Notes on Bowenite or Pseudo-Jade from Afghanistan.

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A STONE called *sang-i-yashm*[1] in Persian, which has some points of resemblance to jade and is sometimes mistaken for it, is utilised at Bhera, in the Shahpur District of the Panjab, for the manufacture of dagger hilts, knife handles, caskets, amulets, and other articles. It is also found useful in mosaic work.

I am indebted to Mr. J. Wilson, B.C.S., Deputy Commissioner of the Shahpur District, for several specimens of the stone in the unworked state, and for information regarding its place of origin. Other specimens I obtained from my son Lieut. A. H. McMahon, Assistant Commissioner, Kohat.

The *sang-i-yashm* is a hard species of serpentine which seems to correspond very closely to that named bowenite, after Dr. Bowen, who, in 1822, published an analysis[2] of a mineral from Smithfield, R.I., which up to that date had been called nephrite.

In 1853 the Smithfield bowenite was re-examined by Messrs. J. Lawrence Smith, M.D. and George J. Brush,[3] who proved its identity with serpentine.

The hardness of the Smithfield mineral was said by Dr. Bowen to be equal to that of felspar. J. D. Dana put it at 5·5 to 6, E. S. Dana at 5·5, and Smith and Brush at 5. The Afghan mineral has a hardness of 5.

The Sp. G. of the Smithfield bowenite, according to Dr. Bowen, varies from 2·59 to 2·787. I found 2·59 to be the Sp. G. of the Afghan mineral.

The following analysis (No. I.) of the Afghan *sang-i-yashm* was made in the British Museum Laboratory by Mr. G. T. Prior, M.A., and has been kindly communicated to me by Mr. Fletcher, F.R.S., the Keeper of the Mineralogical Department. I also give for facility of reference Dr. Bowen's analysis (No. II.) and Smith and Brush's analyses (Nos. III. IV. and V.).

[1] *Sang* means stone. *Yashm*, according to Forbes's and Platt's dictionaries, is a jasper "especially from China, supposed to be an infallible charm against lightning."
[2] *Amer. Jour. of Science.* 1st Series, V. 346 (1822).
[3] *Ibid.* 2nd Series, XV. 212.

	I.	II.	III.	IV.	V.
Silica	44·73	44·69	42·20	42·56	42·10
Magnesia	42·64	34·63	42·50	43·15	41·23
Alumina	0·32	0·56	trace	trace	trace
Ferrous Oxide ..	0·33	1·75	1·56	0·95	1·11
Lime	trace	4·25	trace	..	1·90
Manganese	..	trace	..	..	..
Water	12·21	13·42	13·28	12·84	12·77
	100·23	99·30	99·54	99·50	99·11

The theoretical formula for serpentine is: magnesia, 43·48; silica, 43·48; water, 13·04. The analysis of the Afghan mineral comes very near this standard, and corresponds closely with the analyses of American bowenite made by Smith and Brush.

As regards the lime found in bowenite by Dr. Bowen, Smith and Brush remark :—"The large amount of lime obtained was doubtless due to the limestone and tremolite with which it is often very intimately associated; much care is required to separate those substances entirely from the bowenite, but the mineral so purified, contains no lime."

The colour of the Smithfield mineral is said by Bowen to be "bright apple-green, sometimes tinged with blue;" and by J. D. Dana to be "apple-green or greenish white."[1] My specimens of the Afghan rock vary in colour from a dark greenish grey to a very pale sea-green mottled with white. Some specimens are said to be delicate apple-green.

The Smithfield mineral Dr. Bowen tells us is found "in large nodules" imbedded in "white primitive limestone." The Afghan bowenite appears to occur in rock masses at the head of one of the mountain gorges that run down from the Safed Koh into the valley of the Kàbul river. A man of Bhera, from whom Mr. Wilson derived his information, "went in search of the stone about forty years ago. He says he proceeded to Gandàmak[2] on his way to Kàbul, and from thence travelled up a gorge to the south for about thirty miles. At the head of the gorge he came to a rock where there are great quantities of the stone." "It is sold on the spot at about Rs. 2/8 to 3 Rs. a maund (5 shillings the cwt.). Some of the bits at Bhera have two marks of blasting bores on them. They weigh up to a cwt." After import to Bhera in the Shahpur District of the Panjab it is sold by weight "at about Rs. 40 per maund, or 74 shillings per cwt., and the inferior quality at 10 Rs. per maund, or 18 shillings per cwt. There are only three shops in Bhera of the workers of the stone, and they have between them used up about 5 maunds in three years."

[1] *System of My.* 1882, p. 465.
[2] Gandàmak is between Jalàlàbàd and Kàbul.

The *sang-i-yashm* is partially decomposed by hydrochloric acid, and is completely decomposed by hot concentrated sulphuric acid on prolonged digestion.

When a thin slice of the Afghan bowenite is examined under the microscope between crossed nicols it breaks up into a mass of minute doubly refracting fibrous crystals standing out against a dark background; the latter being due in part to the over-lapping of felted fibres, and consequent compensation, and in part to the extinction of such of the crystals as lie in the same azimuth as one or other of the crossed nicols.

Whenever the cleavage of the original mineral from which the bowenite has been derived can be made out, one set of doubly refracting fibrous crystals are found to lie parallel to it. A second set may be observed at right angles to the first; whilst a third more sparsely distributed series of crystals may also be seen, which indicate that the parent mineral possessed a third, and less easy cleavage, diagonal to the other two.

In other parts of the thin slices examined the crystals assume a somewhat feathery appearance, or arrange themselves in sheaf-like sprays. In some slices the doubly refracting crystals are somewhat micaceous, and the central portions of them exhibit a marked but discontinuous cleavage. These micaceous crystals cannot be talc, inasmuch as they never exhibit colours higher than the blue, yellow, and red of the first order of Newton's scale and no parts of the slices have a hardness of less than 5.

J. D. Dana in his System of Mineralogy remarks :—"If marmolite or thermophyllite is truly crystallized serpentine, as seems probable, the crystallization of the species is actually micaceous like that of chlorite and talc."

On the whole I see no reason to doubt that all the doubly refracting portions of the thin slices of bowenite examined are true serpentine. When thin slices of the rock are digested in sulphuric acid, the fibrous structure of the mineral is well brought out.

The optical properties of the doubly refracting crystals of bowenite coincide with those of serpentine. Extinction is uniformly straight; the major axis is normal to the axis of the fibres; and the crystals that exhibit cleavage, or fibrous structure, do not yield a bisectrix in converging polarised light. The refractive index of the Afghan mineral is evidently close to that of Canada balsam.

The *sang-i-yashm* appears to be a very pure serpentine. In some slices a few microscopic dots of magnetite may be made out, and some microscopic crystals of pyrites. There are also scattered through the slices

granules of a mineral which either remains absolutely dark when revolved between crossed nicols or only shows the feeblest possible glimmer, which may be due to the under-lapping of some of the serpentine. It does not exhibit crystallographic outlines or definite cleavage. It has a rough and cracked surface; it frays out at the ends into needles, and does not exhibit any metallic lustre. It has a high refractive index, and appears to be insoluble in sulphuric acid. In some respects it looks like garnet, but it does not possess the habit of that mineral. Sometimes it occurs in strings in a way to suggest that it is a secondary product; at other times it is penetrated by channels of serpentine very much in the way in which remnants of olivine are found in serpentine. On the whole I am disposed to think that it represents one of the original constituents of the parent rock, and possibly may be a pseudomorph after olivine. I hesitate to give the mineral a definite name.

This mineral, whatever it is, leads to the consideration of the character of the parent rock. The fact stated above relative to the structure of portions of the bowenite indicates that one of the minerals of the original rock possessed a triple cleavage, the two principal planes of which were at right angles to each other: a circumstance which enables us to identify it as pyroxene.

There is no evidence, beyond the suggestion as to olivine alluded to above, to show what the other constituents of the parent rock were, but there is nothing in the microscopic evidence to negative the supposition that the principal one was olivine. The almost complete leaching out of the iron destroyed all trace of *Maschen-structur;* but we must suppose that the original rock was, to a considerable extent, made up of a magnesian mineral, as otherwise the magnesia of the pyroxene of which the rock was evidently in part composed, could hardly have been levelled up to the amount required for its conversion into serpentine.

On the whole the probabilities of the case are in favour of the parent of the Afghan bowenite having been, as in the ordinary run of serpentines, some variety of peridotite.

The conversion of the original rock into pure serpentine has been so complete, that little microscopic evidence remains of the mode in which the aqueous agencies that effected the change in the rock worked their way through its molecular structure. Still there is enough to show that these agents availed themselves of all the facilities that existed; a few straight cracks with microscopic deposits of iron along their margins may, on careful search, still be traced; and, as before stated, when cleavage planes existed the serpentine crystals were formed in alignment with those planes.

The curved, feathery, and sheaf-like crystals were probably formed in the olivines of the parent peridote; curved cracks are commonly observed in this mineral, but regular cleavage is rarely, if ever, seen in sections made for the microscope. Other indications of aqueous agents may be noticed in the occasional deposit of a substance, reddish brown in reflected and transparent in transmitted light, that *runs with* some of the feathery sprays of crystalline serpentine. This reddish brown substance is evidently a secondary product, and it helps to throw light on the mode in which the curved and feathery crystals of serpentine were themselves formed.