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An Occurrence of Chrysotile Asbestos, Usushwana Valley, Mbabane District, Swaziland

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ABSTRACT

An occurrence of chrysotile asbestos in the Usushwana river valley some 10 miles west of Mbabane, has been sporadically prospected since its discovery in 1946. No fibre of economic grade has, however, been discovered but certain features concerning the genesis of this deposit are described and may prove of value in the further search for this valuable mineral.

Cross-fibre asbestos is confined to narrow mylonitized apple green serpentinite (totally serpentinized) occurring as sharply demarcated bands in dark blue-green serpentinite (partially serpentinized). As these mylonitized bands decrease in width they pass out into fractures less than an inch thick filled by verde antique, sometimes with traces of slip fibre. The widest mylonitized band located was 18 inches wide in which were up to a dozen seams of fibre of maximum width ½ in.

The features of the occurrence suggest that fault or shear action has been primarily responsible for the localization of this deposit.

I. INTRODUCTION

CHRYSOTILE asbestos was discovered in 1946 by a Swazi native, allegedly as the result of a dream, in the Usushwana river valley, about 10 miles west of Mbabane, capital of Swaziland, Southern Africa. Since that date sporadic prospecting has taken place which, although failing to locate a deposit of any economic importance, has served to indicate features of interest which may be of value in prospecting other bodies of a similar nature.

II. GEOLOGICAL SETTING

Partially serpentinized ultrabasics intrude quartzites, quartz-schists, and amphibole schists for which the writer has suggested the term Lower Fig Tree Series (Hunter, 1950, p. 34), which comprises the oldest sedimentary stage of the Swaziland System. This association has been intruded first by the Usutu Granite (one of the G.2 post-Pongola System granites), and secondly, by the Usushwana Complex. The former is a typical grey granite composed of quartz, orthoclase, and microcline with subordinate plagioclase and biotite. The term Usushwana Complex (Hunter, 1950, p. 40) has been coined to describe a sequence ranging from pyroxenite to microgranodiorite. In the Usushwana valley the dominant rock type of this Complex is a quartz-diorite with a small isolated dyke of microgranodiorite (see Text-fig. 1).

The serpentinites in question intrude quartz-schists, cherts, and quartzites which normally strike N.E.–S.W. and dip S.E. at variable

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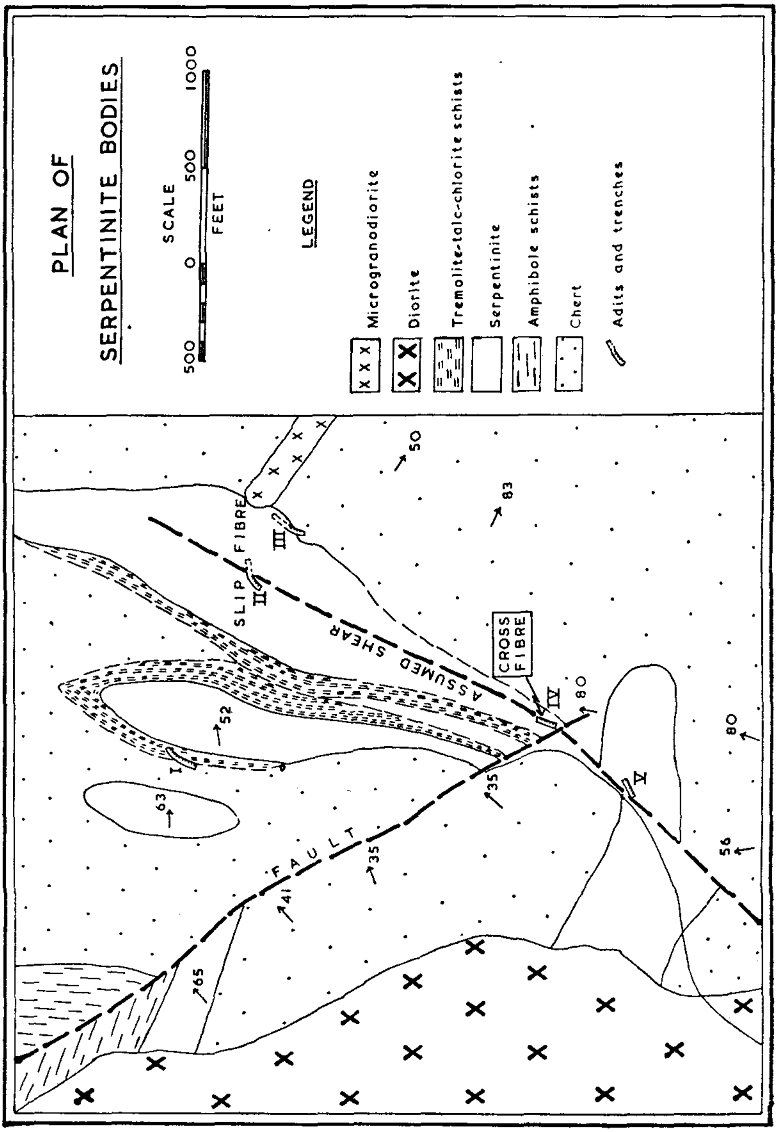

PLAN OF
SERPENTINITE BODIES
SCALE
500 0 500 1000
FEET
LEGEND
Microgranodiorite
Diorite
Tremolite-talc-chlorite schists
Serpentinite
Amphibole schists
Chert
Adits and trenches
SLIP FIBRE
ASSUMED SHEAR
CROSS FIBRE
FAULT
I
II
III
IV
V
50
83
52
63
80
80
35
35
41
65
56

TEXT-FIG. 1.

angles between 40° and 80°. The serpentinites are approximately conformable and appear to have originated as sill-like bodies. They are medium to fine-grained blue-black rocks which build jagged, prominent outcrops, commonly displaying an indefinite gneissose structure which is more noticeable towards the margins of serpentinite bodies. Microscopically they consist of a groundmass of fibro-lamellar antigorite with ragged laths of tremolite, residual cores of olivine, magnetite, and carbonate. The greater abundance of residual olivine over tremolite flakes would seem to indicate that the original rock was a peridotite or dunite.

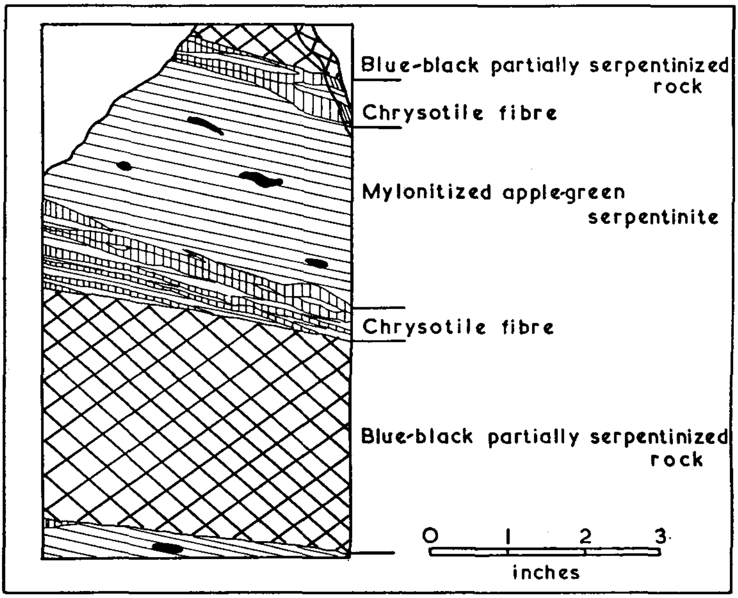
Rimming, though not completely surrounding the serpentinites are soft, yellow-brown schists composed of tremolite, talc, chlorite, magnetite, and some carbonate. These occur commonly as rectangular blocks due to a combination of well-developed cleavages and schistosity planes. A fibrous tremolite has been found sparingly in these schists. The contact between the schists and serpentinites is quite sharp, the contact serpentinites being very " slabby ".

Due to the absence of marker horizons and a sparsity of good outcrops the structure of the area cannot be elucidated with any certainty but it appears likely that the main body of serpentinite may be duplicated by folding. Two faults occur; one of which strikes N.E.–S.W. and is economically the more important for it is along this line that the chrysotile asbestos occurs. This fault has an observed lateral displacement of some 300 feet in the S.W. corner of the area (see Text-fig. 1). The second fault strikes N.W.–S.E. and apparently terminates in the vicinity of the first-mentioned fault.

III. Nature of Occurrence

In the past, three trenches and two adits were put in to prospect the body. These are shown in text-figure 1, numbered I to IV, II and III being adits. Slip fibre was exposed in the central adit, II, and in the south-westernmost trench, III. Cross fibre was located in trench IV near the junction of the two faults. In trench I to the north-west a little chrysotile asbestos was located at the contact between the serpentinite and the talc-tremolite-chlorite schists which surround the serpentinites. Adit III was driven through serpentinite with some slip fibre, whilst trench V, sunk in blue-black serpentinite, revealed some talcose, very weathered fibre, possibly chrysotile.

In adit II the slip fibre occurs closely associated with serpentine mineral (i.e. verde antique). Steeply dipping or nearly slickensided fractures are filled by fibre or serpentine or both. The fractures are about $\frac{1}{8}$ in. to $\frac{1}{4}$ in. thick and average about 1 or 2 inches apart. The full width of this zone has not been exposed, as no exploratory development was directed across the strike. It seems possible that it is not less than 10 feet and may be as much as 20 feet wide. The strike of the cross-fibre seams located in trench IV is the same as that of the slip-fibre fractures, the dip being almost vertical. Here again prospecting was directed along the strike and the full width has not been exposed, although one zone of fibre about 18 inches wide was located. The cross-fibre occurs in apple green, highly sheared serpentinite, zones of which up to 18 inches wide occur separated from each other

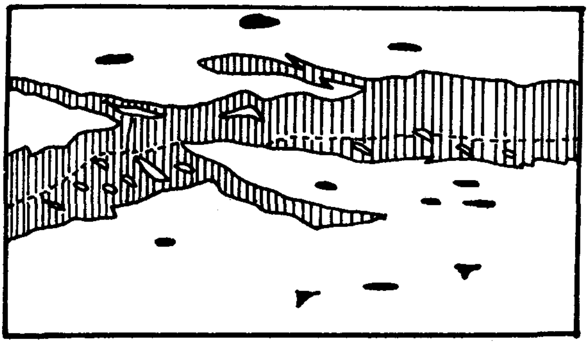


TEXT-FIG. 2.—Section of block of serpentinite from asbestos prospect north of Usushwana River, Crown mineral area No. 14.

by variable thicknesses of massive blue-black serpentinite (see Text-fig. 2). The surfaces between partially and totally serpentinized rock are sharp, often slickensided.

The width of the veins varies widely with a maximum of $\frac{3}{8}$ in. and an average of $\frac{3}{10}$ in., which figures place the deposit in the sub-economic class. The percentage fibre cannot be assessed as there is nowhere a full exposure of the fibre-bearing zone. The position of the fibre in the mylonitized zone varies: in some the fibre lies in a zone close to the contacts with the partially serpentinized rock, whilst in others it is regularly distributed throughout the zone. The edges of the veins are notably linear, either straight or gently curving. The edge is always sharply defined and even up to magnification of 100 × no trace of irregular contacts implying replacement could be observed. No relationship was observed between the width of serpentinization and the width of the asbestos veins. All the fibre was apparently developed simultaneously for the veinlets commonly run into and join each other without a break. No vein cuts across the line of the sub-parallel fractures. The veinlets are not parallel to the edges of the band but lie at a slight angle to it, usually about 10°.

The veinlet may be filled by one set of fibres stretching from wall to wall, but more commonly there is an irregular central fissure which marks the junction of fibres growing from opposite walls. This fissure varies greatly; it may be closer to one wall than the other or it may be mainly central. Its presence may be marked by a line of inclusions of the wall rock, by a thin film of magnetite, or there may be no foreign matter marking the break. In some seams one-half contained more



TEXT-FIG. 3.—Section of chrysotile fibre seam in apple green mylonitized serpentinite. About 3/2 natural size. Broken line indicates contact between silky fibre with many inclusions of apple green mylonite which is shown without symbols. Solid black blebs represent augen of blue-black serpentinite in the mylonite.

inclusion that the other (see Text-fig. 3). Another common structure is the change in direction of the fibres, there being no break at these bends.

Magnetite is largely confined to one wall in the veins so far exposed, although chips and seams of magnetite along the central fissures are common. In some seams the magnetite is clearly replacing the chrysotile, as seen under the microscope. In those veinlets in which the magnetite is concentrated along one wall the fibres always break off more easily from that wall. These features suggest that some of the magnetite was introduced after the formation of the fibres. Microscopically the mylonite consists of bladed antigorite crystals showing only a rude orientation in most cases but sometimes having a well defined parallelism. No residuals occur in this rock, the shearing being responsible for total serpentinization. It is, therefore, important to recognize two stages in serpentinization, just as Cooke did at Thetford, Canada (Cooke, 1937, p. 139).

IV. Relation to Wall Rock

The proportion of the serpentinized zone to the vein has been studied by many observers, notably Dresser (1913). As has been mentioned above chrysotile veins occur in the apple green ribbon alongside the partially serpentinized rock. If, as Dresser (1913, pp. 61–6) suggests, serpentinizing solutions passed along closed cracks in which fibre was deposited simultaneously with total serpentinization of the wall rocks, then it would be expected that total serpentinization of the wall rock would be proportional in extent on either side of the vein to the width of the vein. Text-fig. 3 shows that this is clearly not the case in this occurrence.

Some but not all vein walls show slickensiding which is due to fault movement prior to the formation of the vein, for the fibres filling the vein are not disturbed. Such slickensided planes would be present in a mylonitized rock. Fibres always break more easily from these surfaces. These facts are important for they show that the original fissures were not destroyed by the fibre growth replacing the walls.

V. Genesis of Chrysotile Fibre

The reader is referred to a discussion of the merits of the various theories to the able summaries by Cooke (1937), Keep (1929), and Hall (1930). Bateman (1950, p. 292) has summarized the various theories as follows:—

(1) The veinlets are fissure fillings.
- (*a*) In openings of hydration expansion from serpentine solutions of short distance transportation.
- (*b*) In fractures produced by dynamic stresses, by means of hydrothermal solutions of remote source.

(2) Replacement and re-crystallization of serpentinite walls outward from tight cracks.

(3) Serpentine extracted from rock and deposited as asbestos in tight fractures, the walls are pushed apart by the force of the growing crystals.

The features described above point to the hypothesis that the localization of this occurrence is due to fault or shear action, which mylonitized the partially serpentinized peridotite and which controlled the ingress of the asbestos-forming solutions. The age of this faulting cannot be determined but it is definitely pre-Usushwana Complex as these rocks are not affected. It is also later than the first serpentinization of the peridotites, which was, it is believed, caused by the water present in the original ultrabasic magma reacting with the earlier formed minerals at a later stage in the crystallization. It is highly probable that the faults can be attributed to adjustment movements at the time of the intrusion of the Usutu Granite.

The end products of the total serpentinization in the fault zones strongly suggest that aqueous solutions or vapours were responsible. The presence of magnetite, which is ubiquitous and in some places actually replaces the fibres, suggests that these permeating solutions or vapours were heated. It is believed that this mineral is formed at high temperature (Lindgren, 1933, p. 637) probably in excess of 300° C.

It is considered, therefore, that subsequent to mylonitization heated aqueous solutions entered the sheared zones reacting with the fault " mush " and completely serpentinizing it and carrying off the excess to be deposited as asbestos in the many slickensided fractures which formed an integral part of the mylonite. As the fault material would probably be only moderately consolidated the growing asbestos crystals met little opposition when they opened up the fractures by the force of their crystallization.

The slip-fibre and verde antique probably result in part from the original mylonitization and partly by a similar process postulated for the cross-fibre. In this case the cracks, being very small, lead to rapid crystallization to a glassy serpentine.

VI. Conclusions

The foregoing is a brief summary of this interesting little occurrence. It is appreciated that the genesis of the fibre suggested here will not hold good for every case but the writer believes that the facts observed are sufficiently conclusive to warrant the investigation of faulted serpentinite bodies in the search for chrysotile asbestos.

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