

ART. LIX.—*A description of several Yttria and Thoria Minerals from Llano County, Texas*; by W. E. HIDDEN and J. B. MACKINTOSH.

*History.*—In July, 1886, the first piece of gadolinite (a mass of about  $1\frac{1}{2}$  lbs.) was accidentally discovered, by Mr. J. J. Barringer, in Llano County, Texas. It was noticed projecting from an outcropping of granite and was detached therefrom and preserved merely because of its peculiar appearance. Later Mr. Barringer commenced digging at the locality, and in a short time he unearthed a pocket of huge crystals and masses of this rare mineral aggregating not less than 500 kilos. This remarkable quantity was obtained by digging with pick and shovel, in the partly decomposed surface rock and all came from a space not over 4 ft. deep, 3 ft. wide and 8 ft. long.

Until August, 1888, the true nature of the mineral remained unknown and meanwhile it received such local names as "tin-ore," "black-jack zinc," "volcanic-glass," etc. Later the name "samarskite" was given to it and as such it was known until Mr. Barringer, upon sending it to New York in an endeavor to find a market for it, received the information that it was gadolinite. About this time it came under the notice of one of us, and an effort was made to develop the locality thoroughly. Thus far only the gadolinite had been found and no value having been attached to it the mineral had been free to all who desired "a few pounds of it." Of the large quantity obtained in 1886, only about 100 kilos then remained; the greater portion having been gradually distributed among local visitors. In January of this year, realizing that a locality that could produce the rare mineral gadolinite in such unprecedented masses as had already come under our notice, was worthy of careful investigation, we sent Mr. Wm. Niven, of New York, on a special visit to the region and it was the series of specimens collected by him that induced one of us to personally visit the locality. This was done during the past summer, two months being spent in prospecting the whole region; the results of this investigation are embodied in this announcement.

*Description of locality.*—The spot where the gadolinite has been found is nearly five miles southward from Bluffton, in Llano Co., Texas, and on the west bank of the Colorado River. The whole surrounding region for many miles is Archæan\* (with occasional cappings of limestone), and granite, in various shades of color and texture, is the common country rock. A coarse textured deep-red granite is most abundant, and through it

\* See "Geologic story of the Colorado River." R. T. Hill, in *American Geologist*, vol. iii, No. 5, pp. 291-2.

numerous and extensive quartz veins extend to the surface. Only in these veins have the ores of yttria, etc., been found and only in the wider swellings of these veins or where they have assumed the character of bold uplifts have masses of large size been found. Here is to be seen a mound-like elevation 100×150 feet in area projecting boldly from the surrounding granite and 27 feet in elevation above the river terrace. It is made up of huge blocks and masses of quartz, and red feldspar, all tightly massed together. The mound is nearly circular in form and the contact with the country granite is sharply defined. It is plainly seen to be a widening of a vein that can be traced in a southwesterly direction for some distance and one of a series to be seen at several locations in the near neighborhood.

The quartz masses are from 5 to 20 feet thick, with the interstices filled completely by a highly crystalline red feldspar. Between these irregular masses are found at times thin seams of a black iron-mica and with this mica and in the adjacent feldspar are found the various ores of the rare earths hereinafter to be noticed.

From all sides this mound has been entered with trenches and one or more of the yttria minerals have been found at every opening. At this writing it has been so much cut into by trenching that it is difficult to trace the original boundary. On the river side the mound is rather steep but in other directions its sides slope gradually. Its top is flat and consists of pure white quartz (bleached by weathering) and it is only on the slopes and at the base that the several rare minerals show themselves. The quartz and feldspar are very much stained with red oxide of iron and some yellow and green uranium compounds at the points where at present the larger mineral masses have been found and these stains have constituted a good guide to their discovery.

Up to the present time we have identified the following mineral species, but we will describe in detail only the more important in the present paper. The list of species includes quartz, hyalite, orthoclase, albite, biotite, muscovite, magnetite, martite, gadolinite (several varieties due to alteration), fergusonite (three varieties of hydrous species), allanite, molybdenite, molybdite, cyrtolite (several varieties), fluorite, gummite (two varieties), a carbonate of the rare earths (tengerite?), a thorium-yttrium-lead uranate, a hydrous uranium thoro-silicate, a yttrium-thorium silicate, a fetid gaseous compound (which we first observed upon breaking some of the material for analysis) and several minerals, found in small quantities, which we have not had the opportunity, to identify with certainty.

QUARTZ, is rarely found crystallized at this locality. Only one pocket of smoky crystals (coated with ferric-oxide), of

noteworthy size and transparency, having been as yet found. Small druses of quartz-caps are often met with in the seams of the larger quartz masses.

HYALITE, in mammillary forms was observed coating the seams of the feldspar and quartz, in very small patches.

ORTHOCLASE, occurs massive and finely crystallized and in great variety of form. Twin crystals, of curious complexity, and simple forms are very common. Crystals of huge dimensions, a foot or more in length, more or less perfect, and smaller sizes abound, especially are they abundant on the contact of the vein with the granitic walling.

ALBITE is rare and occurs coating small cavities in the massive orthoclase. Crystals not above 1 inch diameter were observed.

BIOTITE (?), is very abundant and occurs in broad folia in the seams between the quartz and feldspar masses. Diagonal prismatic cleavage surfaces were common. It was intimately mixed with much magnetite and was often the matrix or foundation upon which the rarer minerals rested. Many alteration products were noticed.

MUSCOVITE is quite rare, and occurs as hexagonal implanted prisms only in the albitic cavities. These prisms seem to be made up of 3 or 6 sectors on a basal section. No examination chemical or optical has been made.

MAGNETITE is quite abundant, both massive and crystallized. It is always associated and intermixed with the biotite. Octahedral crystals with planes of the cube, rhombic-dodecahedron and of a trapezohedron were found abundantly, though superficially they were coated with a thin micaceous layer and some uranium hydrate.

MARTITE was very common, being an alteration from the magnetite. Crystals having a black color interiorly and preserving the cleavages of magnetite but having no magnetic properties were very commonly observed.

GADOLINITE.—We have already detailed the events surrounding the discovery of this mineral in Texas. For a description we would refer to the paper by Dr. Genth\* in the September number of this Journal. As Dr. Genth has stated, this gadolinite when unaltered “has a black color; in thin splinters it is translucent with a dark bottle green color; the fine powder is greenish-gray; fracture conchoidal to splintery. Sp. grav. 4.201–4.254.”†

\* Eakins found sp. g. = 4.239. Our own determination on a very compact mass gave us 4.306.

† Dr. Genth was misinformed by the party who supplied him with his “Burnet Co. gadolinite” as it has not as yet been discovered in that county, and the error of crediting Burnet Co. with having produced it was probably owing to the fact that it had been shipped from Burnet (Burnet Co.) which was the nearest R. R. point to the true locality some 19 miles distant.]

Most of the gadolinite is altered into a brownish-red mineral of waxy luster; some of the masses are entirely so altered, while in others the change has only taken place superficially. A further alteration has been to a yellowish-brown, earthy (ochreous) substance which upon drying in the open air becomes a very light powder. The average size of the masses of this Texas gadolinite has been in our experience about half a pound; though embedded crystals (hydrated) were noticed not above half an inch long by one-quarter inch wide (very acutely terminated) and as to large masses there were many of 5, 10 and 15 lbs. each. One double crystal weighed forty-two lbs. and was nearly free from matrix. Another huge pointed mass, in reality a crystal, weighed fully sixty pounds.\* All of the gadolinite had at some time in the past presented smooth crystal surfaces (as the hydrated crust often gave evidences of), but very few masses were found without more or less exterior alteration. This alteration had roughened the underlying surface and had given a dark brick-red color to all the changed mineral.

On only three crystals were we enabled to find sufficiently smooth surfaces to give us even approximate angles, and these we here append :

$I \wedge I = 115^{\circ}-117\frac{1}{2}^{\circ}$	$O \wedge \frac{1}{2}i = 145^{\circ}-146^{\circ}$
$I \wedge 1 = 156^{\circ}-158\frac{1}{2}^{\circ}$	$\frac{1}{2}i \wedge \frac{1}{2}i$ (ov. $O$ ) = $111^{\circ}-112^{\circ}$
$1 \wedge 1 = 119^{\circ}-119\frac{1}{2}^{\circ}$	$O \wedge I = 90^{\circ}-91^{\circ}$
$1 \wedge O = 113^{\circ}-113\frac{1}{2}^{\circ}$	$1 \wedge 1$ (ov. $\frac{1}{2}i$ ) = $77^{\circ}-79^{\circ}$
$-1 \wedge +1$ (ov. $O$ ) = $46^{\circ}$	$\frac{1}{2}i \wedge 1 = 123^{\circ}-126^{\circ}$

All the crystals observed were lengthened in the direction of the vertical axis (in one instance ten inches long), and the plus and minus 1 and 2 pyramids are present often to the total extinction of the basal pinacoid, making acute forms difficult to extract from the matrix in perfect condition. A distinctly monoclinic habit was apparent in many of the masses, and the pyramid 2 was often developed only upon the plus or minus side. The basal plane was only noticed in one instance. At another vein, one mile south, two crystals of gadolinite, of rare beauty and perfection, were found on the land of Mr. Hiram Casner; this goes to show that other discoveries of the rare minerals are possible in the neighborhood.

#### *YTTRIALITE, a new Thorium-Yttrium silicate.*

The mineral which we have named YTTRIALITE was discovered associated with, and often upon, the gadolinite, and but for its characteristic orange-yellow surface alteration (that of gadolinite immediately along side of it being invariably of a dull brick-red color) it might have continued to pass for "green-gadolinite," which was the local name given to it. Of these yellowish masses one weighed over ten pounds, and

\* Stated on the authority of Mr. Barringer and many of his neighbors.

twenty kilos were found in all. Upon being broken open they are of an olive-green color, tending in places to a drab shade. Peculiar minute ragged lines permeate the mineral in all directions, causing an apparent muddiness or semi-opacity. No crystals have as yet been observed, but a seemingly orthorhombic symmetry was apparent in some of the masses. The mineral breaks easily in two directions with a shell-like fracture, but separates into small flakes very readily. (Gadolinite is broken only with difficulty.) Nothing like a cleavage has been noticed. A thin white crust of a mineral related to tengerite occupies the cracks in the mineral and this is equally true concerning the gadolinite of the locality as Genth has already noted. We have named the mineral *yttrialite*, in allusion to the prominent part played by the yttria earths in its composition.

The specific gravity is 4.575; hardness=5-5.5. It is readily soluble in hydrochloric acid. When heated over the Bunsen flame it decrepitates violently, and falls to powder upon being ignited over a blast, becoming snuff-brown, infusible and insoluble. These characteristics serve to at once distinguish it from gadolinite, which has specific gravity from 4.2 to 4.3 (Texas varieties), and which when heated glows vividly and swells into ragged fragments. The analysis shows several fractions of the yttria earths (A, B, C, D), which were separated by successive precipitations with sodium sulphate. The atomic weight of each fraction was determined, showing successive increase with each separation. The fractionation was discontinued after the fourth separation, as the amount of material was getting very small, but the atomic weight shows that the lanthanum and didymium are still mixed with an earth of higher atomic weight. The results obtained are as follows:

		Oxygen ratio.
SiO <sub>2</sub> .....	29.17 %	97.234 = 4
PbO .....	0.854	0.383
ThO <sub>2</sub> .....	12.00	9.108
MnO .....	0.77	1.084
FeO .....	2.89	4.014
CaO .....	0.60	1.071
Al <sub>2</sub> O <sub>3</sub> .....	0.55	1.617
Ce <sub>2</sub> O <sub>3</sub> .....	1.86	1.722
Atomic weight.		72.918 = 3
(A) Y <sub>2</sub> O <sub>3</sub> .....	22.67 = 110.3	25.320
(B) Y <sub>2</sub> O <sub>3</sub> .....	5.30 = 110.53	5.910
(C) Y <sub>2</sub> O <sub>3</sub> .....	4.50 = 114.9	4.860
(D) Y <sub>2</sub> O <sub>3</sub> .....	14.03 = 120.	14.616
(LaDi) <sub>2</sub> O <sub>3</sub> , etc. ....	2.94 = 162.	2.370
UO <sub>3</sub> .....	0.83	0.843
Ignition loss .....	0.79	
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99.754		

Total yttria earths = ... 46.50 % ... erbia spectrum distinct.

Regarding the loss by ignition as non-essential, the oxygen ratio of all the bases to silica is exactly 3:4, which leads to the formula  $R_2O_3, 2SiO_2$ , in which  $R_2O_3$  may be replaced by its equivalent in  $RO, RO_2$  or  $RO_3$ . There is no simple ratio between the sesquioxide and other bases. This mineral, therefore, differs from gadolinite in containing twice as much silica. It has other points of difference, viz: it contains no glucina, which has been regarded as a characteristic constituent of gadolinite, and there is a very large preponderance of sesquioxides among the bases. For comparison we append two analyses of gadolinite from this locality by Genth\* and Eakins.†

GADOLINITE, LLANO CO., TEXAS.									
Genth.		Sp. G. = 4.254			Eakins.		Sp. G. = 4.239§		
		Oxygen ratio.					Oxygen ratio.		
SiO <sub>2</sub> .....	22.80	76.00			23.79	79.30			
ThO <sub>2</sub> .....	---				0.58	0.44			
MnO .....	0.18	0.25			trace				
FeO .....	12.93	17.96			12.42	17.25			
AlO .....	9.19	36.61			11.33	45.18			
CaO .....	0.71	1.27	56.86		0.74	1.32	63.75		
MgO .....	0.11	0.27			traces				
K <sub>2</sub> O .....	0.12	0.13							
Na <sub>2</sub> O .....	0.23	0.37	116.11						
Al <sub>2</sub> O <sub>3</sub> .....	0.31	0.90							
Fe <sub>2</sub> O <sub>3</sub> .....	---	---			0.96	1.80			
Ce <sub>2</sub> O <sub>3</sub> .....	2.66	2.46	59.25		2.62	2.43	56.94		
(DiLa) <sub>2</sub> O <sub>3</sub> ..	5.01	4.59			5.22	4.77			
(Y,Er) <sub>2</sub> O <sub>3</sub> ..	44.45	51.30			41.55	47.94			
H <sub>2</sub> O .....	0.79				1.03				
P <sub>2</sub> O <sub>5</sub> .....	---				0.05				
Insoluble ..	0.93								
100.42					100.29				

Regarding the water and phosphoric acid as accidental and using the molecular weight for the yttria earths determined by Eakins (260) for the calculation of Genth's analysis, we get the oxygen ratio of all the bases to silica of 3.055:2 and 3.054:2 respectively, giving the general formula  $R_2O_3, SiO_2$ , in which  $R_2O_3$  may be replaced by its equivalent in  $RO$  and  $RO_2$ . Both of these analyses seem to show a tendency towards an equality of the sesquioxides to the monoxides, though there is a preponderance of sesquioxides in the one and of protoxides in the other. They differ also from our analysis of yttrialite in the small percentage of thoria, which in the latter amounts to one-eighth of the total bases in equivalency.

\* F. A. Genth, this Journal, September, 1889.

† L. G. Eakins, private communication from Professor F. W. Clarke.

‡ Molecular weight = 260.

§ At 17° C.

¶ Didymium spectrum very strong.

¶ Erbium spectrum weak.

*THORO-GUMMITE, a hydrated uranium thoro-silicate.*

This mineral, of which we have been able to gather about one kilo, occurs intimately associated with fergusonite and cyrtolite, and masses up to three ounces have been found, though for the most part it is in very small pieces. It is of a dull yellowish-brown color, has hardness above that of gummite, or 4-4.5, and occurs commonly massive, though several well defined groups of zircon-shaped crystals have been discovered with angles near to those of zircon. It has a characteristic color, after ignition, becoming of a dull greenish hue, thus it is distinguished from freyalite, eucrasite and thorite, which species it otherwise resembles in some respects. Its specific gravity varies from 4.43 to 4.54. It is easily soluble in nitric acid. The analytical results are :

		Oxygen ratio.	
SiO <sub>2</sub> .....	13.085	43.62 =	2.000
UO <sub>3</sub> .....	22.43	23.37 =	1.071
ThO <sub>3</sub> .....	41.44	31.22	} 43.64 = 2.001
Al <sub>2</sub> O <sub>3</sub> .....	0.965	2.83	
Fe <sub>2</sub> O <sub>3</sub> .....	0.845	1.59	
(CeY) <sub>2</sub> O <sub>3</sub> , etc..	6.69	6.30	
PbO .....	2.16	0.97	
CaO .....	0.41	0.73	} 43.78 = 2.008
H <sub>2</sub> O .....	7.88		
P <sub>2</sub> O <sub>5</sub> .....	1.19		
Moisture.....	1.23		
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98.325			

Regarding phosphorus as non-essential and as combined with the slight excess of uranium, above that which is required by the formula which we derive, and with the undetermined and lost constituents, we get the oxygen ratio of UO<sub>3</sub> : SiO<sub>2</sub> : ThO<sub>3</sub> : H<sub>2</sub>O = 1 : 2 : 2 : 2. The last three terms are in the proportion required by thorite, and we see that the molecule of the mineral may be regarded as made up of three molecules of thorite linked together by one of uranic oxide forming a compound molecule, which at first sight seemingly complex, is really of great simplicity.

Using graphic notation, the formula of the mineral is  $\overset{\text{VI}}{\text{UO}}_3(\overset{\text{VI}}{\text{ThOSi}})_3(\text{OH})_{12}$ , or when written in the usual manner UO<sub>3</sub>, 3ThO<sub>3</sub>, 3SiO<sub>2</sub>, 6H<sub>2</sub>O. The thoria and silica bear the same relation to the uranium, and it seems better to regard the mineral as a hydrated thoro-silicate of uranium, rather than as a urano-silicate of thorium, or as a double silicate of uranium and thorium, if indeed we might not go further and consider the whole as a duo-deci-atomic molecule of a complex inorganic

acid. We name this mineral *thoro-gummite*, because it is a gummite in which the water has been replaced by the thorite molecule.

*NIVENITE, a hydrated thorium-yttrium-lead uranate.*

This mineral we found intimately associated with fergusonite and thoro-gummite. It is as yet a rare mineral at the locality. Its specific gravity is 8.01.  $H.=5.5$ . It is velvet-black in color and when powdered becomes brown-black. After ignition it turns blue-black. As yet only massive pieces have been found, but some of these suggest that the species may be isometric in crystallization. It is easily soluble in nitric and sulphuric acids and some slight effervescence\* was noticed upon dissolving the mineral. The analysis gave the following results:—

			Oxygen ratio.
UO <sub>3</sub> .....	46.75		48.69 = 12.
UO <sub>2</sub> .....	19.89		14.62
ThO <sub>2</sub> .....	7.57		5.74
Y <sub>2</sub> O <sub>3</sub> , etc. ....	11.22	Atomic weight 124.2	11.34
Fe <sub>2</sub> O <sub>3</sub> .....	0.58		1.08
PbO .....	10.16		4.55
(Ignition) loss H <sub>2</sub> O	2.54		
Insoluble .....	1.22		14.11 = 3.48
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	99.93		

The ratios found lead to the general formula 9RO, 4UO<sub>3</sub>, 3H<sub>2</sub>O in which RO may be replaced by its equivalent in R<sub>2</sub>O<sub>3</sub> and RO<sub>2</sub>. If the iron be calculated as protoxide and a corresponding increase be made in the amount of uranic oxide, the ratio for UO<sub>3</sub>:RO:H<sub>2</sub>O becomes 12:8.74:3.40. As it is not possible to determine the state of oxidation of the iron in presence of the two oxides of uranium, by any process known to us, we cannot give the exact ratio, as it exists, but would point out that if only 0.33 per cent of ferric oxide is present and the rest of the iron is present as protoxide, then the ratio of UO<sub>3</sub> to bases will be exactly that which is required by the formula.

This mineral is allied to the rare species cleveite† and bröggerite,‡ and we give below the analyses with the formulæ which we have calculated from them, so that the points of distinction may be made evident.

\* Cf. Hillebrand, who has identified nitrogen in uraninite. This Journal, Oct., 1889, p. 329.

† Dana's Appendix, III. p. 28.

‡ This Journal, June, 1884, p. 493.



CLEVEITE.			BRÖGGERITE.		
Specific Gravity = 7.49.		Oxygen Ratio.	Specific Gravity = 8.73.		Oxygen Ratio.
UO <sub>3</sub> ....	42.04%	43.79	38.82%		40.44
UO <sub>2</sub> ....	23.89	17.56	41.25	30.33	34.61
ThO <sub>2</sub> ..	4.76	3.61	5.64	4.28	
Y <sub>2</sub> O <sub>3</sub> ..	6.87	9.03	2.42	3.18	
Er <sub>2</sub> O <sub>3</sub> ..	3.47	2.73			44.18
Ce <sub>2</sub> O <sub>3</sub> ..	2.33	2.16	0.35	0.33	
Fe <sub>2</sub> O <sub>3</sub> ..	1.05	2.00			
FeO .....	---	20.99	1.26	1.75	9.57
CaO .....	---		0.30	0.54	
PbO .....	11.31		8.41	3.77	
SiO <sub>2</sub> .....	---	23.78	0.81	2.70	4.61 (neglect)
H <sub>2</sub> O .....	4.28		0.83		
100.00			100.09		

In the bröggerite analysis a small amount of silica occurs, which if supposed to exist as admixed silicate will reduce the excess of basic oxygen. Neglecting the water in bröggerite the oxygen ratio for these minerals will be therefore :—

	Bases.		UO <sub>3</sub>	H <sub>2</sub> O
	RO <sub>2</sub> (R <sub>2</sub> O <sub>3</sub> RO)			
Clevéite,	1	1	2	1
Bröggerite,	2	1	1	

The comparison of the three formulæ shows the relationship clearly (RO including RO<sub>2</sub> and R<sub>2</sub>O<sub>3</sub>), as follows :—

Bröggerite	3RO, UO <sub>3</sub> .
Clevéite	6RO, 2UO <sub>3</sub> , 3H <sub>2</sub> O.
Nivenite	9RO, 4UO <sub>3</sub> , 3H <sub>2</sub> O.

We have named this mineral *nivenite*, in recognition of the energy which Mr. Niven has displayed at this locality, and the assistance which he rendered us in obtaining the material for investigation.

#### FERGUSONITE.

This heretofore rare mineral occurs in large quantity at this new locality. Up to this date we have received over seventy kilos, some masses of which weighed over a pound. Broken prisms, rough in form, rarely showing terminal planes and masses of crystals interlacing each other is the manner of occurrence. The immediately associated minerals are cyrtolite and thoro-gummitite and also magnetite. The gadolinite also sometimes encloses it. It also occurs alone in a matrix of orthoclase or of quartz. One large mass of this kind of gangue, upon being broken up, yielded over thirty kilos of pure mineral in the form of fragments, most of which were basal sections of crystals which had been originally four to eight inches long and about 1½<sup>cm</sup> thick.

We have found two distinct varieties, of which we here append analyses and description.

*Fergusonite, mono-hydrated*.—Specific gravity=5.67. Hardness 6–6.5, forms tetragonal, with acute octahedral terminations, a zirconoid plane hemihedrally developed and, rarely, the basal pinacoid. The crystals are rough and dull gray exteriorly but with a bronzy sub-metallic appearance on the surface of fracture, which is small conchoidal and brilliant. Thin splinters show a yellowish-brown translucence. Color bronzy hair-brown. Streak and powder dull brown. It is infusible but on ignition the powdered mineral changes to a pale olive-green color, and a momentary glow creeps over the mass at the point of redness. Fragments decrepitate violently when heated. With a microscope a peculiar light brown muddiness is noticed and the mineral is filled with minute streaks and spots of a darker shade, all of which may indicate incipient alteration.

Crystals often have a thin coating of, or are otherwise partly altered to, the tri-hydrated variety next described. It is decomposed when in fine powder by hydrochloric acid, with separation of columbic acid. The analytical results are as follows.

		Oxygen ratio.	
Cb <sub>2</sub> O <sub>5</sub> .....	46.27%		86.30
UO <sub>3</sub> .....	1.54		1.59
ThO <sub>2</sub> .....	3.38	2.56	} 52.65
Al <sub>2</sub> O <sub>3</sub> .....	0.09	0.27	
Fe <sub>2</sub> O <sub>3</sub> .....	0.98	1.83	
(A) Y <sub>2</sub> O <sub>3</sub> * .....	23.95	110.55	
(B) Y <sub>2</sub> O <sub>3</sub> * .....	18.38	113.3	} 15.79
PbO .....	1.43	26.70	
ZnO .....	0.24	20.07	
CaO .....	0.10	0.64	
MgO .....	0.04	0.30	} 15.79
Ignition H <sub>2</sub> O .....	1.98	0.18	
110° C. H <sub>2</sub> O .....	0.04	0.10	
F .....	0.91	11.00	
		Atomic ratio, 4.79	
	99.33		
Less O = F .....	0.38		
	98.95		

Counting UO<sub>3</sub> as combined with a portion of the bases in the proportion R<sub>2</sub>O<sub>3</sub>–UO<sub>3</sub>, we have for the oxygen ratio of the other constituents, counting fluorine as replacing hydroxyl,

$$\text{Cb}_2\text{O}_5 : \text{R}_2\text{O}_3 : \left(\frac{\text{H}_2\text{O}}{\text{F}}\right) :: 86.30 : 51.06 : 15.79 \text{ or } 5.07 : 3 : 0.928$$

This leads to the formula Cb<sub>2</sub>O<sub>5</sub>, R<sub>2</sub>O<sub>3</sub>, H<sub>2</sub>O; or if bases are counted as RO then R<sub>5</sub>Cb<sub>2</sub>O<sub>7</sub>(OH, F)<sub>2</sub>.

\* Total Y<sub>2</sub>O<sub>3</sub>, etc., and Ce earths = 42.33.

We tested the columbic acid for titanio acid and tin, but although we obtained small quantities of precipitates they proved to be largely if not altogether columbic acid, and we did not detect the presence of any other substance. Tantalio acid was not looked for.

FERGUSONITE, tri-hydrated.—Specific gravity = 4.36–4.48; hardness about 5. Color deep brown, almost black, thin edges show a yellowish-brown translucence. Form and exterior appearance same as the species previously described. Streak and powder pale greenish-gray. On ignition turns light-brown but does not glow nor decrepitate like fergusonite. Is decomposed by hydrochloric acid with separation of columbic acid.

ANALYSIS.		Oxygen ratio.	
Cb <sub>2</sub> O <sub>3</sub> .....	42.79		79.95
UO <sub>3</sub> .....	3.12		3.24
UO <sub>2</sub> .....	3.93	2.90	} 51.08
ThO <sub>2</sub> .....	0.83	0.62	
Al <sub>2</sub> O <sub>3</sub> .....	0.85	2.49	
Fe <sub>2</sub> O <sub>3</sub> .....	3.75	7.03	
Y <sub>2</sub> O <sub>3</sub> , etc. ....	31.36	32.28	} 44.69
PbO.....	1.94	0.87	
CaO.....	2.74	4.89	
Ignition H <sub>2</sub> O.....	7.57	42.05	
110° C. H <sub>2</sub> O.....	0.62	----	
F.....	0.502	Atomic ratio, 2.64	
	100.002		
Less O = F.....	0.206		
	99.796		

Combining UO<sub>3</sub> as before with bases to form R<sub>2</sub>O<sub>3</sub>, UO<sub>3</sub>, the oxygen ratio of the remainder will be

$$\text{Cb}_2\text{O}_3 : \text{R}_2\text{O}_3 : \left(\frac{\text{H}_2\text{O}}{\text{F}}\right) = 79.95 : 47.84 : 44.69 \text{ or } 5 : 2.992 : 2.795$$

This gives the formula Cb<sub>2</sub>O<sub>3</sub>, R<sub>2</sub>O<sub>3</sub>, 3H<sub>2</sub>O, or counting bases as RO then R<sub>3</sub>Cb<sub>2</sub>O<sub>3</sub>(OH, F)<sub>3</sub>. On comparing the properties of the two minerals here described with typical fergusonite we notice a gradation from the one extreme to the other.

		Specific G.	Hardness.	When heated.
Fergusonite	R <sub>3</sub> Cb <sub>2</sub> O <sub>3</sub>	5.838 (?)		
Mono-hydro-fergusonite	R <sub>3</sub> Cb <sub>2</sub> O <sub>3</sub> (OH) <sub>2</sub>	5.67	6.5	Pale olive-green, decrepitates.
Tri-hydro-fergusonite	R <sub>3</sub> Cb <sub>2</sub> O <sub>3</sub> (OH) <sub>3</sub>	4.36–4.48	5.	Light-brown does, not decrepitate.

Of other published analyses of fergusonite that of the Ytterby variety, by Nordenskiöld (Dana's System Min., p. 523), corresponds to the di-hydrated mineral. Since we find fluorine in the specimens we have analyzed from Texas, we are led to con-

clude that the water is not present as water of crystallization, but as hydroxyl which is partially replaced by the fluorine, and this being so we consider that the name fergusonite should be reserved for the anhydrous mineral, and that the various definite alteration products with two, four, six and perhaps more hydroxyls should be distinguished in some manner either by prefixing mono-hydro, di-hydro, etc., or by special names. It seems better that the first method of distinguishing them should be followed. We believe that we have observed a still higher alteration product in traces on some of the specimens we have obtained from Texas.

ALLANITE, has not as yet been found very abundantly at this locality and all of the ten kilos obtained was massive-nodular in form. Its surface alteration is very slight compared with that of the other allied minerals. Its color is shining pitchy-black. Powder and streak dull greenish-brown. Upon ignition it first turns red-brown and then becomes coal-black. It is opaque, except in the very thinnest splinters, when a greenish-brown translucence is evident. Specific gravity = 3.488. We have made no complete analysis as yet, but the specimen tested showed the presence of considerable quantities of the cerium-yttrium earths and of thoria, and we learned that it was completely soluble in acids with separation of gelatinous silica, either before or after igniting the mineral (like the associated gadolinite). The better masses have been found quite isolated from the other occurring minerals.

MOLYBDENITE, occurs sparingly in quite large folia, and in hexagonal tables, with the cyrtolite and fergusonite. Only a few ounces have been collected.

MOLYBDITE, was noticed in the cavities once occupied by molydenite and it often yet retained the plate-like form of the mineral from which it was derived by alteration. Its color was white to greenish-white. Specific gravity = 4.004. On two specimens indistinct crystals have been found, having a light apple-green color and almost perfect transparency. Qualitative tests have shown the absence of any large amounts of anything but molybdic acid.

CYRTOLITE, has been found abundantly in both massive form and in good crystallizations. One hundred kilos have thus far been collected while mining the yttria minerals already herein described. This mineral here occurs in thick plates attached to the biotite and also constituting veins in the coarse pegmatite. It is often the matrix of the thoro-gummite and fergusonite. Specific gravity = 3.652. It occurs in tetragonal forms with all the planes rounded, and polysynthetic groupings of crystals are very common. Its color ranges from dull gray, through various shades of brown to deep brown and

almost black. Hardness about 5. We shall defer further mention of this mineral until we have examined it more thoroughly.

FLUORITE, occurs in some abundance. Masses of a pale greenish kind were found weighing fifty pounds tightly embedded in the pegmatite. Purple and white shades have also been found. A very opaque dark-purple kind has been found in small masses. Its property of phosphorescing (green) when gently heated has given rise to a great local interest in this particular mineral.

GUMMITE, occurs sparingly, but we have not as yet been able to find it in a sufficiently pure condition for examination. Several varieties have been seen, and "yttro-gummite" is very probably one of them.

TENGERITE (?)—In the cracks and fissures of the gadolinite and yttrialite a white mineral rich in  $\text{CO}_2$  is often noticed. We have seen it in globular-radiated incrustations and in one instance in distinct transparent isolated crystals. Dr. Genth has already noted its occurrence and, as he observes, there is not enough now obtainable to show its composition except by qualitative tests.

FETID GAS.—Upon breaking some of the cyrtolite, while at the mine, a fetid odor, quite different from  $\text{H}_2\text{S}$ , was noticed. Simply rubbing two massive specimens together is sufficient to develop this very disagreeable smell.

In conclusion, we take this opportunity to thank Mr. Baringer, for his kind attentions and generous services extended to Mr. Niven and to one of us while visiting this very interesting locality.