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ISHKYLDITE, A NEW STRUCTURAL VARIETY OF CHRYSOTILE

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ABSTRACT

Among the different varieties of asbestos, studied by the author, one specimen showed a number of peculiar properties: in appearance it resembled actinolite-asbestos; in chemical composition it was found to be very near chrysotile-asbestos, while in optical properties it approached antigorite. All the characteristics named, and particularly a peculiar atomic arrangement, permit this asbestos to be singled out as a new mineral, the name of which—*ishkyldite*—has been derived from the locality of its occurrence.

In 1932 in the environs of the village of Ishkyldino (the Orskho-Khalilovo region of the Middle Volga District) engineer Fedorov was prospecting for chrysotile-asbestos deposits in serpentinites. The specimens belonged to the slip-fiber type. Among them two varieties were found. Specimen No. 1 (Adit No. 1) is a slip fiber chrysotile asbestos of the usual appearance, which I have classed with β-chrysotile (1). This specimen was correctly identified by the author at sight, and a further study only confirmed this determination.

Specimen No. 3 (Adit No. 1) was so unusual that at first it was mistaken for an asbestos of the amphibole group. An imperfect fibering, a greasy feel and a low mechanical strength favoured this impression. A slightly greenish colour pointed to a higher iron content. On the strength of these properties the specimen was thought to be actinolite asbestos. A study of the chemical composition showed this identification to be erroneous. An x-ray study has solved the problem and proved that the substance is a new mineral. From the locality of its occurrence it has been named ishkyldite.

Macroscopically, the mineral is characterized by the following features:

It is faintly coloured. The colour of the compact specimen is silvery-bluish-green. Upon fiberization the colour of the mineral becomes still lighter. Its hardness is one. It has a greasy and soft feel. It is easily torn, and is fiberized with difficulty, although it can be readily split into separate fibers. It has a fairly well defined parting,[1] which may sometimes be used for obtaining fairly good laminae from the specimen. The specimen described contains inclusions of magnetite, distributed sporadi-

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[1] Among the specimens collected by eng. M. P. Lozhechkin I succeeded in establishing the presence of a specimen of ishkyldite with a sharply defined parting. Along this parting the mineral can be readily split into laminae. The fibering of this specimen is similar to that of the one described.

cally, and is in some places stained with iron oxides. The specific gravity is 2.62. In chemical composition ishkyldite is a typical serpentine, as shown by the chemical analysis given in Table 1. A recalculation of the analysis yields a formula, approaching the theoretical. Thus, if we assume it to be $H_4Mg_3Si_2O_9$, an excess of SiO_2 of 3% by weight is obtained. This value exceeds greatly the permissible error of the analysis.

TABLE 1. CHEMICAL COMPOSITION OF ISHKYLDITE

	Per cent		Per cent
SiO_2	42.49	H_2O+	11.88
Al_2O_3	1.27	H_2O-	0.79
Fe_2O_3	2.01	CO_2	0.35
FeO	2.73	TiO_2	trace
MgO	38.28	MnO	0.06
CaO	0.00	Cr_2O_3	trace
Na_2O K_2O	0.02	NiO	0.38
		Volatiles	0.04
		Total	100.30

Analysts: P. I. Vasiliev and I. I. Romm

The following empirical formula conforms more nearly with the analysis: $H_{20}\,Mg_{15}\,Si_{11}\,O_{47}$. From the above it is seen that the composition of ishkyldite is characterized by a greater quantity of silica (about one additional molecule of SiO_2 to each 5 molecules of serpentine). It is interesting to note that the author (1) has previously established an excess of silica also for β-chrysotile.

Thus, from its chemical analysis, ishkyldite is to be placed in the chrysotile-asbestos group. A high content of ferrous iron (almost 3 per cent) would incline us to refer it to the group containing brittle asbestos (1). Ishkyldite, in fact, has also a low mechanical strength. Its optical properties and structure, however, are so different, that we have decided to call it an independent variety.

As shown by an x-ray photogram, made by K. V. Vasiliev at the x-ray laboratory of the Institute, the atomic arrangement of ishkyldite is different from that of α-chrysotile (1). No detailed study of the structure has as yet been made. But a measurement of the identity period along the fiber axis has been carried out. In Table 2 the condensed results of calculations, made by the author, are given. (The radiation used, Molybdenum-K series.)

From this table it is seen that the identity period of ishkylidite is nearly twice as great as that of α-chrysotile. The distribution of spots is also different. Consequently, ishkyldite is a new structural modification of chrysotile.

TABLE 2. IDENTITY PERIOD OF ISHKYLDITE

Order of layer line	Radiation	Identity period
1	α_1	9.77Å
2	α_1	9.76
3*a*	β_1	9.66
3*b*	α_1	9.60
4	—	—
5	—	—
6*a*	β_1	9.62
6*b*	α_1	9.66
	Arithmetical mean	9.678Å

The optical constants of ishkylidite are as follows:

$$N_g = 1.573,\ N_p = 1.566$$
$$N_g - N_p = 0.007;\ 2\ V = 58°.$$

The optic angle was measured by the author on the Fedorov stage. The plane of the optic axes is oriented parallel to the fibers and perpendicular to the parting planes (see Fig. 1).

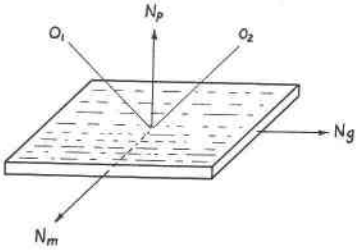

FIG. 1. Orientation of the index ellipsoid in ishkyldite.

The optical properties of ishkylidite are such as to present an interesting subject for speculation and investigation.

Being finely fibrous this mineral is a two-dimensional colloid. The theory of the optical properties of colloids has been developed by Wiener (2), Frey (3), Möhring (4), Lichtenecker (5), Ambronn (6), Wächtler (7), and others. According to the theory of Wiener (2), the birefringence of a complex body, consisting of particles of a definite shape, and of a medium, in which they are regularly distributed, depends on the relation between the values of the refringence of the particles and of the medium. If we change the properties of the medium, the birefringence will be changed also.

Let us attempt to apply this theory[2] first to the more fully investigated α-chrysotile.

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[2] Calculations are omitted.

The intermediate medium for this mineral is probably the absorbed water, filling the interstices between the elementary fibers. Its refringence must be lower than that of chrysotile. The integral index of refraction will lie between the refractive index of water and that of chrysotile. As the fibers of chrysotile are continuous throughout their length, the refractive index N_g must remain constant and independent of the surrounding medium. Hence, we shall be interested chiefly in the optic vector of the section across the length of the fiber. The absorbed water is probably isotropic. We do not know exactly what are the values of N_m and N_p of chrysotile. But this has been found to be of no consequence, since the resulting optic vector will not depend on the direction (9), due to occasional turns of elementary fibers around the direction of fibering. Applying now the theory of Wiener, we are brought to the conclusion that chrysotile is a uniaxial mineral.

All these reasonings are equally applicable[3] to ishkyldite, as this result cannot depend on the atomic arrangement. Ishkyldite, however, is not a uniaxial, but a distinctly biaxial mineral. Its x-ray photogram reveals a regular fine-fibered texture. The latter may exist only when the elementary fibers are oriented in one single direction. Any, even partial, orientation in some other direction would immediately affect the x-ray photogram. Consequently, it is not here that the solution of the said controversy is to be sought. In my opinion it is necessary to turn our attention to the interspaces between the elementary fibers. In chrysotile they are assumed to be equal in all directions, and probably such is actually the case, as the splitting capacity of chrysotile-asbestos does not depend on the direction.[4]

Such is not the case with ishkyldite. It is highly probable that stress has favored the formation of unequal spaces between the "layers" of the fibers. The presence of parting indicates that definite rows of fibers are separated by a greater distance than the individual elementary fibers. If we make a cross section of an ishkyldite fiber and represent the location of the elementary fibers by black dots, a diagram results, shown in Fig. 2. It is a kind of secondary laminated lattice.

Since the value of $m > n$ (see Fig. 2), it is clear, that the forces of cohesion will be changed accordingly. Hence the formation of the parting plane. The same factor must play a part also in forming the integral optic vector. To the extent that the elementary optic vector of the surrounding medium (absorbed water) will play a greater rôle in one direction, and a lesser in the direction normal thereto, the integral optic

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[3] If between the fibers some other isotropic medium, e.g., air, is present, the result will not be different.

[4] We mean the directions lying in the plane, perpendicular to the length of the fiber.

vector will be dependent on the direction. Hence, the mineral will be biaxial. This is not all, for in addition the location of N_p and N_m may be predicted. As water must have, as mentioned above, a lower refractive index than that of the mineral, it is easy to understand that the optic vector perpendicular to the parting must be a minimum, i.e., it will be N_p. Therefore, the plane of the optic axes must be parallel to the length of the fibers and perpendicular to the parting plane. Fig. 1 shows us that we have this optic orientation in ishkyldite.

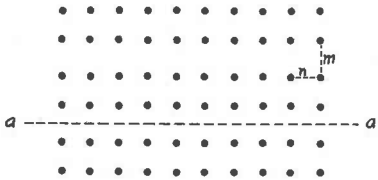

FIG. 2. Diagram showing texture of ishkyldite (cross section); black dots show locations of elementary fibers; a–a=direction of parting plane.

In a previous paper (1) I have shown, that the small amount of this mineral did not permit me to obtain entirely definite data from the thermal analysis. Still, the following peculiarities may be noted for the thermogram of our specimen:

(1) an indistinct endothermal peak at about 100°C.;

(2) a complex endothermal double peak, with apexes at 650° and 710°C.;

(3) a distinct exothermal peak at about 800°C.

A heating curve of such a nature resembles that of the semi-brittle type of α-chrysotile. The difference lies in the lower values of the temperatures of the complex peak. As shown previously (1) the existence of such a peak may be, in my opinion, related to the presence of fibers of abestos of another kind (for the brittle type of α-chrysotile). Ishkyldite, in fact, contains nearly three per cent of ferrous oxide, and therefore a certain analogy with brittle asbestos may be established. We have no data, however, to arrive at a conclusion as to the heterogeneity of ishkyldite. Here too, as in the case of semi-brittle asbestos (1), the reason of the said phenomenon is to be sought in the peculiarities of the inner structure of ishkyldite.

The specimen from Karabash (M. P. Lozhechkin's collection) is on the whole identical with the author's specimen in its properties; but on its thermogram only one of the two apexes of the complex endothermal peak is distinctly visible. It corresponds to a temperature of 700°C. There are but faint indications of the other peak. All the endothermal changes of ishkyldite caused by the removal of water were shown by the preliminary experiments carried on by V. N. Mishina under my supervision, using the method of absorption—thermal dehydration (10). The amount of water given off at various temperatures is shown in the following table. The dehydration at every stage was made at constant temperature until the water had ceased to be evolved. The amount of water was determined from the weight of the absorption tubes filled with P_2O_5. For carrying off the water vapours a stream of dry air was slowly passed through the apparatus. Table 4 shows that the "combined" water is given off not at one but at several temperatures, which is in keeping with the above description of the large endothermal peak.

TABLE 4

t°C.	Time of dehydration in hours	Per cent of water evolved
100	3.4	0.60
200	3.2	0.00
300	2.5	0.16
400	2.8	0.11
500	3.5	0.54
530	8.4	1.50
600	9.5	7.14
700	4.0	1.60
	Total	11.73 per cent

It may be stated, therefore, that the behaviour of water in ishkyldite when heated is more complex than in α-chrysotile of a normal type. I have as yet found no explanation for this fact.

As to the origin of ishkyldite, owing to lack of observations of my own, little can be said at present.

There is no doubt that ishkyldite grew under conditions of stress, directed perpendicular to the axis of the fibers. I do not know as yet how it was oriented with respect to the side walls of the fissure. It is beyond doubt, however, that this direction must have lain in the plane perpendicular to them, since the axis of the fibers of ishkyldite is oriented parallel to the walls of the fissure. It is also clear that ishkyldite could not have been formed by crumpling of α-chrysotile, since it has a different atomic lattice. Finally, it is necessary to assume a somewhat different composition of the parent solutions. A somewhat earlier formation of ishkyldite as compared with α-chrysotile may also be assumed since the latter must have been formed when the mechanical strains had been sufficiently weakened, as is usually the case in a later phase of the history of the massive rock.

SUMMARY

1. Ishkyldite, as shown by its chemical and x-ray analyses, is a new mineral and represents a structural modification of chrysotile.

2. Its composition is expressed with sufficient accuracy by the empirical formula: $H_{20}Mg_{15}Si_{11}O_{47}$.

3. The optical properties of ishkyldite are as follows:

$$N_g = 1.573,\ N_p = 1.566;$$
$$N_g - N_p = 0.007;\ 2\ V = 58°.$$

4. A theoretical explanation is given of the nature and orientation of the optical ellipsoid.

5. The identity period of ishkyldite in the direction of the axis of the fibers is $C = 9.68$ Å.

6. The specific gravity is 2.62.

7. The thermal analysis and the dehydration of this mineral shows distinct peaks.

8. Ishkyldite is probably an earlier mineral than α-chrysotile (chrysotile-asbestos). Characteristic of the conditions of its formation is the existence of stress at the time of growth.

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