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Reported Historic Asbestos Mines, Historic Asbestos Prospects, and Natural Asbestos Occurrences in the Southwestern United States (Arizona, Nevada, and Utah)

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Introduction

This map and the accompanying dataset (***asbestos_sites.xls***) provide information for 113 natural asbestos occurrences in the Southwestern United States (U.S.)—Arizona, Nevada, and Utah—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 southwestern U.S. 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 thus far includes reports of similar format for the Eastern U.S. (Van Gosen, 2005), the Central U.S. (Van Gosen, 2006), and the Rocky Mountain States (Van Gosen, 2007a). 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 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 exploration and 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. 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 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, 2006; 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, 2005; Burragato and others, 2005), 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 and amosite deposits accounts for most of the other asbestos production, and small amounts of anthophyllite 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., since the last U.S. asbestos operation closed in 2002; it mined chrysotile deposits in California.

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/.

A number of federal regulations 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. 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 (2007b). 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). Several examples of occupational and environmental exposures to naturally occurring asbestos are described in Nolan and others (2001) and Ross and Nolan (2003).

The history and study of asbestos and its many complex issues 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), Churchill and Hill (2000), Nolan and others (2001), Clinkenbeard and others (2002), Virta (2002), Plumlee and Ziegler (2003), Dodson and Hammar (2006), Meeker and others (2006), and Fubini and Fenoglio (2007). Federal regulations are listed in the Code of Federal Regulations (available online at http://www.gpoaccess.gov/cfr/). The asbestos regulations do not specifically address exposures to natural occurrences of asbestos, other asbestiform amphiboles, and non-asbestiform, but fibrous amphiboles.

Asbestos in the Southwestern United States

Nevada and Utah asbestos deposits. Only a few, widely scattered asbestos deposits are documented in Nevada and Utah. Most of these deposits are small occurrences of amphibole asbestos, including one small past producer of mass-fiber tremolite asbestos in Utah—the Tremolite no. 1 mine. In the Southwestern U.S., tremolite and actinolite are commonly reported in the contact-metamorphic (skarn) zone of metallic ore deposits, which formed where an igneous body intruded and metamorphosed a magnesium-bearing carbonate rock. In most instances, the literature does not describe the crystal form of the tremolite or actinolite. Thus, several instances of unreported fibrous to asbestiform tremolite-actinolite may occur in skarn geologic environments in these States.

Arizona asbestos deposits. There are at least 103 documented asbestos-bearing sites in Arizona. Of these asbestos deposits, 96 are chrysotile asbestos deposits in Gila and Pinal Counties in central Arizona, with most of these in Gila County. Of the 46 former chrysotile mines that once operated in Arizona, 44 occur in Gila County; the other two chrysotile mines—the Bass and Hance—were small producers during the early 1900s inside the Grand Canyon of northern Arizona.

The chrysotile deposits of Arizona, in Gila County and in the Grand Canyon, are horizontal veins of chrysotile in tabular serpentine lenses that replace magnesian limestone. These serpentine-chrysotile lenses occur within several feet vertically of diabase sills that intruded the host limestone. In the Gila and Pinal County chrysotile deposits, the host magnesian (dolomitic) limestones are layers of the Proterozoic-age Mescal Limestone, which were forcibly intruded by diabase sills 1.1 billion years ago. In this region, the serpentine replacement layers are as much as 2 ft (0.6 m) thick and contain single to multiple veins of cross-fiber chrysotile (occasionally slip-fiber). The individual chrysotile veins vary from microscopic in size to a maximum of 14 in. (36 cm) thick, with most less than 2 in. (5 cm) thick (Wilson, 1928; Stewart, 1955, 1956). A process of chrysotile formation in the Salt River region is proposed by van der Hoeven and others (1999), which invokes an early high-temperature contact metamorphism caused by the intrusion of the diabase sills into the limestone, followed by low temperature (200 to 250 degrees C) magnesium metasomatism (the serpentine and chrysotile formation) caused by regional circulation of heated groundwater.

Chrysotile asbestos was discovered in Arizona in 1872 along Ash Creek in Gila County at Chrysotile, the site of the former Arizona Asbestos Association Group mines. Around 1900, chrysotile asbestos was also discovered in the Grand Canyon at two sites, the Hance and Bass deposits, which are about 30 mi (48 km) apart along the Colorado River. Beginning in 1903, small amounts of chrysotile were shipped from the Hance Asbestos Company properties (Hance deposit); the small production from the Hance and Bass properties was transported by burro out of the Grand Canyon until mining ceased here in 1921.

In 1912 and 1913, asbestos activity grew in the Ash Creek area of Gila County, where mines, a mill and housing were constructed to form the settlement of Chrysotile. By the end of 1915, approximately 500 asbestos claims were staked in the Salt River region between the towns of Young and Globe. Between 1916 and 1921, a number of mines came into production in this region. Chrysotile mining in the region decreased in 1922 and 1923, and during the Depression of the 1930s asbestos mining in Arizona almost completely stopped. Asbestos mining picked up again in the region in the late 1930s. The early chrysotile mining history of Arizona is described by Trischka (1927), Wilson (1928), Bowles (1955), and Stewart (1955, 1956, and 1961).

In 1943, due to U.S. stockpile concerns for World War II, the U.S. Bureau of Mines conducted an exploration and resource assessment study of the Gila County chrysotile deposits. The results of these investigations were published by Stewart and Haury (1947) and Stewart (1955, 1956, and 1961), which provide detailed descriptions of the region's asbestos deposits and the mine workings.

It has been estimated that roughly 75,000 short tons of asbestos were mined from the Salt River region of Gila County from 1913 to 1966 (Harris, 2004). Asbestos mining in this region ended in January of 1982 (Burgin, 1984, p. 70-71).

Fibrous Amphiboles in the Southwestern United 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 undisturbed outcrops. 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. The entries in the database are sorted by State and descending order of latitude (north to south). Each asbestos site entry in the database includes these data fields:

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 its relative abundance in the deposit, but rather its 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_amphibolex.xls***, lists eight 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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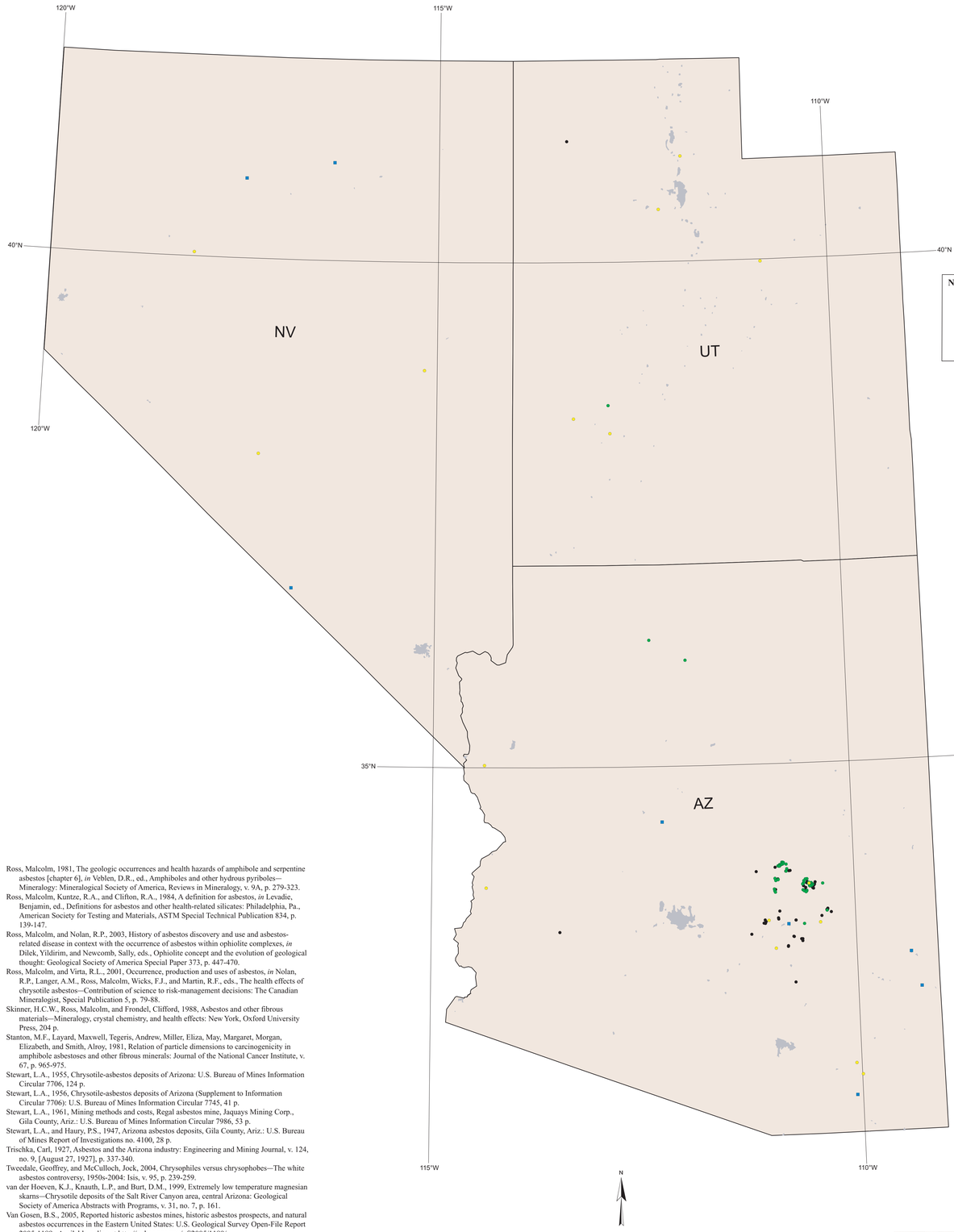

Reported Asbestos and Fibrous Amphibole(s) Occurrences in the Southwestern United States

EXPLANATION

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

Number and Type of Asbestos Sites Reported in the Southwestern United States

State	Former asbestos mine	Former asbestos prospect	Asbestos occurrence
Arizona	46	49	8
Nevada	--	--	3
Utah	1	1	5
	47	50	16

Veins of chrysotile asbestos in serpentine, replacing dolomitic limestone, at the Hance deposit within the Grand Canyon of northern Arizona. Lincoln penny for scale. Photograph by Geoffrey S. Plumlee, May 1979.

Abandoned adits (in red oval) and mine-waste piles of the former Arizona Asbestos Association Group of H.W. Johns-Manville Co., located at Chrysotile, Arizona, above Ash Creek in Gila County. Abandoned truck for scale (circled). Photograph by James S. Webber, N.Y. State Department of Health, Albany, N.Y., March 2006.

Abandoned adits and haulage trestle of the former Regal mines in the Salt River region of Gila County, Arizona. Photograph by James S. Webber, N.Y. State Department of Health, Albany, N.Y., March 2006.

Multiple chrysotile veins (in red oval) replacing magnesian limestone, exposed in an abandoned adit of the former Regal mines in the Salt River region of Gila County, Arizona. The underlying stacked blocks of limestone were placed by miners for wall support. Photograph by James S. Webber, N.Y. State Department of Health, Albany, N.Y., March 2006.