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Structural intergrowth of brucite in anthophyllite

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Abstract

"Mountain wood," a morphological variant of anthophyllite, occurs in the Holénarasipur asbestos mines. High-resolution transmission-electron microscope (HRTEM) images of mountain wood show intimate brucite-anthophyllite intergrowths. Partial dissolution in dilute acids indicates that the intergrown hydroxide may be Fe-containing brucite. Coexisting anthophyllite asbestos does not show the brucite intergrowths, whereas both the anthophyllites have chain-width disorder.

During the course of a mineralogical investigation on amphibole asbestos from Holénarasipur, Hassan District, Karnataka, South India (lat 12°38–49′N, long 76°14–22′E), we noticed a morphological variant of anthophyllite, which the miners call "mountain wood." The mineral occurs in the anthophyllite asbestos mines and has a schistose texture, partly fibrous but more brittle than asbestos; it resembles sandalwood in appearance. Because the physical features of mountain wood specimens are different from those of the coexisting massive and asbestiform anthophyllites, we studied the chemistry and electron microscopic characteristics of this material.

Anthophyllite asbestos occurs within the metamorphosed ultramafic rocks that are part of the complex schist belt near Holénarasipur. The geology of this Archean complex within the regionally metamorphosed amphibolite-facies quartzofeldspathic gneisses has been reported by Chadwick et al. (1978), Naqvi and Hussain (1979), and Kutty et al. (1984). The ultramafic rocks have been completely metamorphosed to anthophyllite + actinolite + talc + antigorite schists. Petrographic studies indicate that anthophyllite is replacing antigorite (Raghavendra et al., 1976). Anthophyllite asbestos occurs in restricted localities as veins and pods. Asbestos fibers in different stages of development and with varying aspect ratios are observable. The fibers are usually arranged parallel to the walls of the veins; random seams with cross-fibers are also present.

Mountain wood anthophyllite has a hardness in the range of 5–5.5, $D \simeq 3.19$, and the hand specimens are pale brown. Under the polarizing microscope, polished thin sections reveal aggregates of long, fine crystallites with subparallel orientation. The thin sections are colorless, optically cloudy (translucent), with very weak pleochroism. Mean refractive index is 1.66. Directional variations in refractive index could not be measured, owing to the texture of the aggregates and small crystal size. SEM images (Cambridge Stereoscan S-150) show the stacking of crystallites giving rise to a subparallel-oriented texture (Fig. 1a). The tip of the same specimen is seen to split into fine fibers (Fig. 1b). An X-ray pattern, recorded with a Philips PW1700 powder diffractometer (Fe*Kα* radiation), could be indexed on the basis of an orthoamphibole unit cell (space group *Pnma*) with $a = 18.48$, $b = 18.09$ and $c = 5.30$ Å.

Chemical analyses by a combination of wet-chemical methods (complexometric and redox titrations, as well as colorimetry and atomic absorption) of mountain wood

Table 1. Representative compositions of anthophyllites

	"Mountain wood"	Asbestos
SiO_2	55.05	56.60
TiO_2	nil	nil
Al_2O_3	0.76	1.22
Fe_2O_3	0.48	0.28
FeO*	19.32	18.09
MnO	0.08	0.19
MgO	21.88	21.38
CaO	0.56	0.40
Na_2O	0.02	0.12
K_2O	0.01	0.01
H_2O^{+}**	2.70	2.05
H_2O^{-}**	0.02	0.08
Total	100.88	100.42
No. of cations per 24 O atoms		
Si	7.754	7.985
Al^{IV}	0.126	0.015
Al^{IV}	—	0.188
Fe^{3+}	0.051	0.030
Fe^{2+}	2.273	2.131
Mg	4.588	4.486
Mn	0.010	0.023
Ca	0.085	0.060
Na	0.006	0.034
K	0.002	0.002
(OH)	2.54	1.93

* Determined by redox titrations.
** Determined by microgravimetric gas analysis.

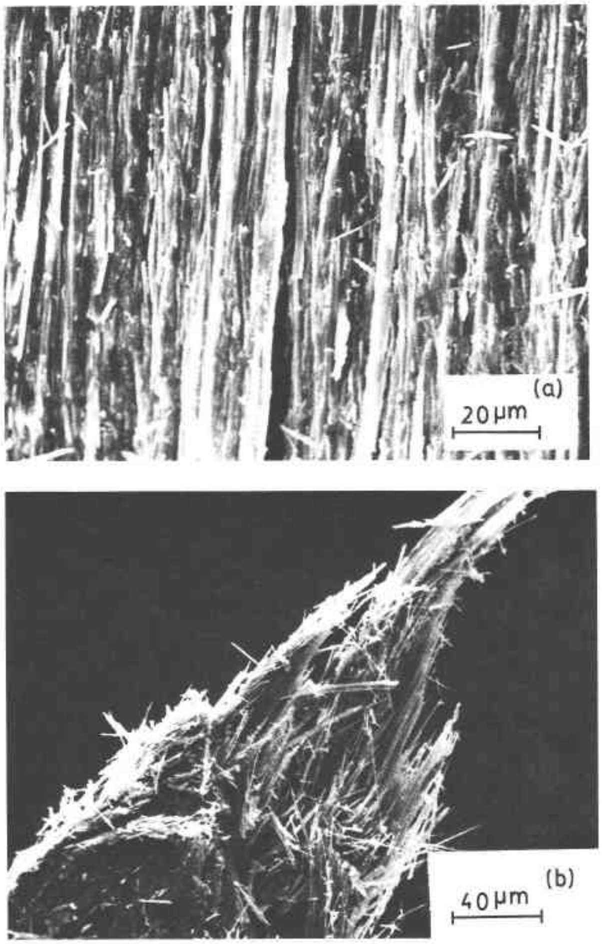

Fig. 1. SEM micrographs of mountain wood showing (a) the oriented crystallites and (b) tip of the specimen splitting into smaller fibers.

and the coexisting asbestiform anthophyllite are given in Table 1. The mountain wood has more Fe and Mg cations and hydroxyl ions and less Si per formula unit than the asbestiform variety. When placed in 0.1 *M* hydrochloric acid, the mountain wood gives rise to soluble Fe^{2+} + Mg^{2+} (up to 8.9 wt% FeO + MgO) (Raghavendra et al., 1978). The asbestiform anthophyllite gives rise to $\leq$1.3% FeO + MgO in the same medium.

Because of the higher octahedral cation contents in the mountain wood, HRTEM analysis of this material was carried out. The investigations were made in a JEOL JEM 200 CX electron microscope operating at 200 kV with a TEG2 objective stage. The samples were prepared by fine grinding in "specpure" acetone.

Figure 2 shows a typical intergrowth of a mineral with 4.9 Å fringe spacings in anthophyllite. The basal spacings of brucite, $Mg(OH)_2$ (00*l*), and gibbsite, $Al(OH)_3$ (0*k*0), are 4.8 and 5.1 Å, respectively (Deer et al., 1962; Veblen and Buseck, 1979). The presence of gibbsite can be ruled out due to the low Al-content of the mountain wood. Therefore, the mineral intergrown with the anthophyllite

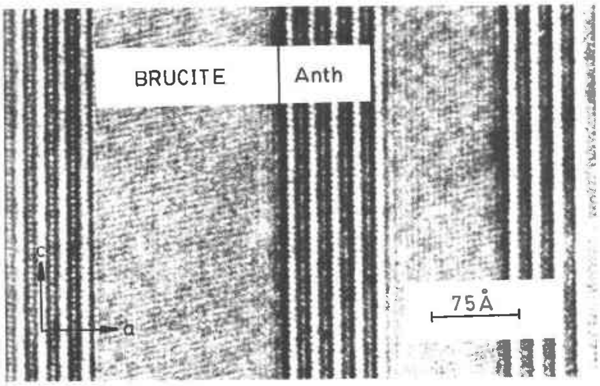

Fig. 2. A HRTEM image of mountain wood anthophyllite containing the structural intergrowths of brucite.

is probably brucite. To our knowledge, this is the first report of the intimate intergrowth of brucite in anthophyllite. Coherent intergrowths of serpentine and brucite type layers are described by Mackinnon and Buseck (1979) from an altered chondrite meteorite. Veblen (1980) has reported brucite-like sheets in talc (5-Å spacings) that fill the grain boundaries between two anthophyllite crystals. Since dissolution in dilute acids liberates both Mg^{2+} and Fe^{2+}, the intergrown mineral is presumably Fe-rich brucite. The observed widths of brucite lamellae vary from 20 to 200 Å. The coexisting asbestiform anthophyllite does not show such brucite intergrowths. The only structural defects observed are apparently random intergrown triple chains (Veblen et al., 1977). Similar chain-width disorder is also observed in the mountain wood anthophyllite. The difference in physical properties between mountain wood and the massive as well as asbestiform anthophyllite may arise from the structural intergrowth of brucite in mountain wood. Since this material exists as relics within the asbestos mines, with the fully developed asbestos fibers apparently growing out of it, mountain wood can be considered as a precursor to the asbestiform anthophyllite.

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