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Reported Historic Asbestos Mines, Historic Asbestos Prospects, and Natural Asbestos Occurrences in the Rocky Mountain States of the United States (Colorado, Idaho, Montana, New Mexico, and Wyoming)

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Introduction

This map and the accompanying dataset (***asbestos_sites.xls***) provide information for 48 natural asbestos occurrences in the Rocky Mountain States of the United States (U.S.)—Colorado, Idaho, Montana, New Mexico, and Wyoming—using descriptions found in the geologic literature. Data on location, mineralogy, geology, and relevant literature for each asbestos site are provided in the aforementioned digital file. Using the map and digital data in this report, the user can examine the distribution of previously reported asbestos occurrences and their geologic characteristics in the Rocky Mountain States. This report is part of an ongoing study by the U.S. Geological Survey to identify and map reported natural asbestos occurrences in the U.S., which began with reports of similar format for the Eastern U.S. (Van Gosen, 2005) and the Central U.S. (Van Gosen, 2006). These reports are intended to provide State and local government agencies and other stakeholders with geologic information on natural occurrences of asbestos.

The file ***asbestos_sites.xls*** was compiled through a systematic State-by-State search of the geologic literature. Although this asbestos dataset represents a thorough study of the published literature, it cannot be construed as a complete list. An asbestos site was included only when the literature source specifically mentioned asbestos and (or) described the commonly recognized asbestos minerals as occurring in the asbestiform crystal morphology. No attempt was made to interpret the presence of asbestos if asbestos was not explicitly described. The user should refer to the references cited for each asbestos site entry for descriptions of these occurrences. These asbestos occurrences were reported to exist in outcrop exposures or rock exposed by mining operations. Note that these site descriptions apply to the time of each report's publication. No field verification of the sites was performed, nor were evaluations of potential exposure made at these sites. Many of the sites are likely to have been subsequently modified by human activities since their description, sometimes substantially. For example, since the time that the source literature was published there may have been remediation of the site or it may have been either exposed or covered by more recent development.

What is Asbestos?

The history of asbestos discovery and usage is at least 5,000 years old, extending back to the ancient civilizations in Greece and what is now Italy (see Ross and Nolan, 2003). Historically, asbestos is a generic commercial-industrial term used to describe a group of specific silicate minerals that form as long, very thin mineral fibers, which can form bundles. When handled or crushed, asbestos bundles readily separate into individual mineral fibers. The special properties of commercial-grade asbestos—long, thin, durable mineral fibers and fiber bundles with high tensile strength, flexibility, and resistance to heat, chemicals, and electricity—have made it well suited for a number of commercial applications (Ross, 1981; Zoltai, 1981; Cossette, 1984; Ross and others, 1984; Skinner and others, 1988). Asbestos has been especially used for its insulating and fire-resistant properties in many types of products (see Virta and Mann, 1994; Ross and Virta, 2001).

Currently, commercial and regulatory definitions of asbestos most commonly include chrysotile, the asbestiform member of the serpentine group, and several members of the amphibole mineral group, including the asbestiform varieties of (1) riebeckite (commercially called crocidolite), (2) cummingtonite-grunerite (commercially called amosite), (3) anthophyllite (anthophyllite asbestos), (4) actinolite (actinolite asbestos), and (5) tremolite (tremolite asbestos). Other amphiboles are known to occur in the fibrous or asbestiform habit (Skinner and others, 1988), such as winchite, richterite (Meeker and others, 2003), and fluoro-edenite (Gianfagna and Oberti, 2001; Gianfagna and others, 2003), but to date they have not been specifically listed in the asbestos regulations. The many different ways that asbestos and asbestiform and other related terms have been described are summarized in Lowers and Meeker (2002).

Historically, chrysotile has accounted for more than 90 percent of the world's asbestos production, and it presently accounts for over 99 percent of the world production (Ross and Virta, 2001; Virta, 2002). Mining of crocidolite (asbestiform riebeckite) and amosite (asbestiform cummingtonite-grunerite) deposits accounts for most of the other asbestos production, and small amounts of anthopyllite asbestos have been mined in Finland and the U.S. in the past (Ross and Virta, 2001; Van Gosen, 2005). Asbestos is no longer mined in the U.S. The last U.S. asbestos operation mined chrysotile deposits in California; this mine closed in 2002.

Naturally Occurring Asbestos

Mounting evidence throughout the 20th century indicated that inhalation of asbestos fibers caused respiratory diseases that have seriously affected many workers in certain asbestos-related occupations (Tweedale and McCulloch, 2004; Dodson and Hammar, 2006). Airborne exposures to asbestos have been linked to a number of serious health problems and diseases, including asbestosis, lung cancer, and mesothelioma. Additional asbestos information is available online at http://www.epa.gov/asbestos/ and http://www.atsdr.cdc.gov/asbestos/.

There are a number of federal regulations that address worker exposure to asbestos released during the manufacture of asbestos products, at shipbuilding and general construction sites, during building demolition or remodeling where asbestos products may be encountered, and during the repair or replacement of commercial asbestos-based products, such as asbestos brake components. There also are regulations governing the release of asbestos into the environment from manufacturing, mining, and other occupational sites. Less straightforward is the regulation and management of "naturally occurring asbestos" (NOA), which has recently gained the attention of regulatory agencies, health agencies, and citizen groups. NOA includes minerals described as asbestos that are found in-place in their natural state, such as in bedrock or soils, which may be exposed by man's excavations or by natural weathering. NOA occurs widely in some areas of the U.S. A discussion of the geology of asbestos deposits in regard to NOA is described in more detail by Van Gosen (2007).

NOA is of concern due to potential exposures to microscopic fibers that can become airborne if asbestos-bearing rocks are disturbed by natural erosion or human activities (road building, urban excavations, agriculture, mining, crushing, and milling, as just a few examples). Examples of occupational and environmental exposures to asbestos are described in Nolan and others (2001) and Ross and Nolan (2003).

Recent concerns over NOA that occurs as an accessory mineral within a larger mineral deposit are typified by the current situation in Libby, Montana, where high incidences of asbestos-related mortality and respiratory disease exist among former vermiculite miners and present residents of Libby. Here it was demonstrated that occupational as well as non-occupational exposures to asbestos have led to asbestos-related health disease. The disease cluster in Libby has been attributed to exposure to fibrous and asbestiform amphibole particles within the vermiculite ore body (site number 29) once mined and milled near the town from 1923 to 1990 (Peipins and others, 2003; Sullivan, 2007). Meeker and others (2003) described in detail the fibrous and asbestiform amphibole minerals in the Libby vermiculite deposit within the Rainy Creek igneous complex.

Large areas of exposed ultramafic bedrock in northern California, some now densely populated by housing and infrastructure, have become the focus of recent attention because they contain chrysotile and, locally, tremolite-actinolite asbestos (Churchill and Hill, 2000; Clinkenbeard and others, 2002; Ross and Nolan, 2003; Swayze and others, 2004; Meeker and others, 2006).

The history and study of naturally occurring asbestos and the multiple, complex issues that surround asbestos are discussed in Campbell and others (1977), Ross (1981), Stanton and others (1981), Zoltai (1981), Levadie (1984), Skinner and others (1988), Mossman and others (1990), Occupational Safety and Health Administration (1992), Guthrie and Mossman (1993), van Oss and others (1999), Nolan and others (2001), Virta (2002), Plumlee and Ziegler (2003), and Dodson and Hammar (2006). Current federal regulations are provided in the Code of Federal Regulations (available online at http://www.gpoaccess.gov/cfr/). However, these asbestos regulations do not specifically address exposures to natural occurrences of asbestos, other asbestiform amphiboles, and fibrous, but non-asbestiform, amphiboles.

Asbestos in the Rocky Mountain States

The asbestos occurrences in the Rocky Mountain region occur in a diverse variety of geologic settings (see ***asbestos_sites.xls***). The asbestos deposits occur in altered magnesium-rich host rocks, such as serpentinized ultramafic rocks and serpentinite, mafic alkaline igneous intrusions and alkalic intrusive complexes, dolomitic marbles, skarns that replace dolostones, mafic igneous rocks (diabase, amphibolite), and mafic metamorphic rocks (amphibolite gneiss and schist). The majority of the sites on the map are relatively small asbestos pods, lenses, or vein deposits within bedrock or a larger mineral deposit. Only five deposits in this region mined and shipped asbestos ore for use in commercial applications. The mined deposits include:

(1) The Kamiah anthophyllite deposits (site number 9) in north-central Idaho were worked on a small scale from 1909 to 1925. The anthophyllite asbestos was used in pipe and boiler covers, wall plaster and paint, and as a binding agent in cements and asphalts (Bowles, 1955, p. 26-27).

(2) The Karst mine (site number 25) in southern Montana had small anthophyllite asbestos production in 1923, 1928, and 1933 to 1935, which was used as insulation at oil refineries, in asphalt roofing compound, and in the manufacture of wall and ceiling insulation (Hauptman, 1971).

(3) In Wyoming, three mines produced chrysotile, including (i) the Fire King deposit (site number 39), which in 1920 shaped blocks of chrysotile-bearing serpentine for chimney construction, and (ii) the Smith Creek (site number 41) and Casper Mountain (site number 45) deposits, south of Casper, which made small shipments of chrysotile to flooring manufacturers in 1912 (Bowles, 1955, p. 24).

Fibrous Amphiboles in the Rocky Mountain States

During this study, several examples were noted in the geologic literature that mentioned the presence of fibrous amphiboles in developed mineral deposits (such as metal mines and prospects) or in outcrops of alkaline igneous intrusions. These examples are shown on the map and described in a separate dataset (***fibrous_amphiboles.xls***). Amphibole asbestos was not specifically mentioned in the descriptions of these deposits. However, these sites indicate geologic settings with the *potential* to host asbestos. The geologic settings for these examples of fibrous amphiboles are similar to those that elsewhere form and host the reported asbestos. Thus, a discovery of asbestos in these areas would not be unusual from a geologic standpoint. Also, the distinction between "fibrous" amphibole and "regulatory" amphibole asbestos is often not clear-cut in natural amphibole-bearing deposits. These amphiboles may or may not meet the regulatory criteria of asbestos, which requires site-specific detailed microscopic analyses.

Digital Databases

The asbestos database (***asbestos_sites.xls***) summarizes information found in geologic references examined by the author. Each asbestos site entry in the database includes the following data fields:

Site number
Number used to identify the dataset entries with their corresponding locations on the map.

State
The State in which in the asbestos deposit occurs, using the two-letter U.S. Postal Service abbreviation.

Historic site name as reported
The name of the former asbestos mine, former asbestos prospect, or reported occurrence, matching the nomenclature used in the source literature.

Development
This field indicates whether the asbestos site represents a former asbestos mine, former prospect, or an occurrence. "Past producer" indicates that the deposit was mined and produced asbestos ore for commercial uses sometime in the past. "Past prospect" indicates that the asbestos deposit was once prospected (evaluated) for possible commercial use, typically by trenching and (or) drilling, but the deposit was not further developed. "Occurrence" indicates that asbestos was reported at this site. The occurrence category includes (1) sites where asbestos-bearing rock is described in a geologic map or report; and (2) asbestos noted as an accessory mineral or vein deposit within another type of mineral deposit.

Latitude
The latitude of the site's location in decimal degrees, measured using the North American Datum of 1927. The number of significant figures following the decimal point indicates the believed accuracy of the location: (1) two significant figures (for example, 44.03) indicates an approximate location based on a general description; (2) three significant figures (for example, 44.094) indicates a fairly accurate location based on a detailed description or location shown on a small-scale map (1:50,000 scale or smaller); and (2) four significant figures (for example, 42.5586) indicates a precise location based on a detailed description or a location shown on a large-scale map (1:24,000 scale or larger).

Longitude
Longitude was calculated in the same manner as latitude.

Asbestiform mineral(s) reported
This field identifies the type of asbestos present as described in the source literature.

Associated minerals reported
Minerals mentioned in association with the asbestos, as they were described in the source literature. The order in which each mineral is listed does not necessarily indicate their relative abundance in the deposit, but rather their order of mention in the source report.

Host rock(s) reported
The host rock type(s) for the asbestos is (are) listed when available as described in the source literature.

References
The references used to compile the site information are listed in this field. The full reference citations are provided in the accompanying digital files ***References.pdf*** and ***References.xls.***

Another database, ***fibrous_amphiboles.xls,*** lists 13 localities where fibrous amphiboles are described in the geologic literature. This database is organized in a manner similar to ***asbestos_sites.xls*** with the exception of two data fields:

1) The data field "Site type" replaces the data field "Development."

2) The data field "Fibrous amphibole(s) description" replaces the data field "Asbestiform mineral(s) reported." This field contains short excerpts of amphibole description, quoted directly from the geologic literature.

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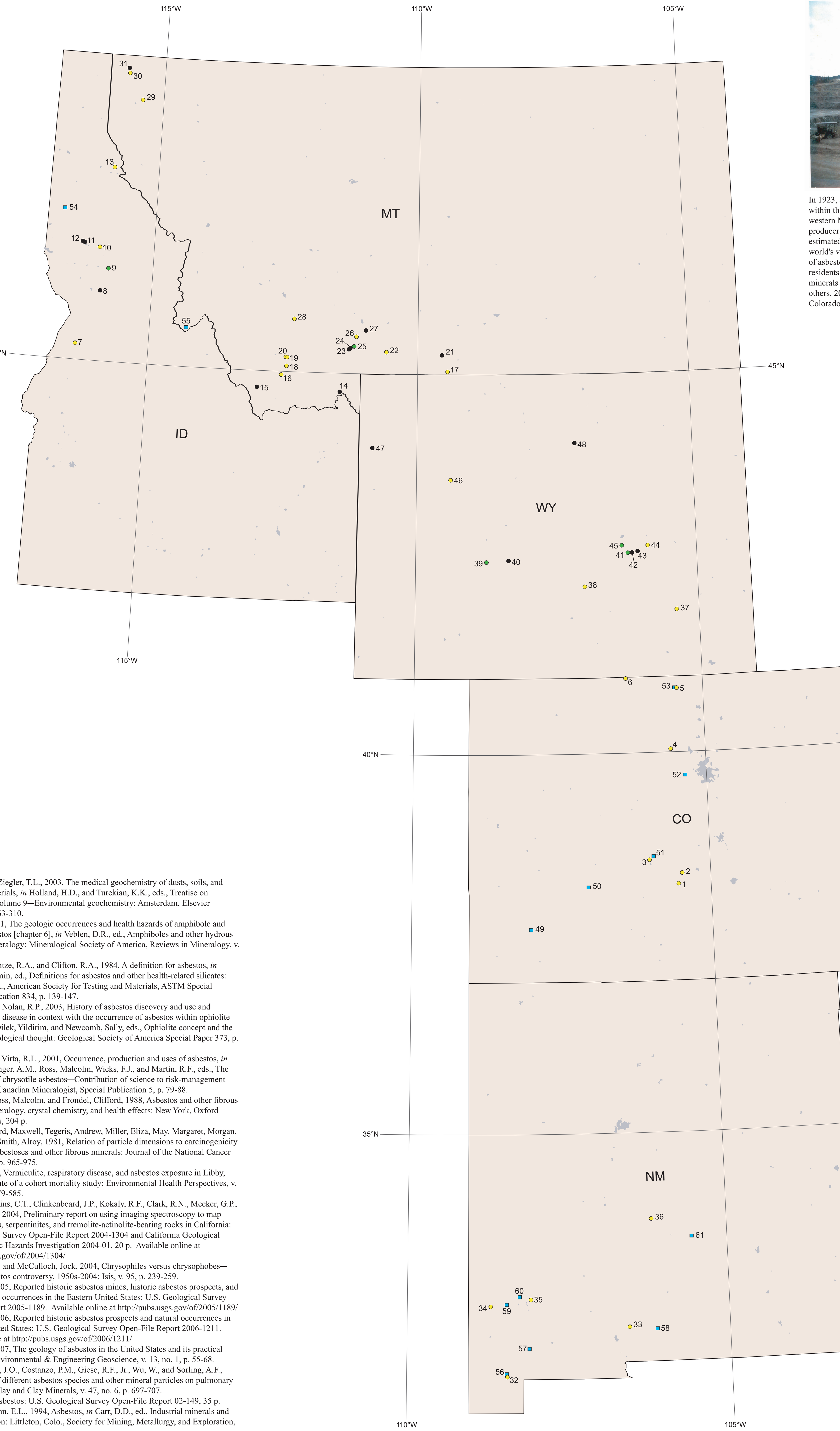

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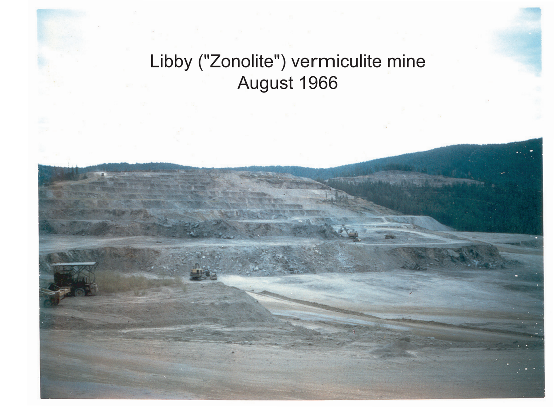
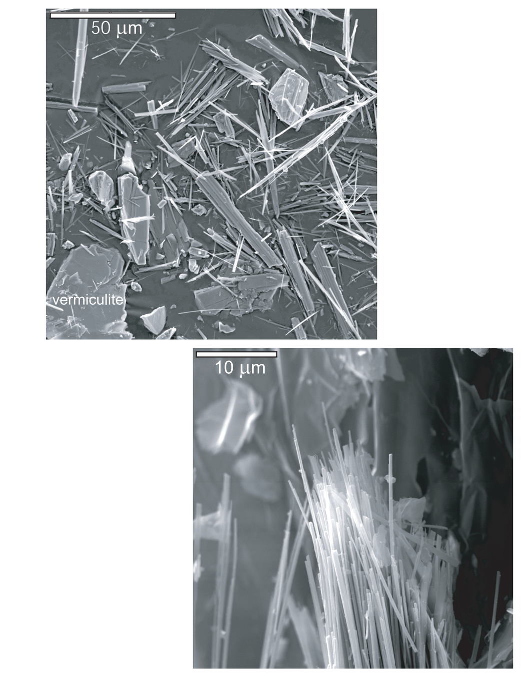


In 1923, a modest vermiculite mine opened in this area, which occurs within the Rainy Creek igneous complex (site number 29) in north-western Montana. The mine grew steadily to become the largest producer of vermiculite in the world, before its closure in 1990. It is estimated that the Libby mine supplied more than 50 percent of the world's vermiculite output between 1924 and 1990. High incidence rates of asbestosis and other respiratory diseases in mine workers and Libby residents have been linked to exposures to asbestiform amphibole minerals in the vermiculite ore mined from this deposit (Peipins and others, 2003; Sullivan, 2007). Photograph by A.L. Bush, USGS, Denver, Colorado.



Scanning electron microscope (SEM) photomicrographs of asbestiform sodic-calcic amphibole in vermiculite ore of the Rainy Creek complex (site number 29) near Libby, Montana. See Meeker and others (2003) for a detailed analysis of the amphiboles of this deposit. Photographs by G.P. Meeker, USGS, Denver, Colorado.

Reported Asbestos and Fibrous Amphibole(s) Occurrences in the Rocky Mountain States of the United States

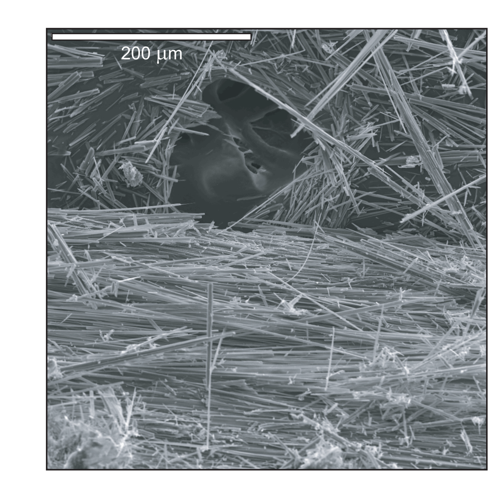
EXPLANATION

[Site number corresponds to a specific entry in the dataset]

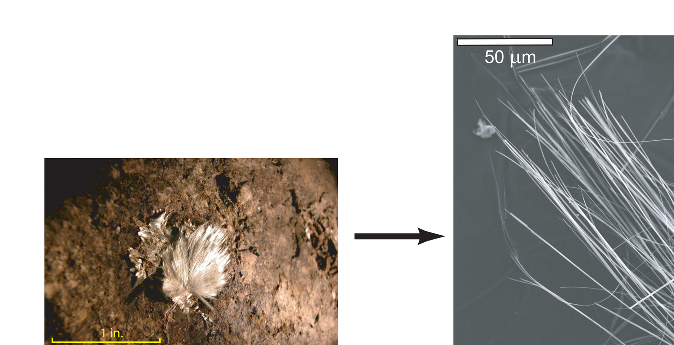
- Former asbestos mine
- Former asbestos prospect
- Reported asbestos occurrence
- Reported fibrous amphibole(s)
- Urban area

Number and Type of Asbestos Sites Reported in the Rocky Mountain States

State	Former asbestos mine	Former asbestos prospect	Asbestos occurrence
Colorado	--	--	6
Idaho	1	3	3
Montana	1	7	10
New Mexico	--	--	5
Wyoming	3	5	4
	5	15	28



SEM photomicrograph of anthophyllite asbestos from the former Karst asbestos mine (site location 25) in southern Montana.



Ferrian winchite fiber bundle in hand specimen

SEM photomicrograph of ferrian winchite

Example of the asbestiform ferrian winchite that occurs in a syenite dike in the historic Camp Albion mining district (site location 4) in north-central Colorado.