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BRANNERITE, A NEW URANIUM MINERAL.*

BY

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United States Geological Survey.

IN 1915 S. M. Ballard sent to one of the writers a highly radioactive mineral that had been obtained from gold placers worked by Henry Sturkey in Stanley Basin in the central part of Idaho. Later other material was sent to the Survey by Mr. Sturkey. Mr. Sturkey's placer is near the head of Kelley Gulch, said to be in granite cut by pegmatites, and it is in the pegmatites that the source of the mineral is probably to be found.

In 1916 Robert N. Bell published a half-tone of a radiograph¹ made with the mineral by A. G. Van Eman, who thought it to be euxenite, with which it is related in composition and which it resembles in color and texture.

The mineral received is in grains, part of which are prisms and most of which show a prismatic tendency (see Fig. 1). They are a brownish yellow on the outside but the visible weathering has extended to a depth not exceeding the thickness of paper. Inside they are brilliant black, with a conchoidal fracture and no sign of cleavage. Polished specimens examined under reflected light show the mineral to be remarkably homogeneous. It is, however, traversed by minute cracks that are in part filled by quartz that undoubtedly accounts for the SiO_2 in the analysis. Although to the eye the mineral is an opaque black, under the microscope very thin chips allow sufficient yellowish green light to pass to make possible optical measurements. The streak is a dark greenish brown. The hardness is about 4.5 as the mineral will scratch apatite but will not scratch orthoclase.

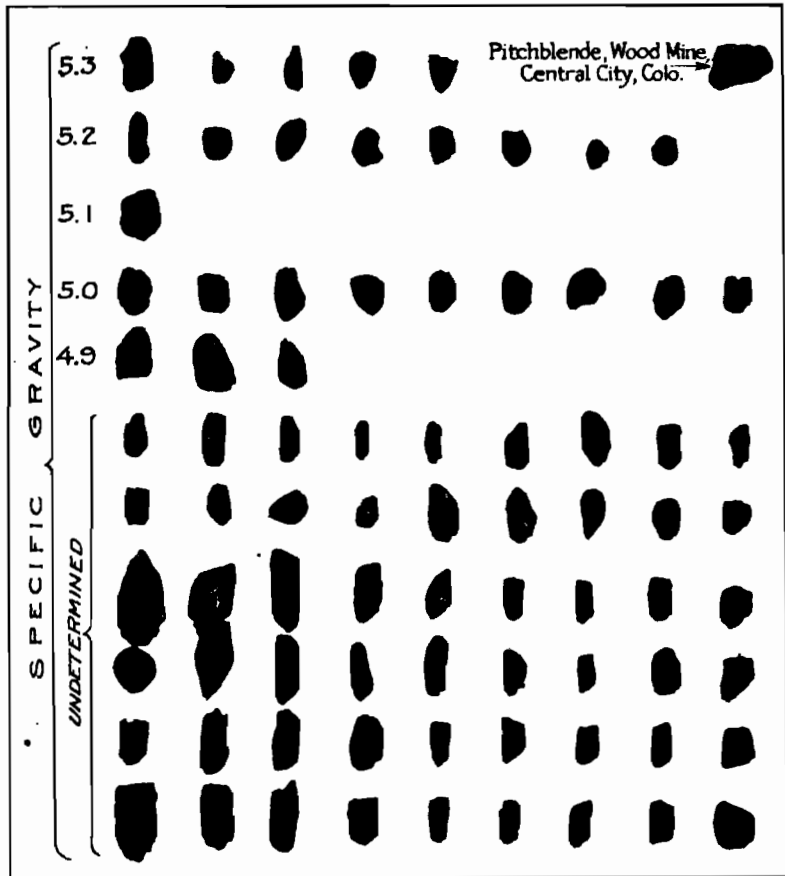
The crystals are not perfect enough to allow a determination of the crystal form, but their shapes suggest that they may be orthorhombic or tetragonal. However, E. S. Larsen determined it to be isotropic with an index of $n_{11} = 2.26 \pm 0.02$ and $n_{N_A} = 2.30 \pm 0.02$. It seems probable that it is an isometric paramorph after either a tetragonal or an orthorhombic form as many of the

* Published by permission of the Director of the United States Geological Survey.

¹ Sixteenth Ann. Rept. Mine Inspector of Idaho (1915), Boise, pp. 29, 30.

complex pegmatitic uranium minerals seem to be. It will be noted in the tables given on other pages of this article that all but one of the minerals (hielmite) are isotropic. Yttrocrasite shows birefringent particles and is probably a mixture. Also like

FIG. 1.

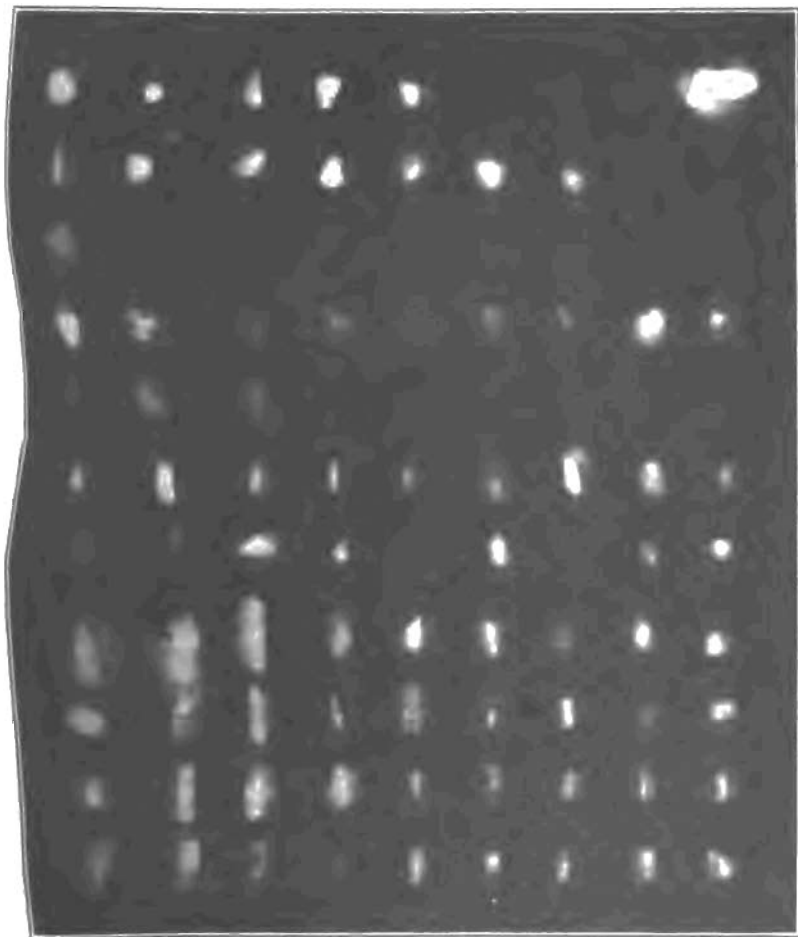


Brannerite pebbles and a piece of pitchblende mounted on a card to test comparative radioactivity. Slightly reduced. See figure on opposite page.

nearly all of the complex pegmatitic minerals, the new mineral is variable in composition and the specific gravity of the specimens tested ranged from 4.5 to 5.43, as determined with the Joly balance. The specimens analyzed had a specific gravity of 5.42 (by pycnometer).

The radioactivity of the specimens of different specific gravities showed slight differences as tested by the exposure of a

FIG. 2.



Radiograph made by the minerals shown in figure 1. They were mounted on thin cardboard which was laid on the sensitive film of a photographic plate for 48 hours. A print was photographed through a prism in order to make comparison easier.

photographic plate. Those having the highest specific gravity appeared most active (see Fig. 2). The material was not tested in an electroscope. Attention may be called to the advantages of making a radiograph of various specimens in a case of this

sort before proceeding with the analysis, as it may be seen from Fig. 2 that some of the pieces were comparatively inactive, and pieces with a like content of uranium or thorium, or both may be readily selected. Two of the least active pieces from the seventh row (Fig. 2) gave on analysis 35.0 per cent. TiO_2 compared with 39.0 per cent. in the best material.

If in quantity the mineral would be of value as a source of radium, but probably only a few pounds could be obtained even at a prohibitive cost.

CHEMICAL ANALYSIS.

Our thanks are due to Mr. W. C. Wheeler for preliminary chemical determinations on the mineral. Mr. Wheeler established the presence of uranium and suggested the separation of titanium and uranium by hydrolysis, as finally carried out.

The mineral is slowly decomposed by treatment with concentrated sulfuric acid, or by hydrofluoric and sulfuric acids. It is more convenient, however, to bring it into solution by gentle fusion with acid sodium sulfate. On dissolving the melt in cold water, or dilute sulfuric acid, there remains a small residue consisting of silica, unattacked mineral, and sulfates of lead, barium and strontium, which was analyzed separately.

Various methods of analysis were tried, using principally the acid sulfate solution, but the unusual association of elements made the analysis largely a process of successive approximations. Each precipitate obtained was tested for impurities and if an admixture was found the method of analysis was modified accordingly.

It was thought at one time that the ammonium carbonate treatment could be relied on to separate the main constituents, uranium and titanium, but so much titanium was carried into the filtrate with the uranium in this process that it was decided to separate the titanium by hydrolysis. The precipitate and filtrate were then further analyzed separately.

For the hydrolytic separation of titanium the sulfate solution was treated with hydrogen sulfide, neutralized, freed from hydrogen sulfide with a stream of carbon dioxide, and finally diluted and boiled after the addition of considerable ammonium sulfate.²

In one analysis 3.1 per cent. of rare earths was found in the titanium separated as described and 5.0 per cent. in the uranium

² Hillebrand, W. F., U. S. Geol. Survey, Bull. 422, 137 (1910).

portion. In another analysis the total rare earths separated directly, first as fluorides and finally as oxalates, amounted to 8.0 per cent.

The filtrate from the titanium was precipitated twice with ammonium hydroxide, leaving calcium in solution. The hydroxides were dissolved in hydrochloric acid, evaporated nearly to dryness, taken up in hydrofluoric acid and the rare earths filtered off. After removing hydrofluoric acid with sulfuric acid, precipitating with ammonia, and dissolving the hydroxides in nitric acid, the remaining elements, chiefly uranium, were subjected to the ammonium carbonate treatment and uranium was finally separated and weighed as pyrophosphate.

The stage of oxidation of the uranium in the mineral was determined separately by decomposition with dilute sulfuric acid in a closed glass tube containing carbon dioxide at 225° C. and subsequent titration with potassium permanganate. It was assumed in calculating the proportion of UO_2 that all the iron of the mineral was in the ferrous condition. The only ground for this assumption is the fact that iron is more easily reduced than uranium, so that the existence of any uranous oxide would imply the absence of ferric oxide. However, the state of oxidation of the iron cannot be regarded as determined. The coating on the grains contained some ferric oxide which could only be removed by carefully chipping off the exterior and selecting the jet black pieces. A determination of iron as Fe_2O_3 on unselected material gave 3.7 per cent., whereas the value obtained on the best selected material was 3.0 per cent., or 2.7 per cent. FeO . Iron seems to be an essential constituent of the mineral. In the extended analysis iron had to be determined in the titanium portion, in the ammonium carbonate precipitate, and in the uranium precipitate.

Thorium was determined in the mixture of rare earths by the sodium thiosulfate method. The ignited oxide was white, and pure as far as could be determined. The yttrium earths were estimated by their solubility in a solution of sodium sulfate. They were a buff color after ignition and gave by conversion of the oxides to sulfates, an average atomic weight of 151, a weight so great that probably erbium or ytterbium or both are present. Lack of time prevented a thorough investigation of the rare earths. No cerium earths could be detected. Water and carbon dioxide were weighed in absorption tubes after heating the min-

eral in a boat in a hard glass tube in a current of dry air. A small correction was applied based on the results of blank determinations run similarly. No magnesium, tin, tungsten, tantalum, columbium, molybdenum, vanadium, copper, or fluorine could be detected.

An attempt was made to heat the mineral, mixed with carbon, in a stream of chlorine and make a fractional condensation of the volatile chlorides. A complete separation of the uranium and titanium was not accomplished, but the non-volatile residue in the boat was found to contain calcium, rare earths chiefly of the yttrium group, iron, and a little uranium.

An attempt was also made to detect helium but without success. On heating 5 grammes of the mineral with acid sodium sulfate in a vacuum a few cubic centimetres of gas were obtained—largely sulfur dioxide, which was probably generated by the action of the UO_2 on the sulfuric acid. Nearly all of the gas was soluble in a solution of sodium hydroxide and what remained gave only nitrogen lines, as far as could be determined, when examined in a Pluecker tube.

The various determinations led to the following results:

Composition of the Mineral from Stanley Basin.

(R. C. Wells, analyst.)

	Per cent.	Molecular values.
SiO_2 .....	.6.....	.010
TiO_2	39.0.....	.488
FeO	2.9.....	.040
CaO	2.9.....	.052
UO_2	10.3.....	.038
UO	33.5.....	.116
ThO_2	4.1.....	.015
Ce_2O_3	none	
Yt_2O_3 , etc. ¹	3.9.....	.011
ZrO_2 .....	.2.....	.001
PbO} .....	.2.....	.001
BaO} .....	.3.....	.002
SrO} .....	.1.....	.001
H_2O	2.0.....	.111
CO_2 .....	.2.....	.005
Fe_2O_3 , Al_2O_3 , P_2O_5	trace	
	—	
	100.2	

Specific gravity, 5.42.

¹ Average molecular weight 350.

CALCULATION OF FORMULA

The following combinations in molecular values seem logical:

FeO	.040	.....	UO ₃	.038	.....	CO ₂	.005
CaO	.052	.....	ThO ₂	.015	.....	SiO ₂	.010
BaO	.002	.....	ZrO ₂	.002	.....	TiO ₂	.488
SrO	.001	.....				
PbO	.001	.....		.055	.....		.503

	.096						

This leaves Yt₂O₃ = 0.011, UO₃ = .116, and H₂O = .111 ungrouped. On this basis the mineral may be simplified to:

RO	.....	.096	.....	8.7
Yt ₂ O ₃	.....	.011	.....	1.0
RO ₂	.....	.055	..... or	5.0
UO ₃	.....	.116	.....	10.5
TiO ₂	.....	.503	.....	45.7
H ₂ O	.....	.111	.....	10.1

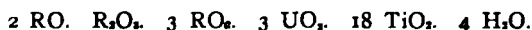
Without any further combination this yields the following approximate formula:



The figures for RO and UO₃ are not very near whole numbers, but this need cause no disappointment as the whole calculation rests on the assumption that the iron is in the ferrous condition. Although this assumption has certain analogies to support it and is given preference, it would not be entirely unreasonable to assume that part or all of the iron is in the ferric condition. The question cannot be settled experimentally in the presence of uranium in two stages of oxidation. If all of the iron is assumed to be present as ferric iron the following percentages and molecular values are obtained in place of those first given:

	Per cent.	Molecular values.
FeO	..... None —
Fe ₂ O ₃	..... 3.2	..... .020
UO ₃	..... 18.4	..... .068
UO ₄	..... 25.1	..... .089

Appropriate grouping now leads to the approximate formula:



The bases are apparently present as titanates, metatitanates, or uranotitanates, but an exact evaluation of the relative pro-

portions of these compounds is obviously very difficult and hardly appears practicable in view of the uncertainty concerning the stage of oxidation of the iron and uranium. There is more TiO_2 present than is required to form normal titanates of all the bases, but not enough to form metatitanates without taking some uranium as the basic radicals UO and UO_2 . To secure an exact balance any excess of TiO_2 may be reduced to the form of a titanyl metatitanate $\text{TiO} \cdot \text{TiO}_3$.

The results below are presented for illustration as one of the possibilities along this line with little to recommend it over others that could be given.

Oxide	Molecular value	Metatitanate	TiO_2 required
RO} .....	.096	R TiO_3 .....	.096
Yt_2O_3 .....	.011	$\text{Yt}_2(\text{TiO}_3)_3$ .....	.033
ThO_2 .....	.016	$\text{Th}(\text{TiO}_3)_2$ .....	.032
ZrO_2 .....	.001	$\text{Zr}(\text{TiO}_3)_2$ .....	.002
UO_2 .....	.038	UO TiO_3 .....	.038
UO_3 .....	.116	$\text{UO}(\text{TiO}_3)_2$ .....	.232
TiO_2 .....	.070	TiO TiO_3 .....	.070
			.503

On this basis the mineral may be represented as a hydrated metatitanate of various bases, thus: $(\text{Ca}, \text{Fe}, \text{UO}, \text{TiO})\text{TiO}_3 + (\text{Th}, \text{Zr}, \text{UO})(\text{TiO}_3)_2 + \text{Yt}_2(\text{TiO}_3)_3 + \text{H}_2\text{O}$. Without implying exact molecular ratios the proportions of these four species would be about 6, 8, 1, 3, respectively. It should be remembered, however, that the stage of oxidation of the iron is unknown and this ignorance introduces uncertainty in these proportions. Nor is it known whether minerals of this kind should be considered as mixed crystals, solid solutions, or salts of complex acids, although in one of these suppositions may lie the correct explanation of their composition.

Analyses of the known complex uranium minerals have been arranged in the tables following so that the uranium content increases progressively toward the end of the series. The newly described mineral from Idaho is designated as *brannerite*.

It will be seen that the new mineral contains more uranium than any other except the pitchblendes. Unlike most of the others it contains no tantalum or columbium and is very high in titanium.

Comparative Analyses of the Complex Uranium Minerals.
(Arranged in the order of their uranium content.)

Name	Risö-rite	Yttria-lite	Zirke-lite	Micro-lite	Yttranta-lite	Yttrocras-ite	Prior-ite	Nae-gite	Sipy-lite
Page, Dana's System	App. 3, p. 68	512	App. 1, p. 75	728	739	App. 2, p. 112	App. 2, p. 17	App. 2, p. 73	731
Analyst	O. Hauser	J. B. Mackintosh	G. T. Prior	Dunnington	Rammelsberg	C. H. Warren	G. T. Prior	Haga	W. G. Brown
Crys. Form*	Isot.	Isot.	I	I	O	O	O	T	T
Isot. or bif.†	Isot.	Isot.	Isot.	Isot.	Isot.	Isot to bif.	Isot.	Isot.	Isot.
Indices	2.05	1.758	2.19	1.930	2.15	2.13	1.818	2.06	2.06
Sp. G.	4.00	4.575	4.741	5.656	5.425	4.8043	4.09	4.89	4.89
Ta ₂ O ₅	36.21			68.43	46.25	Trace	36.68	7.69	48.66
Cb ₂ O ₅	6.00		14.95	7.74	12.32	Present	49.72	21.89	
TiO ₂	Undet.		1.40		1.61		1.98	0.49	3.47
UO ₂		0.83		1.59			0.64	2.14	3.03
Ce ₂ O ₃	2.88	2.94	2.52	0.17	2.22		2.92	4.32	1.37
(Di, La) ₂ O ₃		46.50	0.21	0.23	10.52				7.98
Y ₂ O ₃	36.28				6.71	25.67	17.11	9.12	27.94
Er ₂ O ₃	Undet.	12.00	7.31			8.75	0.61	5.01	
ThO ₂			52.89					55.30	2.09
ZrO ₂	1.93	0.60	10.79	11.80	5.73	1.83	4.12		2.61
CaO			0.22	1.01		Trace	0.22		0.05
MgO	Undet.			0.30	2.36	1.87			0.16
WO ₃	2.61	2.89	7.72	1.05	1.12		0.29		0.08
SnO ₂	1.20				3.80		5.63		2.04
FeO		0.77		0.29		1.44			Trace
MnO	Undet.	0.85				0.13	0.19		
PbO	7.11	0.79	1.02	1.17	6.31	0.48	3.69		3.19
H ₂ O	0.90					0.10			Trace
H ₂ O + X	0.81	0.55		0.13		0.68			
Al ₂ O ₃		39.17				Trace	2.12	20.58	
SiO ₂				2.86					0.16
Na ₂ O				0.29					0.06
K ₂ O				2.85					Trace
F				0.34					0.62
BeO									
	99.93	99.75	99.03	100.25	98.95	100.57	99.50	100.73	100.48

* A, amorphous; I, isometric; O, orthorhombic; T, tetragonal.
 † Isotropic or birefringent. Most of the determinations of optical properties are by E. S. Larsen and were not made on type material.
 ‡ (Ce, La, Nd)₂O₃
 § N₂, He
 ¶ At. wt. 162.
 / Y earths
 A. 22.67 per cent., at. wt. 110.3
 B. 5.30 per cent., at. wt. 110.53
 C. 4.50 per cent., at. wt. 114.9
 D. 14.03 per cent., at. wt. 129.
 # Ignition
 † (Ce, Di)₂O₃
 ‡ CO₂
 § Ta₂O₅ abt. 2 per cent.
 ¶ UO
 † Y₂O₃ abt. 1 per cent.
 ‡ Li₂O

Comparative Analyses of the Complex Uranium Minerals.—Continued.

(Arranged in order of their uranium content.)

Name	Near Samarakite	Hielmite	Blomstrandine	Pyrochlore	Fergusonite	Near Samarakite	Vietinghofite	Wülkite	Delorenzite
Page, Dana's System	740	741	App. 2, p. 17	726	730	740	740	App. 3, p. 85	App. 2, p. 34
Analyst	Hillebrand	A. E. Nordenskiöld	C. W. Blomstrand	Rammelsberg	W. H. Seamon	W. F. Hillebrand	A. Damour	Holmquist	J. Sterba
Crys. Form		O	O	I	T	(?)	A	O	O
Isot. or bif.		uniaxial (?)	Isot.	Isot.	Isot.			Usually isot.	
Indices		$\omega=2.30$ 1.1 $\epsilon=2.40$ 1.1	2.14	1.96	2.19				
Sp.G.	6.18	5.82	4.82	4.22	5.6	6.18	5.53	3.8-4.8	4.7
Ta ₂ O ₅	27.03		4.93		4.08	19.34			
Cb ₂ O ₅	27.77	62.42	1.15	58.27	43.78	27.50	51.00	23.67	
TiO ₂	"		23.35	5.38			1.84	29.58	66.03
UO ₂	4.02	4.87	5.35	5.53 ^a	5.81		8.85 ^d	1.86	9.87 ^m
UO ₃						6.20		7.37	
Ce ₂ O ₃	0.54	1.07		5.50	0.66	0.41			
(Di, La) ₂ O ₃	1.80		2.48		3.49	1.44	1.57		
Y ₂ O ₃	6.41	5.19			37.21	5.64	6.57	4.06	14.63
Er ₂ O ₃	10.71		25.62			9.82			
ThO ₂	3.64		4.28	4.96		3.19			
ZrO ₂	2.29 ^a		1.33			3.10 ^a	0.96		
CaO	0.27	4.26	1.80	10.93	0.65	1.61		4.86	
MgO		0.26	0.15			0.11	0.83		
WO ₃	2.25					5.51			
SnO ₂	0.95	6.56	0.18		0.76	0.82			4.33
FeO	0.32	8.06	1.43	5.53	1.81	0.39	23.00		4.25 ^m
Fe ₂ O ₃	8.77					8.90		7.51	
MnO	0.78	3.32	0.30			0.77 ^a	2.67	1.28 ^a	
PbO	0.72		0.84			1.07			
H ₂ O	1.58	3.26	2.56		1.62	3.94	1.80 ^d	11.06	
X	0.29 ^b	0.10 ^c	0.49 ^d	5.28 ^e				10.55 ^f	
Na ₂ O			0.90	5.31		0.36 ^g			
K ₂ O	0.17		0.18						
	100.31	99.37	99.78	101.16	99.87	100.18	99.09	101.80	99.11

^a Includes some TiO₂

ZnO..... 0.05

(Li, Na)₂O..... 0.24

CuO..... 0.00

^d ZnO..... 0.00SiO₂..... 0.40^e FeO and UO..... 1.53^f Ignition..... 3.75^g MnO and ZnO^h (K, Li, Na)₂Oⁱ U₂O₃^j Ignition^k Mn₂O₄^l Precipitated by H₂S..... 1.06Al₂O₃..... 2.74SiO₂..... 8.75^m State of oxidation not determined.

Comparative Analyses of the Complex Uranium Minerals.—Continued.

(Arranged in the order of their uranium content.)

Name	Euxenite	Euxenite	Samar-skite	Plum-bonio-bite	Noh-lite	Alter-ed Sam-arskite	Hatch-etto-lite	Anne-rödite	Ampan-ga-béite
Page, Dana's System	*	744	739	App. 3, p. 61	740	740	727	741	App. 3 p. 3
Analyst		Rammelsberg	Koenig	Hauser and Finkh A	Norden skiöld	W. H. Seamon O	O. D. Allen	C. W. Blomstrand O	Pisan
Crya. Form	O	O	O		Mas-sive		I		O?
Isot. or bif.	Isot.	Isot.	Isot.				Isot.		Isot.
Indices	2.24	2.24	2.10				1.98		2.13
Sp.G.	4.99	5.103	5.96 6.20	4.801 4.813	5.04	4.33	4.77	5.7 ¹	3.97 4.29
Ta ₂ O ₅	13.89			1.18			29.83		8.90
Cb ₂ O ₅	12.73	33.39	56.40 ^a	46.15	50.43	47.09	34.24	48.13	34.80
TiO ₂	27.70	20.03		1.20			1.61		4.90
UO ₃	10.50 ^b	12.12	13.48	13.72	14.43 ^b			16.28 ^c	19.40
UO ₂						15.15	15.50		
Ce ₂ O ₃	0.62 ^a	3.50			0.25	1.40		2.56	
(Di, La) ₂ O ₃			3.85			4.00			0.60
Y ₂ O ₃	25.64	14.60		14.26		13.46		7.10	
Er ₂ O ₃		7.30	11.90		14.36				4.00
ThO ₂	1.34			0.06				2.37	2.50
ZrO ₂				Trace	2.96			1.97	
CaO	0.09	1.36		3.05	4.67	1.53	8.87	3.35	1.50
MgO	0.12						0.15	0.15	
WO ₃						0.40			
SnO ₂				0.15			0.30	0.16	0.80
FeO	0.51	3.25	8.98	5.70	8.09	7.09	2.19	3.38	
Fe ₂ O ₃	2.63		1.66						8.60
MnO	Trace				0.28 ^d			0.20	
PbO	0.20			7.62			Trace	2.40	
H ₂ O	3.00	2.40	0.30	6.38	4.62	9.55	4.49	8.19	12.40
X	0.74 ^e			0.52 ^f	0.11 ^g			2.51 ^h	
Al ₂ O ₃			2.00	0.28				0.28	2.10
Na ₂ O		0.82					1.37	0.32	
K ₂ O							Trace	0.16	
	99.71	98.77	98.57	100.27	100.20	99.67	98.55	99.51	100.50

* Miller, Willet G., and Knight, Cyril W., Occurrence of euxenite in South Sherbrooke township, Ontario; *Am. Jour. Sci.*, vol. xlv, pp. 243-244, 1917. Name of analyst not given. Analysis made at Imperial Institute, London, England.

^b U₂O₅
^c (Ce, La)₂O₃ etc.
^d SiO₂
^e Sp.G., 5.77

^f Na, He 0.22
 CO₂ 0.19
 MnO 0.11
 CuO Trace
^g UO
^h MnO, MgO
ⁱ CuO
^j Anhydrous mineral
^k SiO₂
 Ignition

Comparative Analyses of the Complex Uranium Minerals.—Concluded.

(Arranged in the order of their uranium content.)

Name	Poly- crase	Sami- résite	Mack- intosh- ite	Blom- stran- dite	Pilbar- ite ^a	Betaf- ite	Bran- nerite	Pitch- blende	Urani- nite
Page, Dana's System.....	745	App. 3, p. 69	App. 1, p. 44	746				891	891
Analyst.....	Mack- intosh	Pisani	Hille- brand	Lind- ström	Simp- son	Pisavi	Wells	Hille- brand	Hille- brand
Crys. Form.....	O	I	T	Mas- sive	A	I		I	I
Isot. or bif.	Isot.	Isot.	Isot.	Isot.	Isot.	Isot.	Isot.	Opaque	Opaque
Indices.....	1.70	1.94	1.77	2.14	1.74	1.92	2.30		
Sp.G.....	4.97	5.24	5.438	4.17	4.68	4.475	5.42	8.07	9.59
	5.04			4.25					
Ta ₂ O ₅		3.70		49.76	0.47	Trace			
Cb ₂ O ₅	19.37	45.80				32.10			
TiO ₂	28.51	6.70		10.71		17.30	39.0		
UO ₂		21.20	22.40	23.68 ^b			10.3	58.51	57.43
UO ₃	19.47				27.09	28.60	33.5	25.26	26.48
Ce ₂ O ₃			45.30 ^d		0.19			0.22	0.25
(Di, La) ₂ O ₃		0.20				1.20			0.13
Y ₂ O ₃	21.23 ^e		1.86 ^e		0.49		3.9 ^h		0.20
ThO ₂					31.34	1.25	4.1		9.79
ZrO ₂			0.88 ^g				0.2	7.59	
CaO.....	0.68		0.59	3.45	0.57	11.61	2.9	0.84	0.08
MgO.....			0.10	0.16	0.21				
SnO ₂		0.10							
FeO.....	2.47	1.06	1.15	3.33			2.0	0.32	
Fe ₂ O ₃	0.18				0.20	1.38	Trace		0.40
MnO.....				0.04	Trace	0.25		0.16	
PbO.....	0.46	7.35	3.74		17.26		0.2	0.70	3.26
H ₂ O.....	4.46	12.45 ^e	0.50	7.96	3.50	5.20	2.0	1.96	0.61
H ₂ O +			4.31		4.16				
H ₂					Trace			0.15 ^m	Undet.
X.....	0.12 ^b		0.67 ^f	0.12 ^a	1.08 ^f		0.6 ⁱ	1.45 ⁿ	0.70 ^p
Al ₂ O ₃		0.74		0.11	0.15	0.50	Trace		
SiO ₂	1.01		13.90		12.72		0.6	2.79	0.16
Li ₂ O.....			0.68						
Na ₂ O.....					0.04				
K ₂ O.....		0.30	0.42		0.09				
	97.96	99.60	96.50	99.32	99.56	99.39	100.2	99.95	99.49

^a At. wt. 114.1^b Insol.^c Ignition^d ThO₂, Ce₂O₃^e La₂O₃, Y₂O₃^f FeO^g UO^h Precipitated by H₂Sⁱ Simpson, Edward S., Pilbarite, a new mineral from the Pilbara Goldfield: *Jour. Nat. Hist. and Sci. Soc. of Western Australia*, vol. iii, p. 131, 1911.

Lacroix, A., "Minéralogie de la France et de ses Colonies," vol. v, pp. 93-94, 1913.

^j Mol. wt. 350^k BaO.....^l SrO.....^m CO₂.....ⁿ FeO.....^o Det. as N^p ZnO.....

FeO.....

As₂O₃.....CuFeS₂.....

FeS.....

0.3

0.1

0.2

Trace

0.44

0.22

0.43

0.12

0.24

The only other minerals having the same general qualitative composition are zirkelite and delorenzite, and to make comparison easier their analyses are repeated.

Analyses of Zirkelite, Delorenzite, and Brannerite.

	Zirkelite Isometric	Delorenzite Orthorhombic	Brannerite Undetermined
Specific gravity.....	4.741	4.7	5.42
TiO ₂	14.95	66.03	39.0 -
UO ₂	1.40	9.87 ^a	10.3 -
UO ₃.....	.....	.....	33.5 -
Ca ₂ O ₃	2.52	.....	.....
Y ₂ O ₃	0.21	14.63	3.9 -
ThO ₂	7.31	.....	4.1 -
ZrO ₂	52.89	.....	0.2 -
CaO.....	.....	.....	2.9 -
MgO.....	0.22	.....	.....
SnO ₂.....	.....	4.33	.....
FeO.....	7.72	4.25 ^a	2.9 -
PbO.....	.....	.....	0.2 -
H ₂ O ±.....	1.02 (ign.)	.....	2.0 -
Na ₂ O.....	10.79	.....	.....
SiO ₂.....	.....	.....	0.6 -
BaO.....	.....	.....	0.3 -
SrO.....	.....	.....	0.1 -
CO ₂.....	.....	.....	0.2 -
Fe ₂ O ₃}.....	.....	.....	} Traces
Al ₂ O ₃.....	.....	.....
P ₂ O ₅.....	.....	.....

^a State of oxidation not determined.

The uranium in zirkelite is almost negligible and the quantity of zirconium present puts it in a class by itself. The analysis of delorenzite makes the mineral appear almost suspiciously simple in composition, only five metals being determined, but the relationship to brannerite is closer than that of zirkelite. However, the quantity of uranium oxide is less than one-sixth that of the titanium oxide, but in brannerite the weight of uranium oxides is greater than that of titanium oxide and is more than four times as great as that in delorenzite.

The new mineral seems worthy of an individual name, and we therefore propose to call it brannerite after Dr. J. C. Branner, formerly head of the Department of Geology and Mining and President of Stanford University.

Brannerite may be described as a complex titanate of uranium with smaller quantities of rare earth and other metals, in which the weight of uranium oxides exceeds that of titanium oxide.