CHEVKINITE (TSCHEFFKINITE) FROM ARIZONA[1]

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ABSTRACT

A new occurrence of chevkinite, a titano-silicate of the rare earths, has been found in Mohave County, Arizona. Petrographic and chemical analyses and the x-ray powder diffraction pattern of this mineral are given. The differences from keilhauite and allanite are shown. Minerals associated with the chevkinite are sphene, monazite, apatite, cronstedtite and quartz.

OCCURRENCE

A new occurrence of chevkinite, a titano-silicate of the rare earths, has been found by L. H. Carson of Seligman, Arizona. The sample, sent to the Bureau of Mines for identification, came from a dike in the Aquarius Mountains, Mohave County, Arizona. Chevkinite previously has been reported from only two localities in this country, Nelson and Bedford Counties, Virginia. A possible additional occurrence, to which the writers cannot find reference in the literature, is Mitchell County, North Carolina. Two samples of chevkinite in the U. S. National Museum are reportedly from this locality; they are from an old collection, and their source cannot be accurately traced. Dr. J. H. Pratt (1916), former State Geologist of North Carolina, states that chevkinite "has been identified in the United States in only one state, Virginia."

The few confirmed foreign localities are widely scattered and include the Ilmen Mountains, Russia; the Salem district of South India; the Tordendrika-Ifasina region of Madagascar; the Kōgendō region of Korea; and Sabaragamuwa Province in Ceylon. According to Carson, the Arizona mineral comes from "a long narrow vein, a few inches to a foot in width, running lengthwise of a high granite dike." Further field information is not available, but the pegmatite veins of the Aquarius Range are well-known; gadolinite, arizonite, samarskite and allanite having been identified in these rocks (*Arizona Bureau of Mines*, **1941**). From Carson's brief description, it appears likely that the Arizona sample of chevkinite is also associated with a pegmatite. Very little information on the mode of occurrence of chevkinite is given in the literature. The most reliable study of the field occurrence of this mineral was made by Lacroix (1915). Of the Madagascar material, he writes, "In conclu-

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sion, one finds that at Torendrika-Ifasina, the rare-earth minerals are a production of the magma of an alkaline aegirine granite; they originated in a pegmatitic phase of this."

Physical and Optical Properties

The sample weighed half a pound and contained a few poorly defined crystal faces. It could not be determined whether these belonged to chevkinite or whether this mineral had pseudomorphously replaced another. The mineral is black; possesses a dull luster; and breaks with an irregular fracture. It is slightly radioactive, a function of the thoria content. Uranium was not detected spectrographically or by means of the very sensitive sodium fluoride fluorescent bead test (Northup, 1945). The specific gravity is 4.67 and the hardness 5.5 to 6. In transmitted light the mineral is moderately pleochroic from brown to dark reddish brown, somewhat resembling tantalite-columbite. It shows no distinct cleavage in thin section or fragment. The intermediate index β is 1.99. The mineral is optically negative, with a moderately large axial angle, and shows marked dispersion with $r>v$. The birefringence is moderate. The birefringence and intermediate index are higher than those previously reported for this mineral. These higher values may result from the relatively high ferric iron content of the Arizona material.

Several samples of chevkinite from other localities, along with samples of allanite and keilhauite, were made available for examination through the courtesy of the U. S. National Museum and the Harvard University Geological Museum. These and the Arizona mineral were studied petrographically, spectroscopically and by x-ray in order to determine whether they showed significant relationships. Although all are much alike megascopically, these minerals were readily distinguished microscopically and by rapid spectroscopic analysis for Ti, Al and Ca. The following diagnostic properties serve to distinguish them:

Mineral	Refractive Index	2 V and sign	Ti	Al	Ca
Chevkinite	>1.85	variable (−)	M*	m**	m
Allanite	1.65 to 1.80	large (−)	—	M	M
Keilhauite	>1.85	small–medium (+)	M	m-M	M

* M = major constituents.
** m = minor constituents.

A powder diffraction pattern of chevkinite was obtained by H. F. Carl of the Bureau Staff with an automatic recording x-ray diffraction spectrometer. This is the first such pattern reported for this mineral. Patterns of keilhauite, sphene and allanite obtained with the same instrument are compared with chevkinite in Table 1.

TABLE 1. X-RAY DIFFRACTION PATTERNS OF CHEVKINITE, ALLANITE, KEILHAUITE AND SPHENE

Chevkinite (Arizona)		Allanite (California)		Keilhauite (S.W. Africa)		Sphene (Bancroft, Ont.)	
d	*I*	*d*	*I*	*d*	*I*	*d*	*I*
4.97	m	3.57	m	4.97	w	4.97	m
4.71	m	3.26	w	3.26	S	3.26	S
3.68	w	2.94	S	3.02	S	3.01	S
3.52	m	2.85	w	2.63	mS	2.62	mS
3.20	S	2.74	mS	2.61	m	2.29	m
3.11	w	2.65	m	2.30	w	2.12	w
3.04	m	2.57	w	2.27	w	2.07	w
2.91	m	2.19	w	2.12	w	1.95	vw
2.77	w	2.14	w	2.08	w	1.81	vw
2.74	S	1.91	w	1.96	w	1.75	vw
2.38	w	1.65	m	1.75	vw	1.71	vw
2.19	w			1.71	w	1.65	m
1.98	m			1.65	m	1.51	w
				1.50	w	1.42	w
				1.42	w		

d=interplanar spacing, in Angstroms
I=relative intensity

S=strong
m=medium
w=weak

X-ray diffraction studies indicate that both chevkinite and allanite may be either amorphous or crystalline. Chevkinite from Arizona gives a diffraction pattern, whereas samples of this same mineral from Virginia and Madagascar do not. Similarly, allanite from California gives a diffraction pattern, whereas allanites from Russia, Madagascar and Virginia available to us give no pattern. Keilhauite from Africa gives a diffraction pattern (Table 1) very similar to that of sphene, of which it is apparently a variety. The amorphous varieties of chevkinite and allanite from Virginia and Madagascar gave no patterns after being heated at temperatures varying between 300° and 600° C. for periods between 1 and 2 hours.

Crystallographic studies by Baldireff (1925) and Bold'irev (1924) on the Russian material indicate that it is monoclinic. Lacroix (1915) and Ungemach (1916) state that the Madagascar material is either monoclinic or orthorhombic, hemimorphic. Eakins (1891) believed the Virginia material to be amorphous. The most recent description of chevkinite (Korea) is very similar to that of the Arizona mineral. Sin Hata (1940) describes the Korean mineral as a crystal whose form is indistinct, color black and fracture uneven. It has a hardness of 7, a specific gravity of 4.72 and $n > 1.85$. The crystal system of the Korean and the Arizona minerals could not be determined.

Chemistry

Chevkinite is a titano-silicate containing iron, thorium and members of the cerium group of rare-earth metals.

Chemical analyses of chevkinite appear in the literature as early as 1844. Analyses have been reported by H. Rose (1844); M. A. Damour (1861); R. Hermann (1866); R. C. Price (1888); L. G. Eakins (1891); Lacroix (1915); L. E. Kaufmann (1924); I. P. Alimarin (1935) and Sin Hata (1940).

Selection of the sample in this, as in every case, is most important; several of the above investigators state that their samples analyzed were impure mixtures. The sample used in this analysis was carefully prepared. Fragments were examined under a binocular microscope and only those free of noticeable impurities were selected. These grains were ground in a boron carbide mortar to avoid contamination by silica, alumina or iron. Numerous mounts examined microscopically indicated only a trace of impurities.

The chemical composition of the Arizona mineral is compared with published analyses of chevkinite in the following table.

Table 2. Chemical Composition of Chevkinite

	1	2	3	4	5	6	7	8	9	10	11
SiO_2	12.04	21.04	20.68	19.03	23.28	20.21	21.49	19.23	17.66	18.60	23.73
TiO_2	17.08	20.17	16.07	20.86	21.16	18.78	18.99	19.61	17.93	19.30	19.55
ThO_2	0.82	—	20.91	—	—	0.85	0.75	0.73	0.67	0.83	2.61
Ce_2O_3	25.29	47.29	22.80	38.38	11.89	20.05	19.08	20.52	14.21	22.67	33.35
$(LaDi)_2O_3$	18.35				20.34	19.72	17.16	18.77	24.09	21.83	—
Y_2O_3	1.50	—	3.45	—	—	1.82	1.64	0.93	2.45	—	1.56
Al_2O_3	0.93	—	—	7.72	—	3.60	3.65	2.17	0.23	3.35	0.58
Fe_2O_3	9.56	—	—	—	5.63	1.88	2.89	2.60	8.81	1.91	3.07
FeO	7.76	11.21	9.17	7.96	5.56	6.91	5.92	8.75	9.95	8.20	6.07
MnO	0.50	0.83	0.75	0.38	—	—	—	1.11	tr.	—	2.00
CaO	3.35	3.50	3.25	4.40	5.48	4.05	5.24	2.49	2.12	3.30	2.91
MgO	0.74	0.22	—	0.27	0.64	0.55	0.48	0.05	0.31	0.60	0.12
Cb_2O_5	—	—	—	—	—	0.08	0.08	0.01	0.63	—	—
Cr_2O_3	—	—	—	—	—	—	—	0.07	—	—	—
$(NaK)_2O$	—	0.12	—	—	0.32	0.06	0.04	0.10	—	—	—
SnO_2	—	—	—	—	—	—	—	—	0.25	—	—
ZrO_2	—	—	—	—	2.29	tr.	tr.	—	—	—	3.42
BeO	—	—	—	—	2.15	—	—	—	—	—	0.04
UO	N.D.*	—	2.50	—	—	—	—	—	—	—	—
SO_3	—	—	—	—	—	—	—	0.15	—	—	—
P_2O_5	0.38	—	—	—	—	—	—	—	—	—	—
H_2O	1.50	—	0.42	1.30	1.90	0.94	2.06	0.81	—	—	—
	99.80	104.38	100.00	100.30	100.64	99.50	99.47	98.10	99.31	100.59	99.01

* N.D. = Not detected.

1. Chevkinite—Mohave County, Ariz.
2. Chevkinite—Urals (H. Rose) (1844)
3. Chevkinite—Urals (R. Hermann)(1866)
4. Chevkinite—Southern India (M. A. Damour) (1861)
5. Chevkinite—Nelson County, Va. (R. C. Price) (1888)
6. Chevkinite—Bedford County, Va., I, lustrous material (R. G. Eakins) (1891)
7. Chevkinite—Bedford County, Va., II, dull material (R. G. Eakins) (1891)
8. Chevkinite—Urals (I. P. Alimarin) (1935)
9. Chevkinite—Korea (Sin Hata) (1940)
10. Chevkinite—Madagascar (Lacroix) (1915)
11. Chevkinite—Sabaragamuwa, Ceylon (G. Tschernik) (1913)

The general formula is considered to be:

$$R''O \cdot R_2'''O_3 \cdot (\text{Si Ti})O_2$$

when: $R'' = \text{Fe, Mn, Ca, Mg}$

$R''' = \text{Fe, Al}$ and the rare-earth metals.

The formulae calculated from the above analyses are:

Sample	$R''O$	$R_2'''O_3$	$(SiTi)O_2$
(1) Arizona	1	1	2
(2) Urals	2	1	5
(3) Urals	1	1	3
(4) So. India	1	1	3
(5) Nelson Co., Va.	2	1	5
(6) Bedford Co., Va.	1	1	3
(7) Bedford Co., Va.	1	1	3
(8) Urals	1	1	3
(9) Korea	1	1	3
(10) Madagascar	1	1	3
(11) Ceylon	1	1	5

The rare-earth metals are a group of elements, nearly all trivalent, whose compounds have marked similarity. The entire group forms oxalates insoluble in oxalic acid, affording a means of separating the group from most of the other elements. The determination of the rare-earth metals as a group can be accomplished easily and rapidly, but the determination of individual members is more difficult.

The group can be precipitated quantitatively by ammonium hydroxide, which serves to separate it from the alkalis, alkaline earths and magnesium. This ammonium group, however, will also contain aluminum, iron, titanium and any other element that will precipitate under these conditions. This precipitate can be dissolved in hydrochloric acid and the rare earths precipitated from the solution by the addition of oxalic acid. A heavy, white granular precipitate will appear after vigorous stirring. (This procedure may be used to determine qualitatively the presence of the group if a spectroscope is not available.)

The analyst can separate quantitatively thorium, cerium, lanthanum and didymium (praseodymium and neodymium) and the yttrium group from this precipitate.

Petrography

Intimately associated with the Arizona chevkinite, in one portion of the sample, are sphene, monazite, apatite, cronstedtite and quartz. Two thin sections were made of the impure portion of the sample to determine the relationship of chevkinite to the associated minerals. The sections contain anhedral chevkinite, which is traversed by irregular cracks and shows no discernible cleavage; numerous euhedral grains of apatite; small euhedral to large anhedral grains of sphene; small subhedral to large euhedral grains of monazite; large, uniformly oriented flakes of cronstedtite; and a small amount of strained quartz. The flaky material, thought to be cronstedtite, always shows the same orientation and is very strongly pleochroic from pale brown to almost opaque. Its lowest refractive index is equal to 1.805. It is biaxial negative with a small axial angle and shows distinct dispersion with $r<v$. Cross, who examined several sections of chevkinite from Virginia for Eakins (1891), describes a similar mineral found replacing chevkinite. He writes, "This mineral is also strongly pleochroic, varying from yellow-brown to chestnut brown. All of it in the sections seems to have a uniform crystallographic orientation, the cause of this uniformity not being apparent." The optical properties of this mineral are similar to those of the high iron chlorite, cronstedtite.

The euhedral character of the monazite, sphene, and apatite, as well as the cross-cutting relationships of these minerals to chevkinite, indicate that they have crystallized after the chevkinite and have been derived, at least in part, from this mineral. The cronstedtite also appears to replace the chevkinite. The rare earths and thoria necessary for the formation of the monazite, the titanium for sphene and the iron for cronstedtite may have been supplied by chevkinite. There is no clue to the source of the phosphate, lime, and additional silica necessary for the formation of monazite, sphene and cronstedtite.

The origin of the chevkinite, in this instance, cannot be definitely established. Its occurrence in a vein associated with a "granite dike" suggests that it was formed in a pegmatitic environment, the host of many of our rare radioactive minerals.

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