Art. XX.—*Mosesite, a New Mercury Mineral from Terlingua, Texas;* by F. A. Canfield, W. F. Hillebrand, and W. T. Schaller.

Introduction.

The name *mosesite* is proposed for a new mercury mineral from Terlingua, Brewster Co., Texas, in honor of Prof. Alfred J. Moses of Columbia University, New York, who first definitely described the interesting mercury minerals found in Texas. The three minerals, montroydite, terlinguaite and eglestonite, were named and definitely determined by him, and he also gave a preliminary notice of a fourth new one (later named kleinite). It is, therefore, with great pleasure on our part that we propose the name *mosesite*, which name, besides perpetuating the high attainments of Professor Moses in the science of mineralogy, is particularly appropriate as it links his name with a group of minerals which he first definitely put on record.

General Description (F. A. Canfield).

While examining a recently acquired specimen of montroydite and calcite the attention of the writer was attracted to some small yellow crystals which were perched upon the crystals of calcite. They did not join the montroydite but were isolated and solitary; they appeared to lie upon the surface of the calcite with but little or no bond. The slightest touch would loosen them, leaving no scar upon the calcite but merely a clean spot. A careful search revealed twenty-six crystals which will weigh, perhaps, ten milligrams. Twenty-two of the crystals are simple octahedrons, the others are spinel twins. No other forms were observed and none of the mineral was massive.

Another specimen has lately been procured which is much the finer in every way. Hundreds of crystals are scattered over a surface ($4^{cm} \times 6^{cm}$) of calcite which rests upon the pinkish rock which is characteristic of the Terlingua specimens. Nearly all of the crystals are spinel twins. They are frequently grouped together in confused masses; one polysynthetic twin—a 5-ling—was seen. Simple octahedrons are rare. None was modified by other forms. No other mercury mineral is present on the specimen unless some delicate, elongated, light yellow particles should prove to be kleinite.

It is impossible to tell to what conditions these specimens have been subjected. It is certain that the first specimen has been badly treated, since it is bruised and very dusty.

There are no indications that the crystals are affected by the light. If light affects the color it must act very slowly. The color of those crystals, which are so situated as to have some protection from the light, is exactly like that of the most exposed. No difference in color could be noted between the surface and the interior of the crystals. Most of the crystals are translucent. The largest crystal found is brilliant and transparent, and measures $0{\cdot}5^{mm}$ along its edge. Generally the faces of the crystals are bright and uneven. They are very brittle with signs of cleavage.* The fracture is uneven. The hardness slightly exceeds that of calcite. The mineral crumbles to a powder under the pressure required for this test. No piece could be obtained that was large enough to determine the density. The luster is adamantine. The color is a rich lemon- to a canary-yellow. The streak and powder are a very pale yellow.

When heated gradually to a low temperature in a closed tube the assay turns to a dark reddish brown, almost black. As the heat increases the color changes rapidly to white, but without changing the form of the original crystals. Fumes of calomel are given off and condense in the tube. Many globules of mercury collect in the tube beyond the coating of calomel. Continued heating soon causes the assay to volatilize and disappear. If a fresh fragment of the mineral is heated rapidly in the closed tube, it decrepitates violently, almost explosively, then it fuses and volatilizes.

In cold hydrochloric acid the mineral is changed slowly to a white substance which retains the original form. If the acid is hot the change is more rapid but the product is the same.

It is to be hoped that enough of the material will be found to enable a complete analysis to be made. No doubt there are specimens of this mineral in some of the collections, but they are overlooked, or they are incorrectly labeled. The second of the above-described specimens was labeled "Terlinguaite." It is more like kleinite in appearance.

Chemistry (*W. F. Hillebrand*).

Chemically, so far as the very scanty material permitted of ascertaining, the composition of mosesite approaches that of kleinite, that is, it is a mercury-ammonium compound containing chlorine and the sulphate group besides a little water. Determinations made on 0·04 gram of material gave 5 per cent Cl and 3·5 per cent SO_4. The former amount is considerably lower and the latter somewhat higher than in kleinite, but the

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* Imperfect octahedral cleavage (W. T. S.).

values are no more than approximations. There is, however, one marked chemical difference, which will be considered later.

Spectroscopic tests, that were kindly made by Dr. P. G. Nutting, at the Bureau of Standards, showed prominent mercury and nitrogen spectra and also the red line of hydrogen, the last being ascribed by him to water vapor. A singular feature of the behavior in vacuo was the immediate appearance, when the current was turned on and before the application of heat, of a mercury spectrum. The mineral was at the time not between the electrodes, but far to the rear of one of them, at the sealed end of the Plucker tube. Under these conditions the color of the mineral fragments underwent a pronounced and permanent change from bright yellow to a yellowish gray. With a minute crystal of kleinite there was a mere indication of the mercury lines before heating, and no color change was observed. As soon as the temperature of mosesite was raised to visible incipient decomposition, the spectra of both nitrogen and mercury became brilliant. As mentioned by Mr. Canfield, mosesite does not seem to undergo the color changes in sunlight and darkness that appear to be characteristic of the deeper colored crystals of kleinite.

When heated in a narrow tube closed at one end, the color changes and the sublimates were much like those afforded by kleinite, and there was the same liberation of an active gas that set free iodine from potassium iodide. Ammonium bromide liberated ammonia as from kleinite.

The behavior towards hydrochloric acid, noticed by Mr. Canfield, affords a certain chemical means of distinguishing mosesite from kleinite, where only these two are concerned. When covered with concentrated hydrochloric acid mosesite is entirely decomposed in a few hours, with separation of a coherent white material that shows the behavior of calomel. The solution contains the sulphate and ammonium groups, beside much mercuric mercury. Kleinite, on the other hand, shows no perceptible change for a long time, but in the course of 48 hours a minute crystal of it was almost entirely decomposed. There remained only a whitish residue that looked as if it might be the clay matter that is such a persistent contaminant of the mineral. It was free from calomel.

It will be remembered that the chemical evidence points to kleinite being a mixture or solution of mercury-ammonium chloride with a mercuric sulphate and perhaps chloride. There would seem to be an association of similar general character in mosesite, but with a mercurous sulphate or chloride replacing in part or wholly the corresponding mercuric salts of kleinite.

Crystallography and Optical Properties (*W. T. Schaller*).

The crystals are apparently octahedra of the isometric system. Twinning on the spinel law has been observed several times, in which case the crystals of mosesite are often flattened parallel to a pair of octahedral faces. Mr. Canfield has mentioned a 5-ling, a spinel twin repeated five times.

The faces of the crystals are never smooth. While bright and often highly polished, they are uneven and only a few of the faces give a single reflection. Most of the faces when measured on the goniometer give a number of signals, no particular one of which is brighter than the others. This has rendered the accurate determination of the form of the crystals impossible. An additional feature that has rendered accurate measurements difficult is the tendency for a number of crystals to grow together, sometimes in nearly parallel position and again in widely different positions. A mass of signals therefore resulted from examining such groups of mosesite on the goniometer, and on the minute crystals that were available it was not possible to know what signals to measure and what ones to exclude. Where only two or three faces were measured in a zone, it was well nigh impossible to be sure of having the zone accurately centered. The measurements, the occurrence of (probable) spinel twins and the optical relations, to be described below, make it fairly certain that the crystals of mosesite are in reality octahedra. No form other than the octahedron was observed.

On part of a spinel twin, the faces of which gave a mass of very poor reflections, there were measured:

$o \wedge o'$	= 68°	70° 32′ calc.
	= 68° (cleavage face)	" "
	= 68° 28′	" "
$o \wedge \underline{o}$	= 41° 13′	38° 56′ "

A second crystal, also a spinel twin, gave:

$o \wedge o'$	= 108° 54′	109° 28′ calc.
	= 107° 53′	" "
	= 71° 38′	70° 32′ "
	= 70° 47′	" "
	= 68° 51′	" "
	= 72° 28′	" "
$o \wedge \underline{o}$	= 37° 06′	38° 56′ "
	= 38° 56′	" "

A third crystal was adjusted as closely as possible in polar position for two-circle measurement and on revolving the crystal, the four octahedra faces were seen to lie in the positions required for the form (111).

From the above data, meager and poor as they are, the isometric character of the crystals is deduced, especially as this is supported by the investigation of the optical properties.

Under the microscope mosesite is pale yellow, non-pleochroic and seems to possess a rather low double refraction. When a fragment is crushed many of the resultant pieces show the octahedral cleavage, either in their triangular or rhombic shape (when only two directions of cleavage are developed) or in three series of cleavage lines, parallel to the octahedral faces. A fragment of fluorite was crushed and examined under the microscope, when similar effects were seen, though in this case the cleavage was much better developed.

The crystallographic investigation has shown that the crystals are in all probability isometric octahedra and should, therefore, be isotropic when examined under the microscope with crossed nicols. Such an examination, however, shows the mineral not to be isotropic but doubly refracting. On heating the mineral to 186°, the crystals lose their double refraction and become isotropic. Mosesite is therefore dimorphic, the isometric optical condition that agrees with the geometrical form being stable only above 186°, the mineral changing to the dimorphous doubly refracting condition at temperatures below 186°.

As examined at ordinary temperatures, i. e., as the mineral now occurs, the sections show great similarity to kleinite. Much of the material does not extinguish at all, other parts do so four times during a complete revolution of the stage and the interference-colors are fairly brilliant. On crushing a fragment between two glass slides and examining the very minute particles, they are seen to be nearly colorless and, unlike the larger pieces, isotropic. It seems as if the local heat developed by the crushing is sufficient to heat these small particles to at least 186° and cause their reversion to the isotropic state.

Several different fragments were heated on glass slides, in an air oven to the temperature given, with the results shown in the following table:

Effect of heating Mosesite.

Slide with mosesite.	Temp.	Effect.	Probable temp. of change.
First	150°	No change, mineral still doubly refracting.	
	200°	Brown and isotropic.	150–200°
Second	160°	Brown and doubly refracting.	
	167°	Still doubly refracting.	
	180°	" " "	
	189°	Isotropic.	180–189°

Third	169°	Doubly refracting, but section too opaque for further study.	Above 169°
Fourth...	169°	Doubly refracting.	
	184°	" "	
	186°	Nearly isotropic.	
	190°	Isotropic.	186–190°
Fifth	184°	Doubly refracting.	
	186°	Nearly isotropic.	
	188°	" "	
	190°	Isotropic, except for a few minute doubly refracting spots.	184–186°
Sixth	186°	Doubly refracting.	
	192°	Still doubly refracting in places but partly isotropic. This particular piece may have been thicker than the others and therefore did not revert so readily.	186–192°+
Seventh ..	186°	Isotropic on thin edges, but doubly refracting in thicker center.	
	192°	Isotropic.	186–192°

From these data the temperature of reversion to the isotropic isometric state probably lies between 180° and 190° and is taken as 186°. If the "molecular inertia" of mosesite is considerable, as is the case with kleinite,* then this temperature, namely 186°, is probably a little high. On cooling, the isotropic mineral does not immediately again become doubly refracting. Examination after 24 hours shows the mineral to be still isotropic. The change back seems to be, like that of kleinite, a very slow one, but doubtless it is gradually taking place. The section of kleinite described† as almost entirely reverted after thirty months is now, after four years, completely changed back again to its original doubly refracting condition.

The optical similarities, shown by these two minerals, coupled with their evident chemical relationship, suggested trying the effect of heating kleinite to the reversion temperature of mosesite (186°). When this was done, kleinite‡ became optically isotropic like mosesite. The results of the experiments are shown in the table below.

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* Hillebrand, W. F., and Schaller, W. T., The Mercury Minerals from Terlingua, Texas. Bull. U. S. Geol. Survey, No. 405, 1909, p. 26.

† Loc. cit., p. 25.

‡ Fragments were used that were not parallel to the base as these would become isotropic at 130°, kleinite being uniaxial, hexagonal.

Effect of heating Kleinite.

Slide with kleinite.	Temp.	Effect.
First	177°	Doubly refracting, no change.
	187°	" " " "
	194°	" " " " Probably too thick.
Second	177°	Doubly refracting, no change.
	194°	Isotropic.
Third	177°	Doubly refracting, no change.
	194°	Partly isotropic, the remainder doubly refracting as before. The isotropic part while still transparent had become brown, the doubly refracting part remaining pale yellow.

It would be premature to speculate on the significance of this observation on the optical behavior of kleinite.