BUREAU OF ECONOMIC GEOLOGY

Geological Circular 73-1

Asbestos in the Allamoore Talc District, Hudspeth and Culberson Counties, Texas

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ASBESTOS IN THE ALLAMOORE TALC DISTRICT, HUDSPETH AND CULBERSON COUNTIES, TEXAS

R. G. Rohrbacher[1]

INTRODUCTION

The Allamoore district of Hudspeth and Culberson counties, Texas has become one of the most significant talc-producing areas of the United States. Exploitation of talc deposits in the district began in 1952 with a cumulative production of 120,000 tons through 1957 (Flawn, 1958). With continued growth, annual production exceeded 160,000 tons in 1968, making the district second only to New York State in national output. Moderate- to large-sized deposits have been developed with near-surface parts inexpensively extracted. Talc reserves are estimated in the tens of millions of tons.

Long-fiber asbestos was first found in association with talc deposits of the Allamoore district in 1960 during exploratory drilling of what became the Buck claim. Small amounts of asbestos were noted in subsequent development of this large talc deposit. Later, small amounts of white asbestos were encountered in the T. & P. No. 1 mine and recently at the Neal-Mann prospect (fig. 1). Early in 1971, Albert Gregory of Van Horn, Texas, discovered an asbestos deposit now known as the Diablo prospect. Subsequently, the Van Horn Soapstone and Talc Corporation was formed and preliminary exploratory work at the prospect indicated the possible presence of commercially exploitable amounts of asbestos.

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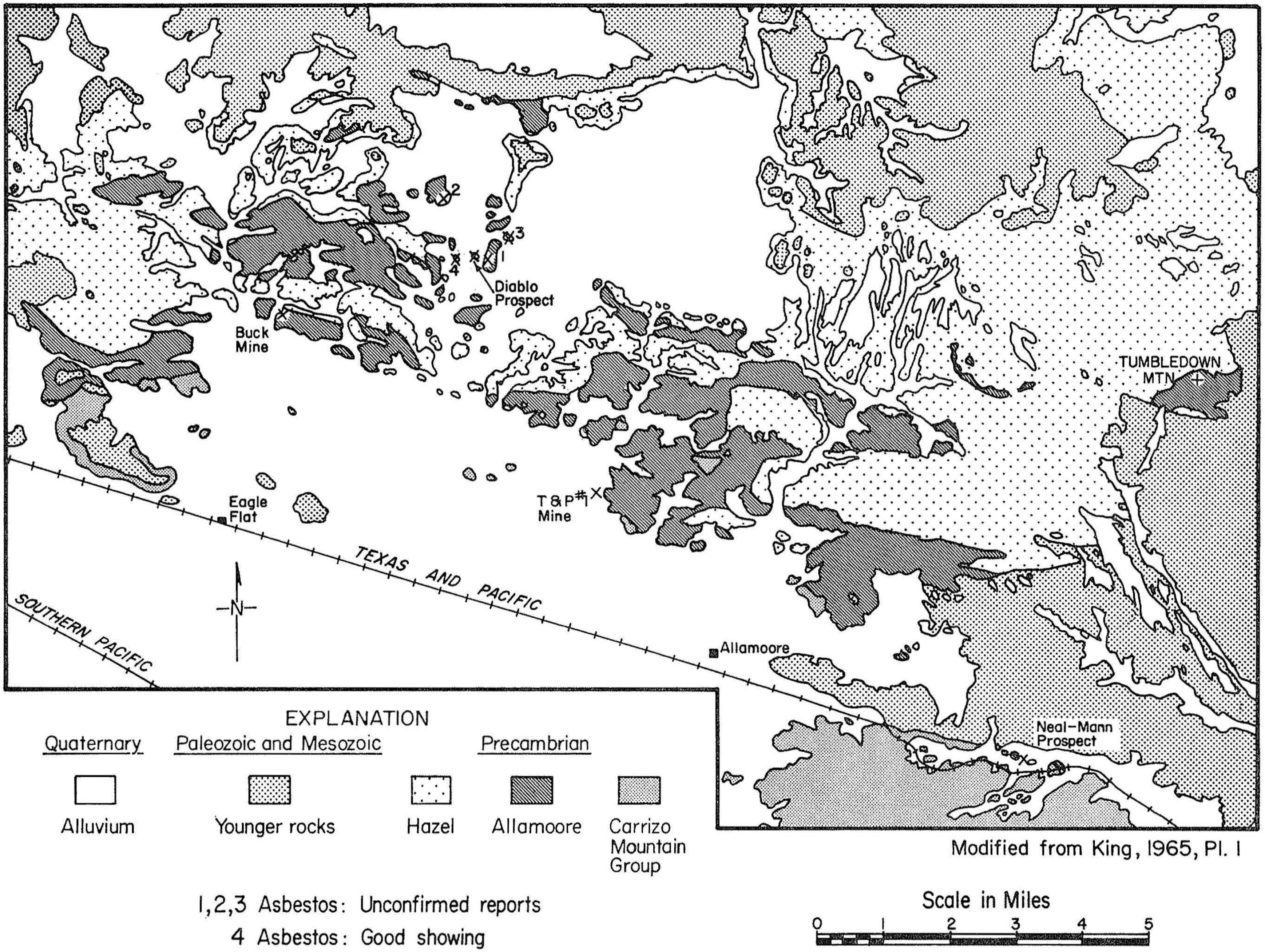

FIG. 1. General geology and asbestos deposits, Allamoore talc district.

This evaluation of asbestos deposits is based on a current study of the stratigraphy, structure, and mineral deposits of the talc district. A subsequent report will detail the mineralogy of metasomatic rocks of the district, including talc and asbestos deposits, and will present a geochemical model for their origin.

GEOLOGY

Regional Setting

Talc and associated asbestos occur in Precambrian rocks in a deformed belt previously described by King and Flawn (1953) and P. B. King (1965).

From north to south, the gently dipping but strongly jointed sandstone and conglomerate of the Hazel Formation change within several miles into a severely deformed mixture of Hazel Formation and the carbonate and volcanic rocks of the Allamoore Formation (fig. 1). Adjoining on the south are the metasedimentary and metaigneous rocks of the Carrizo Mountain Group.

The rocks of these three divisions grade from practically unmetamorphosed in the northern part to greenschist and amphibolite facies in the southern part. Metamorphism of the central division was mostly dynamic, with varied degrees of recrystallization and metasomatism taking place primarily in carbonate rocks.

Mineral associations in the central division suggest that metamorphic grade increases southward, representing pressure-temperature conditions equivalent to both zeolite and greenschist facies. There are minor occurrences of Allamoore-type carbonate rocks, some of which are altered to talc, in the Carrizo Mountain Group. The carbonate rocks may have been originally interstratified with the Carrizo Mountain sedimentary rocks.

Allamoore District

The talc district includes an area about 20 miles long in an NW-SE. direction, and about 5 miles wide in an NE-SW. direction.

The stratigraphic and structural relationships between the Allamoore and Hazel Formations are complex. It was previously suggested that the Hazel Formation, with its conglomeratic portion derived from Allamoore rocks, was tectonically mixed with the Allamoore Formation in a complex structure of folds and thrusts (King, in King and Flawn, 1953). However, remapping in the district suggests that the two formations were originally interbedded and that the rocks constitute a single formation. In this tentative interpretation, the district is viewed as an upside-down sequence that is of general homoclinal form and that includes folds and faults.

The carbonate rocks comprise limestone and dolomite in varying proportions. Layers with a high ratio of dolomite to calcite contain the most chert; vertical and lateral sedimentary facies changes in carbonate and chert layers occur over short distances.

Volcanic rocks include mafic flows and pyroclastic and volcaniclastic types. Mafic flows now directly associated with other volcanic rocks cannot always be distinguished from diabase sills. Alteration of mafic rocks is intense; alteration products include chlorite, mica, calcite, dolomite, hematite, and epidote.

Talc Deposits

Talcose rocks include talc (or talc rock) and talc-carbonate rock. Talc rock contains less than 20 percent carbonate minerals; talc-carbonate rocks contain more than 20 percent carbonate minerals. This division roughly separates commercial (talc rock) from noncommercial (talc-carbonate) material.

Deposits range from talcose streaks to zones of talcose rocks up to 600 feet wide and a mile long. Most are steeply inclined lens-shaped or tabular bodies. Some have been contorted or deformed into isoclinal folds with adjacent carbonate and mafic rocks.

Minerals of talcose rocks are mostly talc and dolomite, with some deposits containing both dolomite and calcite, or rarely dolomite and magnesite. Small amounts of quartz are widespread. Amphibole and poorly to well-crystallized layer silicates occur in varying but generally minor quantities.

Relict sedimentary features and incomplete replacement of some layers clearly indicate that the talcose rocks were originally carbonate rocks. Internal structure of talc bodies is commonly more complex than external form. The purest talc tends to be near the center of talcose units, with increasing amounts of talc-carbonate rock and layers of slightly altered and unaltered carbonate rock and chert toward the margins.

Foliation is well developed in many talc deposits and is generally parallel to original bedding of the host rock. Whereas talc was deformed largely by shear folding and differential movement along foliation planes, many included layers of carbonate rock and chert were folded and broken into segments that were tectonically separated in the talc. The systematic regional change of metamorphic grade, together with the foliation of much of the talcose rock and the lineation of amphiboles in associated rocks described below, suggest that hydrothermal metamorphism was syntectonic.

Altered diabase occurs adjacent to or in the vicinity of talc deposits and may have served as a source of heat in generating the hydrothermal solutions which selectively reacted with favorable carbonate layers.

ASBESTOS

Nearly all of the world's commercially valuable asbestos is chrysotile and most of it occurs in serpentinized ultramafic igneous rocks. Amphibole asbestos is found in a wide variety of igneous and metamorphic rocks, including serpentinite, carbonate rocks, and iron formations. Although its share of the commercial market is small in comparison to that of chrysotile, amphibole asbestos has many uses.

The bundles of long, delicate fibers of white asbestos from the Allamoore district look very much like chrysotile, but x-ray diffraction studies and chemical analyses indicate that the asbestos is an amphibole type. In the discussion that follows, the occurrence of amphiboles and amphibole asbestos is considered in detail appropriate to the purpose of this report, which is to briefly describe the occurrence and geology of the asbestos as a guide to further prospecting.

Blue Amphibole Rock

Blue alkali amphibole and tremolite-actinolite occur in rocks within and near talc bodies in some areas. The total amount of rock containing blue amphibole is insignificant compared with that containing talc; blue amphibole has not been noted at many deposits.

The alkali amphibole varies from pale blue to black; x-ray diffraction and optical study suggest that the amphibole may be magnesioriebeckite-riebeckite of differing compositions. Albite and K-feldspar are apparently more abundant than the amphiboles but are difficult to recognize in the field and may be mistaken for carbonate minerals, with which they are intergrown. Associated minerals that generally occur in trace or accessory amounts include alkali pyroxene, mica, chlorite, talc, tourmaline, rutile, pyrite, hematite, and magnetite. The suite of minerals occurs in different combinations and proportions, and no constituent, including blue amphibole, is always present.

Amphiboles vary in form from fibrous to prismatic and are contained for the most part in carbonate rocks; some thin layers were partially and selectively metasomatized to blue amphibole rock for tens of feet. However, patchy replacements and thin irregular veins largely filled with slip-fiber blue amphibole are the typical modes of occurrence.

Fibrous varieties of magnesioriebeckite-riebeckite are known as crocidolite and have been used as asbestos. However, the blue amphibole in the Allamoore district has only been found in small amounts and generally mixed with large quantities of impurities.

Richterite-Talc Rock

The white fibrous amphibole asbestos present in the Diablo prospect and adjacent areas is richterite, as shown by its chemical composition (table) and verified by comparison of x-ray powder diffraction patterns with the calculated pattern for a K-richterite from western Australia given by Borg and Smith (1969). Richterite may be considered the alkali-rich analog of tremolite, and its composition regarded as the result of substituting two alkali ions for one of the two calcium ions of tremolite. Some richterite contains significant amounts of potassium, probably accommodated by the relatively large A structural site. The 3.54 percent K_2O in the Diablo prospect amphibole is a higher percentage than most richterites contain. However, richterites from volcanic rocks from Murcia, Spain and the Leucite Hills, Wyoming (Carmichael, 1967), and from

West Kimberley, western Australia (Prider, 1939) contain from 4.4 to 6.5 percent K_2O. Such high concentrations of potassium may represent complete filling of the A site (Papike et al., 1969).

Table. Chemical analysis of cross-fiber richterite asbestos from the Diablo prospect. (Collected by C. G. Groat; analysis by J. T. Etheredge and D. A. Schofield, Mineral Studies Laboratory, Bureau of Economic Geology.)

	Percent
SiO_2	56.16
Al_2O_3	1.51
Fe_2O_3 (total Fe)	0.41
TiO_2	0.00
P_2O_5	0.20
CaO	4.50
MgO	22.90
MnO	0.00
Na_2O	6.60
K_2O	3.54
H_2O^-	0.75
Ign. Loss at 1050° C.	1.96
	98.53

Numbers of ions on the basis of 23 oxygens–

Si	7.92	8.00
Al	0.08	
Al	0.17	
Fe	0.04	5.02
Mg	4.81	
Ca	0.68	
Na	1.80	3.12
K	0.64	

Occurrences

North-central part of district. –As previously mentioned, only small amounts of impure blue amphibole asbestos have been found in the Allamoore district. Most of the richterite asbestos discovered to date is in a 2-square-mile area of small hills separated by alluvium (fig. 1).

The carbonate rocks have been deformed so that the common east-trending strike and southward dip are now a north-trending strike and moderate to steep westward dip. Mafic igneous rocks are plentiful and many are probably diabase sills. Several small talc bodies and numerous talc showings in outcrops are present.

The main occurrence of richterite is at the Diablo prospect, a low hill of dolomite in which two layers of richterite-talc rock were exposed by trenching (fig. 2). The two trenched richterite-talc layers vary from about 4 feet to perhaps as much as 10 feet thick, and are at least 135 and 60 feet long, respectively. Asbestos content varies from a trace to about 75 percent. The carbonate rocks contain easily recognizable blue amphibole for about 35 feet west of the longest layer. Blue amphibole fills thin irregular fractures, and intervening carbonate has been partially replaced by alkali feldspar and other minerals.

Asbestos occurs as thin discontinuous seams and lenses in gray foliated talc, generally parallel or at a low angle to the foliation of the talc. The fibers are up to 5 inches long and the higher the asbestos content of the talc rock, the greater the length. Rarely asbestos occurs in veins in thin dolomite layers in the talc. Slip-fiber generally predominates but cross-fiber and bent-fiber forms

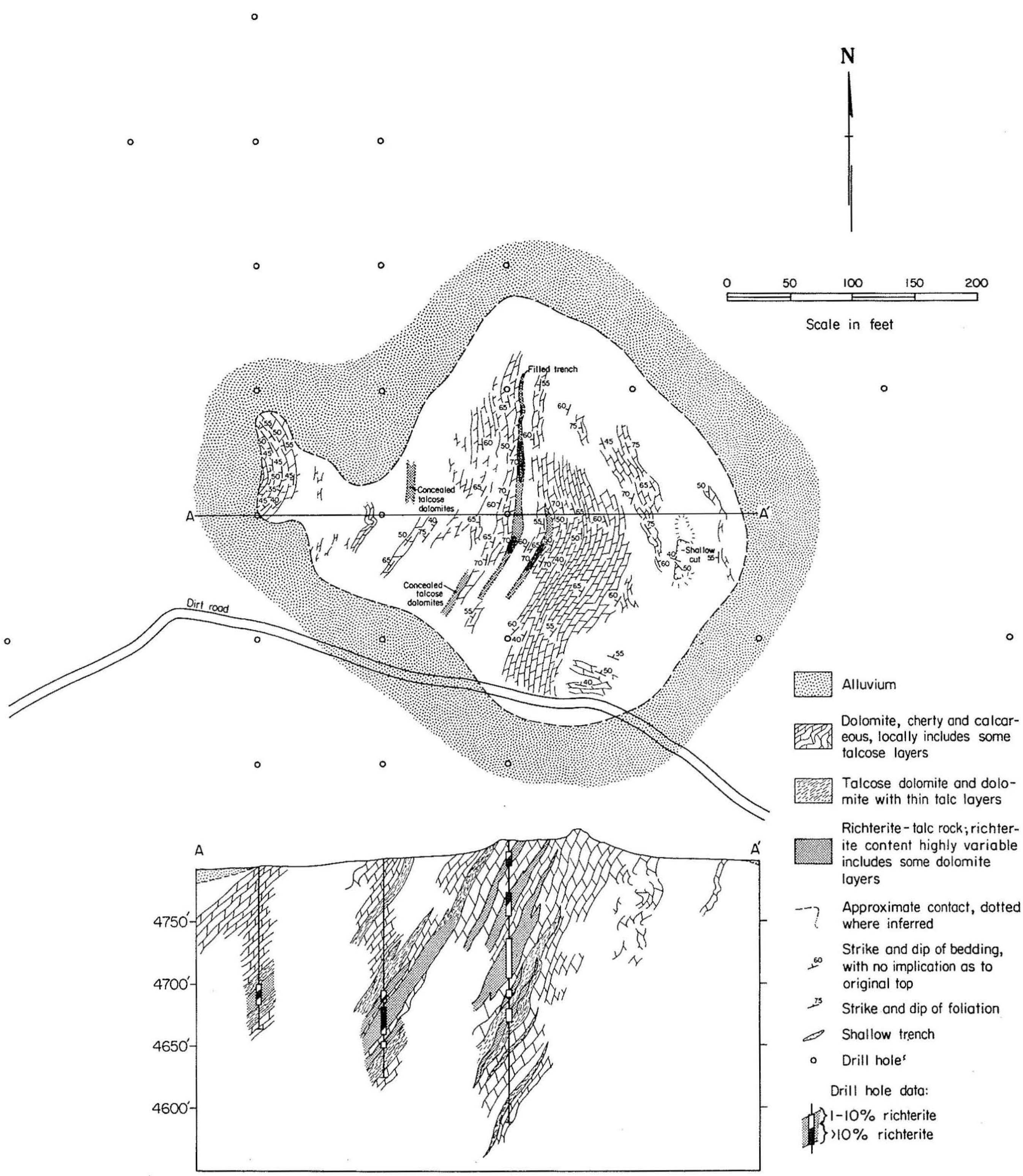

FIG. 2. Geologic map and structure section of Diablo asbestos prospect.

are also common. Some layers of asbestos have been shear folded and with subsequent differential movement along foliation planes in the talc, the layers of asbestos were broken and separated. The complex, small-scale structure is probably the result of deformation which preceded, accompanied, and followed formation of asbestos.

Drill holes in and around the hill penetrated asbestos-bearing talc layers west of the strike line of the two exposed layers. Thickness of talc units ranges up to about 20 feet; some include interlayered dolomite. Lengths of talc units range from a few feet to 200 or more as suggested by drilling and by analogy with talc bodies in other parts of the district. Altered mafic rock was penetrated in two drill holes on the north side of the hill and one on the south side.

Although there are probably five or more talc layers, parts of which contain more than 10 percent asbestos and others which contain 1 to 10 percent asbestos, the wide variation in dimensions of individual layers and the relatively widely spaced drill holes do not permit accurate correlation of units. For this reason, the structure section (fig. 2) is not entirely accurate. Because of the extreme variation in asbestos content within individual layers, a unit showing only a trace of fiber where intersected in drill holes may contain much more in its other parts.

Some x-ray diffraction patterns of apparently pure fiber show the presence of small amounts of talc. This may represent a replacement of richterite during the final stage of metasomatism. Variable but minor amounts of other minerals are closely associated with the richterite. These include talc, tremolite (?), white mica, dolomite, and a poorly crystallized layer silicate. These accessories are white or rarely pink, in marked distinction to the gray talc rock in which this second association of minerals formed. The gray foliated talc itself consists of talc, dolomite, quartz, and poorly crystallized layer silicate.

In addition to the Diablo prospect there are reports of four other separate occurrences of richterite asbestos in the Allamoore district; three of these describe traces of white asbestos noted in drill cuttings from thin talcose layers.

About 1,200 feet west-southwest of the Diablo prospect, a 65-foot-deep drill hole near the base of a small hill of vertical-bedded dolomite penetrated talc with 75 percent long-fiber richterite asbestos occurring between 38 and 60 feet. Several shallow trenches near the hole exposed talc-carbonate rock. Some blue amphibole rock is scattered along the crest of the hill. Several other holes were drilled and although some talc was intersected, asbestos was not found.

Other parts of district.—Minor amounts of white asbestos were found during drilling and development of the relatively large talc body of the Buck mine (fig. 1). Several samples showed the asbestos to be cross-fiber seams up to about two inches thick and at least six inches long, which are concordant with the foliation of the talc. Very thin partings of talc are both roughly parallel and oblique to the margins of the asbestos layers. Bent-fiber asbestos and other deformational structures such as those found at the Diablo prospect are absent. The asbestos in the Buck mine area is richterite and is similar to that at the Diablo prospect and nearby occurrences. X-ray diffraction analysis indicated that what appears to be pure fiber actually contains a small amount of talc.

A little white asbestos was reportedly observed during extraction of talc at the T. & P. No. 1 mine. Later, drill cuttings containing fibers up to about half an inch long were obtained. The fiber is richterite, although more brittle than in the other occurrences. What appears to be pure fiber contains some chlorite, perhaps as pseudomorphous replacement.

There is an unconfirmed report of white asbestos from the relatively small talc body of the Neal-Mann prospect (fig. 1). Very small masses of nearly pure asbestiform actinolite also occur within the talc.

ORIGIN AND GEOLOGIC SIGNIFICANCE

Blue amphibole and richterite-talc rocks are thought to be concentrations of constituents, mainly aluminum, iron, sodium, and potassium, originally present as minor impurities in carbonate rocks that have been replaced by talc. During metasomatism, these constituents first may have been incorporated into new forms such as layer silicates, then mobilized and either concentrated in carbonate layers, in another talc body, or in another part of a single talc body. Formation of richterite-talc rock also involved concentration of alkalies relative to aluminum and iron. The effect of structural controls, though perhaps important, is unknown. Because the impurities may have constituted only a small percentage of the original carbonate rock, concentrations of these elements such as at the Diablo prospect suggest that much more talc may occur in the vicinity.

Richterites have been recognized in a wide variety of rocks, but unlike the relatively low-temperature Allamoore richterite, most occurrences are suggestive of relatively high temperatures of formation. In addition, many richterites are compositionally intermediate between alkali and calcium amphiboles, with $1.00 < Ca < 1.50$ per formula unit, further suggesting high-temperature hypersolvus conditions (Ernst, 1968). However, richterites with calcium contents of less than about one calcium per formula unit, such as the Diablo prospect amphibole, may be considered simply as alkali amphiboles and may be reasonably expected to form at relatively low temperatures.

Examples of asbestiform richterite are rare; however, greenish-gray richterite asbestos with calcium content of 1.03 per formula unit, both disseminated and occurring as cross-fiber veins up to 5 cm thick, has been reported in tremolite-actinolite-bearing rocks and in other lithologies in the Aldan region of Siberia (Ivanov and Sidorenko, 1965). Although rock compositions rich in alkalies relative to aluminum are also comparatively rare and preclude the common occurrence of richterites, the lack of low-temperature examples—especially asbestiform ones—may be due in part to incomplete and inaccurate identifications. For example, veins of cross-fiber asbestos similar in appearance to chrysotile and occurring in serpentinite were described as "soda-rich anthophyllite" by Laudermilk and Woodford (1930). However, the amphibole contains 5.10 percent CaO and 7.40 percent Na_2O, suggesting that it may be richterite.

An assemblage of rocks similar to those in the Allamoore district occurs in the Robertstown-Truro area of southern Australia. Magnesian crocidolite occurs in talcose dolomite and altered dolerite (Wymond and Wilson, 1951), and alkali-rich tremolite asbestos in the talcose dolomite has also been prospected (D. King, 1955). The presence of large talc reserves in the area was recently announced (Industrial Minerals, 1970, 1971).

POTENTIAL

Fibers of much of the richterite asbestos from the Allamoore district are greater than one inch in length, have very small diameters, and have relatively high tensile strength for amphibole fibers. The asbestos is white to light gray; some is greenish or rarely pink. When separated, the fibers form a white, semi-harsh, fluffy mass. The richterite may be similar in its properties to tremolite asbestos which has been used in a wide variety of products; however, in devices like chemical filters, a pure product is required. Although the asbestos can be separated easily from most of the talc, it might prove difficult to remove all the very fine-grained platy particles of talc. In contrast to other types of asbestos, the richterite may have talc as a byproduct or coproduct.

Preliminary work at the Diablo prospect suggests probable reserves of at least 5,000 tons of asbestos in rock containing 10 percent or greater fiber. However, more closely spaced drilling is required to establish proved reserves, and might show considerably more asbestos. This includes additional asbestos at greater depth as downdip extensions of rocks known to contain richterite-talc layers, and also in deposits immediately outside the drilled area.

Prospecting possibilities are excellent in the area surrounding the hill west-southwest of the Diablo prospect, where there was a good showing of asbestos in a drill hole. There are about four square miles in the north-central part of the district where metasomatic rocks are known and where commercial amounts of associated richterite asbestos might be found. Estimation of possible reserves for this area, including the Diablo prospect, is speculative; 50,000 tons or more might be proved by an adequate exploration program. In order to test this possibility, drilling through alluvium would be necessary; depth to bedrock in much of this area probably ranges from a few feet to about 30 feet.

The very small amounts of asbestos found at the Buck and T. & P. No. 1 mines, and Neal-Mann prospect, considering the drilling and talc extraction already accomplished, suggest that further testing for asbestos alone might not be profitable.

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