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OREGON'S ASBESTOS POTENTIAL

By

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Introduction

Asbestos is an essential industrial mineral for which the United States does not have an adequate domestic source. Although this nation is one of the largest users of asbestos in the world, it produced only 66,600 tons in 1963, or less than 10 percent of the domestic consumption. World production of asbestos is shown in Table 1. The principal source of asbestos imported into the United States is Canada, which has been the world's leading supplier for many years. Production of asbestos in the United States has been growing, however, and nearly doubled the 1963 figure to 100,000 tons in 1964, according to U.S. Bureau of Mines preliminary estimates. The increase is due to recent developments in California, which now outranks Vermont in being the leading asbestos producer in the United States.

Certain grades of asbestos are indispensable to our transportation and construction industries, and all grades occupy an important place in our economy. The lack of adequate production, therefore, creates an opportunity for domestic mining if ore bodies can be found. The authors of this article are particularly interested in the development of asbestos in Oregon in sufficient quantity and quality to create a local asbestos industry.

Asbestos Minerals

The term "asbestos" is applied to a group of naturally fibrous, noncombustible minerals. These minerals differ in chemical composition and in the strength, flexibility, and usefulness of their fibers. The physical and chemical properties of asbestos fibers are compared in Table 2. Asbestos

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TABLE 1. World Production of Asbestos (thousands of short tons)
(Figures from U.S. Bureau of Mines Minerals Yearbook, 1963)

Country	1954-58 average	1959	1960	1961	1962	1963
Canada (sales)	995	1,050	1,118	1,174	1,216	1,272
USSR (estimate)	475	600	660	880	1,100	1,200
Republic of South Africa	140	182	176	195	221	206
Southern Rhodesia	113	120	134	162	142	142
China (estimate)	33	90	90	100	100	110
United States	44	45	45	53	53	67
Italy	37	53	61	63	61	63
Swaziland	30	25	32	31	33	33
France	16	23	29	31	28	26
Cyprus	16	14	23	16	22	22
Australia	10	18	16	17	18	15
Japan	1	14	17	19	15	18
Finland	9	10	11	10	11	10
Other countries*	21	17	28	19	35	16

* Includes small production in about 20 other countries, in part estimated.

minerals fall into two general categories - chrysotile and amphibole. Because of the importance of chrysotile and of its relative abundance in areas of serpentine, it is the main subject of this report.

Chrysotile

Chrysotile, a hydrous magnesium silicate ($3MgO.2SiO_2.2H_2O$), is an essential mineral of serpentine and usually occurs in veinlets. Its fibers are strong and very flexible, making it the most valuable of the asbestos minerals. About 95 percent of the world's asbestos production comes from chrysotile, most of it from Canadian deposits. In the United States, chrysotile asbestos occurs in the serpentinized peridotites of Vermont, California, and Oregon; and in serpentinized dolomitic limestones of Arizona.

Chrysotile occurs most commonly as cross-fiber veins, ranging in thickness (fiber length) from microscopic size to 3/8 inch or more, with the parallel fibers approximately perpendicular to the vein walls. The mineral is gray to pale green in the rock, but separates into white fibers that form a a fluffy mass. The basic crystal structure of chrysotile is a cylindrical lattice. Its tubular character has been established by electron microscopy. Chrysotile fibers of good quality are silky, highly flexible, and have a tensile strength 10 times that of nylon. Some fibers are naturally harsh,

TABLE 2. Properties of Asbestos Minerals (modified after Rice [1957]).

	Chrysotile	Tremolite	Crocidolite	Amosite	Anthophyllite
Color	Green, greenish-yellow, gray, or white.	White, grayish-white, greenish-yellow, or bluish gray.	Lavender, blue, or greenish.	Ash-gray, greenish, or brown.	Grayish-white, brownish-gray, or green.
Texture	Soft to harsh, silky.	Generally harsh, some soft.	Soft to harsh.	Coarse, but somewhat pliable.	Harsh
Mineral Association	In serpentine, magnetite, antig-orite, picrolite, etc.	In serpentine, Mg. limestones and various meta-morphic rocks.	Iron-rich siliceous argil-lite in quartzose schists.	In crystalline schists, etc.	In crystalline schists, gneisses, or meta-serpentine.
Veining and fiber length	Cross and slip fibers; short to long.	Slip or mass fiber; rarely cross fiber; short to long.	Cross fiber; short to long.	Cross fiber; mostly long.	Mass or slip fiber, rarely cross fiber; short.
Tensile strength lb/sq in.	80,000 to 100,000.	8,000 or less.	100,000 to 300,000.	16,000 to 90,000.	4,000 or less.
Flexibility	Very flexible.	Fairly flexible to brittle.	Flexible.	Flexible.	Mostly brittle.
Spinnability	Very good.	Generally poor; rarely spinnable.	Fair.	Fair.	Very poor.
Fusibility	Fusible at 6.	Fusible at 4.	Fusible at 3.	Fusible at 6.	Infusible or difficultly fusible.
Acid resistance	Poor.	Good.	Good.	Good.	Very good.

which reduces their flexibility and strength. A simple test for flexibility is to hold a bundle of fibers between the fingers and twist or rotate it. Weak fibers will break readily under this twisting; harsh fibers will tend to spring back when bent the first time. Fibers that lie approximately parallel to the vein are called slip-fiber veins. Such veins lie along faults or slip planes. This fiber, although longer, is weaker than most of the cross fiber.

A mineral sometimes mistaken for chrysotile is picrolite. This vein-like serpentine mineral commonly occurs near chrysotile veins. It is a splintery, semifibrous variety of serpentine that will not fluff when scratched with a knife. It is usually necessary to scratch a vein in order to tell chrysotile from picrolite.

Amphibole

The amphibole group of asbestos minerals includes tremolite, crocidolite, amosite, and anthophyllite (see Table 2). Tremolite and anthophyllite are the only amphibole asbestos minerals found in Oregon. Tremolite ($2CaO.5MgO.8SiO_2.H_2O$), the most common of the amphibole asbestos minerals, generally occurs in narrow veins in fault zones in or adjacent to serpentine. Actinolite, a variation of tremolite containing iron, is usually found with it. In comparison to chrysotile, the fibers of tremolite are coarser and weaker and are easily broken when flexed between the fingers. World production of tremolite is less than $\frac{1}{4}$ of 1 percent of the total asbestos production. Anthophyllite ($[Mg,Fe] SiO_2$) occurs in schists, gneisses, and metaserpentine. Its fibers have the lowest tensile strength and are the most brittle of asbestos minerals.

Crocidolite and amosite are important amphibole asbestos minerals, but no commercial deposits occur in North America. The principal source of crocidolite is South Africa, with lesser amounts coming from Australia and Bolivia. Amosite is produced only from South Africa.

Uses of Asbestos

Chrysotile can be separated by mechanical means into fibers which contribute desirable characteristics to industrial products. Some of these qualities are chemical inertness, resistance to corrosion, good thermal and electrical insulation, and good bonding with portland cement, in addition to high tensile strength. The long fibers (more than 3/8 inch) go into the making of fire-resistant textiles.

The medium-length fibers (ranging from 1/16 inch to 3/8 inch) are used in cement pipe, cement sheets, roofing paper, gaskets, molded brake bands, clutch facings, instrument panels, some molding compounds, and lagging. For industrial construction, asbestos cement products have been universally accepted; as a result, cement-length fibers are at present the main product of the asbestos industry.

In Europe today 60 percent of the pipe used in construction is made of asbestos cement. In Sydney, Australia, more than half of the houses are of asbestos-cement construction using sheets inside and out, and corrugated material on the roof.

In damp climates, such as the coastal areas of Oregon, construction with asbestos cement results in superior resistance to weathering and minimizes maintenance problems.

The shorter fibers, or lengths under 1/16 inch, are used in floor tile, paint, plastics, joint cement, asphaltic compounds, roofing shingles, road paving, and drilling mud.

Tremolite and anthophyllite asbestos have limited application because of the low strength of their fibers. They are, however, used as fillers in various products, welding rod coatings, and acid-resistant filters.

Origin of Chrysotile Asbestos

Serpentine minerals are formed from two general rock types: peridotites and dolomites or magnesia-bearing limestones. It is generally accepted that serpentinization is caused by hydrothermal solutions which alter these rocks, adding water and perhaps some magnesia, silica, and other elements.

Mineralogists Faust and Fahey (1962) in their study of serpentine group minerals recognize only three: namely, chrysotile, lizardite, and antigorite. Other serpentine minerals, such as deweylite, bastite, and picrolite are variations or combinations of these recognized minerals. Serpentine minerals have essentially the same chemical composition and differ only in internal structure and to some extent in outward physical appearance.

It is not well understood what causes abundant cross-fiber veinlets of chrysotile to form in serpentine and various theories have been advanced. Since good deposits of chrysotile are not common, it seems reasonable to assume that the environment in which they formed involved fairly critical physical and perhaps chemical conditions. Time could also be an important factor. In other words, it may be that the temperature, pressure, and chemical balance must be held within certain critical limits for a sufficient time to enable the chrysotile fibers (crystals) to grow.

Shearing stresses set up by folding and faulting are believed by some to be a contributing factor in localizing the deposition of chrysotile. Bateman (1954, p. 293) discusses the occurrence of horizontal layers of serpentine with horizontal cross-fiber chrysotile veins in dolomitic limestone in Arizona. He argues that neither fissure filling nor the force of growing crystals can explain the presence of chrysotile veins, because of the enormous weight of the overlying rocks and the fact that the beds above and below the serpentine layers are undisturbed. Bateman further states: "The most tenable explanation is that certain bands of limestone were converted to serpentine by circulatory solutions and that some slight change in the character of the solutions caused the serpentine to undergo molecular rearrangement into fibrous form. May not the same hypothesis apply to the peridotite occurrences...?"

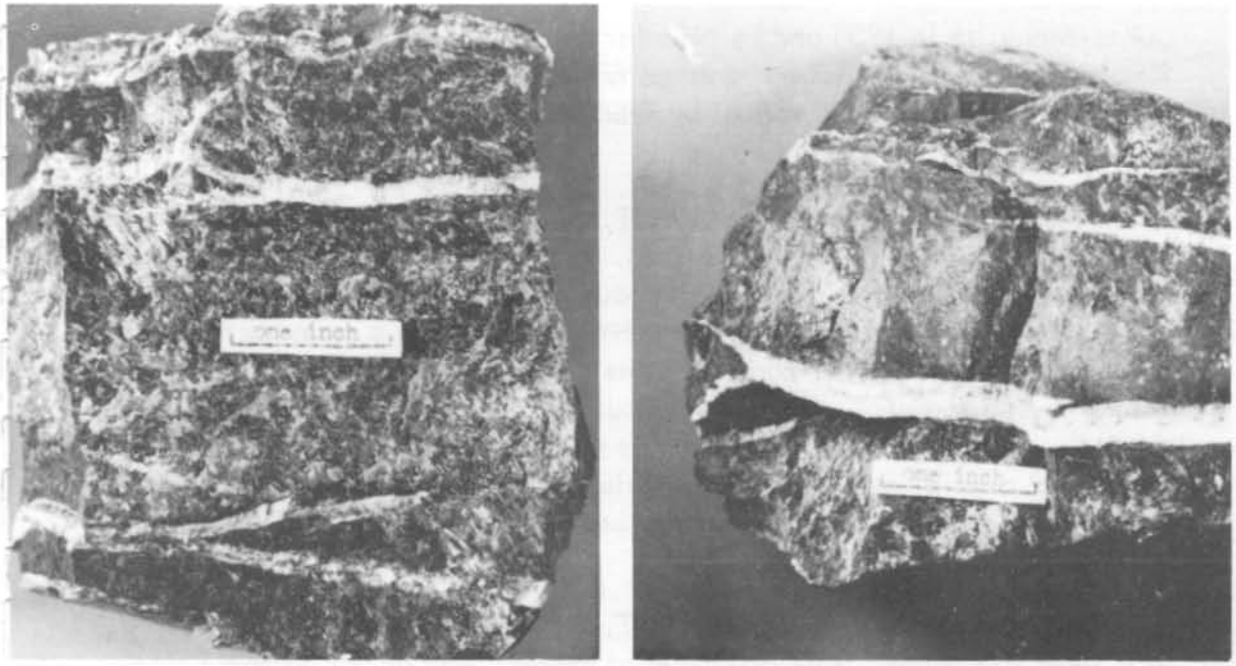
Asbestos Occurrences in Oregon

Southwestern and northeastern Oregon contain many scattered areas of peridotite and serpentine. The distribution of these "ultramafic rocks," as they are often called, is shown on the accompanying maps. The peridotite, an intrusive igneous rock composed largely of olivine and pyroxenes, has been partly (in some areas completely) altered to serpentine. In most outcrops peridotite and serpentine are intermixed. Chrysotile, being one of the serpentine minerals, is of course always present in serpentine. If it occurs in veins of sufficient size and abundance, it may constitute a rich ore body. Tremolite, an amphibole asbestos mineral, also occurs in areas of serpentine, generally in narrow, isolated veins.

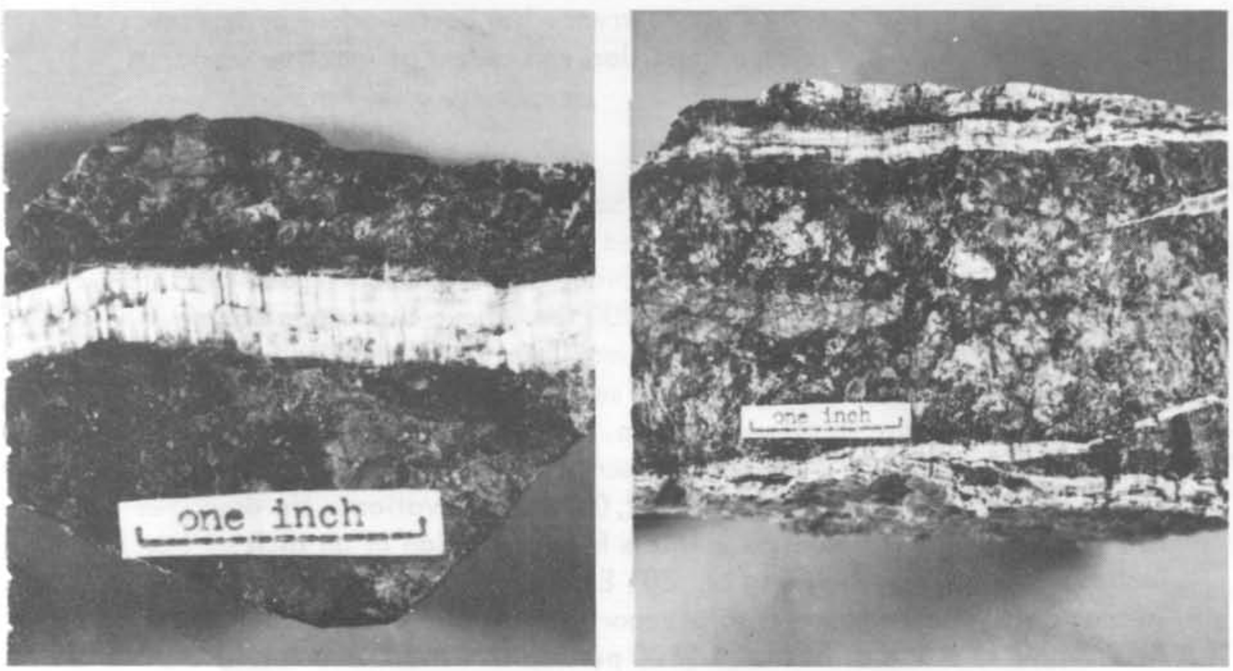
The known asbestos deposits in Oregon are small. Production to date has been limited to a few shipments of hand-sorted tremolite from the Liberty Asbestos in Jackson County and the L.E.J. occurrence in Josephine County; and 525 short tons of milled chrysotile from the Coast Asbestos Co. pilot plant near Mt. Vernon in Grant County (Wagner, 1963). The location of the asbestos mines and prospects is shown on the accompanying map. A brief description of each occurrence is given below.

Southwestern Oregon

C-1 Foster Asbestos (Bear placer): Secs. 35, 36, T. 38 S., R. 9 W., Josephine County. This is the best-known chrysotile occurrence in southwestern Oregon. It is situated on the west bank of Josephine Creek between Days and Fiddler Gulches. Chrysotile was discovered by George Foster while he was drift-placer mining along the surface of serpentine bedrock which underlies a cover of cemented Pleistocene bench gravel as much as 100 feet thick. Cross-fiber chrysotile veinlets are of good quality, but rarely exceed 3/8 inch thickness with partings and are more commonly about 1/8 inch thick. Fiber occurs in both the north and south placer drifts, which are about 900 feet apart. The deposit was explored and drilled by Canadian



Cross-fibre chrysotile veinlets in serpentine from the Foster asbestos deposit near Josephine Creek. Samples were selected from the dump of the southern adit.



Johns-Manville in 1953 and by Nicolet Asbestos Mines, Ltd. in 1960. Results indicated insufficient tonnage to justify further development. The placer is currently being worked by Fred Von Rohder.

A-1 L.E.J. Asbestos: Sec. 9, T. 37 S., R. 6 W., Josephine County. This tremolite claim, held by location, is situated at about 1,200 feet elevation on the southwest side of Bolt Mountain about 6 miles southwest of Grants Pass. Slip fiber of varying quality was found in a main northeast-trending fracture or sheer zone 4 inches to 2 feet thick in serpentine. The tremolite is associated with talc. About 3 tons of hand-sorted fiber was reportedly shipped in bags in 1952. The workings consist of an open cut and trench not over 35 feet deep. The wider fiber-bearing zone pinched down where mining stopped. No new work has been done.

A-2 Liberty Asbestos: Sec. 36, T. 32 S., R. 4 W., Jackson County. This tremolite deposit is on 640 acres of deeded land on the southern flank of Cedar Springs Mountain at 4,500 feet elevation. Treasher (Oregon Dept. of Geology and Mineral Ind., 1943) describes the occurrence as containing some good quality tremolite fiber in several parallel northeast-trending fractures in serpentine and associated altered volcanic rock. Most of the slip fiber is brittle, but where the fracture zones widen occasional "kidneys" of flexible fiber are found. The occurrence has been worked by both surface cuts and tunnels. Present condition and extent of inactive workings was not investigated.

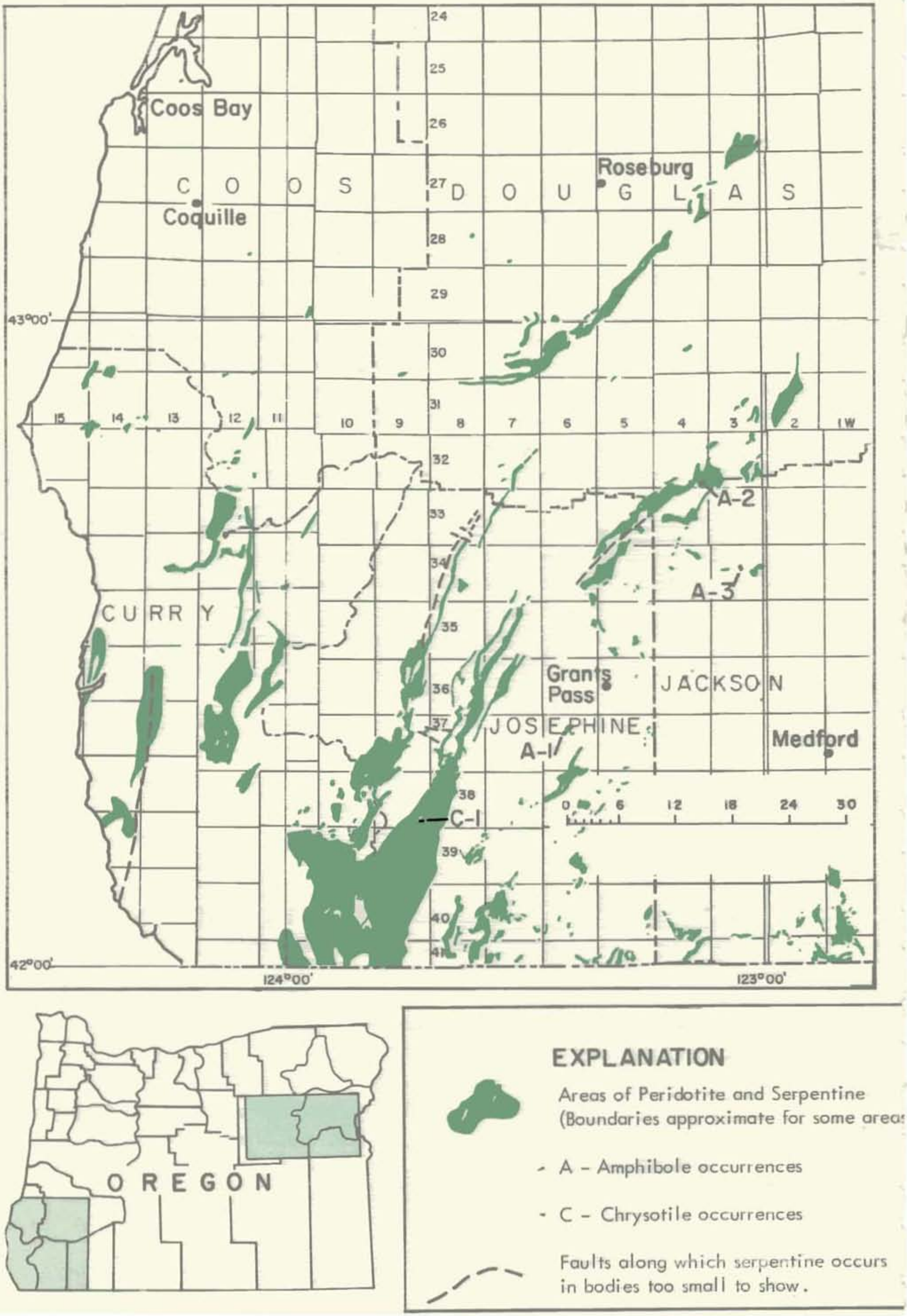
A-3 Raspberry Creek tremolite: Sec. 15, T. 34 S., R. 3 W., Jackson County. The occurrence is situated on the south side of Raspberry Creek about $\frac{1}{4}$ mile west of the west fork of Evans Creek at about 1,800 feet elevation. A small discovery cut about 100 feet above the creek exposes a narrow lens of matted tremolite. The maximum width appeared to be no more than 1 foot. The fiber occurs in serpentine near its contact with metavolcanic rocks of the Applegate Group. An unpublished Department file report, 1945, by E. A. Youngberg describes the main occurrence as being 700 feet north of Raspberry Creek at 2,000 feet elevation. He describes two shallow cuts with asbestos veinlets from a fraction of an inch to 4 or 5 inches wide in a zone striking N. 30° E. Width of the zone was undetermined due to poor exposures. The report also mentions about 600 pounds of fiber mined and sold at a rate of $600 per ton in 1943. In a recent visit to the area, only the southern cut was observed.

Northeastern Oregon

C-2 Mount Vernon deposit: Secs. 12, 13, 14, T. 13 S., R. 30 E., Grant County. The only chrysotile occurrence in the state that has had any production is located on Beech Creek beside U.S. Highway 395 about 3 miles northeast of Mount Vernon. The pilot mill operation of Coast Asbestos Co. was described by Wagner (1963). The deposit has also been examined by geologists of Asbestos Corp., Ltd. and Johns-Manville Co. The chrysotile fiber occurs in a narrow northeast-trending body of serpentine which intrudes Permian metavolcanics and sediments and is partly obscured by overlying Tertiary volcanics and Pleistocene to Recent alluvium. The deposit is reported to contain well-defined cross fiber chrysotile veinlets of good quality from which attractive specimens have been obtained, as well as considerable slip-fiber. The pilot plant recovery from pit-run ore is reported to average about 7 percent fiber so far. Details of the size of the deposit are not indicated in the available reports.

C-3 Spare Time claims: Secs. 7, 8, T. 14 S., R. 32 E., Grant County. These claims lie on the northern slope of Canyon Mountain at 4,500 feet elevation, adjacent to Little Pine Creek and 3 miles by unimproved road from Canyon City. The property consists of six unpatented lode claims located in 1960. The deposit is described in detail by N.S. Wagner (unpublished Department file report, 1961). Veinlets of cross-fiber chrysotile, most of them 1/16 inch or less in width, a few 3/16 inch, and rarely $\frac{1}{4}$ inch, are found in an area of serpentine near its northeast-trending contact with an olivine-rich peridotite. Veinlets strike both northeasternly and northwesterly. The better areas examined contained an estimated 5 percent fiber. Some of the serpentine area is obscured by alluvium in the valley of Little Pine Creek. Additional exploration would be needed to make a satisfactory evaluation of the occurrence.

C-4 Big Butte Creek asbestos: Secs. 17, 18, 19, 20, T. 11 S., R. 34 E., Grant County. The occurrence is about 2 miles northwest of Dixie Butte in the drainage of Big Butte Creek at about 4,400 feet elevation. The deposit is held by 5 unpatented claims located in 1950. It is described by N.S. Wagner (unpublished Department file report 1951, 1955, and 1962). Chrysotile veinlets of $\frac{1}{4}$ to $\frac{1}{2}$ inch widths, with semi-harsh fiber and partings, are common. Fiber lengths are mostly about 1/8 inch and rarely greater than $\frac{1}{4}$ inch. The fiber was originally found in a narrow zone thought to be 300 to 400 feet long, with a fiber content estimated at 10 percent or greater. The Asbestos Corp. of Canada examined the occurrence in November, 1951 and made about 1,000 feet of bulldozer trenches. In 1952-53,


Coos Bay
Coquille
COOS
DOUGLAS
Roseburg
CURRY
JOSEPHINE
JACKSON
Grants Pass
Medford
A-1
A-2
A-3
C-1
43°00'
42°00'
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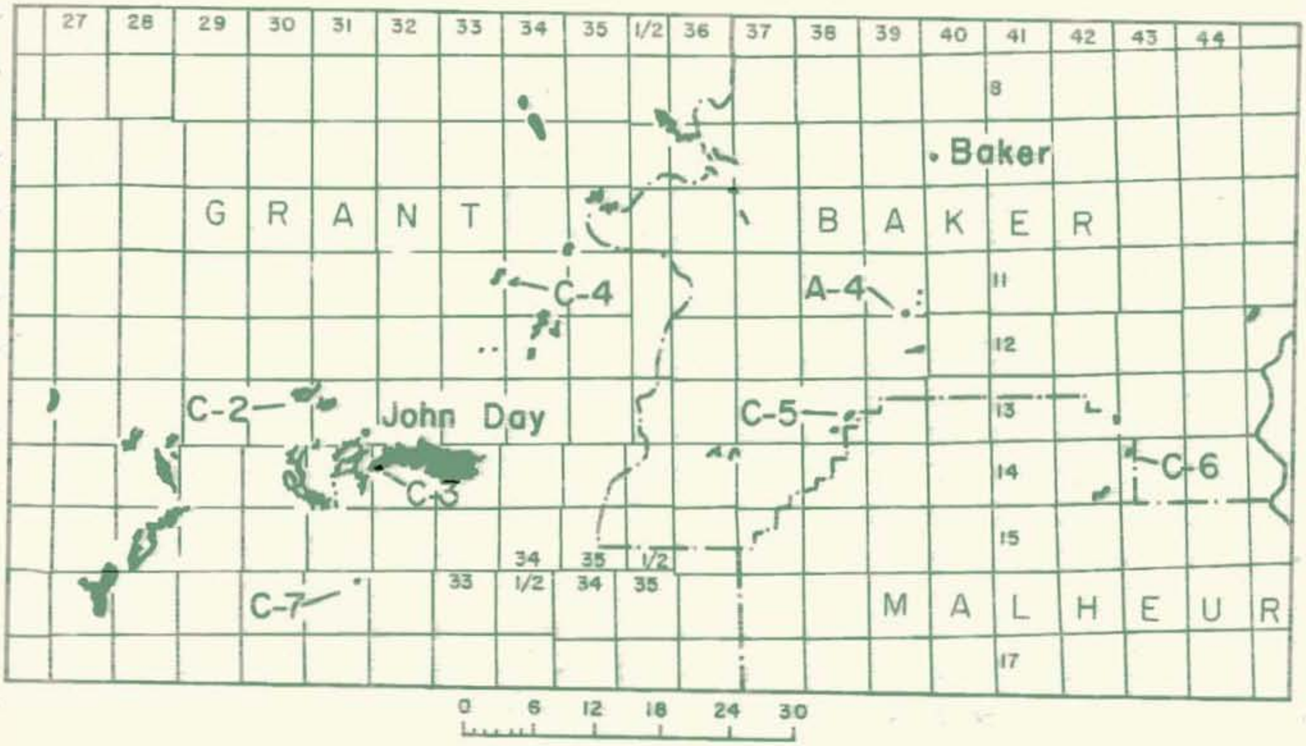
0 6 12 18 24 30
OREGON
EXPLANATION
Areas of Peridotite and Serpentine (Boundaries approximate for some area
A - Amphibole occurrences
C - Chrysotile occurrences
Faults along which serpentine occurs in bodies too small to show.



ASBESTOS OCCURRENCES IN OREGON

Map No.	Name	Location Sec.	T.	R.	County	Reference
Chrysotile						
C-1	Foster Asbestos	35-36	38 S.	9 W.	Josephine	Dept. files
C-2	Mount Vernon	12-13-14	13 S.	30 E.	Grant	Wagner, 1963
C-3	Spare Time Claims	7-18	14 S.	32 E.	Grant	Dept. files
C-4	Big Butte Creek	17-18-19-20	11 S.	34 E.	Grant	Dept. files
C-5	Rock Creek Butte	22	13 S.	38 E.	Baker	Dept. files
C-6	Towell Claims	7	14 S.	43 E.	Malheur	Dept. files
C-7	Bear Valley	1-2-3, 11	16 S.	31 E.	Grant	Dept. files
Amphibole						
A-1	L.E.J. Asbestos	9	37 S.	6 W.	Josephine	Dept. files
A-2	Liberty Asbestos	36	32 S.	4 W.	Jackson	Dept. Bull. 14-C
A-3	Raspberry Creek	15	34 S.	3 W.	Jackson	Dept. files
A-4	Pine Creek Asbestos	34-35	11 S.	39 E.	Baker	Moore, 1937

Canadian Johns-Manville did additional trenching, geologic mapping, and about 1,000 feet of diamond core drilling. The later work indicated a fiber-bearing zone about 400 feet wide and 1,300 feet long trending N. 45° E. on the hillside west of Big Butte Creek. This zone occurs in serpentinized peridotite containing occasional inclusions of argillite and quartzite. Exploration revealed that the fiber occurs in disconnected patches separated by fairly large areas of barren rock.

C-5 Rock Creek Butte occurrence: Sec. 22, T. 13 S., R. 38 E., Baker County. This chrysotile occurrence is situated on the northeast flank of Rock Creek Butte at nearly 5,000 feet elevation, about 8 miles east of Unity and 5 miles south of Hereford. N. S. Wagner describes the deposit in an unpublished Department file report, 1950. The property is held by four unpatented lode claims located in July 1950. Fiber occurs in blocky, serpentinized peridotite over an area estimated to be about 400 feet long and 100 feet wide. The fiber appears to be of good quality in lengths up to $\frac{1}{4}$ inch. A few $\frac{1}{2}$-inch veinlets have partings. The better areas contain 10-percent fiber. No development work had been done when the occurrence was last examined.

C-6 Towell claims: Sec. 7, T. 14 S., R. 43 E., Malheur County. The property is situated about half a mile west of the Baker-Malheur County line at an elevation of 4,000 to 4,500 feet. It is about 15 miles west of Huntington by an improved dirt road. The prospect was examined by Canadian Johns-Manville during 1956 and 1957, and a preliminary report was prepared (Sharratt and Todd, 1957), a copy of which was made available to the Department by the owner of the property. Development consisted of four bulldozer trenches. The fiber occurs in serpentinized peridotite and dunite in narrow zones 4 to 10 feet wide, striking north to N. 30° E. The fiber is mostly harsh and the veins commonly contain partings. Hot-spring activity has altered the serpentine and the chrysotile fibers in places. Picrolite is reported to be abundant.

C-7 Bear Valley occurrence: Secs. 1,2,3,11, T. 16 S., R. 31 E., Grant County. The deposit is about 4 miles east of U.S. Highway 395 between Canyon City and Burns, and is about 7 miles from the town of Seneca. Elevation of the area is about 4,900 feet. The property is held by placer claims totaling 480 acres. Information on the property is given in a Department letter by N. S. Wagner, September, 1954. Small areas of closely spaced chrysotile veinlets in serpentine are scattered over a fairly extensive area, but apparently separated by considerable subgrade to barren serpentine. Exposures of rock are poor and the report indicated that more exploration would be needed to expose larger areas of fiber-bearing serpentine before the occurrence could be considered to have commercial possibilities. Veinlets of apparently good quality chrysotile fiber were reported in the 1/8- to $\frac{1}{4}$-inch range, with $\frac{1}{2}$-inch widths very rare.

<u>A-4 Pine Creek amphibole asbestos:</u> Secs. 34, 35, T. 11 S., R. 39 E., Baker County. The deposits are described by Moore (1937). The area is near the divide between Cow Creek and Pine Creek and between 5,200 and 5,500 feet elevation on the southwest flank of Bald Mountain, 15 air miles south of Baker. The fiber is described as mainly anthophyllite, which occurs at various places in the area, associated with talc in narrow, lens-shaped bodies in crushed zones, fault contacts of greenstone, schist, and serpentine. The fiber is reported to vary in length from 1 to 16 inches. It is characteristically weak and brittle and occurs as both slip- and cross-fiber. The deposits were exposed by several shallow surface cuts when examined in 1931.

Prospecting and Development

There are undoubtedly portions of the Oregon ultramafic outcrops that have never been adequately prospected for asbestos. In the early days of Oregon prospecting, it was considered that only fibers in lengths exceeding $\frac{1}{2}$ inch were commercial. Consequently, the early-day prospectors paid no attention to outcrops that might have contained lengths of fiber that would now be considered commercial.

The usual percentage of fiber recovered from a commercial deposit ranges from 4 to 6 percent; occasionally this may vary if the deposit contains longer fibers. The most interesting fiber lengths from the economic point of view are from 1/8 inch to 3/8 inch. An ore body must contain some $\frac{1}{4}$-inch-plus length fiber to be minable at a profit.

The best manner of prospecting for asbestos is to examine the serpentine outcrops, preferably on a sunny day when the glossy fiber veins are more easily seen. A heavy rock hammer is needed to break lichen-covered rocks and a small knife to scratch likely looking veins. The fiber should fluff up readily when scratched with a knife. The fiber generally occurs in irregular veins scattered throughout the serpentine rock mass.

One cannot safely eliminate any variety of serpentine when prospecting for chrysotile. Even the highly sheared variety sometimes referred to as "slickentite" or "fishscale" should be examined. The new discoveries in Fresno and San Benito Counties northwest of Coalinga, California, occur as matted fiber in a unique type of highly sheared serpentine. The most favorable environment for occurrence of stockwork (crisscrossing) veinlets of

SUBDIVISION OF THE GROUPS OF CANADIAN CHRYSOTILE ASBESTOS

CRUDE ASBESTOS

Class	Standard Designation of Grade	Description
Group No. 1	Crude No. 1	Consists basically of crude ¾ inch staple and longer.
Group No. 2	Crude No. 2	Consists basically of crude ⅜ inch staple up to ¾ inch.
	Crude run-of-mine	Consists basically of unsorted crudes.
	Crudes sundry	Consists of crudes other than above specified.

MILLED ASBESTOS

Groups No. 3 to No. 9 Inclusive	Standard Designation of Grade	Guaranteed Minimum Shipping Test			
Group No. 3	3D	10.5	3.9	1.3	0.3
	3F	7.0	7.0	1.5	0.5
	3K	4.0	7.0	4.0	1.0
	3R	2.0	8.0	4.0	2.0
	3T	1.0	9.0	4.0	2.0
	3Z	0.0	8.0	6.0	2.0
Group No. 4	4D	0.0	7.0	6.0	3.0
	4H	0.0	5.0	8.0	3.0
	4J	0.0	5.0	7.0	4.0
	4K	0.0	4.0	9.0	3.0
	4M	0.0	4.0	8.0	4.0
	4R	0.0	3.0	9.0	4.0
	4T	0.0	2.0	10.0	4.0
	4Z	0.0	1.5	9.5	5.0
Group No. 5	5D	0.0	0.5	10.5	5.0
	5K	0.0	0.0	12.0	4.0
	5M	0.0	0.0	11.0	5.0
	5R	0.0	0.0	10.0	6.0
Group No. 6	6D	0.0	0.0	7.0	9.0
Group No. 7	7D	0.0	0.0	5.0	11.0
	7F	0.0	0.0	4.0	12.0
	7H	0.0	0.0	3.0	13.0
	7K	0.0	0.0	2.0	14.0
	7M	0.0	0.0	1.0	15.0
	7R	0.0	0.0	0.0	16.0
	7T	0.0	0.0	0.0	16.0
	7W	0.0	0.0	0.0	16.0
Group No. 8	8S	under fifty pounds per cubic foot loose measure			
	8T	under seventy-five pounds per cubic foot loose measure			
Group No. 9	9T	over seventy-five pounds per cubic foot loose measure			

cross-fiber chrysotile appears to be in the more blocky varieties of serpentine.

Jenkins (1949) reports that siliceous dikes or sills are often found close to high-grade chrysotile deposits; so the presence of such intrusives in serpentine can be considered a possible guide.

Magnetite is almost always associated with chrysotile that has formed by alteration of peridotite. It is a natural by-product of serpentinization and occurs as segregations along margins and in partings of chrysotile veinlets. This relationship has enabled use of magnetometers in prospecting for chrysotile. Their main value is in helping to determine the extent of known occurrences.

It is sometimes possible to log the surface outcrops by taking a visual reading of the fiber lengths over an exposed surface. Cross-fiber veins are generally recorded as multiples of a sixteenth of an inch over a five-foot length. The average width of irregular veins is estimated. Veins that are of a composite nature or that have kinks that will cause the fiber to break readily into shorter lengths should be recognized.

Field men in the industry have developed a method of mathematically reducing the visual face reading to a dollar value per ton of ore. It is always necessary to mill a portion of the rock in a small pilot mill and grade the fiber to be sure of the value.

Slip-fiber is often associated as a minor constituent in deposits made up mainly of cross-fiber, or slip-fiber can make up an entire ore body. Laboratory assistance is always necessary to evaluate slip-fiber.

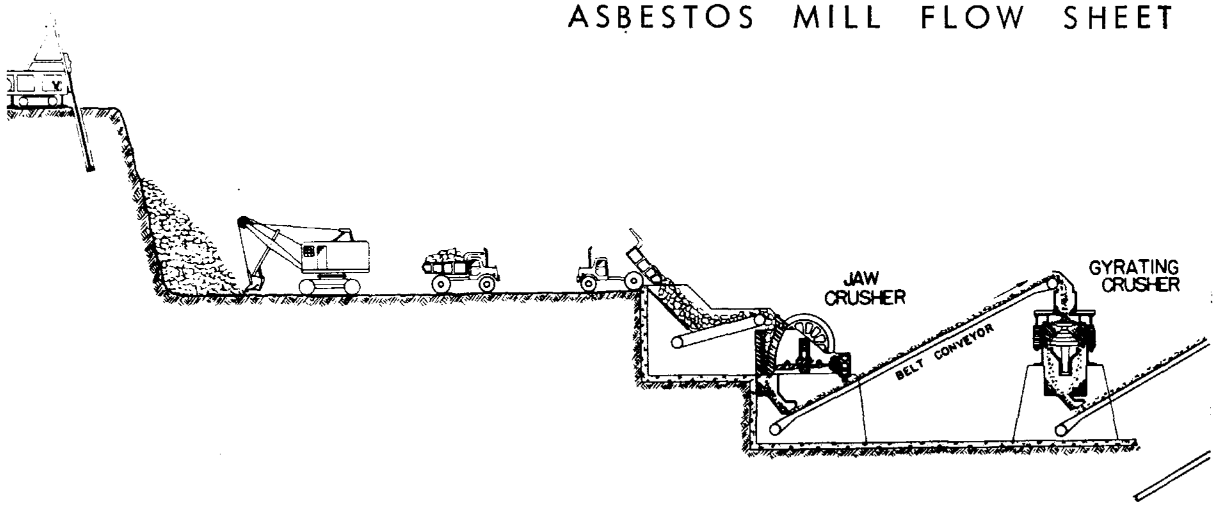
When a likely looking prospect has been found, it should be examined by an engineer or geologist experienced in asbestos. If the prospect warrants further work, the first step is to expose the fiber-bearing rock by trenching, where this is practical. The next step is diamond drilling to recover core from the deeper part of the ore zone, thereby exploring and developing an ore body. Portions of both the ore body and the core must be tested in a small pilot mill before the characteristics of the deposit can be known well enough to design a mill. If sufficient ore can be found by this process, the result could well be a producing asbestos mine. Such mines are usually huge open pits or large, underground block-caving operations.

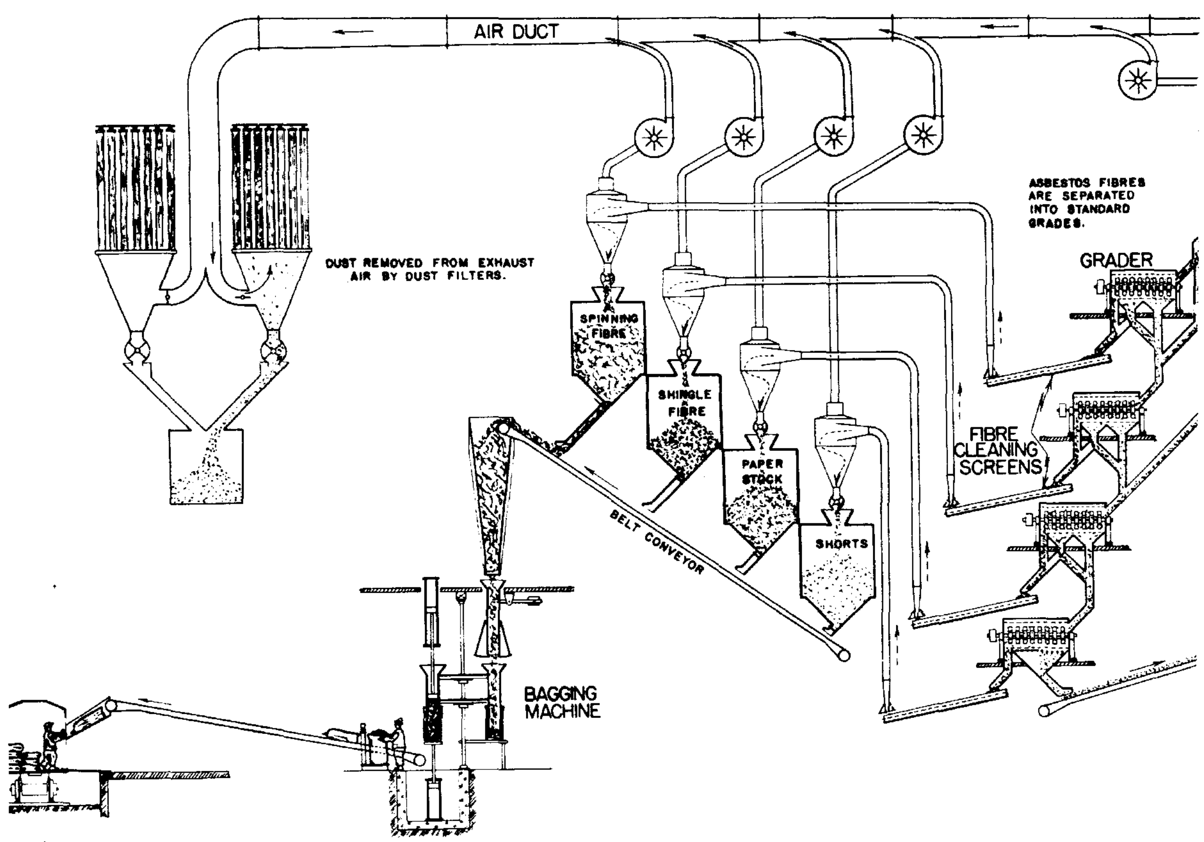
Grading and Processing the Ore

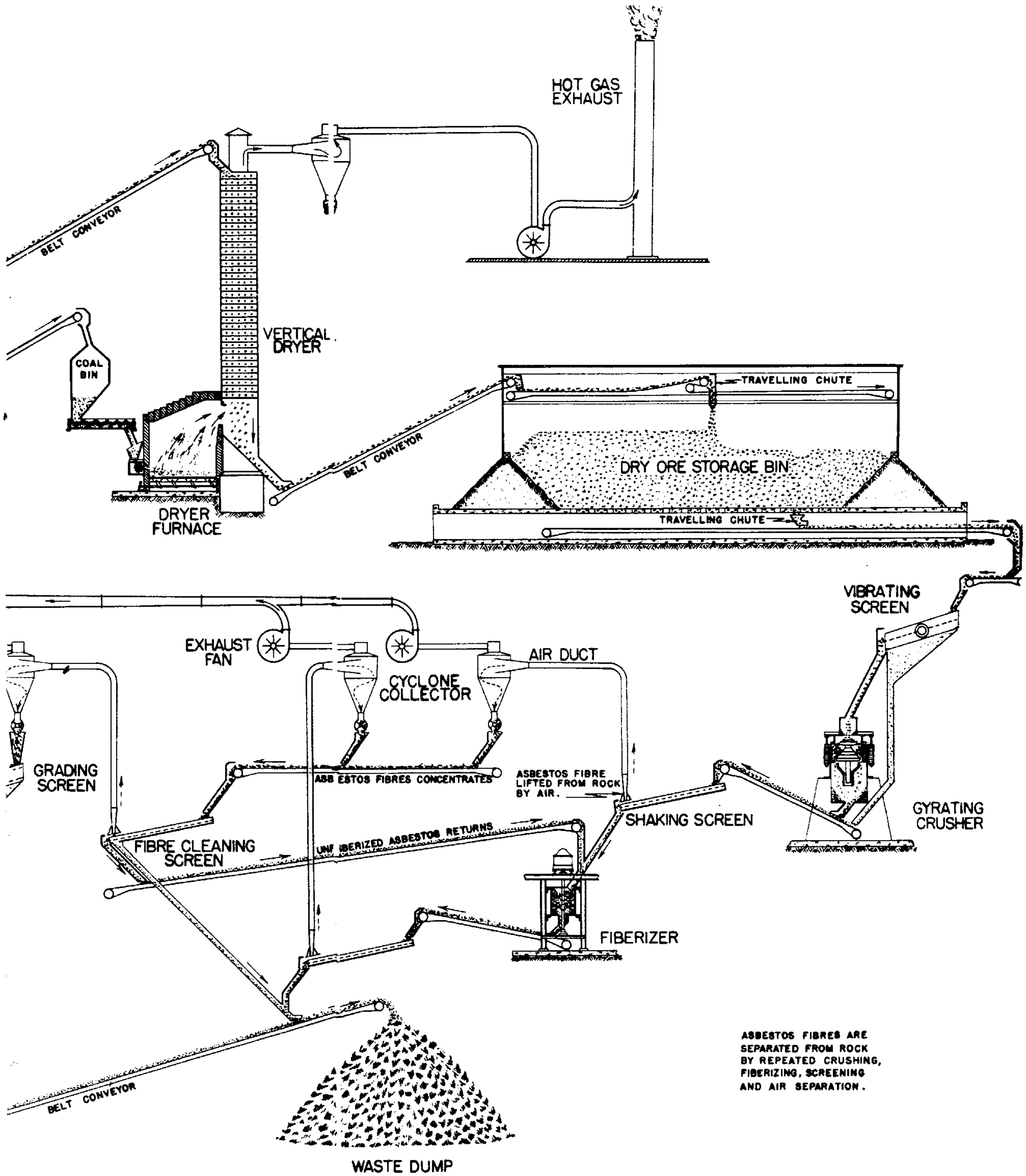
The milling process which removes the fibers from the rock and grades them for sale is fairly complicated and contributes quite a bit to the cost of the product. (See illustration of flow sheet.)

The grading and pricing of all asbestos is governed by the length of the fiber. The longer fibers (more than 3/8 inch) range in price from $345 to

ASBESTOS MILL FLOW SHEET






HOT GAS
EXHAUST
BELT CONVEYOR
VERTICAL
DRYER
COAL
BIN
DRYER
FURNACE
BELT CONVEYOR
TRAVELLING CHUTE
DRY ORE STORAGE BIN
TRAVELLING CHUTE
VIBRATING
SCREEN
EXHAUST
FAN
AIR DUCT
CYCLONE
COLLECTOR
GRADING
SCREEN
ASBESTOS FIBRES CONCENTRATES
ASBESTOS FIBRE
LIFTED FROM ROCK
BY AIR.
SHAKING SCREEN
GYRATING
CRUSHER
FIBRE CLEANING
SCREEN
UNFIBERIZED ASBESTOS RETURNS
FIBERIZER
BELT CONVEYOR
WASTE DUMP
ASBESTOS FIBRES ARE
SEPARATED FROM ROCK
BY REPEATED CRUSHING,
FIBERIZING, SCREENING
AND AIR SEPARATION.

$1,400 per ton. A very small tonnage of the higher priced material is sold in a year. The medium-length fibers, ranging from 1/16 to 3/8 inch, sell for from $90 to $220 per ton. The shorter fibers, or lengths under 1/16th inch, sell for from $28 to $77 per ton.

One of the generally recognized methods of testing asbestos is the Quebec screen test. This test was developed by the Quebec Asbestos Mining Association and has set specifications for the various grades of fiber. The test is used as an ore-evaluation tool and as a production-control method which serves to grade fiber for sale.

The Quebec standard testing machine consists of three rectangular screens -- ½-inch mesh, 4 mesh, 10 mesh -- and a box for the shortest material. The test consists of placing 16 ounces of clean fiber on the top screen and shaking the nest of screens horizontally at 327 rpm for 600 revolutions. The fiber grade is then determined on the basis of the number of ounces remaining on each of the screens and in the box. (See classification chart.)

As an example, if 2 ounces of the fiber remained on the ½-inch screen, 8 ounces remained on the 4 mesh, 4 ounces on the 10 mesh, and 2 ounces in the pan, the fiber would be classed as 3R. The ounces of fiber in each case totals 16. These specifications are minimum tests. Fiber falling between the noted values is carried to the lower scale.

Asbestos milling consists essentially of coarse crushing, drying, and recrushing in stages, each step followed by screening and air separation of fiber from the rock. It is important to separate the fiber from the rock with a minimum of fiber breakage. The process also includes preparing fibers to conform to exacting specifications regarding grading and dust removal.

Mills of several thousand tons per day capacity are customarily built in the asbestos industry. Construction costs are $3,000 to $4,000 per ton of capacity, resulting in an investment of several million dollars in the mill to produce from each mine. It is essential that the mills have enough ore to allow them to operate for 20 or more years, thereby providing for the recovery of the initial investment.

Diligent effort on the part of asbestos prospectors and asbestos mining companies may very well result in one of these large mills being built in Oregon to produce fiber.

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McCOLLOCH REAPPOINTED TO GOVERNING BOARD

Frank C. McColloch, Portland attorney, was reappointed to the Department's Governing Board March 16, 1965, by Governor Mark O. Hatfield. McColloch has been chairman of the board since October 18, 1961. His term continues until March 15, 1969. Mining and water law have been McColloch's special interests during his many years of practice, and he has served on a number of state boards concerned with these problems. He is a member of the Koerner, Young, McColloch, and Dezendorf law firm.

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OREGON ACADEMY OF SCIENCE and NSA PROGRAM SCHEDULED

The joint meeting of the Oregon Academy of Science and the Northwest Scientific Association will be held in Portland April 9 and 10, 1965. The Geology-Geography section will hold its meetings at Portland State College and at the Sheraton Hotel. A field trip to the Columbia River Gorge has been scheduled for Friday, April 9, at 10 a.m. For reservations write to Dr. J. S. Lowther, Geology Department, University of Puget Sound, Tacoma, Washington, 98416. A symposium on the gorge will be held at the Sheraton Hotel on Saturday, April 10, at 9 a.m. Papers to be presented at the two-day program are listed on the following page.

Friday, April 9 (with Engineering Section of the NSA)

8:45 a.m. - Room 338 College Center, Portland State College; J. W. Crosby III and J. E. Sceva presiding.

1. Auger Center - a new approach to new problems; J. E. Allen, Portland State College.
2. Earthquake-induced landslides, Anchorage, Alaska; S. D. Wilson, Shannon & Wilson, Inc., Seattle-Portland.
3. Geologic hazards, what are they and what can be done about them; H. G. Schlicker, Oregon Dept. of Geology and Mineral Industries, Portland.
4. Investigation of a rock slide, site for a dam in the Cedar Creek watershed, Idaho; H.A. Allen and J.L. Holland, Soil Conservation Service.
5. The science of finding, quarrying, and using jetty stone; R.J. McReary, Ureka, Inc., Portland.
6. Geologic design for the foundations of weirs in river channels; G.R. Stephenson, Dept. of Agriculture Research Service, Boise.

1:00 p.m. - Room 338 College Center; W.H. Taubeneck and R.H. Russell presiding.

1. Geomechanics; D.L. Masson, Dept. of Mining, Washington State Univ., Pullman.
2. Potential application of nuclear explosives in water management; A.M. Piper, U.S. Geological Survey, Menlo Park.
3. Land subsidence due to water-level decline, and its engineering significance; J.F. Poland, U.S. Geological Survey, Sacramento.
4. Methods used in locating and testing a major ground-water resource in the Washakie Basin, southern Wyoming; G.A. Duell and W.M. Sahinin, Pacific Power & Light Co., Portland.
5. Use of artesian relief wells for a specific drainage problem; G.E. Neff, Bureau of Reclamation, Ephrata.
6. The role of geology in waste-disposal practice; W.A. Haney and D.J. Brown, Battelle-Northwest, Richland.

Saturday, April 10

9:00 a.m. - Room 71, State Hall, Portland State College; Dr. Ray Broderson and Dr. J.E. Allen presiding.

1. Indicators of Late Pleistocene paleoclimatology, east-central Idaho; Wakefield Dort, Jr., University of Kansas.
2. Glacial geology of the Stuart Range and Leavenworth area, Washington; W.A. Long, Washington State Dept. of Natural Resources, Ellensburg.
3. Late Cenozoic stratigraphic sequence in Oreana quadrangle, southwest Idaho; N. R. Anderson, Univ. of Puget Sound.
4. Palisades lava flow, Clear Fork of Cowlitz River, south-central Cascade Mountains, Wash., J.A. Ellingson, Pacific Lutheran University.
5. Natural gas storage, Marys Corner, Wash., and its effect upon water resources which overlie the structure; R.H. Russell, Wash. State Dept. of Conservation, Olympia.
6. Development of ridges in plastic layers; Z.F. Danes, University of Puget Sound.
7. Geochemical prospecting in the Darrington-Granite Falls area, northern Cascade Mountains, Wash.; Paul Eddy, University of Puget Sound.

1:30 p.m. - Room 71 State Hall; Dr. H.E. Wheeler presiding.

1. Problems associated with the extension of the stratigraphic units of south-central Washington: the late basalt flows, Ellensburg and Ringold Formations; R.E. Brown and D.J. Brown, Battelle-Northwest, Richland.
2. Problems associated with the extension of the stratigraphic units in south-central Washington: the post-basalt sediments; D.J. Brown and R.E. Brown, Battelle-Northwest.
3. The Touchet Beds; W.F. Scott, Washington State University.
4. Some fossil plants from the Naches Formation of central Washington; E.P. Klucking, Central Washington State College.