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GORCEIXITE FROM DALE COUNTY, ALABAMA*

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ABSTRACT

Two specimens of hydrous alkali-earth rare-earth aluminum phosphate from Eocene marl in southeastern Alabama have compositions approximating $RAl_3(PO_4)_2(F,OH)_5(H_2O)_3$ and $R_{0.8}Al_{4.6}(PO_4)_2(F,OH)_{10}(H_2O)_{0.3}$ respectively; the *x*-ray diffraction pattern of each is that of the alunite-plumbogummite-beudantite group. The mineral is isotropic, with *n* about 1.61, *d* about 3.09. No explanation of the difference in composition is offered; it is noted that the other recorded analyses of similar minerals show similar differences.

OCCURRENCE IN ALABAMA

Gorceixite, essentially $(Ba,Ca,Sr,Ce)Al_3(PO_4)_2(OH)_5 \cdot H_2O(?)$, occurs in four localities a few miles apart in southeastern Alabama, and is also found in Arkansas (Young, 1958). These occurrences are the first reported discoveries in North America of what may be a fairly widespread mineral, for it can be easily confused with bauxite, chert nodules, and similar appearing material. The Alabama occurrences are of special interest because of a substantial content (6–8 per cent) of rare earths.

The Alabama gorceixite is found as irregular nodules up to several inches across, in the weathered outcrops of the Bashi marl, the basal member of the Hatchetigbee formation, which is the youngest formation of the lower Eocene Wilcox group of Alabama. MacNeil first noted these nodules in 1943 in the vicinity of Ariton and Ozark, Dale County, Alabama. The Bashi is a highly fossiliferous glauconitic sand; it maintains a thickness of between 3 and 15 feet in the eastern Gulf region and is one of the most continuous single beds in the Tertiary of the Gulf Coast.

Gorceixite has been found at these four Dale County localities (the analyzed specimens are from A and B).

A. Road cut NW¼NE¼ sec. 18, T. 7 N., R. 24 E., about 2 miles southeast of Ariton, Dale County, Alabama.
B. Near the railroad on highway 53, 1 mile north of Dill, Dale County, Alabama.
C. Four hundred feet west of railroad cut on highway 53, near western boundary of Ariton, Dale County, Alabama.
D. On old road parallel to highway 53, about 0.9 mile west of intersection of these roads, at Ariton, Dale County, Alabama.

Nodular material superficially resembling gorceixite is present in many localities in Dale County. However, study by *x*-ray fluorescence of several of these nodules, in some instances further confirmed by *x*-ray diffraction, showed that none of this material is gorceixite.

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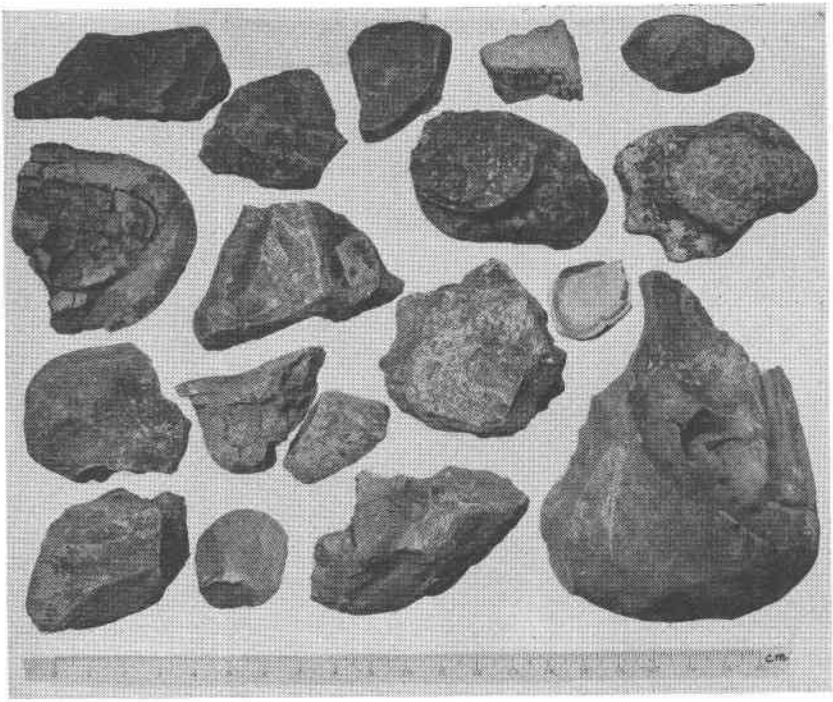

Fig. 1. Gorceixite nodules from Bashi marl member of the Hatchetigbee formation, Dale County, Alabama, one mile north of Dill. Shows typical aspect of nodules. These are free from glauconite, and are the material analyzed as sample B.

Physical Properties

The *x*-ray diffraction pattern of the gorceixite is very similar to those of svanbergite from Sweden, U. S. National Museum no. C 4444, harttite (calcian svanbergite) from Brazil, U. S. National Museum no. 94797, and gorceixite from Brazil, U. S. National Museum no. C 4296. These are all members of the alunite-plumbogummite-beudantite group.

The density of the Alabama gorceixite (analysis A, including quartz and calcite) is 2.93, with correction for quartz and calcite (analysis A_1) the density is computed as 3.09. The index of refraction of the isotropic substance is 1.61. The color of the nodules is generally dirty white; there are dark specks of glauconite in some nodules. The nodules are firmly coherent. Thin sections (Figs. 2 and 3) indicated as much as 70 per cent of apparently isotropic gorceixite, with lesser quartz and glauconite (the latter removed before analysis by the electromagnet and hand-picking). Sample B-B_1 is nodular gorceixite (free from glauconite); typical such nodules are shown in Fig. 1.

FIG. 2. Thin section of nodule, such as shown in Fig. 1. The white areas are quartz, the dark spots are light brown organic (phosphatic) material. The gray matrix is gorceixite.

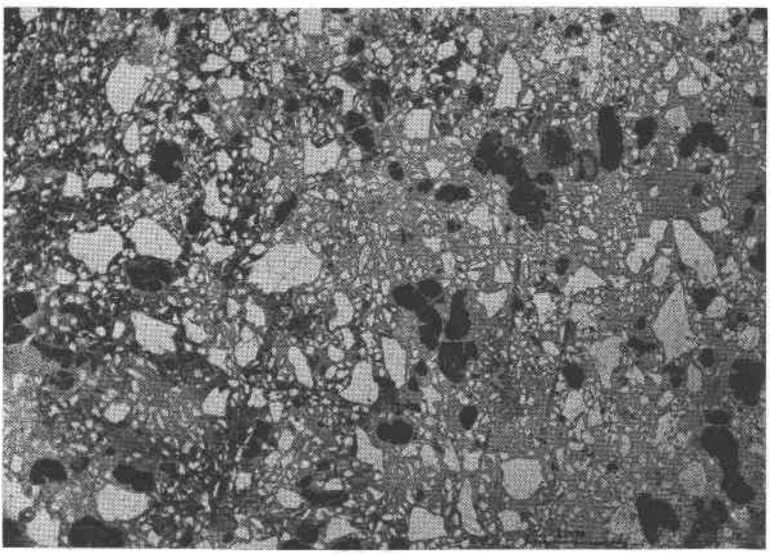

FIG. 3. From 2 miles southeast of Ariton, Alabama. Thin section of glauconitic marl, showing abundant quartz (white) and glauconite (dark). The gray matrix is gorceixite. Material such as this was analyzed after removal of glauconite (Sample A).

Analyses

Gorceixite is one of the plumbogummite group of hexagonal minerals of general formula,

> $AB_3(XO_4)_2(OH)_5H_2O_{(1-0)}$ where A may be Pb, Ba, Sr, Ca, or Ce; B may be Al, or Fe, and X may be P or As.

Chemical analyses of two specimens were made by M. K. Carron; supplementary spectrographic investigations of the rare-earth content of specimen A were made by H. J. Rose, and of minor elements, including rare earths, of specimen B by Harry Bastron. The analyses are given in Tables 1, 2, and 3.

Discussion of Analyses

Analysis A_1, corrected for quartz and calcite, agrees reasonably well with the theoretical $BaAl_3(PO_4)_2(OH)_5 \cdot H_2O$ (although H_2O is 3 instead of 1). This formula is by no means fixed, in fact, it is expressly stated to be "uncertain," "perhaps $BaAl_3(PO_4)_2(OH)_5 \cdot H_2O$." (2). The same uncertainty is noted about other members of the plumbogummite group, in particular plumbogummite itself and crandallite. One source of uncertainty may be analytical, involving the troublesome estimation of the respective alkaline earths, another may be the valence state of cerium, CeO_2 or Ce_2O_3. At any rate, scrutiny of the three analyses of gorceixite cited by Palache, Berman, and Frondel (1944), shows a much closer approximation to $BaAl_5(PO_4)_2(OH)_{11}$. This, again, is close to our analysis B_1 which computes near to (Ba,Sr,Ca,RE, etc.)$Al_5(PO_4)_2 \cdot (F,OH)_{11}$.

The excess of Al_2O_3 and H_2O, in sample B as compared to sample A, cannot be referred to any impurity, observable either optically or by *x*-ray pattern; in particular, diaspore, gibbsite, or boehmite. Because the quartz present is practically equivalent to the total silica, there can be little if any mica or clay.

In summary, analyses of gorceixite, one of the two from Alabama included, tend to show an excess of $Al(OH)_3$ over the simple formula generally given; however, this excess cannot be referred to any specific mineral as admixture.

The mineral from Alabama which we have called gorceixite contains more or less equivalent amounts of Ba, Sr, Ca, and rare earths, corresponding to the recognized end member minerals gorceixite, goyazite, crandallite, and florencite. Thus, the name given is not entirely satisfactory, but a new name does not seem warranted.

The origin of these gorceixite nodules is an unsolved problem. They

TABLE 1. CHEMICAL ANALYSES OF GORCEIXITE, DALE COUNTY, ALABAMA
M. K. Carron, analyst

	A	A_1	B	B_1
SiO_2	31.90	—	17.82	—
Al_2O_3	17.17	25.70	33.72	41.14
Fe_2O_3	2.58	3.86	1.03	1.26
P_2O_5	18.30	27.40	20.10	24.52
BaO	4.56	6.83	2.90	3.54
SrO	3.56	5.33	3.94	4.81
CaO	2.14	2.29	1.02	1.24
MgO	.08	.12	.22	.27
Ce_2O_3	1.29	1.93	3.88*	4.73*
La_2O_3, etc.	3.91	5.85		
TiO_2	.54	.81	.03	.04
Na_2O	.05	.07	.17	.21
K_2O	.24	.36	.48	.58
PbO	—	—	.08	.10
H_2O-	1.32	1.98	1.15	1.40
H_2O+	10.16	15.21	11.93	14.56
CO_2	.48	—	—	—
SO_3	.29	.43	.73	.89
F	2.11	3.16	1.01	1.23
	100.68	101.33	100.21	100.52
$O=F_2$	−.89	−1.33	−.43	−.52
	99.79	100.00	99.78	100.00

Density: 2.93 (measured). 3.09 (corrected).

* Total rare earth oxides.

A—Gorceixite associated with glauconite, etc., in nodules about 2 miles southeast of Ariton, Dale County, Alabama.

A_1—Analysis A, recalculated after deducting 31.90 per cent SiO_2 (quartz) and 1.09 per cent $CaCO_3$ (based on 0.48 per cent CO_2).

B—Gorceixite from glauconite-free nodules 1 mile north of Dill, Dale County, Alabama.

B_1—Analysis B, recalculated after deducting 17.82 per cent SiO_2 (quartz).

Analysis A_1 is computed to:

$(Ba_{0.23}Sr_{0.26}Ca_{0.21}Mg_{0.02}RE_{0.24}Na_{0.01}K_{0.04})$ $\Sigma=1.01$

$(Al_{2.58}\overset{3+}{Fe}_{0.25}\overset{4+}{Ti}_{0.05})$ $\Sigma=2.88$

$(PO_4)_{1.97}(SO_4)_{0.03})$ $\Sigma=2.00$

$(F_{0.85}(OH)_{4.07})$ $\Sigma=4.92$

$(H_2O_{2.85})$ $\Sigma=2.85$

giving (Ba, Sr, Ca, RE, etc.)(Al, Fe, Ti)$_3(PO_4)_2(F, OH)_5(H_2O)_3$

Analysis B_1 is computed to:

$(Ba_{0.13}Sr_{0.26}Ca_{0.12}Mg_{0.04}RE_{0.16}Pb_{0.003}Na_{0.04}K_{0.07})$ $\Sigma=0.82$

$(Al_{4.53}\overset{3+}{Fe}_{0.09}\overset{4+}{Ti}_{0.003})$ $\Sigma=4.62$

$(PO_4)_{1.94}(SO_4)_{0.06})$ $\Sigma=2.00$

$(F_{0.36}(OH)_{9.29})$ $\Sigma=9.65$

$(H_2O_{0.34})$ $\Sigma=0.34$

giving (Ba, Sr, Ca, RE, etc.)$_{0.82}$(Al, etc.)$_{4.6}(PO_4)_{2.0}(F, OH)_{10.0}(H_2O)_{0.3}$

Essentially this formula is equivalent to that of A_1 with excess of $(Al)_{1.6}(OH)_{5.0}$, or $[Al(OH)_{3.0}]_{1.6}$, and deficiency of $(H_2O)_{2.7}$.

Table 2. Rare Earth Distribution (Spectrographic) of Gorceixite, Dale County, Alabama (Composition of the 5.20 Per Cent Total Rare Earths of Analysis A, Table 1)

Harry Ross, U. S. Geological Survey, analyst

CeO_2	36.8
La_2O_3	16.5
Nd_2O_3	25.0
Pr_6O_{11}	5.9
Y_2O_3	4.1
Yb_2O_3	—
Sc_2O_3	—
ThO_2	.0
Sm_2O_3	6.1
Gd_2O_3	3.9
	98.3

Table 3. Minor Element Content (Spectrographic) of Gorceixite, Dale County, Alabama, Analysis B, Table 1

Harry Bastron, U. S. Geological Survey, analyst

Cu	0.002			
Pb	.06			
Cr	.003			
V	.005			
Ti	.1			
Zr	.01			
Be	.01			
Sr	1.2			
Ba	4.5			
B	.01			
Ce	1.5	=	Ce_2O_3	1.75
La	1.0	=	La_2O_3	1.17
Nd	1.0	=	Nd_2O_3	1.16
Pr	.2	=	Pr_2O_3	.23
Y	.07	=	Y_2O_3	.09
Yb	.005			
Sc	.02			4.40

Note: The total of rare earths spectrographically 4.40 per cent is reasonably close to the chemically determined (weighed) total rare earths 3.88 per cent. The spectrographic and chemical Ba and Sr differ: Spectrographic (BaO) 5.0, (SrO) 1.4, chemical (BaO) 2.90, (SrO) 3.94. This discrepancy may reflect the difficulty of separating Ba and Sr chemically. The sum of the two oxides spectrographically is 6.4, chemically 6.8.

may have been deposited as such on the sea floor, or accumulated in the sediment during its diagenesis. Or, they may have formed subaerially during the weathering of the Bashi marl member, either directly, or perhaps as partial replacement of more common calcareous phosphate concretions.

Acknowledgment

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References

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