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CHARACTERISTICS OF A POTASSIAN WINCHITE – ASBESTOS FROM THE ALLAMOORE TALC DISTRICT, TEXAS

ANN G. WYLIE
Department of Geology, University of Maryland, College Park, Maryland 20742, U.S.A.

CHARLES W. HUGGINS
U.S. Bureau of Mines, Avondale Metallurgy Research Center, 4900 LaSalle Road, Avondale, Maryland 20782, U.S.A.

Abstract

Asbestos from the Diablo prospect, Allamoore talc district (Texas) has cell dimensions a 9.944(5), b 17.951(6), c 5.271(4) Å, β 104.41(5)° (powder-diffraction data); the data are consistent with space groups $C2$, Cm or $C2/m$. Chemical analyses indicate a potassian winchite-asbestos, $(K_{0.43}Na_{0.02})$ $(Na_{1.12}Ca_{0.68}Mg_{0.20})$ $(Mg_{4.82}Al_{0.11}Fe^{3+}{}_{0.07})$ $(Si_{7.99}Al_{0.01})$ $O_{21.55}$ $(OH_{1.88}F_{0.51})$. Low indices of refraction, $n\alpha' = 1.576$–1.596, $n\gamma' = 1.590$–1.600, are probably related to the presence of fluorine and the low Ca and Fe contents. EDAX indicates that their variability is related to Na, K, Ca and Mg contents. In composition, this asbestos probably ranges from a potassian richterite to a potassian winchite. The asbestos habit is here well developed: fibres are composed of fibrils 200–400 Å wide, oriented with c axes parallel, but with no preferred orientation of a and b. This fibril-bundle structure explains the optical properties of parallel extinction and anomalous interference figures. This asbestos is considered a product of low-temperature metasomatism of a siliceous dolomite (Rohrbacher 1973). The chemical and physical characteristics described here are consistent with this interpretation.

Keywords: Potassian winchite-asbestos, Allamoore district, Texas, potassian richterite, fibril-bundle structure, low-temperature metasomatism, siliceous dolomite.

Sommaire

L'asbeste de Diablo, district de table d'Allamoore (Texas) a la maille suivante: a 9.944(5), b 17.951 (6), c 5.271(4) Å, β 104.41(5)°; son groupe spatial est $C2$, Cm ou $C2/m$. L'analyse chimique indique une winchite potassique asbestiforme, $(K_{0.43}Na_{0.02})$ $(Na_{1.12}Ca_{0.68}Mg_{0.20})$ $(Mg_{4.82}Al_{0.11}Fe^{3+}{}_{0.07})$ $(Si_{7.99}Al_{0.01})$ $O_{21.55}$ $(OH_{1.88}F_{0.51})$. Les faibles valeurs des indices de réfraction, $n\alpha'$ 1.576–1.596, $n\gamma'$ 1.590–1.600, reflète probablement la présence du fluor et les basses teneurs en Ca et Fe; la variabilité des indices dépend des teneurs en Na, K, Ca et Mg. En composition, cette asbeste varie probablement d'une richtérite potassique à une winchite potassique. Le facies typique de l'asbeste est ici bien développé: les fibres consistent en fibrilles, larges de 200 à 400 Å avec c parallèles, mais a et b quelconques. La structure en faisceau de fibrilles explique l'extinction parallèle des fibres et les figures d'interférence anomales. Rohrbacher (1973) considère l'asbeste comme produit du métasomatisme de basse température d'une dolomie siliceuse; les caractères chimiques et physiques de l'asbeste de Diablo sont compatibles avec cette interprétation.

(Traduit par la Rédaction)

Mots-clés: winchite potassique asbestiforme, district d'Allamoore, Texas, richtérite potassique, fibrilles en faisceau, métasomatisme de basse température, dolomie siliceuse.

Introduction

In 1971 a new deposit of amphibole-asbestos was discovered in the Allamoore talc district, Sierra Diablo, Texas. The asbestos, described by Rohrbacher (1973) as a potassian richterite, occurs interlayered with talc in beds 1.2 to 3 m thick in dolomitic rocks of the Precambrian Allamoore Formation; the regional geology has been described by King & Flawn (1953) and King (1965). The asbestos content of the talc beds varies from a trace to about 75%. The occurrence of minor quantities of crocidolite is also noted at this locality. The origin of the asbestos and talc is attributed to low-temperature metasomatism of a siliceous dolomite (Rohrbacher 1973).

The asbestos is light grey; individual fibres longer than five centimetres are common, and the fibres are of sufficient flexibility to be woven easily. Microscopic examination reveals that the ends of some of the fibres have been altered to talc, forming the pseudomorphic "fibrous talc" similar to that associated with tremolite in the Gouverneur district, New York (Stemple & Brindley 1960). Small amounts of quartz, dolo-

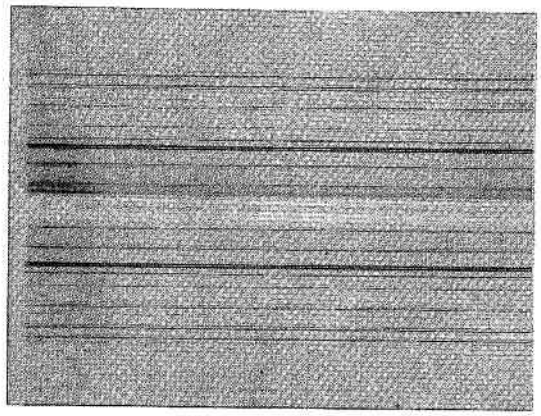

FIG. 1. Zero-level Weissenberg photograph of a potassian winchite fibre. The axis of rotation of the fibre is the *c* crystallographic axis. Ni filtered Cu radiation. 30 kV, 20 mA.

mite and opaque minerals also are distributed throughout the samples but represent < 2% of their total weight.

CRYSTALLOGRAPHY AND MORPHOLOGY

Unit-cell dimensions were determined by least-squares refinement of 41 reflections from the powder-diffraction record (Table 1) using the computer program of Finger (1969). Table 1 containing the indexed diffraction data is on file with the Depository of Unpublished Data, National Science Library, National Research Council of Canada, Ottawa. These dimensions are: *a* 9.944(5), *b* 17.951(6), *c* 5.271(4) Å, β 104.41 (5)°. The data are consistent with space groups *C*2/*m*, *C*2 and *Cm*.

A zero-level Weissenberg photograph taken with Ni-filtered Cu radiation produced at 30 kV and 20 mA is shown in Figure 1. The fibre studied is approximately 0.08 mm in width and 2 mm in length. The *c* crystallographic axis parallel to the fibre length was the axis of rotation. The presence of lines indicates that the fibre is composed of a large number of individual crystals, all of which have their *c* axes parallel but which are randomly oriented with respect to the directions of their *a* and *b* axes.

FIG. 2. Scanning electron-micrograph of a potassian winchite fibre.

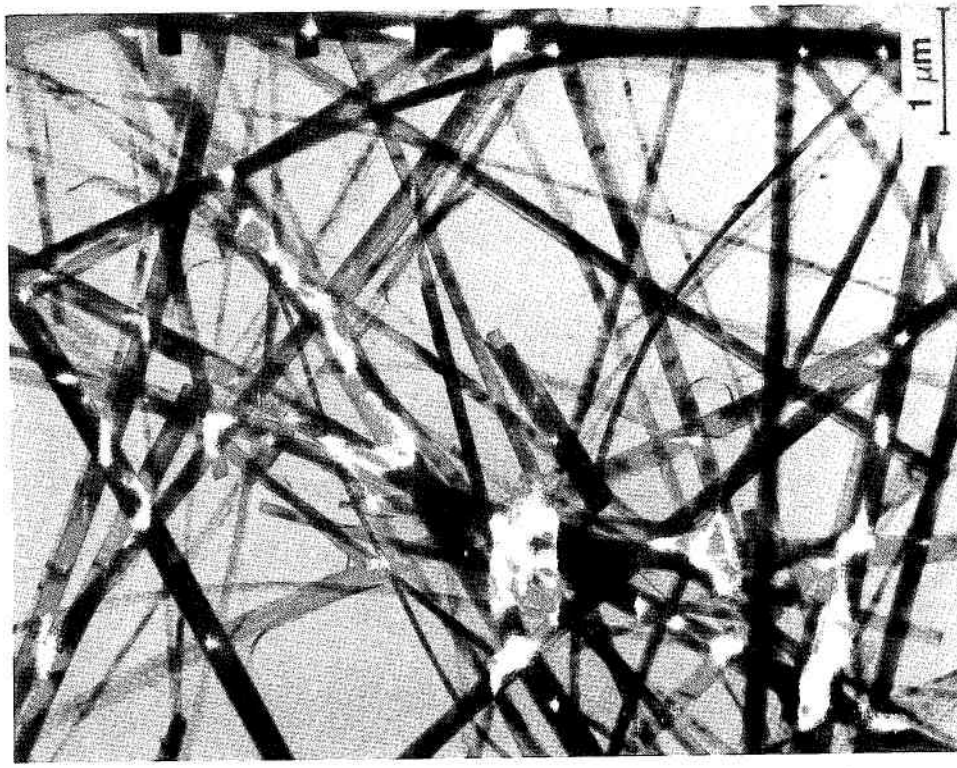

FIG. 3. Transmission electron-micrograph showing potassian winchite fibrils. The ribbon-shaped fibrils are between 200 and 400 Å in cross-section. Some are slightly wrinkled, and some portions appear as dark streaks because they are in the correct position to produce Bragg reflections.

Figure 2, a scanning electron-micrograph taken of what appeared macroscopically to be a single fibre, clearly shows the composite nature of the fibres. Examination of the fine size-fraction of the sample using a transmission electron-microscope shows that long, flexible ribbons have nearly uniform cross-section measurements of 200 – 400 Å (Fig. 3). Electron-diffraction patterns obtained on these single fibres show rows of spots having the 5.3 Å spacing typical of amphiboles. No streaking or other evidence of structural disorder were observed.

We suggest that the word *fibril* be used to describe these flexible ribbon-like crystals. This term is commonly accepted in describing the single chrysotile fibre and may be equally appropriate for amphibole-asbestos unit fibres. Throughout this paper, the term *fibre* implies a bundle of fibrils.

CHEMICAL ANALYSIS AND STRUCTURAL FORMULA

Chemical analyses, performed on the asbestos by two laboratories, are given in Table 2. Both analyses show a greater loss on ignition than can be accommodated into the model formula for

TABLE 2. CHEMICAL ANALYSES OF POTASSIAN WINCHITE-ASBESTOS

Constituent	1*	2**
SiO_2	58.0	57.5
Al_2O_3	.74	.72
Fe_2O_3	.63	.71
FeO	-	-
CaO	4.44	4.53
MgO	23.9	25.0
K_2O	2.58	2.19
Na_2O	4.45	3.87
TiO_2	.06	-
F	1.22	1.34
Loss on ignition	4.35	4.48
	100.37	100.34
Oxygen equivalent of F	- .51	- .56
Total	99.86	99.78

* Analysis by A. Dinsdale, British Ceramic Research Association, Great Britain ** Analysis by Wayne Lowry, Bureau of Mines

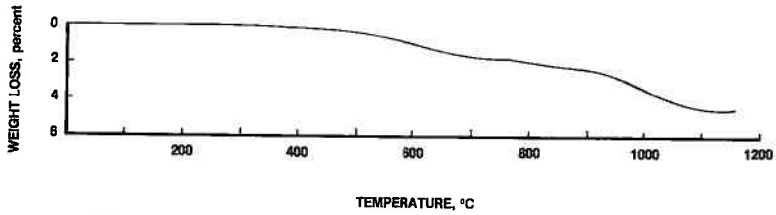

FIG. 4. TGA tracing of potassian winchite-asbestos. Heating rate was 5° *per* minute. The analysis was performed in a N_2 atmosphere.

the amphiboles as H_2O. Therefore, weight-loss measurements were made using a DuPont microbalance with a heating rate of 5°C *per* minute in a N_2 atmosphere on a 20 mg sample of < 60 mesh material. Figure 4 shows a gradual weight-loss of 2.2% between 400 and 925°C and a more rapid loss of an additional 2.1% between 925 and 1180°C.

It is possible that the majority of the lower temperature 2.2% weight-loss represents adsorbed water. Although we would expect such water to be lost at temperatures below these, it is retained possibly because of the very small size of the fibrils. In addition, the higher temperature 2.1% weight-loss closely approximates the water content expected for the ideal amphibole. Another possible source of excess water is H_3O^+ in the *A* site, but this would probably be released as the structure is destroyed at the higher temperatures. In addition, there are only 0.55 *A*-site vacancies available. Some of this weight loss could be derived from the talc impurity, but optical and powder X-ray-diffraction studies indicate that 2% by weight is probably the maximum talc content. Undetected multiple chains such as those described by Veblen *et al.* (1977) in chesterite, jimthompsonite and clino-jimthompsonite might also be present. Such biopyribole-asbestos should contain more water than an amphibole (Veblen & Burnham 1978) but none would approach 4.3%. Finally, it is possible that H^+ ions are related to anion sites other than those with which they are normally associated. This hypothesis was proposed by Ernst (1968) to explain the excess water in an amphibole of similar composition synthesized by Christophe-Michel-Lévy (1957). This seems the most likely explanation if the water is not adsorbed.

Based on the present study, it is not possible to determine the exact nature of all the water. If 2.2 wt. % H_2O is assumed to be adsorbed, the formula based on 24(O,OH,F) is $(K_{0.43}Na_{0.02})(Na_{1.12}Ca_{0.88}Mg_{0.20}(Mg_{4.82}Al_{0.11}Fe^{3+}_{0.07})(Si_{7.99}Al_{0.01})O_{21.55}(OH_{1.88}F_{0.57})$. According to Leake (1978), this amphibole is potassian winchite-asbestos, a member of the sodic–calcic amphibole group.

The chemical analyses given in Table 2 differ from that given by Rohrbacher (1973). His analysis shows more K_2O (3.54 wt. %) and Na_2O (6.60 wt. %) and less H_2O (1.96 wt. %), whereas fluorine is not reported. Potassium richterite-asbestos is the proper name for an amphibole with the composition he reports. Since there is no reason to doubt his analysis, it must be concluded that there is considerable variation in the bulk composition of this asbestos.

Optical Properties

It is clear from the Weissenberg photograph (Fig. 1) that fibres resolvable by the optical microscope are composed of tiny fibrils oriented in such a way that they share only a common *c*-axis direction. Therefore, all fibres show parallel extinction, and most small fibres show only two indices of refraction. Conoscopically, both clearly defined, negative, obtuse, bisectrix interference figures ($2V$ 75°) as well as optic normal or flash figures are common. The same properties are common to other commercial asbestos: crocidolite, grunerite-asbestos (amosite) and chrysotile.

The indices of refraction were determined for sodium light by standard immersion-techniques employing Cargille oils calibrated in increments of 0.002. They have been designated $n\gamma'$ and $n\alpha'$. There is considerable variability in the magnitude of the refractive indices; $n\alpha'$ varies among fibres from 1.576(2) to 1.596(2); $n\gamma$ varies from 1.590(2) to 1.600(2); along-fibre variations of $n\alpha'$ and $n\gamma'$ may be as great as 0.006. All fibres have positive elongation.

The indices of refraction are not only variable, they are also unusually low for an amphibole. Most natural amphiboles of similar composition have an $n\alpha > 1.600$. However, Gibbs *et al.* (1962) reported $n\alpha$ 1.576 and $n\gamma$ 1.595 for a synthetic fluor-magnesio-richterite. The presence

of fluorine and the absence of calcium and iron these same factors also probably affect the in- are probably responsible for its low indices, and dices of the potassian winchite.

EDAX Study of Chemical Variation

Variation in optical properties implies a variation in chemical composition. In order to correlate these variations, a qualitative chemical study employing an AMR Model 1400 scanning electron-microscope equipped with a spectrometer for energy-dispersive X-ray analysis (EDAX) was undertaken.

Two aluminum tabs were prepared for examination. Randomly selected, dispersed fibres were mounted on one tab, and a fibre 2 cm in length was mounted on the other; $n\alpha'$ and $n\gamma'$ of the single fibre had previously been determined. Each varies by 0.004 parallel to the length, but seems constant across the fibre. Both tabs were carbon coated. Counting for each analysis was done for 100 seconds; all data were in excess of 1000 counts *per* second. The total area under the spectrograph peaks for Na, Mg, Si, Ca and K was recorded after correction for background. The peak area/peak area Si was then calculated for each element.

Figure 5 and Table 3 summarize the results of this study. The analyses are numbered in order of increasing Mg/Si. It is evident from the data that Mg/Si and Na/Si are inversely proportional to K/Si and Ca/Si. The error introduced by instrumentation should affect the magnitude of these ratios by no more than ± 0.004. The estimate of compositional variation among the fibres is based on the assumptions that (1) the ratio of peak areas is proportional to the ratios of wt. % oxides and (2) wt. % SiO_2 is constant. Whether or not these assumptions are valid, there seems little doubt that there is significant compositional variation among the fibres and within a single fibre with respect to Na, K, Mg and Ca.

The EDAX was originally undertaken to relate composition and optical properties. Gladstone's Law (Larsen & Berman 1934) predicts an increase in indices of refraction when K_2O and

TABLE 3. SUMMARY OF EDAX STUDY OF POTASSIAN WINCHITE-ASBESTOS

Oxide	Peak area element / Peak area Si		Wt. % oxide* / Wt. % SiO_2	Predicted wt. % range
	Mean	Range		
MgO	.275	.240 - .340	.423	21.3 - 30.2
Na_2O	.024	.015 - .033	.072	2.6 - 5.7
K_2O	.057	.045 - .068	.041	1.9 - 2.8
CaO	.067	.050 - .083	.078	3.4 - 5.6

* From Table 2.

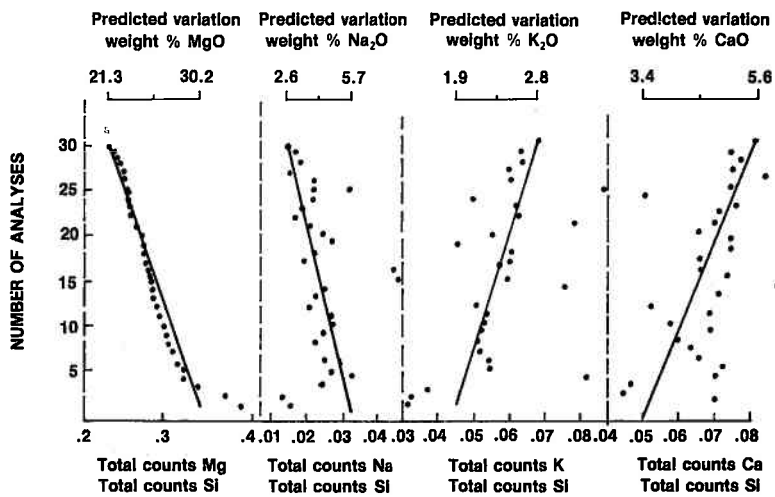

FIG. 5. Summary of the variations in peak area (element)/peak area(Si) determined in 30 analyses of potassian winchite-asbestos by a scanning electron-microscope equipped with an energy-dispersive X-ray spectrometer. From the spectrograph, total peak-areas of Mg, Na, K and Ca are compared to total peak-area of Si. The variations in weight percent of the oxides MgO, Na_2O, K_2O and CaO, as predicted from the spectrometer data, are indicated.

CaO increase and MgO and Na_2O decrease. Although an increase in Ca/Si and K/Si and an associated decrease in Mg/Si and Na/Si seem to be associated with increasing refractive indices along the length of the single fibre, this can only be considered a tentative conclusion. Despite the apparent optical homogeneity, the variations in composition laterally across the fibre are so extensive that they preclude a definite correlation between optical properties and composition without many more analyses.

Discussion

Richterite commonly occurs in metamorphosed dolomite. Although winchites are not commonly associated with this paragenesis, some amphiboles previously identified as richterite probably are winchites (see, for example, richterite analysis #2, Deer *et al.* 1963). In addition, many previously identified "winchites" are not winchite at all. Of the seven analyses of "winchite" listed by Nayak & Leake (1975), only one (anal. #4) refers to a winchite as defined by Leake (1978). The occurrence of winchite in metamorphosed carbonates may therefore be more common than previously supposed.

The habit of the potassian winchite-asbestos has all the characteristics of commercial asbestos. The fibres are silky, flexible, and have good tensile strength. The fibril size and bundle structure are similar to those of crocidolite, grunerite-asbestos, tremolite-asbestos, actinolite-asbestos and chrysotile, all of which have fibril diameters ranging from 200 to 5000Å. The parallel extinction and anomalous interference-effects reflecting the fibril-bundle structure are also characteristic of this habit.

There is some evidence of incipient alteration of the fibres: (1) there is an unusually high amount of water reported in the chemical analysis, which may or may not be adsorbed, and (2) fibrous talc is present in small amounts throughout the deposit. The asbestos fibres are chemically inhomogeneous on a microscopic scale as well as macroscopically within the Diablo prospect, ranging from potassium richterite to potassian winchite. The composition is notable for its low calcium content and the presence of fluorine. All of these characteristics are consistent with the low-temperature metasomatic origin for the asbestos as proposed by Rohrbacher (1973).

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