

TSCHERMIGITE, AMMONIOJAROSITE, EPSOMITE, CELESTITE, AND PALIGORSKITE FROM SOUTHERN UTAH

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INTRODUCTION

During the summer of 1927 Mr. Frank Haycock, of Panguitch, Utah, sent a lot of specimens to the United States National Museum for identification. These proved of such interest that additional material was requested and Mr. Haycock generously responded by sending a second lot. The minerals recognized were tschermigite, the rare ammonia alum, ammoniojarosite, a new member of the jarosite group in which ammonium oxide replaces the potash of jarosite, epsomite, celestite, and a mountain cork or paligorskite. Later another lot of specimens of the associated paligorskite and celestite was sent independently for identification by Mr. M. J. Proctor, also of Panguitch. These minerals have all been studied in the Museum laboratory and the results of the examinations are given below.

OCCURRENCE

Following preliminary examination of the minerals and their identification, a report was rendered the sender and he was asked to give the locality from which the material came. This was considered desirable before any detailed work was done on the minerals as the associated tschermigite and ammoniojarosite in lignitic shale were identical in appearance with the tschermigite and associated jarosite from Wamsutter, Wyo., described by Erickson¹ and it was thought that they might have been brought from the Wyoming locality. Mr. Haycock, in his reply, said that, inasmuch as he thought the deposit might have some commercial value, he did not wish to divulge its exact whereabouts until he had an opportunity to file mining claims to cover the occurrence. He assured me, how-

¹ E. Theodore Erickson. Tschermigite (ammonia alum) from Wyoming. *Journ. Wash. Acad. Sci.*, vol. 12, No. 13, pp. 49-54, 1922.

ever, that it was in southern Utah and thus about 300 miles, air line, from the Wyoming occurrence. His description of the occurrence is as follows:

The tschermigite and jarosite occur intermingled at the top of a butte on the top of a hard sandstone bluff 200 feet high. The mineral-bearing structure is approximately 100 feet high with a more or less rounded contour 1,500 feet in diameter. It is located 20 miles from the nearest good road * * *. Will say that this deposit lies on the western slope of the Kaibab (also called variously Pahreah, Potato Valley, or Kaiparowitz) fault. The top of the butte is covered with about 1 foot of the "egg-shell" stuff which is being sent you. Additional samples of the minerals are also being sent.

Of the samples received as associated material, the most abundant is a grayish clay which contains obscure fragments of what may be plant remains. This disintegrates in water in a manner suggesting that it is largely bentonitic in character. Scattered through the samples and intimately associated with the ammoniojarosite are some obscure fossils which were provisionally identified as *Ostrea glabra* and *Corbula perundata* by Dr. John B. Reeside. These fix the age of the beds as upper Cretaceous.

The paligorskite and celestite are inclosed in friable red sandstone similar to that of the Triassic "Red Beds."

DESCRIPTION OF THE MINERALS

TSCHERMIGITE

The ammonia alum, tschermigite, was first described by Beudaunt under the name "ammonalaun"² as occurring in fibrous veins in the lignite of Tschermig in Bohemia. The name tschermigite was given to the substance by von Kobell in 1853. Aside from the Tschermig locality and one in a mine at Dux, also in Bohemia, the mineral has been more recently described as occurring in cubic crystals at a mine in Brux, Bohemia, by Sachs.³ In all of the Bohemian localities the mineral is associated with lignitic coal. It has also been found as a volcanic sublimate at Mount Etna and at Solfatara at Puzzuoli.

The first American occurrence of the ammonium alum noted was 3 miles south of Wamsutter, Wyo. This material has been analyzed and described by Erickson.⁴ The mineral occurs in a 6-foot bed of lignitic shale and the ledge is traceable along the brink of the hills for nearly 3 miles. The tschermigite forms fibrous veins and cements shale fragments, nodules of yellow jarosite, and a few scattered gypsum crystals.

² Traite de Mineralogie, vol. 2, p. 497, 1832.

³ Centralbl. Mineralogie, 1907, p. 465.

⁴ E. Theodore Erickson. Journ. Wash. Acad. Sci., vol. 12, pp. 49-54, 1912.

The Utah mineral is so similar in appearance and associations to that from Wyoming that, were specimens from the two localities mixed it would be impossible to separate them. Like those described by Erickson the Utah specimens consist of fibrous veins up to 1 centimeter thick, of glassy transparent tschermigite cementing fragments of lignitic shale and nodules of yellow jarositic material. People familiar with the Wyoming specimens insisted that the Utah material must be from the same locality but, aside from the other evidence, this is disproven by the upper Cretaceous fossils in the Utah specimens. The Wyoming mineral occurs in the Wasatch formation of lower Eocene age and the tschermigite-bearing bed is immediately below the upper Eocene Green River shale.

The veinlets of Utah tschermigite seldom exceed 1 centimeter in thickness, and most of them are much thinner than this in the specimens at hand. The mineral is transparent, colorless, and glassy, with only an indistinctly fibrous structure or appearance, which is mostly due to canals or elongated cavities in one direction across the veins. Ample material was available for analysis. After washing with alcohol and drying in air a 2.5-gram sample was weighed out, dissolved in water, and filtered. The insoluble material was chiefly lignite, which was weighed after air-drying for several days. The solution, made up to definite volume, was divided into aliquot portions, each equivalent to one-half gram of sample. All constituents except water were determined on these portions. Ammonia was determined by the addition of an excess of potassium hydroxide and distilling the liberated ammonia into a measured volume of standard acid, the excess of acid being titrated with standard alkali in the usual manner. The other constituents were determined by the customary methods. The analysis gave the following results:

Analysis of tschermigite from Utah

(Earl V. Shannon, analyst)

	Per cent
Insoluble (lignite, etc.)	0.04
Al ₂ O ₃	11.86
Fe ₂ O ₃	Trace.
CaO	.10
MgO	.28
Na ₂ O	.48
K ₂ O	.25
(NH ₄) ₂ O	4.78
Cl	.04
SO ₃	35.78
H ₂ O above 110° C.	21.68
H ₂ O below 110° C.	25.16
	100.45

After standing a year in the laboratory the mineral is still clean, fresh, and glassy and exhibits no tendency to alteration or dehydration. Under the microscope the analyzed material was pure and uniformly isotropic with an index of refraction of 1.460. The specimens exhibit no crystal faces, the free ends of the fibers being in most cases somewhat dissolved or corroded. For comparison several previous analyses of tschermigite from other localities, including Erickson's analysis of the Wyoming material are given in the following table:

Previous analyses of tschermigite

	1	2	3	4
Al ₂ O ₃	11.57	11.28	11.40	11.39
(NH ₄) ₂ O.....	5.23	5.74	5.86	5.62
Na ₂ O.....	.21			
K ₂ O.....	Trace.		.06	.17
MgO.....	.13			
SO ₃	35.11	35.33	34.99	35.14
H ₂ O.....	47.82	47.65	47.69	47.59
Insoluble.....	.06			.08
Fe ₂ O ₃ , CaO, Cl.....	Trace.			.01
	100.13	100.00	100.00	100.00

1. Average analysis of tschermigite from Wyoming. E. T. Erickson, analyst. Journ. Wash. Acad. Sci., vol. 12, p. 50, 1922.

2. Composition for formula $.Al_2(SO_4)_3.(NH_4)SO_4.24H_2O$.

3. Tschermigite from Dux, Bohemia. J. V. Duchmuller, analyst, Centr. Min. Geol., 1907, pp. 465-467.

4. Tschermigite, from Brux, Bohemia. A. Sachs, analyst, Centr. Min. Geol., 1907, pp. 465-467.

AMMONIOJAROSITE

A preliminary paper announcing ammoniojarosite as a new mineral has already been published by the writer.⁵ Jarosite is a hydrous ferric-iron-potash sulphate which has been known since 1838. It is widespread in occurrence and has been identified at a large number of localities. The large content of ferric iron gives it a brown color, and, although occasionally lustrous transparent crystals a millimeter or two in diameter are found, the usual form of the mineral is a friable earthy-appearing mass of fine grained silky lustered material. It greatly resembles earthy or ochrous limonite but, when examined microscopically, it is found to consist of loose aggregates of microscopic transparent crystals which are tabular rhombohedral in form. Its resemblances to limonite have often caused it to be overlooked and many occurrences have doubtless failed of recognition for this reason.

Sixty-four years after the description of the original potash jarosite Hillebrand and Penfield⁶ described two new members of the group. In the first of these potash is replaced by soda, a very ordinary instance of the substitution of one alkali for another, and the mineral was named natrojarosite. In the other, however, the somewhat surprising situation was found wherein the univalent potassium oxide

⁵ Earl V. Shannon. Ammoniojarosite, a new mineral of the jarosite group from Utah. Amer. Mineralogist, vol. 12, No. 12, pp. 424-426, 1927.

⁶ W. F. Hillebrand and S. L. Penfield. Amer. Journ. Sci., vol. 14, p. 211, 1902.

was replaced by the oxide of a heavy bivalent metal, lead, and the mineral was named plumbojarosite. In the hand specimen these two new members of the group had the same appearance as ordinary jarosite, from which they can not be distinguished without chemical tests, although the lead member may be recognized by its higher specific gravity in some specimens. Numerous examples appear to exist isomorphously intermediate between the plumbojarosite, natrojarosite, and jarosite. Plumbojarosite carries sufficient lead to have been smelted in several instances as an ore. Utahite, vegasite, and several other supposedly distinct species have been found to be identical with one or the other of the above minerals.

Still more recently a jarosite mineral very rich in silver from the Tintic district in Utah has been examined by Schaller⁷ and found to have silver oxide as the essential base in place of potash. To this interesting mineral, the first known in which silver enters as an oxygen compound, the name argentojarosite was given. This, again, had superficially all of the characteristics of ordinary jarosite. Since such unexpected cases of isomorphism in this group it is hard to predict what others may be found. In the Boss mine in Nevada a small amount of plumbojarosite was mined which carried comparatively large amounts of platinum and palladium.⁸ These apparently were not entirely present as the native metals and the platinum and palladium may have replaced the lead of the plumbojarosite. The jarosites are essentially minerals of arid climate. Although occurring in numerous localities where sulphides have oxidized in dry regions, the minerals of the group are almost unknown in areas of more humid climate.

Erickson⁹ described jarosite occurring associated with the tschermigite from Wyoming as coating or sometimes inclosed in the alum and also in pure nodular masses. It was pale yellow in color and fine grained, but the individual crystals could be recognized under the highest magnifying power of the petrographic microscope. Since an ammonia member of the jarosite group was anticipated the ammonia content of this Wyoming material was determined and found to be 1.30 per cent $(\text{NH}_4)_2\text{O}$, or 1.25 per cent when corrected for included tschermigite. Although an ammoniacal variety, this obviously did not closely approach the ammonia end member of the group. With Erickson's results in mind, the present writer very carefully examined the jarosite associated with the Utah tschermigite and upon analysis this was found to contain a definite preponderance of am-

⁷ Waldermar T. Schaller. Argentojarosite, a new silver mineral. Preliminary note. Journ. Wash. Acad. Sci., vol. 13, No. 11, p. 233, 1923.

⁸ Adolph Knopf. A gold-platinum palladium lode in southern Nevada. U. S. Geol. Survey Bull. 620, pp. 1-18, 1916.

⁹ E. Theodore Erickson. Journ. Wash. Acad. Sci., vol. 12, pp. 49-54, 1922.

monia over soda and potash. Consequently it has been given the name ammoniojarosite. Thus five definite members of the jarosite group are now known, having the following formulas:

Jarosite,	K ₂ O,	3Fe ₂ O ₃ , 4SO ₃ , 6H ₂ O.
Natrojarosite,	Na ₂ O,	3Fe ₂ O ₃ , 4SO ₃ , 6H ₂ O.
Plumbojarosite,	PbO,	3Fe ₂ O ₃ , 4SO ₃ , 6H ₂ O.
Argentojarosite,	Ag ₂ O,	3Fe ₂ O ₃ , 4SO ₃ , 6H ₂ O.
Ammoniojarosite	(NH ₄) ₂ O,	3Fe ₂ O ₃ , 4SO ₃ , 6H ₂ O.

These minerals form a division of the large alunite-beudantite series of minerals as defined by Schaller¹⁰ and numerous other related compounds are to be expected. Ammoniojarosite and argentojarosite, the two newest members of the group, have their type localities in Utah and all of the known members of the group have been found in that State.

The Utah ammoniojarosite forms small, soft, ocherous lumps of pale yellow color and darker hard, irregular, flattened nodules up to 4 centimeters broad by 5 millimeters thick, embedded in blackish-brown lignitic material. Some of it is stained darker brown by limonite and a little occurs in shaly masses largely composed of the imperfect Cretaceous fossils mentioned above. On fresh fracture the color of most of the purer lumps is light ocherous yellow and the luster is dull-waxy to earthy.

One of the largest and purest lumps was selected and freed as far as possible from adhering lignite. This was finely ground and digested with frequent stirring in hot distilled water long enough to remove all tschermigite and other water-soluble salts. It was then filtered out of suspension, washed thoroughly with hot water, dried in air, reground, and allowed to stabilize its water content in air for several days. The powder was then analyzed by standard methods. Five grams were weighed out, dissolved in hot hydrochloric acid and filtered. The undissolved material was dried in air for several days and then weighed, after which it was ignited and again weighed. It consisted principally of lignite with a very little clayey material. The solution was made up to 500 cc. and divided into 5 aliquot parts. On these portions, equivalent to 1 gram of sample each, the constituents other than water and ammonia were determined. Water and ammonia were determined by standard methods on separate portions of the same powder. The analysis gave the following results and ratios:

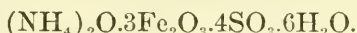
¹⁰ Waldemar T. Schaller. The alunite-beudantite group. U. S. Geol. Survey Bull. 509, pp. 70-76, 1912.

Analysis and ratios of ammoniojarosite

(Earl V. Shannon, analyst)

	Per cent	Ratios	
Insoluble.....	0.76		
TiO ₂	Trace.		
Al ₂ O ₃.....	.02	0.0001	0.309 0.103×3
Fe ₂ O ₃	49.30	.309	
CaO.....	.05	.001	
MgO.....	.13	.003	.106 .106×1
Na ₂ O.....	.22	.004	
K ₂ O.....	1.56	.017	
(NH ₄) ₂ O.....	4.23	.081	.431 .108×4 .547 .091×6
PbO.....	Trace.	-----	
Ag ₂ O.....	None.	-----	
SO ₃	34.49		
H ₂ O.....	9.86		
	100.62		

Except in that the water content is a little low the results agree very well with the formula



The existence of the ammonia member of the group is thus established. The theoretical composition to satisfy the above formula is: (NH₄)₂O 5.43; Fe₂O₃ 49.92, SO₃ 33.38, and H₂O 11.27 per cent.

Under the microscope the analyzed sample was found to be made up of minute transparent tabular grains, a few of which showed hexagonal outline. These were too small to yield an interference figure, but those lying on the basal plane are dark between crossed nicols, so the mineral is uniaxial or nearly so. Plates on edge show positive elongation, so the mineral is probably optically negative. The refractive indices could not be accurately measured but they are approximately $\omega=1.800$, $\epsilon=1.750$ both ± 0.005 . The ammoniojarosite has probably been formed through the oxidation of pyrite in the lignitic material.

EPSOMITE

One lot of material, when received, consisted of long-fibrous masses and shorter fibers having a pearly or silky luster. This gave the qualitative reactions of epsomite. The only impurity in this material was a little bentonite, and fragments of the epsomite occur in another sample of the bentonite, indicating that the magnesium sulphate occurs associated with the bentonitic clay and not in the lignite which carries the tschermigite and ammoniojarosite. When received this fibrous epsomite was lustrous and firm. Microscopic examination was fortunately made immediately after the samples were received before any dehydration had begun. The mineral was biaxial and negative with 2E medium small. The grains are lath-shaped and showed parallel extinction. They lie on either one of

two cleavages, presumably parallel to the prism (110) and the pinacoid (010). The acute bisectrix is perpendicular to the latter cleavage and the axial plane is across the elongation, so that the long direction of the fibers is Y. The dispersion, $r < v$ is strong and the mean index of refraction, β , is 1.455. These are essentially identical with the properties given by Larsen¹¹ for epsomite, $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ as determined on the freshly crystallized salt. Almost immediately, however, the material began to dehydrate and become chalky and opaque-looking on the outside and this dehydration proceeded until when analyzed after having been exposed for a year to the air of the museum the whole lot was dead and lusterless and exceedingly fragile and friable. Since several examples of epsomite which had naturally dehydrated in the open air have recently been shown to consist of the material called hexahydrate¹² some interest attached to the analysis of the altered Utah material. A sample was accordingly analyzed with the following results:

Analysis of air dried epsomite

(Earl V. Shannon, analyst)

	Per cent	Ratios				Per cent	Ratios		
Insoluble (clay) ..	1.75	0.525	0.525×1	0.91×1...	H ₂ O	32.72	1.816	0.605×3	1.05×3
MgO	21.16				CO ₂	None.			
Al ₂ O ₃ .....	.10				Cl .....	.04	
Fe ₂ O ₃	Trace.				(NH ₄) ₂ O	None.			
CaO .....	.42				SO ₃	43.38		
Na ₂ O .....	.28							
K ₂ O	Trace.								
						99.85			

These results show that the material has been dehydrated to a degree where the composition approximates the formula $\text{MgSO}_4 \cdot 3\text{H}_2\text{O}$. Under the microscope this analyzed powder was found to be very finely crystalline granular with the grains were too small to yield a definite interference figure although very hazy and questionable figures appear to indicate a biaxial negative mineral with 2V medium. The refractive indices are variable, but the mean index is about 1.490. This powder, when exposed to dry air in a desiccator over calcium chloride for 40 hours did not change in weight. Heated for six hours at 110° C. the powder lost 22.90 per cent and the sample thus dehydrated regained 1.10 per cent on standing three weeks over calcium chloride.

A second specimen of the lot was unlike the fibrous epsomite in appearance and was granular, translucent, and white in color. It was readily soluble in water and by qualitative tests was proven to

¹¹ Esper S. Larsen, Microscopic determination of the nonopaque minerals. U. S. Geol. Survey Bull. 679.

¹² T. L. Walker and A. L. Parsons. Hexahydrate from Oroville, Wash., U. S. A., Univ. Toronto Geol. Series No. 24. Contributions to Canadian mineralogy, 1927, p. 21.

be a hydrous magnesium sulphate free from ammonia, potash, chlorine, and carbon dioxide. Under the microscope this was seen to consist of small equidimensional euhedral crystals loosely aggregated. These lie on faces either perpendicular to Y or to an optic axis. They are biaxial and negative with $2E$ medium small, dispersion weak. The indices of refraction are $\alpha=1.430$, $\beta=1.455$, $\gamma=1.460$. These optical properties indicate that this material at the time of examination was also, epsomite and this also has altered completely and the specimen has fallen to pieces. It was not analyzed.

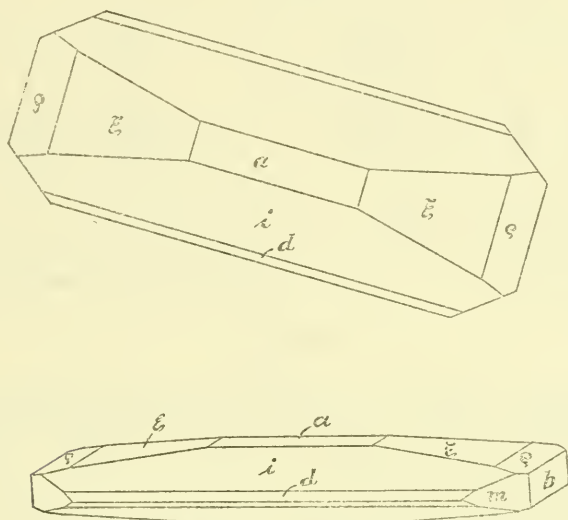


FIG. 1.—CELESTITE CRYSTAL. PANGUITCH, UTAH

CELESTITE

Celestite does not occur immediately associated with the epsomite and ammonia bearing sulphates but is a constituent of separate specimens made up of celestite and paligorskite in friable red sandstone. Some of the specimens consist almost entirely of massive-granular celestite with very little paligorskite and others are paligorskite free from celestite. The best specimens are of a vein in sandstone which has an open cellular filling of mixed paligorskite and celestite. The celestite is later than the paligorskite and some of the smaller celestite crystals which are supported by the fibers are doubly terminated. They range from 1 millimeter to 2 centimeters in length although the larger ones show parallel growth and are curved and imperfect. The smaller transparent and more perfect crystals have the habit shown in figure 1 and are tabular from the development of very flat domes, and elongated parallel to the b axis. The larger and less perfect crystals are similar but the

prism faces $m(110)$ are extended to a point eliminating the pinacoid face $b(010)$. The optical properties are the normal ones for celestite, and the mineral gives the characteristic blowpipe reactions and strontium flame. The crystal measured gave the following angles:

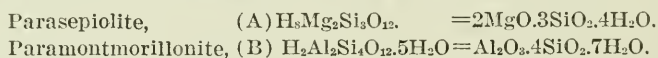
Measurements of celestite, Figure 1

Form		Symbol		Quality description	Measured		Calculated	
No.	Letter	Gdt.	Miller		ϕ	ρ	ϕ	ρ
1	<i>c</i>	0	001	Medium		0 00		0 00
2	<i>m</i>	∞	110	do.	52 01	90 00	52 00	90 00
3	<i>m</i>	∞	110	Poor	52 00	90 20	52 00	90 00
4	ξ	$0\frac{1}{2}$	0. 1. 12	Blurred, rounded	0 12	5 17	0 00	6 06
5	ρ	$0\frac{1}{8}$	018	Narrow, faint	0 00	10 10	0 00	9 06
6	<i>l</i>	$\frac{1}{4}0$	102	Good	90 10	39 47	90 00	39 23
7	<i>l</i>	$\frac{1}{4}0$	102	do.	90 01	39 33	90 00	39 23
8	<i>d</i>	$\frac{1}{4}0$	104	Medium	90 10	22 10	90 00	22 19
9	<i>d</i>	$\frac{1}{4}0$	104	do.	90 01	22 25	2 00	22 19

Even the smaller crystals are somewhat imperfect and do not give good measurements. The minerals of the veins do not penetrate the adjacent sandstone which appears unaltered and is scarcely cemented.

PALIGORSKITE

Paligorskite is an old name used to indicate matted fibrous and very light felted material of the character of "mountain cork" when in masses and "mountain leather" when in thin sheets. Most of the material so designated may have been merely a structure phase of ordinary fibrous or asbestiform tremolite or possibly in some cases serpentine of the chrysolite variety. Much of the material included under this classification has been known to contain considerable water and for this reason paligorskite has been considered an altered and hydrated asbestiform amphibole. Fersmann¹³ in describing a specimen of the mineral from Russia attempted to interpret the collected analyses by postulating a "paligorskite group" made up of variable isomorphous mixtures of two end members, namely:



Like too many theories as to the chemical constitution of the silicate minerals, this appears to lack sufficient proof to make it readily acceptable and, inasmuch as many of the analyses are old and not made upon microscopically studied material they doubtless include both inaccurate analytical work and analyses made on inhomogeneous materials. It seems certain that many mountain corks are really

¹³A. E. Fersmann. Min. Inst. Univ. Moscow. Bull. Acad. Imp. St. Petersburg, 1908. pp. 255-274, Chem. Abstr., vol. 2, p. 403.

composed of sepiolite. A very typical example which was found to be abundant in one place in the iron ores of the Cerro Mercado, Durango, Mexico, by Dr. W. F. Foshag has recently been analyzed by him in the museum laboratory. The results of this analysis are given together with two other sepiolites of similar structure and composition:

Analyses of fibrous sepiolites

	1	2	3		1	2	3
SiO ₂	55.34	52.97	51.84	N ₂ O.....			.45
Al ₂ O ₃	1.81	.86	1.51	K ₂ O.....			.25
Fe ₂ O ₃.....	.43	.70	None.	H ₂ O above 110° C.....	10.20	9.90	9.63
Mn ₂ O ₃		3.14		H ₂ O below 110° C.....	8.60	8.80	10.55
CaO.....	.24						
CuO.....		.87					
MgO.....	22.95	22.50	24.54		99.57	99.74	98.77

1. Light corky snow-white masses associated with clear yellow apatite crystals in iron ore, Cerro Mercado, Durango, Mexico. Wm. F. Foshag, analyst.

2. Fibrous material "from a silver mine in Utah." A. H. Chester, analyst. Amer. Jour. Sci., vol. 13, p. 296, 1877. Dana System of Mineralogy, 6 ed. p. 681.

3. "Hydrous anthophyllite" Alorton, Md. Geo. P. Merrill, analyst. Cat. U. S. N. M. No. 62778. 'Asbestos and asbestiform minerals. Proc. U. S. Nat. Mus., vol. 18, pp. 281-292, 1895.

These fibrous sepiolites are very similar to the aluminous materials properly designated paligorskites.

The paligorskite associated with the celestite in the Utah specimens at hand is, superficially, very nearly identical with the Mexican material. It forms typical "mountain cork" masses up to several inches in diameter, which are so porous as to float on absolute methyl alcohol of gravity 0.79. Where not soiled or dirty it is snow-white in color and is lusterless, with a dry meager and papery feel. A purified sample was analyzed, giving then results and ratios of columns 1 and 2 of the following table: The analysis is very similar to that of Fersmann on material from the Kadainsk mine, Nertschinsk, Siberia, as given in column 3.

Analyses and ratios of paligorskite

	1	2	3
SiO ₂	52.55	0.872 0.145×6 0.98×6.....	55.57
Al ₂ O ₃	13.64	.134 .134×1 .91×1.....	12.63
Fe ₂ O ₃	Trace.		
FeO.....			.43
CaO.....	1.39	.025} .145×2 .98×2.....	.15
MgO.....	10.63	.264}	9.75
SrO.....	Trace.		
H ₂ O 100° C.....	14.16	} 1.205 .151×8 1.03×8.....	12.34
H ₂ O-110° C.....	7.66		9.10
	100.03		99.97

1. Paligorskite from Utah. Earl V. Shannon, analyst.

2. Ratios of same.

3. Paligorskite, Nertschinsk, Siberia. A. E. Fersmann, analyst.

The above analysis of the Utah material yields rather closely the formula 2MgO.Al₂O₃.6SiO₂.8H₂O. The material from Russia represented by Fersmann's analysis is interpreted by him as composed of

1 part of parasepiolite (A) with 2 parts of paramontmorillonite (B). The isomorphous mixture in these proportions he calls beta-paligor-skite. Under the microscope the Utah material appears in matted aggregated of fine fibers which have a more or less parallel position. The material is not suitable for exact optical measurements. The masses show moderate birefringence, parallel extinction, and positive elongation. The mean index of refraction is about 1.490. The masses of fibers show a confused interference figure with the emergence of a negative bisectrix, apparently of large angle and possibly the obtuse bisectrix. This would make the mineral optically positive with Z the elongation. These are similar to the properties given by Larsen for parasepiolite which, however, is optically negative.

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