many of the Survey's geologic folios also contain notes on stone resources that may be of local importance.

ALDEN, W. C., The stone industry in the vicinity of Chicago, Ill.: Bull. 213, 1903, pp. 357–360. 25c.

BAIN, H. F., Notes on Iowa building stones: Sixteenth Ann. Rept., pt. 4, 1895, pp. 500–503. $1.20.

BURCHARD, E. F., Structural materials available in the vicinity of Minneapolis, Minn.: Bull. 430, 1910, pp. 280–291.

——— Structural materials available in the vicinity of Austin, Tex.: Bull. 430, 1910, pp. 292–316.

——— Stone industry in 1912: Mineral Resourses U. S. for 1912, 1913.

BUTTS, CHARLES, Variegated marble southeast of Calera, Shelby County, Ala.: Bull. 470, 1911, pp. 237–239.

COONS, A. T., Slate in 1912; Mineral Resources U. S. for 1912, 1913.

DALE, T. N., The slate belt of eastern New York and western Vermont: Nineteenth Ann. Rept., pt. 3, 1899, pp. 153–200. $2.25.

——— The slate industry of Slatington, Pa., and Martinsburg, W. Va.: Bull. 213, 1903, pp. 361–364. 25c.

——— Notes on Arkansas roofing slates: Bull. 225, 1904, pp. 414–416. 35c.

——— Note on a new variety of Maine slate: Bull. 285, 1906, pp. 449–450. Exhausted. May be found at large public libraries.

——— Commercial qualities of the slates of the U. S. and their localities: Mineral Resources U. S. for 1912, 1913.

——— The granites of Maine: Bull. 313, 1907, 202 pp. 35c.

——— The chief commercial granites of Massachusetts, New Hampshire, and Rhode Island: Bull. 354, 1908, 228 pp.

——— The granites of Vermont: Bull. 404, 1909, 138 pp.

——— Supplementary notes on the granites of New Hampshire: Bull. 430, 1910, pp. 346–372.

——— Supplementary notes on the commercial granites of Massachusetts: Bull. 470, 1911, pp. 240–288.

——— The commercial marbles of western Vermont: Bull. 521, 1912, 170 pp.

DALE, T. N., and GREGORY, H. E., The granites of Connecticut: Bull. 484, 1911, 137 pp.

DALE, T. N., and others, Slate deposits and slate industry of the United States: Bull. 275, 1906, 154 pp. Exhausted.

DARTON, N. H., Marble of White Pine County, Nev., near Gandy, Utah: Bull. 340, 1908, pp. 377–380. 30c.

——— Structural materials in parts of Oregon and Washington: Bull. 387, 1909, 36 pp.

——— Economic geology of Richmond, Va., and vicinity: Bull. 483, 1911, 48 pp.

DILLER, J. S., Limestone of the Redding district, California: Bull. 213, 1903, p. 365. 25c.

ECKEL, E. C., Slate deposits of California and Utah: Bull. 225, 1904, pp. 417, 422. 35c.

GARDNER, J. H., Oolitic limestone at Bowling Green and other places in Kentucky: Bull. 430, 1910, pp. 373–378.

HILLEBRAND, W. F., Chemical notes on the composition of the roofing slates of eastern New York and western Vermont: Nineteenth Ann. Rept., pt. 3, 1899, pp. 301–305. $2.25.

HOPKINS, T. C., The sandstone of western Indiana: Seventeenth Ann. Rept.; pt. 3, 1896, pp. 780–787. $1.

——— Brownstones of Pennsylvania: Eighteenth Ann. Rept., pt. 5, 1897, pp. 1025–1043. $1.

HOPKINS, T. C., and SIEBENTHAL, C. E., The Bedford oolitic limestone of Indiana: Eighteenth Ann. Rept., pt. 5, 1897, pp. 1050–1057. $1.

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KEITH, A., Tennessee marbles: Bull. 213, 1903, pp. 366–370. 25c.

KÜMMEL, H. B., and others, Raritan (N. J.) folio (No. 191), Geol. Atlas U. S., 1914. (In press.) 25c.

LEIGHTON, HENRY, and BASTIN, E. S., Road materials of southern and eastern Maine: Bull. 33, Office of Public Roads, U. S. Dept. Agr., 1908. (May be obtained from Department of Agriculture.)

PAIGE, SIDNEY, Marble prospects in the Chiricahua Mountains, Arizona: Bull. 380, 1909, pp. 299–311. 40c.

——— Mineral resources of the Llano-Burnet region, Texas, with an account of the pre-Cambrian geology: Bull. 450, 1911, 103 pp.

PURDUE, A. H., The slates of Arkansas: Bull. 430, 1910, pp. 317–334.

RIES, HEINRICH, The limestone quarries of eastern New York, western Vermont, Massachusetts, and Connecticut: Seventeenth Ann. Rept., pt. 3 (continued), 1896, pp. 795–811.

SHALER, N. S., Preliminary report on the geology of the common roads of the United States: Fifteenth Ann. Rept., 1895, pp. 259–306. $1.70.

——— The geology of the road-building stones of Massachusetts, with some consideration of similar materials from other parts of the United States: Sixteenth Ann. Rept., pt. 2, pp. 277–341. $1.25.

SIEBENTHAL, C. E., The Bedford oolitic limestone [Indiana]: Nineteenth Ann. Rept., pt. 6, 1898, pp. 292–296.

SMITH, G. O., The granite industry of the Penobscot Bay district, Maine: Bull. 260, 1905, pp. 489–492. Exhausted.

UDDEN, J. A., The oolitic limestone industry at Bedford and Bloomington, Ind.: Bull. 430, 1910, pp. 335–345.

WATSON, T. L., Granites of the southeastern Atlantic States: Bull. 426, 1910, 282 pp.

SURVEY PUBLICATIONS ON CEMENT AND CEMENT AND CONCRETE MATERIALS.

The following list includes the principal publications on cement materials by the United States Geological Survey or by members of its staff. The Government publications, except those marked with an asterisk and those to which a price is affixed, can be obtained free by applying to the Director, United States Geological Survey, Washington, D. C. Applications for publications marked with an asterisk (*) should be addressed to the United States Bureau of Standards at Washington. The priced publications may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C.

ADAMS, G. I., and others, Economic geology of the Iola quadrangle, Kansas: Bull. 238, 1904, 80 pp. 25c.

BALL, S. H., Portland cement materials in eastern Wyoming: Bull. 315, 1907, pp. 232–244. 50c.

BASSLER, R. S., Cement materials of the valley of Virginia: Bull. 260, 1905, pp. 531–544. Exhausted.

BURCHARD, E. F., Portland cement materials near Dubuque, Iowa: Bull. 315, 1907, pp. 225–231. 50c.

——— Concrete materials produced in the Chicago district: Bull. 340, 1908, pp. 383–410. 30c.

——— Structural materials available in the vicinity of Minneapolis, Minn.: Bull. 430, 1910, pp. 280–291.

——— Structural materials available in the vicinity of Austin, Tex.: Bull. 430, 1910, pp. 292–316.

——— The cement industry in the United States in 1912: Mineral Resources U. S. for 1912, 1913.

BUTTS, CHARLES, Sand-lime brick making near Birmingham, Ala.: Bull. 315, 1907, pp. 256–258. 50c.

——— Ganister in Blair County, Pa.: Bull. 380, 1909, pp. 337–342. 40c.

CATLETT, C., Cement resources of the valley of Virginia: Bull. 225, 1904, pp. 457–461. 35c.

CLAPP, F. G., Limestones of southwestern Pennsylvania: Bull. 249, 1905, 52 pp.

CRIDER, A. F., Cement resources of northeast Mississippi: Bull. 260, 1905, pp. 510–521. Exhausted.

——— Geology and mineral resources of Mississippi: Bull. 283, 1906, 99 pp.

DARTON, N. H., Geology and water resources of the northern portion of the Black Hills and adjoining regions in South Dakota and Wyoming: Prof. Paper 65, 1909, 104 pp.

——— Structural materials in parts of Oregon and Washington: Bull. 387, 1909, 36 pp.

——— Cement materials in Republican Valley, Nebraska: Bull. 430, 1910, pp. 381–387.

DARTON, N. H., and SIEBENTHAL, C. E., Geology and mineral resources of the Laramie Basin, Wyoming: Bull. 364, 1908, 81 pp.

DURYEE, E., Cement investigations in Arizona: Bull. 213, 1903, pp. 372–380. 25c.

ECKEL, E. C., Cement-rock deposits of the Lehigh district: Bull. 225, 1904, pp. 448–450. 35c.

——— Cement materials and cement industries of the United States: Bull. 243, 1905, 395 pp. 65c.

——— The American cement industry: Bull. 260, 1905, pp. 496–505. Exhausted.

——— Portland cement resources of New York: Bull. 260, 1905, pp. 522–530. Exhausted.

——— Cement resources of the Cumberland Gap district, Tennessee-Virginia: Bull. 285, 1906, pp. 374–376. Exhausted. Available for reference in larger public libraries.

——— Portland cement materials of the United States, with contributions by E. F. Burchard and others: Bull. 522, 1913, 401 pp.

ECKEL, E. C., and CRIDER, A. F., Geology and cement resources of the Tombigbee River district, Mississippi-Alabama: Senate Doc. 165, 58th Cong., 3d sess., 1905, 21 pp.

FENNEMAN, N. M., Geology and mineral resources of the St. Louis quadrangle, Missouri-Illinois: Bull. 438, 1911, 73 pp.

*HUMPHREY, R. L., The effects of the San Francisco earthquake and fire on various structures and structural materials: Bull. 324, 1907, pp. 14–61. 50c.

*——— Organization, equipment, and operation of the structural-materials testing laboratories at St. Louis, Mo.: Bull. 329, 1908, 85 pp. 20c.

*——— Portland cement mortars and their constituent materials: Results of tests, 1905 to 1907: Bull. 331, 1908, 130 pp. 25c.

*——— The strength of concrete beams; results of tests made at the structural-materials testing laboratories: Bull. 344, 1908, 59 pp. 10c.

*——— The fire-resistive properties of various building materials: Bull. 370, 1909, 99 pp. 30c.

KÜMMEL, H. B., and others, Raritan (N. J.) folio (No. 191), Geol. Atlas U. S. (in press). 25c.

LANDES, H., Cement resources of Washington: Bull. 285, 1906, pp. 377–383. Exhausted. May be seen at many public libraries.

MARTIN, G. C., The Niobrara limestone of northern Colorado as a possible source of Portland cement material: Bull. 380, 1909, pp. 314–326. 40c.

PEPPERBERG, L. J., Cement material near Havre, Mont.: Bull. 380, 1909, pp. 327–336. 40c.

RICHARDSON, G. B., Portland cement materials near El Paso, Tex.: Bull. 340, 1908, pp. 411–414. 30c.

RUSSELL, I. C., The Portland cement industry in Michigan: Twenty-second Ann. Rept., pt. 3, 1902, pp. 620–686. $2.

*SEWELL, J. S., The effects of the San Francisco earthquake on buildings, engineering structures, and structural materials: Bull. 324, 1907, pp. 62–130. 50c.

SHAW, E. W., Gravel and sand in the Pittsburgh district, Pennsylvania: Bull. 430, 1910, pp. 388–399.

SMITH, E. A., The Portland cement materials of central and southern Alabama-Senate Doc. 19, 58th Cong., 1st sess., 1903, pp. 12–23.

——— Cement resources of Alabama: Bull. 225, 1904, pp. 424–447. 35c.

TAFT, J. A., Chalk of southwestern Arkansas, with notes on its adaptability to the manufacture of hydraulic cements: Twenty-second Ann. Rept., pt. 3, 1902, pp. 687–742. $2.

SURVEY PUBLICATIONS ON CLAYS, FULLER'S EARTH, ETC.

In addition to the papers named below, some of the publications listed on pages 375–376 and certain of the geologic folios contain references to clays. These publications, except those to which a price is affixed, can be obtained free by applying to the Director, United States Geological Survey, Washington, D. C. The priced publications may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C. The publications marked "Exhausted" are no longer available for distribution but may be consulted at the larger libraries of the country.

ADAMS, G. I., and HAWORTH, ERASMUS, Economic geology of the Iola quadrangle, Kansas: Bull. 238, 1904, pp. 69–74. 25c.

ALDEN, W. C., Fuller's earth and brick clays near Clinton, Mass.: Bull. 430, 1910, pp. 402–404.

ASHLEY, G. H., Notes on clays and shales in central Pennsylvania: Bull. 285, 1906, pp. 442–444. Exhausted.

ASHLEY, H. E., The colloid matter of clay and its measurement: Bull. 388, 1909, 65 pp.

BASTIN, E. S., Clays of the Penobscot Bay region, Maine: Bull. 285, 1906, pp. 428–431. Exhausted.

BRANNER, J. C., Bibliography of clays and the ceramic arts: Bull. 143, 1896, 114 pp. Exhausted.

——— The clays of Arkansas: Bull. 351, 1908, 247 pp.

BUTTS, CHARLES, Economic geology of the Kittanning and Rural Valley quadrangles, Pennsylvania: Bull. 279, 1906, pp. 162–171. 50c.

——— Clays of the Birmingham district, Alabama: Bull. 315, 1907, pp. 291–295. 50c.

CRIDER, A. F., Clays of Western Kentucky and Tennessee: Bull. 285, 1906, pp. 417–427. Exhausted.

DARTON, N. H., Geology and water resources of the northern portion of the Black Hills and adjoining regions in South Dakota and Wyoming: Prof. Paper 65, 1909, 106 pp.

——— Economic geology of Richmond, Va., and vicinity: Bull. 483, 1911, 48 pp.

DARTON, N. H., and SIEBENTHAL, C. E., Geology and mineral resources of the Laramie Basin, Wyoming; a preliminary report: Bull. 364, 1909, 81 pp.

DEUSSEN, ALEXANDER, Notes on some clays from Texas: Bull. 470, 1911, pp. 302–352.

ECKEL, E. C., Stoneware and brick clays of western Tennessee and northwestern Mississippi: Bull. 213, 1903, pp. 382–391. 25c.

——— Clays of Garland County, Ark.: Bull. 285, 1906, pp. 407–411. Exhausted.

FENNEMAN, N. M., Clay resources of the St. Louis district, Missouri: Bull. 315, 1907, pp. 315–321. 50c.

——— Geology and mineral resources of the St. Louis quadrangle, Missouri-Illinois: Bull. 438, 1911, 73 pp.

Fisher, C. A., The bentonite deposits of Wyoming: Bull. 260, 1905, pp. 559–563. Exhausted.

——— Clays in the Kootenai formation near Belt, Mont.: Bull. 340, 1908, pp. 417–423. 30c.

Fuller, M. L., Clays of Cape Cod, Massachusetts: Bull. 285, 1906, pp. 432–441. Exhausted.

Hill, R. T., Clay materials of the United States: Mineral Resources U. S. for 1891, 1893, pp. 474–528, 50c.; idem for 1892, 1893, pp. 712–738, 50c.; idem for 1893, 1894, pp. 603–617, 50c.

Katz, F. J., Clay in the Portland region, Maine: Bull. 530, pp. 202–206, 1913.

Landes, Henry, The clay deposits of Washington: Bull. 260, 1905, pp. 550–558. 40c. Exhausted.

Lines, E. F., Clays and shales of the Clarion quadrangle, Clarion County, Pa.: Bull. 315, 1907, pp. 335–343. 50c.

Matson, G. C., Notes on the clays of Florida: Bull. 380, 1909, pp. 346–356. 40c.

——— Notes on the clays of Delaware: Bull. 530, 1913, pp. 185–201.

Middleton, Jefferson, Clay-working industries in the U. S. in 1912: Mineral Resources U. S. for 1912, 1913.

——— Fuller's earth in 1912: Mineral Resources U. S. for 1912, 1913.

——— Pottery industry in U. S. in 1912: Mineral Resources U. S. for 1912, 1913.

Miser, H. D., Developed deposits of fuller's earth in Arkansas: Bull. 530, 1913, pp. 207–220.

Phalen, W. C., Clay resources of northeastern Kentucky: Bull. 285, 1906, pp. 412–416. Exhausted.

——— Economic geology of the Kenova quadrangle, Kentucky, Ohio, and West Virginia: Bull. 349, 1908, pp. 112–122.

Phalen, W. C., and Martin, Lawrence, Clays and shales of southwestern Cambria County, Pa.: Bull. 315, 1907, pp. 344–354. 50c.

——— ——— Mineral resources of Johnstown, Pa., and vicinity: Bull. 447, 1911, 140 pp.

Porter, J. T., Properties and tests of fuller's earth: Bull. 315, 1907, pp. 268–290. 50c.

Richardson, G. B., Clay near Calhan, El Paso County, Colo.: Bull. 470, 1911, pp. 293–296.

Ries, Heinrich, Technology of the clay industry: Sixteenth Ann. Rept., pt. 4, 1895, pp. 523–575. $1.20.

——— The pottery industry of the United States: Seventeenth Ann. Rept., pt. 3, 1896, pp. 842–880. $1.

——— Kaolins and fire-clays of Europe: Nineteenth Ann. Rept., pt. 6 (continued), 1898, pp. 377–467.

——— The clay-working industry of the United States in 1897: Nineteenth Ann. Rept., pt. 6 (continued), 1898, pp. 469–486.

——— The clays of the United States east of the Mississippi River: Prof. Paper 11, 1903, 298 pp. 40c.

Schrader, F. C., and Haworth, Erasmus, Clay industries of the Independence quadrangle, Kansas: Bull. 260, 1905, pp. 546–549. Exhausted.

Shaler, M. K., and Gardner, J. H., Clay deposits of the western part of the Durango-Gallup coal field of Colorado and New Mexico: Bull. 315, 1907, pp. 296–302. 50c.

Shaler, N. S., Woodworth, J. B., and Marbut, C. F., The glacial brick clays of Rhode Island and southeastern Massachusetts: Seventeenth Ann. Rept., pt. 1, 1896, pp. 957–1004. $2.

Shaw, E. W., Clay resources of the Murphysboro quadrangle, Illinois: Bull. 470, 1911, pp. 297–301.

SIEBENTHAL, C. E., Bentonite of the Laramie Basin, Wyoming: Bull. 285, 1906, pp. 445–447. Exhausted.

STOSE, G. W., White clays of South Mountain, Pennsylvania: Bull. 315, 1907, pp. 322–334. 50c.

UDDEN, J. A., Geology and mineral resources of the Peoria quadrangle, Illinois: Bull. 506, 1912, 103 pp.

VAN HORN, F. B., Fuller's earth: Mineral Resources U. S. for 1907, pt. 2, 1908, pp. 731–734. $1.

VAUGHAN, T. W., Fuller's earth of southwestern Georgia and Florida: Mineral Resources U. S. for 1901, 1902, pp. 922–934. 70c.

——— Fuller's earth deposits of Florida and Georgia: Bull. 213, 1903, pp. 392–399. 25c.

VEATCH, OTTO, Kaolins and fire clays of central Georgia: Bull. 315, 1907, pp. 303–314. 50c.

WOOLSEY, L. H., Clays of the Ohio Valley in Pennsylvania: Bull. 225, 1904, pp. 463–480. 35c.

——— Economic geology of the Beaver quadrangle, Pennsylvania: Bull. 286, 1906, pp. 55–65.

SURVEY PUBLICATIONS ON GYPSUM AND PLASTERS.

The more important publications of the United States Geological Survey on gypsum and plasters are included in the following list. These publications, except those to which a price is affixed, can be obtained free by applying to the Director, United States Geological Survey, Washington, D. C. The priced publications may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C. The publications marked "Exhausted" are no longer available for distribution, but may be consulted at the larger libraries of the country.

Adams, G. I., and others, Gypsum deposits of the United States: Bull. 223, 1904, 123 pp. 25c.

Boutwell, J. M., Rock gypsum at Nephi, Utah: Bull. 225, 1904, pp. 483–487. 35c.

Burchard, E. F., Gypsum deposits in Eagle County, Colo.: Bull. 470, 1911, pp. 354–366.

Darton, N. H., and Siebenthal, C. E., Geology and mineral resources of the Laramie Basin, Wyoming; a preliminary report: Bull. 364, 1909, 81 pp.

Eckel, E. C., Gypsum and gypsum products: Mineral Resources U. S. for 1905, 1906, pp. 1105–1115. $1.

Harder, E. C., The gypsum deposits of the Palen Mountains, Riverside County, Cal.: Bull. 430, 1910, pp. 407–416.

Hess, F. L., A reconnaissance of the gypsum deposits of California: Bull. 413, 1910, 37 pp.

——— Gypsum deposits near Cane Springs, Kern County, Cal.: Bull. 430, 1910, pp. 417–418.

Lupton, C. T., Gypsum along the west flank of the San Rafael Swell, Utah: Bull. 530, 1913, pp. 221–231.

Richardson, G. B., Salt, gypsum, and petroleum in trans-Pecos Texas: Bull. 260, 1905, pp. 573–585. Exhausted.

Shaler, M. K., Gypsum in northwestern New Mexico: Bull. 315, 1907, pp. 260–265. 50c.

Siebenthal, C. E., Gypsum of the Uncompahgre region, Colorado: Bull. 285, 1906. pp. 401–403. Exhausted.

——— Gypsum deposits of the Laramie district, Wyoming: Bull. 285, 1906, pp. 404–405. Exhausted.

Stone, R. W., Gypsum industry in 1912: Mineral Resources U. S. for 1912, 1913.

Stose, G. W., Geology of the salt and gypsum deposits of southwestern Virginia. Bull. 530, 1913, pp. 232–255.

SURVEY PUBLICATIONS ON GLASS SAND AND GLASS-MAKING MATERIALS.

The list below includes the important publications of the United States Geological Survey on glass sand and glass-making materials. These publications, except those to which a price is affixed, can be obtained free by applying to the Director, United States Geological Survey, Washington, D. C. The priced publications may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C. The publications marked "Exhausted" are no longer available for distribution, but may be consulted at many public libraries.

BURCHARD, E. F., Requirements of sand and limestone for glass making: Bull. 285, 1906, pp. 452–458. Exhausted.

——— Glass sand of the middle Mississippi basin: Bull. 285, 1906, pp. 459–472. Exhausted.

——— Glass-sand industry of Indiana, Kentucky, and Ohio: Bull. 315, 1907, pp. 361–376. 50c.

——— Notes on glass sands from various localities, mainly undeveloped: Bull. 315, 1907, pp. 377–382. 50c.

FENNEMAN, N. M., Geology and mineral resources of the St. Louis quadrangle, Missouri-Illinois: Bull. 438, 1911, 73 pp.

PHALEN, W. C., and MARTIN, LAWRENCE, Mineral resources of Johnstown, Pa., and vicinity: Bull. 447, 1911, 140 pp.

STONE, R. W., Sand and gravel in 1912: Mineral Resources U. S. for 1912, 1913.

STOSE, G. W., Glass-sand industry in eastern West Virginia: Bull. 285, 1906, pp. 473–475. Exhausted.

WEEKS, J. D., Glass materials: Mineral Resources U. S. for 1883–84, 1885, pp. 958–973, 60c.; idem for 1885, 1886, pp. 544–555, 40c.

SURVEY PUBLICATIONS ON LIME AND MAGNESITE.

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 under the heads "Cement" and "Building stone." These publications, except Bullletins 285 and 315, can be obtained free by applying to the Director, United States Geological Survey, Washington, D. C. Bulletin 315 can be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C.

Bastin, E. S., The lime industry of Knox County, Me.: Bull. 285, 1906, pp. 393–400. Exhausted. May be seen at many public libraries.

Burchard, E. F., Butts, Charles, and Eckel, E. C., Iron ores, fuels, and fluxes of the Birmingham district, Alabama: Bull. 400, 1910, 204 pp.

Butts, Charles, Limestone and dolomite in the Birmingham district, Alabama: Bull. 315, 1907, pp. 247–255. 50c.

Hess, F. L., The magnesite deposits of California: Bull. 355, 1908, 67 pp.

Ries, Heinrich, The limestone quarries of eastern New York, western Vermont, Massachusetts, and Connecticut: Seventeenth Ann. Rept., pt. 3 (continued), 1896, pp. 795–811.

Stone, R. W., Lime in 1912: Mineral Resources U. S. for 1912, 1913.

Yale, C. G., and Gale, H. S., Magnesite in 1912: Mineral Resources U. S. for 1912, 1913.