

On the species Pilolite, and the examination of a specimen from China.

By G. STAFFORD WHITBY, A.R.C.S., B.Sc.

Analytical Laboratories, Royal College of Science, London.

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A SAMPLE of supposed 'vegetable asbestos' obtained in the west of the province of Szechwan, China, was forwarded in 1907 by Mr. J. H. Bristow,¹ the British Consul at Chungking. It was later² reported by Mr. H. Phillips, the British Consul at Chungking, that the so-called 'vegetable' asbestos previously mentioned 'is found in crevices between rocks in the districts of Lei Po T'ing and P'ing Shang Hsien, in the prefecture of Sui-fu.' The author has recently been informed that it occurs along the length of the Yangtse-kiang generally, from Sui-fu to the Huili-chou neighbourhood—i. e., along the Szechwan-Yunnan border on the outskirts of the Man Tzu country. According to the quaint idea of the local Chinese, this so-called 'vegetable' asbestos (Ti Chien P'i) is formed by the action of certain gases on the secretion of a worm.

This is the material the results of an examination of which are here recorded, and which proves to be neither 'vegetable' nor 'asbestos', but a very interesting specimen of pilolite. It has the appearance of a mountain-leather of particularly fine quality. It consists of thin, flexible sheets, soft and felt-like, which remind one of glove kid; and, when rubbed against itself, it emits a squeaking noise, similar to that obtained when two pieces of leather rub over one another. It is white in colour, but is crossed by very light brown lines, which are parallel and about one-eighth of an inch apart. It is the finest specimen of mountain-leather that the author has seen. There is a sample of it in the Mineral Collection of the British Museum (Natural History).

Under the microscope it is seen to consist of fine, interlaced fibres. The felted structure of the mineral is very obvious during the process of

¹ Board of Trade Journal, October 24, 1907, vol. lix, p. 183.

² Op. cit., December 24, 1908, vol. lxiii, p. 620.

grinding; the pestle has to be urged backwards and forwards in order to pull the fibres apart. The fibres have a refractive index of about 1.5, and, with polarized light, give straight extinction.

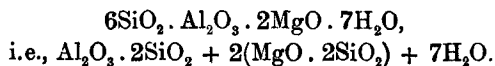
At 100° C. a considerable amount of water is lost, but no change in appearance occurs; and, further, on allowing the mineral, which had been dried at 100° C., to stand in the atmosphere for several days, it re-absorbed exactly the same amount of moisture as that which had previously been expelled. At a higher temperature, more water was lost, the whole of it being driven off at the temperature of the Bunsen-burner. The mineral does not give up its water in a vacuum-desiccator. A powdered specimen had undergone no change in weight after a week *in vacuo*. The contraction undergone on heating is very great. When a whole (i.e. unpowdered) piece is heated in a platinum crucible over a Bunsen-flame, no contraction takes place, but when this piece is held directly in the Bunsen-flame, it shrinks at once. (No change in weight accompanies this contraction.) That the very characteristic contraction which the mineral undergoes on heating is due to partial fusion effected by the higher temperature, is shown by the fact that, when heated in the oxyhydrogen flame, it easily melts. When the material contracts, or even when it is heated only sufficiently to expel the water, it becomes brittle. This fact bears on its proposed commercial applications. An experimental shipment was made some time ago, and it was suggested that, since the material was stated to be 'incombustible and bullet-proof,' it might be employed in some naval or military direction. Another suggestion was that it might be used in the preparation of incandescent mantles. The fact that it contracts greatly and becomes brittle when heated makes it difficult to conceive how it could be applied in such ways.

The following results were obtained on analysis (using 0.6221 gram of material):—

	Per cent.	Molecular ratios.
(Water lost at 100° C.)	6.06)	
Total water (lost on ignition) ...	18.12 ...	1.0067 or 6.94
Silica	54.94 ...	0.9111 ... 6.28
Alumina	14.83 ...	0.1451 ... 1.00
Ferrous oxide	0.55 ...	0.0076
Magnesia	10.94 ...	0.2713 } 0.2789 1.92
	<hr/> 99.38	

A trace of manganese is also present. These numbers were confirmed by

the analysis of another but smaller quantity. The formula most nearly corresponding to the above figures is—



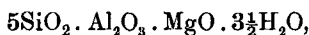
This formula requires—

	Per cent.
Silica	53.95
Alumina	15.24
Magnesia	12.02
Water	18.79
	100.00

The large amount of water present shows the mineral not to be a true amphibole-asbestos. Thus it cannot be regarded as a mountain-leather in the narrower sense of that term, as applied to leather-like forms of asbestos. Further, the amount of magnesia present is too small to allow of the mineral being regarded as a serpentinous asbestos. Of asbestiform minerals, it conforms most nearly to pilolite.

Pilolite was described as an independent species in 1879 by Heddle,¹ who applied the term to certain felted asbestiform minerals found in Scotland, which could not be identified with asbestiform hornblende or serpentine. The mean of Heddle's seven analyses (three of 'mountain-leather' and four of 'mountain-cork') is: SiO_2 , 51.64; Al_2O_3 , 8.62; Fe_2O_3 , 0.78; FeO , 2.88; MnO , 1.41; CaO , 0.98; MgO , 10.21; H_2O , 23.27; and the nearest corresponding formula is $10\text{SiO}_2 \cdot \text{Al}_2\text{O}_3 \cdot 4\text{MgO} \cdot 15\text{H}_2\text{O}$, i.e., $\text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2 + 4(\text{MgO} \cdot 2\text{SiO}_2) + 15\text{H}_2\text{O}.$

G. Friedel² in 1901 described a silicate which he then regarded as a new species, and to which he gave the name lassallite, but which he later³ recognized as being sufficiently accurately described for the present as belonging to Heddle's species pilolite. Friedel's specimens were from Miramont in Auvergne, and gave analytical data the simplest corresponding formula to which is $12\text{SiO}_2 \cdot 2\text{Al}_2\text{O}_3 \cdot 3\text{MgO} \cdot 8\text{H}_2\text{O}.$ The mean of Friedel's analyses of a specimen from the Pyrenees is SiO_2 , 52.1; Al_2O_3 , 16.83; MgO , 7.5; CaO , 0.71; FeO , 1.32; H_2O , 20.85; and the simplest corresponding formula may be taken as



¹ M. F. Heddle, *Mineralogical Magazine*, 1879, vol. ii, p. 206.

² G. Friedel, *Bull. Soc. franç. Min.*, 1901, vol. xxiv, p. 6.

³ G. Friedel, *op. cit.*, 1907, vol. xxx, p. 80.

but these figures are not so valuable, owing to the presence of grains of quartz in the mineral.

The material described in this paper is from quite a new source, China, and is seen to differ in some respects from the specimens from Scotland and France. It contains no calcium, and only a trace of manganese. It contains rather more silica than the specimens from the other localities; the water-content is somewhat different; whilst the amounts present of alumina and magnesia differ distinctly from those in the other samples, which themselves do not agree with one another. Again, the formulæ corresponding to the analytical data found for the specimens of pilolite obtained from the three different parts of the globe mentioned are not the same. Heddle represents pilolite as a combination of one molecule of aluminium silicate with four molecules of magnesium silicate and fifteen molecules of water ($\text{Al}_2\text{Si}_2\text{O}_7 \cdot 4\text{MgSi}_2\text{O}_6 \cdot 15\text{H}_2\text{O}$); Friedel's formulæ do not correspond to any definite combination of simple silicates; whilst the formula arrived at in this communication represents pilolite as a combination of one molecule of aluminium silicate with two molecules of magnesium silicate and seven molecules of water,



It will thus be seen that the species pilolite is not yet as precisely defined as one could wish, and, for the present, the term must be given such an extension as is implied in its application to those varieties of mountain-leather and mountain-cork which—

(1) cannot be identified with asbestos on account of the presence of a large amount of water and the absence of any considerable amount of lime;

(2) cannot be referred to serpentinous asbestos on account of the relatively small amount of magnesia which they contain; and

(3) hold their water in such a way that, when it has been expelled by heating, it is gradually re-absorbed from the atmosphere exactly in such amount as to make the water-content what it was originally.

Such a definition of the species seems to allow considerable latitude, but it takes account of all the differences, applies to all the pilolites hitherto described, and must be regarded as marking out the species in what, for the present, is a satisfactory manner. Further, it may be pointed out that the pilolite described in this paper probably represents a typical and particularly pure variety, on account of (1) its clean appearance; (2) the absence of lime and manganese, and the lowness of the iron-content; and (3) the simplicity of its chemical formula. The

analytical figures lead one to presume that the type of the mineral is a combination of aluminium silicate and magnesium silicate with water, and it is to be observed that the Chinese specimen conforms to this type very closely—much more than do the Scotch or French samples. There is merely a replacement of a little of the magnesia by ferrous oxide; whilst in the original specimens of Heddle there is, in addition, a replacement of some of the magnesia by lime and by manganese oxide, and of some of the alumina by ferric oxide; and in the specimens of Friedel, a replacement of some of the magnesia by ferrous oxide and by lime.

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