

GEOLOGICAL SURVEY OF GEORGIA

W. S. YEATES, State Geologist

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BULLETIN NO. II.

A PRELIMINARY REPORT

ON THE

BAUXITE DEPOSITS

OF

GEORGIA

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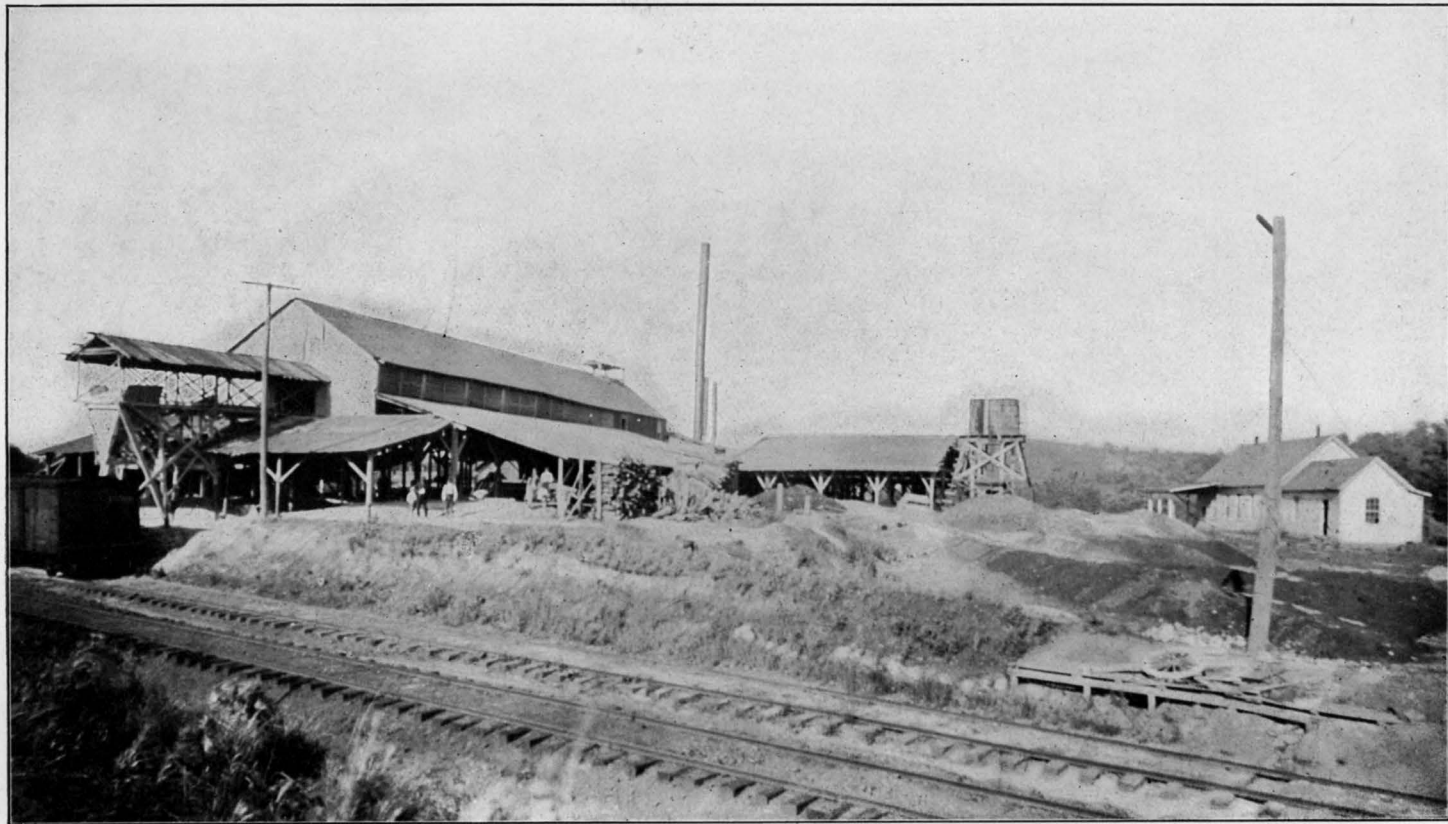
BY

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1904



THE DRYING PLANT AND OFFICE OF THE SOUTHERN BAUXITE COMPANY, CAVE SPRING, FLOYD COUNTY, GEORGIA.

THE ADVISORY BOARD  
of the  
Geological Survey of Georgia

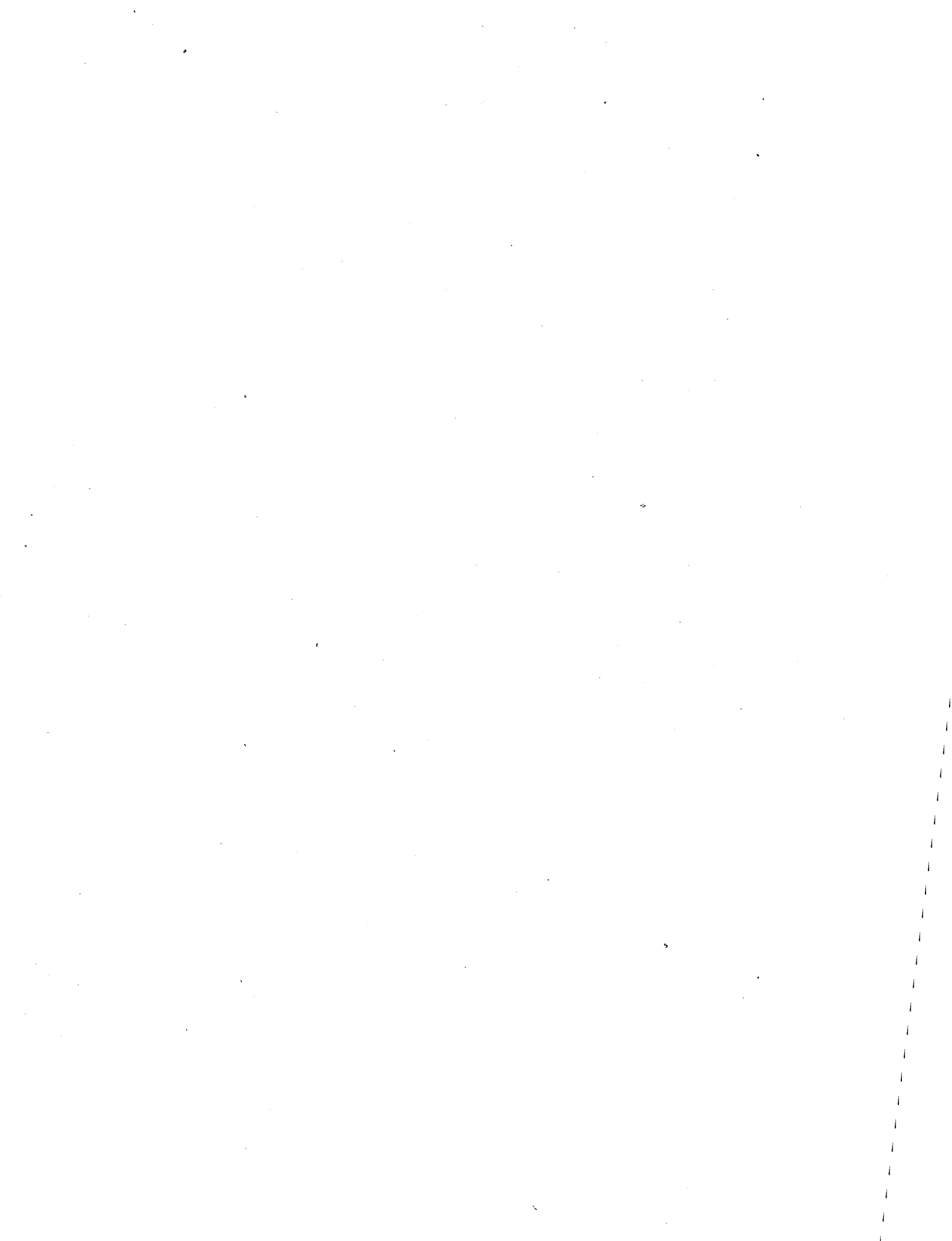
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## LETTER OF TRANSMITTAL

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GEOLOGICAL SURVEY OF GEORGIA,  
Atlanta, March 20, 1903.

*To His Excellency, J. M. TERRELL, Governor.*

SIR:— I have the honor to submit the report of Dr. Thomas L. Watson, formerly Assistant State Geologist, on the Bauxite Deposits of Georgia, to be published as Bulletin No. 11 of this Survey.

Very respectfully yours,

W. S. YEATES,  
State Geologist.



## INTRODUCTION

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This report embodies the results obtained from a detailed field-study of the bauxite area in Georgia, supplemented by subsequent laboratory-study of the material collected in the field. The results are based on field examinations of all the known deposits of this mineral in the State, and a study of the general geologic conditions of the region, that bear directly on the economic features and genesis of the ore-bodies.

As seen from the accompanying map, the distribution of the bauxite deposits is limited for the most part to the Coosa Valley region of the State. This area includes five of the central and southern northwestern counties of the so-called Paleozoic Group. The bauxite belt begins with the most northerly deposits of Gordon and Walker counties, and extends in a southwesterly direction for approximately 60 miles in Georgia, and is continuous for nearly a like distance and direction in Alabama.

The field-work was greatly facilitated by the carefully prepared topographic and geologic maps of the United States Geological Survey, based on a detailed survey of the region by Dr. C. W. Hayes; and also, by similar work of former State Geologist J. W. Spencer. Owing to an extended and detailed study of the region in question, by the National and State Surveys, its general geology is the most complete of any area in the State. Apart from a detailed study of its general geology, both Hayes and Spencer have given special attention to the deposits of bauxite.

Hayes has published numerous papers and monographs on the various structural and economic phases of the geology of the Paleozoic Group in Georgia, which have appeared, from time to time, in the Bulletin of the Geological Society of America; the Transactions of the American Institute of Mining Engineers; and the Annual Reports and Folios of the United States Geological Survey. Spencer's report on the Paleozoic Group of Georgia con-

tains much information on the bauxite deposits, that is of value. The writer has drawn freely from these various papers<sup>1</sup> in the preparation of this report, for which credit is given in the text. Owing to the careful manner, in which the general geology of the region has previously been worked up and reported, the writer's efforts were directed more particularly to the individual deposits of bauxite and their economic bearing.

In conclusion, I wish to acknowledge the generous aid of numerous gentlemen, afforded me in the prosecution of the work, without which a much longer time would have been necessary for its completion. More particularly, am I indebted to Mr. John H. Hawkins, of Hermitage, Georgia, Superintendent of the Republic Mining and Manufacturing Company; Mr. R. S. Perry, of Cave Spring, Georgia, General Manager of the Southern Bauxite Mining and Manufacturing Company; Mr. B. F. A. Saylor, of Rome, Georgia, General Manager of the Dixie Bauxite Company; and Mr. A. W. Bobo, of Van's Valley, Georgia; for valuable help and information. I wish, also, to acknowledge my indebtedness to Prof. W. S. Yeates, State Geologist, for making the negatives of the various subjects, illustrated by half-tone plates in this bulletin.

- <sup>1</sup> Hayes, C. W., *The Overthrust Faults of the Southern Appalachians*,  
Bull., Geol. Soc. America, 1891, Vol. 2, pp. 141-154.
- " , *Report on the Geology of North-Eastern Alabama, and Adjacent Portions of Georgia and Tennessee*, Geol. Surv. of Alabama, 1892, pp. 1-85.
- " , *Geology of a Portion of the Coosa Valley in Georgia and Alabama*,  
Bull., Geol. Soc. America, 1894, Vol. 5, pp. 465-480.
- " , *The Geological Relations of the Southern Appalachian Bauxite-Deposits*,  
Trans., Amer. Inst. Min. Engineers, Virginia Beach Meeting,  
Feby., 1894, pp. 1-12.
- " , *Bauxite*, Sixteenth Ann. Rept., U. S. Geol. Surv., Part III, 1893-'94 (1895), pp  
547-597.
- " , *The Southern Appalachians*, National Geographic Monographs, 1895, Vol. I,  
No. 10, pp. 305-336.
- " , *Physiography of the Chattanooga District in Tennessee, Georgia and Alabama*,  
Nineteenth Ann. Rept., U. S. Geol. Surv., 1897-'98 (1899), Part  
II, pp. 1-58.
- Hayes, C. W., & Campbell, M. R., *Geomorphology of the Southern Appalachians*,  
National Geographic Magazine, 1894, Vol. VI, pp. 63-126.
- Willis, Bailey, & Hayes, C. W., *Conditions of Appalachian Faulting*,  
Amer. Jour. Science, 1893, Vol. XLVI, pp. 257-268.
- Spencer, J. W., *The Paleozoic Group*, Geol. Surv. of Georgia, 1893, pp. 1-406.
- McCalley, Henry, *Report on the Valley Regions of Alabama. Part II, On the Coosa Valley Re-  
gion*, Geol. Surv. of Alabama, 1897, pp. 1-862.

# THE BAUXITE DEPOSITS OF GEORGIA

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## CHAPTER I

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### THE DISTRIBUTION AND GENERAL OCCURRENCE OF BAUXITE, WITH A BRIEF DESCRIPTION OF THE KNOWN WORKABLE AREAS

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#### THE OCCURRENCE AND DISTRIBUTION OF BAUXITE

The known distribution of bauxite in commercially workable deposits is exceedingly limited. At present, the known workable deposits of this mineral are limited exclusively to a few localities in Europe and the United States. Its occurrence in Europe is in France, Germany, Austria and Ireland; and, in the United States, in the Coosa Valley of Georgia and Alabama, and in Arkansas and New Mexico. A majority of these localities have been worked, to some extent, resulting in the removal of a considerable quantity of bauxite from most of them; and all, thus far exploited, indicate large, but somewhat limited, supplies of the ore.

#### EUROPEAN LOCALITIES

FRANCE. — Bauxite was first discovered in 1821, by the famous chemist, Berthier, at the Village of Baux, Bouches du Rhone, in Southern France, from which locality the mineral takes its name. This is described as a highly ferriferous, pisolitic variety of bauxite. The Baux deposits were the first to be worked, and are, accordingly, the most widely known deposits of the mineral. The French deposits have been extensively and almost continuously

worked, since 1872, resulting in the production of large quantities of the ore. They vary between 66 and 79 per cent. in aluminum oxide.

As described by Coquand<sup>1</sup> and Augé,<sup>2</sup> the ore is of the pisolitic type. The deposits are 30 feet or more in thickness, and occur alternating with beds of limestone, pisolitic sandstones and clays, of Upper Cretaceous age. The rocks of the region are described as having been much disturbed, and are highly tilted. Both the bauxite and the overlying alternating beds are distinctly stratified, and bear the same characteristics as similar beds deposited in lacustrine or estuarine bodies of water. According to those geologists, who have studied them in greatest detail, it is thought, that they represent the products of a Cretaceous lake or estuary. The Baux deposits, discovered by Berthier, are characterized by Laur<sup>3</sup> as impure, more or less ferruginous and siliceous bauxite.

The deposits at Thoronet and Villeveyrac are very similar in geologic occurrence to those at Baux. They rest on an eroded surface of limestone, of Cretaceous or Jurassic age, and alternate with various lacustral formations. The Villeveyrac deposits are characterized in general by their prevailingly small amounts of iron oxide; while those at Thoronet are non-pisolitic, breaking with a conchoidal fracture, and are dark-red in color. In the Thoronet type, the silica is said to be almost wholly replaced by ferric oxide.

The following is an analysis of the bauxite found near Villeveyrac (Hérault, France):—<sup>4</sup>

Al <sub>2</sub> O <sub>3</sub> . . . . .	82.00
Fe <sub>2</sub> O <sub>3</sub> . . . . .	0.10
SiO <sub>2</sub> . . . . .	2.00
H <sub>2</sub> O . . . . .	14.20
Undetermined . . . . .	1.70
Total . . . . .	<u>100.00</u>

<sup>1</sup> Coquand, M. H., *Sur les Bauxites de la chaîne des Alpes (Bouches-du-Rhône) et leur âge géologique*. *Bulletin de la Société Géologique de France*, 2nd Ser., 1870-'71, XXVIII, pp. 98-115.

<sup>2</sup> Augé, M., *Note sur la Bauxite, son origine, son âge et son importance géologique*. *Bulletin de la Société Géologique de France*, 3rd Ser., 1888, XVI, p. 345.

<sup>3</sup> Laur, Francis, *The Bauxites: A Study of a New Mineralogical Family*, *Trans. Amer. Inst. Mining Engineers, Virginia Beach Meeting, February, 1894*.

<sup>4</sup> *Ibid.*

Laur states, that this "is a native monohydrate of alumina,  $\text{Al}_2\text{O}_3 \cdot \text{H}_2\text{O}$ ."

The deposits at Puy-du-Dôme, France, differ from the other French deposits, in resting directly on an eroded surface of gneiss instead of limestone, and they are covered by basalt and clays of Miocene age. The Puy-du-Dôme beds will average from 15 to 75 feet in thickness, and are said to be associated with gneissic and basaltic rocks. The entire section is marked by the absence of associated limestone; and, in mode of occurrence and associated rocks, the Puy-du-Dôme deposits bear a striking resemblance to those of Germany.

Both Coquand and Augé ascribe the French deposits to the action of hot springs and geysers in lakes, in which the material was deposited along with other sediments. The following analyses of the bauxite from Baux will give some idea of the composition of the ore:—<sup>1</sup>

$\text{Al}_2\text{O}_3$ . . . . .	60.0	75.0
$\text{Fe}_2\text{O}_3$ . . . . .	25.0	12.0
$\text{SiO}_2$ . . . . .	3.0	1.0
$\text{H}_2\text{O}$ . . . . .	12.0	12.0

GERMANY.—Bauxite occurs at a number of localities in Germany, characterized, as a rule, by a marked difference in type from the French ores. The deposits in the vicinity of Vogelsberg are perhaps the best known of the German beds. The mineral occurrence is in small masses embedded in a vari-colored clay. Associated in the same clay with the bauxitic masses, are similar masses of iron ore and weathered fragments of basalt. The clay, containing the masses of ore and basalt, is further characterized by a rather pronounced stratification in places. Petrographic study of these deposits, by several of the German geologists, indicate, that certain of them are derived from the decomposition of the closely associated basalt.

The following notes relating to the occurrence of the German deposits are taken from George P. Merrill's "Guide to the Study of the Collections in the Section of Applied Geology. The Non-

<sup>1</sup> Richards, Joseph W., Aluminium, Baird & Company, Philadelphia, 3rd Edition, 1896, p. 42.

metallic Minerals" [U. S. National Museum]<sup>1</sup>, in which he quotes from a paper by R. L. Packard:—<sup>2</sup>

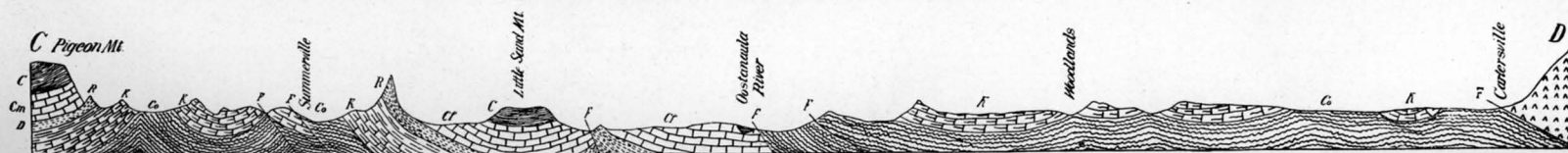
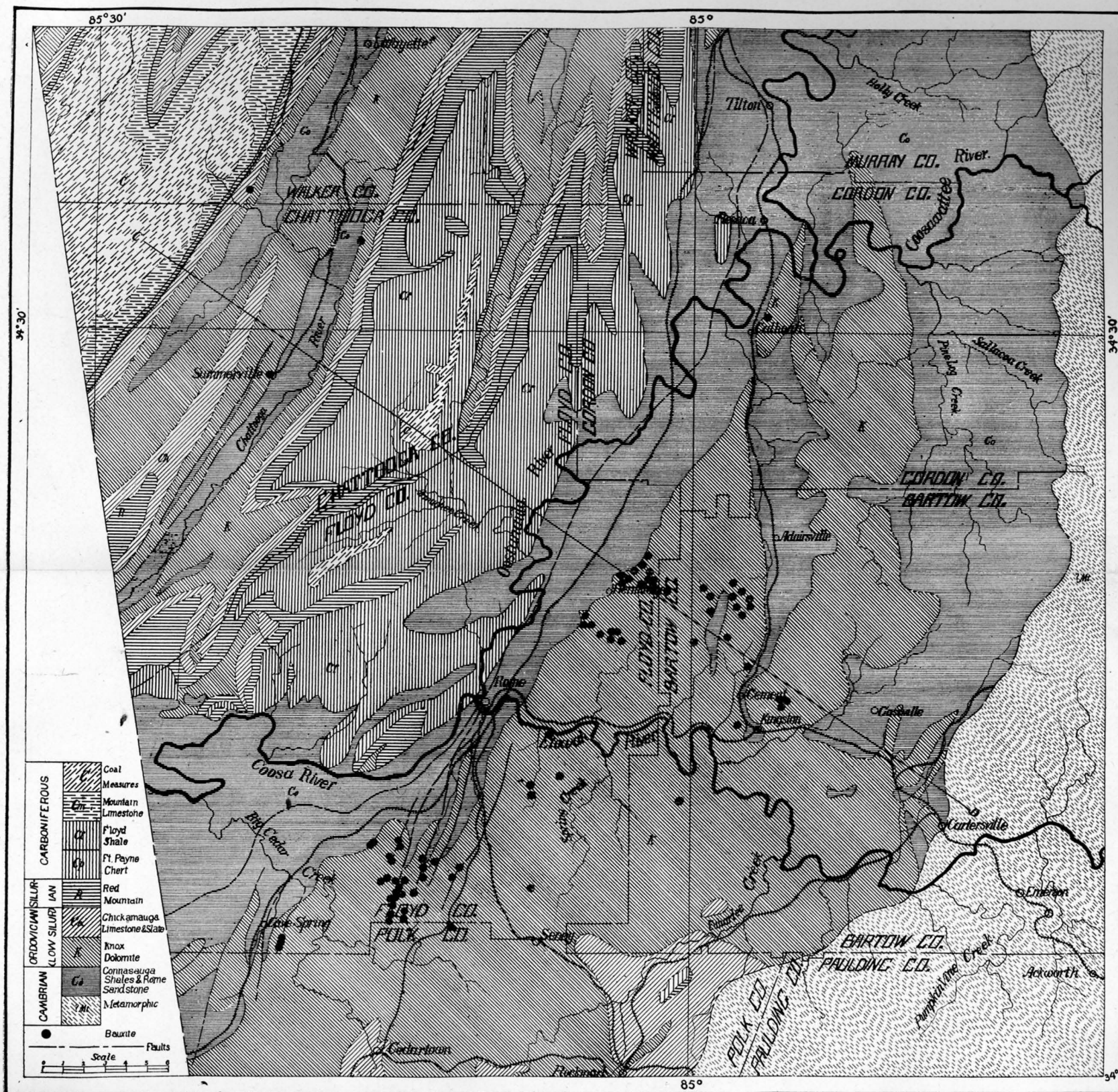
"The first is a paper by Lang [in the *Berichte der Deutschen Chemischen Gesellschaft*, XVII, 1884, p. 2892]. He describes the bauxite in Ober-Hessen, which is found in the fields in round masses up to the size of a man's head, embedded in a clay which is colored with iron oxide. The composition varies very widely. The petrographical examination showed silica, iron oxide, magnetite, and augite. The chemical composition and petrographical examination show the bauxite to be a decomposition product of basalt. By the weathering of the plagioclase feldspars, augite, and olivine, nearly all the silica had been removed, together with the greater part of the lime and magnesia; the iron had been oxidized and hydrate of alumina formed as shown by its easy solubility in hydrochloric acid. The residue of the silica had crystallized as quartz in the pores of the mineral.

"The more detailed account of the derivation of bauxite from basalt is given in an inaugural dissertation by A. Liebreich, abstracted in the *Chemisches Centralblatt*, 1892, p. 94. This writer says that the well-known localities of bauxite in Germany are the southern slope of the Westerwald near Mühlbach, Hadamar, in the neighborhood of Lesser Steinheim, near Hanau, and especially the western slope of the Vogelsberg. Chemical analyses show certain differences in the composition of bauxite from different places, the smaller amount of water in the French bauxite referring it to diaspore, while the Vogelsberg mineral is probably gibbsite (hydrargillite). The bauxites of Ireland, of the Westerwald, and the Vogelsberg, show by certain external indications their derivation from basalt. The bauxite of the Vogelsberg occurs in scattered lumps or small masses, partly on the surface and partly embedded in a grayish white to reddish brown clay, which contains also similar masses of basaltic iron ore and fragments of more or less weathered basalt itself. Although the latter was associated intimately with the bauxite, a direct and close connection of the two could not be found, but an examination of thin sections of the Vogelsberg bauxite showed that most specimens still possessed a basaltic (anamesite) structure, which enabled the author to determine the former constituents with more or less certainty. The clays from different points in the district carrying basalt, basaltic iron ore, and bauxite were examined, some of which showed clearly a sedimentary character. Some of the bauxite nodules were a foot and a half in diameter and possessed no characteristic form. They were of an uneven surface, light to dark brown, white, yellowish, and gray in color, speckled and pitted, sometimes finely porous and full of small colorless or yellowish crystals of hydrargillite. The thin sections showed distinct medium-granular anamesitic structure. Lath-shaped portions filled with a yellowish substance preponderated (the former plagioclases) and filling the spaces between these were cloudy, yellow, brown, and black transparent masses which had evidently taken the place of the former augite. Laths and plates of titanitic iron, often fractured, were commonly present and the contours of altered olivine could be clearly made out. The anamesitic basalt of the neighborhood showed a structure fully corresponding with the bauxite. Olivine and titanitic iron oxide were found in the clay by washing. The basaltic iron ore also showed the anamesite structure."

<sup>1</sup> *Report of the U. S. National Museum for 1899* (1901), pp. 231-233.

<sup>2</sup> *Mineral Resources of the United States*, 1891, p. 149 et seq.





Map Showing the Distribution of the Bauxite Deposits of Georgia.

Important deposits of the mineral are said to be found in Styria at Wochein, and at Freistritz in Austria. The mineral from the former locality, Wochein, is called Wocheinite. It is said to differ from the French mineral in being dense and earthy in structure. The following are analyses of the dark and light colored Wocheinite:—<sup>1</sup>

	Dark	Light
Al <sub>2</sub> O <sub>3</sub> . . . . .	63.13	72.87
Fe <sub>2</sub> O <sub>3</sub> . . . . .	23.55	13.49
SiO <sub>2</sub> . . . . .	4.15	4.25
Na <sub>2</sub> O } . . . . .	0.79	0.78
K <sub>2</sub> O } . . . . .		
H <sub>2</sub> O . . . . .	8.34	8.50

The following analyses of the German bauxite, representing three different localities, will indicate to some degree the composition of the ores:—<sup>2</sup>

	Hadamar	Hesse	Klein Steinheim	Langsdorff
Al <sub>2</sub> O <sub>3</sub> . . . . .	45.76	55.61	76.3	50.85 49.02
Fe <sub>2</sub> O <sub>3</sub> . . . . .	18.96	7.17	6.2	14.36 12.90
SiO <sub>2</sub> . . . . .	6.41	4.41	11.0	5.14 10.27
(Na+K) <sub>2</sub> O . . . . .	0.38	—	—	0.26 0.31
H <sub>2</sub> O . . . . .	27.61	32.33	26.4	28.38 25.91

IRELAND.—The deposits of bauxite in Glenariff Valley, Ireland, are said to resemble those of Germany, in that they are intimately associated with volcanic rocks, from which they have been probably derived by decay. The ore occurs in the form of bedded deposits; and, in this particular, they resemble the French deposits. They are associated with flows of dolorite and beds of tuff, which both underlie and overlie the bauxite deposits, with the beds further overlain by pisolitic iron ore and clays. Hayes says,<sup>3</sup> that both the beds of iron ore and bauxite are probably lacustral deposits derived from the decay of the underlying dolorite and tuff; and that they probably represent both alteration in place and secondary replacement of the beds of volcanic rock.

The Irish bauxites are said to range high in alumina, silica and

<sup>1</sup> Richards, Joseph W., *Loc. Cit.*, p. 42.

<sup>2</sup> *Ibid.*

<sup>3</sup> Sixteenth Ann. Report, U. S. Geol. Survey, Part III, 1895, p. 549.

titanium oxide. The best material ranges as high as from 8 to 11 per cent. of silica, with about 6 per cent. of titanium oxide, and from 0.5 to 1.5 per cent. of iron oxide. Those, averaging low in silica, contain considerably over 10 per cent. of iron oxide. The composition of the Irish bauxite is shown, to some degree, in the following analyses:—<sup>1</sup>

	Irish Hill	County Antrim	Glenrave
Al <sub>2</sub> O <sub>3</sub> . . . . .	48.12	43.44	61.89
Fe <sub>2</sub> O <sub>3</sub> . . . . .	2.36	2.11	1.96
SiO <sub>2</sub> . . . . .	7.95	15.05	6.01
H <sub>2</sub> O . . . . .	40.33	35.70	27.82

FRENCH GUIANA.—Deposits of bauxite are also reported as occurring in French Guiana; but our knowledge concerning the mineral in this locality amounts to hardly more than a mention of its existence.

#### AMERICAN LOCALITIES

Thus far, the American localities include only three known areas of bauxite in commercial quantities. These are the Georgia-Alabama district; the Arkansas district; and a small area in southwestern New Mexico. Only two of these, the Coosa Valley deposits of Georgia and Alabama, and those of Arkansas, are available at present. The New Mexico deposits, should they prove to be in workable quantities, are not yet available, on account of inaccessibility and the lack of transportation facilities. The extent and character of the New Mexico deposits are but meagerly known.

ARKANSAS.—The bauxite deposits of Arkansas have been known since 1891, when they were discovered by the Geological Survey of Arkansas. They have been described by Branner,<sup>2</sup> Williams<sup>3</sup> and Hayes.<sup>4</sup> In 1891, Dr. John C. Branner, State Geologist of Arkansas, published an account of these deposits in the *American Geologist*, in which he advocated their genetic relationship to the eruptive syenites of that State. ;

<sup>1</sup> Richards, Joseph W., *Aluminium*, Baird & Co., Phila., 1896, 3rd Edition, p. 42.

<sup>2</sup> *Bauxite in Arkansas*, *American Geologist*, March, 1891, Vol. XII, pp. 181-183. *The Bauxite Deposits of Arkansas*, *Jour. of Geol.*, 1897, Vol. V.

<sup>3</sup> *Igneous Rocks of Arkansas*, *Ann. Rept. Geol. Surv. of Arkansas*, 1890, Vol. II, pp. 22, 29-31, 124-125 and 162.

<sup>4</sup> *The Arkansas Bauxite Deposits*, *Twenty First Ann. Rept. U. S. Geol. Surv.*, Part III, pp. 435-472.

Dr. Branner says : —

“The Arkansas beds occur near the railway in the vicinity of Little Rock, Pulaski County, and near Benton, Saline County. The exposures vary in size from an acre to twenty acres or more, and aggregate over a square mile. This does not in all probability include the total area covered by bauxite in the counties mentioned, for the method of occurrence of the deposits leads to the supposition that there are others as yet undiscovered by the Survey. In thickness the beds vary from a few feet to over 40 feet, with the total thickness undetermined; the average thickness is at least 15 feet.

“These Arkansas deposits occur only in Tertiary areas and in the neighborhood of eruptive syenites (“granites”), to which they seem to be genetically related. In elevation they occur only at and below 300 feet above tide level, and most of them lie between 260 and 270 feet above tide. They have soft Tertiary beds both above and below them at a few places, and must therefore be of Tertiary age. As a rule, however, they have no covering, the overlying beds having been removed by erosion, and are high enough above the drainage of the country to be readily quarried. Erosive action has removed a part of the bauxite in some cases, but there are in all probability many places at which it has not yet been even uncovered. It is pisolitic in structure, and, like all bauxite, varies more or less in color and in chemical composition. At a few places it is so charged with iron, that attempts have been made to mine it for iron ore. Some of the samples from these pits assay over 50 per cent. of metallic iron. This ferruginous kind is exceptional, however. From the dark-red varieties it grades through the browns and yellow to pearl-gray, cream-colored, and milky-white, the pinks, browns and grays being the more abundant. Some of the white varieties have the chemical composition of kaolin, while the red, brown, and gray have but little silica and iron, and a high percentage of alumina.”

The deposits form somewhat continuous beds, varying in thickness, and are beginning to attract considerable attention. Although known since 1891, only a small quantity of the ore has yet been shipped; but it is now stated, that preparations are being made for a large output in the near future. As a rule, the Arkansas deposits are less pure, and of a lower grade than those of the Georgia-Alabama area.

The following results closely approximate the general average composition of the Arkansas bauxite :—

	White	Red
SiO <sub>2</sub> . . . . .	10.0	4.0
Al <sub>2</sub> O <sub>3</sub> . . . . .	52.0	53.0
Fe <sub>2</sub> O <sub>3</sub> . . . . .	4.0	10.0
TiO <sub>2</sub> . . . . .	4.0	4.0
H <sub>2</sub> O . . . . .	30.0	29.0
Total . . . . .	100.0	100.0

Dr. C. W. Hayes, of the U. S. Geological Survey, spent some time, during the spring of 1900, in a detailed field-study of the Arkansas bauxite deposits; and his results are incorporated in a very full report, issued by the U. S. Geological Survey.<sup>1</sup> The principal points developed in this study by Doctor Hayes have been abstracted and are briefly outlined below by the present writer.

The bauxite area is 20 miles long by three to four miles wide, and extends in a southwesterly direction from near Little Rock. The deposits are spread out in beds or layers, ranging in thickness from nothing to 40 feet, with a probable average of 10 to 15 feet. The area is divided into two districts, which occupy the extremities of the area. Several scattered deposits occur between the two districts. In the Bryant district, which is the most southwesterly one, the ore occurs in two distinct forms: (1) granitic bauxite, and (2) pisolitic bauxite. The former, or granitic variety, forms the basal portions of the beds; and, in most cases, it rests immediately on a layer of kaolin derived by decay from the syenite. This type of ore is spongy in texture, showing partial traces of the granitic structure, in which the individual feldspars are replaced by a porous skeleton of alumina. It is probable, says Hayes, that this variety of bauxite is, in every case, derived, directly from the syenite, by the decomposition of the feldspar and *elæolite*; and, the removal in solution of silica, lime and alkalis, the alumina alone remaining, of the original constituents.

The pisolitic type of ore is more uniform, than that of the Georgia-Alabama district; and it forms the upper parts of the beds. In the same section, the two types of the ore are not separated, as a rule, by any sharp and definite line.

Thus far, only the pisolitic type of ore has been found in the Fourché mountain district, which, when nearest the syenite margin, rests directly on a layer of kaolin, as in the Bryant district. Those deposits, more distant from the syenite margin, are probably interstratified with sedimentary beds of Tertiary age.

The few scattered deposits, found between the two districts, are

<sup>1</sup> *The Bauxite Deposits of Arkansas*, Twenty First Ann. Rept., U. S. Geol. Surv., Part III, pp. 435-472.

said to resemble, in their mode of occurrence, the Georgia-Alabama deposits.

The chemical composition of the Arkansas bauxite varies within wide limits. The granitic type is the purest; and, in selected samples, it contains less than three per cent. of silica and one per cent. of iron oxide. It corresponds in composition to the formula  $\text{Al}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$ —the trihydrate of alumina, gibbsite. In the white bauxitic kaolins, the silica ranges as high as 20 to 30 per cent., and the iron oxide assays as much as 50 per cent. in some of the highly ferruginous types of material.

Concerning the origin of the Arkansas deposits, Dr. Hayes says, that they are so intimately associated with the igneous rocks of the region, that genetic relationship between the two is at once suggested. The characteristic pisolitic structure of the upper portion of the deposits indicates chemical precipitation. The granitic bauxite, forming the lower or basal portions of the beds, and the boulders, are evidently of a different origin from the pisolitic variety. The bauxite was probably laid down on the syenite rather than on the kaolin, as there is no indication that the kaolin is an intermediate product between the fresh syenite and the bauxite.

In his report on the igneous rocks of Arkansas, Dr. J. Francis Williams suggested two theories, to account for the deposition of the bauxite.<sup>1</sup> The first theory was, that the bauxite was formed by the decomposition of a bed of clastic material, which was derived principally from the syenite. The second one, which he regards as the more probable, involved the action of the waters of the Tertiary sea on the still highly heated igneous rocks, by which, under high temperature and pressure, the constituents of the syenite were dissolved and brought to the surface in solution, the water emerging as hot springs.

Dr. Hayes has pointed out, however, a number of serious objections to this theory; and, after a clear statement of the main or essential facts, which a theory for the origin of the bauxite deposits must explain, he has outlined the following one:—<sup>2</sup>

<sup>1</sup> *Op. cit.* p. 124.

<sup>2</sup> Twenty First Ann. Rept., U. S. Geol. Surv., Part III, pp. 464-465.

“The syenite of the bauxite region was intruded under a light cover of Paleozoic rocks. These were subjected to rapid erosion and the surface of the syenite was exposed. Either its subjacent portions retained a considerable portion of their original heat or a fresh supply of heat was furnished by renewed intrusions or dynamic disturbances. The region was then covered by a body of water probably cut off from the sea, and salt or highly alkaline. The alkaline waters by some means gained access to the heated portions of the syenite and dissolved its minerals. The heated waters returned to the surface heavily charged with the constituents of the syenite in solution. They were still efficient solvents, however, and acted upon the syenite at the surface, removing most of the silica along with the lime and alkalis, but leaving the alumina and depositing in place of the constituents removed about as much more alumina as the rock originally contained. Some of the alumina brought to the surface in solution was thus deposited by this metasomatic process, replacing a part of the silica removed from the syenite, but a larger part was thrown down as a gelatinous precipitate on the bottom of the water body and somewhat evenly distributed over the undulating syenite surface, at the same time acquiring the pisolitic structure and becoming mingled with the boulders of aluminized syenite. Most of the spring exits were in the immediate vicinity of the syenite areas, so that there the water was most strongly impregnated with the various salts in solution and hence precipitation of the alumina was most rapid. Wherever the ascending solutions found their way to the surface by an isolated conduit through the Tertiary sediments already deposited a local deposit of greater or less extent was formed. The precipitation of the alumina must have taken place almost immediately after the solution emerged from the conduit, otherwise the bauxite would have been much more widely disseminated, or even entirely dissipated, in the surrounding sediments.

“The formation of the bauxite bed marks a single episode in the history of the region, during which conditions were very exceptional. This episode was abruptly inaugurated and as abruptly terminated. Conditions returned to the normal, and the change from the unusual chemical deposits to the ordinary sedimentary beds is sharp and distinct. The formation of the chemical deposits may have been terminated by a cessation of circulation of the chemical solvent, by a sudden exhaustion of the heat supply, or by a change in the conditions of the water body in which the deposits were being formed. The latter cause appears the more probable one for the production of so abrupt a change. If such a water body were comparatively small, of exceptional composition, and protected from the incursion of detrital sediments, as appears probable, the establishing of free connection with the open sea would introduce changes which might completely alter the character of the deposits being formed.”

Dr. Hayes says, that the theory outlined above is the best at present available; though it is, he says, confessedly unsatisfactory and incomplete.

The following analyses will indicate the character and composition of the bauxite from Pulaski county, Arkansas: —<sup>1</sup>

<sup>1</sup> Spencer, J. W., *The Paleozoic Group*, Geol. Surv. of Georgia, 1893, p. 236.

Al <sub>2</sub> O <sub>3</sub> . . .	55.59	57.62	55.89	46.40	58.60	62.05	55.64	51.90
Fe <sub>2</sub> O <sub>3</sub> . . .	6.08	1.83	19.45	22.15	9.11	1.66	1.95	3.16
SiO <sub>2</sub> . . .	10.13	11.48	5.11	4.89	3.34	2.00	10.38	16.76
TiO <sub>2</sub> . . .	—	—	—	—	—	3.50	3.50	3.50
H <sub>2</sub> O . . .	28.99	28.63	17.39	26.68	28.63	30.31	27.62	24.86
Total . . .	100.79	99.56	97.84	100.12	99.68	99.52	99.09	100.28

NEW MEXICO.—The New Mexico deposits of bauxite occur in the southwest part of the Territory, near Silver City. They were first discovered some six or eight years ago; but, on account of their inaccessibility, they have never been worked. Exact information concerning these deposits has not yet been published. The most accurate account of them, known to the writer, is that given by Professor William P. Blake.<sup>1</sup> Mr. Blake describes the deposits of New Mexico in part, as follows:—

“In a region about half a mile square, of nearly horizontal strata of volcanic origin, there has been extensive alteration and change by solfataric action, or possibly by decomposition of disseminated pyrites producing aluminous solutions, which, flowing slowly by capillary movement from within outward, suffer decomposition at the surface with the production of sulphate of alumina (alunogen), in crusts and layers upon the outer portions of the rock, attended by the decomposition of siliceous crusts and the separation of ferric sulphate; while the rocks so traversed appear to be deprived of a part, at least, of their silica and of their alkalis with the formation of bauxite. The alunogen is thus an outer deposit, while the bauxite is not a deposit, but is an internal residual mass in place. Its color is generally bluish-white; structure amorphous, granular, without concentric or pisolitic grains. When dried in the sun and air it will still lose about 20 per cent. by ignition. It gives only about 1 per cent. of soluble matter by leaching with water; is infusible and reacts for alumina. The amount of residual silica and alkalis has not yet been ascertained, and no careful full analysis has been made. The composition is no doubt variable in samples from different places, for the original rocks give evidence of a great difference within short distances. The rocks appear to have been originally highly basic, volcanic porphyries and basalts, accumulated in massive beds of brecciated fragments, the outlines of which have nearly disappeared, so that the mass appears to be homogeneous; careful observation as the rocks are freshly broken out discloses, however, the outlines of former fragments.”

This description apparently indicates, that the bauxite deposits of New Mexico are somewhat closely similar to, though not entirely like, those at Vogelsberg, derived from a basic volcanic rock, by decomposition and alteration in place.

<sup>1</sup> Blake, Wm. P., *Alunogen and Bauxite of New Mexico*,  
Trans. Amer. Inst., Min. Engrs., 1894, Vol. XXIV, p. 571.



GEORGIA-ALABAMA.—In point of origin and occurrence the Georgia-Alabama bauxites form an important group of deposits, entirely different from those of other known areas. They do not occur in the form of stratified deposits, nor have they been derived from the decay or decomposition of pre-existing rocks. On the other hand, they occur as well-defined compact masses in the form of pocket deposits, entirely different from the enclosing or surrounding material, usually grouped about certain centers and along certain lines. The bauxite area extends, as an irregular belt, from Adairsville, Georgia, southwest to Jacksonville, Alabama; and, the deposits are limited, for the most part, to the Coosa Valley.

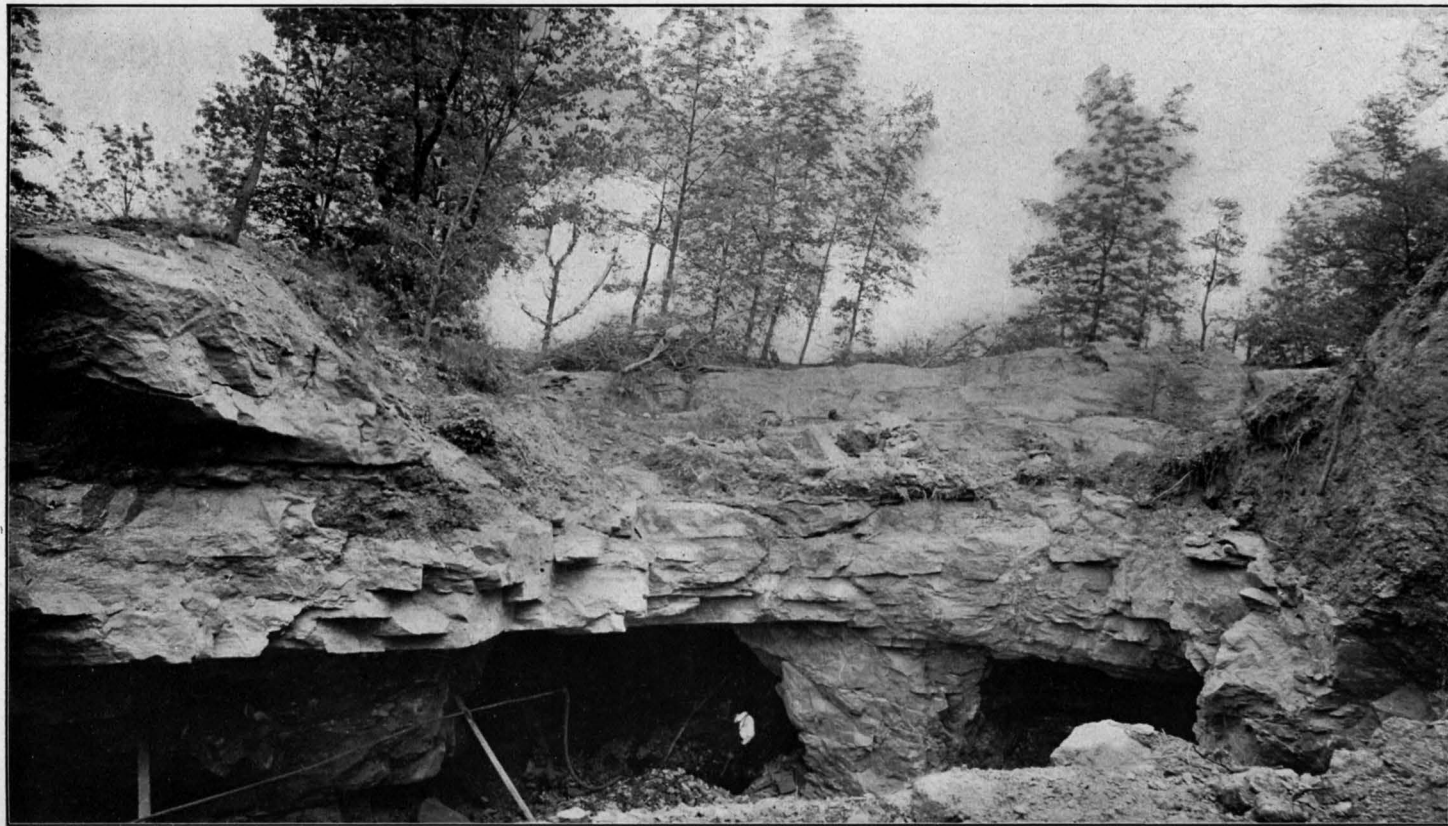
The Georgia portion of this area forms the subject of the present report; and, therefore, it does not require further mention here.

While the belt of deposits in Alabama is nearly as long as its northeastern correlative in Georgia, work has been entirely limited to an area in Cherokee county, known as the Dyke district, which extends southwestward from the Georgia line for a distance of four miles. This district is one of greater dynamic forces than the corresponding districts in Georgia, resulting in a somewhat larger number of deposits of bauxite, of larger size, and made up usually of several connecting ore-bodies. So great have been the effects of the dynamic agencies operating in this district, that the rocks are profoundly disturbed, rendering it difficult, if not impossible, frequently to determine their original position and composition. The faults of the Dyke district are quite unlike those of the Bobo district in Georgia. The ore-bodies are distributed along the northwestern base of Indian mountain, which is an extensive mass of Cambrian (Weisner) quartzite.

The following are analyses of the white and red types of bauxite from the Rock Run district, in Cherokee county, Alabama:—<sup>1</sup>

	White				Red	
Al <sub>2</sub> O <sub>3</sub> . . . . .	58.21	61.68	61.00	61.87	40.93	53.87
Fe <sub>2</sub> O <sub>3</sub> . . . . .	3.60	1.20	2.20	2.38	22.60	8.16
SiO <sub>2</sub> . . . . .	2.90	2.10	2.10	0.40	8.99	4.52
TiO <sub>2</sub> . . . . .	3.40	—	3.12	—	—	—
H <sub>2</sub> O . . . . .	31.89	31.45	31.58	30.50	20.43	24.86

<sup>1</sup> McCalley, Henry, *Report on the Valley Regions of Alabama, Part II. The Coosa Valley Region*, Geol. Surv. of Alabama, 1897, pp. 779, 781.



EXPOSURE OF KNOX DOLOMITE, HOWARD CEMENT QUARRY, BARTOW COUNTY, GEORGIA.

A BRIEF SKETCH OF THE DISCOVERY OF BAUXITE  
IN GEORGIA

The first discovery of bauxite in America was in 1887, at a point a few miles northeast of Rome, in Floyd county, Georgia. A few fragments of the unknown mineral were picked up on the Holland lot, two miles north of the Ridge Valley Iron Company's furnace at Hermitage. The intimate association, in this locality, of the bauxite with deposits of limonite, which latter deposits had been worked to some extent, led to the discovery of the mineral, bauxite. The bauxite fragments were highly ferruginous and deep-red in color, and were taken by their discoverer, James Holland, to Edward Nichols, President and Acting Chemist of the Ridge Valley Iron Company, thinking they represented an ore of iron. Mr. Nichols attached no special importance to the find at that time; but, shortly afterwards, he made a chemical analysis of the fragments. Finding the percentage of iron low and that of alumina correspondingly high, as compared with iron ores in general, Mr. Nichols identified the material as the mineral, bauxite. He briefly described the discovery and occurrence of the mineral in the Transactions of the American Institute of Mining Engineers for 1887.<sup>1</sup>

Bauxite mining in the United States had its beginning in Georgia, when, in April, 1888, the deposits of the mineral on the Holland property, *lot 61, 23rd district* of Floyd county, were first opened and worked. The first shipments of the ore were made in May, 1889, to the Pennsylvania Salt Company at Natrona, Penn., and to Greenwich Point, near Philadelphia. This lot of ore is said to have been used for the manufacture of both alum and metallic aluminum. In 1889, 728 tons of the ore from Georgia included the total output of bauxite from the United States.

Work in the Alabama field, which marks the continuation of the Georgia area to the southwest, was begun in 1891, when the total output from Alabama, for that year, was 292 tons. The next year, 1893, proved an extremely active one in the Alabama territory, resulting in a greater production than in Georgia; and

<sup>1</sup> Nichols, Edward, *An Aluminum Ore*, Trans., Amer. Inst., Min. Engrs., 1887, Vol. XVI, p. 105.

the production for each successive year since, has been greater for Alabama than for Georgia.

Companies, operating bauxite deposits in the two States, claim, that the tardiness in development of this industry in Georgia, is largely to be attributed to the greater benefits and more generous provisions in property leases, obtainable in Alabama. Vastly more than half of the Georgia-Alabama product is used in the manufacture of alum; while the remainder is employed in the extraction of the metal, aluminum.

Extensive deposits of bauxite were discovered in Pulaski and Saline counties, Arkansas, in 1891, by the Geological Survey of that State.<sup>1</sup> Prior to 12 or 18 months ago, the Arkansas deposits remained practically undeveloped. Since that time, however, they have attracted considerable attention; and, in the near future, they will doubtless contribute very largely to the increase in the production of this mineral in the United States.

The New Mexico deposits, discovered several years later, have not yet been seriously considered as workable areas.

The following tables show the production of bauxite and aluminum, respectively, in the United States from 1889 to 1900. The amounts are stated in long tons (2,240 pounds per ton):—

*Production of Bauxite in the United States from 1889 to 1900<sup>2</sup>.*

Years	Georgia Long Tons	Alabama Long Tons	Total Long Tons	Value
1889	728	—	728	\$ 2,366
1890	1,844	—	1,844	6,012
1891	3,301	292	3,593	11,675
1892	5,110	5,408	10,518	34,183
1893	2,415	6,764	9,179	29,507
1894	2,050	9,016	11,066	35,818
1895	3,756	13,313	17,069	44,000
1896	7,313	11,051	18,364	47,338
1897	7,507	13,083	20,590	57,652
1898	— <sup>3</sup>	— <sup>3</sup>	25,149 <sup>3</sup>	75,437
1899 <sup>4</sup>	15,736	14,499	35,280 <sup>5</sup>	125,59 <sup>85</sup>
1900 <sup>6</sup>	20,715	650	21,365	78,310

<sup>1</sup> Branner, John C., Amer. Geol., 1891, Vol. VII, pp. 181-183.

<sup>2</sup> Twentieth Ann. Rept., U. S. Geol. Surv., 1899, Part VI, p. 269.

<sup>3</sup> Production for 1898 not separated by States. The production for Georgia and Alabama included together as one total.

<sup>4</sup> Twenty First Ann. Rept., U. S. Geol. Surv., 1899-1900, Part VI, p. 270.

<sup>5</sup> Includes 5,045 long tons produced and sold by Arkansas.

<sup>6</sup> *The Mineral Industry*, 1902, Vol. X, p. 11.

*Production of Aluminum in the United States from 1883 to 1900<sup>1</sup>*

Calendar Years	Pounds
1883 . . . . .	83
1884 . . . . .	150
1885 . . . . .	283
1886 . . . . .	3,000
1887 . . . . .	18,000
1888 . . . . .	19,000
1889 . . . . .	47,468
1890 . . . . .	61,281
1891 . . . . .	150,000
1892 . . . . .	259,885
1893 . . . . .	333,629
1894 . . . . .	550,000
1895 . . . . .	920,000
1896 . . . . .	1,300,000
1897 . . . . .	4,000,000
1898 . . . . .	5,200,000
1899 . . . . .	5,200,000
1900 . . . . .	6,000,000

<sup>1</sup> Twentieth Ann. Rept., U. S. Geol. Surv., 1899, Part VI, p. 267.

## CHAPTER II

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### THE GENERAL GEOLOGY OF THE GEORGIA BAUXITE REGION

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Since the occurrence and distribution of the deposits of bauxite are intimately related to the various geologic phases of the region, it is very essential, from an economic as well as a scientific viewpoint, that some account of its geology be given. The ore-bodies are observed to occur within certain limits of elevation, and to further sustain fairly definite relations to the ridge-valley topography. They are found somewhat irregularly grouped about certain centers, and along certain lines of structural weakness, and are also definitely associated with certain rock strata.

TOPOGRAPHY.—The accompanying map indicates, to some degree, the surface configuration of the region in the contour lines, and in addition to the ore distribution, shows the various geologic formations and the delineation of the faults of the ordinary Appalachian type. The distribution of the ore-bodies is limited for the most part to the great Appalachian Valley province, which extends southwestward into Alabama, and is limited on the west, by the Cumberland Plateau, and on the east, by the Appalachian Mountains.

The Appalachian Valley province forms a long narrow belt, composed of successively smaller or subordinate north-south valleys, separated by moderately high and fairly steep-sided ridges. The valleys are prevailingly deep and narrow, and have been determined by the underlying soft shales and limestones, by the usual processes of erosion. The form and attitude of the ridges are determined by the character of the rock and the position of the strata composing them. Accordingly, the ridges may vary from approximately symmetrical to unsymmetrical types, the latter type predominating; and from those, with irregular, narrow crests,

to those, of broad and regular flat tops. As would be expected, the highest and most persistent ridges of the region are composed of sandstone, which forms the hardest and most resistant rock in the area.

The Knox dolomite occupies the entire eastern part of the Valley province, and is rendered highly siliceous by abundantly included masses and lenses of chert or flint, of varying sizes. On weathering, the Knox dolomite surface is covered with a heavy mantle of the insoluble siliceous material, chert and clay, which, on account of extreme prevalence, rarely leaves an exposure of the magnesian limestone to view. The resistance offered by this less easily eroded siliceous limestone by the usual processes of weathering, gives rise to a broadly undulating surface, which is intermediate in elevation between the high sandstone ridges and the corresponding deeply incised valleys, etched in the soft shales and limestone. Only where the Knox dolomite is cut by faults of the ordinary Appalachian type, of sufficient throw to expose the underlying soft shales, as in the Bobo district, is it characterized by very pronounced ridges.

As pointed out by Hayes,<sup>1</sup> these topographic features, which owe their present form to the attitude and character of the rocks and the operative reducing forces, record the geographic cycles, through which the region has passed. A correct interpretation of them enables us to formulate, to some degree, the forces that have been operative, and to reconstruct the past geologic history of the area. As with most land areas, the one in question, has been subjected to at least a series of successive elevations and depressions—*land oscillations*. The periods of elevation were sufficient, to increase the activity of the streams and to proportionately augment other forces of erosion, in accomplishing the down-wearing of the land-surface. After each elevation, the periods of quiescence were of sufficient duration, to enable the streams to establish a system of uniform base-levels over the entire region; and the area was furthermore stationary, for a time sufficient to admit of the interstream areas being reduced to a level, approximating that of the stream base-levels. The hard sandstone rocks proved, of course, the most resistant, and were, therefore, the last of the

<sup>1</sup> Sixteenth Ann. Rept., U. S. Geol. Surv., 1895, Part III, pp. 551-554.

rock areas to be reduced. These, however, were never entirely reduced during any single period of erosion; but they marked partially unreduced residuals, standing in slight relief above the general level of the nearly undulating surface of the erosion-plane—*peneplain*.

Accordingly, the present topographic forms indicate traces of three periods of base-leveling and planation. The first and most complete reduction was probably accomplished near the close of Cretaceous time. The surface of the Cretaceous plain is marked by the approximate level of the subordinate sandstone ridges of the region. The higher ridges, such as Indian mountain in Alabama, formed residuals on the general upland level of the plain. The ridges of sandstone, north of Coosa river, also mark the remnants of this plain. The interval, during which the formation of this peneplain was accomplished, was perhaps the longest, and the planation, the most complete of the entire number. An uplift of the area once more renewed the activity of the streams, and they were engaged in a second reduction or base-leveling. Only the softest rocks, however, were base-leveled during this period, as the region suffered a second uplift before the hard and somewhat insoluble siliceous Knox dolomite was reduced to the stream-levels. The intermediate surface elevations of this formation, therefore, mark the level of the second plain. The last period of base-leveling was confined to the valleys of the major streams, namely, the Coosa and Oostanaula rivers. Cumulative deposits of *débris* along the lower stretches of the streams indicate periods of depression, following those of general uplift in this region.

The present streams are now engaged in a further lowering of their channels, as a result of the latest recent uplift in the region.

#### STRATIGRAPHY

As seen from the accompanying map, the rocks of this area range from Cambrian to Carboniferous in age. They include schists, slates, limestones, shales, sandstones and conglomerates, in considerable variety. These have all suffered profound metamorphism, and in consequence are considerably changed, as a rule, in lithologic character and structure. As yet, no rocks of igneous origin are known to occur within the area. The accompanying



map and geologic column mark their distribution and order of geologic sequence. No deposits of bauxite have been found, so far, in association with rocks higher in the series than the formation immediately above the Knox Dolomite; hence, descriptions of the rocks belonging to the Upper Silurian, Devonian and Carboniferous are omitted; and only descriptions of the formations below the Upper Silurian, with which the known bauxite deposits are associated, are given.

### THE CAMBRIAN ROCKS

Named in order, from the oldest to the youngest, the following formations among the Cambrian rocks of the region are recognized: the Weisner Quartzite; the Beaver Limestone; the Rome Sandstone; and the Conasauga Shale.

THE WEISNER QUARTZITE.<sup>1</sup> — The Weisner Quartzite is exposed in the southern part of the region forming Indian mountain, the greater part of which is in Alabama. Hayes describes the Weisner quartzite as follows: —<sup>2</sup>

“In the southern portion of the region the Rome sandstone is underlain by the Weisner quartzite, which consists of a series of interbedded lenticular masses of conglomerate, quartzite and sandy shale, and probably represents a delta deposit which may be contemporaneous with the lower portion, but more probably is older than any part of the Rome. The relations of these lower formations have an indirect bearing on the bauxite deposits, since they have in a large degree influenced the structure of the region with which the deposition of the ore is directly connected.”

THE ROME FORMATION. — This formation occupies a narrow belt in the middle portion of the map, with a northeast-southwest trend. Its estimated thickness is between 3,000 and 4,000 feet. Accurate measurements, however, are impossible, since the rocks have been considerably folded and crumpled, and the above figures are probably subject to some variation. The lower 1,500 to 2,000 feet of the Rome series consist of alternating layers of sandstone and shale, of varying thickness. Passing upward near the top, it is composed principally of shales, containing but few, thin, siliceous layers or beds. The rocks vary in color, from brown to dark-green for the shales, and from white to reddish-brown and purple

<sup>1</sup> Chilhowie Sandstone of Safford.

<sup>2</sup> Ann. Rept., U. S. Geol. Surv., 1895, p. 555.

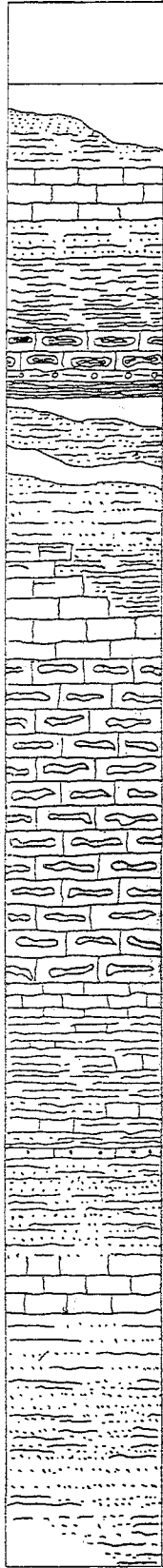
for the sandstones. The heavy bedded sandstones indicate, in somewhat numerous ripple-marks, deposition in shallow water, with increasing depth shown in the deposition of the immediately overlying shales and limestone.

THE CONASAUGA SHALES. — The Conasauga formation takes its name from the Conasauga Valley in Georgia, on the Dalton sheet of the United States Geological Survey. The Conasauga formation lies immediately above the Rome formation, and has an estimated thickness of between 1,500 and 3,000 feet, subject to some variation from conditions obtaining, similar to those stated in the case of the Rome formation above. The formation at its base consists of thin layers of limestone interbedded with shales, which pass near the top into blue seamy limestone and calcareous shale. In lithologic character, the rocks belonging to this formation vary from very finely granular, highly aluminous or clayey shales to somewhat massive siliceous limestone, with the former type predominating.

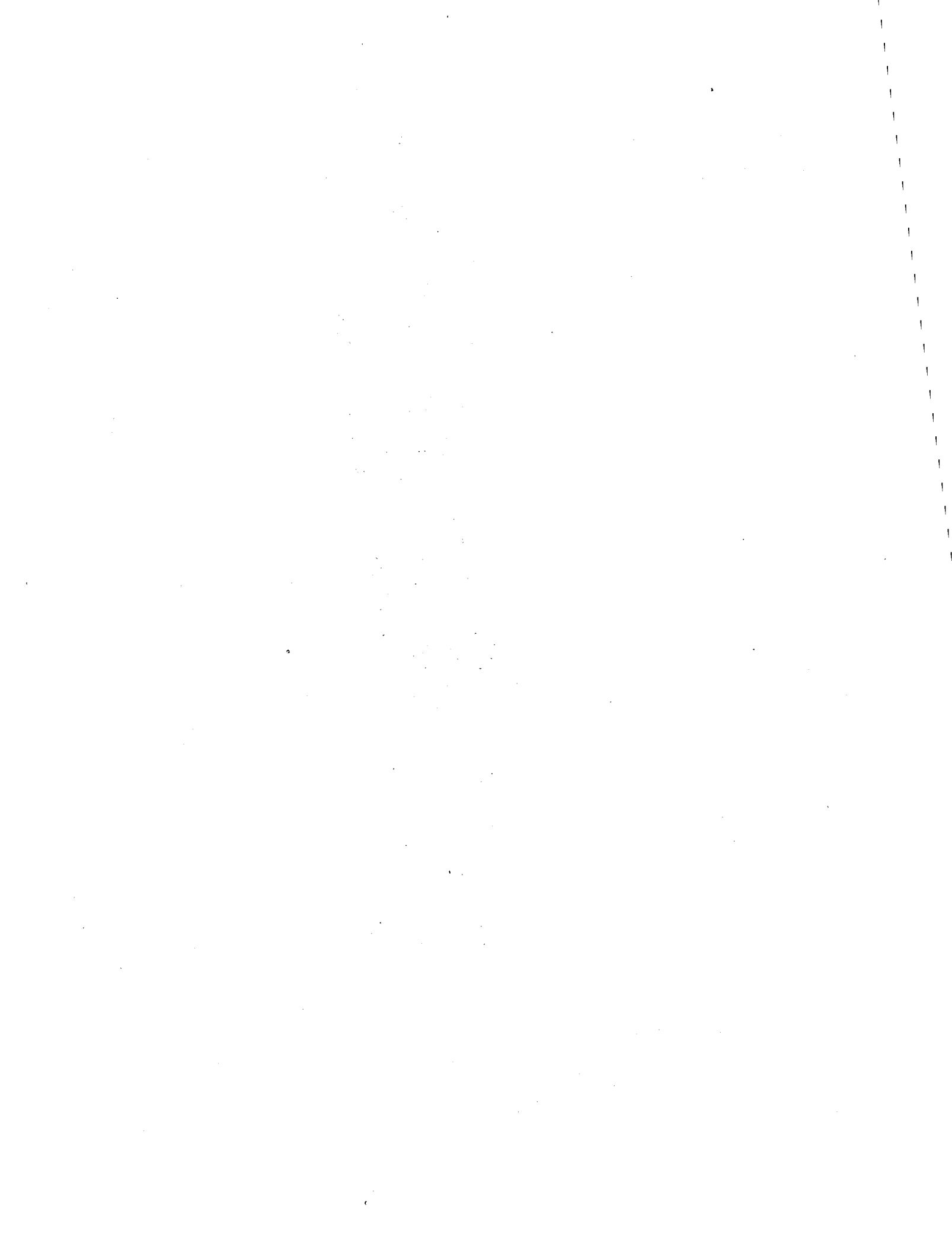
The following analyses indicate the general composition of the Middle Cambrian shales of the bauxite region :—

	I	II
SiO <sub>2</sub> . . . . .	55.02	52.82
Al <sub>2</sub> O <sub>3</sub> . . . . .	21.02	26.17
Fe <sub>2</sub> O <sub>3</sub> . . . . .	5.00	9.46
FeO . . . . .	1.54	—
MgO . . . . .	2.32	1.08
CaO . . . . .	1.60	trace
Na <sub>2</sub> O . . . . .	0.81	0.20
K <sub>2</sub> O . . . . .	3.19	2.71
H <sub>2</sub> O at 110° C. (hygroscopic) . . . . .	2.44	0.23
H <sub>2</sub> O above 110° C. (combined) . . . . .	5.65	7.00
TiO <sub>2</sub> . . . . .	0.65	—
P <sub>2</sub> O <sub>5</sub> . . . . .	0.06	—
MnO . . . . .	trace	—
BaO . . . . .	0.04	—
SrO . . . . .	trace	—
Li <sub>2</sub> O . . . . .	0.03	—
SO <sub>3</sub> . . . . .	0.02	—
Cl . . . . .	trace	—
CO <sub>2</sub> . . . . .	0.83	—
Carbonaceous Matter . . . . .	0.32	—
Total . . . . .	<u>100.54</u>	<u>99.67</u>

Fig. 1



Generalized Stratigraphic Section of the Georgia Bauxite Field. Scale, approximately, 2,000 feet = 1 inch.



- I. Middle Cambrian Shale, Coosa Valley, near Blaine, Cherokee county, Alabama; Dr. H. N. Stokes, Analyst, Bull. No. 168, U. S. Geol. Surv., 1900, p. 283.
- II. Oostanaula Shales, about two miles northwest from Cartersville, Bartow county, Georgia; J. M. McCandless, Analyst, Paleozoic Group, Geol. Surv. of Georgia, 1893, p. 285.

Where best exposed, the lithologic characteristics of the rocks indicate the following sequence in this formation: Upper part, calcareous passing into blue limestone; middle portion, prevailingly shaly; bottom part, thin layers of interbedded limestone and shale.

The following are analyses of specimens of the dark-blue, seamy limestone, forming the upper portion of the Conasauga Shale, collected by the writer 5 miles north and 5 miles south of Rome, Georgia, respectively; and analyzed by him in the Survey laboratory:—

	I	II
CaCO <sub>3</sub> . . . . .	92.89	91.41
MgCO <sub>3</sub> . . . . .	2.12	4.51
Fe <sub>2</sub> O <sub>3</sub> + Al <sub>2</sub> O <sub>3</sub> . . . . .	0.97	1.28
SiO <sub>2</sub> . . . . .	4.11	2.89
Moisture . . . . .	0.10	0.12
Total . . . . .	100.19	100.21

- I. Specimen collected from the Rome public road, 1 mile north of Six Mile Station.
- II. Specimen collected 5 miles north of Rome at Buckhead creek quarry.

Owing to the marked similarity in the physical and chemical characteristics of the Rome and Conasauga formations near the point of contact, the separation of the two becomes exceedingly difficult at times.

The following analyses afford some idea of the composition of the more or less siliceous and clayey, thin-bedded limestones, of variable texture, interbedded with the Oostanaula Middle Cambrian shales:—<sup>1</sup>

<sup>1</sup> Spencer, J. W., *The Paleozoic Group*, Geol. Surv. of Georgia, 1893, pp. 263, 264.

	I	II	III
CaCO <sub>3</sub> . . . . .	74.38	43.50	55.00
MgCO <sub>3</sub> . . . . .	8.79	26.00	26.10
Al <sub>2</sub> O <sub>3</sub> . . . . .	3.50	5.45	6.10
Fe <sub>2</sub> O <sub>3</sub> . . . . .	2.05		
FeO . . . . .		1.80	2.00
SiO <sub>2</sub> . . . . .	10.95	22.10	10.00
H <sub>2</sub> O . . . . .		1.00	0.30
Organic matter . . . . .		0.13	0.50
Total . . . . .	99.57	99.98	100.00

I. Three miles southwest of Rome, Floyd county, Georgia ;  
J. M. McCandless, Analyst.

II & III. Specimens of hydraulic limestone, used for the man-  
ufacture of cement, near Kingston, Bartow county,  
Georgia ; William J. Land, Analyst.

### THE SILURIAN ROCKS

THE KNOX DOLOMITE. — Hayes groups the upper portion of the Knox Dolomite as Silurian, and the lower part as probable Cambrian.<sup>1</sup> Because of the general absence of fossils and the striking uniformity in lithologic character, attempt at a division of the formation, as Hayes remarks, appears impracticable just now, and the entire series is therefore treated in this report as a whole, under the Silurian. The Knox Dolomite is the most uniform and persistent formation in the region ; and, in connection with the ore deposits, it forms the most important one of the rock terranes. It marks the lowest division of the Silurian, immediately above the Conasauga shales, and has an estimated thickness of 3,000 to 4,000 feet. It is composed of massively bedded, partially crystalline, gray magnesian limestone. An abundance of included silica, in the form of nodules and layers of chert or flint is a prevailing characteristic of this dolomite. The soluble carbonates of calcium and magnesium are carried away in solution upon weathering, leaving the chert and other insoluble portions of the rock, which form a vari-colored siliceous clay with chert fragments as a surface covering. The prevailing depth of this residual material leaves but few exposures of the dolomite visible, except where the streams have cut through into the underlying fresh rock.

<sup>1</sup> Sixteenth Ann. Rept., U. S. Geol. Surv., 1895, Part III, p. 555.

The following analyses of the Knox Dolomite series of limestones, of the Georgia bauxite region, give some idea of their composition:—<sup>1</sup>

	I	II	III	IV
CaCO <sub>3</sub> . . . . .	53.44	52.05	52.64	34.070
MgCO <sub>3</sub> . . . . .	41.15	36.32	39.44	55.736
Al <sub>2</sub> O <sub>3</sub> } . . . . .	1.50	2.68	1.76	1.236
Fe <sub>2</sub> O <sub>3</sub> }		2.10		
SiO <sub>2</sub> . . . . .	3.75	6.47	6.25	7.252
Moisture . . . . .	—	—	—	1.622
Total . . . . .	<u>99.84</u>	<u>99.62</u>	<u>100.09</u>	<u>99.916</u>

- I. Cave Spring, Floyd county, Georgia; J. M. McCandless, Analyst.
- II. Egyptian Quarry, Mr. Gibbons' farm, near Hall's station, Bartow county, Georgia; J. M. McCandless, Analyst.
- III. Fine-grained, light-gray dolomite, Dyke's creek; J. M. McCandless, Analyst.
- IV. Ladd's Mountain, three miles southwest of Cartersville, Bartow county, Georgia. Analyzed at the Pratt Laboratory, Atlanta, Georgia.

The Knox dolomite passes upward into the blue, fossiliferous Chickamauga limestone. Over most, if not all, of the bauxite region, however, the Chickamauga limestone is entirely absent, the conditions pointing apparently to a stratigraphic break in this area.

The following analyses indicate the general composition of the Chickamauga limestone in the Georgia area:—<sup>2</sup>

	I	II	III	IV
CaCO <sub>3</sub> . . . . .	94.37	95.203	55.47	91.40
MgCO <sub>3</sub> . . . . .	2.10	2.171	25.33	3.75
Al <sub>2</sub> O <sub>3</sub> } . . . . .	2.23	0.400	9.50	1.80
Fe <sub>2</sub> O <sub>3</sub> }				
Insoluble . . . . .	—	2.300	8.16	2.82
Total . . . . .	<u>98.70</u>	<u>100.074</u>	<u>98.46</u>	<u>99.77</u>

- I. Cedartown, Polk county, Georgia; Wm. J. Land, Analyst.
- II. Devitte Lime Quarry.

<sup>1</sup> Spencer, J. W., *The Paleozoic Group*, Geol. Surv. of Georgia, 1893, p. 265, 266, 267.

<sup>2</sup> *Ibid.*, pp. 268, 269.

III & IV. Light-colored, crystalline limestone in the valley of Lookout creek, south of Trenton, Dade county, Georgia; J. M. McCandless, Analyst.

#### STRUCTURE

As is shown in a subsequent part of this report, in an attempt to explain the genesis of the bauxite deposits, it is observed, that the ore-bodies bear a definite genetic relationship to the structural features of the region. The rocks of the region represent unquestionable sedimentaries; and, when originally laid down on the sea bottom, they must have preserved a more or less horizontal position. This original position, however, has been profoundly disturbed, as is shown in the tilting and folding of the rocks at steep and varying angles. In this section, as with Appalachian folds in general, the folds show unequal dips on the two sides of the arch and belong to the unsymmetrical type. They further harmonize with the normal Appalachian type in gentle dips on the southeast sides, and correspondingly steep ones on the northwest. The continued action of the same forces, which produced the folding, resulted in the fracturing and breaking across of the strata in many places — *faulting*.

Two classes of faults have been observed in the region, which show marked differences in many particulars. These are designated by Hayes<sup>1</sup> as (a) minor thrust faults, and (b) major thrust faults. The two apparently bear no close relationship to each other. From field evidence, they were probably formed at different periods of disturbance. The minor thrust faults were likely developed first, and are therefore the older. The two types of faults usually characterize separate or different parts of the area.

THE MINOR THRUST FAULTS. — This type of fault is characteristic of certain portions of the area, namely, Six Mile Station, Silver Creek and Cave Spring, to the south of Rome; and in general, they represent the ordinary or normal Appalachian type of fault. Hayes describes the minor thrust faults as follows: —<sup>2</sup>

<sup>1</sup> *Geology of a Portion of the Coosa Valley in Georgia and Alabama*, Bull., G. S. A., 1893, Vol. V., pp. 465-480.

*Bauxite*, Sixteenth Ann. Rept., U. S. Geol. Surv., 1894, Part III, pp. 557-560.

<sup>2</sup> *Ibid.*, pp. 473-474.



"A great majority of these faults extend nearly due north and south, and hence intersect the main structure axis of the region at angles of 30° or 40°. Immediately south of Rome at least seven of these minor thrusts occur within a belt three miles wide. They vary in length from 3 to 8 miles and overlap along the strike. The strata are thus cut into a number of narrow strips which form monoclinals dipping steeply toward the east. In the vicinity of Cave Spring is another series of faults similar in most respects to those south of Rome.

"Between Indian and Weisner mountains there is less regularity in the arrangement of the minor thrusts, and their general trend is somewhat east of north. A strip of Knox dolomite from one to four miles in width extends from near Cave Spring toward the southwest, lying north of Indian and south of Weisner mountains. This belt of dolomite is intersected by a series of nearly parallel thrust-faults which cut diagonally across, separating it into irregular monoclinical blocks. The faults disappear in the belt of Conasauga shale on the north, while their throw is greatest at the northern edge of the dolomite, decreasing southward, and in some cases disappearing within the dolomite area. These faults give rise to the narrow belts of shale which branch from the northern belt and extend varying distances toward the south, forming narrow valleys among the dolomite hills."

THE MAJOR THRUST FAULTS. — At least three of this type of thrust faults occur within this area, namely, the Rome, Coosa and Cartersville faults. They are characterized by the low inclination of the fault-plane, approximating to, or quite, horizontal, when visible, and the great horizontal displacement of the rocks. The horizontal displacement is measured in miles instead of in feet.<sup>1</sup>

#### MINERALS ASSOCIATED WITH THE BAUXITE

Several aluminous minerals are found associated with the bauxite. These deserve some mention. They are gibbsite, halloysite and kaolin or clay.

GIBBSITE. — This mineral differs from bauxite in being crystalline instead of concretionary or clay-like in structure, and in containing a larger percentage of water. Its chemical formula is  $\text{Al}(\text{OH})_3$ , or  $\text{Al}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$ ; and, when pure, it contains 65.4 per cent. of alumina and 34.6 per cent. of water. This mineral is called hydrargillite, when in crystals, and is sometimes associated with corundum deposits when in this form. As gibbsite, it is

<sup>1</sup> For a complete description of this type of thrust-faults, the reader is referred to the following publications by Dr. C. W. Hayes, who describes them in considerable detail, after tracing them in the field:—

*The Overthrust Faults of the Southern Appalachians*, Bull., Geol. Soc. Amer., 1891, Vol. II, pp. 141-154.

*Geology of a Portion of the Coosa Valley in Georgia and Alabama*, *Ibid.*, 1893, Vol. V, pp. 465-480.

*Bauxite*, Sixteenth Ann. Rept., U. S. Geol. Surv., 1894, Part III, pp. 558-560.

stalactitic in form. It has been observed in the deposits of bauxite of the Hermitage district in Georgia, where it occurs incrusting cavities in the bauxite. The incrustations are colorless and transparent, and have not been observed to be more than one-eighth of an inch in thickness in any case; and, as a rule, it is much less. In some of the Arkansas deposits, gibbsite appears to be more abundant, and in larger masses, of a slightly reddish-white color, than in the Georgia ore-bodies.

**HALLOYSITE.** — This mineral has the same chemical composition as kaolin, from which it differs essentially in having a larger percentage of water. Its composition is  $H_4Al_2Si_2O_9 + Aq.$ , or  $2H_2O \cdot Al_2O_3 \cdot 2SiO_2 + Aq.$ ; and, when pure, it contains 43.5 per cent. of silica, 36.9 per cent. of alumina, and 19.6 per cent. of water. It is usually light (white) in color, and compact in texture, breaking with a conchoidal fracture; and is easily cut with a knife; but it can not be scratched with the finger-nail. Its occurrence here is in the form of well defined veins, of varying size, cutting the bauxite, and in irregular masses and nodules of various dimensions, usually small, however. These are often lens-shaped, and are highly polished and slickensided, indicating subsequent movement in the bauxite masses.

**KAOLIN OR CLAY.** — From an economic standpoint clay is vastly the most important associate of the bauxite deposits. Like halloysite, it is also regarded as a silicate of alumina, having the chemical composition, when pure,  $H_4Al_2Si_2O_9$ , or  $2H_2O \cdot Al_2O_3 \cdot 2SiO_2$ , yielding silica, 46.5, alumina, 39.5, and water, 14.0. It is very abundant in the bauxite area, where it occurs surrounding the ore-bodies, and, in many cases, cutting them, in the form of dikes, veins or "horses." It shows considerable variation in texture, color and composition. The clay, associated with the bauxite, is quite different in character, and is readily differentiated from that derived from the weathering of the Knox dolomite. The two types of clay bear no resemblance to each other, and are always sharply differentiated. The residual clay is very impure, containing, in most cases, commingled fragments of chert and sandstone, in various stages of decay. These fragments of siliceous material are entirely absent from the bauxite deposits.

proper, and their associated clays or kaolins; and, in this respect, the deposits of bauxite are entirely different from those of the nearby limonite. The limonite beds are almost invariably intimately associated with large and small fragments of the residual siliceous rocks. In color, the associated bauxitic clay varies from white and cream, through pink and purple, to chocolate-brown, with the mottled pink-and-white predominating. It varies from hard and compact in texture, resembling halloysite, to a soft, putty-like material. The bauxitic clay and ore are frequently observed to pass by imperceptible gradations into each other.

The following is an analysis of specimens of the white clay from the Flowery Branch bauxite deposit in the Hermitage district:—<sup>1</sup>

SiO <sub>2</sub> (combined)	40.40
SiO <sub>2</sub> (free sand)	0.80
TiO <sub>2</sub>	1.95
Al <sub>2</sub> O <sub>3</sub>	38.60
Fe <sub>2</sub> O <sub>3</sub>	1.45
MgO	0.30
Na <sub>2</sub> O	0.02
K <sub>2</sub> O	0.09
H <sub>2</sub> O (combined)	16.35
H <sub>2</sub> O (hygroscopic)	0.35
Total	<u>100.31</u>

An analysis of a pure white, non-gritty, slickensided specimen of kaolin, collected from the Bobo bank in the Bobo district, yielded the writer, in the Survey laboratory, the following results:—

				Molecular Ratio	
SiO <sub>2</sub>	43.31	÷ 60	=	.721	1.70
TiO <sub>2</sub>	none				
Al <sub>2</sub> O <sub>3</sub>	43.08	÷ 102	=	.422	1.00
Fe <sub>2</sub> O <sub>3</sub>	none				
CaO	none				
MgO	none				
Na <sub>2</sub> O	none				
K <sub>2</sub> O	none				
H <sub>2</sub> O, at 100° C.	0.43				
H <sub>2</sub> O, combined	14.12	÷ 18	=	.784	1.85
Total	<u>100.94</u>				

<sup>1</sup> Spencer, J. W., *Paleozoic Group of Georgia*, Geol. Surv. of Georgia, 1893, p. 281.

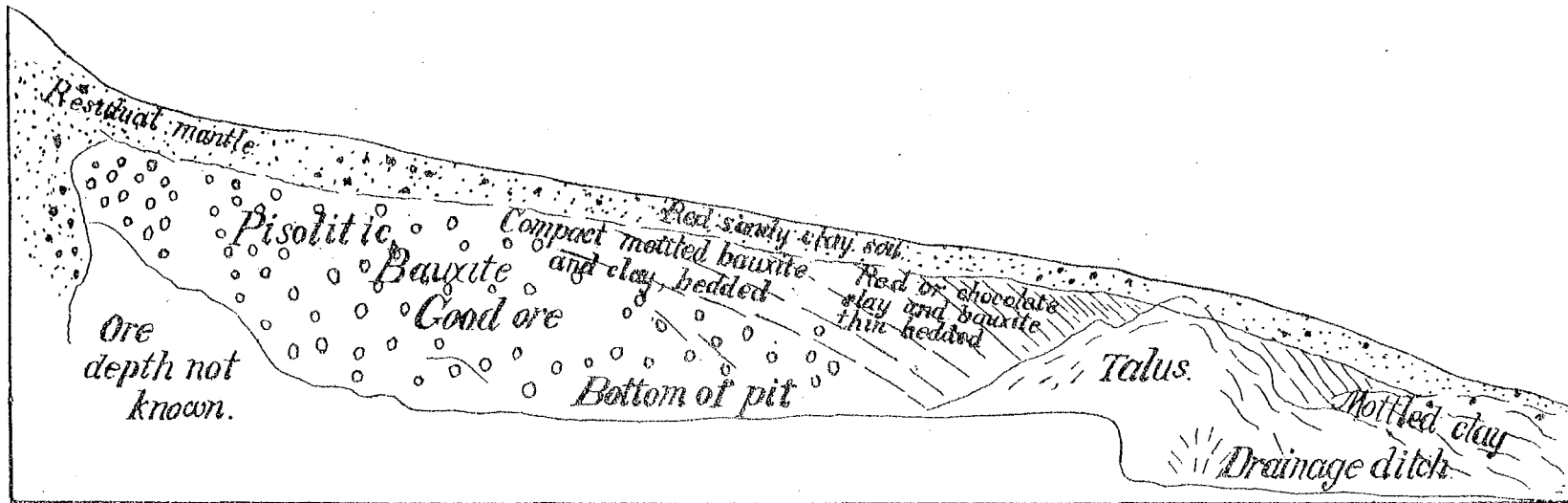
The ratio of  $\text{SiO}_2 : \text{Al}_2\text{O}_3 : \text{H}_2\text{O}$  is nearly 2 : 1 : 2, as required by the formula of kaolin,  $2\text{H}_2\text{O} \cdot \text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2$ .

The bauxitic clays are found in great abundance, and in numerous cases they possess a high degree of purity. In view of their abundance and excellence, it is indeed quite remarkable, that they have not thus far been utilized for some purpose. The white and cream-colored clays are the purest, and they apparently possess the important properties of whiteness and plasticity, and hardening under heat in an eminent degree, which, in many cases, certainly fits them for use in the manufacture of a fine quality of porcelain. Finely pulverulent silica is found in considerable quantity in the same region, frequently along with the clays. If sufficient clay be mixed with the silica to bind it together, the mixture might be successfully employed in the manufacture of fire-brick. The highly colored types of clay are rendered fusible by the presence of the iron oxide contained in them, and might be utilized, to some degree, in the manufacture of common pottery or stoneware and bricks. From an economic standpoint, these clays form an important group of deposits, which, from their quantity and general quality, should be profitably employed for various uses.

#### IRON AND MANGANESE ORES ASSOCIATED WITH THE BAUXITE DEPOSITS

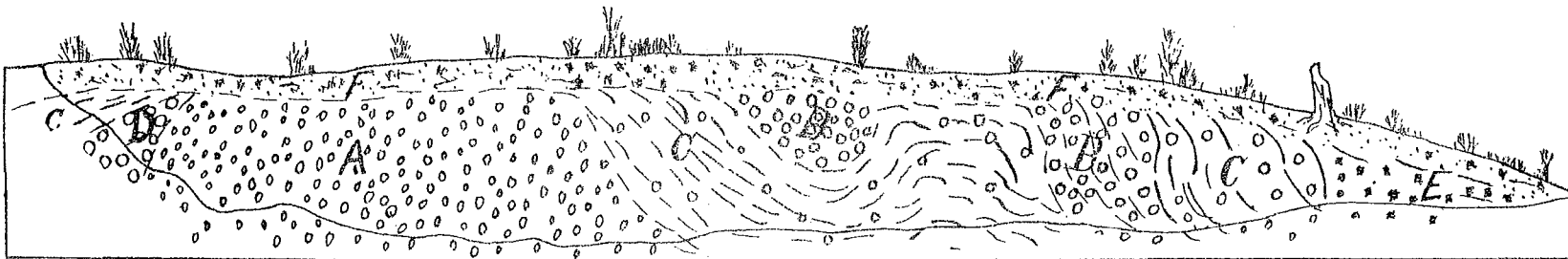
The bauxite belt is coextensive with a large part of the iron and manganese area. Somewhat extensive deposits of brown iron ore have been worked over a considerable part of the bauxite belt. In the Hermitage district and at several banks in the Bobo district, the brown ore is found in nearly direct contact with the bauxite, and deposits of the two minerals occur at all times in the vicinity of each other. The manganese, while intimately associated with the deposits of brown iron ore, is not so closely related to the bauxite; although they are frequently found close together.

Fig. 2



Section Showing the Relations of the Bauxite and the Residual Mantle. (After Hayes).

Fig. 3



Sketch of the Mary Bauxite Mine, Floyd County, Georgia.

Scale, 24 Feet = 1 Inch. A. Main Ore-body (Fine, Pisolitic Bauxite). B. Pisolitic Bauxite in White Clay. C. Mottled Clay Containing Few Pisolites. D. Hard, Mottled Bauxite. E. Mottled Clay Containing Angular Chert. F. Cherty Clay, Surface Soil. (After Hayes).

## CHAPTER III

### I. CHEMICAL COMPOSITION<sup>1</sup>

There are three recognized hydrates of alumina; namely, the monohydrate,  $\text{Al}_2\text{O}_3 \cdot \text{H}_2\text{O}$ , or  $\text{AlO}(\text{OH})$ , known as the mineral diaspore, and containing—

Alumina . . . . .	85.0 per cent.
Water . . . . .	15.0 " "

the dihydrate,  $\text{Al}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$ , or  $\text{Al}_2\text{O}(\text{OH})_2$ , containing—

Alumina . . . . .	73.9 per cent.
Water . . . . .	26.1 " "

and the trihydrate,  $\text{Al}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$ , or  $\text{Al}(\text{OH})_3$ , known as hydrargillite and gibbsite, containing—

Alumina . . . . .	65.4 per cent.
Water . . . . .	34.6 " "

The chemical formula generally given for bauxite is  $\text{Al}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$  or  $\text{Al}_2\text{O}(\text{OH})_2$ , the dihydrate of alumina, containing the percentages of alumina and water as given above. Some analyses, however, give  $\text{Al}_2\text{O}_3 \cdot \text{H}_2\text{O}$  like the mineral diaspore. Roscoe and Schorlemmer<sup>3</sup> give the formula  $(\text{Al},\text{Fe})_2\text{O}(\text{OH})_2$  for bauxite; but, as Phillips says,<sup>4</sup> this seems not to apply to the Georgia-Alabama material.

Phillips and Hancock conclude,<sup>5</sup> after a chemical investigation of the Georgia-Alabama bauxite, based upon the solubility of the alumina in different strengths of sulphuric acid, that it consists of

<sup>1</sup> Watson, Thomas L., *The Georgia Bauxite Deposits; Their Chemical Constitution and Genesis*; Amer. Geologist, Vol. XXVIII, July, 1901, pp. 25-45.

<sup>2</sup> Dana, E. S., *A System of Mineralogy*, 1893, Sixth Edition, p. 251.

<sup>3</sup> Roscoe and Schorlemmer, *A Treatise on Chemistry*, Vol. I, p. 444.

<sup>4</sup> Phillips, W. B., and Hancock, David, *The Commercial Analysis of Bauxite*, Jour., Amer. Chem. Soc., 1898, Vol. V, p. 211.

<sup>5</sup> *Ibid.*, pp. 210, 213-216.

a mixture of the trihydrate,  $\text{Al}_2(\text{OH})_6$ , or  $\text{Al}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$ , with clay, and probably a lower hydrate,  $\text{Al}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$ , the trihydrate being the base or essential part.

In the reports issued by the United States Geological Survey, on the Mineral Resources of the United States, the mineral, bauxite, is referred to as the trihydrate of alumina.

In a report, "On the Coosa Valley Region of Alabama," Henry McCalley concludes,<sup>1</sup> after a study of the same belt of bauxite deposits in Alabama, that the mineral is a trihydrate of alumina.

Dr. C. W. Hayes says,<sup>2</sup> that the chemical composition of the Arkansas bauxite varies within wide limits, of which the granitic type is the purest. He states, that this type corresponds to the formula,  $\text{Al}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$ , the trihydrate, gibbsite.

After a study of many hundreds of analyses of the French bauxites, Laur makes the following statement, concerning the composition and chemical constitution of bauxite:—<sup>3</sup>

"When these minerals [bauxites] are studied, not in isolated specimens but in mass, it is quickly noticed, that there is in their composition one constant, so to speak, namely, the general proportion of anhydrous alumina,  $\text{Al}_2\text{O}_3$ , the average of which is about 66 to 69 per cent. This figure is given by the analyses of thousands of shipments. Representing this constant by A, we find three variable elements, e, besides, namely, water, silica, and ferric oxide; and it is a remarkable fact, that the sum of the weights of these is constant also at about 27 per cent. We will represent it by Pe.

"Finally, the various accessory substances (titanium, vanadium, etc.) which occur even in the purest bauxites, present a constant total of about 3 to 4 per cent. These we represent by C.

"Thus, the centesimal formula of the bauxites: 68 to 70  $\text{Al}_2\text{O}_3$  + 27 ( $\text{SiO}_2$ ,  $\text{Fe}_2\text{O}_3$ ,  $\text{H}_2\text{O}$ ) + 4 (sundry accessories) may be written in general form as A+Pe+C.

"But the three variable elements of Pe have the singular property of replacing one another, in whole or in part, separately increasing, diminishing, or totally disappearing, without change of the total of 27 per cent., and without altering the fixed mineral species, which is, according to our view, the bihydrate of alumina, forming the base of the mineral. These varying substitutions give rise to the different types . . . . ."

<sup>1</sup> McCalley, Henry, *Report on the Valley Regions of Alabama*, Part II, *On the Coosa Valley Region of Alabama*, Geol. Surv. of Alabama, 1897, pp. 79-84.

<sup>2</sup> Hayes, C. W., *op. cit.*

<sup>3</sup> Laur, Francis, *The Bauxites: A Study of a New Mineralogical Family*, Trans., Amer. Inst. Min. Engrs., Virginia Beach Meeting, February, 1894. Author's separate, 9 pages, p. 4.

Continuing, Laur distinguishes four types of bauxite, whose formulæ are given as follows: —<sup>1</sup>

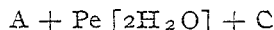
- “(1) Mixed bauxite of Baux, A + Pe, . . . . .  $\left\{ \begin{array}{l} \frac{1}{3}\text{H}_2\text{O} \\ \frac{1}{3}\text{SiO}_2 \\ \frac{1}{3}\text{Fe}_2\text{O}_3 \end{array} \right\} + \text{C}$
- (2) Pale bauxite of Villeveyrac, A + Pe, . . . . .  $\left\{ \begin{array}{l} \frac{1}{2}\text{H}_2\text{O} \\ \frac{1}{2}\text{SiO}_2 \end{array} \right\} + \text{C}$
- (3) Red bauxite of the Var, A + Pe, . . . . .  $\left\{ \begin{array}{l} \frac{1}{2}\text{H}_2\text{O} \\ \frac{1}{2}\text{Fe}_2\text{O}_3 \end{array} \right\} + \text{C}$
- (4) Pure bauxite of Alabama, A + Pe, . . . . .  $[2\text{H}_2\text{O}] + \text{C}.$ ”

Laur says: —<sup>2</sup>

“And it may be affirmed that the basis of the bauxite is the bihydrate of alumina or hydrargillite, with about 27 per cent. of water, which has not yet been, but may be some day, developed in workable deposits.”

In referring to the Georgia-Alabama type, Laur gives the following description: —<sup>3</sup>

“HYALINE BAUXITE. — Finally, there has been discovered in Alabama and Georgia, and in the Yellowstone National Park, a fourth variety of bauxite, in which silica and ferric oxide are not found, and two equivalents of water determine the type. It is this form which occurs as an easily discernible admixture in the siliceous bauxite of the Villeveyrac variety. As may there be observed, the mineralogical type remains the same, only the particles of bauxite have a more glaucous, translucent, slightly horny appearance, and are soft, easily scratched with the finger-nail. This is the bihydrate of alumina, and the formula is, therefore,



“It is nothing else than amorphous hydrargillite, nearly pure, with 3 to 4 per cent. of accessory constituents and 27 per cent. of water.

“This variety has not yet been thoroughly tested by continuous exploitation and repeated analyses. It is yet in the beginning of its development, and what has been produced so far is a pale bauxite of the Villeveyrac type, but containing nodules of hydrargillite in considerable abundance.”

An abstract in the *Chemisches Centralblatt* for 1892, page 14, of an inaugural dissertation by A. Liebreich, in which an account of the derivation of bauxite from basalt, with special reference to the German deposits is given, says:<sup>4</sup> “Chemical analyses show certain differences in the composition of bauxite from different places, the smaller amount of water in the French bauxite referring it to

<sup>1</sup> *Ibid.*, p. 7.

<sup>2</sup> *Loc. cit.*, p. 7.

<sup>3</sup> *Ibid.*, p. 6.

<sup>4</sup> Packard, R. L., *Mineral Resources of the United States*, 1891, p. 149.



diaspore, while the Vogelsberg mineral is probably gibbsite (hydrargillite) [the trihydrate of alumina].''

I have gotten together as many authentic analyses of the Georgia bauxites as possible, which are tabulated below, and from them I have calculated the ratio of alumina ( $\text{Al}_2\text{O}_3$ ) to water ( $\text{H}_2\text{O}$ ). The percentage amounts of the impurities, silica ( $\text{SiO}_2$ ), titanio-oxide ( $\text{TiO}_2$ ) and ferric oxide ( $\text{Fe}_2\text{O}_3$ ), are also given. Calculations are made and given for the two types of bauxite, namely, the non-ferruginous type, in which iron enters as an impurity; and the ferruginous type, in which the iron replaces a part of the aluminum. The analyses were carefully selected; and, in the case of the non-ferruginous type, only those which gave 55 per cent. and more of alumina were used. This minimum percentage of alumina, 55 per cent., in the non-ferruginous type, is the lowest amount of alumina, indicating the purest grade of the ore or mineral. In the ferruginous type, all analyses are included, that show 10.5 per cent. and more of ferric oxide.

Unless otherwise stated, the figures given in the columns of analyses below were obtained by analytical methods, which yield the soluble alumina. On a 55 per cent. alumina basis, however, the small percentages, shown in the insoluble residues ( $\text{SiO}_2$ ), indicate that the soluble alumina is also practically the total alumina. This conclusion is based on a close comparison of the analyses given below, with numerous analyses, in which the total alumina was determined; and also from the analyses of several samples, in which the soluble and the total alumina were separately determined. The analytical methods in general use, at present, by bauxite chemists, are essentially the same as those used in the Pittsburgh Testing Laboratory, and are so modified, as to extract only the soluble alumina, leaving the insoluble alumina, which is present mostly as the silicate, in the form of admixed clay, and probably as a lower hydrate, practically undissolved. As Phillips and Hancock have shown<sup>1</sup>, the soluble alumina is dissolved at  $100^\circ\text{C}$ . by sulphuric acid of  $50^\circ\text{B}$ ., and is combined with water in the form of the trihydrate.

<sup>1</sup> *The Commercial Analysis of Bauxite*, Jour., Amer. Chem. Soc., 1898, Vol. XX, p. 217.

(1)

*Analyses Made in the Pittsburgh Testing Laboratory, Pittsburgh, Pennsylvania* <sup>1</sup>

No.	H <sub>2</sub> O	Al <sub>2</sub> O <sub>3</sub>	SiO <sub>2</sub>	TiO <sub>2</sub>	Fe <sub>2</sub> O <sub>3</sub>	Total
1	32.66	57.18	1.86	6.40	1.90	
2	31.70	59.50	2.93	5.40	0.47	
3	30.03	54.55	1.54	3.99	9.09	
4	31.40	58.55	4.54	2.95	1.40	
5	33.06	58.45	3.24	2.65	1.63	
6	31.36	57.81	7.41	tr.	2.36	
7	30.53	62.52	5.36	tr.	0.71	
8	30.16	55.97	7.56	3.51	1.65	
9	31.23	57.50	3.52	6.57	1.40	
10	32.20	56.39	3.08	4.13	2.35	
11	30.70	62.03	3.66	3.44	0.23	
12	30.56	58.96	5.80	5.00	2.90	
13	32.40	59.68	2.60	4.32	0.23	
14	32.23	59.42	3.50	4.48	none	
15	31.86	59.16	4.26	4.80	none	
16	30.03	56.75	7.84	3.13	1.86	
17	31.23	57.75	5.55	3.56	1.87	
18	30.23	56.91	8.33	2.73	1.63	
19	31.50	61.98	3.22	0.86	1.18	
20	30.66	57.72	5.05	3.51	1.90	
21	31.97	58.98	4.37	4.28	0.14	
22	32.23	56.39	2.43	8.24	0.71	
23	31.40	58.08	5.40	3.68	tr.	
24	33.27	61.50	1.28	2.76	1.19	
25	32.47	60.88	2.67	3.11	0.71	
26	32.66	62.08	0.71	4.10	0.59	
27	29.87	57.17	6.84	5.16	1.47	
28	30.58	57.58	5.14	3.41	2.63	
Average	31.435	58.622	4.274	3.791	1.507	99.629

1.746 : .574; 9.572

3.042 : 1.000, or

 $1.00 \text{ Al}_2\text{O}_3 : 3.04 \text{ H}_2\text{O} = \text{Al}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$ .<sup>1</sup> Furnished by courtesy of Mr. John R. Gibbons, Supt., Georgia Bauxite Mining Company.

(2)

Analyses Made by Booth, Garrett and Blair, Philadelphia, and the Pittsburgh Testing Laboratory, Pittsburgh, Penn. <sup>1</sup>

No.	H <sub>2</sub> O	Al <sub>2</sub> O <sub>3</sub>	SiO <sub>2</sub>	TiO <sub>2</sub>	Fe <sub>2</sub> O <sub>3</sub>	Total
1	30.08	55.56	4.85	3.26	5.62	
2	35.00	60.00	0.80	3.65	0.65	
3	34.20	58.90	1.40	4.30	1.20	
4	32.60	60.80	0.85	3.90	1.82	
5	28.40	61.25	5.10	4.80	0.45	
6	32.70	61.08	1.55	3.95	0.72	
7	32.40	58.72	1.80	6.20	0.88	
8	30.70	61.64	4.30	3.10	0.36	
9	32.70	59.08	2.30	4.80	1.12	
10	32.10	54.96	1.50	5.05	6.39	
11	31.60	55.30	8.04	4.04	1.02	
12	30.40	58.34	3.35	3.40	4.51	
13	30.70	59.22	3.30	3.60	3.16	
14	30.54	57.06	6.32	3.68	1.80	
15	32.20	57.56	3.35	4.40	2.40	
16	31.00	60.06	4.20	3.80	0.94	
17	31.70	61.31	1.40	4.55	1.04	
18	30.80	62.68	1.30	4.70	0.52	
19	30.70	57.73	5.10	5.35	1.12	
20	31.40	56.96	6.03	4.05	1.69	
Average	31.596	58.910	3.342	4.179	1.87	99.897

$$\begin{aligned}
 1.755 & : .577 & & 9.391 \\
 3.042 & : 1.000, \text{ or} & & \\
 \text{Al}_2\text{O}_3 : 3.04\text{H}_2\text{O} & = & \text{Al}_2\text{O}_3 \cdot 3\text{H}_2\text{O}.
 \end{aligned}$$

(3)

Analyses Made by the Pittsburgh Testing Laboratory <sup>2</sup>

No.	H <sub>2</sub> O	Al <sub>2</sub> O <sub>3</sub>	SiO <sub>2</sub>	TiO <sub>2</sub>	Fe <sub>2</sub> O <sub>3</sub>	Total
1	28.40	57.92	12.08	none	1.33	
2	28.00	67.53	1.34	2.92	tr.	
3	32.00	60.61	2.47	4.18	0.21	
4	31.00	60.63	3.20	4.76	tr.	
Average	29.85	61.672	4.772	2.955	0.385	99.634

$$\begin{aligned}
 1.658 & : .604 & & 8.112 \\
 2.745 & : 1.000, \text{ or} & & \\
 \text{Al}_2\text{O}_3 : 2.75\text{H}_2\text{O} & = & \text{Al}_2\text{O}_3 \cdot 3\text{H}_2\text{O}.
 \end{aligned}$$

<sup>1</sup> Furnished by the courtesy of Mr. John H. Hawkins, Supt., Republic Mining and Manufacturing Company.

<sup>2</sup> Furnished by the courtesy of Mr. B. F. A. Saylor, Supt., Dixie Bauxite Company.



In his report, "On the Coosa Valley Region of Alabama," Mr. Henry McCalley gives several analyses of the Alabama bauxite, showing 22 per cent. and more, of  $\text{Fe}_2\text{O}_3$ .

## SUMMARY

<i>Non-Ferruginous Bauxite</i>							
	$\text{Al}_2\text{O}_3$	:	$\text{H}_2\text{O}$	$\text{SiO}_2$	$\text{TiO}_2$	$\text{Fe}_2\text{O}_3$	Total
(1)	58.622	:	31.435	4.274	3.791	1.507	99.629
	.574	:	1.746	}			
	1.000	:	3.042	9.572			
(2)	58.910	:	31.596	3.342	4.179	1.870	99.897
	.577	:	1.755	}			
	1.000	:	3.042	9.391			
(3)	61.672	:	29.850	4.772	2.955	0.385	99.634
	.604	:	1.658	}			
	1.000	:	2.745	8.112			
(4)	60.340	:	30.362	4.75	2.39	1.700	99.540
	.591	:	1.686	}			
	1.000	:	2.853	8.84			
(5)	61.920	:	30.613	.68	3.543	0.816	99.582
	.607	:	1.700	}			
	1.000	:	2.800	7.039			
Average	.591	:	1.709	8.590			99.656
	1.000	:	2.892, or				

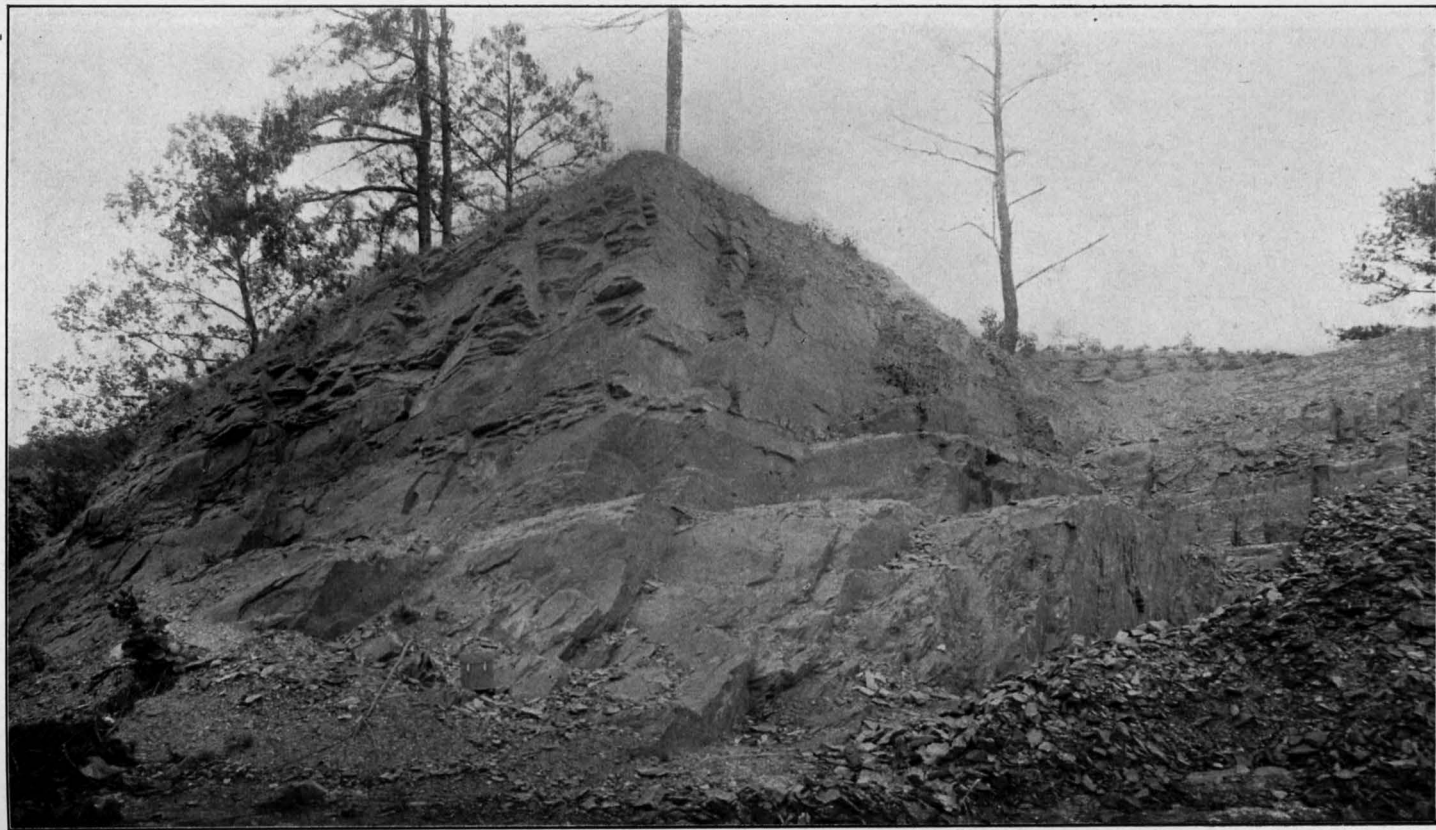
$\text{Al}_2\text{O}_3 : 2.89\text{H}_2\text{O} = \text{Al}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$ .

*Ferruginous Bauxite*

$\text{Al}_2\text{O}_3$	$\text{Fe}_2\text{O}_3$	:	$\text{H}_2\text{O}$	$\text{SiO}_2$	$\text{TiO}_2$	Total
52.941	12.290	:	28.396	2.83	3.78	100.23
.519	.076	:	1.577	}		
}			6.61			
	.595	:	1.577			
	1.000	:	2.650, or			

$\text{Al}_2\text{O}_3 : 2.65\text{H}_2\text{O} = \text{Al}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$ .

From the prevailing pisolitic structure of the mineral, bauxite, in all known workable deposits, it seems a little remarkable, that separate analyses of the matrix and pisolites have never been undertaken. While it is generally true, that the pisolitic structure grades into a structureless mass, the pisolites or concretions are, as a rule, perfectly sharp, and distinct from the enclosing matrix, and the two may or may not have the same chemical composition. The question of chemical composition or relationship between



EXPOSURE OF RED SHALE AT THE FLOYD COUNTY ROCK QUARRY, NEAR ROME, GEORGIA.

matrix and pisolite has an important economic, as well as scientific, bearing. So far as the writer can find out, separate analyses of the matrix and pisolites have never been made. Thus far, all analyses of the pisolitic bauxites represent results obtained from samples, that included mixtures of the two.

Having in view the idea of possibly settling this point, the writer selected specimens of the ore, and carefully separated matrix and pisolites, and separately analyzed them in the laboratory of the Geological Survey, with the results shown below. Sufficient time was not at my disposal, however, in which to make as exhaustive a series of analyses, as I had hoped; but the ones here given are, I believe, of both value and interest in illustrating, if not entirely establishing, the comparative chemical composition of the two parts of the mineral.

No attempt has been made at separate analyses of isolated thin layers of the pisolites, or concretions, from each other, nor of the layers from the enclosed powder. In those concretions, showing scarcely more than a trace of iron oxide, many of the very thin layers were colored highly by the presence of iron; while the majority of the layers were entirely free from the iron coloring. This well illustrates the variableness in composition, as well as in almost every physical property of the mineral, arising from the peculiar conditions of formation in the presence of associated iron and alumina in the same solution.

The samples were carefully selected and prepared for analysis, and were freed, as far as possible, from any adhering clay. A brief, but complete, description of each sample, prior to and during its grinding for analysis, is given below.

	Pisolites			Matrix			
	Maddox	Bobo	Warrior	Maddox	Church	Watters	Perry
Al <sub>2</sub> O <sub>3</sub> . . . . .	52.36	57.26	52.40	64.91	46.92	63.60	48.30
H <sub>2</sub> O (combined) . . . . .	33.17	31.69	24.06	33.00	21.68	27.15	28.01
SiO <sub>2</sub> . . . . .	3.74	0.99	4.21	0.62	20.46	6.43	3.17
TiO <sub>2</sub> . . . . .	9.70	7.63	8.79	1.05	9.80	1.95	9.75
Fe <sub>2</sub> O <sub>3</sub> . . . . .	0.76	1.89	10.44	0.28	0.28	0.28	trace
H <sub>2</sub> O (100° C.) . . . . .	0.20	0.39	0.39	0.53	0.34	0.56	0.53
CaO	none	none	none	none	none	none	none
MgO							
Na <sub>2</sub> O							
K <sub>2</sub> O							
Total . . . . .	<u>99.93</u>	<u>99.85</u>	<u>100.29</u>	<u>100.39</u>	<u>99.48</u>	<u>99.97</u>	<u>99.76</u>

## THE PISOLITES

*The Maddox Sample.*—Ten pisolites nearly spherical in shape, ranging from three-eighths to one inch in diameter, were selected for the sample. The pebbles were freed, in the usual manner, from all adhering clay. They were hard and firm, and could not be scratched with the finger-nail; but they were readily scratched with a knife, and could be pulverized only in a heavy porcelain mortar by hard pounding. They were of a uniform dull grayish-brown color. Eight of the pisolites were solid throughout, breaking with a hackly or uneven fracture, and showed slightly porous or spongy interiors, due, likely, to a loss of water on contraction from drying after formation; and they were dark grayish-brown in color. Several pisolites showed partially powdery interiors, of a lighter color than the outer solid portion. In only one of them was the concentric (layer) structure apparent. It was composed of variously colored layers enclosing a small powdery nucleus.

*The Bobo Sample.*—Six pisolites, nearly spherical in shape, ranging from three-quarters to one and one-half inches in diameter, were selected for the sample, and were prepared as the Maddox sample, described above. They were of the same color and hardness, as the Maddox sample, but they differed as to the concentric structure, the layers being strongly marked in each one. Each pisolite was formed about a small structureless, indurated nucleus, which varied from red to lavender in color.

*The Red Warrior Sample.*—Six pisolites, of the usual shape, and varying from three-quarters to two inches in diameter, were used for the sample, which was prepared, as described above. They were deep red in color, with pronounced concentric structure, and were composed of several nuclei—*compound*. The interiors were of a deeper red in color, with a majority of them harder than the outer portions. Several showed a red powdery interior without concentric structure. The interiors of several pisolites showed a light-colored, hard, horny mass, closely resembling gibbsite.

## THE MATRIX

*The Maddox Sample.*—A hard, pisolitic ore, composed of a dense and compact cream- to buff-colored matrix, in which were



thickly embedded pisolites, one-quarter to one-half inch in diameter. The matrix breaks with a hackly, partially conchoidal fracture. The pisolites make up more than half of the mass, and vary from red to cream and buff in color. The matrix could not be scratched with the finger-nail.

*The Church Sample.* — A very soft, flour-like, white- to cream-colored, clayey material, without trace of the pisolitic structure.

*The Perry Sample.* — A hard, pisolitic ore, composed of a dense and compact buff-colored matrix, in which were embedded pisolites varying in size, and from pink to white in color. The two (matrix and pisolites) are approximately in the ratio of 1 : 1. The matrix breaks with a hackly fracture and can not be scratched with the finger-nail.

*The Watters Sample.* — A very soft, structureless, flour-like, white to cream-colored clayey material, closely resembling the Church material, described above.

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It will be observed from the analyses, that the pisolites indicate more uniformity in composition, than the matrix; but the analyses further show no appreciable difference in the composition of the two parts of the mineral.

In its purest form, bauxite contains more or less foreign material, either chemically combined or mechanically admixed. Iron sesquioxide, present in variable amounts, ranging from a trace to percentages equal to and occasionally exceeding that of the alumina, is usually present, in part replacing the alumina and in part only as an impurity. So common is iron, as a constituent or impurity, that it serves as a commercial basis for classifying the ore as (a) light-colored or non-ferruginous bauxite, and (b) red-colored or ferruginous bauxite, averaging from 10 to, in extreme cases, 50 per cent. of iron oxide.

Titanium is invariably present, ranging usually from 1 to 10 per cent., when estimated in the form of titanium dioxide. Analyses indicate, that this constituent averages higher in the pisolitic ore, and is lowest for the structureless bauxitic clays. The form, in which the titanium exists in the ore, is seemingly dependent, in large measure, upon the origin of the bauxite. A study of those

deposits, derived from basalt and similar igneous rocks, indicates, that the titanium occurs in the form of free oxide, or as titanitic iron oxide. This is true of the Vogelsberg deposits in Germany, as shown in the study of thin sections of the bauxite by A. Liebreich.<sup>1</sup> Also, of the Ober-Hessen deposits, by Lang.<sup>2</sup> Very little, if any, of the titanium in the Georgia deposits exists as free oxide; as a microscopic examination of a large number of thin sections of the mineral failed to indicate the presence of free oxides. Separations, by means of heavy solution and by elutriation, confirm the microscopic evidence.

Approximately 200 grammes of the powdered bauxite, consisting of both matrix and pisolites mixed, were placed in a separatory funnel, nearly filled with Thoulét solution, of specific gravity slightly less than quartz, and thoroughly shaken. After standing for 12 hours, less than two grammes of the material fell. This was carefully drawn off and examined microscopically. The grains proved to be colorless and transparent, and more or less rounded under the microscope. They were made up almost entirely of quartz. Not a single individual was positively identified as free oxide of titanium, or a titanium bearing mineral.

An examination of numerous thin sections of both matrix and pisolites, under the microscope, also indicated the general absence of titaniferous minerals.

Chemical analyses of the purest bauxites invariably show some silica, which varies from a fraction of one per cent. to several per cent., in the purest ore, and from 30 to 35 per cent., in the low grade types of material—*bauxitic clay*. The silica is usually present in the form of the hydrated aluminum silicate, clay, which is invariably admixed in varying proportions with the bauxite. It is also present, to some extent, as free silica, as is shown by the microscope.

In addition to these, other common impurities, such as lime, magnesia, phosphoric and carbonic acids, and sometimes the alkalis, soda and potash, amounting to, usually, scarcely more than a trace in each case, are mentioned by various writers. The Georgia

<sup>1</sup> Abstracted by R. L. Packard, *Mineral Resources of the United States*, 1891, p. 150.

<sup>2</sup> *Ibid.*, p. 149.

bauxite appears generally to be free from these last named impurities. No trace of them was found in any of the specimens analyzed by the writer.

### RÉSUMÉ

From the preceding data, it is clear, that the formulá, given by Laur<sup>1</sup> for the French bauxites and applied to the Georgia-Alabama mineral, the bi-hydrate of alumina, is not applicable to the Georgia deposits. The average percentages of  $\text{Al}_2\text{O}_3$  and  $\text{H}_2\text{O}$  in the best grade of the Georgia mineral certainly correspond to the formula  $\text{Al}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$ , the tri-hydrate of alumina. In a majority of the analyses, a variable percentage of alumina, insoluble in  $100^\circ \text{C}$ . of  $50^\circ \text{B}$ . sulphuric acid, is present, which ranges from a fraction of one per cent., in the purest ore, to from 40 to 45 per cent. in the associated bauxitic clays, which are elsewhere shown to grade into each other. This insoluble alumina is probably present in the form of the hydrous aluminum silicate, clay, admixed possibly, as Phillips suggests,<sup>2</sup> with a lower hydrate of alumina. Thus the Georgia bauxite, in its purest form, is, in most cases, a mixture, whose base or essential part is the tri-hydrate of alumina. All gradations, in which the soluble alumina ranges from 60 or more per cent. to less than one per cent., or from the pure tri-hydrate of alumina into the bauxitic clay, corresponding to the hydrous aluminum silicate, are known.

As remarked by Liebreich,<sup>3</sup> chemical analyses of the mineral from different localities show differences in chemical composition. Thus we have analyses, which correspond to the three hydrates of alumina, namely, the mono-, di- and tri-hydrates, which strikingly illustrate the variable character of the so-called mineral, bauxite.

So far as the writer can gather, from the various accounts and descriptions, in which analyses of bauxites from the principal localities, both foreign and American, are given, much depends on the origin, as to the chemical constitution of the mineral. Indeed, if the results can be relied on, we might put it a little stronger,

<sup>1</sup> Laur, Francis, *Op. Cit.*

<sup>2</sup> Phillips, W. B., and Hancock, David, *Op. Cit.*

<sup>3</sup> Packard, R. L., *Op. Cit.*

and say, that the origin controls the chemical composition. Alumina forms, however, in all cases, the basis, and ranges from 55 to 85 per cent., according to locality, with correspondingly variable proportions of water of chemical combination, ranging accordingly from 15 to 34 per cent. Thus, deposits of the mineral are known, which correspond, on analysis, with the three hydrates of alumina, namely, the mono-, di- and tri-hydrates.

While the so-called mineral, bauxite, corresponds in chemical composition, according to locality, to the three natural hydrates of alumina; as a rule, no resemblance in physical properties, known at present, is shown, to the minerals, diaspore (mono-hydrate) and gibbsite (tri-hydrate).

Since this correspondence, therefore, in chemical composition, to the three hydrates does exist, the question is naturally suggested, whether the mono- and tri-hydrates, known as the minerals diaspore and gibbsite, do not really occur, with physical properties different from those usually recorded, and closely resembling those of the mineral, bauxite? In other words, is not what is called bauxite in some localities, diaspore or gibbsite in a different physical state? Or, whether the commonly accepted formula for bauxite,  $\text{Al}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$  or  $\text{Al}_2\text{O}(\text{OH})_4$  must be modified, according to locality, to correspond to the mono-, di- or tri-hydrate, as the case may be, the general formula to be applied, irrespective of locality, and in its broadest usage, to be written  $\text{Al}_2\text{O}_3 \cdot N\text{H}_2\text{O}$ , in which  $N$  is variable and may correspond to one, two or three molecules of water.

Certainly if chemical work has any value in determining the constitution of material, we are forced to accept one of the two alternatives.

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## 2. VARIETIES OF THE BAUXITE<sup>1</sup>

It must be understood in the beginning, that the classification of the ore into types or varieties is by no means well defined or differentiated at all times, but that the several types here designated grade imperceptibly into each other. The classification serves, however, as a convenient basis for description of the indi-

<sup>1</sup> Hayes, C. W., Sixteenth Ann. Rept., U. S. Geol. Surv., 1894, Pt. III, p. 562.

vidual deposits. The bauxite in the Georgia area shows considerable variation in color and hardness, chemical composition and structure. The concretionary structure is characteristic of all the varieties of the bauxite; although it becomes almost entirely absent in some cases.

The following types, based on structure, were previously recognized by Hayes, and in essential details they are in accord with the writer's observations: (1) Pebble ore; (2) Pisolitic ore; (3) Oölitic ore; (4) Vesicular ore; (5) Amorphous ore.

In the first three varieties, the size of the concretions and the character of the matrix are made the basis of differentiation. In the vesicular and amorphous types of ore, "the degree of compactness of matrix and concretions and the relative amounts of the two components" are the distinguishing factors.

(1) PEBBLE ORE. — In this type, the matrix is soft, and is not sufficiently strong to hold the pebbles together, when worked or handled; hence they fall apart like loose gravel, when mined. The pebbles vary greatly in size; but the majority of them, perhaps, measure between three-quarters and one and one-half inches in diameter. They may be simple or complex in structure; perfectly rounded and spherical, to irregular in outline; with the nuclei usually powdery and enclosed by hard concentric layers of varying thickness.

(2) PISOLITIC ORE. — The pisolitic differs from the pebble type of ore in the size of concretion and the firmness of the matrix. The matrix is usually hard and compact, with the concretions between a quarter and a half inch in diameter, and hard, so that both matrix and concretion break with a conchoidal fracture.

(3) OÖLITIC ORE. — The oölitic differs from the pisolitic type, by a decrease in size of the concretions. The concretions of this type vary from the size of a pea down to the smallest ore-grain.

(4) VESICULAR ORE. — This type consists of a compact, dense matrix, from which the concretions have fallen out. In either type of the hard concretionary ore, the concretions, when softer than the matrix, frequently weather upon exposure and fall out, giving a typical vesicular ore on the surface, which grades into the concretionary varieties in the fresh ore underneath.

(5) AMORPHOUS ORE. — This type, as the name implies, consists of the structureless bauxitic clayey matrix, in which concretionary structure is scarcely, if at all, visible. It varies from soft to hard and dense material, closely resembling halloysite.

In all of the types, the ore varies from deep red in color, in which the aluminum is replaced by iron in all proportions, to white and cream-colored. Color serves, then, in a general way, to classify the ore into (a) *Ferruginous, Red-colored Bauxite*; and (b) *Non-ferruginous, White to Cream-colored Bauxite*.



ANOTHER VIEW IN THE FLOYD COUNTY RED SHALE QUARRY, NEAR ROME, GEORGIA.

## CHAPTER IV

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### DISTRIBUTION AND DESCRIPTION OF THE INDIVIDUAL BAUXITE DEPOSITS IN GEORGIA

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The distribution of the ore-bodies, so far known in Georgia, is shown on the accompanying map. The deposits are limited to six contiguous counties, namely, Walker, Chattooga, Gordon, Bartow, Polk and Floyd, which constitute the middle and south parts of the so-called Paleozoic Group, in northwest Georgia. Of these, Bartow and Floyd counties include the vast majority of the ore-bodies, grouped into fairly well defined districts. The remaining counties include only one or two deposits each, widely separated, as a rule, from each other.

While all parts of the region have a similar geologic history, the two districts possess certain peculiar structural geologic features, with which the ore distribution is apparently intimately associated. That geologic, as well as geographic relations, serve as a basis for the grouping of these deposits is apparent from the individual descriptions of the two districts, given below. The two may be conveniently designated (1) *The Hermitage District*, and (2) *The Bobo District*. A third district, less well defined than the Hermitage and Bobo districts, which includes the deposits of Chattooga and Walker counties, is designated *The Summerville District*. The deposits of Polk county occur in its extreme northern part, just across the Floyd county-line, and constitute the most southern, of the Bobo district.

The occurrence of bauxite in Gordon county is near Calhoun, in the central-western part of the county, about 15 miles north of Hall's station. A belt, 12 to 15 miles in width, in which bauxite has not yet been discovered, separates the extreme northern de-



posits of the Hermitage district from those of Gordon county. The ore-bodies in this county are, therefore, best described under a fourth and separate district, designated *The Calhoun District*.

The ore-belt continues southwestward into Alabama, for a distance nearly equal to that in Georgia; but no active developments have been made outside of the Dyke's district in Cherokee county, whose eastern limit is the State-line between Georgia and Alabama.

Somewhat extensive deposits of iron ore occur, more or less closely associated with the bauxite, throughout the Georgia belt. The association of the bauxite with the iron ore deposits is particularly marked in the Hermitage and Bobo districts. The deposits of iron in the Hermitage district were somewhat extensively worked, for many years previous to the discovery of the closely associated bauxite. Indeed, it was the working of the iron deposits, that led to the discovery of bauxite in the Hermitage district.

A description of the geology of the region is given elsewhere in this report. The conditions peculiar to each district are given in the classification and description of the individual deposits below.

#### I THE HERMITAGE DISTRICT

In number of deposits, the Hermitage district is the largest in the State. It includes an area of more than 50 square miles, lying between Rome, Kingston and Adairsville, east of the Oostanaula river, and north of the Etowah river. It further occupies the contiguous northeastern and northwestern portions, respectively, of Floyd and Bartow counties. As a rule, the deposits are irregularly distributed over the district; but, in some cases, they are sufficiently numerous and near together, to form separate smaller groups, such as the Ridge Valley deposits, etc. As may be seen on the map, the distribution of the ore-bodies in this district, as a whole, is into a roughly oval-shaped area in outline. The northwestern limits of the area are along a line of contact between the Knox dolomite plateau and the underlying Connasauga shales.

The geologic structure of the region is comparatively simple, with no visible lines of fracture or faulting at the surface, such as

characterize the Bobo district. The surface-rock consists almost entirely of the massive Knox dolomite, which is only slightly folded. At several points, however, the underlying shales appear at the surface in narrow anticlines, indicating more or less folding of the overlying limestone. The most noteworthy case is near Barnsley, where the shale exposures are traceable, for several miles to the south, as long and narrow arched belts. The Cambrian shales are further exposed along the valley occupied by the Western and Atlantic Railway, to the east of Barnsley, and again at Kingston. Wherever exposed, the shales are much broken and crushed. The magnesian limestone is prevailingly covered with a thick mantle of vari-colored, siliceous residual clays derived therefrom, and not entirely free from commingled fragments of chert. The surface is thickly strewn with large and small, angular and subangular fragments of the chert. Owing to the depth of residual decay, exposures of the underlying rocks are rare. Beside private individuals, the following companies either own or have worked, under lease, the various deposits in this district:—

The Republic Mining & Manufacturing Company;

The Georgia Bauxite & Mining Company;

The Dixie Bauxite Company;

The Southern Bauxite Mining & Manufacturing Company.

The first three companies have operated very extensively in the Hermitage district; while the latter company's property, in Georgia, lies, for the most part in the Cave Spring section of the Bobo district.

The following is a list of the known deposits of bauxite in the Hermitage district:—

Name	Land Divisions				Remarks
	County	Section	District	Lot	
Holland Spring . . . . .	Floyd	3	23	61	Worked
Holland House . . . . .	"	3	23	61	"
Holland . . . . .	"	3	23	61	"
Church . . . . .	"	3	23	61	"
Ridge Valley No. 1 . . . . .	"	3	23	60	
" Lot 103" . . . . .	"	3	23	103	Worked
" Lot 104" . . . . .	"	3	23	104	"
Ward . . . . .	"	3	23	136	"
Braden . . . . .	"	3	23	137	"
Ridge Valley No. 3 . . . . .	"	3	23	20	Prospected
Stockade . . . . .	"	3	23	21	Worked
Grier . . . . .	"	3	23	22	"
Pinson . . . . .	"	3	15	31	Prospected
Ridge Valley No. 4 . . . . .	"	3	23	59	
Maddox . . . . .	"	3	23	138	Worked
Watters . . . . .	"	3	23	147	"
Wright . . . . .	"	3	23	134	Prospected
Burney . . . . .	"	3	23	148	"
Ridge Valley No. 2 . . . . .	Bartow	3	16	1	"
Hardee . . . . .	"	3	16	60	
" Lot 29" . . . . .	"	3	16	29	
Davis No. 1 . . . . .	"	3	16	6	Prospected
" " 2 . . . . .	"	3	15	106	Worked
Veach . . . . .	"	3	15	27	Prospected
McGuire No. 1 . . . . .	"	3	15	23	"
" " 2 . . . . .	"	3	16	142	"
Terry-Shaw . . . . .	"	3	16	10 and 21	Worked
Sheets . . . . .	"	3	16	22	Prospected
Morrow . . . . .	"	3	16	36	"
Montague & Co . . . . .	"	3	16	97	"
Connaseena . . . . .	"	3	16	128	Worked
Mary . . . . .	"	3	16	54	"
Holt . . . . .	"	3	16	65	"
Julia . . . . .	"	3	16	117	"
Warring . . . . .	"	3	16	108	Prospected
Spurlock . . . . .	"	3	16	102	"
Green . . . . .	"	3	16	98	"
Akin . . . . .	"	3	5	7 and 106	"
" Lot 115" . . . . .	"	3	16	115	"

#### LOCATION AND DESCRIPTION OF THE INDIVIDUAL DEPOSITS

THE HOLLAND SPRING BANK.—This deposit, owned by the Republic Mining & Manufacturing Company, is located on *lot 61, 23rd district, 3rd section*, Floyd county, and is from 450 to 500 yards west of the Church bank. It has been opened to some extent, and a fair quantity of the ore, taken out. The work done consists of a shallow pit, from 30 to 45 feet in diameter, with a 36-foot tunnel, from 6 to 8 feet high, driven into the eastern slope,

at the base of a low dolomite ridge. Several drifts have been opened on each side of the tunnel. Veins and "horses" of pink-and-white mottled clay, several feet in width, cut the ore-body. The exposure is not sufficient to show the extent of the ore. The ore is a soft bauxitic clay, through which are scattered the small, vari-colored concretions. The concretions are small, and, when perfectly formed, are regular and spherical in outline, varying from deep-red through lighter shades to white in color. They consist of walls made up of layers of several thicknesses enclosing the white-and-red powder. Some hard ore is met with, consisting of a firm and compact buff-colored, siliceous appearing matrix, in which the oölites are embedded.

Numerous irregular partially lens-shaped areas of perfectly white halloysite, averaging from a fraction of an inch to several inches in diameter, are thickly scattered through the amorphous type of ore — *bauxitic clay*. The workings had not reached the limits of the ore on either side.

THE HOLLAND HOUSE BANK. — This opening is from 50 to 75 paces east of the Holland Spring bank, on *lot 61, 23rd district, 3rd section*, Floyd county. The two are similarly situated with reference to the ridge, and the workings and character of the ore are closely similar. The openings in the Holland House bank are not sufficient to show the extent of the deposit; although a cut from 30 to 35 feet long, and from 15 to 20 feet deep, showed ore through its entire length. The ore-body is covered with a red clay, and is further cut by a series of vertical clay dikes, of small dimensions and of the same color as the covering. A partial parallel banding to the outer surfaces was observed in several places in the clay dikes. The ore is generally of a poorly defined pisolitic type, with the concretions scattered through a soft, clayey matrix. The entire mass crumbles readily. Occasional boulders, "dornicks" of hard ore, varying from a few inches to several feet in diameter, are mixed with the body of soft ore.

The following analysis furnished by Mr. John H. Hawkins, Superintendent of the Republic Mining & Manufacturing Co., Hermitage, Georgia, represents an average of about 100 tons of the ore: —

Al <sub>2</sub> O <sub>3</sub> . . . . .	51.65
Fe <sub>2</sub> O <sub>3</sub> . . . . .	1.29
TiO <sub>2</sub> . . . . .	3.49
SiO <sub>2</sub> . . . . .	10.62
Ignition . . . . .	32.45
Total . . . . .	<u>99.50</u>

THE HOLLAND BANK. — This deposit is three miles due east from the Hermitage furnace, and 300 yards north of the Church bank on *lot 61, 23rd district, 3rd section*, Floyd county. Previous to 1895, the Holland bank furnished a considerable part of the ore shipped from Georgia, and the work done was more extensive and in a more systematic way, than at most of the other banks. It was from this locality, that James Holland picked up fragments of the highly ferruginous bauxite in 1881, and submitted them to Mr. Edward Nichols, Acting Chemist to the Ridge Valley Iron Company for analysis, thinking they represented an ore of iron. An analysis was made, which resulted in a lower percentage of iron and a higher percentage of alumina as compared with iron ores in general, and led Mr. Nichols to identify the material as the mineral bauxite. In 1887, Mr. Nichols briefly described the results in the "*Transactions of the American Institute of Mining Engineers.*" In 1888, the bauxite on this property was opened for the first time, which marked the inauguration, or beginning, of the bauxite mining industry in Georgia.

The ore-body is enclosed by a deep-red to chocolate-brown, sometimes mottled clay; and, from the workings, it was apparently nearly circular in outline. The working consists of one circular pit, 100 feet in diameter at the top, with the ore removed to a depth of from 50 to 60 feet. Nearly the entire mass of ore has been removed to this depth, except a little ferruginous ore still in contact with the surrounding clay. At the time of the writer's visit, in August, 1899, the opening was nearly half filled with water, and the examination of the bottom of the pit was impossible; but he was informed, that the ore was by no means exhausted, when operations were suspended.

Above the surface of the water in the pit, the enclosing clay walls had an angle of slope approximating 45°, which, if uniform

for the entire depth of the pit, would indicate that the ore would become entirely exhausted at an additional depth of from 20 to 30 feet.

Nothing but red ore was in sight, at the time of the writer's visit, a large amount of which, judging from the extent of the dump-piles, was rejected, on account of the high percentage of iron. The type of ore commonly represented in this bank is vesicular, forming originally, perhaps, the pisolitic variety. It consists of concretions, averaging a quarter of an inch in diameter, embedded in a harder and lighter colored matrix. More often, the concretions are represented by cavities of a darker colored lining than the matrix, partially filled with fine powder.

The character of the ore is well shown in the following analysis,<sup>1</sup> which represents an average of 106 cars of bauxite from this bank:—

Al <sub>2</sub> O <sub>3</sub> . . . . .	52.93
Fe <sub>2</sub> O <sub>3</sub> . . . . .	9.23
TiO <sub>2</sub> . . . . .	3.49
SiO <sub>2</sub> . . . . .	4.55
Ignition . . . . .	29.80
Total . . . . .	<u>100.00</u>

THE CHURCH BANK.<sup>2</sup>—This was the only one of the Hermitage group of deposits working in August, 1899. It is located on *lot 61, 23rd district, 3rd section*, Floyd county, about 350 yards south of the Holland bank. According to aneroid measurements, it is 40 feet lower than the Holland bank. Two openings have been worked, located 200 yards from each other in an east-west line, representing a large quantity of ore removed from both. The most westerly one of the openings is the older, and consists of a cut, 20 feet wide, 200 feet long, and 30 feet deep. Conditions indicate, that the main body of the ore has been removed from this

<sup>1</sup> From John H. Hawkins, Supt. of the Republic Mining & Manufacturing Company, Hermitage, Georgia.

<sup>2</sup> The writer was informed, in September, 1901, that the *Church bank* in the Hermitage district had been exhausted. The Republic Mining & Manufacturing Company was working, during 1902, the deposits on *lots 103 and 104* of the Hermitage district, and the "*Fat John*" bank of the Bobo district. The writer visited the "*Fat John*" bank, during the summer of 1902, and found the results very satisfactory. The deposit is a large one, and the grade of ore good (See half-tone of the "*Fat John*" bank.)

opening, leaving a lean bauxitic clay. On the assumption, that the Holland deposit extends 20 feet below the bottom of the present pit, the limit of the two ore-bodies is observed to be on the same level. If, as is probable, the two had the same upper limits, the Church bank has suffered considerably more erosion than the Holland bank. This has resulted in the removal of the bulk of the original body of ore from the Church deposit. The bottom and sides show a white, and occasionally slightly mottled, bauxitic clay containing embedded concretions of various sizes, along with a few scattered small boulders of the compact pisolitic type of ore. This opening was abandoned, on account of the material, exposed at present, ranging too high in silica, to be utilized by the present methods.

The most easterly opening, the one working during the summer of 1899, consisted of a circular pit, from 150 to 200 feet in diameter at the top, which had been worked to a depth of from 35 to 40 feet. The surrounding clay is prevailingly light in color. The walls of the opening are nearly vertical, without appreciable narrowing of the ore-body at the 40-foot depth; on the contrary, it has equal lateral dimensions at this depth as at the top, and the ore maintains its uniform quality and character throughout. The bottom of this opening had not reached the local base-level of the neighboring ravines. The ore-body is cut by two series of parallel vertical clay seams or dikes. The principal series, including the largest seams, which average 2 feet in width in case of the widest ones, trend east and west. The smaller ones average from two to six inches in thickness, cutting the principal series at right angles, and accordingly having a general north-south direction. The seams are not uniform in thickness, and all contain more or less commingled ore. As a rule, the smaller seams contain mixtures of the soft type of ore; while that associated with the larger seams is mostly of the hard compact variety. The proportion of ore to clay in the seams is not large enough to render separating from the clay, by washing, profitable; hence, the associated ore is usually rejected along with the clay.

Both soft and hard types of ore are met with, the former greatly predominating. It is prevailingly white or light in color, with a

small proportion of the ore, near the surface, highly ferruginous and red in color. The uniformly light-colored ore from this deposit is strongly contrasted with the prevailing red ore from the almost adjacent Holland bank on the north. The enclosing clays, as well as the ore, are also generally light-colored. The small area of red ore, near the limits of the ore-body proper, would seemingly favor the suggestion, that some of the ferruginous bauxite owes its red color, not to iron as an original constituent, but as a probable secondary infiltration and replacement, subsequent to the deposition of the ore. The hard type of ore is the usual boulder form, compact pisolitic variety, made up of concretions enclosing a white powder, the whole embedded in a dense, firm light-colored matrix.

The ore is raised by steam, on an inclined track with cable. An average of 300 tons of this ore yielded the following results:—<sup>1</sup>

Al <sub>2</sub> O <sub>3</sub> . . . . .	55.30
Fe <sub>2</sub> O <sub>3</sub> . . . . .	1.02
TiO <sub>2</sub> . . . . .	4.04
SiO <sub>2</sub> . . . . .	8.04
Ignition . . . . .	31.60
Total . . . . .	<u>100.00</u>

An analysis, made of a specimen of the soft and structureless bauxitic clayey matrix, yielded the writer, in the Survey laboratory, the following results:—

SiO <sub>2</sub> . . . . .	20.46
TiO <sub>2</sub> . . . . .	9.80
Fe <sub>2</sub> O <sub>3</sub> . . . . .	0.28
Al <sub>2</sub> O <sub>3</sub> . . . . .	46.92
H <sub>2</sub> O at 100° C. . . . .	0.34
H <sub>2</sub> O (Combined) . . . . .	21.68
Total . . . . .	<u>99.48</u>

THE RIDGE VALLEY BANK NO. I.—On *lot 60, 23rd district, 3rd section*, Floyd county, four test-pits, of average dimensions, have been opened. The pits are in pairs, and are approximately 500 feet apart, along a north-south line. The northern-

<sup>1</sup> From John H. Hawkins, Sup't, Republic Mining & Manufacturing Company, Hermitage, Georgia.



most two show a white ore; while the southern ones indicate a very ferruginous red ore. So far as is opened, the ore belongs to the hard type. The openings are entirely insufficient to show the extent and form of the ore-body. The work has been wholly in the nature of prospecting, with no shipment of ore yet made.

LOT "103," 23RD DISTRICT, 3RD SECTION, FLOYD COUNTY.— On this lot, four openings have been made within from 400 to 500 feet of each other. It is estimated, that approximately 500 tons of ore have been shipped from the main pit. This opening is roughly elliptical in outline, 25 feet long, 18 feet wide, and 35 feet deep, and was partially filled with water at the time of the writer's visit in August, 1899; but he was informed, that the ore had been entirely exhausted. The ore from the main opening was of the pebble type, and light in color.

Three test-pits, within a radius of 100 feet from each other, and west 400 feet from the working described above, have been dug. In these, a highly ferruginous red-colored ore is shown. The ore-body is probably a large one; although its exact limits can not be defined, on account of insufficient development. The association of a highly ferruginous ore with one nearly free from iron, as is shown in the analysis below, and light in color, within a few hundred feet, is a very noteworthy feature. It is quite similar to the grades of ore found in the Holland and Church banks, previously described.

The following analysis<sup>1</sup> represents an average of 40 tons of ore from the main opening on "lot 103":—

Al <sub>2</sub> O <sub>3</sub> . . . . .	57.06
Fe <sub>2</sub> O <sub>3</sub> . . . . .	1.80
TiO <sub>2</sub> . . . . .	3.68
SiO <sub>2</sub> . . . . .	6.32
Ignition . . . . .	<u>30.54</u>
Total . . . . .	<u>99.40</u>

"LOT 104," 23RD DISTRICT, 3RD SECTION, FLOYD COUNTY.— Several test-pits, of average size, have been sunk in different places on this lot, revealing a fair grade of soft, white ore mixed with

<sup>1</sup> From John H. Hawkins, Sup't, Republic Mining & Manufacturing Company, Hermitage, Georgia.

some of the compact boulder type. No regular work has been done on this lot, and no ore has yet been shipped.

THE WARD BANK. — This deposit is located on *lot 136, 23rd district, 3rd section*, Floyd county. Very little work has been done, and only one car of the ore had been shipped, up to August, 1899. The developments are entirely too meager to define the limits of the ore-body; although present conditions would favor an estimate of a moderately extensive deposit. Specimens of the ore show the pisolitic type, consisting of perfectly spherical concretions, from a fourth to a half-inch in diameter, embedded in a compact light-colored matrix. When broken, the interiors of the concretions are seen to be filled with a red powder.

THE BRADEN BANK. — Considerable prospecting has been done on *lot 137, 23rd district, 3rd section*, Floyd county. Three shafts, having the following dimensions, have been sunk:—(1) 4 x 5-foot opening and 32 feet deep; (2) 4 x 5-foot opening and 40 feet deep; and (3) 4 x 5-foot opening and 42 feet deep. A medium light-colored bauxite was pierced at a depth of 3 or 4 feet from the surface, composed of a cherty clay soil. None of the shafts penetrated the entire depth of the ore-body. One hundred and fifty yards southeast of the shafts, a pit 30 x 40 feet, and 8 feet deep, was dug in a solid body of ore, after removing a residual soil covering to the depth of three feet. One hundred and fifty yards northeast of the pit, less than half-a-dozen smaller prospect openings, averaging six feet in depth, have been made. Ore was found in all the openings, varying from a ferruginous to a non-ferruginous type.

The following partial analyses,<sup>1</sup> made on specimens of ore collected from this lot, will give some idea of the character of the bauxite:—

	I	II
Al <sub>2</sub> O <sub>3</sub> . . . . .	62.53	—
Fe <sub>2</sub> O <sub>3</sub> . . . . .	1.97	1.03
Insoluble Matter . . . . .	5.46	5.15

THE RIDGE VALLEY BANK NO. 2. — On *lot 1, 16th district, 3rd section*, Bartow county, one test-pit has been opened, revealing

<sup>1</sup> Furnished by Mr. B. F. A. Saylor, Sup't of the Dixie Bauxite Company.

a hard, siliceous, bauxitic clay, flinty in appearance, and breaking with a conchoidal fracture, but easily cut with a knife, and closely resembling the mineral halloysite.

In the Dykes district, near Rock Run in Cherokee county, Alabama, a similar prospect, after passing through the same material for a depth of from 7 to 10 feet, exposed a 40-foot deposit of a high grade of oölitic ore, of white color.

RIDGE VALLEY BANK NO. 3. — *Lot 20, 23rd district, 3rd section*, Floyd county, has been prospected to some extent and a white pebble type of ore, found. The extent of the deposit is wholly unknown, since practically no developments have been undertaken.

THE STOCKADE BANK. — This deposit is located on *lot 21, 23rd district, 3rd section*, Floyd county. Numerous openings occur; and 60 tons of the ore are estimated to have been shipped. The openings are in the nature of shafts and pits in a slight ravine, with a north-and-south alignment. In some cases, the ore was found at the surface; while in others, a covering of residual clay, from 10 to 16 feet in depth, was removed, before the ore-body was encountered. The deepest opening is near the head of the ravine. It was worked to a depth of 35 feet, without penetrating the entire depth of the deposit. The ore is of the hard, compact, ferruginous boulder type. The following analysis<sup>1</sup> is of an average of 60 tons of the ore, which gives an accurate idea of its character:—

Al <sub>2</sub> O <sub>3</sub> . . . . .	58.34
Fe <sub>2</sub> O <sub>3</sub> . . . . .	4.51
TiO <sub>2</sub> . . . . .	3.40
SiO <sub>2</sub> . . . . .	3.35
Ignition . . . . .	30.40
Total . . . . .	100.00

Dr. Spencer<sup>2</sup> gives the following results, on analysis of a "white porcelanous mass, with subordinate pisolitic grains, associated with white clay beds upon the side of a ridge," in the same lot:—

<sup>1</sup> Furnished by John H. Hawkins, Sup't, Republic Mining & Manufacturing Company.

<sup>2</sup> *The Paleozoic Group of Georgia*, Geological Survey of Georgia, 1893, p. 216.

Al <sub>2</sub> O <sub>3</sub> . . . . .	46.72
Fe <sub>2</sub> O <sub>3</sub> . . . . .	2.14
TiO <sub>2</sub> . . . . .	0.87
SiO <sub>2</sub> . . . . .	29.01
Ignition . . . . .	20.15
Total . . . . .	<u>98.92</u>

The following analysis<sup>1</sup> is of specimens of white clay from the Flowery Branch bauxite deposit on the same lot:—

Al <sub>2</sub> O <sub>3</sub> . . . . .	38.60
Fe <sub>2</sub> O <sub>3</sub> . . . . .	1.45
K <sub>2</sub> O . . . . .	0.09
Na <sub>2</sub> O . . . . .	0.02
MgO . . . . .	0.30
TiO <sub>2</sub> . . . . .	1.95
SiO <sub>2</sub> (Combined) . . . . .	40.40
SiO <sub>2</sub> (Free sand) . . . . .	0.80
H <sub>2</sub> O (Combined) . . . . .	16.35
H <sub>2</sub> O (Hygroscopic) . . . . .	0.35
Total . . . . .	<u>100.31</u>

Mining was suspended on this lot some years ago.

THE GRIER BANK. — This deposit is located on *lot 22, 23rd district, 3rd section*, Floyd county. Only one opening has been made, and this is in the form of a circular pit, worked to the depth of from 15 to 20 feet, with an estimate of approximately 25 tons of the ore taken out. The pit was sunk on a 3-foot-square surface outcrop of the ore. The opening is more in the nature of a prospect, than an attempt at regular working; and neither the lateral nor the vertical limit of the ore-body has been reached. The soft pebble type of ore predominates, mixed, to some degree, with the hard pisolitic variety of bauxite. It is very similar to that of the Church bank, described above. An average of 20 tons of the ore gave the following results on analysis:—<sup>2</sup>

Al <sub>2</sub> O <sub>3</sub> . . . . .	59.22
Fe <sub>2</sub> O <sub>3</sub> . . . . .	3.16
TiO <sub>2</sub> . . . . .	3.60
SiO <sub>2</sub> . . . . .	3.30
Ignition . . . . .	30.70
Total . . . . .	<u>99.98</u>

<sup>1</sup> Spencer, J. W., *op. cit.*, p. 281.

<sup>2</sup> Furnished by John H. Hawkins, Sup't, Republic Mining & Manufacturing Company.

THE HARDEE BANK. — Near the northwest corner of *lot 60, 16th district, 3rd section*, Bartow county, in a slight depression on the south side of a ridge, is an outcropping, in the form of scattered fragments of bauxite over an area, from 500 to 600 feet in length. The longer axis of the area, over which the fragments are strewn, has an east-west direction. Some four or five test-pits have been dug along the axis of the area, revealing, for the most part, a ferruginous ore mixed with some of a lighter color.

Near the center of the same lot, and 300 yards south of the above deposit, on top of the ridge, is a second deposit of bauxite, belonging to the pisolitic variety, made up of red oölites sparingly scattered through a light to pink colored matrix. Some prospecting in the nature of test-pits has been done. Both deposits have good promise as to quality and quantity.

THE PINSON BANK. — Two test-pits have been sunk on *lot 31, 15th district, 3rd section*, Floyd county; and a light solid body of ore has been shown in each. So far as prospecting has extended, the ore is the hard, oölitic type, usually pink in color, and mixed with some pebble ore.

THE RIDGE VALLEY BANK NO. 4. — One small opening, from which a quarter of a ton of hard, white bauxite has been shipped, has been made on *lot 59, 23rd district, 3rd section*, Floyd county. Present indications point to no very extensive body of ore.

THE MADDOX BANK. — This deposit is located on *lot 138, 23rd district, 3rd section*, Floyd county. The openings consist of two large connecting pits in a north-and-south line. The work done has been very extensive, and in a systematic manner. The pits are nearly circular in outline, and have the following dimensions: South pit, 60x130 feet; worked to a depth of 32 feet, with a 27-foot depth of ore. The north pit has approximately the same dimensions, and has been worked to a depth of 25 feet. At the time of the writer's visit, the two openings were filled with water, to within 10 to 15 feet from the surface; but the writer was informed, that the ore was not entirely exhausted in the bottoms. The water filling the pits is a turbid green in color.

The entire deposit was originally covered, to a depth of from

3 to 6 feet, with a bright-yellow, siliceous residual clay, containing a considerable quantity of commingled angular masses of chert, of various sizes. It is further situated on a broad and even surface-plain of dolomitic limestone, whose surface, in turn, is thickly strewn with chert fragments. The walls of the openings vary but slightly from the vertical, showing apparently a large amount of ore still in sight.

The ore is of the pisolitic variety, prevailingly white in color, although some highly ferruginous red masses occur. The oölites, or concretions, vary in size from an eighth to an inch in diameter, and are usually white and perfectly rounded in outline. In these, the concentric (layer) structure is highly developed. Some of the layers are red; but the majority are light in color, and frequently the two colored layers alternate in the same individual. The concretions are embedded in a compact, buff-colored matrix. Both hard and soft ore are represented. The ore-body is cut by the usual number of clay seams and "horses," some of which were apparently of large size in this deposit. It is estimated, that several thousand tons of the ore have been worked, and shipped from this property.

The following partial analyses<sup>1</sup> give a general idea of the character of this ore:—

	I	II	III
Al <sub>2</sub> O <sub>3</sub> . . . . .	62.73	61.78 <sup>2</sup>	62.54
Fe <sub>2</sub> O <sub>3</sub> . . . . .	2.86	3.32	1.36
SiO <sub>2</sub> . . . . .	4.73	2.76	5.46
H <sub>2</sub> O . . . . .	—	32.11	—

Separate determinations of silica and iron oxide in different specimens of the ore gave the following results:—

	I	II	III
SiO <sub>2</sub> . . . . .	9.36	3.16	19.64
Fe <sub>2</sub> O <sub>3</sub> . . . . .	3.51	—	—

The silica in the first and third columns of the last determinations evidently represent an imperfectly washed ore. The following partial analyses are of specimens of clay from the "horses," cutting the ore-body in the two pits:—

<sup>1</sup> Furnished by Mr. B. F. A. Saylor, Sup't, Dixie Bauxite Company.

<sup>2</sup> Includes TiO<sub>2</sub>.

	North Pit		South Pit		
Al <sub>2</sub> O <sub>3</sub> . . . . .	40.60	46.33	45.05	—	—
Fe <sub>2</sub> O <sub>3</sub> . . . . .	0.99	—	—	—	—
Insol. Matter . . . . .	43.30	43.75	37.42	31.80	38.80

A determination of the insoluble matter in the waste, from the ore-washer in the Maddox bank, gave 20.70 per cent.

Separate analyses of the pisolites and matrix, made by the writer in the Survey laboratory, on selected samples of ore from the Maddox bank, gave the following results:—

	Pisolites	Matrix
SiO <sub>2</sub> . . . . .	3.74	0.62
TiO <sub>2</sub> . . . . .	9.70	1.05
Fe <sub>2</sub> O <sub>3</sub> . . . . .	0.76	0.28
Al <sub>2</sub> O <sub>3</sub> . . . . .	52.36	64.91
H <sub>2</sub> O at 100° C. . . . .	0.20	0.53
H <sub>2</sub> O (Combined) . . . . .	33.17	33.00
Total . . . . .	99.93	100.39

One of the largest plants for washing, drying and hoisting ore in the bauxite district is located on the side of the Maddox opening, and is in excellent condition.

**THE WATTERS BANK.**—This deposit is located in the northwest corner of lot 147, 23rd district, 3rd section, Floyd county, 5 miles slightly east of north from Rome. It is owned by the Southern Bauxite Mining and Manufacturing Company, whose post-office is Cave Spring, Georgia. The deposit occupies the southeast slope, and near the top, of a broad and gently sloping dolomite ridge, whose surface is thickly strewn with angular fragments of chert of various sizes. Measurement with the aneroid barometer gave an elevation of 971 feet for the deposit, above sea-level.

This is one of the most extensive deposits, yet worked in the State, yielding a rather uniformly high-grade ore. More than 25,000 tons of the ore had been shipped, up to September, 1901.

The deposit consists of two distinct ore-bodies, separated from each other by a distance of 40 yards in a northwest-southeast direction. The ore-bodies are enclosed in the light- and varicolored mottled clays, the light-colored clays predominating. On the north side of the northwest body, where the ore had been ex-



THE "FAT JOHN" BAUXITE MINE, FLOYD COUNTY, GEORGIA.



hausted in September, 1901, at a depth of 80 feet, the angle of slope of the surrounding clays with the ore-body was approximately 35 degrees. Near the centre of the pit, the ore continues to a depth of more than 14 feet below the 80-foot level on the north side, referred to above. The surrounding clays, enclosing the northwest ore-body, are the same on the north and south sides, and are generally light in color; although the purple tints are much in evidence. The dimensions of the pit were 200 feet long, 150 feet wide, and 84 feet deep. The ore-body is covered by an average of 15 feet of yellow-and-red residual cherty clay. The ore is almost entirely of the soft, light-colored pisolitic and gravel types, admixed, to some degree, with boulders of the hard pisolitic ore ("dornick").

The southeast ore-body, which occurs lower down the slope, has been worked to a depth of only 40 feet. The bauxite is mostly of the soft, ferruginous, pisolitic or gravel type, carrying a greater percentage of iron oxide than the light-colored ore from the northwest pit. The ore-body is cut by an east-west clay dike or "horse," 30 feet in width. Some boulders of hard ore ("dornick") occur admixed with the soft red ore.

The general character of the two grades of bauxite from the Watters bank is well shown in the following commercial analyses, made by Mr. S. L. Graham of Rome, Georgia:—

1. *A Light Colored, Non-ferruginous Bauxite, from the Northwest Ore-body*

SiO <sub>2</sub> . . . . .	5.30	6.22	6.24	6.85	6.92	6.01	9.68	7.14
Fe <sub>2</sub> O <sub>3</sub> . . . . .	0.94	1.32	1.14	1.34	0.72	1.59	1.18	1.36
Al <sub>2</sub> O <sub>3</sub> . . . . .	59.21	57.70	58.10	57.01	57.82	57.10	54.17	53.58
SiO <sub>2</sub> . . . . .	5.56	9.53	10.10	11.03	5.79	4.82	18.69	
Fe <sub>2</sub> O <sub>3</sub> . . . . .	1.01	1.78	0.93	0.73	0.66	0.68	0.88	
Al <sub>2</sub> O <sub>3</sub> . . . . .	61.18	58.47	53.21	52.89	54.63	56.87	43.10	

2. *Red Colored, Ferruginous Bauxite, from the Southeast Ore-body*

SiO <sub>2</sub> . . . . .	9.40	9.95	9.33	13.62	10.70	11.95		
Fe <sub>2</sub> O <sub>3</sub> . . . . .	1.53	1.60	2.04	2.11	1.75	1.60		
Al <sub>2</sub> O <sub>3</sub> . . . . .	51.27	49.80	49.96	47.49	49.25	48.30		
SiO <sub>2</sub> . . . . .	10.95	10.60	11.20	8.85	9.80			
Fe <sub>2</sub> O <sub>3</sub> . . . . .	1.89	1.67	2.18	1.67	1.45			
Al <sub>2</sub> O <sub>3</sub> . . . . .	49.75	49.18	48.26	52.33	51.57			

A comparison of the analyses of the two grades of bauxite, from this bank, shows a higher average in  $\text{SiO}_2$  and a lower average in  $\text{Al}_2\text{O}_3$ , for the ferruginous type, than for the light-colored or non-ferruginous ore. The iron oxide in the red bauxite of the Watters bank averages very low indeed; and, in no single analysis, is it shown to be sufficiently high, to, in any way, affect the general good qualities of the ore for alum manufacture.

This property was first opened late in the summer of 1900. The work was in the form of shafts and tunnels, with several open-cuts. Three shafts were sunk, having depths of 33, 55 and 60 feet, respectively. The shafts roughly formed an equilateral triangle, the shortest line, connecting the nearest two, being 165 feet in length. After piercing several feet of a residual cherty clay covering, each shaft was in ore the remaining depth. The main cut was begun well down near the middle slope of the ridge, and continued directly into the ridge, N.  $33^\circ$  W., for a distance of 235 feet, when the depth became too great for the width of cut for open work, and a tunnel was driven the remaining distance, 350 feet. The 55-foot shaft caught the tunnel near the middle of its course, and the 60-foot shaft fixed the northwest limit of the tunnel. The level of the cut extended to the valley, by means of bridge work; a track was laid for the entire distance; and the waste was carted off by trucks, and dumped from the elevated portion of the track to the valley bottom.

Subsequently, open-work was employed for mining the ore, and the shafts and tunnels were destroyed, and were replaced by two large roughly circular pits, 40 and 84 feet deep, respectively.

A siding, a fraction more than two miles long, has been run to the bank, from the Southern Railway, at a point six miles north of Rome.

While engaged in field-work on the manganese deposits of Floyd county, during the summer of 1902, the Watters bank was still being worked, yielding large outputs of good ore.

THE WRIGHT BANK<sup>1</sup>. — This deposit is located on top of the same ridge, approximately 150 yards northeast from the Watters 60-foot shaft, in the southwest corner of *lot 134, 23rd district, 3rd*

<sup>1</sup> Also known as the Hight Bank.

*section*, Floyd county. The deposit has never been worked ; but it has been thoroughly prospected by numerous test-pits, most of which indicated a high-grade ore of the hard, white type. Several openings were drilled to a depth of 25 feet. The section showed three feet of a red, cherty soil covering, and 22 feet of hard, white bauxite. The drilling did not pass through the entire depth of the ore-body. The prospects indicate a large deposit of ore, closely similar to that on the adjacent Watters property.

Some additional prospecting has recently been done on the Wright lot, revealing a large deposit of very good ore, quite similar to that mined on the adjoining lot—the Watters. No ore had been shipped up to September, 1901 ; although approximately two cars of the ore had been mined.

The following commercial analysis of a specimen of the ore from this bank, made by Mr. S. L. Graham, of Rome, Georgia, indicates its general character :—

SiO <sub>2</sub> . . . . .	5.20 per cent.
Fe <sub>2</sub> O <sub>3</sub> . . . . .	1.38 “ “
Al <sub>2</sub> O <sub>3</sub> . . . . .	57.32 “ “

This property is owned by the Southern Bauxite Mining & Manufacturing Company.

**THE BURNEY BANK.**—This deposit is located on the top of the same ridge, about 200 yards west from the Watters bank, on *lot 148, 23rd district, 3rd section*, Floyd county. The prospecting consists of one open-cut, 30 feet long, exposing a white, amorphous, bauxitic clay through its entire length. Several small test-pits have been dug in places, near the cut, with ore found in most of them. The developments are entirely insufficient, as yet, to define the limits and shape of the ore-body.

**LOT 29, 16TH DISTRICT, 3RD SECTION, BARTOW COUNTY.**—Three shafts have been sunk to a depth of 30 feet, within a radius of 100 feet of each other, near the north line of the lot. The shafts penetrated ore for their entire depths. Both soft pebble and hard oölitic types of ore, usually red in color, occur mixed together. The present conditions favor a large body of ore.

**THE DAVIS BANKS.**—Openings have been made on two land

lots, approximately three miles southwest from Adairsville, in separate deposits of a pisolitic type of bauxite. The deposits differ widely in color and in the percentage of iron in the ore.

On *lot 6, 16th district, 3rd section*, Bartow county, one pit, 5 feet deep, 15 feet long and 6 feet wide, located on a ridge 300 yards east of the Davis dwelling-house, was opened about fourteen months prior to the writer's visit in 1899. The ore-body is covered by a deep-red, residual, cherty clay, derived from the limestone and the included chert. The surface of the ground is heavily strewn with angular chert fragments, of varying sizes. About 100 pounds of this ore was shipped to Nashville, Tenn., for exhibition at the Nashville Exposition in 1897. A compact body of highly ferruginous ore is shown in the pit. It is not sufficiently well exposed to say, whether the ferruginous ore is confined to the outer limits of the deposit next to the enclosing clays, as is often the case, or whether it dominates the entire body. The pisolites vary from a quarter to an inch in diameter, readily crumbling to a brick-red powder. The matrix is prevailingly deep-red in color, and mottled light-buff in places. While a solid body of ore is shown in the pit, developments are not sufficient to define its limits, or to say what quantity of ore is present.

The second opening is on *lot 106, 15th district, 3rd section*, Bartow county, approximately half-a-mile northeast of the one described above, and two miles southwest from Adairsville. The prospect is in a nearly level field, covered with a cherty soil, derived from the limestone. A few scattered fragments of the ore, on the surface, led to its discovery. The main pit is 25 feet long, 10 to 12 feet wide, and 8 feet deep. Several smaller test-pits have been dug within a few yards of the large one, revealing ore, of the same character. The openings cover approximately 80 feet square of surface, which would indicate a large ore-body. The main pit was sunk some years ago, and one car-load of the ore, shipped. The ore-body, where exposed, is enclosed by a light-colored bauxitic clay, and, in several places, is cut by clay seams of the same color. Unlike the ore on *lot 6*, this is prevailingly a light-colored ore, averaging very low in iron. The pisolites are somewhat smaller, averaging a quarter of an inch, and less, in diameter, and

are closely crowded in a compact light-colored matrix. The ore is remarkably uniform in character, in all the openings. Some boulder-ore occurs near the top of the main pit, mixed with the surrounding clay.

THE VEACH BANK.—This deposit is located on *lot 27, 15th district, 3rd section*, Bartow county. Several prospect openings have been made; but not more than one car-load of the ore has been shipped. The main pit is 25 feet long, 12 feet wide and 12 feet deep. About four feet of a deep-red, plastic clay were removed, before the ore-body was reached. Several smaller pits have been dug near the large one; but ore was not found in all of them. The ore is prevailingly red in color, with occasional lighter colored areas, closely resembling the Davis bank on *lot 6*. The pisolites vary from a quarter- to a half-inch in diameter.

THE MCGUIRE BANKS.—A small opening has been made in a highly ferruginous red-colored pisolitic type of ore on *lot 23, 15th district, 3rd section*, Bartow county. The pit is irregular in outline, 6 to 8 feet deep, and is located near the top of a dolomite ridge in a body of woods. The opening is cut through from 3 to 4 feet of deep-red clay before striking the ore-body. Several small boulder outcrops of red bauxite occur near the pit. The pisolites vary from a quarter- to a half-inch in diameter.

On *lot 142, 16th district, 3rd section*, Bartow county, near the east line of the lot, and a quarter of a mile west of the Western and Atlantic railroad, four test-pits, averaging 3x5 feet, and seven feet deep, have been opened. The pits cover approximately 50 square-feet of surface. A good quality of hard, white pisolitic ore was found in all the openings. It is stated, that the ore will not exceed three per cent. of silica, and one per cent. of iron oxide, and it will, therefore, average more than 60 per cent. of alumina. The ore-body is located at the head of a ravine near the top of a dolomite ridge. At the time of the writer's visit, the property was under lease to a St. Louis firm; but no work had been done.

THE TERRY-SHAW BANKS.—This deposit, operated by the Georgia Bauxite Company, is located on top of a high dolomite ridge, with an east-west line passing directly through it, which forms the north-and-south boundary line, respectively, of *lots 10*

and 21, 16th district, 3rd section, Bartow county. Lot 10 is known as Mrs. Terry's; and lot 21 is owned by Mr. Frank Shaw. Fragments of bauxite are strewn over the surface for a considerable distance, in both lots. Two large open-cuts have been made and a considerable quantity of the ore, taken out. The largest cut is approximately 100 feet long, 25 feet wide and from 15 to 20 feet deep; while the next one is not quite so long and wide; but it has been worked to nearly the same depth. A number of test-pits have been opened at different points near the cuts, with ore showing in most of them.

The ore is prevailing red in color, and, for the most part, is of the hard, pisolitic type. The pisolites are usually small in size, crumbling in some cases to a red powder, but hard and firm in others, breaking with a conchoidal fracture. They are embedded in a compact, red-colored matrix. The ore is stained, in places, with manganese oxide, which, in many cases, is in the form of small crystals. The ore-body outcrops at the surface, and is enclosed by a deep-red clay, containing, near the surface, abundant commingled fragments of chert. Soft ore is not entirely absent, mixed with the predominating hard boulder type.

The following analyses give a good idea of the character of the ore from the Terry and Shaw properties:—

	Shaw <sup>1</sup>	Terry <sup>1</sup>	Terry <sup>1</sup>	Terry <sup>1</sup>	Terry <sup>1</sup>	Terry <sup>1</sup>
Al <sub>2</sub> O <sub>3</sub> . . . . .	53.32	58.91	53.52	57.81	49.94	62.52
Fe <sub>2</sub> O <sub>3</sub> . . . . .	2.14	4.72	2.85	2.36	4.28	0.71
TiO <sub>2</sub> . . . . .	9.04	trace	3.26	trace	4.18	trace
SiO <sub>2</sub> . . . . .	2.66	4.46	7.02	7.41	11.38	5.36
H <sub>2</sub> O . . . . .	32.26	29.16	30.97	31.36	30.07	30.53
Total . . . . .	99.42	97.25	97.62	98.94	99.85	99.12

	Terry <sup>1</sup>	Shaw <sup>1</sup>	Shaw <sup>1</sup>	Shaw <sup>1</sup>	Shaw <sup>1</sup>	Shaw <sup>2</sup>	Shaw <sup>3</sup>
Al <sub>2</sub> O <sub>3</sub> . . . . .	55.97	58.58	57.33	58.25	57.30	55.56	51.22
Fe <sub>2</sub> O <sub>3</sub> . . . . .	1.65	0.74	5.00	2.38	2.59	5.62	4.83
TiO <sub>2</sub> . . . . .	3.51	2.68	3.33	3.07	3.28	3.26	—
SiO <sub>2</sub> . . . . .	7.56	22.53	4.36	5.43	5.28	4.85	13.33
H <sub>2</sub> O . . . . .	30.16	—	—	—	—	30.08	29.82
Total . . . . .	98.85	—	—	—	—	99.37	99.20

<sup>1</sup> Furnished by Mr. John R. Gibbons, Sup't of the Georgia Bauxite Mining Company.

<sup>2</sup> Furnished by Mr. John H. Hawkins, Sup't, Republic Mining & Manufacturing Company.

<sup>3</sup> Spencer, J. W., *The Paleozoic Group*, Geol. Surv. of Georgia, 1893, p. 218.

THE SHEETS BANK.—One small test-pit has been sunk on *lot 22, 16th district, 3rd section*, Bartow county, revealing a light-colored, pisolitic type of ore. No attempt at working has been made, and the extent of the ore-body is entirely unknown.

THE MORROW BANK<sup>1</sup>.—This deposit is one and a quarter miles northeast from the Holt bank, on *lot 36, 16th district, 3rd section*, Bartow county. Several test-pits have been opened, resulting in the finding of ore in only two of them. The two pits indicating ore are approximately 20 feet apart. So far as the prospecting extends, a light-colored, hard, pisolitic type of ore is shown. The developments are insufficient to define the extent and shape of the ore-body.

MONTAGUE & COMPANY'S BANK<sup>2</sup>.—One mile slightly south of east, from Barnsley, on *lot 97, 16th district, 3rd section*, Bartow county, one small pit has been opened in a deep-red residual clay on the side of a limestone ridge. The pisolitic type of ore is shown. The pisolites are deep-red in color, varying from an eighth- to a half-inch in diameter, and are embedded in a reddish but lighter colored matrix. Several other smaller pits have been opened near each other, and the one just described reveals ore of the same character. The property is said to be owned by a Chattanooga company. No work has been done. The following partial analysis<sup>3</sup> made of specimens of "earthy, and white with reddish concretions," located on the side of the ridge, gives some idea of the character of this ore:—

Al <sub>2</sub> O <sub>3</sub> . . . . .	43.18
Fe <sub>2</sub> O <sub>3</sub> . . . . .	8.74
SiO <sub>2</sub> . . . . .	28.11
H <sub>2</sub> O . . . . .	19.22
Total . . . . .	<u>99.25</u>

THE CONNESENNA BANK.—This deposit, worked by the Georgia Bauxite and Mining Company, is located three miles southeast of Barnsley, and a quarter- to a half-mile west of Connesenna creek,

<sup>1</sup> Originally known as the Newman bank.

<sup>2</sup> Marked as the Conway lot on the map.

<sup>3</sup> Spencer, J. W., *The Paleozoic Group*, Geological Survey of Georgia, 1893, p. 217.

on *lot 128, 16th district, 3rd section*, Bartow county. The ore is found in the bottom and on the sides of a moderately deep, narrow ravine, which cuts directly into the eastern side of a dolomite ridge; and it is also found scattered over a surface of from 400 to 450 feet in length. Two open-cuts, averaging more than 200 feet in length, and, in one case, from 30 to 40 feet deep, have been opened, indicating the removal of a considerable quantity of the ore. The ore is distributed in streaks and pockets through a red, white and mottled clay. The clays contain more or less of the pebble and boulder types of ore scattered through them. The indications were, that the soft pebble type of ore predominated; although boulders of the hard ore, of various dimensions, were, by no means, uncommon. The pisolites, or concretions, vary from an eighth to three-quarters of an inch in diameter, often light in color, though prevailingly red, as a rule. The conditions strongly indicate, that the present deposit represents the lower limits of a once very extensive body of ore, the greater part of which, has been removed by erosion.

The following analyses indicate the general character of the ore, from this property:—

	I <sup>1</sup>	II <sup>1</sup>	III <sup>1</sup>	IV <sup>1</sup>	V <sup>1</sup>	VI <sup>2</sup>
Al <sub>2</sub> O <sub>3</sub> . . . . .	57.18	59.50	52.84	54.55	63.46	61.88
Fe <sub>2</sub> O <sub>3</sub> . . . . .	1.90	0.47	10.15	9.09	1.42	0.21
TiO <sub>2</sub> . . . . .	6.40	5.40	4.71	3.99	—	4.04
SiO <sub>2</sub> . . . . .	1.86	2.93	2.34	1.54	0.50	2.13
H <sub>2</sub> O . . . . .	32.66	31.70	29.93	30.03	—	31.50
Total . . . . .	<u>100.00</u>	<u>100.00</u>	<u>99.97</u>	<u>99.20</u>	<u>—</u>	<u>99.76</u>

A good grade of light-colored ore, not yet tested, is reported to be on the property of Mr. Knowles, of Rome, Georgia, near the Connesenna bank.

**THE MARY BANK.**—This deposit, owned by the Georgia Bauxite and Mining Company, is about three miles north of the Connesenna bank, and is located on *lot 54, 16th district, 3rd section*, Bartow county. The work has been done on a very extensive scale, and the deposit, sufficiently opened to show a large body of ore.

<sup>1</sup> Furnished by Mr. John R. Gibbons, Sup't, Georgia Bauxite Mining Company.

<sup>2</sup> Spencer, J. W., *The Paleozoic Group*, Geological Survey of Georgia, 1893, p. 220.





THE GULLIVER BAUXITE MINE (FORMERLY THE ARMINGTON), WALKER COUNTY, GEORGIA.

The deposit is further located on the eastern slope of a broad dolomite ridge, separating the valley of Tom's creek from the valley of Connaseena creek. The ridge surface, is covered with a yellow-colored, cherty, residual soil derived from the limestone, with an average thickness of three feet covering the ore-body. The workings extend over approximately half-an-acre of ground, to a depth of 20 feet. The ore varies somewhat in character; but the greater part of the deposit consists of the pisolitic type. The pisolites or concretions are usually small in size, varying from an eighth of an inch to one inch in diameter, generally red in color, and embedded in a lighter red to cream-colored, slightly porous matrix. In some cases, both matrix and pisolites are deep-red in color. A second variation in the ore may be seen near the contact of the ore-body with the surrounding clay. The texture is compact, and both matrix and concretions break with a conchoidal fracture. The color is usually some grayish tint mottled with red. Gibbsite is rather a common associate, in this type of ore, at the Mary, bank, and is found lining the cavities of the matrix in places.

The following analyses kindly furnished by Mr. John R. Gibbons, Sup't of the Georgia Bauxite Mining Company, of Linwood, Georgia, give a good idea of the prevailing character of the Mary ore:—

	I	II	III	IV	V	VI
Al <sub>2</sub> O <sub>3</sub> . . . . .	62.03	58.96	59.68	59.42	59.16	59.26
Fe <sub>2</sub> O <sub>3</sub> . . . . .	0.23	2.90	0.23	none	none	4.86
TiO <sub>2</sub> . . . . .	3.44	5.00	4.32	4.48	4.80	3.31
SiO <sub>2</sub> . . . . .	3.66	5.80	2.60	3.50	4.26	2.98
H <sub>2</sub> O . . . . .	30.70	30.56	32.40	32.23	31.86	28.86
Total . . . . .	<u>100.06</u>	<u>103.22</u>	<u>99.23</u>	<u>99.63</u>	<u>100.08</u>	<u>99.27</u>
	VII	VIII	IX	X	XI	XII
Al <sub>2</sub> O <sub>3</sub> . . . . .	63.01	56.75	57.75	53.23	56.91	61.98
Fe <sub>2</sub> O <sub>3</sub> . . . . .	2.84	1.86	1.87	11.17	1.63	1.18
TiO <sub>2</sub> . . . . .	3.58	3.13	3.56	3.20	2.73	0.86
SiO <sub>2</sub> . . . . .	1.04	7.84	5.55	0.79	8.33	3.22
H <sub>2</sub> O . . . . .	29.83	30.03	31.23	31.50	30.23	31.50
Total . . . . .	<u>100.30</u>	<u>99.61</u>	<u>99.96</u>	<u>99.89</u>	<u>99.83</u>	<u>98.74</u>

	XIII	XIV	XV	XVI	XVII	XVIII
Al <sub>2</sub> O <sub>3</sub> . . . . .	55.09	57.72	58.77	56.07	56.94	57.26
Fe <sub>2</sub> O <sub>3</sub> . . . . .	1.18	1.90	1.01	1.80	2.66	2.17
TiO <sub>2</sub> . . . . .	3.53	3.51	4.96	3.16	3.76	3.53
SiO <sub>2</sub> . . . . .	9.70	5.05	7.60	9.35	8.43	7.25
H <sub>2</sub> O . . . . .	28.33	30.66	—	—	—	—
Total . . . . .	99.83	98.84	—	—	—	—

THE HOLT BANK. — This deposit is located on *lot 65, 16th district, 3rd section*, Bartow county, on the top of a broad dolomite ridge, from a half to three-quarters of a mile north of Barnsley.

One opening, from 25 to 30 feet deep, and as many feet wide, has been made, showing a compact, and what appears to be an excellent body of ore. The following section is exposed near the entrance to the pit: —

A yellowish white cherty clay soil, three feet thick ;

A stiff, plastic, white-and-pinkish-red mottled bauxitic clay, containing scattered cavities, the size of the concretions of the ore, 3 feet ;

Light-colored pisolitic bauxite.

The ore is of the pisolitic type, with the concretions varying from a quarter to an inch in diameter, prevailingly white in color, and embedded in a white to slightly reddish stained, compact matrix. In the north and northwest corners of the opening, the pebble variety of ore prevails. Occasional large boulders of the hard "dornick" ore are distributed through the mass of pebble ore. Developments are yet insufficient, to state the exact limits and form of the ore-body ; but indications favor a large deposit of excellent ore.

The character of the ore is well brought out in the following analyses, kindly furnished by Mr. John R. Gibbons, Sup't of the Georgia Bauxite Mining Company, of Linwood, Georgia: —

Al <sub>2</sub> O <sub>3</sub> . . . . .	58.55	58.45	57.50	49.71	51.03	56.39	55.83
Fe <sub>2</sub> O <sub>3</sub> . . . . .	1.40	1.63	1.40	1.18	1.43	2.35	0.92
TiO <sub>2</sub> . . . . .	2.95	2.65	6.57	2.57	2.50	4.13	2.55
SiO <sub>2</sub> . . . . .	4.54	3.24	3.52	21.47	20.92	3.08	12.49
H <sub>2</sub> O . . . . .	31.40	33.06	31.23	24.66	23.86	32.20	—
Total . . . . .	98.84	99.03	100.22	99.59	99.74	98.15	—

An analysis, made of a specimen of the soft, cream-colored bauxitic clay, from the Holt bank, yielded the writer, in the Survey laboratory, the following results:—

SiO <sub>2</sub> . . . . .	40.16
TiO <sub>2</sub> . . . . .	9.25
Fe <sub>2</sub> O <sub>3</sub> . . . . .	trace
Al <sub>2</sub> O <sub>3</sub> . . . . .	35.80
H <sub>2</sub> O at 100° C. . . . .	0.50
<sub>2</sub> O (combined) . . . . .	15.05
Total . . . . .	<u>100.76</u>

THE JULIA BANK. — This deposit, owned by the Georgia Bauxite and Mining Company, is located about a mile southwest of Barnsley, on *lot 117, 16th district, 3rd section*, Bartow county. This property formed a part of the original Godfrey Barnsley estate. The surface of the immediately surrounding country is generally level, with an altitude little less than 900 feet; and the bottoms of the neighboring ravines and some portions of the surface are covered with coarse fragments of chert. The work done has been more extensive than at any other bank in the Hermitage district. Two large bodies of ore have been exposed in working, and are approximately 350 feet apart, with a northwest-southeast alignment.

The northwest deposit has been more extensively worked than the other, and its limits and form are fairly well known. The opening is roughly circular (oval) in outline, with the lateral dimensions at the top, from 200 to 250 feet. It is said to have been worked to a depth of 90 feet. Irregular tongues of the ore are to be seen cutting into the surrounding clays on the sides of the pit. These have not been worked entirely out. The southeast ore-body has been worked to a depth of 60 feet, with the lateral dimensions of the opening, about the same as those on the northwest deposit. The writer was informed, that the depth of the ore had been reached in the northwest pit, but not in the southeast one. This, however, could not be verified by the writer, since the two openings were nearly filled with water, at the time of his visit. Dr. C. W. Hayes has examined and accurately described the two ore-bodies, and I quote in full from his report:—

<sup>1</sup> Sixteenth Ann. Report, U. S. Geol. Surv., 1894-'95 (1895), pp. 572-574.

"The best contact of the ore body [northwest body] with the surrounding mantle is shown on the east side of the pit where the drainage ditch leaves it. The outer portion of the ore body, particularly near the surface, forming a band from 1 to 3 feet thick, is deeply stained with iron. This ferruginous ore is in contact with mottled clay which at a depth of 20 feet or more is plastic like putty, and white, gray, or pink, but nearer the surface is harder and more ferruginous. The outer portion of the mottled clay shows faint traces of steeply inclined bedding and contains a few boulders of bauxite. It merges gradually into the surrounding ferruginous, siliceous clay which contains fragments of chert and coarse granular sandstone. The upper surface of the ore body is smooth and even and slopes gently toward the west, a little more steeply than the present land surface. The sharp contact of the ore with the overlying siliceous clay is entirely different from its contact with the same material around its edges. It is evident that the upper portion of the deposit, how much it is impossible to say, has been removed by erosion, and the smooth erosion surface subsequently covered by the 3 or 4 feet of residual clay now resting upon it. The ore body is penetrated by several masses of clay having the form of narrow vertical dikes; two of these are nearly parallel and cut entirely across the ore body from side to side. They are nearly straight and vertical, 3 or 4 feet thick at the top and decreasing downward to 1 or 1½ feet at the bottom of the pit. They are composed of yellowish clay similar to that overlying the ore with which they are continuous, and they contain some fragments or small lenses of bauxite. The clay composing the dikes shows a somewhat distinct banding parallel with their outer surface. In addition to these two principal dikes several smaller ones intersect the ore body at varying angles, generally vertical, but sometimes inclined. Some of these are mere clay streaks an inch or less in thickness, but however thin they always extend entirely to the surface.

"These dikes were undoubtedly formed subsequent to the deposition of the ore body. As will be shown later, in discussing the origin of the bauxite, it probably contained, when first deposited, a much larger amount of water than at present. Indeed a part at least may have been originally in a semi-gelatinous condition. As the ore gradually lost a part of its water its bulk decreased and shrinkage cracks were formed, widest at the top where the desiccation was most rapid. These cracks were filled chiefly from above by the overwashed residual clay, but also partly from the sides. Further shrinking of the ore body opened the cracks again and they were again filled by material from above and from the sides. These successive fillings produced the observed banding parallel with the sides of the dike.

"The bauxite from this bank is mostly coarse pebble ore. It resembles a mass of somewhat compact and partially cemented gravel without any trace of bedding. The individual pebbles are mostly from one-quarter of an inch to 2 inches in diameter and are both simple and complex. The simple pisolites seldom reach 1½ inches in diameter, while the complex are seldom under three-quarters of an inch. Taking all which are an inch or thereabouts, perhaps two-thirds would be simple and one-third complex. The latter are not generally so nearly spherical as the former, though in many cases it is impossible to distinguish them by their external form. Scattered throughout this mass of pebble ore are numerous well-rounded boulders from 2 inches in diameter, the larger complex pebbles, up to 2 feet. They

are composed of quite uniform pisolitic ore made up of soft pisolites embedded in a dense, compact matrix. This material is quite similar to that forming the main ore body at the Mary mine. The complex pebbles and bowlders were doubtless derived from some preëxisting ore body in the immediate vicinity which was broken down and worked over by water while this deposit was forming. The fragments of the previously formed ore were not only rounded by wear of the currents, but received layers of fresh material which helped to round out or conceal their surface irregularities. The amount of rounding which the bowlders have suffered by wear would indicate that they had traveled some distance; but it is more probable that the rounding was produced largely, if not wholly, by the strong ascending currents of a spring or geyser.

“From the northeast side of the pit a tunnel penetrates 20 feet into a mass of amorphous bauxite consisting of cream-colored material, having a compact uniform structure somewhat like halloysite but not so hard. This material contains from 14 to 20 per cent. of silica, less than half the per cent. contained in halloysite, and little or no iron. It may be regarded either as a mixture of bauxite and halloysite, or perhaps more properly as a bauxite, in which all the iron and part of the water were replaced by silica. There is no present demand for this material, but it will undoubtedly some time find utilization, its freedom from contamination by iron being an extremely desirable feature for some purposes.

“The second ore body is about 350 feet southeast of the one above described. Although it has not been worked so extensively, numerous test pits show it to be probably fully as large as the other. The character of the ore, however, is quite different, approaching more closely to the pisolitic than the pebble type. In general the pisolites are much smaller, being mostly under half an inch in diameter with, so far as observed, no complex pisolites or rounded bowlders. Portions of the ore closely resemble the material composing the bowlders of the first described deposit. Indications of somewhat extensive limonite deposits are seen in contact with the bauxite along one side of the ore body. Fragments of bauxite are found on the surface for a quarter of a mile in a southeast direction from these deposits. Until further prospecting has been done it will be impossible to say whether other deposits exist in this region or whether this float all comes from those now known. It seems highly probable, however, that other deposits will be discovered in the immediate vicinity when systematic prospecting is undertaken.”

Work had been suspended for several months prior to the writer's visit in 1899. The equipment consists of a commodious drying plant, and machinery for hoisting and handling the ore. The output from this property in 1895 was estimated at 400 tons per month.

On the same lot, 300 yards east of the Julia mines, a compact, hard, white ore has been found. Two small test-pits, three by five feet, and seven feet deep, have been sunk about 60 feet apart, showing four feet of solid ore.

The character of the ore from the Julia mines is well shown in the following analyses:—

	I <sup>1</sup>	II <sup>1</sup>	III <sup>1</sup>	IV <sup>1</sup>	V <sup>1</sup>	VI <sup>1</sup>	VII <sup>1</sup>
Al <sub>2</sub> O <sub>3</sub> . . .	58.98	59.46	58.91	59.22	55.83	56.39	52.25
Fe <sub>2</sub> O <sub>3</sub> . . .	0.14	0.20	0.20	0.21	0.21	0.71	0.23
TiO <sub>2</sub> . . .	4.28	4.00	6.75	2.44	3.56	8.24	8.48
SiO <sub>2</sub> . . .	4.37	4.93	3.33	8.30	13.33	2.43	4.40
H <sub>2</sub> O . . .	31.97	—	—	28.83	27.43	32.23	31.73
Total . . .	99.74	—	—	99.00	100.36	100.00	97.09

	VIII <sup>1</sup>	IX <sup>1</sup>	X <sup>1</sup>	XI <sup>1</sup>	XII <sup>1</sup>	XIII <sup>1</sup>	XIV <sup>1</sup>
Al <sub>2</sub> O <sub>3</sub> . . .	58.08	54.44	61.50	60.88	62.08	60.75	55.75
Fe <sub>2</sub> O <sub>3</sub> . . .	trace	4.25	1.19	0.71	0.59	0.71	2.85
TiO <sub>2</sub> . . .	3.68	4.38	2.76	3.11	4.10	trace	5.10
SiO <sub>2</sub> . . .	5.40	2.89	1.28	2.67	0.71	8.99	4.73
H <sub>2</sub> O . . .	31.40	32.30	33.27	32.47	32.66	29.27	—
Total . . .	98.56	98.26	100.00	99.84	100.14	99.72	—

	XV <sup>1</sup>	XVI <sup>1</sup>	XVII <sup>1</sup>	XVIII <sup>1</sup>	XIX <sup>1</sup>	XX <sup>1</sup>
Al <sub>2</sub> O <sub>3</sub> . . . . .	53.14	46.72	57.46	56.91	55.05	57.17
Fe <sub>2</sub> O <sub>3</sub> . . . . .	1.40	8.28	2.37	1.00	4.00	1.47
TiO <sub>2</sub> . . . . .	3.73	2.60	2.63	4.20	3.08	5.16
SiO <sub>2</sub> . . . . .	11.16	18.15	7.28	23.30	11.60	6.14
H <sub>2</sub> O . . . . .	—	23.33	28.33	—	—	29.87
Total . . . . .	—	99.08	98.07	—	—	99.81

	XXI <sup>1</sup>	XXII <sup>1</sup>	XXIII <sup>2</sup>	XXIV <sup>3</sup>	XXV <sup>3</sup>	XXVI <sup>3</sup>
Al <sub>2</sub> O <sub>3</sub> . . . . .	57.58	53.08	60.06	67.53	60.61	60.63
Fe <sub>2</sub> O <sub>3</sub> . . . . .	2.63	0.72	0.94	trace	0.21	trace
TiO <sub>2</sub> . . . . .	3.41	3.45	3.80	2.92	4.18	4.76
SiO <sub>2</sub> . . . . .	5.14	16.71	4.20	1.34	2.47	3.20
H <sub>2</sub> O . . . . .	30.58	25.44	31.00	28.00	32.00	31.00
Total . . . . .	99.34	99.40	100.00	99.79	99.47	99.59

THE WARRING BANK<sup>4</sup>.—On lot 108, 16th district, 3rd section, Bartow county, some prospecting has been done, and one car-load of the ore, shipped. The openings show a medium light-colored to white ore, low in iron and high in silica. The surface indications are, by no means, extensive. The developments are insufficient, however, to show the extent and shape of the ore-body.

<sup>1</sup> Furnished by Mr. John R. Gibbons, Sup't of the Georgia Bauxite Mining Company.

<sup>2</sup> Furnished by Mr. John H. Hawkins, Sup't of the Republic Mining & Manufacturing Company.

<sup>3</sup> Spencer, J. W., *The Paleozoic Group*, Geological Survey of Georgia, 1893, p. 219.

<sup>4</sup> Also known as the Seay lot.

The following is an analysis made of specimens of this ore, described by Spencer as "white, small grained pisolitic in mass":—<sup>1</sup>

Al <sub>2</sub> O <sub>3</sub> . . . . .	45.21
Fe <sub>2</sub> O <sub>3</sub> . . . . .	0.52
SiO <sub>2</sub> . . . . .	35.88
H <sub>2</sub> O . . . . .	17.13
Total . . . . .	<u>98.74</u>

THE SPURLOCK BANK.— One and a quarter miles east of Hall's station, on *lot 102, 16th district, 3rd section*, Bartow county, a prospect pit, 3x7 feet, and six feet deep, shows a soft, pink-colored, amorphous bauxitic clay.

THE GREEN BANK.— One mile west of Hall's station, on *lot 98, 16th district, 3rd section*, Bartow county, some prospecting has been done, and a bauxitic clay, similar to that on the Spurlock place, was found.

THE AKIN BANK.<sup>2</sup>— About two miles east of Hall's station, on *lot 7, 5th district, 3rd section*, and *lot 106, 16th district, 3rd section*, Bartow county, some prospecting has been done, and a good quality of white bauxite, found. No regular work or mining has been done. The ore is principally found on *lot 7*.

LOT 115, 16TH DISTRICT, 3RD SECTION, BARTOW COUNTY.— About two and a half miles west of Hall's station, on the Barnsley estate, bauxite is found on *lot 115, 16th district, 3rd section*, Bartow county. Both the hard, boulder, pisolitic, and soft, pebble types of ore are reported, covered by a yellowish, residual siliceous clay.

The following analysis indicates a very high grade ore from this lot:—<sup>3</sup>

Al <sub>2</sub> O <sub>3</sub> . . . . .	61.25
Fe <sub>2</sub> O <sub>3</sub> . . . . .	1.82
TiO <sub>2</sub> . . . . .	2.38
SiO <sub>2</sub> . . . . .	1.98
H <sub>2</sub> O . . . . .	31.43
Total . . . . .	<u>98.86</u>

<sup>1</sup> *Loc. cit.*

<sup>2</sup> Formerly known as the Sherman Place

<sup>3</sup> Spencer, J. W., *The Paleozoic Group*, Geological Survey of Georgia, 1893, p. 219.



The type, or variety, of ore yielding specimens, from which the analysis was made, is described by Spencer as "white, small grained pisolitic in mass," and situated on a flat-topped ridge.

## 2. THE BOBO DISTRICT

In area, the Bobo district is the largest in the State. It includes all the known deposits of bauxite in the south half of Floyd county, and those of the northern part of Polk county. It is in strong contrast in topography with the Hermitage district. The area is cut by a number of parallel faults of the ordinary Appalachian type, which have an approximate north-south course. Long and narrow southward strips of the soft Cambrian shales are brought in contact with the Knox dolomite, resulting in the formation of deep and narrow valleys etched in the shale belts, that are limited by correspondingly high and steep-sided ridges of Knox dolomite, more or less irregular in form, and extending in a nearly north-south direction. The faults are easily located where the shales are exposed; but they apparently die out toward the south in the Knox dolomite, which appears unbroken. To the southward, the ridge-valley type of topography becomes less strongly accentuated, and finally merges into a broad, undulating plateau. The lines of fracture very evidently extend for a greater or less distance in the magnesian limestone southward; but they are not visible, since the dolomite occurs on both sides of the faults, with its surface covered to some depth by residual chert and clay. Where the faults are visible, the strata are observed to dip steeply to the east with the fault-blocks overlapping each other.

In the Hermitage district, it was observed, that the bauxite deposits were frequently irregularly grouped about certain centers. In the Bobo district, they apparently follow or lie along approximately north and south lines, which, in the northern part of the area, are closely coincident with the lines of fracture—*faults*. For this reason, the ore-bodies of the Bobo district undoubtedly bear a very intimate relationship to the structural lines of weakness (faults), a condition referred to later.

The altitude of most of the ore-bodies in this district have been



GENERAL VIEW OF THE GULLIVER BAUXITE PLANT, WALKER COUNTY, GEORGIA.

measured as accurately as possible with an aneroid barometer, and are found to be remarkably uniform. Several of them are found above the 950-foot level, and as many are found below the 850-foot level; but the majority lie between these limits, more often near the 900-foot level. This difference in elevation is readily accounted for, on the grounds of subsequent erosion. The ridges rise to greater elevations in most cases. Dr. Hayes has previously noted the uniformity in altitude, of these deposits, and has discussed its significance and bearing on their possible age, which is elsewhere discussed in this report.<sup>1</sup>

The following is a list of the known deposits of bauxite in the Bobo district:—

<sup>1</sup> Sixteenth Ann. Rept., U. S. Geol. Surv., 1894-'95 (1895), p. 531 *et seq.*

Name	Land Divisions				Remarks
	County	Section	District	Lot	
Penny . . . . .	Floyd	4	3	1072, 1089	Worked
Gordon . . . . .	"	4	3	1017, 1018	Prospected
Culbertson . . . . .	"	4	3	999	"
Fat John . . . . .	"	4	3	607	"
Red Warrior . . . . .	"	4	3	606	"
Bobo . . . . .	"	4	3	535	Worked
Lanham . . . . .	"	4	3	536	Prospected
Woods . . . . .	"	4	3	551	"
Hatch . . . . .	"	4	3	552	"
Little Lamb . . . . .	"	4	3	534	"
"Lot 620" . . . . .	"	4	3	620	"
Henry . . . . .	"	4	3	910	Prospected
Burkhalter . . . . .	"	4	3	891	"
Moseley . . . . .	"	4	3	820	"
"Lot 765" . . . . .	"	4	3	765	"
"Lot 766" . . . . .	"	4	3	766	"
"Lot 749" . . . . .	"	4	3	749	"
Louis Reynolds . . . . .	"	4	3	750	"
"Lot 690" . . . . .	"	4	3	690	"
"Lot 678" . . . . .	"	4	3	678	"
"Lot 692" . . . . .	"	4	3	692	"
"Lot 677" . . . . .	"	4	3	677	"
Doyle . . . . .	"	4	3	896	"
"Lot 906" . . . . .	"	4	3	906	"
Willis Reynolds . . . . .	"	4	3	833	"
Louis Reynolds . . . . .	"	4	3	761	"
Minter . . . . .	"	4	3	687	"
Howell . . . . .	"	4	3	160	"
Brannon . . . . .	"	4	22	14	"
Minter . . . . .	"	4	22	13	"
"Lot 23" . . . . .	"	4	22	23	"
"Lot 685" . . . . .	"	4	3	685	"
Hawkins . . . . .	"	4	3	?	"
Whorton . . . . .	"	3	22	59	"
Ritch . . . . .	"	3	22	151	"
Fomby . . . . .	"	3	22	150	"
Bonsack . . . . .	"	3	22	129	"
Reese . . . . .	"	3	22	60	"
Cochran . . . . .	"	3	22	182, 183	"
"Lot 12" . . . . .	"	3	22	12	"
"Lot 682" . . . . .	"	4	3	682	"
Freeman . . . . .	"	3	23	332	"
Bigelow . . . . .	Polk	3	22	?	"
Broadaway . . . . .	"	3	22	53	"

#### LOCATION AND DESCRIPTION OF THE INDIVIDUAL DEPOSITS

The Cave Spring section, as is shown on the accompanying map, includes three deposits, grouped along a north-south line, within half-a-mile of each other, and not more than two miles a

little east of south from the town of Cave Spring. These form the most southwesterly known deposits in the State, and are within a comparatively short distance of the Alabama State-line. While they are removed some little distance from the Bobo district proper, they are properly grouped in this district, on geologic grounds. Their mode of occurrence is geologically identical with those of the Bobo district. They form the most interesting series of deposits in the State, from the standpoint of erosion, which furnishes a possible clue to the vertical limits of the ore-bodies. The most northerly deposit has the greatest altitude above sea-level; and field-study indicates, that it has suffered but little, if any, erosion. The most southerly one, on the other hand, is in a deep valley of erosion, 170 feet below the northernmost deposit, and half-a-mile distant therefrom. After being worked to a depth of 20 feet, it is entirely exhausted, indicating that nothing more than the remnant bottom portion of the deposit was left, the greater bulk having been entirely removed by erosion. The middle ore-body, a quarter of a mile north and south, respectively, from the other two, is 90 feet higher than the southern deposit and 80 feet lower than the northern one, indicating, from its position, as well, that a considerable part of this one has been removed by erosion. It will be observed, therefore, from the geologic position and occurrence of this series of ore-bodies, that some idea may be gained of the possible original depth of the bauxite deposits. A detailed description of these three deposits is given below.

THE PENNY BANK. — This is the most southwesterly known deposit in the State. It is located one and a half miles a little east of south from Cave Spring, on *lots 1,072 and 1,089, 3rd district, 4th section*, Floyd county, in a deep and narrow ravine, at an elevation of 780 feet above sea-level. The summit of the surrounding ridge is from 100 to 175 feet higher. This deposit is said to be entirely exhausted. Operations had been suspended for so long a time, prior to the writer's visit, and the opening had caved in to such an extent, that no ore was visible. The actual form and size of the ore-body, also, were not clearly discernible. The opening was in the shape of a cut from 40 to 50 feet wide, 100 feet long in

a north-south direction, and probably averaging 20 or more feet in depth.

The white-and-pink mottled clay, surrounding the ore-body, was exposed in a number of places. At several points in the cut, the clay dips under the ore-body at an angle of from 30 to 40 degrees, as nearly as could be determined. The ore was apparently a mixture of coarse gravel, whose concretions measured from half-an-inch to one and one-half inches in diameter, and fine pisolitic bauxite. The pisolitic type of ore showed a pronounced pinkish to red color, for both pisolites and matrix. The indications are, that a considerable quantity of ore has been removed.

THE GORDON BANK. — This deposit is located on *lots 1,017 and 1,018, 3rd district, 4th section*, Floyd county, about a quarter of a mile further north, and in the same ravine, as the Penny bank. Aneroid measurements show this deposit to be from 90 to 95 feet higher than the Penny bank. The ridge has an elevation at this point of from 50 to 75 feet above the ore-body. A tunnel has been driven into the east side of the ridge at the above elevation, exposing a part of the ore-body. The beginning of the tunnel is in a red clay, the relationship of which to the ore-body is not entirely shown. A few test-pits have been sunk near the tunnel, showing similar conditions. The ore, thus far exposed, is prevailingly white in color, and is, for the most part, of the amorphous type, mixed with some boulders of hard and light-colored pisolitic ore. The tunnel leads from a circular-shaped pit from 50 to 75 feet in lateral dimensions.

The work is mostly in the nature of prospecting, and is entirely insufficient to reveal the extent and character of the ore-body. The following partial analysis,<sup>1</sup> sampled from 40 tons of first-grade ore, gives some idea of its character:—

Al <sub>2</sub> O <sub>3</sub> (soluble) . . . . .	56.12
Fe <sub>2</sub> O <sub>3</sub> . . . . .	1.38

THE CULBERTSON BANK. — This deposit is located a quarter of a mile north of the Gordon bank, at the approximate altitude of the old peneplain, 950 feet, and 80 feet above the Gordon bank,

<sup>1</sup> Furnished by the Southern Bauxite Mining & Manufacturing Company, Cave Spring, Georgia.

on lot 999, 3rd district, 4th section, Floyd county. The ore outcrops over a surface of approximately 30 feet square. A cut, 20 feet long, 10 feet wide and three feet deep, has been opened on the outcrop, exposing a solid, compact body of ore. The ore is a pink-colored typical oölitic variety, and apparently promises well as to extent and quality. The following partial analyses indicate the character of the ore:—

	I <sup>1</sup>	II <sup>2</sup>	III <sup>2</sup>	IV <sup>2</sup>
Al <sub>2</sub> O <sub>3</sub> . . . . .	39.75	49.72	48.55	49.80
Fe <sub>2</sub> O <sub>3</sub> . . . . .	1.62			
SiO <sub>2</sub> . . . . .	41.47			
H <sub>2</sub> O . . . . .	16.14			

Dr. Spencer describes the specimens of ore, from which the above analysis was made, as follows: "Small pisolitic concretions in mass, grayish white, with some iron stains," occurring on top of ridge.<sup>3</sup>

It will be observed, that these three deposits have a nearly due north-south alignment, and are in close proximity to each other. The indications are, that the three were deposited at the same elevation, and at about the surface altitude of the old peneplain in this section. If this be true, the Culbertson bank has suffered practically no erosion since deposition; while the Penny bank has been removed almost entirely, and the Gordon, in greater part, by subsequent erosion. The most southerly one of the three deposits, the Penny bank, was exhausted at a depth of from 20 to 25 feet, which would indicate, in case the deposits had the same depth, a remaining deposit of 110 and 190 feet, respectively, for the Gordon and Culbertson banks.

THE FAT JOHN BANK.— This deposit is located on lot 607, 3rd district, 4th section, Floyd county, 10 feet below the summit; and on the southwest side of the highest point of a broad dolomite ridge. The surface of the ridge is covered with chert fragments, of various sizes and angularity. Three test-pits, of small

<sup>1</sup> Spencer, J. W., *The Paleozoic Group*, Geological Survey of Georgia, 1893, p. 216.

<sup>2</sup> Furnished by the Southern Bauxite Mining & Manufacturing Company, Cave Spring, Georgia.

<sup>3</sup> *Op. cit.*, p. 216.

dimensions, had been dug near each other, revealing a solid compact ore in each one. The ore is exposed at the surface, in different sized fragments, scattered over an area, 50 feet square. The ore is of the pisolitic type, varying from light to red in color. The pisolites range from a quarter of an inch to one inch in diameter, with the nuclei composed of a red powder enclosed by lighter colored hard and firm walls, several layers in thickness, the whole embedded in a dense, compact, buff-colored matrix. The character of the ore is shown in the following analysis, kindly furnished by Mr. John H. Hawkins, Sup't, Republic Mining & Manufacturing Company, of Hermitage, Georgia:—

Al <sub>2</sub> O <sub>3</sub> . . . . .	61.31
Fe <sub>2</sub> O <sub>3</sub> . . . . .	1.04
TiO <sub>2</sub> . . . . .	4.58
SiO <sub>2</sub> . . . . .	1.40
H <sub>2</sub> O . . . . .	31.70

THE RED WARRIOR BANK.— On the adjoining *lot, No. 606*, to the west of the Fat John bank, is an extensive deposit of bauxite, 50 feet lower in elevation, it being in all probability, a continuation of the same ore-body, inasmuch as scattered fragments and partially buried boulders of the ore are readily traced over the surface between the two. The two combined represent 100 square yards of surface, roughly circular in outline. If the surface indications are a true index to the extent of the deposit, a very large body of ore occurs on the two lots, *Nos. 606 and 607*. The developments, however, are wholly insufficient to determine the extent and shape of the ore-body. The surface outcrops are composed of boulders of the pisolitic type of ore, light-pink to red in color. The prospecting on *lot 606* consists of two open-cuts, 25 and 30 feet long, from 5 to 6 feet wide, and 10 feet deep. Both cuts are in solid, compact ore. Several small test-pits had been dug near the cuts, each of which showed ore of a similar character.

The openings show, for the most part, the pebble type of bauxite, embedded in a soft, clayey material. The pebbles vary from a quarter of an inch to two inches in diameter, usually red in color. The larger pebbles are oval-shaped and compound. The smaller ones are spherical and simple. Small boulders, of different di-



ameters, are mixed with the pebble ore. The boulder ore is of the pisolitic type, with pisolites and matrix colored red. The following analyses, kindly furnished by Mr. John H. Hawkins, Sup't, Republic Mining & Manufacturing Company, show the character of the Red Warrior ore:—

	I	II	III
Al <sub>2</sub> O <sub>3</sub> . . . . .	59.08	54.96	51.14
Fe <sub>2</sub> O <sub>3</sub> . . . . .	1.12	6.39	13.86
TiO <sub>2</sub> . . . . .	4.80	5.05	3.40
SiO <sub>2</sub> . . . . .	2.30	1.80	1.40
H <sub>2</sub> O . . . . .	32.70	32.10	32.20

An analysis, by the writer in the Survey laboratory, of the deep-red pisolites collected from the Red Warrior bank, gave the following results:—

SiO <sub>2</sub> . . . . .	4.21
TiO <sub>2</sub> . . . . .	8.79
Fe <sub>2</sub> O <sub>3</sub> . . . . .	10.44
Al <sub>2</sub> O <sub>3</sub> . . . . .	52.40
H <sub>2</sub> O, at 100° C. . . . .	0.39
H <sub>2</sub> O (combined) . . . . .	24.06
Total . . . . .	<u>100.29</u>

THE BOBO BANK. — This is the most extensively worked deposit in the Bobo district. It is located on *lot 534, 3rd district, 4th section*, Floyd county, about three miles a little west of south from Six Mile station (Van's Valley) on the Southern Railway. The deposit is near the 900-foot contour on the eastern side of a broad dolomite ridge. The ridge is steeply sloping, with its highest point about 150 feet above the deposit. Its slope is covered by several feet of residual clay, containing fragments of chert mixed with the clay, and strewn over the surface. The contact, where observed, between the residual clay and the ore-body was perfectly sharp, and no fragments of chert were found in the deposit of bauxite. The pit, from which the ore has been removed, is 100 feet long, from 35 to 40 feet wide and from 20 to 25 feet deep. The ore has been exhausted laterally, but not in depth. The indications are, that probably from 35 to 50 feet more of ore is obtainable. A shaft, 16 feet deep, was sunk, from the bottom of the pit in a solid body of white pebble ore, of superior quality. It is

estimated, that 3,000 tons of the ore have been shipped from this opening.

Approximately, 75 feet above the head of the pit and near the top of the ridge, several test-pits have been dug, revealing the same grade and quality of ore, as described from the working above. Since the ore has been worked out laterally in the larger opening, that, shown in the pits higher up the ridge, apparently represents a separate deposit. The ore-body in the large cut is enclosed by a white-and-pink mottled clay, which dips under the ore, on the west side of opening, at an angle of about 45°. At several places in the opening, the bauxite appears to pass, by imperceptible gradations, into a light-colored bauxitic clay.

The ore is very white or light-colored, and of the pebble type, entirely, or nearly, free from iron stain. The pebbles vary from a quarter of an inch to one and a half inches in diameter, crumbling easily; and are embedded in a soft, white, clayey matrix. Both matrix and pisolites crumble with readiness, and are mixed in equal parts of the matrix and the pebbles. Near the center of the opening, on the north side, numerous red boulders, of large dimensions, of the hard pisolitic type, were mixed with the soft ore. Occasional halloysite lenses and masses were observed in the ore-body.

The deposit was worked, under lease, by the Southern Bauxite Company, when it was first opened, early in the spring of 1891. It was worked continuously for a period of nearly two years. The character of the ore from the Bobo bank is well illustrated by the following analyses:—

	I <sup>1</sup>	II <sup>1</sup>	III <sup>1</sup>	IV <sup>1</sup>	V <sup>2</sup>
Al <sub>2</sub> O <sub>3</sub> . . . . .	61.25	61.08	58.72	61.64	59.82
Fe <sub>2</sub> O <sub>3</sub> . . . . .	0.45	0.72	0.88	0.36	2.16
TiO <sub>2</sub> . . . . .	4.80	3.95	6.20	3.10	—
SiO <sub>2</sub> . . . . .	5.10	1.55	1.80	4.30	6.62
H <sub>2</sub> O . . . . .	28.40	32.70	32.40	30.70	31.10

Analyses of the hard, white, concentric structured pisolites, and of a pure white kaolin from the Bobo bank, yielded the writer, in the Survey laboratory, the following results:—

<sup>1</sup> Furnished by Mr. John H. Hawkins, Sup't, Republic Mining & Manufacturing Co.

<sup>2</sup> Spencer, J. W., *The Paleozoic Group*, Geological Survey of Georgia, 1893, p. 218.

	Pisolites	Kaolin
SiO <sub>2</sub> . . . . .	0.99	43.31
TiO <sub>2</sub> . . . . .	7.63	none
Fe <sub>2</sub> O <sub>3</sub> . . . . .	1.89	none
Al <sub>2</sub> O <sub>3</sub> . . . . .	57.26	43.08
H <sub>2</sub> O at 100° C. . . . .	0.39	0.43
H <sub>2</sub> O (combined) . . . . .	31.69	14.12
Total . . . . .	<u>99.85</u>	<u>100.94</u>

The analysis of the pisolites corresponds to the formula Al<sub>2</sub>O<sub>3</sub>.-3H<sub>2</sub>O; while that of the kaolin has the SiO<sub>2</sub> : Al<sub>2</sub>O<sub>3</sub> : H<sub>2</sub>O ratio approximately 2 : 1 : 2, corresponding to the formula 2H<sub>2</sub>O.Al<sub>2</sub>O<sub>3</sub>.2SiO<sub>2</sub>.

The analyses indicate one of the highest grade ores, yet worked in the State. The soluble alumina averages uniformly high, with practically no iron; and the silica is proportionally low. This is a most desirable ore.

THE LANHAM BANK. — Near the southwest corner of *lot 536, 3rd district, 4th section*, Floyd county, and close to the base of a dolomite ridge, and 90 feet below the Bobo bank, some half-dozen test-pits have been sunk, only three of which showed ore. The pits indicating ore covered a surface area of from 15 to 20 feet square. The ore-body is covered by three feet of residual red clay; and it is of the oölitic variety. The oölites are white to pink in color, embedded in a buff- or light-colored compact matrix. The interiors of the oölites are usually filled with a white powder.

THE WOODS BANK. — This deposit is located near the central western portion of *lot 551, 3rd district, 4th section*, Floyd county, on the west slope of a steep and broad dolomite ridge. The aneroid barometer gave an elevation of 941 feet above tide-level. One shaft, 22 feet deep, has been sunk, penetrating a solid body of ore, for its entire depth. Several test-pits have been dug within a few feet of the shaft, and ore was found in each one. The openings are arranged in a roughly circular shape, including about 25 feet square of surface. The ore-body is covered by two feet of a light-colored, residual, cherty soil. Numerous boulders, of large size, scattered over the surface, first led to the discovery of this deposit.

The ore is a high-grade, white- or cream-colored pebble variety,

closely resembling that of the Bobo bank. The pebbles vary in size; but they are generally large. Some boulders of the hard, pisolitic type are mixed with the soft ore, and are made up of white pisolites embedded in a firm, compact, buff-colored matrix. While developments are yet insufficient, to give the limits of the ore-body, conditions are favorable to a large deposit of high-grade ore. The following analysis, kindly furnished by Mr. John H. Hawkins, Sup't., Republic Mining & Manufacturing Company, indicates a very high-grade bauxite:—

Al <sub>2</sub> O <sub>3</sub> . . . . .	62.68
Fe <sub>2</sub> O <sub>3</sub> . . . . .	0.52
TiO <sub>2</sub> . . . . .	4.70
SiO <sub>2</sub> . . . . .	1.30
H <sub>2</sub> O . . . . .	30.80

THE HATCH BANK.— On the west side of an adjacent, parallel dolomite ridge, across a deep and narrow valley opposite the Woods bank, a very small prospect opening has been made, revealing a white bauxitic clay, or amorphous type of ore. The opening, according to aneroid measurements, is 911 feet above sea-level, and is nearly half-way up the steeply sloping ridge. Scattered fragments of chert prevail over the ridge surface. The opening is near the east central part of *lot 552, 3rd district, 4th section, Floyd county.*

THE LITTLE LAMB BANK.— On *lot 534, 3rd district, 4th section, Floyd county,* near the center of the lot, and about half-way up the south slope of a ridge, is a small prospect opening, showing a white amorphous ore.

LOT "620," 3RD DISTRICT, 4TH SECTION, FLOYD COUNTY.— In the northeast corner of *lot 620,* fragments of a light-colored, hard, pisolitic type of ore are scattered over a small area of surface. No prospecting has been undertaken. The lot belongs to Mr. A. W. Bobo, of Van's Valley.

THE HENRY BANK.— This is probably the largest surface exposure of bauxite, yet known in the Bobo district. It is located near the center of *lot 910, 3rd district, 4th section, Floyd county,* near the Polk county-line. According to aneroid measurements,



THE DEAN LIMESTONE QUARRY, ON THE SUMMERVILLE ROAD, ROME, GEORGIA.

it has an altitude of 885 feet above sea-level. It occurs on the western side of a gently sloping ridge, only a short distance east of the public road; and it covers an oval-shaped area of surface, approximately 500 by 800 feet in dimensions. The neighboring ravines all show ore. The ore-body is covered by two feet of residual clay, containing commingled chert fragments. One shaft, 40 feet deep, penetrated ore for its entire depth. Several test-pits have been sunk near the shaft, revealing, in each one, ore, of a closely similar character.

The ore is a hard, pisolitic variety; and, as a rule, it is highly ferruginous, carrying a larger percentage of iron oxide. Much light-colored bauxite is present, with the depth of color (red) increasing toward the outer portions of the ore-body. The pisolites are small, and well rounded in shape, usually deep-red in color, and powdery in character. The pisolites make up, by far, the mass of the ore, the proportion of the matrix being considerably less than that of the pisolites, which is also of deep-red color. The ore, exposed at the surface, closely resembles the vesicular type, until broken open, when the pisolites are observed to have fallen out, apparently on prolonged exposure, from weathering. The pit, nearest the base of the ridge, is 60 feet below the uppermost limits of the ore-body, and shows a compact deposit of bauxite. The character of the ore is well shown in the following analyses:—

	I <sup>1</sup>	II <sup>1</sup>	III <sup>1</sup>	IV <sup>1</sup>	V <sup>2</sup>
Al <sub>2</sub> O <sub>3</sub> . . . . .	59.00	62.28	57.21	56.48	56.10
Fe <sub>2</sub> O <sub>3</sub> . . . . .	6.23	2.91	12.14	8.17	10.64
SiO <sub>2</sub> . . . . .	5.92	3.46	2.97	7.60	2.56
H <sub>2</sub> O . . . . .	—	—	—	—	30.10

Spencer characterizes the type of bauxite, yielding the results given in column V, as follows: "Light reddish porous mass, as the interior of the grains is largely dissolved away; somewhat earthy. At a depth the mineral is not likely to be so porous as on top, and consequently richer in alumina. It occurs on side of a ridge." Other determinations of silica and iron oxide gave the following results:—

<sup>1</sup> Furnished by Mr. B. F. A. Saylor, Sup't., Dixie Bauxite Co.

<sup>2</sup> Spencer, J. W., *The Paleozoic Group*, Geological Survey of Georgia, 1893, p. 217.

SiO <sub>2</sub> . . . . .	2.08	4.80	5.70	—
Fe <sub>2</sub> O <sub>3</sub> . . . . .	—	—	13.10	1.99

In the northeast corner of the same lot, and in the valley, 200 yards north of the Henry bank, occurs a white bauxitic clay in the bottom of a ditch, 5 or 6 feet deep. The clay contains pebbles of bauxite, varying from a quarter of an inch to two inches in diameter.

THE BURKHALTER BANK.—A short distance north of the Henry bank, in the bottom of the same valley, on *lot 891, 3rd district, 4th section*, Floyd county, at an altitude of 821 feet above sea-level, three small prospect-pits have been opened. The openings are from 150 to 200 feet apart, with ore shown in each one. The ore is highly ferruginous, and is closely similar to that of the Henry deposit. The iron content may possibly decrease with the depth of ore, on working. The following is an analysis<sup>1</sup> of pieces of the ore which appeared as a whitish mass, with occasional pisolites, the sample having been collected from the side of a narrow gully, some little distance from the openings:—

Al <sub>2</sub> O <sub>3</sub> . . . . .	58.61
Fe <sub>2</sub> O <sub>3</sub> . . . . .	2.63
TiO <sub>2</sub> . . . . .	3.15
SiO <sub>2</sub> . . . . .	8.29
H <sub>2</sub> O . . . . .	27.42
Total . . . . .	<u>100.10</u>

LOT 892, 3RD DISTRICT, 4TH SECTION.—On the adjoining lot east of the Burkhalter place, *No. 892, 3rd district, 4th section*, Floyd county, at a point 200 yards east of the deposit on *lot 891*, is a small outcrop of a highly ferruginous ore. The deposit occurs directly in the valley, at the base of the west slope of the dolomite ridge. No prospecting has been undertaken. The surface ore is in every respect similar to the red ore of the Henry deposit.

THE MOSELEY BANK.—This deposit is located near the south line of *lot 820, 3rd district, 4th section*, Floyd county, near the base of the west slope of a dolomite ridge, with an altitude of 850 feet above sea-level. It is further situated about 200 yards southeast

<sup>1</sup> Spencer, J. W., *The Paleozoic Group*, Geological Survey of Georgia, 1893, p. 217.

from New Prospect church. One pit has been opened in a solid body of ore, from which one car-load of the ore has been shipped. The dimensions of the opening are 12 feet long, 8 feet wide and 6 feet deep. The prospecting is wholly insufficient, to indicate the extent and shape of the ore-body.

The ore is of the pisolitic variety, and is very light in color. The matrix is dense and compact, varying from cream to pink in color, through which are distributed the white and regularly rounded small pisolites.

Near the center of the same lot, No. 820, immediately on the east side of the Haney Mill road, and 150 yards north of New Prospect church, an exposure, in the form of large boulders of light-pink, pisolitic bauxite, occurs. The specimens show up well, and fragments of the ore are scattered over a dozen or more square feet of surface.

LOT 765, 3RD DISTRICT, 4TH SECTION, FLOYD COUNTY. — A white amorphous bauxitic clay is exposed in shallow ravines near the south line of *lot 765*. No prospecting has been done.

LOT 766, 3RD DISTRICT, 4TH SECTION, FLOYD COUNTY. — Near the southwest corner of *lot 766*, is a small exposure of white pisolitic bauxite. This is known as the Hatch place. No prospecting has been undertaken.

LOT 749, 3RD DISTRICT, 4TH SECTION, FLOYD COUNTY. — Near the northeast corner of *lot 749*, on the two slopes of the ridge, at an altitude of 900 feet above sea-level, a small prospect pit has been made in a light-colored bauxitic clay.

THE LEWIS REYNOLDS BANK. — This deposit is in the northwest corner of *lot 750, 3rd district, 4th section*, Floyd county, about 200 yards north of the water-parting — a broad, flat divide — separating the Rome and Cedartown drainage. The ore-body has an elevation, according to aneroid measurement, of 875 feet above sea-level.

Two shafts, 35 feet in depth, have been sunk, penetrating a solid body of ore. The ore-body is covered by four feet of a light-colored, residual cherty clay. The ore is of the pisolitic type. The pisolites are generally small in size, averaging one-eighth of



an inch in diameter. They are pink in color, and are embedded in a hard, compact, buff-colored matrix. Larger concretions, of irregular shape, averaging from three-quarters of an inch to one inch in diameter, and white in color, are frequently met with in the same matrix. Some red ore is shown in one of the shafts. The conditions favor a good body of ore. The following partial analyses, furnished by Mr. B. F. A. Saylor, Supt., Dixie Bauxite Company, give some idea of its character:—

SiO <sub>2</sub> . . . . .	7.20	10.44	10.08
Fe <sub>2</sub> O <sub>3</sub> . . . . .	2.62	0.36	—
—————			
Insoluble Matter . . . . .		13.02	12.08
Fe <sub>2</sub> O . . . . .		—	1.33
Al <sub>2</sub> O <sub>3</sub> . . . . .		—	57.92
H <sub>2</sub> O (Combined) . . . . .		—	28.40

LOT 690, 3RD DISTRICT, 4TH SECTION, FLOYD COUNTY. — Near the center and north line of *lot 690*, is a small exposure of red, mottled bauxitic clay containing a few scattered pisolites.

LOT 678, 3RD DISTRICT, 4TH SECTION, FLOYD COUNTY. — On *lot 678*, on the east slope of a dolomite ridge and at an altitude of 975 feet above sea-level, several prospect-pits have been opened. The material exposed is mostly a white bauxitic clay, passing by imperceptible gradations into an imperfect oölitic type of ore.

LOTS 677 AND 692, 3RD DISTRICT, 4TH SECTION, FLOYD COUNTY. — Near the center of the east-and-west line, between lots 677 and 692, on the south slope of a ridge, at an elevation of 960 feet above sea-level, are somewhat extensive surface indications of an amorphous-vesicular type of bauxite. The exposure is mostly on *lot 692*, where several small prospect-pits have been opened, showing a red ore, of the type mentioned above. Fragments of the bauxite are scattered over a considerable surface.

THE DOYLE BANK. — In the valley bottom, near the base of the west slope of a steep dolomite ridge, on *lot 896*, 3rd district, four test-pits have been opened, in each of which ore was found. The elevation of this deposit is 900 feet above sea-level. The ore is exposed over a surface of 50 feet square, and is of the soft pebble type. The pebbles vary from a quarter to one-and-a-half inches

in diameter. They are prevailingly white in color, although some red pebbles are distributed through the mass. The conditions favor a fairly large body of ore, of good quality. The following is an analysis of the ore from this property:—<sup>1</sup>

Al <sub>2</sub> O <sub>3</sub> . . . . .	52.13
Fe <sub>2</sub> O <sub>3</sub> . . . . .	1.12
TiO <sub>2</sub> . . . . .	2.08
SiO <sub>2</sub> . . . . .	19.56
H <sub>2</sub> O . . . . .	24.21
Total . . . . .	<u>99.10</u>

The specimens of ore, yielding this analysis, are described by Spencer as follows: "Large concretionary pellets partially dissolved away, leaving a semi-vesicular mass somewhat poorer in alumina than would be expected. It occurs in the valley."

LOT 906, 3RD DISTRICT, FLOYD COUNTY.—On *lot 906, 3rd district*, Floyd county, a quarter of a mile north of the Polk county-line, a small exposure of the mixed pebble and boulder type of ore is found.

THE WILLIS REYNOLDS BANK.—On *lot 833, 3rd district, 4th section*, Floyd county, about 75 yards north of the Doyle bank, ore is exposed over a surface area, 100 feet square. Two test-pits have been opened, ore showing in each. The elevation of this bank is 900 feet above sea-level. The ore is of a soft pebble type of bauxite. The pebbles vary from a quarter of an inch to two inches or more in diameter. The ore is very white and practically free from iron-oxide staining. Some boulders, of hard pisolitic ore, are distributed through the soft pebble bauxite. The pebbles readily fall out of the soft clayey matrix, on handling, in the case of the soft ore. The ore on this lot is in every respect similar to that of the Doyle bank, which is about seventy-five yards farther south. The following determinations of the insoluble matter in the washed and unwashed ore have been made,<sup>2</sup> which would indicate the presence of considerable siliceous material mixed with the ore, probably in the form of clay:—

	Washed Ore	Unwashed Ore	Difference
Insoluble Matter . . . . .	3.10	16.60	13.50

<sup>1</sup> Spencer, J. W., *The Paleozoic Group*, Geological Survey of Georgia, 1893, p. 216.

<sup>2</sup> By B. F. A. Saylor, Supt., Dixie Bauxite Co.

THE LEWIS REYNOLDS BANK.—Approximately half-a-mile from the Willis Reynolds bank, and on the opposite side of the valley, in the southwest corner of *lot 761, 3rd district, 4th section*, Floyd county, is an exposure of bauxite. The ore is scattered over about 50 feet square of surface, at an elevation of 976 feet above sea-level, in the form of small fragments and boulders, occupying the eastern basal slope of a high and steeply-sloping dolomite ridge. The top of the ridge shows an elevation of 1,100 feet above sea-level, by aneroid measurement. The fragments of ore, exposed on the surface, are of the red-colored pisolitic type, some of which are more highly colored than others.

THE MINTER BANK, No. 1.—On the east side of the broad dolomite ridge, along the main Cedartown public road, and at an elevation of 1,000 feet, a bauxitic clay is exposed on *lot 687, 3rd district, 4th section*, Floyd county. A small test-pit has been sunk to the depth of four feet, revealing a light-colored bauxitic clay, through which are sparingly distributed somewhat imperfect concretions of bauxite.

THE HOWELL BANK.—This deposit is located on the dolomite ridge, half-a-mile east of Mr. A. W. Bobo's dwelling-house, on *lot 160, 3rd district, 4th section*, Floyd county. Several prospect-pits have been opened on the top and on the east slope of the ridge. The opening on the top of the ridge has an elevation of 971 feet above sea-level. The pit on the east slope of the ridge is 80 feet lower than the topmost one. The ore-body is covered by several feet of a residual cherty soil, with the surface of the ridge strewn with chert fragments, of varying sizes. The ore is of a hard, ferruginous, pisolitic variety, containing pisolites of various diameters. The property is owned by Mr. R. S. Perry, of Cave Spring, Georgia.

THE BRANON BANK.<sup>1</sup>—Near the west side of *lot 14, 22nd district, 4th section*, Floyd county, in a slight depression or shallow ravine, on the public road, and at an altitude of 931 feet above sea-level, some prospecting has been done, in what is probably a limited deposit of ore. Two pits have been opened near each other,

<sup>1</sup> Formerly known as the Howell bank.

and about two tons of the ore, taken out, none of which has been shipped, however. The lateral dimensions of the larger pit are 40 by 20 feet, exposing a slightly cream-colored, almost pure white ore. The ore is soft, and contains only a few small pisolites distributed through it. Some parts of the ore-body grade into the pisolitic type, although the most of it belongs to the amorphous variety. The opening probably represents the lateral dimensions of the ore-body; and, where the mottled clay is exposed, the indications strongly suggest, that the depth of the deposit is very slight.

About 250 yards west of the above opening, near the west side of the same lot, a second opening has been made, which is 60 feet in elevation above the one just described. Two test-pits, of small dimensions, have been opened, revealing ore somewhat similar to that on *lot 13*, but somewhat more ferruginous. The developments are insufficient to state the size and shape of the ore-body.

Still a third opening, on the east-west line of *lot 14*, about half-a-mile due east from the Branon bank, has been dug, showing an ore, similar to that in the other openings, on this lot. The pit was opened to a depth of only three feet.

THE MINTER BANK, NO. 2. — This deposit is located in the eastern part of *lot 13, 22nd district, 4th section*, Floyd county, in a depression on the west slope of a dolomite ridge, at an altitude of 950 feet above sea-level. The deposit had just commenced working, a few days prior to the writer's visit, with an average force of 18 hands per day; and, in all, not more than two car-loads of the ore had been removed. On the north side of the opening, a yellow, white and red, mottled clay, surrounding the ore-body, dips under the ore at an angle of about 25 degrees. A few feet south of the clay exposure, is a "horse", of white, putty-like clay, containing some ore. Both the "horse" and the ore were nearly worked out.

The ore is a soft-white to cream-colored pebble variety, of apparently high-grade. The pebbles vary in size; are prevailingly white in color; and are embedded in a soft, clayey matrix, both of which readily crumble in handling and working. So far as developments extend, the boulder type of ore is shown to be almost en-

tirely absent. The main body of the ore is of the amorphous type, passing by imperceptible gradations into the pebble variety.

On the north side of the ridge, a quarter of a mile north from the above opening, and in the northern part of the same lot, bauxite has been very extensively worked, at an elevation of 991 feet above sea-level. The main pit, from which about 1,000 tons of the ore have been removed, has been worked to a depth of 40 feet, with lateral dimensions, 50x75 feet. A highly mottled clay forms the pit-lining on all sides; but, in some places, ore is found back of the clay outside of the working. The clay has a nearly vertical dip on all sides. The ore-body has, by no means, been exhausted in depth. It is very similar to that mined in the eastern part of the same lot. It differs, however, in containing a considerable percentage of the hard boulder type of ore. Some of the boulders were said to weigh as much as two tons.

Several small test-pits have been opened about a dozen paces from the main pit, each of which shows ore. Besides this, on top of the ridge, about 300 yards from this working, and from 40 to 50 feet in elevation above the main opening, prospecting shows similar ore. Scattered boulders of the ore on the surface led to the discovery of this deposit. The character of the ore is well shown in the following partial analyses, kindly furnished by Mr. J. C. Lamb, of Rome, Georgia:—

Al <sub>2</sub> O <sub>3</sub> . . . . .	61.81	61.40	42.61	—	—
Fe <sub>2</sub> O <sub>3</sub> . . . . .	1.12	1.12	—	—	—
SiO <sub>2</sub> . . . . .	6.90	7.00	28.70	17.22	24.28
Insoluble Matter . . . .	7.90	8.00	30.00	18.28	25.19
Al <sub>2</sub> O <sub>3</sub> . . . . .	—	—	—	—	—
Fe <sub>2</sub> O <sub>3</sub> . . . . .	—	—	0.38	—	—
SiO <sub>2</sub> . . . . .	—	27.60	5.99	—	—
Insoluble Matter . . . . .	—	28.80	6.95	8.73	6.80

Screenings, passed through a ¼-inch mesh sieve, gave:—

Insoluble Matter . . . . .	13.51
SiO <sub>2</sub> . . . . .	12.53

Likewise, the lumps from screening yielded:—

Insoluble Matter . . . . .	14.70
SiO <sub>2</sub> . . . . .	13.72



THE CHURCH BAUXITE MINE, FLOYD COUNTY, GEORGIA.

"LOT 23."—In the south half of *lot 23, 22nd district*, Floyd county, eight openings, mostly in the form of test-pits, have been made within 200 feet of each other, exposing a large body of high-grade bauxite. The openings are on the east side, and near the top, of a high dolomite ridge. The ore is of the pisolitic type, generally white, though occasionally colored a pale pink by iron oxide. The owner of this property, Mr. Earle Sloan, of Charleston, S. C., informs the writer, that numerous analyses of the ore show an average of more than 60 per cent. of alumina, averaging proportionately low in both iron oxide and silica. The developments indicate a large body of bauxite of excellent grade.

"LOT 685."—Surface indications point to a considerable deposit of a low-grade, siliceous bauxite on *lot 685, 3rd district*, Floyd county. The property is owned by Mr. Earle Sloan, of Charleston, S. C. Little or no prospecting has been done.

THE HAWKINS BANK.—On a lot in the *3rd district, 4th section*, Floyd county, along both sides of a plantation road, is a surface area, from 175 to 200 yards square, strewn with fragments of a hard pisolitic bauxite. Some half-dozen test-pits, of small dimensions, have been sunk in different places, the most of which showed ore. The ore is a hard, pisolitic type of bauxite, highly ferruginous, as is shown by its prevailing deep-red color. The ore-body will likely prove a large one, and the ore, upon depth in working, may change to a lighter color, containing, should this prove true, less iron oxide.

On another lot in the *3rd district, 4th section*, on top of a ridge, two small prospect-pits have been opened, showing a light-colored ore, of seemingly good quality. Indications point, however, to only a slight deposit of the ore.

THE WHORTON BANK.—Near the top of a dolomite ridge, at an altitude of 1,050 feet above sea-level, on *lot 59, 22nd district, 3rd section*, Floyd county, a good deposit of ore is shown in several prospect openings. The surface of the ridge is thickly covered by chert fragments. The openings consist of one test-pit, of average dimensions, and a shaft, sunk to the depth of 25 feet. A solid body of ore is shown in both openings. The shaft did not penetrate the entire depth of the ore-body. The ore is of the oölitic

type. The matrix is hard and compact, and the concretions, or oölites, soft and powdery, easily crumbling under pressure of the hand. It is light in color and apparently of good quality; and a large deposit is indicated from the present developments. The following is an analysis of this ore, furnished by Mr. John H. Hawkins, Supt., Republic Mining and Manufacturing Company:—

Al <sub>2</sub> O <sub>3</sub> . . . . .	57.73
Fe <sub>2</sub> O <sub>3</sub> . . . . .	1.12
TiO <sub>2</sub> . . . . .	5.35
SiO <sub>2</sub> . . . . .	5.10
Ignition . . . . .	30.70
Total . . . . .	<u>100.00</u>

THE RITCH BANK. — In the northwest corner of *lot 151, 22nd district, 3rd section*, Floyd county, two pits, 50 yards apart, and with a north-south alignment, have been opened at an elevation of 851 feet above sea-level. The south pit is 25 feet long by six feet wide, and six feet deep, with a shaft of unknown depth sunk from the bottom of the pit. The depth of the shaft could not be determined, on account of its being filled with water at the time of the writer's visit. The north pit is 18 feet long by six feet wide and four feet deep. The deposit is covered by three feet of a stiff red plastic clay. The type of ore is different in the two openings. That exposed in the south pit is a hard, pisolitic variety and highly ferruginous. The pisolites vary in size. They are deep-red in color, and are held together by but little cementing material; and, in many cases, they are coated with a black covering of manganese dioxide. A few boulders, of light color, are to be observed, the matrix of which is hard and dense, and buff in color, with the pisolites more or less pink.

The ore exposed in the north pit is a white amorphous type, with small and imperfect oölites sparingly distributed through it. Determinations of the insoluble matter and the iron oxide, in specimens of the Ritch ore gave —<sup>1</sup>

Insoluble Matter . . . . .	2.65	6.90	3.12
Fe <sub>2</sub> O <sub>3</sub> . . . . .	—	—	3.00

<sup>1</sup> Furnished by Mr. B. F. A. Saylor, Supt., Dixie Bauxite Company.



THE FOMBY BANK. — Some prospecting has been done in the northeast corner of *lot 150, 22nd district, 3rd section*, Floyd county, a quarter of a mile north of and at approximately the same elevation as the Ritch bank. Loose fragments of bauxitic clay and hard light-colored pisolitic bauxite, scattered over the surface of a knoll, lead to the location of this deposit. One test-pit, eight feet long by six feet wide and four feet deep, is opened in a white bauxitic clay. A few feet from the pit, a shaft, 35 feet in depth, has been sunk, penetrating, for the most part, a white clay, similar to that of the pit. This clay contains some hard, pisolitic, and soft, pebble ore. It is stated that further developments were abandoned, on account of the scarcity of ore. The amorphous, clayey material carries imperfectly formed concretions, which, to some degree, resemble an imperfect pebble ore. A specimen of the clay from the ore-body yielded 45.20 per cent. of insoluble matter. Other specimens of the ore gave —<sup>1</sup>

Insoluble Matter . . . . .	2.70	1.20				
Fe <sub>2</sub> O <sub>3</sub> . . . . .	2.35	—				
Al <sub>2</sub> O <sub>3</sub> . . . . .	53.69	64.60	63.00	61.47	64.09	65.74
Fe <sub>2</sub> O <sub>3</sub> . . . . .	14.80	0.95	1.73	2.98	2.31	0.85
SiO <sub>2</sub> . . . . .	2.62	4.00	3.21	1.96	3.22	—

THE BONSACK BANK. — In *lot 129, 22nd district, 3rd section*, Floyd county, 911 feet in elevation, and a half-mile east of the Southern Railway, is an extensive surface exposure of bauxite. Fragments of the ore are somewhat thickly strewn over an area of at least 100 square yards of surface. A part of the exposed ore is in the nature of boulders, of fairly large dimensions. Three test-pits have been opened at different points over the area, but near together. The first and largest is 12 feet long by 4 feet wide, and from 6 to 7 feet deep; the second is 4 x 4 feet and 8 feet deep; and the third has approximately the same lateral dimensions as the second, but it is not quite so deep. The pits all reveal a solid, compact body of ore. They are about 50 yards apart, with lines connecting them, forming a triangle. The exposed ore is of a hard, pisolitic type, for the most part, and is deep red in color. The matrix and pisolites usually have the same color. Light-colored ore

<sup>1</sup> Furnished by Mr. B. F. A. Saylor, Supt., Dixie Bauxite Company.

is by no means absent. It occurs frequently mixed with the predominating red bauxite. The indications, here, are very favorable for a large ore-body; and the red ore, found at present on the surface, will very likely give way to a very much lighter-colored ore upon increased depth in working; insuring, if this be true, a decreased percentage of iron oxide, with, other things being equal, a corresponding increase in alumina.

Through the kindness of Col. Junius F. Hillyer, of Rome, Georgia, the owner of this property, the writer is able to furnish the following analyses of the two grades of ore, which were made by the Pittsburgh Testing Laboratory in Pittsburgh, Pennsylvania:—

	Red Ore		Light-Colored Ore
Al <sub>2</sub> O <sub>3</sub> . . . . .	52.30	52.40	56.96
Fe <sub>2</sub> O <sub>3</sub> . . . . .	13.33	12.60	1.69
TiO <sub>2</sub> . . . . .	3.60	3.70	4.05
SiO <sub>2</sub> . . . . .	3.70	3.95	6.03
H <sub>2</sub> O . . . . .	27.07	27.35	31.40

**THE REESE BANK.**—This deposit is located on *lot 60, 22nd district, 3rd section*, Floyd county, about 200 yards east of the Southern Railway, in a slight depression on the slope of a dolomite ridge, and at an elevation of 871 feet. The ore is exposed in a test-pit about 30 x 40 feet, with an average depth of 10 feet. It is prevailingly light in color, and of the coarse pebble variety. The pebbles vary from a quarter of an inch to three inches in diameter, and are both simple and complex in structure. They are embedded in a soft, white, clayey matrix. It very closely resembles the ore from the Julia bank in the Hermitage district, described on pages 83 to 86 of this report. Some large boulders of hard pisolitic bauxite are mixed with the soft ore; but the soft pebble type greatly predominates. In some places, the ore has a reddish color, due to slight iron staining. The ore-body is almost in contact with a considerable iron ore deposit, exposed in an adjoining pit. The present developments indicate a fairly large ore-body, of good quality.

**THE BIGELOW BANK.**—<sup>1</sup> This deposit is located in Polk county, on a broad dolomite plateau, at an elevation of 1,051 feet above

<sup>1</sup> Known at present as the Williams property.

sea-level; and an eighth of a mile south of the Floyd county line. The ore is exposed in a prospect pit, 6 x 10 feet, and about 4 feet deep. It is slightly pinkish in color, and it belongs to the pisolitic type. The pisolites vary in size; are light in color and powdery; and they crumble under slight pressure. The matrix is moderately firm, clay-like material, which greatly predominates in quantity over the proportion of pisolites. The following are partial analyses of specimens of the Bigelow ore, kindly furnished by Mr. J. C. Lamb, of Rome, Georgia:—

		Surface Ore Mixed with Clay
Insoluble Matter . . . . .	9.05	43.36
SiO <sub>2</sub> . . . . .	8.09	41.76
Fe <sub>2</sub> O <sub>3</sub> . . . . .	1.22	—

THE BROADAWAY BANK.— On the same broad plateau, but 20 feet higher than the Bigelow bank, surface indications of ore are rather extensive, on *lot 53, 22nd district, 3rd section*, Polk county. Some half-dozen test-pits, of small dimensions, have been opened, extending over several hundred square feet of surface, with ore found in each one. The ore is prevailingly white, though mottled with small red to pink-colored patches in places, and is, for the most part, of the amorphous type, containing sparingly-distributed, imperfect pisolites. Some few fragments of the hard pisolitic type of ore were observed in places. While the developments are yet insufficient to speak with certainty, the conditions suggest an ore-body of more than the average dimensions. The following represents partial analyses of specimens of this ore, furnished by Mr. B. F. A. Saylor, Supt., Dixie Bauxite Company:—

Al <sub>2</sub> O <sub>3</sub> . . . . .	58.97	—
Fe <sub>2</sub> O <sub>3</sub> . . . . .	—	2.86
SiO <sub>2</sub> . . . . .	9.24	8.16
Insoluble Matter . . . . .	10.37	—

On *lot 179, 16th district*, Polk county, owned by Mr. J. H. Shaw, of Cave Spring, several fragments of hard pisolitic, ferruginous bauxite were found in the valley near Mr. Shaw's dwelling-house.

On *lot 182, 16th district*, Polk county, owned by the Southern

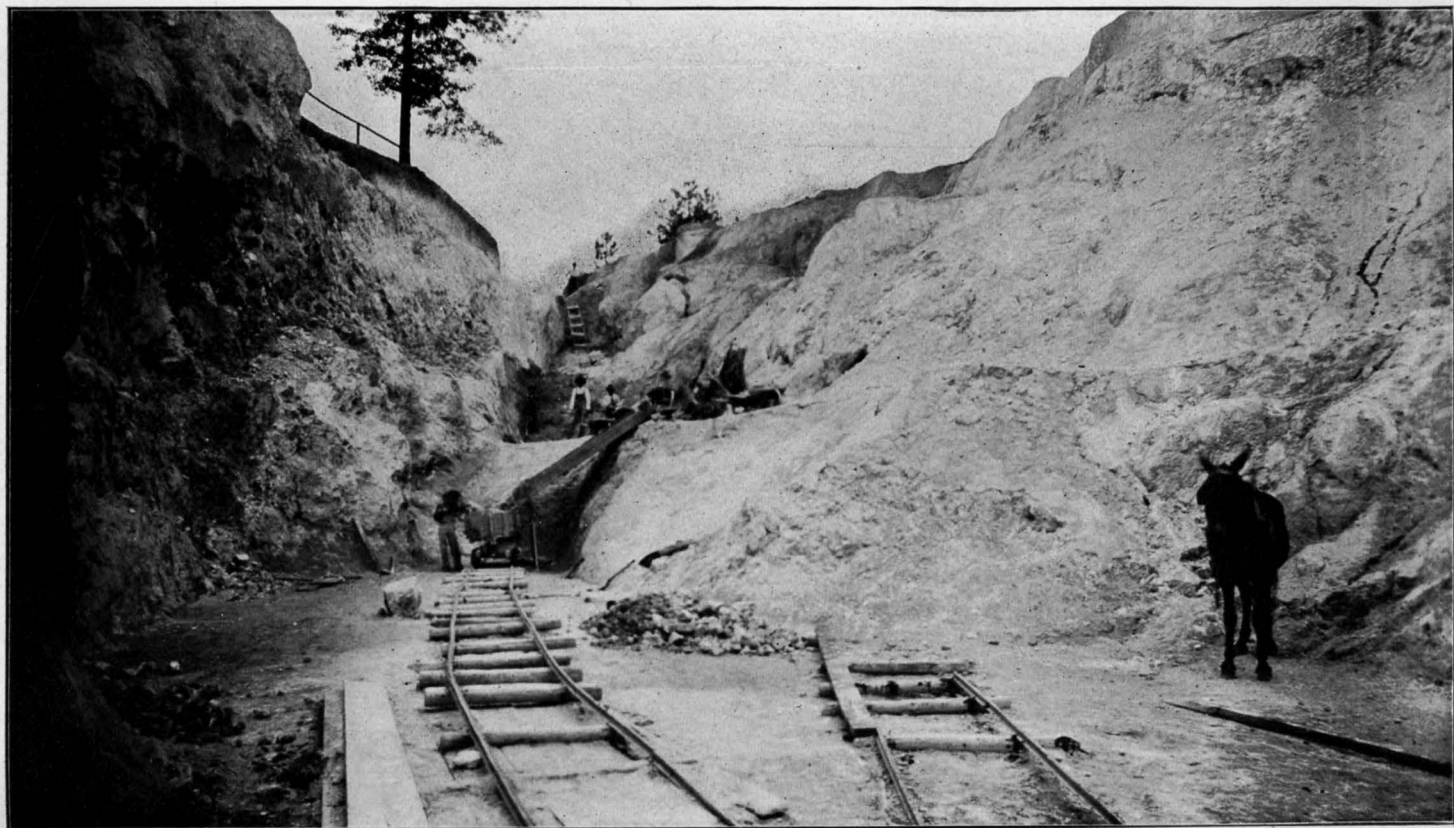
Bauxite Company, Cave Spring, surface indications, similar to those mentioned on *lot 179*, appear.

THE COCHRAN BANK.—Fragments of light-colored bauxite and abundant rounded concretionary pebbles of the ore are somewhat thickly strewn over a surface area, from 150 to 250 feet square, on *lots 182 and 183, 22nd district, 3rd section, Floyd county*. The area is mostly on *lot 183*; but it crosses near the middle of the north line of the lot, into *lot 182*. The ore fragments occupy a portion of the western slope of a steeply sloping dolomite ridge, whose summit elevation is 940 feet above sea-level. The upper limits of the ore-body are fifty feet lower than the summit of the ridge. Fragments of ore are traceable over an elliptical shaped surface from 250 to 300 feet in length. Southward from this area and near the top of the ridge, are excellent surface indications of a moderately large body of brown iron ore.

The surface material indicates a preponderance of the hard, pisolitic type of bauxite, generally light in color, though sometimes stained red by iron oxide. Boulders, measuring from one to two feet in diameter, are commonly found over the surface. There is abundant evidence of considerable pebble ore, in the nature of more or less perfectly spherical concretions, of variable diameters, and light in color, covering parts of the surface. As a rule, the pebbles are very hard and compact, breaking with a conchoidal fracture. No prospecting has been undertaken.

LOT No. 12, 22ND DISTRICT, 3RD SECTION, FLOYD COUNTY.—Several small test-pits have been opened in a red bauxite on this lot. The surface indications are not very extensive, and developments are insufficient to define the size and shape of the ore-body.

LOT No. 682, 3RD DISTRICT, 4TH SECTION, FLOYD COUNTY.—This deposit is located on the eastern slope of a steep dolomite ridge, whose surface is thickly covered by angular chert fragments, on *lot 682*. The principal opening, from which probably one car-load of the ore has been removed, but not shipped, is near the head of a deep and narrow ravine. The opening was more in the nature of an open-cut, and had caved in on all sides, leaving no ore in place visible; and the depth could not, therefore, be determined.



THE WATERS BAUXITE MINE, FLOYD COUNTY, GEORGIA.

The ore removed from the opening is piled to one side of the cut; it is a hard, white, pisolitic bauxite. The matrix is firm and compact, containing nearly pure white pisolites, of variable size, which crumble with much readiness. The matrix forms more than a half of the bauxitic material. Numerous smaller prospect openings have been made, higher up and lower down the ridge slope; and, in some cases, several hundred yards from the large cut, some of the pits show iron ore. The developments are entirely inadequate to define the limits and form of the ore-body.

An analysis, made of fragments of the hard, compact, cream-colored matrix separated from the pisolites, in a specimen of the ore collected from lot 682 and analyzed by the writer in the Survey laboratory, yielded the following results:—

SiO <sub>2</sub> . . . . .	13.17
TiO <sub>2</sub> . . . . .	9.75
Fe <sub>2</sub> O <sub>3</sub> . . . . .	trace
Al <sub>2</sub> O <sub>3</sub> . . . . .	48.30
H <sub>2</sub> O at 100° C. . . . .	0.53
H <sub>2</sub> O (combined) . . . . .	28.01
Total . . . . .	<u>99.76</u>

THE FREEMAN BANK.—Near the center of *lot 332, 23rd district, 3rd section*, Floyd county, and about a quarter of a mile south from the Etowah river, several test-pits have been opened near the bottom of a deep and narrow ravine. The ore is covered by several feet of a deep-red cherty clay. Very little ore is exposed in the openings. It is of the hard, pisolitic type, deep-red in color, closely resembling that of the Bonsack bank. The deposit has an altitude of only 651 feet above sea-level. An analysis of specimens of this ore gave the following results:—<sup>1</sup>

Al <sub>2</sub> O <sub>3</sub> . . . . .	56.00
Fe <sub>2</sub> O <sub>3</sub> . . . . .	9.64
SiO <sub>2</sub> . . . . .	6.31

### 3. THE SUMMERVILLE DISTRICT

The Summerville district is less well defined than the ones previously described. As yet, only five deposits of bauxite are known

<sup>1</sup> Furnished by Mr. B. F. A. Saylor, Sup't., Dixie Bauxite Company.

in this district. They are widely separated, and occur in different, but adjoining, counties, as follows: Three, near Summerville, in Chattooga county; a fourth, near Trion Factory, in the same county; and a fifth, a short distance from McConnell's station on the Chattanooga Southern Railway, in the southern part of Walker county.

#### LOCATION AND DESCRIPTION OF THE INDIVIDUAL DEPOSITS

**THE TAYLOR BANK.**—Two separate ore-bodies, 400 yards apart, and in a nearly north-south line, have been opened near the base and along the eastern slope of a dolomite ridge, which limits the Chattooga valley on the west. The ridge has a northeast-southwest trend, and by means of a fault, of the ordinary Appalachian type, the Knox Dolomite is brought in contact along its eastern base with the soft drab-colored Cambrian shales, out of which shales the Chattooga valley has been eroded. The deposits of bauxite are located near the fault-line, along the western limits of the town of Summerville, and are 768 feet above tide-level.

The most southerly one of the deposits is exposed in half-a-dozen or more test-pits, extending over a surface area of from 200 to 300 feet. A majority of the pits showed ore. In the largest opening, the ore is associated with halloysite; and, in all cases, with a white-and-pink mottled clay. Near the top of several of the openings, some pebble ore is exposed; although the hard, pisolitic type of bauxite predominates, which in most cases is highly ferruginous. The pisolites vary in size and hardness. As a rule, they crumble with readiness to a powder, breaking, however, at times, with a conchoidal fracture. Not much ore was in sight at the time of the writer's visit; and it was scattered through a large mass of bauxitic clay. The top of the ridge in the wagon-road was 200 feet above the ore deposit, giving an altitude of 968 feet for the ridge-summit above tide-level.

The most northerly one of the two deposits is in the rear of Mr. Taylor's dwelling-house. It has been somewhat extensively worked. About 100 tons of the boulder-ore have been shipped from this opening. The ore-body is exposed in a cut, from 75 to 100 feet long; and it has been worked to a depth of from 20 to 25

feet. The cut has a west course, directly into the east slope of the ridge. No work had been done for some years previous to the writer's visit, and the cut had caved in, to such an extent, on all sides, that the exact conditions were not clearly visible. After the removal of several feet of a residual cherty clay, the entire cut was in a white, structureless, bauxitic clay containing the embedded pisolitic type of ore, usually light in color, and but slightly stained with iron. The clay is uniformly light-gray, and frequently vesicular in type, from the falling out of the original pisolites. Only the boulder-ore has thus far been shipped, the bauxitic clay or matrix probably containing too much silica to be utilized.

The bauxite is in contact, along its eastern side, with a vein of limonite, from five to seven feet thick and dipping about 80 degrees to the east. This vein was not entirely visible, at the time of the writer's visit; but Dr. Hayes describes it as composed "of two sheets of solid limonite, each about a foot thick, separated by a layer of ferruginous clay."<sup>1</sup> The ore is further associated with a considerable amount of carbonaceous clay and impure lignite, the exact relationships of which were not fully determined. The following are the results of an analysis of specimens of the ore from the opening in the rear of Mr. John D. Taylor's house:—<sup>2</sup>

Al <sub>2</sub> O <sub>3</sub> . . . . .	57.56
Fe <sub>2</sub> O <sub>3</sub> . . . . .	2.40
TiO <sub>2</sub> . . . . .	4.40
SiO <sub>2</sub> . . . . .	3.35
Ignition . . . . .	32.20

THE SCRUGGS BANK.—On *lot 15, 4th district*, Chattooga county, near the limits of the town of Summerville, and on the public road in front of Mr. J. T. Scruggs's dwelling-house, some prospecting was recently done, and a good grade of bauxite, exposed in some half-dozen openings. The openings are near together, and extend over approximately one acre of ground. The deepest opening reached a depth of 40 feet in bauxite and bauxitic clay. A second opening was sunk fifteen feet in solid ore.

The ore is an excellent grade of white pebble and gravel bauxite,

<sup>1</sup> Sixteenth Ann. Report, U. S. Geol. Survey, 1894-'95 (1895), p. 587.

<sup>2</sup> Furnished by Mr. John H. Hawkins, Supt., Republic Mining and Manufacturing Company.



the concretions being held in a soft clay-like matrix. The ore is generally free from iron oxide. The pebbles or concretions range in size from a sixteenth to a half-inch in diameter. The ore averages about 3 per cent. in silica, and 1 per cent. in iron oxide. One car-load of the ore is reported to have been shipped.

On the west side of the bauxite deposit, a little higher up the ridge slope, occurs a good grade, apparently of brown iron ore, one car-load of which is reported to have been shipped.

This deposit of bauxite represents the most southwesterly one, of three deposits found near or within the town of Summerville, the Taylor bank being the northernmost one. The Scruggs deposit is less than a quarter of a mile southwest of the deposit occurring within the town limits, and at the west end of Main street. The three deposits occur along a fault-line at the base of a low Knox Dolomite ridge, and near the contact of the dolomite with the Middle Cambrian shales. At the Scruggs bank, no dolomite is exposed, although excavations in the cherty clay, derived from the limestone, have been made, exposing a section more than fifty feet in depth. Much chert has been removed from the Scruggs bank for road purposes.

TRION FACTORY. — About three miles northeast of Trion Factory, a small deposit of bauxite has been found, from scanty surface indications. A little prospecting has been done, resulting in the exposure of a hard, red-colored ore.

THE ARMINGTON BANK. —<sup>1</sup> This deposit is located in the southern part of Walker county, eight miles due north from the Taylor bank at Summerville, near McConnell's station on the Chattanooga Southern Railway. The deposit is in an elevated portion of the western part of the valley, about a quarter of a mile east of a very high and steeply sloping dolomite ridge. One open-cut, about 50 feet long, and one shaft, 39 feet deep, with several small test-pits near by, constitute the entire prospecting done. Nearly an acre of the surface is thickly covered by large and small fragments of bauxite. A solid body of ore was shown in each of the openings. Near the top of the excavations, considerable pebble

<sup>1</sup> Also known as the Thurman bank.

ore is shown, the pebbles ranging in size from a half-inch to two and three inches in diameter. The bulk of the ore, however, is the hard pisolitic variety, generally light in color, though deeply stained with iron in many places. By aneroid measurements, the ore-body has an altitude of 868 feet above tide-level. About one car-load of the ore has been shipped. The character of the ore is well shown in the following analysis:—

	I <sup>1</sup>	II <sup>2</sup>	III <sup>2</sup>	IV <sup>2</sup>
Al <sub>2</sub> O <sub>3</sub> . . . . .	75.03	60.00	58.90	60.83
Fe <sub>2</sub> O <sub>3</sub> . . . . .	1.84	0.65	1.20	1.82
TiO <sub>2</sub> . . . . .	0.96	3.65	4.30	3.90
SiO <sub>2</sub> . . . . .	2.66	0.80	1.40	0.85
H <sub>2</sub> O (combined) . . . . .	16.00	35.00	34.20	32.60
Moisture . . . . .	3.00			
Total . . . . .	<u>99.49</u>	<u>100.10</u>	<u>100.00</u>	<u>100.00</u>

These figures indicate an excellent grade of ore, very low in iron oxide and silica; and the surface indications and developments undoubtedly point to a large deposit of bauxite. <sup>3</sup>

#### 4. ISOLATED DEPOSITS

In addition to the deposits of the two districts above described, several isolated deposits occur in the region. None of these, however, have yet been worked, and their true value remains unknown. Their location is indicated in the accompanying general map.

##### CALHOUN

A single deposit occurs about one mile northeast of Calhoun. The map, plate I, is an accurate representation of the geology of the region around Calhoun.

THE BAILEY BANK. — The William Bailey place is located approximately one mile northeast of Calhoun, the county-seat of

<sup>1</sup> Hayes, C. W., Sixteenth Ann. Rept., U. S. Geol. Survey, 1895, p. 587.

<sup>2</sup> Furnished by Mr. John H. Hawkins, Supt. Republic Mining and Manufacturing Company.

<sup>3</sup> Since the field work was completed on this report, Mr. John H. Hawkins, of Rome, Georgia, has established a commodious plant at the *Armington Bank*, and has mined a large quantity of the ore. From the length of time working and the amount of ore shipped, this is one of the largest deposits of bauxite yet opened in the State. See plate of the Hawkins plant.

Gordon county, and is owned by Hon. O. N. Starr, of the above town. The bauxite deposit occurs about half-a-mile east of the Oostanaula river, along a transverse ravine in the northeast slope of a cherty limestone ridge. The surface of the ridge is somewhat heavily covered with large and small angular fragments of the chert. Fragments of a hard and red ferruginous bauxite, of various sizes, litter the surface from near the top of the ridge for nearly the entire length of the ravine. The deposit is not so extensive as the scattered surface fragments would indicate. Along the middle and lower portions of the ravine, the fragments of ore are not in place, but have been washed down from near the top of the ridge, where the ore-body is located.

One small opening was made near the middle of the slope of the ridge, ten or more years ago; but no ore was shipped, and no work has subsequently been done. The ore exposed is of the deep-red ferruginous, pisolitic type. The pisolites are hard and red in color; and in size, they vary from an eighth of an inch to half-an-inch in diameter. They break with a conchoidal fracture, and the usual concretionary structure is generally absent. The concretions are held in a hard and dense buff-colored matrix, of which the concretions make up more than half of the total ore-mass.

The writer was reliably informed, that the ore becomes lighter in color and therefore freer from iron oxide, in passing from the surface toward the interior of the ore-body. No exact estimate of the size of the ore-body could be made, from the lack of development; but the surface indications would favor a fairly large deposit.

#### 17TH DISTRICT, BARTOW COUNTY

THE T. M. MARTIN PROPERTY. — In the 17th district, Bartow county, approximately five miles southwest from Kingston and three miles west of the Etowah river, a good grade of light-colored bauxite is reported on Mr. Martin's place. No work has been done, and none of the ore has been shipped.

## CHAPTER V

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# THE GENESIS, AGE, ESTIMATION AND USES OF THE GEORGIA BAUXITE

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### I. GENESIS OF THE GEORGIA BAUXITE DEPOSITS <sup>1</sup>

From the brief statement, or summary, given in the early part of this report, of the known workable deposits of bauxite, it readily follows, from their widely varying geologic modes of occurrence, that the same explanation can not apply to each locality. In some localities, the deposits occur in regularly stratified beds; in others, they unquestionably represent alteration or residual deposits; while in others, still, they form well-defined pocket deposits, entirely distinct from the enclosing residual material. It is evident, therefore, that the above strongly contrasted modes of occurrence of this mineral renders a general explanation for the accumulation of its various deposits for all localities, entirely beyond question. The conclusions reached in the study of one type can not be applied to the explanation of another.

The bauxite deposits in the Georgia area have been previously studied in considerable detail by Dr. J. W. Spencer, formerly State Geologist of Georgia, and by Dr. C. W. Hayes of the U. S. Geological Survey. Both Spencer and Hayes have offered explanations for the accumulation of the ore-bodies, which differ greatly from each other. The two theories are separately taken up and discussed below.

Spencer suggested the following theory to explain the origin of the Georgia bauxite deposits: — <sup>2</sup>

“This is an open question. Its situation along with the iron and manganese ores in dolomites suggests a common genesis. The formation skirts the crystalline

<sup>1</sup> Watson, Thomas L., *The Georgia Bauxite Deposits: Their Chemical Constitution and Genesis*, Amer. Geologist, Vol. XXVIII, July, 1901, pp. 25-45.

<sup>2</sup> *The Paleozoic Group*, Geol. Survey of Georgia, 1893, pp. 225-226.

rocks of Central Georgia, whence the materials were originally obtained. Prof. Branner says that the Arkansas beauxite, although in Tertiary rocks, is located near eruptive syenites, or hornblende granites. Such rocks in Georgia have given rise, in part, to the iron and manganese minerals. The feldspar, in others, contains the aluminium, and there remains only the necessary solvent to transport and deposit it as the mineral bauxite.

"In the weathering of the rocks carbonic and vegetable acids remove the iron, manganese, lime, etc., from the hornblende, and potash and soda from the feldspar. So also carbonic acid in water can dissolve small quantities of alumina; thus the same waters can remove the iron, manganese and alumina. The alkalis derived from the decay of feldspars can also dissolve the alumina. Thus transported, the alumina may be precipitated in the lagoons in which the ferruginous and manganiferous clayey limestones were being formed. The white clays associated with the beauxite and iron ore deposits are usually of fine texture, indicative of deposition in quiet waters. The frequent replacement of part of the alumina by ferric oxide further shows the presence of both metals in the original solution, but in variable quantities at different times and places.

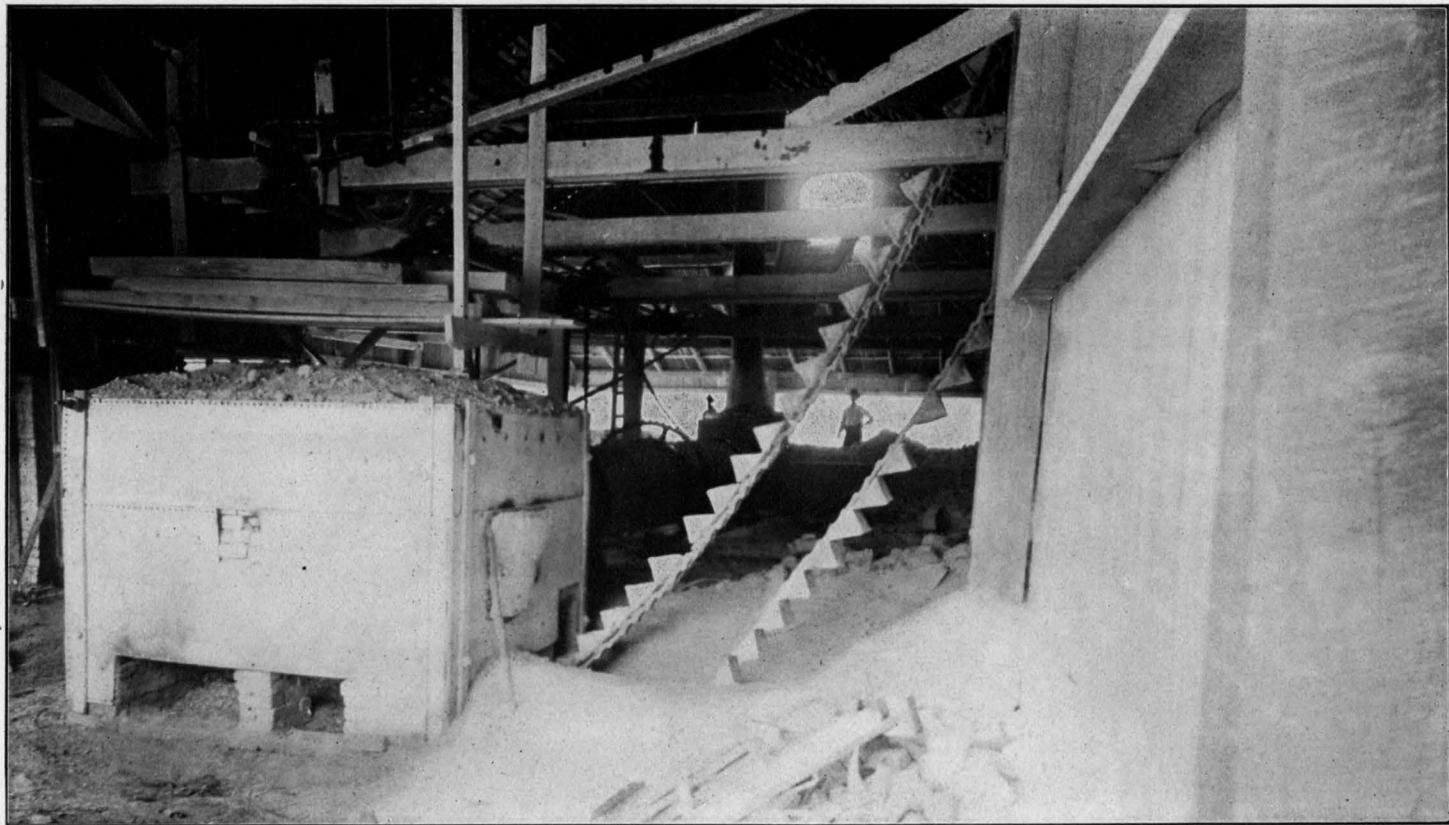
"Upon the subsequent decomposition of the Knox limestone, the calcareous matter being removed, the ores were concentrated, leaving accumulations of beauxite more prominent than in the original beds.

"The position of the beauxite appears to be more or less in pockets and lenticular masses in certain strata, and if workings are ever carried beneath the decayed rocks, the mineral will likely be found in pockets in compact limestone. Indeed, some of the apparent clays may be found to be the soluble aluminous mineral, which is so far as known in Georgia, generally more or less oölitic and concretionary, as are the iron and manganese deposits. The beauxite beds or pockets are less interrupted, and are much more extensive than the latter named mineral."

Briefly summarized, Dr. Spencer's explanation for the accumulation of the bauxite deposits in Georgia is: (a) The source of the alumina was from the crystalline rocks of Central Georgia. (b) The alumina was carried to its present place by carbonated or alkaline waters, and precipitated in the lagoons, in which the ferruginous and manganiferous, clayey limestones were being formed. (c) The ores were further concentrated, upon weathering of the Knox limestone; the soluble calcareous material of the limestone was removed in solution; and the insoluble aluminous material, bauxite, was accumulated and left more prominent than in the original beds.

Dr. Spencer's theory fails to explain the following essential conditions and characteristic modes of occurrence of the Georgia ore-bodies, which have recently been studied in considerable detail by the writer. These are —

(1) The deposits are compact ore-bodies, existing in the form of



MACHINERY OF THE REPUBLIC MINING AND MANUFACTURING COMPANY'S BAUXITE DRYING PLANT,  
HERMITAGE, FLOYD COUNTY, GEORGIA.

well-defined pockets; and, as a rule, with the vertical nearly equal to the horizontal dimensions. This mode of occurrence of the bauxite can not, by any known possible process, apply to the accumulation of ore-bodies, which have resulted from weathering.

(2) The relationship of the bauxite and its associated kaolins to the surrounding residual siliceous material. In no instance, has gradation from the bauxitic clay into the enclosing residual clays been observed; but, on the contrary, the line between the two is at all times definite and pronounced. Not the slightest resemblance is shown in the two types of clay. Furthermore, the ore-bodies are free from inclusions of the residual material. The concentration or accumulation of ore deposits from weathering *in situ* usually shows more or less residual material variously admixed. This forms the most convincing evidence, in the case of deposits derived from rock-weathering. This point is well illustrated in the case of the somewhat closely associated manganese and some of the iron deposits in the bauxitic area of Georgia.

(3) The relation of the deposits to the present topography of the region, and their altitude above sea-level. Upon Spencer's theory, the ore-bodies, if they represent accumulation from weathering of the Knox limestone, should occur only at definite and uniform positions in that formation. The deposits, on the contrary, do not conform to these conditions; but they are found in all parts of the Knox Dolomite, giving, as Hayes has shown, a stratigraphic range of at least 4,000 feet.

(4) While the bauxite deposits in question are somewhat closely associated with those of iron and manganese, more particularly the iron ore-bodies, it by no means follows, as Spencer states, that the conditions suggest "a common genesis." In fact, recent work in this region has shown, that the three types of ore-deposits have likely had different origins. The manganese deposits of the Cartersville district represent undoubted residual accumulations, concentrated by physical and chemical processes incidental to weathering. Only a small percentage of the iron ore deposits of this region are believed by Hayes<sup>1</sup> and McCallie<sup>2</sup> to represent accumu-

<sup>1</sup> Hayes, C. W., *Geological Relations of the Iron Ores in the Cartersville District, Georgia*, Trans., Amer. Inst. Min. Engrs, 1901, Vol. XXX, pp. 403-419.

<sup>2</sup> McCallie, S. W., *Geol. Survey of Georgia*, Bull. 10-A.

lations from residual decay. The iron and manganese ores are more intimately associated than any two metalliferous deposits known in the area; and yet, with several exceptions, they are shown to have different origins.

The above facts constitute some of the essential features of the bauxite deposits, which must be accounted for in any satisfactory explanation. It is very apparent, that the process of bauxite accumulation outlined by Spencer can in nowise apply to the Georgia deposits; and the assumption, that they exist in the form of beds instead of separate pockets, is wholly misleading.

After a detailed study of the structural geology of the region, and of the ore-bodies, Dr. C. W. Hayes says,<sup>1</sup> that any theory offered to satisfactorily explain the bauxite deposits must give —

- (1) The source from which the material was derived.
- (2) The means by which it was transported.
- (3) The process of its local accumulation.

Hayes discusses separately each one of the three premises given above, in considerable detail, the greater part of which I quote from his report.<sup>2</sup>

THE SOURCE OF THE MATERIAL. — Concerning this, Hayes says: "Immediately underlying the ore is in most cases the Knox dolomite, but this formation could scarcely have furnished the material for the deposits since, so far as known, it contains only a small amount of aluminum and that always in the form of the silicate as clay.

"The process by which the small amount of iron contained in the dolomite was segregated during the weathering of the rock into masses of limonite is wholly inapplicable to the segregation of aluminum as bauxite. Iron does not ordinarily occur in sedimentary rocks as the silicate but as the oxide and carbonate, compounds which readily unite with the organic acids in the soil to form soluble compounds. From such solutions the iron is precipitated by oxidation and so forms limonite. Aluminum, on the other hand, although much more abundant than iron in the sedimentary rocks, is practically all in combination with silica, forming a compound which is almost or quite unaffected by organic acids or other chemical agents active in rock weathering at the earth's surface.

"Beneath the Knox dolomite there is throughout the whole of this region a great mass of calcareous clay shales which are probably the source of the alumina forming the bauxite. The Connasauga shales are generally several thousand feet in thickness and they contain from 15 to 20 per cent. of alumina. Although this is in combination with silica, the conditions requisite for its removal are also present.

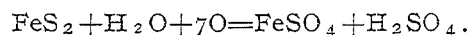
<sup>1</sup> Sixteenth Ann. Rept., U. S. Geol. Surv., 1895, Part III, p. 587.

<sup>2</sup> *Ibid.*, pp. 587-591.



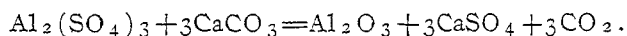
THE MEANS OF TRANSPORTATION. — "The faults of the region have been described at some length. In the Dyke district [Alabama] they are numerous and profound, and practically obliterate all other structures. In the Bobo district they are also numerous, but have less displacement and greater regularity. Even the Hermitage district, in which no faults of the ordinary type are known, probably overlies a great shear zone, the major thrust plane of the Rome fault. Hence, it is safe to say that the strata of the entire bauxite region have been intersected by many fractures, while in some places the rocks have been crushed and ground up so that they form a breccia. \* \* \* \*

"In the bauxite region the numerous faults intersect the massive dolomite by comparatively sharp fractures, while in the underlying soft shale the motion was distributed through a wider zone and many fractures were formed instead of a single one, as in the dolomite. Water containing oxygen in solution flowed downward through the open fissures in the dolomite and percolated slowly through the underlying shales. In addition to 15 or 20 per cent. of alumina which the shales contain, they always hold a considerable amount of iron, mostly as the sulphide, and also some potash, together with more or less lime, magnesia, and free silica. Various chemical reactions are possible under such conditions. The first and most important is the oxidation of iron sulphide to sulphate which takes place theoretically, as follows:



"In this way a powerful chemical agent is furnished, namely, sulphuric acid, which is capable of taking potash and alumina away from the silica with which they are combined in the shale. In the presence of an abundant supply of potash the double sulphate of potassium and aluminum or ordinary alum would be formed, the process being precisely the same as that formerly employed on a large scale for the artificial preparation of alum from aluminous shales. The supply of potash failing, the principal products of the oxidation of the shale would be iron and aluminum sulphates, both of which are easily soluble, and therefore can be carried any distance by the circulating currents so long as the chemical conditions remain the same.

THE PROCESS OF LOCAL ACCUMULATION. — "Sooner or later the water bearing these salts in solution would reach a point where the current was directed upward by reason of a lower outlet or the uneven temperature of different portions of the fissure. The solution would at once encounter new chemical conditions, causing a new set of reactions among its constituents. The ferrous sulphate would remain practically unchanged except by an oxidizing agent, which it would meet only at the surface when exposed to the oxygen of the air. It would there be slowly oxidized, the iron separating as hydrated ferric oxide or limonite. The aluminum sulphate, however, is a much less stable compound. It does not require exposure to the air to break it down, but a weak base, such as calcium carbonate, is sufficient. The reaction which would take place in such a case is theoretically as follows, omitting, for the sake of clearness, the water with which both the aluminum sulphate before the reaction and the alumina afterward are combined:—



"The carbonic acid passes off as a gas, the calcium unites with the sulphuric acid, forming calcium sulphate or gypsum, which remains in solution, while the alumina, which is entirely insoluble, forms a light, gelatinous precipitate.

"On leaving the shales in which the aluminum sulphate is formed by the oxidizing process above described, the ascending solution would pass through from 500 to 4,000 feet of limestone before reaching the surface. During this passage a large amount of lime would necessarily be taken into solution, and the conditions would then be favorable for the reaction as given above. The reaction in nature was doubtless more complicated than that indicated, and instead of simple hydrated alumina the precipitate at first formed probably contained some basic aluminum sulphate. It also contained varying proportions of iron and silica, which replaced an equivalent quantity of the water in combination with alumina. The iron and silica remain in the bauxite, while the sulphuric acid has been removed by subsequent reaction. \* \* \* \* \*

"The ascending currents reached the surface upon or near the faults, forming large springs which were probably thermal, and may in some cases have formed geysers. The precipitated, gelatinous alumina was carried upward by the water and probably at the same time compacted into the concretions of various sizes which characterize the bauxite. These concretions must have been kept in motion for a long time either in the subterranean passage or in the basin of the spring, while successive layers of material were deposited on their surface. The concretions formed in this manner accumulated about the springs and in some cases after they had solidified were broken up, the fragments worn more or less smooth by the currents, and new material was deposited in concentric layers upon the outer surfaces. Such worn and renewed fragments form the complex pisolites, pebbles, and bowlders which are found in most of the deposits. \* \* \* \* \*

"In general, the greater the proportion of silica in the precipitate the less tendency did it have to form concretions. This is not an invariable rule, but holds in most cases. Hence the siliceous bauxite or bauxitic clay remained in suspension longer than the bauxite and was carried by the overflow out of the basin or deposited about its edges. The bedding often observed in the clays adjoining the bauxite deposits doubtless originated in the quiet overflow from the springs, and its steep dip is due to subsequent settling of the adjacent residual materials."

Hayes has briefly summarized his theory as follows: —<sup>1</sup>

"The deposits are there [Georgia-Alabama region] found embedded in residual clay derived from the weathering of limestone. The limestone overlies a great mass of shales, and the formations are intersected by numerous faults, along which water has in the past found easy access to great depths. The shales are made up largely of silicate of aluminum. They also contain considerable iron sulphide in the form of pyrites. It is believed that the surface waters, carrying oxygen in solution, gained access to these shales and, by oxidizing the pyrites, set free sulphuric acid. This, under the conditions present, decomposed the aluminous shales, forming alum and sulphate of aluminum. Ascending currents carried these salts in solution to the surface, and, coming in contact with the limestone

<sup>1</sup> *The Arkansas Bauxite Deposits*, Twenty-first Ann., Rept., U. S. Geol. Surv., 1899-1900 (1901), Part III, p. 461 *et seq.*

during their upward passage, they were decomposed, forming sulphate of lime and aluminum hydroxide, together with basic sulphate of aluminum, which was subsequently changed to aluminum hydroxide on exposure to the air. The aluminum hydroxide thus produced formed a gelatinous precipitate which collected about vents of springs. It was kept in motion by the ascending water and thus formed concentric structures. The reactions indicated above are all known to take place in nature, and the process is one which is readily understood."

Briefly summarized, then, the main or essential facts, which a satisfactory theory for the origin of the Georgia deposits of bauxites must explain, are now stated in full, as follows:—<sup>1</sup>

(1) The bauxite deposits in the Georgia district are mostly confined to the Knox Dolomite; although some scattered deposits in the Dyke's district of Alabama, a continuation of the Georgia belt, are found in beds immediately overlying the Knox Dolomite. They are not found at any definite or uniform position in the Dolomite; but they are associated with all parts of the formation, having therefore a wide stratigraphic range.

(2) The ore occurs in the form of distinct pocket deposits, of varying sizes and disconnected, with the vertical nearly equal to the horizontal dimensions. This mode of occurrence could by no possible means be made to apply to the weathering of a limestone containing lenticular beds or masses of the ore.

(3) The absence of foreign material, such as might be derived from the decay of the rocks, in which the ore-bodies occur. The bauxitic clays and kaolins, which surround the ore-bodies, proper, bear no resemblance whatever to the enclosing highly siliceous residual clays derived from the weathering of the limestone; but, on the other hand, the two types of clay are strongly contrasted, without the slightest indication of commingling with, or gradation into, each other. Furthermore, the two types of clay have evidently had different origins.

(4) The location of the deposits with reference to sea-level (*altitude*), and their relation to the present topography. Some of the ore-bodies are found below the 850-foot level, and a few occur above 950 feet; but, where erosion has not removed any considerable part of the deposits, they are generally found near the 900-foot level.

<sup>1</sup> Some of these were stated in connection with Dr. Spencer's theory.

(5) The prevailing pisolitic structure of the bauxite. While the process of formation of the pisolitic structure in aluminous compounds or materials has not been observed in nature, so far as the writer is aware, the process producing the same structure in calcareous and siliceous materials has been fully observed and described. In these cases, where the process of formation of the pisolitic structure has been observed, it plainly resulted from the deposition of the material in solution or from its suspension in the form of a fine precipitate. The precipitated material collects about nuclei, of some foreign substance, or about compact portions of the same precipitate, and the whole is kept in motion, which causes the exposure of fresh surfaces, on which additional layers of the material are deposited, resulting in the concentric structure. Hayes says this applies to all material having a pisolitic structure.

(6) The grouping or occurrence of the ore-bodies along apparent lines of weakness and about certain centers. Reference to the accompanying map makes this point clear.

(7) The prevailing absence of igneous rocks from the bauxite area. The nearest area of known igneous material to the bauxite deposits is the Corbin porphyritic granite area, about five miles east of Cartersville, which is shown by Hayes<sup>1</sup> to be Pre-Cambrian in age. This granite is located some distance from the nearest point of the bauxite area, and no connection whatever can be traced between the deposits and the granite mass.

The theory which best conforms to these premises is the one already outlined by Dr. Hayes, as given above, which, as set forth by its author, is based on the three essential features required of any satisfactory theory, namely, (1) the source from which the material was derived, (2) the means by which it was transported, and (3) the process of its local accumulation. Each of the three premises is fully discussed above; and it is only necessary here to summarize the essential points under each one.

(1) THE SOURCE OF THE MATERIAL.—The Knox dolomite, with its mantle of residual clay, in which the deposits are found embedded, contains, as is shown by the analyses, a very small per-

<sup>1</sup> Hayes, C. W., Trans. Amer. Inst. Min. Engrs., Washington Meeting, February, 1900.

centage of alumina, which, by the process of accumulation required, is believed to be entirely inadequate as the source of the material.

Four analyses of the Knox dolomite, made by the writer in the Survey laboratory, showed its composition to vary within the following limits:—

SiO <sub>2</sub> . . . . .	3.75 to 7.25 per cent.
Al <sub>2</sub> O <sub>3</sub> } . . . . .	1.23 to 1.76 per cent.
Fe <sub>2</sub> O <sub>3</sub> }	
CaCO <sub>3</sub> . . . . .	34.07 to 53.44 per cent.
MgCO <sub>3</sub> . . . . .	36.32 to 55.73 per cent.

The following analyses of the Knox dolomite and its accompanying residual clay, from Morrisville, Calhoun county, Alabama, were made by Dr. W. F. Hillebrand,<sup>1</sup> and the rock was described by Professor I. C. Russell.<sup>2</sup> They are inserted here to illustrate the chemical changes accompanying the weathering of this rock. In his description of the rock, Professor Russell makes the following statement: "The original rock in this instance was a grayish-white dolomite, typical of its class over a large area in the southern part of the Great Appalachian Valley, while the clay left by its decay is a fair sample of the red soil of the South."<sup>3</sup>

Constituents	Fresh Dolomite	Residual Clay
SiO <sub>2</sub> . . . . .	3.24	55.42
Al <sub>2</sub> O <sub>3</sub> . . . . .	0.17	22.17
Fe <sub>2</sub> O <sub>3</sub> . . . . .	0.17	8.30
FeO . . . . .	0.06	trace
MgO . . . . .	20.84	1.45
CaO . . . . .	29.58	0.15
Na <sub>2</sub> O . . . . .	—	0.17
K <sub>2</sub> O . . . . .	—	2.32
H <sub>2</sub> O at 110° C. } . . . . .	0.30	2.10
H <sub>2</sub> O above 110° C. }		7.76
CO <sub>2</sub> . . . . .	45.54	—
Total . . . . .	<u>99.90</u>	<u>99.84</u>

As indicated by the above analysis, the residual product clearly

<sup>1</sup> *Analyses of Rocks*; Laboratory of the U. S. Geol. Surv., 1880 to 1899; by F. W. Clarke; Bull. No. 168, U. S. Geol. Surv., 1900, pp. 258 and 295.

<sup>2</sup> *Subaerial Decay of Rocks and Origin of the Red Color of Certain Formations*; Bull.No. 52, U. S. Geol. Surv., 1889, pp. 24-25.

<sup>3</sup> *Ibid.*, p. 24.

represents a highly siliceous, ferruginous clay, in which barely more than a trace of the original more soluble calcium and magnesium salts is retained.

This formation is, everywhere in the district, underlain by several thousand feet in thickness of calcareous clay or aluminous shales, which contain from 20 to 30 per cent. of alumina, as indicated by the analyses, in addition to the other constituents commonly found in the deposits, such as silica, titanite and iron oxides. The Connesauga shales are, for these reasons, believed to have been the source of the material.

The following analyses indicate the general composition of the Middle Cambrian shales of the bauxite region :—

	I	II
SiO <sub>2</sub> . . . . .	55.02	52.82
Al <sub>2</sub> O <sub>3</sub> . . . . .	21.02	26.17
Fe <sub>2</sub> O <sub>3</sub> . . . . .	5.00	9.46
FeO . . . . .	1.54	—
MgO . . . . .	2.32	1.08
CaO . . . . .	1.60	trace
Na <sub>2</sub> O . . . . .	0.81	0.20
K <sub>2</sub> O . . . . .	3.19	2.71
H <sub>2</sub> O at 110° C. . . . .	2.44	0.23 (hygroscopic)
H <sub>2</sub> O above 110° C. . . . .	5.65	7.00 (combined)
TiO <sub>2</sub> . . . . .	0.65	—
P <sub>2</sub> O <sub>5</sub> . . . . .	0.06	—
MnO . . . . .	trace	—
BaO . . . . .	0.04	—
SrO . . . . .	trace	—
Li <sub>2</sub> O . . . . .	0.03	—
SO <sub>3</sub> . . . . .	0.02	—
Cl . . . . .	trace	—
CO <sub>2</sub> . . . . .	0.83	—
Carbonaceous Matter . . . . .	0.32	—
Total . . . . .	<u>100.54</u>	<u>99.67</u>

I Middle Cambrian shales, Coosa valley, near Blaine, Cherokee county, Alabama; Dr. H. N. Stokes, Analyst; Bulletin No. 168, U. S. Geol. Survey, 1900, p. 283.

II Oostanaula shales, about two miles northwest of Cartersville, Bartow county, Ga.; J. M. McCandless, Analyst; Spencer, J. W., Paleozoic Group, Geological Survey of Georgia, 1893, p. 285.



GENERAL VIEW OF THE BAUXITE DRYING PLANT OF THE REPUBLIC MINING AND MANUFACTURING COMPANY,  
HERMITAGE, FLOYD COUNTY, GEORGIA.

(2) THE MEANS OF TRANSPORTATION. — The formations of this region, both limestone and shale, are intersected by numerous faults, which are described elsewhere in this report. These lines of fracture doubtless afforded easy access in the past for the percolation of water to great depths. In addition to the silicate of aluminum, which composes the greater part of the shales, the Connesauga shales contain considerable iron disulphide in the form of disseminated pyrite. The descending waters, carrying oxygen in solution and percolating through the shales, oxidized the pyrite, setting free sulphuric acid, which, under the conditions present, decomposed the shales, forming the sulphates of aluminum and iron. The ascending waters returned these salts to the surface in solution, where, coming in contact with the limestone during their upward passage, the salts were decomposed, forming sulphate of lime and aluminum hydroxide, along with the basic sulphate of aluminum, which, on exposure to the air, was converted into aluminum hydroxide.

(3) THE PROCESS OF LOCAL ACCUMULATION. — The ascending currents are believed to have reached the surface near or upon the fault lines, forming large springs, and the aluminum hydroxide, produced as described above, formed a gelatinous precipitate, which collected about the vents of the springs.

In the accumulation of the bauxite, Hayes describes the process of formation of its pisolitic structure as follows: —<sup>1</sup>

“From analogy with pisolitic sinter and travertine now forming, such conditions would appear to be highly favorable for the production of the structure actually found in the bauxite. The precipitate was apparently collected in globular masses by the motion of the ascending water, and constant changes in position permitted these to be coated with successive layers of more compact material. Finally, after having received many such coatings, the pisolites were deposited on the borders of the basin, and the interstices were filled by minute oölites formed in a similar manner or by the flocculent precipitate itself. Slight differences in the conditions prevailing in the several springs, such as concentration and relative proportion of the various salts in solution, also temperature and flow of the water, would produce the variation in the character of the ore observed at different points.”

The theory, above outlined, was originated and applied by Dr. Hayes to the group of deposits in question, to whom is accorded

<sup>1</sup> Transactions, Amer. Inst. Min. Engrs., *Op. cit.*



the entire credit. The theory is reviewed and discussed here at some length, for the reason, that, after a careful study of the same region by the writer, Dr. Hayes's theory more completely covers the essential features required of a satisfactory theory, than any yet advanced, and explains the conditions in the field as the writer saw them. The theory is also extended by Dr. Hayes, to cover the similar deposits in Alabama, which represent the southwest extension of the Georgia belt into that State.

## II. AGE OF THE BAUXITE DEPOSITS

It was stated in the early part of this report, that the majority of the bauxite deposits occur between the elevations of 900 and 950 feet above tide-level. Those occurring at lower levels indicate, in those cases where worked, shallow deposits, which represent only remnants, perhaps, of originally more extensive ore-bodies. It has been further shown, that the region has passed through several periods of base-leveling (*planation*), in which the remnants of at least two more-or-less distinct peneplains are preserved. The evidences of the first and older plain are preserved in the harder sandstones and quartzites of the region; and it is referred to Cretaceous age by Hayes.<sup>1</sup> The second plain is better preserved, and, therefore, more pronounced, as shown by the surface of the Knox dolomite plateau to the north, and its corresponding ridge crests to the south, of the Etowah river. The formation of this plain was probably during Eocene time. Numerous measurements show the surface of the Eocene plain to be about 950 feet above tide-level. The elevation, then, of the Eocene base-leveled plain and that of a majority of the bauxite deposits is approximately the same. The nature of the ore-bodies indicate, that they are surface, pocket deposits, with no very extensive depth. In this event, they must have been formed near the close of the period of the Eocene base-leveling. Also, if their genesis is that, which is elsewhere described and discussed in this report, then it follows, that deposition occurred prior to the uplift and elevation of the Eocene plain; otherwise, they would have different positions from that shown at present, from the nature of their formation. From the above considera-

<sup>1</sup> Sixteenth Ann. Rept., U. S. Geol. Surv., 1895, Part III, p. 592.

tions, the period during which the formation of the present deposits occurred, was near the close of the Eocene.

### III. METHOD OF ESTIMATING THE ORE-BODIES

The method, suggested by Hayes for estimating the ore-bodies, if diligently followed out by intelligent workers, will doubtless prove of vast economic importance in the working of some of the Georgia-Alabama bauxite deposits.<sup>1</sup> The method is based entirely on the character and mode of occurrence of the ore-bodies. It considers, first, that, in the few cases where the ore-body has been entirely or nearly exhausted by working, the resulting depression is fairly regular and cup-shaped in outline. Naturally, there are, of course, many exceptions to this form of opening. Second, the occurrence of the deposits in somewhat regular groups, with indications, that all deposits belonging to the same group have approximately the same depth. It necessarily follows from this, that those deposits occupying the highest positions contain the largest amounts of ore, because they have suffered the least erosion; and, conversely, that the lowest deposits contain only the remnants of perhaps originally more extensive bodies. Third, the kind of ore is considered as furnishing a possible clew to the amount present; but this varies so greatly, that it cannot be relied on.

In conclusion, it must be said, that pocket forms of ore-bodies are at best irregular and uncertain as to quantity. Surface indications cannot be relied upon in all cases, and prospecting, of a systematic kind, often fails to indicate the amount as well as the quality of the ore present. Not until the ore-bodies have been entirely worked out, can any exact estimate be formed of the amount of ore originally contained. However, it is believed, that, in the case of the Georgia bauxite deposits, the above method, when diligently and intelligently applied, will prove to be of considerable economic value in many cases.

### IV. THE USES OF BAUXITE

At present the bauxite mined in Georgia and Alabama is used almost exclusively in the manufacture of alum and the aluminum

<sup>1</sup> Sixteenth Ann. Rept., U. S. Geol. Surv., 1895, Part III, pp. 593-594.

alloys and compounds, and the metal aluminum. More than three-fourths of the ore is consumed, at present, in the manufacture of alum; while the remainder is employed in the manufacture of the metal aluminum, its alloys and compounds. These proportions are subject, however, to more or less variation from year to year, dependent upon numerous conditions.

Bauxite is also employed, to some extent, in the manufacture of certain aluminum salts used in the manufacture of baking-powders and dyes. A by-product, alumino-ferric cake, which is obtained in the purifying process, is said to be of value for sanitary and deodorizing purposes.

The price of the crude ore varies considerably, from time to time, according to several conditions, the most important ones of which are purity and supply. When the Georgia bauxite was first mined, the first-grade ore commanded a price of \$9.00 per ton in the markets. There is little or no demand, at present, however, for other than a high-grade ore. For the past few years, the price has varied but little from \$5.00 per ton for first-grade Georgia-Alabama bauxite.

The quotations on first and second grades of Georgia-Alabama bauxite showed some advance at the beginning of 1901. The quotations for January, 1901, on the Georgia-Alabama product were as follows:—

First grade Georgia-Alabama bauxite \$6.00 per ton.

Second grade Georgia-Alabama bauxite \$5.50 per ton.

Some of the Georgia producers were, in September, 1901, marketing their first-grade ore at \$7.00 per ton.

## CHAPTER VI

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# THE TECHNOLOGY OF BAUXITE IN THE MANUFACTURE OF ALUMINUM AND ALUM

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### I. ALUMINUM MANUFACTURE

Various aluminous compounds have been employed in the extraction and manufacture of the metal, aluminum. Of these compounds, the following are considered the most important:—

	Composition	Per Cent. Al <sub>2</sub> O <sub>3</sub>	Per Cent. Al
Bauxite . . . . .	Al <sub>2</sub> O <sub>3</sub> . 2H <sub>2</sub> O	73.9	39.1
Cryolite . . . . .	3NaF. AlF <sub>3</sub>	24.1	12.8
Corundum . . . . .	Al <sub>2</sub> O <sub>3</sub>	100.0	52.9
Kaolin . . . . .	2H <sub>2</sub> O. Al <sub>2</sub> O <sub>3</sub> . 2SiO <sub>2</sub>	39.5	20.9

For the past few years, bauxite and cryolite have become the principal minerals used in the production of aluminum, largely due, it is claimed, to their purity. As yet, native alums have not been found, to any considerable extent, in commercially workable quantities; but, if found, they would doubtless prove a valuable source of the metal. Corundum is very hard to crush; and, when broken in fine pieces, it becomes more valuable in the market as an abrasive, than as an ore of aluminum. The extensive and rapid development of bauxite mining in certain districts has resulted in excluding corundum as a source of aluminum; and it is claimed, that not one pound of the metal is produced at present from this mineral. The extensive, nearly inexhaustible beds of kaolin, of great purity, mark it as one of the most important natural ores of aluminum; but, as yet, no process sufficiently cheap for separating the aluminum from the silica has been discovered. The discovery of a sufficiently cheap process is all that is necessary, however, to

make kaolin the main source of the metal in the aluminum industry. The ordinary clays are much too impure to become a source of aluminum; and they could in no wise compete with the extensive beds of nearly pure kaolin, of which there are vast deposits in Georgia.

Prior to 1891, when the recently discovered deposits of bauxite in Georgia and Alabama had begun to be worked, the source of the ore for the extraction of the metal, aluminum, was confined almost exclusively to the Greenland cryolite, a double fluoride of sodium and aluminum,  $\text{Na}_3\text{AlF}_6$ , containing 12.8 per cent. of aluminum. Cryolite was first used for its soda by soap-makers; and it is still used in making soda and alumina salts, and, to some extent, a white glass, an imitation of porcelain; and it is in general use, at present, as a flux. The entire supply is from the west coast of South Greenland. It is claimed, that natural cryolite is found to be too impure for use in many operations, which aim to produce pure aluminum; and several methods for the preparation of the artificial salt have been suggested. The importers sell what they term a pure prepared cryolite at \$60 per ton. The crude cryolite is quoted in the *Engineering and Mining Journal*, for January, 1901, at  $6\frac{1}{2}$  cents per pound or \$130.00 per ton.

The metallurgical processes formerly in vogue for the extraction of metallic aluminum from cryolite, involving the use of the very costly material, metallic sodium, taken in connection with the remote locality of the cryolite (Greenland) entailed a proportionately high cost on the cryolite, and necessarily caused a correspondingly high price to be placed on the finished product or metal. The price of the metal was controlled, therefore, by the processes employed in its extraction and by the cost of the material used. Conversely, the change in the metallurgical process and the substitution of a much cheaper material for the extraction have correspondingly lowered the cost of the product.

Upon the discovery of bauxite in commercially workable quantities near at hand, closely followed changes in the metallurgy, which resulted in a considerable decrease in the cost of extraction, and therefore in the cost of the metal. Assuming all other conditions to be equal, the price of first grade bauxite, which is \$5.00

as against \$130.00 per ton for cryolite; and the percentage of aluminum, which is 39.1 per cent. in bauxite against 12.8 per cent. in cryolite, are factors which would very greatly favor bauxite as the source of the metal. As is well known, the conditions of mining and handling the two minerals, and, indeed, most, if not all others, are vastly in favor of the bauxite.

Aluminum was first isolated, and some of its physical properties determined, by Wöhler in 1827. Wöhler succeeded in isolating the metal by reducing the chloride of aluminum by means of metallic potassium. The chemical process, afterwards employed for the extraction of the metal, as developed by H. St. Claire Deville and others, consisted in substituting the double chloride of aluminum and sodium for aluminum chloride, and using metallic sodium instead of metallic potassium as the reducing agent.

Metallic aluminum is now extracted in commercial quantities from its ores by means of electro-metallurgical processes. Broadly speaking the metallurgical processes may be said to include two general steps:—<sup>1</sup>

- (1) The preparation of aluminum compounds for reduction.
- (2) The reduction of the aluminum compounds.

Under the first heading, the following compounds are included: Alumina; the chlorides of aluminum, including the double chloride of aluminum and sodium; the fluorides of aluminum, including the double fluoride of aluminum and sodium; and the sulphide of aluminum. Of these, alumina is vastly the most important; and it is prepared in commercial quantities from —

- (a) *Aluminum sulphates or alums;*
- (b) *Bauxite;*
- (c) *Cryolite.*

The attention of the earlier workers was mainly directed to the reduction of the chlorides of aluminum and of sodium and aluminum, and of cryolite, by means of metallic sodium or potassium, based on various methods. The principal one of these was that of Deville, first discovered in 1854. It was improved and changed,

<sup>1</sup> Richards, Joseph W., *Aluminum, Its Properties, Metallurgy and Alloys*, 1896, 3rd Edition, pp. 133-441.

from time to time, until as late as 1886, when it was modified by Castner; and it is known, at present, as the Deville-Castner process. The lowest cost for producing aluminum by this process, however, is placed between four and five shillings; and this necessitated its being abandoned in 1891.

The reduction of cryolite by means of metallic sodium or potassium was never entirely successful; although the Grabau process, it is claimed, was successful in reducing unusually pure aluminum, averaging more than 99.5 per cent. on actual analysis; but the process was too expensive to compete with the best commercial grade of the metal produced by electrolytic methods.

The investigation of electrolytic processes was, for some time after the beginning, directed along two general lines:—

- (1) *Deposition from aqueous solutions*, and
- (2) *Non-aqueous, electric processes*.

While numerous methods have been advocated by various investigators, for the production of aluminum from aqueous solutions, no commercial results have yet come from this general principle. Of the various methods proposed for the production of aluminum from non-aqueous electric processes, the following are the most important:—

*The Cowles Brothers' process*, patented August 18th, 1885;

*The Hall process*, worked on a small scale February, 1886, and patented April 2nd, 1889;

*The Héroult process*, patented in France, April 23rd, 1886.

THE COWLES BROTHERS' PROCESS.—The Cowles Brothers' process, which employs electricity, is said to be rather better adapted for the production of certain valuable alloys than of pure aluminum. This process is briefly described as follows:—<sup>1</sup>

“The inventors use a furnace, the iron cover of which contains openings, for the escape of the carbon monoxide evolved. At the bottom is a stratum of powdered coal, saturated with milk of lime, about a hand's-breadth in depth. Over this is spread the mixture to be reduced, consisting of broken corundum, mixed with fragments of charcoal and the requisite quantity of copper (i. e., for

<sup>1</sup> Rudolph von Wagner, *Manual of Chemical Technology*, 1892, p. 222.

the formation of bronze) in small grains. By means of a rectangular frame of sheet-metal, it is arranged that the coarser materials lie only in the middle. The electrodes, which enter the hearth, serve for the production of a powerful electric arc. They are blocks of carbon, 7.5 centimeters, in square sections of 75 centimeters in length. \* \* \* \* \* After the charge of ore, more charcoal is spread, in the first place, between the wall of the hearth and the sheet-metal frame, and, after its removal as a layer, to cover the whole. The furnace is then closed with its cover, and the current is passed through.”<sup>1</sup>

HALL'S PROCESS. — The Hall process for obtaining aluminum by electro-metallurgy was instituted by the Pittsburg Reduction Company, at Pittsburg, Penn., in 1888. The manufacture of aluminum in the United States, for some years, has been nearly, if not entirely, by the Hall process. Packard briefly describes this process as follows:—<sup>2</sup>

“The process [Hall] consists in providing a bath of fused fluorides to which alumina is added, and then reducing this alumina by the current from a dynamo. The bath is contained in carbon-lined iron pots or crucibles, which form the cathodes, while the anodes are large carbon cylinders which are made to dip into the baths. The specific gravity of aluminum being greater than that of the bath employed, the metal sinks to the bottom of the pots, and can be tapped off. To make alloys the required metal (e. g., copper) may be introduced into the pot containing the bath and alumina, and, becoming melted, forms a cathode with which the aluminum, as it is reduced from the alumina unites to form the alloy.”<sup>3</sup>

<sup>1</sup> For a more detailed description of the Cowies Brothers' process, the reader is referred to the following papers:—

Richards, Jos. W., *Op. Cit.*, pp. 329-347.

Mabery, Chas. F., *Proceedings, Amer. Asso. Adv. Science*, Ann Arbor Meeting, August 28, 1885.

Hunt, T. Sterry, *Trans., Amer. Inst. Min. Eng.*, Halifax Meeting, Sept. 16, 1885.

Thompson, W. P., *Journal of the Society of Chemical Industry*, April 29, 1886. Read before the Liverpool section of the Society.

<sup>2</sup> The Production of Aluminum in 1894, 16th Ann. Rept., U. S. Geol. Surv., 1894, Part III, p. 540.

<sup>3</sup> For a more detailed description of the Hall process, the reader is referred to Richards, Jos. W., *Aluminum, Its Properties, Metallurgy and Alloys*, 1896, 3rd Edition, pp. 372-386.



THE HÉROULT PROCESS. — The Héroult process, invented by P. L. V. Héroult, of Paris, France, and patented in 1886, differs but slightly from that of the Hall process. Concerning this, Mr. Richards says: <sup>1</sup> “The idea or principle involved in the above [Héroult process] is exactly similar to Hall’s process, and when Héroult applied for United States patents in 1886 the two claims interfered, and the evidence given in the Patent Office, showed Hall to be the prior inventor, so that the process in this country belongs entirely to Hall. It is evident that the process was discovered by these two inventors, on opposite sides of the ocean, at very nearly the same time, and entirely independent of each other.”

Various methods for the production of aluminum compounds, other than by means of metallic sodium or potassium and electricity, have been reported; but no use commercially has yet resulted.

PRODUCTION. — The production of aluminum in 1898 amounted to 5,200,000 pounds, an increase of 30 per cent. over the amount produced in 1897. <sup>2</sup> A marked increase has been noted each year, in the production, over the previous year; and the industry has grown from 83 pounds in 1883 to more than 5,000,000 pounds in 1898. In 1898, the product was valued at \$1,716,000 with a decline in the price of the metal, in the first stage of its manufacture, from 37½ to 33 cents per pound. The price for sheets, wire, and other manufactures retained their usual cost. The production of aluminum and its variety of uses continue to increase.

On account of completeness and the continued interest in the metal aluminum, the following quotations are taken from a paper published by Mr. R. L. Packard in the Mineral Resources of the United States, for the year, 1891, entitled *Aluminum, Its Sources and Uses*: —

#### USES

“Besides the metallurgical use of aluminum in casting iron and steel, to be referred to below, the metal is used for an infinity of small articles as has always been the case, and for which its lightness, strength, and freedom from tarnish eminently adapt it. Indeed, with a total production of between 500 and 600 tons, of which, perhaps, 300 only are available for manufactured articles, no extensive use

<sup>1</sup> Richards, Jos. W., *Aluminum, Its Properties, Metallurgy and Alloys*, 1896, 3rd Edition, p. 387.

<sup>2</sup> Twentieth Ann. Report, U. S. Geol. Surv., 1899, Part VI, p. 267.

on the large scale could be expected. The newspapers have frequently spoken of the Swiss steam launch of aluminum. A life-boat of aluminum was under construction at Stralsund, Prussia, in December, 1891. It was expected that the lightness of the metal would be of great advantage in dragging the boat over the sands and in hoisting and lowering it. The list of proposed uses continue to increase. Disregarding them, the actual use is sufficiently varied. Small articles, viz., drinking cups, rulers, and paper-cutters, perfumery stands, smokers' sets, ash-receivers, toothpick and match holders, watch cases, lemonade shakers, card-receivers, butter dishes, rings, spoons, picture frames, bracelets, napkin rings, sleeve and collar buttons, scarf and shawl pins, penracks, dog collars, key chains, hairpins, pencil cases, and pannikins are advertised.

"In Germany aluminum tubing is used for penholders, umbrella handles, walking sticks, billiard cues, chair legs, photograph frames, and newspaper holders.

"Powdered aluminum mixed with chlorate of potassium has been used for flashlights instead of magnesium. It is said to make an excellent light and to give no smoke like magnesium.

"Mr. Alfred E. Hunt, president of the Pittsburg Reduction Company, in a lecture delivered in March, 1891, gives some information in regard to the use of aluminum in railroad work. He says that the metal has been used, on account of its lightness, for slide valves (experimentally); for valves to control the passage of the air from the storage to the brake cylinders in the new and larger forms of the Westinghouse air brake, the inertia of the heavy iron or brass valves being a serious consideration; for the fan blades and frames of windmills; in semaphore signal disks and their moving frame work.

"The use of aluminum for canteens and military equipments in the German army has suggested a similar use in this country, and aluminum curb bits, saber-belt plates, canteens, meat cans, cartridge-belt plates, and spoons and forks have been submitted to the War Department in Washington for consideration. The object is to save weight and avoid rust.

"The substitution of aluminum for glass flasks for the army and its use in general for vessels which are designed for holding foods and drinking fluids have given rise to experiments in Germany to test the action of various fluids upon the metal. The results are on the whole favorable to its employment for such purposes. It must be remembered that the aluminum of commerce contains small quantities of other metals and metalloids, sometimes amounting to 2 per cent., so that it is virtually an alloy. The resistance of aluminum to acids has long been a popular belief, and, before giving the results of the experiments as to the action of drinking fluids upon aluminum, the following account of some experiments with nitric and sulphuric acids is given to show that the former belief in the resistance of the metal to all acid except hydrochloric must be modified. Undoubtedly the physical condition of the metal operated on, as well as its chemical composition, makes a great difference in its power to resist the action of acids, a finely divided metal being much more easily attacked than the same metal in large pieces. G. A. LeRoy (*Chemisches Centralblatt*, 1892, Bd. I., No. 2, p. 51) found that nitric and sulphuric acids of different strengths acted upon aluminum as shown below under the conditions specified. He used aluminum foil having the composition 98.29 per cent. to 99.6 per cent. aluminum, 1.60 per cent. to 0.30 per cent. iron, and 0.10 per cent. to 0.25 per cent. silicon. The foil was polished, freed from fat with caustic

soda, washed with alcohol, dried in the bath, cut up, weighed, and introduced into the acids. In this fine condition the action of the acids was as shown in the following table, the weight being the amount of metal dissolved expressed in grams per square meter. The action lasted twelve hours.

ACTION OF VARIOUS ACIDS ON ALUMINUM FOIL.

ACIDS	Specific Gravity	Temperature (centigrade)	Samples			
			A	B	C	D
Pure H <sub>2</sub> SO <sub>4</sub> . . . . .	1.842	15°-20°	<i>Grams</i> 18.40	<i>Grams</i> 18.90	<i>Grams</i> 16.40	<i>Grams</i> 14.50
Common H <sub>2</sub> SO <sub>4</sub> . . . . .	1.842	15°-20°	21.00	21.30	17.50	16.40
Pure H <sub>2</sub> SO <sub>4</sub> . . . . .	1.711	15°-20°	24.50	25.00	22.00	20.00
Common H <sub>2</sub> SO <sub>4</sub> . . . . .	1.711	15°-20°	25.80	25.70	24.60	22.40
Pure H <sub>2</sub> SO <sub>4</sub> . . . . .	1.580	15°-20°	19.00	18.00	17.90	16.30
Pure H <sub>2</sub> SO <sub>4</sub> . . . . .	1.263	15°-20°	4.60	. . . . .	2.60	3.40
Pure HNO <sub>3</sub> . . . . .	1.383	15°-20°	17.00	16.00	15.50	14.50
Common HNO <sub>3</sub> . . . . .	1.383	15°-20°	20.50	19.60	18.00	16.60
Common HNO <sub>3</sub> . . . . .	1.332	15°-20°	16.30	16.30	14.00	13.40
Pure H <sub>2</sub> SO <sub>4</sub> . . . . .	1.842	150°	240.	225.	150.	200.
Common H <sub>2</sub> SO <sub>4</sub> . . . . .	1.842	150°	267.	250.	210.	220.
Pure HNO <sub>3</sub> . . . . .	1.382	100°	. . . . .	. . . . .	Violent action.	Violent action.
Common HNO <sub>3</sub> . . . . .	1.382	100°	. . . . .	. . . . .		

"According to these results almost pure aluminum, 99.5 per cent., is attacked even in the cold by nitric and sulphuric acids, so that the metal should not be used in apparatus for preparing these acids.

"As to the action of drinking fluids, coffee, tea, beer, wines, brandy, etc., the following appears to be the state of the case: Messrs. Lübbert and Roscher, (*Chem. Centralbl.*, 1891, Bd. II., No. 18, p. 780) tested the resistance of aluminum to the action of alcohol, ether, aldehyde, coffee, tea, wines and antiseptics, by allowing aluminum leaf to remain in concentrated solutions of the different liquids four days at the temperature of the room, and the fluids were examined either directly for alumina or were evaporated and the ignited residue so examined. The conclusion reached was that aluminum possesses only a slight degree of resistance to the agents named, except alcohol, ether and aldehyde, and that it is therefore unsuitable for wares which are to be used for acid drinks, coffee, tea, etc., or articles which are to be cleaned with soda or soap. Its application in daily life would therefore be very limited.

"On the other hand, G. Rupp, (*Dingler*, 283, I, January 21, 1892,) criticizes the methods employed by Lübbert and Roscher for determining the action of the fluids by estimating the alumina contained in them, as well as the use of aluminum leaf for their experiments, which is attacked much more easily than the compact metal, the former being acted on even by boiling water, while the latter is unaffected. His own experiments were made upon aluminum vessels (canteens, drinking cups, etc.) and foil, the object being to determine the availability of the metal for use in the army. The carefully dried and weighed vessels were filled with the different fluids or the foil was immersed in them, and the action was allowed to continue

four, eight and twenty-eight days, at the temperature of the room with frequent stirring. The fluids included wines of different kinds, beer, kirschwasser, cognac, coffee, tea, milk, drinking water, 1 per cent. solution of tartaric acid, acetic acid (1 per cent., 4 per cent., 10 per cent. solutions), vinegar (10 per cent.), soda solution (1 per cent.), besides butter, honey and preserved fruits. The articles were then cleaned, dried and weighed, to determine the loss of weight. The results, which fill a large table, showed that in most cases there was absolutely no action and in the few cases where there was a perceptible loss of weight it was so trifling as to be disregarded. To the objection that continued drinking of fluids containing a small quantity of alumina would eventually be dangerous, the author points out that the ash of all the fluids usually drunk contains alumina, as well as most foods and drinking water itself. His conclusion is that there is no objection to the use of aluminum for canteens and similar vessels.

“These conclusions of Rupp were confirmed by Dr. A. Arche (*Dingler*, Vol. 284, No. 11, p. 255), whose experiments show that the purity of aluminum (using the percentage of silicon as a means of classification) has much to do with its power of resisting the solvent action of fluids, and they also show that the mechanical preparation of the metal is an important factor. He found that hammered aluminum was least attacked, rolled metal came next, and then the drawn metal, while cast metal was much more easily attacked (by acetic acid).

#### METALLURGICAL USE

“The quantity of aluminum used in this country in the manufacture of iron and steel castings is probably from 25 to 30 per cent. of the total production. In Europe it is estimated by Professor Wedding to be 54 per cent. This use, as was explained in the last number of this series, consists in adding from 0.10 to 0.15 per cent. of aluminum to iron or steel just before casting, by which blow-holes are prevented and sounder castings are produced. This use is becoming general. The beneficial effect, as was shown by experiments referred to last year, is due in part at least to the deoxidizing action of aluminum upon carbon monoxide at a high temperature, a reaction which was demonstrated directly between the metal and the gas. This subject has not yet received an exhaustive examination. For this purpose it would be necessary to know the composition of the iron or steel operated on in each case and make comparative tests on the different specimens. It is also probable that the method of melting employed has an effect on the result.

“A detail of manipulation in the method of applying aluminum, especially in castings for steam and pump cylinders and other castings intended to resist high pressures, is reported in *Dingler's Journal* (Vol. 284, No. 11, p. 255). The addition is made by first forming a mixture of aluminum and iron, which is effected by placing the proper quantity of heated aluminum in the bottom of a small ladle, running some iron into the ladle from the furnace, and waiting until the mixture begins to stiffen. Then the iron to be operated on is run into a large ladle and the iron-aluminum mixture is poured into it, whereby an intimate mixture of the whole is effected. For 100 kilograms of iron to be operated on, 200 grams of aluminum are used (=0.20 per cent.). The iron is not poured at once from the large ladle, but is allowed to stand until it is orange yellow and a thin film begins to form on the surface. As soon as this occurs the film is removed and the iron is poured. The mold should be kept full. No reason is assigned for this procedure,

but it appears that iron containing aluminum is inclined to shrink excessively and that this tendency must be obviated by pouring as cold as possible.

“According to a paper read by Mr. J. W. Langley, at the Glen Summit meeting of the American Institute of Mining Engineers, the practice in the United States in pouring ingots is as follows: The aluminum, in small pieces of  $\frac{1}{4}$  or  $\frac{1}{2}$  pound weight, is thrown into the ladle during the tapping, shortly after a small quantity of steel has already entered it. The aluminum melts almost instantaneously and diffuses with great rapidity throughout the contents of the ladle. The diffusion seems to be complete, for the writer has never seen the slightest action indicating want of homogeneity of mixture, all of the ingots poured from one ladle being precisely alike so far as the specific action of the aluminum is concerned. The quantity of aluminum to be employed will vary slightly according to the kind of steel and the results to be obtained. For opened-hearth steel, containing less than 0.50 per cent. carbon, the amount will range from 5 to 10 ounces per ton of steel. For Bessemer steel the quantities should be slightly increased, viz., 7 to 16 ounces. For steel containing over 0.50 per cent. carbon, aluminum should be used cautiously; in general between 4 and 8 ounces to the ton. If these statements are put in the form of percentages, it will at once be seen how extremely minute is the quantity of aluminum which causes such marvelous results, for the numbers are:

4 ounces = 0.0125 per cent. . . . .	= 1-8000
5 ounces = 0.0156 per cent. . . . .	= 1-6500
8 ounces = 0.0250 per cent. . . . .	= 1-4000
16 ounces = 0.0500 per cent. . . . .	= 1-2000

#### SOLDERING

“From the articles which occasionally appear in the trade journals, both in this country and Europe, and the patent list, it appears that the difficulties of soldering aluminum have not been overcome. Some of the new solders are introduced here without comment.

“Chloride of silver has been recommended as a solder. It is to be finely powdered and spread along the junction to be soldered and melted with the blow pipe. Mr. Joseph W. Richards makes an alloy of aluminum 1 part, zinc 8 parts, tin 32 parts, and phosphor-tin, containing 5 per cent. phosphorus, 1 part. The aluminum is first melted, then the zinc is added, and finally the tin, which has been melted separately and mixed with the phosphor-tin. The alloy is poured into small bars for use. The object is to provide in the phosphorus a powerful reducing agent to prevent the formation of the film of oxide which usually prevents the intimate contact of the opposed surfaces. (United States patent 407789, October 5, 1891.) Another formula is, cadmium 50 parts, zinc 20, tin 30. The zinc is first melted, then the cadmium is added, and finally the tin. (*Dingler's Journal*, Vol. 284, No. 6, page 144.) Electroplating the surfaces with copper and then applying the solder was mentioned last year.

“Other solders which have been used are composed of —

COMPOSITION OF CERTAIN SOLDERS FOR ALUMINUM

	I	II	III	IV	V
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Aluminum . . . . .	12	9	7	6	4
Copper . . . . .	8	6	5	4	2
Zinc . . . . .	80	85	88	90	94

"In making these solders the copper should be melted first, the aluminum then added, and the zinc last. Stearin is used as a flux to prevent the rapid oxidation of the zinc. When the last metal is fused, which takes place very quickly, the operation should be finished as rapidly as possible by stirring the mass, and the alloy should then be poured into an ingot mold of iron, previously rubbed with fat. The pieces to be soldered should first be cleaned thoroughly and roughened with a file and the solder placed on the parts in small fragments, the pieces being supported on a piece of charcoal. The place of juncture should be heated with the blast lamp. The union is facilitated by the use of a soldering tool of aluminum. This last is said to be essential to the success of the operation. Alloy I. is recommended for small objects of jewelry; alloy IV. is said to be the best adapted for larger objects and for general work, and is that most generally used. The successful performance of the act of soldering appears to require skill and experience, but the results obtained are said to leave nothing to be desired. Soldering tools of copper or brass should be avoided, as they would form colored alloys with the aluminum and solder. The skillful use of the aluminum tool, however, requires some practice. At the instant of fusion the operator must apply some friction, and, as the solder melts very suddenly, the right moment for this manipulation may be lost unless the workman is experienced.

## ALLOYS

"It is regretted that no statistics of the production of aluminum bronze and ferro-aluminum in this country can be given for 1891. Both of these valuable alloys have been produced by the Cowles Electric Smelting and Aluminum Company for a number of years, and have found their way into the market on a considerable scale. The ferro-aluminum made by this company was used as a vehicle for adding aluminum to iron and steel in making sound castings when that method was first introduced. Aluminum bronze is coming into use in Germany for torpedoes on account of its strength and non-corrodibility, and for telephone wires. It was estimated that 280,000 kilograms would be used during 1892. The 5 per cent. bronze has been used for some time for nozzles of gas motors on account of its non-oxidizable character, and the 12 per cent. bronze is used for the pins of needle guns, for which purpose it is said to be better than steel.

"The number of patents which have been granted for aluminum alloys, either where that metal forms a minor ingredient or has small quantities of other metals added to it for special purposes, shows that experimenting in this direction is increasing. As yet much of this experimenting is done without definite knowledge or aim on the part of inventors. Doubtless, in time, valuable conclusions may be derived from this kind of work, after rigid experiments with a definite purpose or

idea have been undertaken. Of alloys formed with a specific purpose in view, that containing a small quantity of titanium, and another containing silver, were described last year. Others are mentioned in a lecture by Mr. Hunt, president of the Pittsburg Reduction Company, whose statements are valuable because they are based on knowledge and experience. He says:

“The alloys of from 2½ to 12 per cent. aluminum with copper, have so far achieved the greatest reputation. With the use of 8 per cent. to 12 per cent. aluminum in copper we obtain one of the most dense, finest grained, and strongest metals known, having remarkable ductility as compared with its tensile strength. A 10 per cent. aluminum bronze can be made in forged bars with 100,000 pounds tensile strength, 60,000 pounds elastic limit, and with at least 10 per cent. elongation in 8 inches. An aluminum bronze can be made to fill a specification of 130,000 pounds tensile strength and 5 per cent. elongation in 8 inches. Such bronzes have a specific gravity of about 7.50, and are of a light yellow color. For cylinders to withstand high pressures such bronze is probably the best metal yet known.

“The 5 to 7 per cent. aluminum bronzes have a specific gravity of 8.30 to 8, and are of a handsome yellow color, with a tensile strength of from 70,000 to 80,000 pounds per square inch, an elastic limit of 40,000 pounds per square inch. It will probably be bronzes of this latter character that will be most used, and the fact that such bronzes can be rolled and hammered at a red heat with proper precautions will add greatly to their use. Metal of this character can be worked in almost every way that steel can, and has for its advantages its great strength and ductility, and greater power to withstand corrosion, besides its fine color. With the price of aluminum reduced only a very little from the present rates, there is a strong probability of aluminum bronze replacing brass very largely.

“A small percentage of aluminum added to Babbitt metal gives very superior results over the ordinary Babbitt metal. It has been found that the influence of the aluminum upon the ordinary tin-antimony-copper Babbitt is to very considerably increase the durability and wearing properties of the alloy. Under compressive strain aluminum Babbitt proves a little softer than the ordinary Babbitt. A sample 1½ inches in diameter by 1½ high began to lose shape at a pressure of 12,000 pounds. A similar sample of the same Babbitt metal without the addition of the aluminum (having a composition of 7.3 per cent. antimony, 3.7 per cent. copper, and 89 per cent. tin) did not begin to lose its shape until a compressive strain of 16,000 pounds had been applied. Both samples have stood an equal strain of 35,000 pounds. In comparative tests of the ordinary Babbitt metal and the aluminum Babbitt metal, the latter has given very satisfactory results.

“The following alloys have recently been found useful: Nickel-aluminum, composed of 20 parts nickel, and 8 parts aluminum, used for decorative purposes; rosine, composed of 40 parts nickel, 10 parts silver, 30 parts aluminum, and 20 parts tin, for jewelers' work; sun bronze, composed of 60 parts cobalt (or 40 parts cobalt), 10 parts aluminum, 40 (or 30) parts copper; metalline, composed of 35 parts cobalt, 25 parts aluminum, 10 parts iron, and 30 parts copper.

“Prof. Robert Austin has discovered a beautiful alloy containing 22 per cent. aluminum and 78 per cent. gold, having a rich purple color, with ruby tints.

“The addition of from 5 per cent. to 15 per cent. aluminum to type metal composed of 25 per cent. antimony and 75 per cent. lead makes a metal giving sharper castings and much more durable type.’

"Mr. A. H. Cowles makes an alloy for electrical purposes consisting of manganese 18 parts, aluminum 1.2 parts, silicon 5 parts, zinc 13 parts, and copper 67.5 parts. This alloy has a tensile strength of 26,000 kilograms and 20 per cent. elongation. Its electric resistance is greater than that of 'neusilber,' and it is therefore especially applicable for rheostats. (*Chemiker-Zeitung*, March 12, 1892.)

"Mr. C. C. Carroll makes an aluminum alloy for dentists' fillings, consisting of silver 42.3 per cent., tin 52 per cent., copper 4.7, and aluminum 1 per cent. It is reduced to powder and then forms an amalgam with mercury. (U. S. patent 475382, May 24, 1892.)

"Mr. Chas. B. Miller has patented an antifriction alloy of lead 320 parts, antimony 64, tin 24, aluminum 2. (U. S. patent 456898, July 28, 1891.)

"Mr. Thomas MacKellar has patented an alloy for type metal of lead 65 parts, antimony 20, and 10 parts of an alloy consisting of equal parts of tin, copper and aluminum. The tin-copper-aluminum alloy is first melted, the antimony added to it, and the mixture is then added to the melted lead. (U. S. patent 463427, November 11, 1891.)

"An aluminum bronze alloy contains aluminum 12 to 25 parts, manganese 2 to 5, copper 75 to 85. It is the product of John A. Jeancon. (U. S. patent 446351, February 10, 1891.)

"The antifriction metal (Babbitt metal plus aluminum) contains antimony 7.3 parts, tin 89, copper 3.7, with from  $\frac{1}{4}$  to 2.5 parts of aluminum. It is patented by Alexander W. Cadman. (U. S. patent 464147, December 1, 1891.)

ALUMINUM IMPORTED AND ENTERED FOR CONSUMPTION IN THE UNITED STATES  
FROM 1870 to 1891

Year ending—	Quantity	Value	Year ending—	Quantity	Value
	<i>Pounds</i>			<i>Pounds</i>	
June 30, 1870 . . . . .		\$ 98	June 30, 1882 . . . . .	566.50	\$ 6,459
1871 . . . . .		341	1883 . . . . .	426.25	5,079
1873 . . . . .	2.00	2	1884 . . . . .	595.00	8,416
1874 . . . . .	683.00	2,125	1885 . . . . .	439.00	4,736
1875 . . . . .	434.00	1,355	Dec. 31, 1886 . . . . .	452.10	5,369
1876 . . . . .	139.00	1,412	1887 . . . . .	1,260.00	12,119
1877 . . . . .	131.00	1,551	1888 . . . . .	1,348.53	14,086
1878 . . . . .	251.00	2,978	1889 . . . . .	998.00	4,840
1879 . . . . .	284.44	3,423	1890 . . . . .	2,051.00	7,062
1880 . . . . .	340.75	4,042	1891 . . . . .	3,906.00	6,263
1881 . . . . .	517.10	6,071			



*Imports of Crude and Manufactured Aluminum from 1891 to 1898*<sup>1</sup>

Calendar Year	Crude		Leaf		Plates, Sheets, Bars and Rods		Manu- facture	Total Value
	Quan- tity	Value	Packs of 100	Value	Quan- tity	Value		
	<i>Pounds</i>				<i>Pounds</i>			
1891	3,922	\$ 6,266	10,033	\$ 1,135			\$ 1,161	\$ 8,562
1892	43	51	11,540	1,202			1,036	2,289
1893	7,816	4,683	18,700	1,903			1,679	8,265
1894	5,306	2,514	10,780	1,210			386	4,110
1895	25,294	7,814	6,610	646			1,841	10,301
1896	698	591	4,657	523			2,365	3,479
1897	1,822	1,082	4,260	368	4,424	\$ 3,058	221	4,729
1898	60	30	2,000	174	18,442	8,991	4,675	13,870
1899	53,622	9,425	693	112	4,254	2,413	5,303	17,253

By the Hall process, the price of the metal varied from \$5.00 per pound for ingots to \$7.00 and \$9.00 per pound for sheets; but early in the year 1899 these prices were reduced to approximately one-half, in lots of 1,000 pounds or more. Two other methods have been employed to some extent in the manufacture of the metal. One, a modification of the chemical process by Deville in 1856, involving the use of sodium, was introduced about 1891. The other, a method by electrolysis, closely resembling that by Hall, was introduced by Héroult in 1899. Neither of these, however, was ever established in the United States.

## 2. ALUM MANUFACTURE

By far the greater part of the bauxite mined in Georgia is consumed in the manufacture of alum, and only a very small proportion of the ore is used in the extraction of the metal, aluminum.

All the alums of commerce are artificial preparations. Potash and ammonia alums occur, to some extent, as natural products; but, on account of their very limited occurrence, they are more of mineralogical than of technical or commercial interest. Concern-

<sup>1</sup> Twenty-first Ann. Rept., U. S. Geol. Surv., 1899-1900, Part VI, p. 269.

ing the principle, upon which the artificial preparation is based, including the classification of the aluminous material, from which alum has been made, Wagner says:—<sup>1</sup>

MATERIAL OF ALUM MANUFACTURE. — “The manufacture of alum is based on the formation of aluminium sulphate and sodium aluminate from the various alum ores. These ores of earths, necessitating different methods of treatment, may be divided into four groups, viz.:

[1.] “Those which contain alumina, potassa and sulphuric acid in such proportions that the addition of an alkaline salt is not requisite. To this group belong the alum-stone and several varieties of alum-shale.

[2.] “Those in which the aluminium sulphate is alone present necessitating the addition of alkali salts in large quantities. To this group belong the alum-shale and alum-earth found in the brown-coal formation.

[3.] “Those in which alumina only is contained, and to which both sulphuric acid and alkali salts must be added. To this group belong — (a) clay, (b) cryolite, (c) bauxite, alumina terhydrate (gibbsite), (d) refuse slack.

[4.] “To the fourth group belong those materials, such as feldspar, containing alumina and potash in sufficient quantity, but needing the addition of sulphuric acid.”

Only the preparation of alum from the mineral, bauxite, will be considered here. The manufacture of alum from its various ores and earths may be found in any of the standard text books on chemical technology, which must be consulted by those who would pursue the subject further.

The method first used in the preparation of alum from bauxite consisted in first disintegrating the mineral by igniting with sodium carbonate, or with a mixture of sodium sulphate and charcoal. In either case, the ignited mass yields, upon lixiviation, the aluminate of sodium. Carbonic acid gas is then passed through the solution, precipitating the hydrated gelatinous alumina, the sodium combining with the carbonic acid to form sodium carbonate, which remains in solution. The precipitated alumina is then

<sup>1</sup> Manual of Chemical Technology, 1892, p. 435.

treated with sulphuric acid, and the solution is either evaporated to obtain aluminum sulphate (so-called concentrated alum), or is treated with a potassium or ammonium salt and converted into alum.<sup>1</sup>

Naturally enough, the source of the bauxite employed in the manufacture of alum at this time was principally, if not entirely, from the French deposits.

At present, the method in vogue in the United States, for the manufacture of alum, eliminates the use of sodium carbonate, and consists of the direct treatment of the ore (bauxite) with sulphuric acid of a certain strength, usually 50° B. As the method now stands, certain important points must be considered in the selection of the ore used in the manufacture of the alum. These may be given as follows:—<sup>2</sup>

1 The easy solubility of the alumina in sulphuric acid. The strength of sulphuric acid usually employed in the manufacture of alum, and, to some extent, by commercial chemists in the determination of the soluble alumina in bauxite, is 50° B. So far as this point enters as a consideration, the valuation of the ore is based directly on the amount of soluble alumina, and not on the amount of total alumina contained in the ore. Sulphuric acid, of 50° B., therefore, is not sufficiently strong to dissolve the total alumina in the Georgia-Alabama ore; but it is adopted as a standard strength for removing all soluble alumina, without taking into solution deleterious amounts of certain impurities within certain limits, which are almost always present. The composition of the ore will condition, of course, the percentage amount of soluble alumina present.

2 Freedom from substances in the ore, generally as impurities, which, on going into solution, are likely to affect the quality of the alum or other products. This desideratum is a most important one, in the case of bauxites high in iron oxide; as this constituent dissolves in part and passes into the product. Some limitation is necessarily placed, therefore, on the percentage of iron and other

<sup>1</sup> Wagner, *op. cit.*, p. 438.

<sup>2</sup> Phillips, W. B., and Hancock, David, *The Commercial Analysis of Bauxite*, Journ. Amer. Chem. Soc. 1898, Vol. XX, pp. 209-210.

impurities present in the ore, used for this purpose. It is claimed, that an ore, averaging 10 per cent. of ferric oxide and 20 per cent. of silica, can be readily employed in the manufacture of alum. Unfortunately, only the best grade of ore has been shipped. This is not due to the fact, however, that the other grades of ore can not be used ; but it has undoubtedly resulted directly from the fact, that the Georgia mines were new enterprises, which had to meet the competition of cheap foreign ores, of established reputation.

As stated above, the demand, at present, is for first grade bauxite only, with scarcely any demand for second grade material. This lessens the danger of contamination from the presence of iron oxide.

A method for the manufacture of alum, recently patented by Dr. Edgar Everhart of Atlanta, Ga., and employed by him at his manufacturing plant in this city, consists in treating bauxite with nitre-cake, sodium sulphate, instead of with free sulphuric acid. So far, the results are reported to be satisfactory ; and, on account of the utilization of the by-product, nitre-cake, it is said to be much cheaper than that in which the free acid is used.

## CHAPTER VII

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### METHODS OF MINING, TRANSPORTATION AND PREPARATION OF THE GEORGIA BAUXITE FOR SHIPMENT

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NATURE OF THE DEPOSITS TO BE MINED. — The problem to be dealt with in the Georgia area is principally that of mining an ore, distributed in somewhat irregular, disconnected pockets, which grades into an enclosing structureless bauxitic clay. The clay surrounding the ore-bodies is always in strong contrast with, and different from, the mantle of overlying siliceous clay, derived from the decay of the associated rocks. The ore-bodies are usually covered with from one to ten feet of the siliceous residual clay; but they are frequently exposed on the surface, with scanty, or no clay covering. The deposits generally occupy the summits and slopes of the limestone ridges; and, at times, they are found in the valleys near the basal slopes of the ridges.

As a rule, the size of the ore-body is sufficiently large to warrant working, other things being equal, except in case of some of the valley deposits, the greater portions of which have been removed by erosion. The ore is very variable in composition, and is so deceptive in appearance, that its quality cannot be determined by the eye alone. Its value depends of course upon the percentage of alumina present and the freedom of the ore from impurities. At present, more than three-fourths of the bauxite is used in the manufacture of alum, and there is but little demand for any, except the first-grade ore. Bearing this in mind, the worker is confronted with two leading questions, which must be considered in the opening and successful working of any deposit. These are the percentages of insoluble matter (silica and iron oxide) present in the ore. The source of the silica is mostly, if not entirely, the

admixed bauxitic clays; while the iron oxide is in part a chemical constituent replacing the alumina, and in part an impurity derived from the infiltrating from the surrounding rocks. In many cases, where the iron is present as an impurity, the ore, after working to some depth, is considerably freer from iron oxide contamination and is of good grade. This, of course, can only be determined by intelligent preliminary investigation, of such nature as the sinking of prospect-shafts of sufficient depth, near the centre of the ore-body.

Again, in the present methods of alum-making from bauxite, only what is termed soluble alumina, in a certain known strength of sulphuric acid, is extracted. If then aluminous material, of a more refractory nature, is used, in which the alumina is but slightly soluble in the above strength of acid, such as clay, the material must be rejected. For this reason, due care should always be had, in working a deposit, that the clay content be at the minimum, and for the separation of the ore from the invariably associated clay. This, however, cannot, in many cases, be done in working, since the ore and clay are variously mixed, and grade imperceptibly into each other. In those deposits, where the hard types of ore predominate, this condition is not a desideratum; but, in the case of soft ore, the gradations into a structureless clay invariably occur, and the line to be drawn is by no means an easy one.

It sometimes happens, from the position of the deposit, that the methods of operation to be applied in one case cannot be applied in another. In places, where the capping of residual material is heavy, and where the ridge slope is very steep, underground work is frequently necessary; but, in most other cases, operations in open-cuts or pits can be more cheaply employed.

THE PRESENT METHODS OF MINING.—With one exception, the only systematic mining done in the Georgia area is by means of open-cuts or pits and shafts. In case the deposit is located on the ridge-slope, a level cut is made, sufficiently wide for a tramway or for barrows, and deep enough to give a good working-face on reaching the ore-body. This cut usually serves, also, to drain the working. The method of mining on the Watters property, five miles northeast of Rome, consists, in a large degree, of under-

ground work (tunnels and drifts), with some open-cuts and shafts. With these exceptions, all the rest of the mining in the bauxite region consists of small pits and prospect-holes.

The method of mining in open-cuts or pits, such as that recently employed at the Julia and the Maddox mines in the Hermitage district, consists in raising the ore by means of steam-hoists or derricks. At the Church bank, in the same district, the ore is raised by means of an inclined cable and cars, operated by steam. In the working of shafts, the usual method of hoisting by a hand windlass is practiced; although, in some cases, the steam-hoist or derrick doubtless might be employed to some advantage and profit.

As a rule, the ore is easy to mine, because of its comparative softness beneath the surface. It is soft enough, in most cases, to be dug up with the pick; although blasting is necessary in some cases. Notwithstanding the readiness with which the ore can be removed from its place, more or less expense is involved in mining, on account of its variableness in quality, which makes it necessary to assort the ore. Several grades of ore are found in every deposit, and the various grades are separated, in the pit, by means of screens and the hands, and are kept so, afterwards.

In no case, has any one of the banks been opened to the depth of permanent ground-water-level, which fact, when taken in connection with the land slope, causes no trouble in drainage. The only trouble, thus far experienced, is with surface water.

**MINING MACHINERY.** — With the exception of washers and dryers, the use of expensive machinery should be avoided, since it is both unnecessary and unwarranted by the nature of the deposits. Boilers and hoists constitute, when required, the only necessary machinery. The equipment should be as light and portable as possible, so that, when one deposit is exhausted, it can be easily moved to another.

**PREPARATION OF THE ORE PREVIOUS TO SHIPPING.** — When removed from the pit, the ore contains a large percentage of uncombined water, which, unless expelled or driven off before shipment, makes it a very important item in connection with the high freight-rates paid on the ore at present. A large percentage of the

ore, however, has been shipped in the past without drying. The moisture is expelled by subjecting the ore to an artificial drying process, which is the one mostly employed; although the natural process of drying under sheds has been practiced to a limited extent. Several forms of artificial dryers have been used. At the Julia mines in the Hermitage district, the operators first experimented with a form of dryer, which consisted of sheets of boiler-iron covering brick arches, on which the ore was spread out; but this was abandoned, as unsatisfactory, as well as expensive. The company then operating the Julia mines replaced the form of dryer just described, with an improved furnace erected at Linwood, a station on the Western & Atlantic railroad, several miles distant from the mines, from which station the ore is shipped. The construction of the furnace, a brick cupola with a central flue, was such that free circulation of the hot air through the ore was insured.

A form of drying, practiced at some banks, consists of piling the ore on a platform of wood and setting fire to the wood. While the heat produced has been found sufficient, in most cases, to greatly reduce the weight of the ore by expulsion of the moisture, the disadvantages of the process are readily apparent.

The most improved form of dryer, the one commonly employed, at present, at the largest mines, consists of a large, slightly inclined rotary-cylinder, continuous feeder, which was first built and operated by the Southern Bauxite Company at the Warhoop banks in Alabama. The cylinder is maintained at a red heat, and the ore, which requires 20 minutes to pass through it, is frequently passed through, a second time, which practically insures the removal of all the moisture from the bauxite.

Screening is employed before shipment in case of the coarse-gravel ore. This removes the greater part of the siliceous clayey matrix and slightly increases the percentage of alumina over that in the unscreened ore. In the case of pebble ore containing a large amount of clay matrix, washing, by means of a log-washer similar to that used in the treatment of the iron and manganese ores in the same section of the State, is often employed. The log-washer operated at the Julia mines is said to have given very satisfactory



results. The process is a very simple and inexpensive one; and, if more extensively used in the case of certain low-grade ores, it would doubtless prove very profitable. By this means, an ore, that has practically no value at present, could be so assorted as to be classed as a high-grade material.

THE EFFECT OF CALCINING ON THE SOLUBILITY OF ALUMINA.—Phillips and Hancock<sup>1</sup> have recently published some results, showing the effect of heating on the solubility of the alumina, causing the expulsion of certain percentage amounts of the chemically combined water in bauxite. The results are as follows:—

	Soluble Alumina Per Cent.
Bauxite dried at 100° C., not calcined . . . . .	59.00
Loss on calcining 12.55 per cent. H <sub>2</sub> O . . . . .	57.60
“ “ “ 18.55 “ “ “ . . . . .	57.10
“ “ “ 26.60 “ “ “ . . . . .	53.10
“ “ “ 32.15 “ “ “ . . . . .	20.40

These results certainly show a tendency toward a decrease in the solubility of alumina on calcination, which, as the authors state, does not seriously affect the alumina solubility, until about 80 per cent. of the total combined water is removed. Quoting from these authors, “With a loss of about 38 per cent. of the water there is a loss of 1.40 per cent. soluble alumina; with a loss of about 58 per cent. of the combined water the loss of soluble alumina is 1.9 per cent.; with a loss of about 82 per cent. of the combined water there is a much greater loss of soluble alumina; viz., 5.9 per cent., while the loss of soluble alumina rises to 38.60 per cent., when the material is thoroughly calcined.”

These results would seem to indicate, that the heat might be continued, until more than half of the combined water was removed, without seriously affecting the solubility of the alumina.

The investigation of this point was undertaken by the authors, with special reference to the drying of the ore previous to shipment; and also, looking to the possibility of establishing uniformity in the methods employed in the chemical analysis of the ore.

<sup>1</sup> The Commercial Analysis of Bauxite, Journ. Amer. Chem. Soc., 1898, pp. 220-221.

The conclusion reached is, that the heat used in expelling the moisture from the ore before shipment should not be sufficient to cause a loss of combined water.

MARKETS. — The principal markets at present are New York, Philadelphia, Pittsburg, Buffalo, Brooklyn, Bayonne, Syracuse, Cleveland, Natrona, Lockport and Chicago, where the alum and aluminum works are located. A little of the ore has been shipped to Germany, on account of its superior quality.

TRANSPORTATION. — The entire bauxite region in Georgia is traversed by numerous railroads, which offer outlets to various points north, south, east and west, and afford abundant facilities for transportation. Most of the workable deposits of bauxite are located almost immediately along the lines of railroad, and none are more than a few miles distant therefrom. As a rule, the country roads, connecting with the railway points in this area, are especially good, and are among the best highways in the State. On account, therefore, of nearness to the railroad points, and the prevailingly good condition of the county roads, the cost of transportation by teams is reduced to a minimum. At present, the market for this ore, as seen above, is confined exclusively to the North, where the chemical plants utilizing it are located.

STREAMS. — The immediate region is further traversed by a number of large streams, which, with their multitude of ramifying tributaries, insure ample water-supply and facilities at all seasons. Among the principal streams, may be mentioned the Etowah and Oostanaula rivers, which unite at Rome to form the Coosa river, which latter, after joining the Alabama, empties into an arm of the Gulf of Mexico, Mobile bay.

#### SUGGESTIONS

Since the beginning of the bauxite industry in the Georgia-Alabama area, new deposits of the mineral have naturally been added, from year to year, to those then known. With scarcely an exception, the existing deposits are included within the limits of the Coosa Valley area. The various companies, engaged in the mining of this mineral, have, from the beginning, persistently

prospected for additional sources of supply. From the period of time, therefore, during which the deposits have been worked, the continued search instituted for new ones, in connection with the accurate knowledge of the geology of the area, and the nature and occurrence of the ore-bodies, makes it now safe to say, that we can not hope to greatly extend, if at all, the present limits of the well known Georgia area. The occurrence of the ore is in the form of pocket deposits, which is positive evidence of their exhaustible nature. At the present rate of output,<sup>1</sup> however, the amount of the marketable grade of ore is probably sufficient to last for many years.

The possible yield is greatly limited by the fact, that nearly all but the first-grade material is discarded, thereby necessitating the exclusion of a vast quantity of ore, which should, by proper skill and manipulation, find ready utilization at good prices. This condition was, perhaps, made necessary in the beginning, when markets had to be established, in order that the home material might compete with the cheap and less pure foreign bauxites of long standing and reputation. The principle has been so rigidly adhered to, by both operator and consumer, during the period of working in the American fields, that it has resulted in creating a demand for the first-grade ore only, with practically no sales for the lower-grade bauxite.

The writer believes, after a careful survey of the Georgia fields, that the time is not far distant, when a change from this state of affairs must take place, and that the grade of ore, now regarded as inferior and cast aside, will, from necessity, be accepted. Otherwise, new fields, yet unknown, must be discovered and developed, if they exist.

It is apparent, that, in the present methods of alum-manufacture, mixing the different grades of bauxite, which has been practiced to some extent, is undesirable, except to a very limited degree, inasmuch as the value of the ore is based on the amount of soluble alumina in sulphuric acid of certain known strength. Treatment of the low-grade, siliceous bauxite with 50° B. sulphuric acid, for

<sup>1</sup> The year 1899, when the writer began the field-work for this report.

three hours, is not sufficient to extract the alumina, owing to its form of chemical combination in the bauxitic clays and kaolins.

Since the field-work on this report was begun, the supply of first-grade bauxite has become exceedingly limited in the Georgia-Alabama territory. The price for the first-grade ore has increased from \$4.50 per ton in 1899 to \$7.00 in 1901, with every probability of a continued increase. This leaves us confronted with a vast quantity of low-grade ore, not yet marketable, which should be utilized in some way. This grade of bauxite, for reasons already stated, can not be profitably employed in the manufacture of alum by the present process; hence, it does not pay to ship it.

In view of these conditions, two alternatives are suggested to the writer, whereby the low-grade ore may be successfully utilized.

First, a change or modification in the present process of alum manufacture is necessary to the use of the lower grades of bauxite. So far as the writer is able to judge, this seems, for several reasons, unlikely just now. The second, which is probably the more plausible and likely one, is, that the low-grade bauxite, which does not pay to ship, at present, must be worked up on the ground, into anhydrous aluminum oxide, and this product, placed on the market for the manufacture of both alum and the metal aluminum.



## BIBLIOGRAPHY

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- Augé, M.**, *Note sur la bauxite, son origine, son âge et son importance géologique.* *Bull., Soc. Géol. de France, 3me Sér.*, 1888, XVI, 345-350.
- Berthier, R.**, *Analyse de l'alumine hydratée des Baux, département des Bouches-du-Rhône.* *Annales des Mines, 2me Sér.*, 1821, VI, 531.
- Bischof, C.**, Analysis of Bauxite. *The Metallurgical Review*, 1878, II, 523.
- Blackwell, G. G.**, Bauxite. *Trans., Manchester Geol. Soc.*, 1894, XXII, 525-527.
- Blake, W. P.**, Alunogen and Bauxite of New Mexico. *Trans., Amer. Inst., Min. Engrs.*, 1894, XXIV, 571-573. Abstract, *Amer. Geol.*, 1894, XIV, 196.
- Branner, J. C.**, Bauxites of Arkansas. Third Biennial Report, Bureau of Mines, Manufactures, and Agriculture of the State of Arkansas for 1893 and 1894, Little Rock, 1894, 119-125.  
*Ibid.* Fourth Biennial Report of same, 1896, 105-110.  
Bauxite in Arkansas. *Amer. Geol.*, 1891, VII, 181-183; also, see *Engr. and Min. Journ.*, 1891, 114; *Trans., Federated Inst. M. E.*, III, 1,057; *Journ., Iron and Steel Inst.*, 1891, I, 275; *Science*, 1891, XVII, 17.  
The Bauxite Deposits of Arkansas. *Journ. Geol.*, 1897, V, 263-289.
- Brewer, W. M.**, The Warhoop Bauxite Bank, Alabama. *Engr. and Min. Journ.*, 1893, LV, 461.
- Cole, G. A. J.**, The Rhyolites of the County Antrim (Ireland) with a Note on Bauxite. *Sci. Trans., Roy. Dublin Soc.*, 1896, Ser. II, VI, 105-109.
- Collot, L.**, *Age de la bauxite dans le Sud-est de la France.* *Compt. Rendus*, 1887, CIV, 127-130. Abstract, *Neues Jahrb. f. Min.*, 1888, I, 452.  
*Age des bauxites du Sud-est de la France.* *Bull., Soc. Géol. de France, 3me Sér.*, XV, 331-345.

- Collot, L.**, *Sur la bauxite d'Ollières. Description géologique des environs d'Aix en Provence*, 1880, 84.
- Coquand, M. H.**, *Sur les bauxites de la chaîne des Alpes (Bouches-du-Rhône) et leur âge géologique. Bull., Soc. Géol. de France, 2me Sér.*, 1870-'1, XXVIII, 98-115. Abstract, *Neues Jahrb. für Min.*, 1871, 940-941; *Jahresbericht der Chem.*, 1871, 1144.
- D'Aoust, Virlet**, *De la Formation des oolithes et des masses nodulaires en général. Bull., Soc. Géol. de France, 2me Sér.*, 1857-'8, XV, 187-205.  
*Sur le minéral de fer alumineux pisolithique de Mouriés, dit aussi des Baux. Bull., Soc. Géol. de France, 2me Sér.*, 1864-'5, XXII, 418-420.
- Daubrée, A.**, *Sur l'existence de gisements de bauxites dans les départements de l'Hérault et de l'Ariège. Bull., Soc. Géol. de France, 2me Sér.*, 1868-'9, XXVI, 915-918.  
*Note sur un silicate alumineux hydraté, déposé par la source thermale de Saint-Honoré (Nièvre) depuis l'époque romaine. Comptes Rendus*, 1876, LXXXIII, 421.  
*Les eaux souterraines aux époques anciennes. Paris*, 1887, 96.
- Damour, A.**, *Note sur un hydrate d'alumine ferrugineuse trouvé dans l'île d'Égine, Grèce. Bull., Soc. Géol. de France*, 1864-'5, XXII, 413-416.
- Deville, H. Sainte-Claire**, *De la présence de vanadium dans un minéral alumineux du Midi de la France. Ann. de Chimie et de Phys.*, 3me Sér., 1861, LXI, 309-342.  
*Analyse d'une bauxite du Paradon. Ann. de Chimie et de Phys.*, 3me Sér., LXI, 309. Abstract, *Jahresbericht der Chemie*, 1861, 980.
- Dieulafait**, *Les bauxites, leur âges, leur origine. Comptes Rendus*, 1881, XCIII, 804-807.
- Ditte, A.**, *Sur la préparation de l'alumine dans l'industrie. Comptes Rendus*, CXVI, 509-510.  
*Préparation industrielle de l'alumine. Ann. Chimie et de Phys.*, 1893, XXX, 280-282.
- Drechsler, E.**, *Analyse des Bauxites aus der Wochein. Dingler's Poly. Journ.* 1872, CCIII, 479-481.
- Fabre, G.**, *Note sur les failles et fentes à bauxite dans les environs de Mende. Bull., Soc. Géol. de France*, 1869-70, XXVII, 516-518.
- Fuchs, Ed., et de Launay, L.**, *Traité des gîtes minéraux et métallifères. Paris*, 1893, I, 595-599.

- Handy, J. O.**, Analysis of Bauxite. Journ. Amer. Chem. Soc., 1896, XVIII, 766.
- Hauer, F. von**, (*Bauxite, Krain.*) *Jahrb. der K. K. Geol. Reichsanstalt*, 1866, XVI, 457.
- Hayes, C. W.**, Bauxite. Mineral Resources of U. S., 1893, 159-167.  
 Geological Relations of the Southern Appalachian Bauxite Deposits. Trans., Amer. Inst. Min. Engrs., 1894, XXIV, 243-254.  
 Bauxite. 16th Annual Report, U. S. Geol. Survey, 1893-'4 (1895), Part III, 547-597.  
 The Arkansas Bauxite Deposits. 21st Annual Report, U. S. Geol. Survey, Part III, 1899-1900, 435-472. Abstract, Journ. Geol., 1901, IX, 737-739.  
 The Overthrust Faults of the Southern Appalachians. Bulletin, Geol. Soc. Amer., 1819, Vol. II, pp. 141-154.  
 Report on the Geology of Northeastern Alabama, and Adjacent Portions of Georgia and Tennessee. Geological Survey of Alabama, 1892, 85 pages.  
 The Southern Appalachians. National Geographic Monograph, 1895, Vol. I, No. 10, pp. 305-336.  
 Geology of a Portion of the Coosa Valley in Georgia and Alabama. Bulletin, Geol. Soc. Amer., 1894, Vol. V, pp. 465-480.  
 Physiography of the Chattanooga District in Tennessee, Georgia and Alabama. 19th Annual Report, U. S. Geological Survey, 1897-'98 (1899), Part II, pp. 1-58.
- 
- **and Campbell, M. R.**, Geomorphology of the Southern Appalachians. National Geographic Magazine, 1894, Vol. VI, pp. 63-126.
- Hunt, A. E.**, Bauxite (Discussion). Trans., Amer. Inst. Min. Engrs., 1894, XXIV, 855-861.  
 The Properties, Uses, and Processes of Production of Aluminum. Technology Quarterly, 1891, IV, 1-35.  
 Aluminum. Mineral Resources of the U. S., 1892, 227-254.<sup>1</sup>
- Jannettaz, Ed.**, *La composition d'une variété pisolithique de bauxite.* Bull., Soc. Géol. de France, 1877-'8, VI, 392.  
*Gibbsite et Bauxite, de la Guayane française.* Bull., Soc. Min. de France, I, 70-71, Paris, 1879.

<sup>1</sup> In addition to the metallurgy of aluminum and a description of the aluminum ores, this contribution contains a description of the methods for analyzing bauxite.



- Lang, J.**, *Ueber Bauxit von Langsdorf. Bericht der Deutschen Chemischen Gesell.*, 1884, XVII, 2892-2894. Abstract, *Neues Jahrb. f. Min.*, 1886, II, 342.
- Laur, F.**, The Bauxites: A Study of a New Mineralogical Family. *Trans., Amer. Inst. Min. Engrs.*, 1894, XXV, 234-242.  
On Bauxite. *Minutes of the Proceedings, Inst. Civ. Engrs.*, 1894-'5, CXX, Part II, 442.
- Liebrich, A. von**, *Bauxit. Zeitschr. für Kryst. u. Mineral.*, XXIII, 296.  
*Bauxit. Bericht der Oberhess. Gesellschaft für natur. u. Heilkunde*, XXVIII, 57-98.  
*Beitrag zur Kenntniss des Bauxits vom Vogelsberge*, 1892. Abstract, *Chemisches Centralblatt*, 1892, p. 94.
- McCalley, H.**, Alabama Bauxite. *Proc., Ala. Indust. and Scientific Soc.*, 1892, II, 20-32.  
Bauxite Mining. *Science*, 1894, XXIII, 29-30.  
Bauxite. *The Mineral Industry*, 1893, II, 57-67.  
The Valley Regions of Alabama. Part II. On the Coosa Valley Region. *Geological Survey of Alabama*, 1897, 862 pages.
- Meunier, S.**, *Sur l'existence de la bauxite a la Guayane francaise. Comptes Rendus*, 1872, LXXIV, 633-634. Abstract, *Jahresbericht der Chemie*, 1872, 1099.  
*Sur l'origine et la mode de formation de la bauxite et du fer en grains. Comptes Rendus*, 1883, XCVI, 1737-1740.  
*Réponse á des observations de M. Augé et de M. A. de Grossouvre sur l'histoire de la bauxite et des minéraux siderolithiques. Bull., Soc. Géol. de France*, 1889, XVII, 64-67.
- Mierzinski, Dr.**, *Die Fabrication des Aluminiums*. Vienna, 1885.
- Minet, A.**, *L'Aluminium; fabrication, emploi, alliages.*, Paris, 1893.
- Nichols, Edward**, An Aluminum Ore. *Trans., Amer. Inst. Min. Engrs.*, 1887, XVI, 905-906.; Abstract, *Iron and Steel Inst.*, 1888, II, 228-229.
- Packard, R. L.**, Aluminum. 16th Annual Report, U. S. Geol. Survey, Part III, 542-554. (Bauxite), 1895.  
*Mineral Resources, U. S.*, 1891, p. 147.<sup>1</sup>  
The Production of Aluminum in 1894. Sixteenth Annual Report, U. S. Geological Survey, 1895, Part III, pp. 539-546.<sup>2</sup>

<sup>1</sup> This paper contains numerous references, to which the writer has not had access.

<sup>2</sup> For production, statistics, metallurgy etc. of aluminum and alum, the reader is referred to the annual volumes of the Mineral Resources of the United States from 1882 to date, U. S. Geological Survey.

- Petersen, Th.**, *Ueber den Anamesit von Rudigheim bei Hanau und dessen bauxitische Zersetzungsproducte. Jahresbericht de Phys. Ver. zu Frankfurt a. M.* 1891-'2, 10.  
*Ueber Bauxitbildung (Bei. d. XXVII, Vers. d. Oberrhein. Geol. Ver. 2S., 1893.)* Abstract, *Neues Jahrb. f. Min.*, 1894, 460.
- Phillips, Wm. B., and Hancock, David**, The Commercial Analyses of Bauxite. *Journal, Amer. Chem. Society*, 1898, XX, 209-225.
- Richards, Joseph W.**, Aluminium: Its History, Occurrence, Properties, Metallurgy and Applications, Including Its Alloys. Baird & Co., Phila., 3rd edition, 1896, XXXV, 666 pp.
- Roth, Ludw.**, *Der Bauxit u. seine Verwendung zur Herstellung von Cement aus Hochofenschlacke.* Wetzlar, 1882.
- Roulé, Louis**, *Sur les gisements et l'âge de la bauxite dans le Sud-est de la France. Comptes Rendus*, 1887, CIV, 383-385; Abstract, *Neues Jahrb. f. Min.*, 1888, I, 452.  
*Recherches sur le terrain fluvio-lacustre inférieur de Provence. Ann. des Sciences Geol.*, XVIII, 1885, 138. Abstract, *Neues Jahrb. f. Min.*, I, 1887, 98-100.
- Saemann**, *Sur la bauxite des Baux. Bull., Soc. Géol. de France, 2me Sér.*, XXII, 416-417.
- Seeger, H.**, *Zusammensetzung von Bauxit aus Ireland. Dingler's Poly. Journ.*, 1880, CCXXIV, 334.
- Sena, J. da Costa**, *Note sur hydrargillite des environs d'Ouro Preto (Brésil). Bull., Soc. Min. de France*, 1885, VII, 220-222.
- Spencer, J. W.**, Aluminium Ores. Geological Survey of Georgia Atlanta, 1893, 210-230.  
How Aluminum is Obtained from Its Ores. *Science*, 1894, XXXIII, 89.
- Sutherland, James**, The Preparation of Aluminum from Bauxite *Engr. and Min. Journ.*, 1896, LII, 320-322.
- Tissier, Ch. et Alex.**, *Guide Pratique de la recherche de l'extraction et de la fabrication de l'aluminium et des métaux alcalins, Paris*, 1863.
- Wagner, R.**, *Ueber die Bedeutung des Bauxits für die Chemische Industrie. Berg. u. Hüttenmännische Zeitung*, 1865, 264.  
A Handbook of Chemical Technology, New York, 1891, pp. 113, 259-260.

- Watson, Thomas L.**, The Georgia Bauxite Deposits: Their Chemical Composition and Genesis. *Amer. Geol.*, 1901, XXVIII, 25-45.
- Wedding**, *Notiz über den Bauxit (Niederrhein. Gesellschaft für Natur. u. Heilkunde zu Bonn)*. *Sitzg.* V, 8, 1863.
- Williams, C. H.**, Bauxite. *Trans., Manchester Geol. Soc.*, XXII, 521.
- Williams, J. F.**, Igneous Rocks of Arkansas (Age, Origin and Distribution of Arkansas Bauxite), *Ann. Rept. for 1890, Vol. II, Geological Survey of Arkansas*, 1891, 124-125.
- Will, W.**, *Bericht der Oberhess. Gesellschaft für Natur. u. Heilkunde*, 1883; XXII, 314.

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