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Asbestos in Arizona

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Arizona Geological Survey

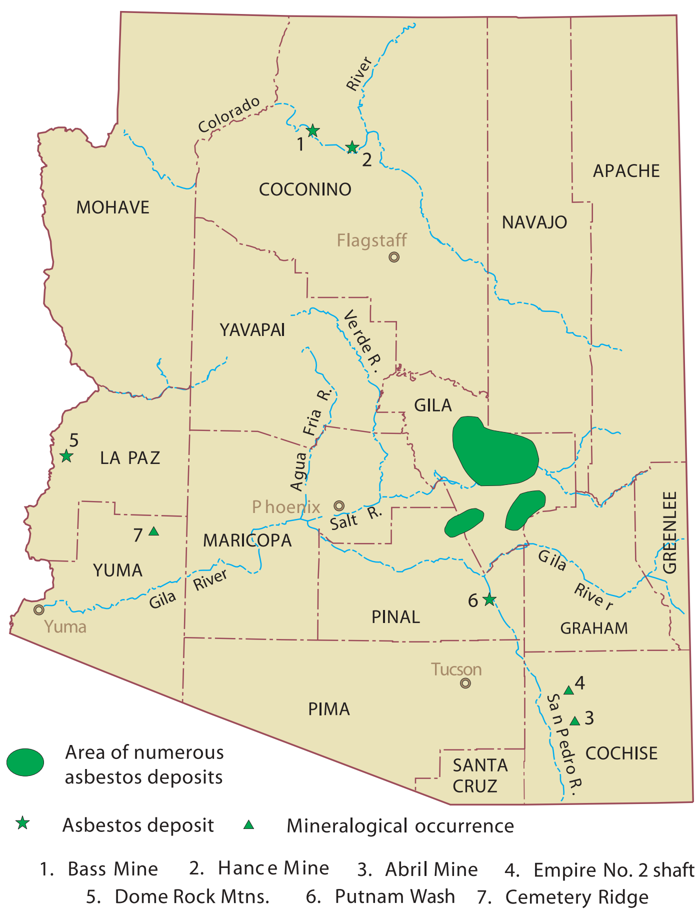

Figure 1. Asbestos deposits and occurrences in Arizona.

Do sand and gravel deposits in the Agua Fria River near Sun City contain asbestos? During the past several years Sun City residents have periodically asked the Arizona Geological Survey (AZGS) that question. They have a good reason to want to know: Someone in the area has repeatedly stated that nearby sand and gravel operations produce dust that contains asbestos, which is alleged to be causing health-related problems among Sun City residents.

In response to those requests for information, I reviewed the occurrence of asbestos in Arizona, including the Agua Fria River drainage basin, to determine the validity of such claims. The AZGS released a 15-page report of my findings (Open-File Report 03-06, "Is asbestos present in Agua Fria River sand and gravel?") in November 2003.* This article is a summary of the findings presented in that report. The conclusion of the report is that, although asbestos occurrences are known throughout Arizona (Figure 1), there is no evidence that asbestos is present within the Agua Fria drainage basin.

What is asbestos? Asbestos is a term applied to six different silicate minerals that, when present in fibrous form (fibers), have special properties that make the minerals useful for industrial applications. Silicate minerals contain atoms of silicon (Si), oxygen (O), and usually other elements such as potassium (K), sodium (Na), calcium (Ca), magnesium (Mg), and iron (Fe). More than 95 percent of the asbestos used in the United States is the chrysotile type (Ross, 1982), a silicate mineral in the serpentine family. The other five

Table 1. Asbestos minerals and their chemical compositions.

Serpentine minerals	
Chrysotile	$Mg_3Si_2O_5(OH)_4$
Amphibole minerals	
Grunerite (Amosite)	$(Fe^{2+})_2(Fe^{2+}, Mg)_5Si_8O_{22}(OH)_2$
Riebeckite (Crocidolite)	$Na_2Fe^{2+}{}_3Fe^{3+}{}_2(Si_8 8O_{22})(OH)_2$
Anthophyllite	$Mg_7(Si_8O_{22})(OH)_2$

Table 2. Past uses of asbestos.

Pipe insulation	Brake pads
Structural steel insulation	Home siding
Electrical cable insulation	Roofing tiles and asphalt
Cement water pipes	Acoustic ceiling tile
Paint	Vinyl floor tiles
Boilers	Spackling compound
Gasket materials	Cigarette filters
Safety clothing	Hair dryers
Filtration aids	Ironing board covers

asbestos minerals are in the amphibole family. Asbestos minerals and their chemical formulas are listed in Table 1.

Molecules in serpentine minerals are arranged in sheets. In chrysotile, the sheets tend to curl into long tubes, forming hollow fibers. Amphibole minerals, characterized by molecules in long chains, are very common in igneous and metamorphic rocks. Of the numerous varieties of amphiboles, five may in certain cases develop in a fibrous form in metamorphic rocks. These five are amosite (the fibrous form of grunerite), crocidolite (fibrous form of riebeckite), anthophyllite, tremolite, and actinolite.

The minerals listed in Table 1 most commonly occur in massive or granular crystalline form. In rare instances conditions were right to produce the loosely-bound fibrous form of the mineral and in very rare situations the fibrous minerals were formed in quantities that can be mined. Although many minerals can occur in a fibrous form, only the minerals listed in Table 1 and discussed above constitute "asbestos."

The Occupational Safety and Health Administration (OSHA) defines an asbestos fiber as a particle that is "5 microns or longer, with a length-to-width ratio of 3 to 1 or longer." Fibers less than 5 microns in diameter are the most likely to cause asbestos disease. For comparison, human hair is generally 80 to 100 microns in diameter.

Asbestos was once a widely used material because it is plentiful, easy to mine and process, and has many beneficial properties. Asbestos minerals have high tensile strength and are nearly chemically inert, fireproof, and electrically nonconductive. These properties made them ideal for use in many industrial applications, building materials, and consumer items (Table 2). Because asbestos minerals were used in so many applications in the past and can also result from the weathering of certain rocks, they are common in small quantities in the environment.

Health effects of asbestos exposure. High levels of occupational asbestos exposure are associated with three specific diseases: asbestosis, mesothelioma, and lung cancer. Asbestos diseases usually begin to occur at least 20 years after exposure, and peak about 30 to 40 years after exposure. Those who worked in industries that involved asbestos are most likely to have experienced exposure to asbestos in harmful amounts. Chrysotile is the least harmful of the six asbestos minerals; crocidolite is considered the most harmful.

Most dust particles that are inhaled into the lungs are trapped by mucous and removed from the lungs. Some fibers are not removed efficiently and may lodge in the lower respiratory tract, triggering production of collagen that makes the lung tissue hard and fibrous, a condition called asbestosis.

Mesothelioma is a disease that results in tumors in the mesothelium (lining) of the chest (pleura), abdominal cavity (peritoneum), or heart (pericardium). The majority of mesothelioma cases are seen in males who have had occupational exposure to asbestos. The risk of developing mesothelioma from exposure to amosite is 100 times greater than from chrysotile, and exposure to crocidolite presents 500 times greater risk than from chrysotile.

In Arizona the number of deaths from asbestos increased from 6 in 1990 to 21 in 1999 (National Institute for Occupational Safety and Health [NIOSH], 2003). Arizona ranks in 31st place among the 50 states in age-adjusted mortality rate from asbestosis.

For asbestosis in particular, the age-at-death statistics are quite illuminating. From 1993 to 1999, 8,061 asbestosis deaths were recorded in the U.S. (NIOSH, 2003). Of these, 97 percent were men. The median age of death increased from 73.1 years in 1991 to 77 years in 1999. Only 11 of the 8,061 people who died were less than 45 years of age, and only one was younger than 35 years old. This skewed distribution of 96-97 percent male deaths strongly argues against incidental or background exposure being responsible. If such low-level exposure caused asbestosis, the distribution of deaths would be more equal between men and women and more people would die at a younger age. The increase in median age at death from asbestosis reflects lower occupational exposure in younger generations.

The current OSHA health standard for *occupational* exposure to asbestos is 0.1 fiber per cubic centimeter (cm^3)(equivalent to 100 fibers per liter) of air, time-weighted and averaged over an eight-hour work day, or, 1 fiber per cm^3 (equivalent to 1,000 fibers per liter) over a 30 minute period (29 CFR 1910.1001). Because of the decline in workplace exposure to chrysotile, the lifetime risk of chrysotile-exposed workers today is about 1,000 times lower than before most uses of asbestos were banned.

At a level of 100 fibers per liter of air, a worker would breathe in about 333,000 fibers in an 8-hour work day and more than 83 million fibers in a 250-day work year. Over

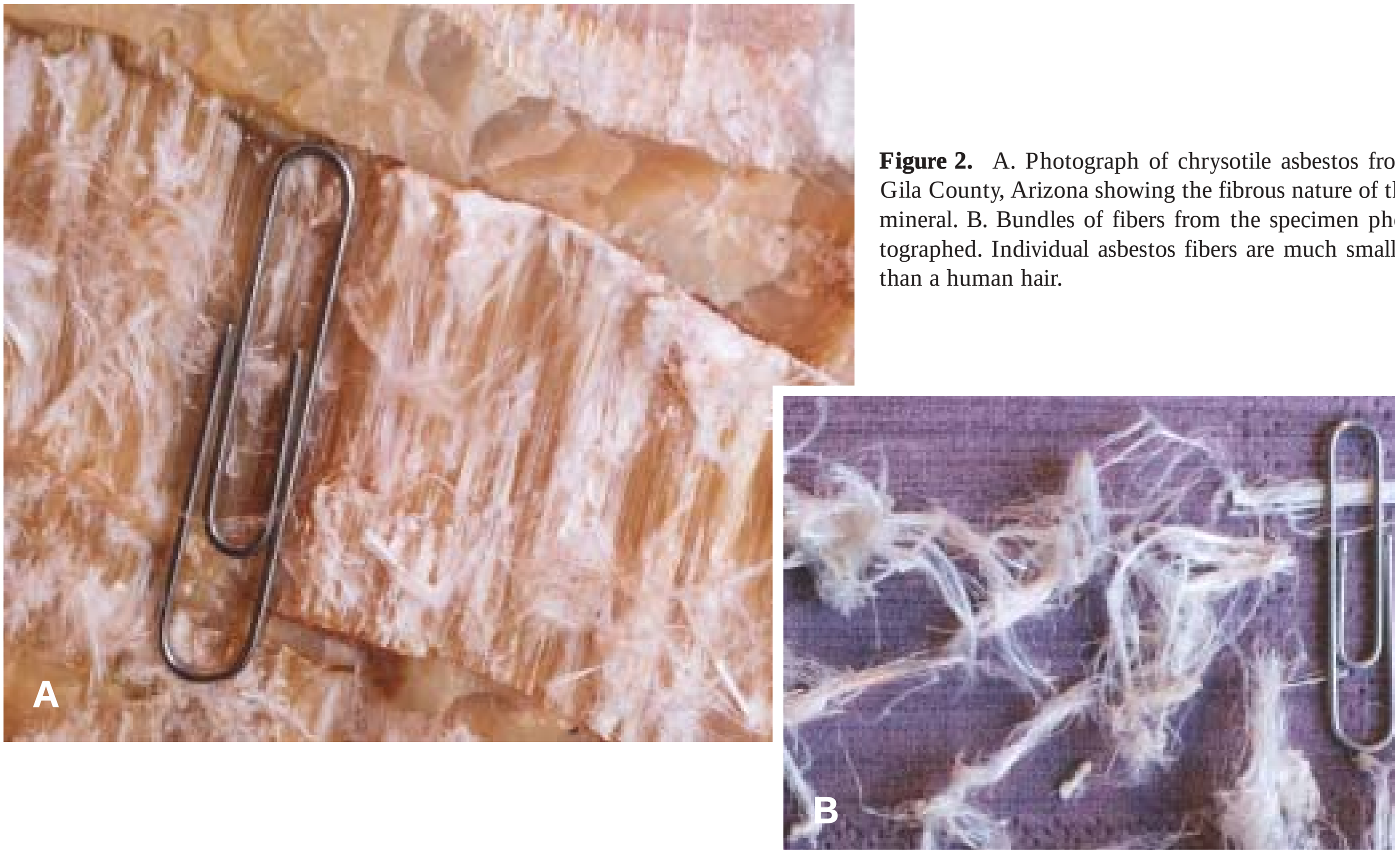

Figure 2. A. Photograph of chrysotile asbestos from Gila County, Arizona showing the fibrous nature of the mineral. B. Bundles of fibers from the specimen photographed. Individual asbestos fibers are much smaller than a human hair.

a period of 20 years that worker would inhale nearly 1.7 *billion* fibers, only a tiny fraction of which would become lodged in the worker's lungs. About one in 400 (0.25) percent of those who worked in that setting for 20 years develop asbestos-related disease, and virtually all of them are smokers. Incidental or background exposure is trivial when compared with occupational exposure, and occupational exposure at maximum allowable levels will result in lung cancer in only a tiny fraction of workers.

Extensive testing of schools in the U.S. has revealed that the mean concentration of asbestos is 0.00024 fiber per cm^3 (equivalent to 24 fibers per 100 liters). This is *lower* than the mean concentration of asbestos in outdoor air, which is 0.00039 fiber per cm^3 (equivalent to 39 fibers per 100 liters) (Mossman and others, 1990). For perspective, at that concentration the average person inhales 3,900 fibers of asbestos each day in outdoor air.

One person proposed to the Mine Safety and Health Administration (MSHA) that the government "establish a permissible exposure level at 0.0000" (MSHA, 2002). Given that the average person breathes asbestos at a background level outdoors of 0.00039 fiber per cm^3, the proposal to lower the permissible exposure to zero is absurd.

Should the average person worry about non-occupational asbestos exposure? The World Health Organization (1986) concluded the following: "In the general population, the risks of mesothelioma and lung cancer, attributable to asbestos, cannot be quantified reliably and are probably undetectably low. Cigarette smoking is the major etiological factor in the production of lung cancer in the general population. The risk of asbestosis is virtually zero."

Known occurrences of asbestos in Arizona. Asbestos deposits are present in Coconino, Gila, La Paz, and Pinal counties (Figure 1). By far the most deposits are concentrated in northern Gila County northeast of Globe. About 90 are in a 100-square-mile area near where U.S. Highway 60 crosses the Salt River Canyon 25-35 miles northeast of Globe. Another 80 deposits are in a 60-square-mile area about the same distance due north of Globe. Minor occurrences of asbestos have been described in Cochise and Yuma counties.

All known chrysotile asbestos deposits in Arizona were formed by contact metamorphism. The deposits north and northeast of Globe consist of veins and masses of chrysotile in the Mescal Limestone that was intruded by diabase, a dark igneous rock rich in iron and magnesium. The limestone reacted with silica-bearing fluids heated by the diabase, forming the serpentine mineral chrysotile (Figure 2).

About 75,000 tons of asbestos were mined from the Salt River region of Gila County from 1913 to 1966 from more than 160 mines. The amount produced from the 60-70 other occurrences in the district is unknown. Mining in the district ceased by the early 1980s.

The geology of a drainage area upstream from river-deposited sand and gravel determines whether the sand and gravel contain asbestos. Geologic investigations of portions of the Agua Fria River drainage area upstream from Sun City have been conducted at various levels of detail. Those studies have been described in the published literature. The most common amphibole in the schists of the region is hornblende, generally described as coarse grained.

Hornblende is not one of the asbestos minerals. In references that list known asbestos deposits in Arizona, none are indicated in Yavapai County. Most of the watershed of the Agua Fria River is within Yavapai County.

MSHA tested 28 sand and gravel operations in the Salt River drainage in the Phoenix area and found no asbestos in air samples (Mine Safety and Health Administration, 2002). This result is pertinent to the question of whether asbestos is present in Agua Fria River sand and gravel deposits. Even though the Salt River at Phoenix is downstream from a large asbestos district, MSHA found no asbestos in air samples taken at sand and gravel operations along the Salt River at Phoenix. Because the Agua Fria River drainage area contains no asbestos deposits, it is scientifically indefensible to expect that asbestos would be present in air samples taken at sand and gravel operations along the Agua Fria River.

Conclusion. Based on geologic considerations, the Agua Fria River is unlikely to contain detectable asbestos. The drainage area of the river contains no known asbestos deposits, nor any asbestos mining or milling facilities. The contention that there is asbestos in the Agua Fria River near Sun City is scientifically unfounded and inconsistent with all available geologic information.

*** Is asbestos present in Agua Fria River sand and gravel?**: Harris, R.C., 2003, Arizona Geological Survey Open-File Report 03-06 (OFR 03-06), 15 p. $3.00 plus shipping and handling.

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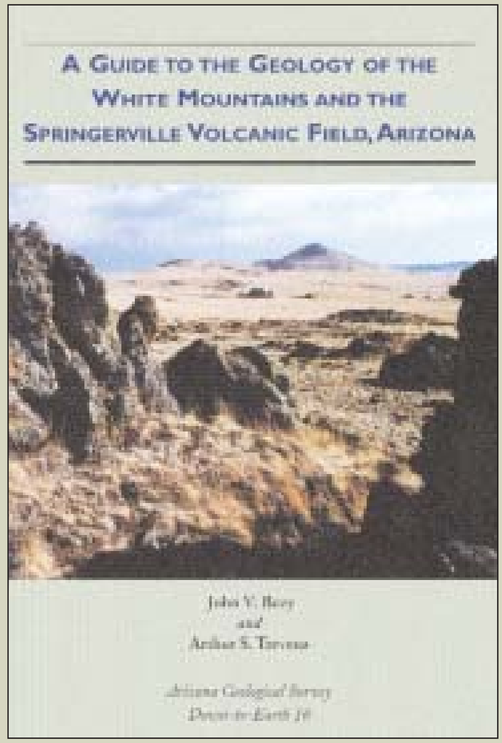

A guide to the geology of the White Mountains and the Springerville Volcanic Field, Arizona: Bezy, J.V., and Trevena, A.S., 2003, Arizona Geological Survey Down-to-Earth 16 (DTE 16), 56 p. $7.95 plus shipping and handling.

This guide begins with a description of the general geology of the area, which includes the communities of Greer, Eagar, and Springerville, as well as Lyman Lake State Park and Casa Malpais Archaeological Park. The authors describe 26 geologic features, including volcanic cinder cones, lava flows, pressure ridges, squeeze-ups, stream terraces, springs, and travertine mounds. Mt. Baldy, the highest peak in the White Mountains, was glaciated several times during the Ice Age; adventuresome individuals are guided along the Mt. Baldy trail to view some of the glacial features. Several rock formations that were present when the volcanic activity began may be viewed.

This 6x9-inch book, written in nontechnical terms, will be of interest to residents as well as summer and winter visitors.

Geologic map of the Twin Buttes 7.5' Quadrangle, Pima County, Arizona: Richard, S.M., Spencer, J.E., Youberg, Ann, and Johnson, B.J., 2003, Arizona Geological Survey Digital Geologic Map 31 (DGM 31), 1 CD-ROM that includes a 1:24,000-scale geologic map. $15.00 plus shipping and handling. (A paper copy of the map is available for $18.00 plus shipping and handling.)

Geologic map of the Benson 7.5' Quadrangle, Cochise County, Arizona: Youberg, Ann, Skotnicki, S.J., Shipman, T.C., and Ferguson, C.A., 2004, Arizona Geological Survey Digital Geologic Map 34 (DGM 34), 1 CD-ROM that includes a 1:24,000-scale geologic map. $15.00 plus shipping and handling. (A paper copy of the map is available for $15.00 plus shipping and handling.)

Geologic map of the McGrew Spring 7.5' Quadrangle, Cochise County, Arizona: Shipman, T.C., and Ferguson, C.A., 2003, Arizona Geological Survey Digital Geologic Map 35 (DGM 35), 1 CD-ROM that includes a 1:24,000-scale geologic map. $15.00 plus shipping and handling. (A paper copy of the map is available for $15.00 plus shipping and handling.)

Geologic map of the Huachuca City 7.5' Quadrangle, Cochise County, Arizona: Pearthree, P.A., 2003, Arizona Geological Survey Digital Geologic Map 36 (DGM 36), 1 CD-ROM that includes a 1:24,000-scale geologic map. $15.00 plus shipping and handling. (A paper copy of the map is available for $15.00 plus shipping and handling.)

U-Pb isotope geochronologic data from 23 igneous rock units in central and southeastern Arizona: Spencer, J.E., Isachsen, C.E., Ferguson, C.A., Richard, S.M., Skotnicki, S.J., Wooden, Joe, and Riggs, N.R., 2003, Arizona Geological Survey Open-File Report 03-08 (OFR 03-08), 40 p. $7.00 plus shipping and handling.

Modal mineralogy of some granitic rocks from eastern Maricopa and northern Gila counties, Arizona: Spencer, J.E., Skotnicki, S.J., and Richard, S.M., 2003, Arizona Geological Survey Open-File Report 03-09 (OFR 03-09), 18 p. $3.50 plus shipping and handling.

Giant desiccation cracks in Arizona: Harris, R.C., 2004, Arizona Geological Survey Open-File Report 04-01 (OFR 04-01), 93 p. $21.00 plus shipping and handling

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