AREAS MORE LIKELY TO ContAIN NATURAL OCCURRENCES OF ASBESTOS IN WESTERN EL DORADO COUNTY, CALIFORNIA

2000

DEPARTMENT OF CONSERVATION
Division of Mines and Geology

STATE OF CALIFORNIA
GRAY DAVIS
GOVERNOR

THE RESOURCES AGENCY
MARY D. NICHOLS
SECRETARY FOR RESOURCES

DEPARTMENT OF CONSERVATION
DARRYL YOUNG
DIRECTOR
Copyright © 2000 by the California Department of Conservation. All rights reserved. No part of this publication may be reproduced without written consent of the Department of Conservation.

“The Department of Conservation makes no warrantees as to the suitability of this product for any particular purpose.”
AREAS MORE LIKELY TO CONTAIN NATURAL OCCURRENCES OF ASBESTOS IN WESTERN EL DORADO COUNTY, CALIFORNIA

By

Ronald K. Churchill, Chris T. Higgins and Bob Hill

2000
CONTENTS

Contents ......................................................................................................................................... iii
Tables and Illustrations .................................................................................................................. vi
Executive Summary ..................................................................................................................... viii
Introduction ..................................................................................................................................... 1
  Purpose of this Report ............................................................................................................... 1
  Asbestos Health Issues ............................................................................................................. 1
  History of the El Dorado County Asbestos Issue and Asbestos Maps ....................................... 2
Geology and Map Unit Categories ............................................................................................. 4
  Geologic Setting of Western El Dorado County ....................................................................... 4
  Map Unit Categories ................................................................................................................ 5
  Relative Likelihood of Asbestos Occurrences for the Five Map Unit Categories ...................... 5
  Areas More Likely to Contain Asbestos—Ultramafic Rocks and Serpentinite ......................... 5
    Ultramafic Rocks and Serpentinite—Basic Information ........................................................ 5
    Chrysotile Asbestos—Serpentinite Association .................................................................... 7
    Tremolite/Actinolite (Amphibole) Asbestos—Serpentinite Association ................................. 8
  Faults and Fault Zones—Asbestos Associations .................................................................... 9
    Small Serpentinite Bodies ..................................................................................................... 9
    Tremolite/Actinolite Asbestos—Non-Serpentinite Associations ......................................... 10
  Areas Where the Presence of Asbestos is Possible But Unlikely—The Pine Hill
    Igneous Complex Altered Gabbro ....................................................................................... 10
  Carbonate Rocks That May Contain Asbestos—Contact Metamorphic Carbonate Rocks ...... 11
  Areas That Probably Do Not Contain Asbestos—Geologic Settings Where Asbestos
    is Unlikely To Occur ............................................................................................................ 12
Map Compilation Project Overview .......................................................................................... 12
Chapter 4. Finances

Article 1. Improvement Act of 1911; Municipal Improvement Act of 1913; Improvement Bond Act of 1915

Article 2. Financial Assistance

Chapter 5. Improvements

Chapter 6. Maintenance

TABLES AND ILLUSTRATIONS

Table 1. Processing algorithms applied to Landsat TM spring scene.

Figure 1. Page-size map showing ultramafic rock areas and major faults released by DMG in 1998.

Figure 2. The relative likelihood for asbestos occurrences in rock units shown on the map for El Dorado County.

Figure 3. Photomicrograph of cross-fiber chrysotile asbestos from the vicinity of Little Bald Mountain.

Figure 4. Photograph of a ¾-inch wide vein of cross-fiber chrysotile asbestos in serpentinite, along Green Valley Road east of Lotus Road.

Figure 5. Photomicrograph of slip-fiber chrysotile asbestos from the vicinity of Mother Lode Drive and Greenstone Road.

Figure 6. Photomicrograph of tremolite asbestos from the vicinity of Cothrin Ranch Road-Wild Turkey Road.

Figure 7. Western El Dorado County displayed as a normal, or “true,” color composite image by combining Bands 3, 2, and 1 of a subsection of the Landsat TM spring scene as red, green, and blue, respectively (RGB 321).

Figure 8. Western El Dorado County displayed as a false-color composite image by combining Bands 4, 3, and 2 as red, green, and blue, respectively (RGB 432).

Figure 9. Western El Dorado County displayed as a color composite image by combining Bands 5, 4, and 3 as red, green, and blue, respectively (RGB 543).

Figure 10. Western El Dorado County displayed in gray-scale by means of Principal Component 3 of Bands 1 through 7.
Figure 11. Western El Dorado County displayed as a false-color image of the Normalized Difference Vegetation Index (NDVI).......................................................... 39

Figure 12. Western El Dorado County displayed by draping the Normalized Difference Vegetation Index (NDVI) over Principal Component 1, which emphasizes topography. .......................................................... 40

Figure 13. Western El Dorado County displayed by means of an unsupervised classification using Bands 1-5 and 7. ..................................................................................... 41

Figure 14. Western El Dorado County displayed by means of an unsupervised classification using the results of the RGB 543 algorithm ........................................................................... 42

Figure 15. Enlargement of the RGB 543 display (Figure 9), highlighting the Latrobe-Cosumnes River area in the southwestern part of the county. ........................................ 44

Figure 16. Enlargement of the RGB 543 display (Figure 9), highlighting the Garden Valley-Coloma area northeast of Folsom Lake ........................................................................ 45

Figure 17. Enlargement of the RGB 543 display (Figure 9), highlighting the Latrobe-Cosumnes River area in the southwestern part of the county, with overlays of geology and soils ........................................................................................................... 46

Figure 18. Enlargement of the NDVI display (Figure 11), highlighting the Latrobe-Cosumnes River area in the southwestern part of the county, with overlays of geology and soils ........................................................................................................... 47

Figure 19. Enlargement of the RGB 543 display (Figure 9), highlighting the Garden Valley-Coloma area northeast of Folsom Lake, with overlays of geology and soils ........................................................................................................... 48

Figure 20. Enlargement of the NDVI display (Figure 11), highlighting the Garden Valley-Coloma area northeast of Folsom Lake, with overlays of geology and soils ........................................................................................................... 49

Plate 1. Areas More Likely to Contain Natural Occurrences of Asbestos in Western El Dorado County, California ................................................................................... In Pocket
EXECUTIVE SUMMARY

The Division of Mines and Geology of the Department of Conservation (DOC) has completed a pilot project to compile an environmental-asbestos map for western El Dorado County, California. The map produced during this project shows areas in El Dorado County where geologic conditions suggest natural occurrences of asbestos\(^1\) may be present. The purpose of this map is to provide information to local, state and federal agencies and the public as to where natural occurrences of asbestos are most likely to be found in El Dorado County. It does not indicate whether asbestos minerals are present or absent in bedrock or soil associated with a particular parcel of land. The determination of the likelihood of asbestos presence or absence for a parcel can only be made during a detailed site-specific examination of the property. The map is primarily a computer mapping (GIS) compilation of a number of previously available published and unpublished geologic and soil maps. Limited fieldwork resulted in some modifications of the compiled map. This map and report greatly benefited from peer review and comments by a technical review committee comprised of geologists from state, federal and county government agencies, universities, private consulting, and individuals with land-use planning experience.

The rocks exposed in the Sierra Nevada Foothills of western El Dorado County are predominantly metamorphic rocks\(^2\) created at high pressures and temperatures at depth by recrystallization of sedimentary rocks\(^3\) (shales, limestones,\(^4\) and sandstones) and igneous rocks\(^5\) (derived from melts). Numerous small irregularly distributed natural occurrences of chrysotile\(^6\) and tremolite/actinolite\(^7\) asbestos occur in these metamorphic rocks, especially near faults. Most often, these asbestos occurrences are associated with the metamorphosed igneous rock serpentinite\(^8\) (often called serpentine\(^9\)). Metamorphism of any of several related high-magnesium and high-iron igneous rock types, collectively called ultramafic rocks,\(^10\) may result in the formation of serpentinite. Depending on its metamorphic history, serpentinite may contain chrysotile and/or tremolite/actinolite asbestos, or no asbestos. Tremolite/actinolite asbestos also

---

1. **asbestos**—A term used for the fibrous crystal form (asbestiform) of the silicate minerals chrysotile, tremolite, actinolite, crocidolite, anthophyllite, andamosite (cummingtonite-grunerite).
2. **metamorphic rock**—Any rock derived from a pre-existing rock by mineralogical, chemical, and/or structural changes in response to heat, pressure, shearing stress, and chemical environment, generally at depth in the crust of the earth.
3. **sedimentary rock**—A water deposited rock formed by the consolidation and compaction of loose sediment or by chemical precipitation.
4. **limestone**—A bedded sedimentary rock composed chiefly of calcium carbonate (the mineral calcite).
5. **igneous rocks**—Rocks that formed by the solidification of molten or partly molten material (magma).
6. **chrysotile**—A serpentine-group mineral that usually occurs in asbestos form.
7. **tremolite and actinolite** are closely related minerals in the amphibole group. The more common non-fibrous forms of these minerals are often present in several types of metamorphic rocks.
8. **serpentinite**—A rock consisting mainly of serpentine-group minerals, often formed by the metamorphism of magnesium rich intrusive igneous rocks.
9. **serpentine**—Often used by non-geologists as a synonym for the rock serpentinite. Serpentine is actually the name of a group of common rock-forming minerals composed of magnesium, silica and hydroxyl ions. See serpentine in the appendix for additional information about this mineral group.
10. **ultramafic rock**—An igneous rock composed chiefly of mafic (dark colored iron-magnesium) minerals. Asbestos minerals may form during the metamorphism of ultramafic rock.
may occur less commonly in certain other metamorphic rocks, especially near faults. However, not all serpentinite or fault zones contain asbestos. The currently available information and knowledge of asbestos occurrences in El Dorado County allow the identification of areas where geologic conditions appear favorable for the formation of asbestos minerals. Not all areas where conditions appear favorable will actually contain asbestos. Available information and knowledge is not sufficient to allow prediction of asbestos occurrences at specific locations within these areas.

The 1:100,000-scale\textsuperscript{11} map produced in this study is primarily a compilation of geologic information related to ultramafic rocks, faults and other rock types from a number of previously existing geologic and soil maps. Limited field work was conducted to check the accuracy of the compiled map and some modifications were made based on this work. As part of the El Dorado County asbestos pilot project, black and white and infrared air photos were utilized during field work, and the potential usefulness of maps derived from satellite imagery for identifying ultramafic rock areas was investigated. Analysis of the satellite imagery indicates that it can be useful in certain situations for refining the locations of ultramafic rock.

DOC undertook to produce this derivative map of areas more likely to contain natural occurring asbestos as a pilot project for several reasons. Potential for exposure to natural occurrences of asbestos, particularly during excavation activities, has been an active environmental health issue in El Dorado County for several years. During this period, numerous government agencies and private citizens have sought to obtain maps at detailed scales showing those areas in El Dorado County which would be more likely to have natural occurrences of asbestos. No existing geologic or soil map satisfactorily filled this need. These existing maps were not designed to address the environmental asbestos issue, so they are complicated to use for that purpose and subject to misinterpretation, especially by non-geologists. The various geologic maps seldom agree in detail on the location and extent of the rock units having potential for asbestos occurrences. In some areas, significant differences exist between location and extent of asbestos related rock units from geologic maps and the locations of related soil types on soil maps. Some of the existing maps are not sufficiently detailed or utilize base maps which are obsolete, so they are of limited use.

This pilot project allowed DOC to produce a map specifically designed to overcome many of these shortcomings at 1:100,000-scale (a scale allowing the depiction of individual city block sized areas). In its final report, March 1999, the El Dorado County Asbestos Task Force recommended that DOC provide maps identifying areas more likely to have natural occurrences of asbestos in California. As a pilot project, important information was obtained on the usefulness of approaches and the resources needed to produce such maps for a county-size region

\textsuperscript{11} 1:100,000-scale--A map scale where one inch represents a distance of about 1.6 miles.
At 1:100,000-scale. If funding were available, DOC should be able to prepare similar maps for other parts of California more efficiently because of the information and experience gained from this study.
INTRODUCTION

Purpose of this Report

This report provides background information about why this project was undertaken, the supporting geologic assumptions on which the map is based, an overview of activities involved in map compilation, information on map accuracy, and guidance on map usage and limitations. To assist lay readers, footnotes are provided and a glossary of terms is available the end of this report.

Asbestos Health Issues

Asbestos is classified as a known human carcinogen by state, federal and international agencies. State and federal health officials consider all types of asbestos to be hazardous. There is no agreed-upon “safe” level of asbestos exposure because there is insufficient scientific information to support the identification of an exposure level at which there would be zero risk of cancer.

In March 1998, environmental health concerns were raised about potential exposures to airborne asbestos near areas where serpentinite is actively being disturbed in El Dorado County. Examples of such areas are construction sites within serpentinite and areas near serpentinite quarry operations. Also, potential asbestos exposure related to traffic on unpaved roads and driveways surfaced with crushed serpentinite was raised as an issue.

The following information has been summarized from the California Air Resources Board (CARB) web site at http://www.arb.ca.gov/toxics/asbestos. (DOC has not conducted air sampling in El Dorado County). “Between April 1998 and October 1998, and during the months of April and August 1999, CARB has collected 435 24-hour air samples at 41 sites in El Dorado County. Of these samples, 181 had results above the minimum detection level. Overall, the risks estimated for these samples by CARB ranged from 0 to 290 potential mesothelioma cases in a million and 1 to 170 potential lung cancer cases in a million. These estimated potential cancer risks assume that a person would be continuously breathing those levels for 24 hours a day for 70 years. To put these numbers into perspective, background cancer risk from air toxics in a large urban area are estimated by CARB to be about 500 chances in a million.”

CARB qualifies these data and calculates risks with the following statements. “These air-sampling results are individual measurements at specific sites. They do not represent what the average or typical asbestos exposures may be in El Dorado County.” Additional information on

12 carcinogen—Any substance that tends to produce cancer.
13 mesothelioma—Mesothelioma is a rare cancer of the thin membranes lining the lungs, chest, and abdominal cavity. Almost all cases of mesothelioma are linked to prior occupational asbestos exposure.
14 lung cancer—Lung cancer is a relatively common form of cancer that has been linked to smoking and a variety of occupational exposures. Cigarette smoking significantly increases the risk of lung cancer for those people exposed to asbestos.
the air sampling procedures and sampling results for El Dorado County is available on the CARB web site.

**History of the El Dorado County Asbestos Issue and Asbestos Maps**

El Dorado County is located east of Sacramento, beginning at the edge of the Sacramento Valley and extending east to Lake Tahoe and the Nevada border. Beginning in March 1998, the Sacramento Bee newspaper ran a series of articles on potential health risks from naturally occurring asbestos in El Dorado County. Government agency and general public concerns about public health resulting from these articles led to the formation of a task force to provide information and advice regarding asbestos to the County of El Dorado. This task force was a volunteer group consisting of public officials and representatives from federal, state and local agencies, including the DOC, and had its organizational meeting on April 14, 1998. On May 15, 1998, the Asbestos Task Force published an informational document on asbestos, the “White Paper”, for County residents. At the request of other task force members, DOC prepared an 8.5 X 11-inch page size map showing ultramafic rock areas and major faults (Figure 1). These are the geologic features believed more likely to have associated chrysotile or tremolite/actinolite asbestos occurrences, the asbestos varieties occurring in El Dorado County. To construct the map for the White Paper, information on the location of these geologic features was taken from a 1:250,000-scale geologic map of the Sacramento Quadrangle (Wagner and others, 1981) and placed on a simplified base map. Because of the limited geologic detail that can be shown at this scale, the White Paper map was recognized as only a general guide to what parts of El Dorado County may have natural occurrences of asbestos.

During the preparation of the White Paper map, a review of available geologic maps and the soil map for El Dorado County indicated no single map was comprehensive in showing locations with asbestos potential in the county. The various geologic maps seldom agree in detail on the location and extent of the rock units having potential for asbestos occurrences. In some areas, significant differences exist between location and extent of asbestos related rock units from geologic maps and the locations of related soil types on soil maps. Some of the existing maps were not at sufficiently detailed map scales or utilized obsolete base maps so they were of limited use. The existing maps were not designed to address the environmental asbestos issue, so they are complicated to use for addressing asbestos issues and subject to misinterpretation, especially by non-geologists. Consequently, at that time it was realized that a map compilation project of at least several person-months duration would be needed if a more detailed asbestos map were to be developed for El Dorado County. DOC did not have sufficient time to undertake such a project for the White Paper.

Asbestos Task Force information-gathering activities continued until March 11, 1999, when the task force issued its final report and disbanded. A recommendation in the final report was that DOC provide maps showing potential areas of naturally-occurring asbestos for other parts of the State, pending identification of adequate funding resources for this effort. Because of this recommendation, DOC temporarily redirected staff from other projects to undertake a one-time pilot mapping project for El Dorado County by placing another mineral hazard project on temporary hold and extending deadlines for several other projects. The 1:100,000-scale map
Figure 1. Page-size map showing ultramafic rock areas and major faults released by DMG in 1998, slightly reduced from original size for publication in this report.
of Areas More Likely to Contain Natural Occurrences of Asbestos in El Dorado County, California and this report, are the result of this pilot study. The time required for completion of the pilot study was six months.

GEOLOGY AND MAP UNIT CATEGORIES

Geologic Setting of Western El Dorado County

A north-northwest-trending belt of metamorphic rocks extending from Mariposa northward to Lake Almanor underlies the western slope of the Sierra Nevada and, consequently, western El Dorado County. This belt consists of accumulations of seafloor rocks and marine sedimentary and volcanic rocks (formed by crystallization of magma at or near the surface of the earth) of various types. These rocks have been buried and recrystallized at depth under elevated temperatures and pressures to produce the Western Sierra Nevada Metamorphic Belt and range in age from about 160 to 300 million years. Within the county, the belt is intruded by numerous small to moderately large bodies of igneous rock (the 165 million year old Pine Hill Intrusive Complex, and the slightly younger granitic\textsuperscript{15} intrusions of the Sierra Nevada Batholith and small dikes).

The structural framework of the Western Sierra Nevada Metamorphic Belt is dominated by a group of north-northwest-trending faults, also referred to as fault zones, that mark the boundaries of different packages of rocks along the length of the belt. These packages of rocks, called terranes, are believed to have been emplaced along the western margin of the North American continent at various times when a convergent plate tectonic setting existed (when the oceanic plate was sliding under the continental plate). Throughout the metamorphic belt, including western El Dorado County, the faults are locally characterized by long bands and isolated lenses of serpentinite, schist containing the minerals talc and chlorite, quartz vein\textsuperscript{16} complexes, and by highly sheared country rock.\textsuperscript{17} In western El Dorado County, the faults cut across the county from north to south and include segments of the Bear Mountains and Melones Fault Zones, a probable segment of the Calaveras-Shoo Fly Thrust, and several other unnamed structures. See the 1:100,000-scale map accompanying this report for fault locations and names.

For additional information on the geology of the Western Sierra Nevada Metamorphic Belt, a detailed overview and an extensive reference list may be found in Schweickert and others (1999). Jones and others (1997) provide details about the different tectonic belts and geologic terranes within El Dorado County.

\textsuperscript{15} granitic—A general term applied to any light-colored coarse-grained intrusive (igneous) rock containing quartz, feldspar and mafic (dark colored iron-magnesium) minerals.

\textsuperscript{16} vein—The mineral filling in a fracture or fault in a host rock.

\textsuperscript{17} country rock—The rock enclosing or hosting a mineral deposit, mineral occurrence or an igneous intrusion.
Map Unit Categories

Five map units that relate to the likelihood of asbestos occurrences are shown on the map. These units are titled: Areas More Likely to Contain Asbestos; Faults and Fault Zones, Areas Where the Presence of Asbestos is Possible but Unlikely; Carbonate Rocks that may Contain Asbestos; and Areas that Probably Do Not Contain Asbestos. The characteristics of each of these units are discussed in the following sections.

Relative Likelihood of Asbestos Occurrences for the Five Map Unit Categories

The relative likelihood for natural occurrences of asbestos for each of the five map categories that are displayed on Plate 1, based on currently available geologic information, is illustrated in Figure 2. This figure is included to assist the reader in visualizing how the map unit categories relate to each other regarding the incidence of natural occurrences of asbestos. It is not drawn to scale, and the length of the vertical axis does not represent 0 to 100 percent asbestos. Data are insufficient to present the numbers, sizes and locations of individual asbestos occurrences within the map unit categories.

Figure 2 shows the relative order of the different map unit categories from highest to lowest likelihood for asbestos occurrences. It indicates that the likelihood of asbestos occurrences associated with faults and fault zones is substantially smaller than for areas designated as “more likely to contain asbestos,” but has a greater likelihood than the remaining categories for asbestos occurrences. In addition, the figure indicates the likelihood for asbestos associated with the categories “where tremolite/actinolite asbestos occurrences are possible but unlikely” and where contact metamorphic carbonates may contain asbestos” are small. Their likelihood for asbestos occurrences is only slightly higher than the category least likely for asbestos occurrences, “areas that probably do not contain asbestos.”

Areas More Likely to Contain Asbestos—Ultramafic Rocks and Serpentinite

Ultramafic Rocks and Serpentinite—Basic Information

Ultramafic rocks are those igneous rocks composed mainly of the iron-magnesium silicate minerals. They include the rock types dunite, peridotite and pyroxenite. Ultramafic rocks form in high-temperature and high-pressure environments well below the surface of the earth. By the time they are exposed at the surface of the earth by erosion, they are usually partially to completely altered to serpentinite. This alteration results from metamorphism of the original iron-magnesium-silicate minerals to create one or more water-bearing magnesium silicate minerals belonging to the serpentine mineral group. The three main serpentine minerals are lizardite, chrysotile, and antigorite, with the first two probably being the most common in California serpentinites (Post and others, 1997, p. 382; Coleman, 1971). Chrysotile often is
Figure 2. The relative likelihood for asbestos occurrences in rock units shown on the map for El Dorado County.
present in its asbestiform18 habit in the resulting serpentinite. In addition to serpentine minerals, other minerals such as talc, brucite, actinolite, carbonate minerals and magnetite may form as products of the serpentinization process19 (Coleman, 1971 p. 898).

Because it is difficult for enough water to move into a body of ultramafic rock at one time for complete serpentinization to occur, the serpentinization process normally proceeds in successive steps (Coleman, written communication, January 2000). Consequently, many ultramafic rocks are only partially serpentinized when they are finally exposed at the surface of the earth. Often, fault zones within ultramafic rocks are more completely serpentinized because they allow water to move into the ultramafic rock and provide space for expansion of the resulting serpentinite (the resulting serpentinite takes up a larger volume than the original ultramafic rock). Consequently, any one or combinations of the following rock types may be included within an area defined as ultramafic rock on a geologic map: peridotite, dunite, pyroxenite, serpentinite (predominantly serpentine minerals), and talc or talc-carbonate schist. Asbestos may form at any time during the conversion of ultramafic rocks to serpentinite.

Chrysotile Asbestos—Serpentineite Association

Serpentinite, the host rock for chrysotile asbestos occurrences, is widely distributed in California, and mostly derived from peridotite. Chrysotile asbestos veins probably can be found in many of the serpentinite masses in California (Rice, 1957, p. 53).

In southern California, many small bodies of serpentinite have also been generated by contact metamorphism20 of the calcium-magnesium carbonate rock dolomite by granitic intrusives (Rice, 1957, p. 53) and these may also contain chrysotile asbestos.

Chrysotile asbestos, cross-fiber21 and slip or oblique fiber22 occurrences, are present in serpentinite bodies in western El Dorado County and were observed during the field work portion of this study (see Figures 3, 4 and 5). Confirmation of fibrous appearing mineral material collected during field work as chrysotile asbestos was made by X-ray diffraction,23 limited microscopic examination, and microscopic analysis at a commercial lab by California Air Resources Board (CARB) method 435.

---

18 asbestiform—A specific type of mineral fiber that occurs in bundles and possesses high tensile strength and flexibility. “Asbestiform” and “asbestos” are essentially synonymous in current usage. The length to width ratio for asbestos fibers is typically large, usually greater than five to one.

19 serpentinization (process)—The process of hydrothermal alteration (metamorphism) by which magnesium-rich silicate minerals in ultramafic rocks are converted into or replaced by serpentine minerals.

20 contact metamorphism—A local process of thermal metamorphism taking place in rocks at or near their contact with a body of igneous rock at the time the igneous rock was emplaced.

21 cross-fiber (asbestos)—Occurrences of asbestos in veins where the long direction of the fibers is oriented perpendicular to the vein walls.

22 oblique-fiber (asbestos)—Asbestos occurrences where the orientation of the long axis of the fibers is at an angle to the vein walls.

23 X-ray diffraction—A mineral identification method that uses characteristic interference patterns of X-rays. These patterns are obtained when pulverized mineral samples are exposed to X-rays and relate to the three dimensional arrangement of atoms in minerals.
Figure 3. Photomicrograph of cross-fiber chrysotile asbestos from the vicinity of Little Bald Mountain. Scale bar equals 0.2 mm. Photo by Mike Fuller, DOC.

Figure 4. Photograph of a ¾-inch wide vein of cross-fiber chrysotile asbestos in serpentinite, along Green Valley Road east of Lotus Road. The ruler is seven inches in length. Photo by Ron Churchill, DOC.

Figure 5. Photomicrograph of slip-fiber chrysotile asbestos from the vicinity of Mother Lode Drive and Greenstone Road. Scale bar equals 0.1 mm. Photo by Mike Fuller, DOC.

Figure 6. Photomicrograph of tremolite asbestos from the vicinity of Cothrin Ranch Road-Wild Turkey Road. Scale bar equals 0.1 mm. Photo by Mike Fuller, DOC.

Tremolite/Actinolite (Amphibole) Asbestos—Serpentineite Association

Tremolite/actinolite asbestos is probably the most common amphibole mineral group asbestos in California. Tremolite asbestos has been found in most of the counties of the Sierra Nevada and Klamath Mountains, where it most commonly occurs as slip fiber\textsuperscript{24} veins associated with fault or shear zones in serpentinite (Rice, 1957). Such veins are ordinarily no more than a few inches

\textsuperscript{24} slip-fiber (asbestos)—Asbestos occurrences where the orientation of the long axis of the fibers is parallel to the vein walls.
wide, but some contain lenticular pockets several feet wide and maximum lengths on the order of 50 to 110 feet (Rice, 1957). Tremolite/actinolite asbestos also occurs along serpentine contacts with other metamorphic rocks such as amphibolite, slate, and schist in the Sierra Nevada foothills and other parts of the state (Rice, 1957; Wiebelt and Smith, 1959; and reports of the State Mineralogist between 1900 and 1957).

A possible explanation for the association of tremolite/actinolite with serpentine contacts is given by Coleman (1971, p. 907) and Hietanen (1973, p. 27). They suggest that these minerals develop by calcium liberated from pyroxene minerals during ultramafic rock serpentinization combining with silicon and oxygen from wall rock. However, Coleman (2000, January, written communication) also points out that most unserpentinized peridotites in California do not contain enough calcium to produce tremolite/actinolite. Consequently, tremolite/actinolite in serpentine or partially-serpentinized ultramafic rocks should have a very limited distribution when compared to chrysotile. Tremolite/actinolite occurrences associated with serpentine, including occurrences of tremolite/actinolite asbestos, would be expected to be concentrated along boundaries and faults where calcium could be introduced during serpentinization. Occurrences of slip and oblique fiber tremolite/actinolite asbestos, associated with ultramafic rocks, are present in western El Dorado County (see Figure 6). A small amount of tremolite asbestos was commercially recovered between 1904 and 1906. Like the chrysotile occurrences, some of the tremolite/actinolite asbestos occurrences were sampled during the field work portion of this study and confirmed as tremolite/actinolite asbestos by X-ray diffraction (XRD), limited microscopic examination, and analysis by CARB (California Air Resources Board) Method 435. In western El Dorado County, tremolite/actinolite asbestos was observed in or along the sheared contacts of ultramafic rock serpentinite bodies, or along the contacts of igneous dikes that cut serpentinite bodies. These field observations document tremolite/actinolite asbestos in locations where calcium and silica would most likely be introduced into serpentinite (or partially serpentinized ultramafic rocks) and agree with Coleman’s statements on tremolite/actinolite distribution in serpentine as previously discussed.

Faults and Fault Zones—Asbestos Associations

Usually, serpentinite occurs near major faults or within fault zones (areas of highly fractured or crushed rock). Fault zones in the Sierra Nevada Foothills are seldom less than two hundred feet in width and may be several thousand feet wide or more. The width of a fault zone usually varies along its length.

Small Serpentinite Bodies

According to Clark (1964, p. 42) small sheets and slivers of serpentinite too small to show on geologic maps (some less than a foot thick) are widely distributed in shear zones in the Sierra Nevada foothills (in the Western Sierra Nevada Metamorphic Belt). These serpentinite sheets and slivers may have associated asbestos occurrences.
Tremolite/Actinolite Asbestos—Non-Serpentinite Associations

In addition to serpentinite, other rock types in California with documented occurrences of tremolite/actinolite asbestos are carbonates (limestone, dolomite and marble), metamorphic rocks such as schists containing the minerals hornblende or piemontite (hornblende schist, piemontite schist), and igneous rocks primarily composed of the mineral albite (albitite), (Wiebelt and Smith, 1959; Rice, 1957; Murdoch and Webb, 1966). However, the number of documented occurrences of tremolite/actinolite asbestos is much lower for these rock types than for serpentinite. The most favorable areas for asbestos occurrences within these non-serpentinite rock types are probably along faults or within fault zones that traverse them. One reason for this is that any chemical components needed for tremolite or actinolite development (calcium, magnesium, iron, or silica) could be supplied from aqueous fluid25 moving through fault zones. Carbonate associated tremolite/actinolite asbestos occurrences will be discussed in further detail below.

Areas Where the Presence of Asbestos is Possible But Unlikely—The Pine Hill Igneous Complex Altered Gabbro26

Springer (1971) designated areas of the Pine Hill Intrusive Complex gabbro where 10 percent or more of plagioclase was converted to epidote by hot watery solutions present when crystallization was nearly complete (deuteric alteration). During microscopic examination of thin sections of altered gabbro, he noted the presence of acicular27 tremolite/actinolite, typically in minor amounts between 0 and 3 modal percent, but occasionally up to 30 percent (Springer, 1999, written communication; and Springer, 1971). The term “acicular” means a needle-like crystal shape rather than fibrous (asbestiform) in shape. However, this previous work may not be sufficient to completely rule out the possibility of some of this tremolite/actinolite being fibrous (asbestos). Springer (1999, written communication) has stated that sometimes he has used the terms “acicular” and “fibrous” interchangeably. Such detail was inconsequential to his investigation of the Pine Hill Intrusive Complex (the investigation occurred 30 years ago, before natural occurrences of asbestos became an environmental issue). Also, the microscopic method employed, utilizing thin-sections,28 is not normally used for asbestos identification and it may be difficult to distinguish a small fibrous mineral occurrence from a small acicular crystal with this method in certain situations. Because of these uncertainties, the possibility that some of the altered gabbro tremolite/actinolite is fibrous (asbestos) instead of acicular cannot be completely ruled out at this time. Consequently, the altered gabbro within the Pine Hill intrusive is

---

25 aqueous fluid—Water dominated fluid that exists in and may move through fractures and pore spaces in rocks. Such fluids are capable of supplying or removing certain chemical components in rocks during metamorphic processes, particularly at higher temperatures.
26 gabbro—A dark colored plutonic (igneous) rock principally composed of the minerals plagioclase and clinopyroxene (augite), with or without olivine and orthopyroxene. The volcanic rock basalt is approximately equivalent in chemical composition to a gabbro.
27 acicular—The shape of an extremely slender crystal with small cross-sectional dimensions (a special case of the prismatic form). Acicular crystals may be blunt-ended or pointed. The term “needlelike” refers to an acicular crystal with pointed termination at one or both ends.
28 thin-section—A fragment of rock mechanically ground to 0.03 millimeters in thickness and mounted with epoxy onto a glass slide. Most rocks are transparent at this thickness and the optical properties of their minerals can be examined with a polarizing-light microscope and used for their identification.
considered to have a potential for asbestos slightly above areas in the map category “Areas that Probably do not Contain Asbestos,” and is shown on the El Dorado Map. Areas of altered gabbro are indicated by a brown stippled pattern but can only be approximately located on the map. The locations are approximate because the source map (Springer, 1971 p. 160) does not have reference locations needed to locate it precisely on the El Dorado 1:100,000 map base. The chance for exposure to asbestos from the disturbance of this material should be very much less than for the disturbance of serpentinite (Springer, 1999 written communication). Further study is needed to determine whether any of the tremolite/actinolite present in the altered gabbro is asbestos.

Any future work undertaken to further resolve the issue of the presence or absence of tremolite/actinolite asbestos in Pine Hill Intrusive Complex altered gabbro will have to be done with care. U.S. Bureau of Mines research on the shapes of fragments generated by crushing asbestos and non-asbestiform forms of tremolite has shown that there will often be overlap in length-width ratios\(^29\) of the resulting asbestos and non-asbestos fragments (Campbell and others, 1979). What this means with regard to the altered gabbro is that, upon crushing, it is possible that some of the acicular fragments could be broken into length-width ratios such that they could be counted as asbestos by standard analytical methods even if it contains only acicular tremolite/actinolite. Careful work will be needed to assure that tremolite/actinolite cleavage fragments\(^30\) (non-asbestos) are being distinguished from fibers (asbestos) in this case.

**Carbonate Rocks that May Contain Asbestos—Contact Metamorphic Carbonate Rocks**

The possibility of carbonate rocks asbestos in El Dorado County has been raised at several public meetings during the last year. There are documented occurrences of chrysotile asbestos in altered dolomitic rocks and tremolite asbestos in altered limestone, dolomite and marble elsewhere in California. These asbestos occurrences are associated with zones of contact metamorphism where intrusive igneous rocks invade carbonate rocks. Examples of these types of asbestos occurrences are found in Inyo and Riverside counties (Rice, 1957, p. 54; Murdoch and Webb, 1966, p. 68). With regard to DMG historical literature, the only reference found for an occurrence of amphibole asbestos associated with carbonate rocks in the Sierra Nevada foothills is for Tuolumne County. That reference states that white fibrous tremolite occurs in marble near Columbia (Eakle, 1922, p. 167), the exact location was not given.

Two small areas of contact metamorphosed carbonate with asbestos potential have been identified in El Dorado County from the scientific literature. The locations of these areas are shown with symbols on the map for El Dorado County. The first was identified by Springer

---

\(^{29}\) **length-width ratio**—For elongated crystals, ratio equaling the length of the crystal divided by its width. This ratio is sometimes called the aspect ratio. Asbestos fibers usually have large to very large length to width ratios, often much larger than five to one. Cleavage fragments usually have small length to width ratios, typically less than five to one.

\(^{30}\) **cleavage fragment**—A fragment produced by the breaking of crystals in directions that are related to the planes of weakness in the crystal structure. Minerals with perfect cleavage can produce perfect regular fragments. Amphiboles with prismatic cleavage will produce prismatic fragments. These fragments may be elongated and, on superficial observation, some may resemble fibers. However, because they did not grow as fibers, they cannot have the characteristics of fibers and cannot be called fibers.
(1971) and is located just north of the south fork of the American River near the northeast contact of the Pine Hill intrusion. He found these metamorphosed carbonate rocks to contain “very acicular” tremolite. This occurrence is within a few tens to several hundred meters from the Pine Hill intrusive contact. The second area involves carbonate rocks near the Cosumnes Copper mine, a skarn type deposit, in which an asbestos occurrence was reported by Crowley (1974). At this mineral deposit, an actinolite zone in the skarn is reported to be present with the actinolite crystals, acicular to prismatic in habit (not asbestos), and up to several centimeters long. One occurrence of fibrous actinolite (asbestos) was found in underground workings of this deposit (Crowley, 1974, p. 15). Additional study to evaluate the habit and extent of tremolite and actinolite in both these areas is needed.

The remaining limestone deposits in western El Dorado County are not included on the 1:100,000-scale western El Dorado County asbestos map because there has been no documentation of asbestos minerals present in these deposits. Springer (1999, written communication) indicates that other carbonate rocks located just east of Flagstaff Hill and southwest of the Pine Hill intrusive are very pure calcite marbles without acicular tremolite present. Information on the composition of a number of El Dorado County limestone deposits from published and unpublished DMG reports shows them to be high-purity limestone in most cases, often with less than 0.5 weight percent silica.

Areas that Probably Do Not Contain Asbestos—Geologic Settings Where Asbestos is Unlikely to Occur

The geology of some areas in western El Dorado is such that they are unlikely to have natural occurrences of asbestos. These areas have little or no serpentinite, ultramafic rocks or related soils. Metamorphic rocks away from fault zones, non-metamorphic rocks, and granitic intrusive rocks usually have little or no potential for asbestos occurrences. Data from historic and recent observations do not indicate that asbestos is present in carbonate rocks in El Dorado County, except for the small isolated occurrences in contact metamorphic settings as previously described.

MAP COMPILATION PROJECT OVERVIEW

Goals

This project had two goals. First, to produce a 1:100,000-scale comprehensive map of areas where geologic conditions are favorable for occurrences of asbestos, either the chrysotile or tremolite/actinolite varieties, in El Dorado County. The second goal was to evaluate the

31 skarn (deposit)—A mining term referring to rocks where metamorphic processes have caused silicate minerals such as amphiboles, pyroxene, and garnet to replace limestone and dolomite.

32 intrusive rocks—Igneous rocks formed by the solidification of magma that has moved into pre-existing rock.
usefulness of different data types and the individual project activities to see which were most helpful.

**Development of the Map of Areas More Likely to Contain Natural Asbestos**

This map was prepared using digital geographic information system (GIS) computer mapping methods. For reasons discussed in the geology section of this report, areas shown on this map that may contain natural occurrences of asbestos are primarily the areas of ultramafic rocks. The location and extent of these ultramafic rock areas were compiled from existing geology and soil maps (see Map References section). Areas which are less favorable for asbestos and more restricted in occurrence, altered gabbroic rocks within the Pine Hill intrusion and several contact metamorphic carbonate deposits, are also indicated on the map.

Initially, two separate GIS map layers were prepared; one derived from geologic maps and one from the county soil map (Rogers, 1974). The geologic map layer was compiled by digitizing ultramafic rock areas from the original geologic maps. For areas of the county with multiple map coverage, the geologic map at the most detailed scale was usually selected as best representative of the geology. Limited field work conducted during this project, and edge-matching requirements between the different geologic maps resulted in modifications in the locations and boundaries of some of the areas compared to the original source maps. The soil map layer was prepared by digitizing occurrences of two ultramafic rock related units from numerous maps within the Soil Conservation Service soil report for El Dorado County (Rogers, 1974). The ultramafic rock related soil map units are Serpentine Rock Land (SaF) and Delpiedra (DeE) Series soils. Serpentine Rock Land is in areas of highly resistant serpentine and other ultramafic rock formations. Rock outcrops make up from 50 to 90 percent of the surface and there is a thin mantle of soil. The Delpiedra Series soil consists of somewhat excessively drained soils that are underlain by hard serpentine rock at a depth of 10 to 24 inches.

After completion of the geology and soil GIS layers, these layers were combined to develop a new derivative GIS layer of ultramafic rock areas. Ultramafic rock areas on the geologic layer generally correspond with the ultramafic rock related soil areas from the Soil Conservation Service soil map when these map layers are overlain. However, slight to moderate differences in ultramafic rock area boundaries were encountered when comparing corresponding ultramafic areas of the geology layer and the soil layer. This was expected because of the different techniques utilized in geologic mapping and soil mapping. For such areas, there will be areas of overlap or areas of only ultramafic related soil or ultramafic rock. For the final derivative ultramafic rock GIS layer, the boundary of composite areas was taken as the outermost soil or geologic boundary, unless information was available to indicate an interior boundary was better.

---

33 **GIS map layer**—A set of digital data (a digital file) related to a particular GIS map feature such as rocks, soils, roads, water features, property boundaries, etc. that extend over the geographic area of the map.

34 **digitizing**—The process of creating a digital GIS file of the locations of geographic features by using special equipment to convert their positions on a map into a series of x,y Cartesian coordinates that can be stored in computer files.
Thus, the resulting boundary for overlapping geologic and soil ultramafic areas is either a combination of soil area and rock area boundaries, wholly soil if a geologic area is completely encompassed by a soil area, or wholly geologic if a soil area is completely encompassed by a geologic area. Ultramafic rock areas without a corresponding soil layer area, and soil areas without a corresponding ultramafic rock area, are shown as ultramafic rock areas on the derivative map.

In addition to the ultramafic rock GIS layer, GIS layers were prepared for two other geologic settings where asbestos may occur. The first of these is for areas of altered gabbro within the Pine Hill Intrusion, as defined by Springer (1971). These areas can only be approximately located because the source map in Springer’s dissertation does not have reference points for map registration (accurately located with respect to the base map used in this project). The second is for contact metamorphosed carbonate rocks. Preparation of this layer involved digitizing contact metamorphic carbonate rock occurrence with acicular tremolite/actinolite related to the emplacement of the Pine Hill Intrusion (Springer, 1971). Also, carbonate rocks in the immediate area of the Cosumnes Copper Mine site, a copper skarn deposit, are included on the El Dorado County map because of an asbestos occurrence noted there by Crowley (1974).

An additional step in the mapping process was to prepare a GIS layer for the major faults by digitizing these faults from the geologic maps.

The final step in map preparation involved overlaying the ultramafic rock derivative map layer, the altered gabbro and contact metamorphosed carbonate layers, and the fault layer on the 1:100,000 base map for El Dorado County. At this point an index and explanatory text were developed and added to finalize the map.

**Field Work**

Twenty-one person days of field work were completed over the duration of this project, mostly from September through December. Field work goals were to:

1. Confirm the locations of ultramafic rock mapped areas and to refine the boundaries of these areas where possible;

2. Evaluate the accuracy of boundaries for ultramafic rock areas; and

3. Resolve discrepancies between the locations of geologic map related ultramafic rock areas and soil map related ultramafic rock areas.

Some field time was also spent examining carbonate rocks for asbestos occurrences. A limited number of rock and asbestos samples were collected during the field work portion of this study for X-ray diffraction analysis to document asbestos types (chrysotile or tremolite/actinolite) and for asbestos percentage determinations by the California Air Resources Board Method 435.

In general, field work was hampered by access problems related to private property and the numerous private roads and gated communities in much of western El Dorado County. In spite of access limitations, work along public roads proved useful in allowing confirmation of many of
Areas more likely to contain natural occurrences of asbestos in Western El Dorado County, California

the previously mapped ultramafic rock areas in western El Dorado County, removal of a previously mapped ultramafic rock area, and refinement of the boundaries of several others.

Air Photos and Satellite Imagery

Because serpentinized ultramafic rocks tend to have distinctive associated vegetation, it was felt that examination of air photos and Landsat imagery would be useful in this mapping project. Black and white and infrared air photos were obtained and utilized during field work. They were particularly useful for locating roads postdating the 7.5-minute topographic quadrangle maps and were an aid for confirming some ultramafic area boundaries.

Landsat imagery was obtained for El Dorado County, but the necessary software for evaluating these data was not available until late in the study. This prevented interactive use of this imagery during compilation of the various GIS layers and during field work. However, a preliminary evaluation of the usefulness and limitations of the Landsat imagery for ultramafic rock mapping in the Sierra Nevada was completed and the results of this work are provided in Appendix A.

Base Map Information

The map base for this project was compiled from U.S. Geological Survey 1:100,000 Digital Line Graph (DLG) data for roads and water features. Additional data on roads completed after the DLG data were compiled were provided by the El Dorado County Surveyor’s Office. National Forest boundary locations, Bureau of Land Management land boundaries, and other federal and state land boundaries were obtained from the Bureau of Land Management. DOC GIS staff labeled map features such as roads, water features, and landmarks. The map base projection is Albers Equal Area. The scale of the finalized base map is 1:100,000 (or 1-inch equals 1.578 miles). This scale was chosen because the DLG data are readily available at 1:100,000-scale from the U.S. Geological Survey and because city-block size features are resolved at this scale.

MAP CHARACTERISTICS

Map Accuracy

The accuracy of a geologic (rock type) boundary on a geologic map is dependent upon a number of factors. Some of these factors directly related to geology are:

1. The amount of geologic boundary, or contact, exposed for observation.

---

35 DLG—Digital Line Graph files from the U.S. Geological survey. These files include digital information from the U.S. Geological Survey map base categories, such as transportation, hydrography, contours, and public land survey boundaries.

36 Map projection—A mathematical model that transforms the locations of features on the surface of the earth to locations on a two-dimensional surface (map). Some map projections preserve the integrity of shape; others preserve accuracy of area, distance, or direction.
2. The extent of rock outcrops in the area and the distances between them.

3. The regularity and consistency in the occurrence of geologic units within an area.

4. Whether the geologic unit is sufficiently consistent in appearance to be properly identified throughout the map area.

5. Whether the unit is homogeneous or is intimately associated with occurrences of other rock types that cannot be readily separated at the scale of mapping.

6. Whether an occurrence of the geologic unit is sufficient in size to show at the scale of mapping.

The accuracy of the base map upon which geologic boundaries are plotted is another factor, particularly for older geologic maps. Geologic units from maps using an obsolete base often cannot be precisely registered onto a modern base map. Mapping style of the geologist can also affect map accuracy. Because geologic mapping is an art as well as a science, mapping styles of individual geologists will vary depending upon the skill and experience of the individual. Some styles may work better in one area but not another. With the large number of geologic maps utilized in the compilation of the El Dorado County asbestos map, the accuracy of boundaries of areas with asbestos potential are probably influenced by all of the above factors.

Observation of differences in the location of a given geologic boundary on different geologic maps can provide some insight into map boundary accuracy. Typically, the mapped boundaries for ultramafic rock areas in western El Dorado County from the different geologic maps are located within 0 to 500 feet of each other. The worst case, in an area of poor exposure, had differences in contact locations of 300 to 1500 feet. Comparison of ultramafic rock area boundaries from geology maps with corresponding soil map boundaries typically show unit boundary differences of 0 to 2,000 feet. The greatest differences were observed within the Latrobe 7.5-minute Quadrangle where geology and soil boundaries for ultramafic areas differed by up to 3,500 feet in two locations. The discrepancy in the Latrobe 7.5-minute Quadrangle may be the result of the soil being associated with gabbro rather than ultramafic rock.

Field work revealed that, in many instances, soil cover obscures ultramafic rock contacts. Consequently, contact locations must be interpolated between available outcrops of ultramafic and non-ultramafic rocks. Limited field observations suggest uncertainties in contacts of hundreds of feet are common in these situations in El Dorado County.

The approach taken to minimize uncertainty in locations of areas mapped as having asbestos potential was to utilize the most detailed mapping available for each portion of the study area. Field checking was done where public access was possible. The author believes that the accuracy of the boundaries for areas with asbestos potential are generally better than plus or minus 1000 feet (0.1 inches on the map equals 833 feet on the ground).

Finally, possibilities exist for the presence of unmapped (previously undiscovered) ultramafic rock areas and for areas currently mapped as ultramafic rock to be misidentified. The chance of
 AREAS MORE LIKELY TO CONTAIN NATURAL OCCURRENCES OF ASBESTOS IN WESTERN EL DORADO COUNTY, CALIFORNIA

these situations generally decreases with increasing size of the occurrence, but cannot be entirely eliminated.

Continuing excavation activities in western El Dorado County will undoubtedly lead to the identification of additional ultramafic rock occurrences with potential for asbestos occurrences and opportunities to refine the location of currently mapped boundaries. The accuracy of this map should be periodically reviewed and revised as necessary as new geologic information becomes available for western El Dorado County.

Map Use and Limitations

This map indicates areas and major faults within western El Dorado County where geologic conditions are favorable for natural occurrences of either chrysotile or tremolite/actinolite asbestos. It is based on a compilation of geologic and soil data from various published and unpublished sources and limited geologic field work by DOC staff. The purpose of this map is to provide information to local, state and federal agencies and the public as to where natural occurrences of asbestos are more likely to be found in El Dorado County. It does not indicate whether asbestos minerals are present or absent in bedrock or soil associated with a particular parcel of land. The determination of the likelihood of asbestos presence or absence for a parcel can only be made during a detailed site-specific examination of the property. Consequently, no representations or warranties as to the actual presence or absence of natural occurrences of asbestos at specific locations within the area covered by this map can be made. Further, no representations or warranties regarding the accuracy of the data from which these maps were derived are made.

Use of the Map by Local Government Agencies

This map is intended to aid cities, counties, special districts, and state agencies in determining where they may wish to consider actions that may help minimize generation of and exposure to asbestos dust. Because of the uncertainties in the map, it should not be used as an inflexible tool for prescribing pre-selected mitigation measures. Rather it is intended to be used as a tool for determining where it may be appropriate to require site-specific investigations prior to the issuance of grading and development permits to aid in the selection of appropriate, cost-effective mitigation measures. The report and map also contain an index to published and unpublished geologic maps at more detailed scales that agencies and geoscientists may wish to consult when investigating particular areas.

County officials or residents might wish to consider forming a Geologic Hazard Abatement District (GHAD) to fund testing and mitigation actions that would benefit the community as a whole. GHAD’s are special districts created under Public Resources Code Sections 26500-26554 (Appendix B) to address prevention, mitigation, abatement or control of geologic hazards.37 Such

---

37 The Beverly Act of 1979 (Appendix 2) which authorizes creation of such districts broadly defines “geologic hazard” as “an actual threatened landslide, land subsidence, soil erosion, earthquake or other natural or unnatural movement of land or earth.” Given that the source of the asbestos is the natural rock and soil and that it becomes airborne (a “movement” action) by natural
a district would allow the community to set mitigation priorities and jointly finance or cost-share actions that may benefit neighbors as well as the immediate owner of the property on which asbestos is found. Several GHAD’s have been successfully created to address landslide hazards and maintenance of landslide-prevention systems (Olshansky, 1986).

Map uncertainties in ultramafic rock boundary locations and fault zone widths may be addressed in one or more ways. The most conservative approach might be to apply whatever investigation requirements are adopted to a specified buffer zone around ultramafic rock areas of some width (1,000 feet for example). Such an approach will increase the odds of finding small or poorly exposed ultramafic rock occurrences where mitigation might prove beneficial. A less conservative approach would be to use the ultramafic rock mapped boundaries as is without the addition of buffer zones. Similar approaches could be used to address fault zone uncertainties.

A final point is that geologic maps often require modifications of rock unit boundaries and fault locations as new information becomes available. Regulations involving geologic maps related to asbestos issues should allow for such modifications so that decisions will always be made based upon the most accurate geologic map available at the time.

ACKNOWLEDGMENTS

The following staff greatly assisted the author with geologic discussions, information research, references, and assistance with field work: Trinda Bedrossian, Larry Busch, Mike Fuller, John Clinkenbeard, Dave Wagner, Susan Kohler-Antablin, Ted Smith and Rinda Holt. Les Youngs, Joy Arthur, Ross Martin, Milton Fonseca, Kim Larose and Robert Sinclair worked on the various GIS aspects of this project. From outside of the Department, John Rogers provided information on the preparation of the El Dorado County soil report. Dr. Robert Springer kindly provided additional information related to the tremolite and actinolite associations with the Pine Hill intrusion and associated contact zone rocks.

The following individuals served as volunteer members on a technical review committee for this map and report: Dr. Roger Ashley, U.S. Geological Survey; Dr. Robert Coleman, Professor Emeritus-Stanford, Dr. Howard Day, U.C. Davis Geology Department; Mr. Bruce Hilton, Kleinfelder, Inc.; Dr. Terence Kato, C.S.U. Chico Geoscience Department, Mr. Lester Lubetkin, El Dorado National Forest; Mr. Wessly A. Reeder, County of San Bernardino; Mr. John Rogers, retired--Soil Conservation Service; Mr. David Seiderquist, Youngdahl and Associates (representing El Dorado County), and Ms. Julia Turney, Caltrans Environmental Program. The authors and the Department of Conservation greatly appreciate of the efforts of these individuals in reviewing and suggesting improvements to the El Dorado map and report. Discussions with

(wind) and unnatural (man-caused dust-generating activities), it probably qualifies as a potential GHAD. However, the county may wish the Legislature to explicitly add asbestos and other hazardous minerals to the Act remove thereby removing any uncertainty. Similarly, the Legislature could be requested to clarify whether GHADs may also address hazards associated with asbestos-laden gravel used for road surfacing.
Dr. David Jones, Professor Emeritus-U.C Berkeley, provided the principal author with helpful insights into the geologic terranes and tectonic history of western El Dorado County.

GLOSSARY OF TERMS

The following sources were consulted during the development of the definitions provided below: Bates and Jackson, 1987; Campbell and others, 1979; Deer, Howie and Zussman, 1966; ESRI, Inc., 1990; Hyndman, 1972; and Rice, 1957.

**accessory (mineral)**—A mineral present in a rock, usually in minor amounts, that is not essential for the proper classification (naming) of the rock.

**acicular**—The shape of an extremely slender crystal with small cross-sectional dimensions (a special case of the prismatic form). Acicular crystals may be blunt-ended or pointed. The term “needlelike” refers to an acicular crystal with pointed termination at one or both ends.

**actinolite**—A common rock-forming mineral of the amphibole mineral group that commonly occurs in prismatic or acicular form and less commonly in fibrous (asbestos) form. Actinolite is similar to tremolite, but contains iron in place of some of the magnesium in the composition \((\text{Ca}_2\text{(Mg,Fe}^{2+}_5\text{))[Si}_8\text{O}_{22}](\text{OH})_2)\). Actinolite asbestos is green, with fibers that are weak and somewhat brittle. It is similar to tremolite in occurrence and has always been of little commercial significance.

**albitite**—An igneous rock with phenocrysts (large crystals) of the mineral albite surrounded by small crystals of albite (a porphyritic igneous rock). Muscovite, garnet, apatite, quartz and oxides are common accessory minerals.

**amphibole asbestos**—The asbestiform varieties of the following amphibole minerals—tremolite-actinolite, riebeckite (crocidolite), cummingtonite-grunerite (amosite), and anthophyllite are collectively referred to as amphibole asbestos.

**amphibolite**—A metamorphic rock composed chiefly of an amphibole mineral, most often hornblende.

**antigorite**—A brown to green colored serpentine mineral.

**aqueous fluid**—Water dominated fluid that exists in and may move through fractures and pore spaces in rocks. Such fluids are capable of supplying or removing certain chemical components in rocks during metamorphic processes, particularly at higher temperatures.

**asbestos**—A mineralogical term referring to the fibrous crystal form (asbestiform) of the silicate minerals chrysotile, tremolite, actinolite crocidolite, anthophyllite, and amosite (cummingtonite-grunerite). The most common type of asbestos found in California is chrysotile, a serpentine mineral. The other types are amphibole minerals. The term also refers to an industrial product obtained by mining and processing deposits of the asbestiform minerals listed above. The
quality of asbestos depends upon: (1) the mineralogy of the asbestiform variety; (2) the degree of asbestiform development of the fibers; (3) the ratio of asbestiform fibers to acicular crystals or other impurities; and (4) length and flexibility of the fibers.

asbestiform—A specific type of mineral fiber that occurs in bundles and possesses high tensile strength and flexibility. “Asbestiform” and “asbestos” are essentially synonymous in current usage. The length to width ratio for asbestos fibers is typically large, usually greater than five to one.

brucite—A mineral with the chemical composition of magnesium hydroxide.

carbonate minerals—A group of minerals with the dominant structure related to the carbonate ion, \( \text{CO}_3^{2-} \). This group of minerals includes calcite (CaCO\(_3\)) and dolomite ((Ca,Mg)CO\(_3\)).

carcinogen—Any substance that tends to produce cancer.

chlorite—One of a group of minerals with a layered structure, which somewhat resemble micas. They are magnesium-iron-aluminum hydrous silicates in composition and are most often green to brown in color. There principal occurrences are in lower temperature metamorphic rocks, in hydrothermally altered (metamorphosed by reactions with hot water) igneous rocks, and in clay-rich sediments.

chrysotile—A white, gray, or greenish mineral of the serpentine group, magnesium silicate hydroxide in composition. It is a highly fibrous, silky variety of serpentine. Commercially it is the most important type of asbestos.

cleavage fragment—A fragment produced by the breaking of crystals in directions that are related to the planes of weakness in the crystal structure. Minerals with perfect cleavage can produce perfect regular fragments. Amphiboles with prismatic cleavage will produce prismatic fragments. These fragments may be elongated and, on superficial observation, some may resemble fibers. However, because they did not grow as fibers, they cannot have the characteristics of fibers and cannot be called fibers. Minerals do not always break into the same shapes as their growth habits (for example calcite).

clinopyroxene—Any of a group of monoclinic calcium-rich silicate minerals of the pyroxene group, such as diopside, hedenbergite, clinoenstatite, clinohypersthene, clinoferrosilite, augite acmite, pigeonite, spodumene, jadeite and omphacite.

contact—The boundary between two types or ages of rock.

contact metamorphism—A local process of thermal metamorphism taking place in rocks at or near their contact with a body of igneous rock at the time the igneous rock was emplaced.

cross-fiber (asbestos)—Occurrences of asbestos in veins where the long direction of the fibers is oriented perpendicular to the vein walls.
country rock—The rock enclosing or hosting a mineral deposit, mineral occurrence or an igneous intrusion.

deuteric alteration—After crystallization of a silicate melt (magma) is complete, sometimes hot corrosive watery solutions remain in the resulting igneous rock. These solutions account for what is called deuteric (late magmatic) alteration of many igneous rocks. Some of the changes caused by the magmas own late-stage solutions may include the alteration of the mineral biotite to chlorite and less commonly amphiboles and pyroxenes to chlorite or actinolite.

DLG—Digital Line Graph files from the U.S. Geological Survey. These files include digital information from the U. S. Geological Survey map base categories, such as transportation, hydrography, contours, and public land survey boundaries.

digitizing—The process of creating a digital GIS file of the locations of geographic features by using special equipment to convert their positions on a map into a series of x,y Cartesian coordinates that can be stored in computer files.

dolomite—A common rock-forming mineral composed of calcium, magnesium and carbonate ion. The name is also used for a carbonate sedimentary rock of which more than 50 percent by weight or by areal percentages under the microscope consists of the mineral dolomite. The term also may be used to refer to a variety of limestone or marble rich in magnesium carbonate.

dunite—A plutonic igneous rock composed almost entirely of the mineral olivine.

default—A fracture or a zone of fractures along which there has been displacement, parallel to the fracture, of the rocks on one side relative to the other.

fault zone—A fault that is expressed as a zone of numerous small fractures.

fibrous—The occurrence of a mineral in bundles of fibers, resembling organic fibers in texture, from which the fibers can usually be separated (for example, chrysotile asbestos). Fibrous is a more general term used to describe all kinds of minerals that crystallized in habits resembling organic fibers, including asbestos minerals. The term “fiber” is not limited to asbestos. However, it is distinct from the term “acycular” because it requires the resemblance to organic fibers. Until recently, the term “asbestiform” was never used for fibrous mineral habits other than asbestos.

foliated—A term for a planar arrangement of textural or structural features in any rock type; especially the planar structure that results from flattening of the constituent grains of a metamorphic rock.

gabbro—A dark colored intrusive igneous rock principally composed of calcium magnesium iron silicate minerals (clinopyroxene, with or without orthopyroxene and olivine). The extrusive igneous (volcanic) rock basalt is approximately equivalent in chemical composition to gabbro.

GIS—Geographical Information System—An organized collection of computer hardware, software, geographic data, and personnel designed to efficiently capture, store, update,
manipulate, analyze, and display all forms of geographically referenced information (maps). Certain complex spatial operations are possible with a GIS that would be very difficult, time consuming, or impracticable otherwise.

**GIS map layer**—A set of digital data (a digital file) related to a particular GIS map feature such as rocks, soils, roads, water features, property boundaries, etc. that extend over the geographic area of the map.

**granitic**—A general term applied to any light-colored coarse-grained intrusive igneous rock containing quartz, feldspar and mafic (dark colored iron-magnesium) minerals.

**hornblende schist**—A schist (metamorphic rock) with the mineral hornblende as a principal component.

**igneous dike**—A tabular igneous intrusion that cuts across the bedding or foliation of the country rock (host rock).

**igneous rocks**—Rocks that formed by the solidification of molten or partly molten material (magma).

**intrusive rocks**—Igneous rocks formed by the solidification of magma that has moved into pre-existing rock.

**intrusive complex**—An assemblage of intimately associated and roughly contemporaneous plutonic igneous rocks.

**Landsat imagery**—Multi-spectral images of the surface of the earth taken by unmanned earth-orbiting satellites.

**length-width ratio**—For elongated crystals, ratio equating the length of the crystal divided by its width. This ratio is sometimes called the aspect ratio. Asbestos fibers usually have large to very large length to width ratios, often much larger than three to one. Cleavage fragments usually have small length to width ratios, typically less than three to one.

**limestone**—A bedded sedimentary rock composed chiefly of calcium carbonate (the mineral calcite).

**lung cancer**—Lung cancer is a relatively common form of cancer that has been linked to smoking and a variety of occupational exposures. Cigarette smoking significantly increases the risk of lung cancer for those people exposed to asbestos.

**lizardite**—The most abundant serpentine group mineral. Lizardite occurs mostly in extremely fine-grained aggregates. Massive green serpentinite often contains both lizardite and chrysotile.

**magnetite**—A black highly magnetic opaque mineral of the spinel group largely composed of iron oxide. It is frequently a minor accessory mineral in igneous rocks.
map projection—A mathematical model that transforms the locations of features on the surface of the earth to locations on a two-dimensional surface (map). Some map projections preserve the integrity of shape; others preserve accuracy of area, distance, or direction.

marble—A metamorphic rock consisting predominantly of fine- to coarse-grained recrystallized calcite and/or dolomite.

Mesothelioma—Mesothelioma is a rare cancer of the thin membranes lining the lungs, chest, and abdominal cavity. Almost all cases of mesothelioma are linked to prior occupational asbestos exposure.

metamorphic rock—Any rock derived from a pre-existing rock by mineralogical, chemical, and/or structural changes in response to heat, pressure, shearing stress, and chemical environment, generally at depth in the crust of the earth.

oblique-fiber (asbestos)—Asbestos occurrences where the orientation of the long axis of the fibers is at an angle to the vein walls.

olivine—A magnesium-iron silicate mineral or group of minerals, common in many igneous rocks that tend to crystallize at higher temperatures, such as ultramafic rocks. Olivine is also found in some metamorphic rocks and volcanic rocks.

orthopyroxene—One of several magnesium-iron silicate minerals of the pyroxene group, common in many igneous rocks that crystallize at relatively high temperatures. For example, these minerals are common constituents of some ultramafic rocks. These minerals may also occur in some metamorphic rocks.

peridotite—A coarse-grained plutonic igneous rock chiefly composed of olivine with or without other mafic (dark colored, magnesium-iron) minerals such as pyroxenes, amphiboles, or micas, and containing little or no feldspar. Peridotite is commonly altered to serpentinite.

piemontite schist—A schistose metamorphic rock containing the mineral piemontite as a significant component. Piemontite is a dark-red or reddish-brown manganese-bearing mineral of the epidote group.

plutonic rock—Igneous rocks that form at great depths below the surface of the earth.

pyroxene—A group of dark colored rock-forming silicate minerals commonly containing magnesium, iron and calcium, with or without manganese, aluminum, or chromium. They tend to crystallize as short prismatic shaped crystals. Pyroxene minerals are common constituents of igneous rocks. Because of differences in crystal structure and related properties among the pyroxene minerals, they are often subdivided into two groups, orthopyroxene and clinopyroxene.

quartz—A common rock-forming mineral composed of crystalline silica (silicon dioxide—SiO₂), widely distributed in igneous, metamorphic and sedimentary rocks.
**schist**—A strongly foliated crystalline rock, formed by dynamic metamorphism, that can be readily split into thin flakes or slabs. This splitting characteristic is due to well-developed parallelism of more than 50 percent of the minerals present in the schist, particularly minerals with platy or elongate prismatic habits, such as mica or amphibole minerals.

**sedimentary rock**—A water deposited rock formed by the consolidation and compaction of loose sediment or by chemical precipitation.

**serpentine**—A group of common rock-forming minerals composed primarily of magnesium, silica and hydroxyl ions. Serpentines have a greasy or silky luster, a slightly soapy feel, and a conchoidal fracture (a fracture producing a smooth curved surface). They are usually compact but may be granular or fibrous, and are commonly green, greenish yellow, or greenish gray and often veined or spotted with green and white. Serpentines are always secondary minerals, derived by alteration (metamorphism) of magnesium-rich silicate minerals. The most common serpentine minerals are lizardite, chrysotile, and antigorite. These minerals all have approximately the composition Mg$_3$[Si$_2$O$_5$](OH)$_4$.

**serpentinite**—A rock consisting mainly of serpentine-group minerals, often formed by the metamorphism of magnesium rich intrusive igneous rocks such as peridotite or dunite.

**serpentinization (process)**—The process of hydrothermal alteration (metamorphism) by which magnesium-rich silicate minerals such as olivine, pyroxenes, and/or amphiboles in ultramafic rocks are converted into or replaced by serpentine minerals.

**shear zone**—A zone of rock that has been crushed and brecciated by many parallel fractures due to shear strain.

**silica**—The chemical compound silicon dioxide. Silica occurs naturally as five crystalline minerals, the most common of which is quartz. It also occurs in poorly crystalline or amorphous forms such as chalcedony, chert, flint and opal. Silica is an essential component of many other minerals such as olivine, pyroxene, amphibole, mica, clay, and feldspar.

**skarn (deposit)**—A mining term referring to rocks where metamorphic processes have caused silicate minerals such as amphiboles, pyroxene, and garnet to replace limestone and dolomite (carbonate rocks).

**slate**—A compact, fine-grained metamorphic rock that possesses slaty cleavage, meaning that it can be split into thin plates.

**slip-fiber (asbestos)**—Asbestos occurrences where the orientation of the long axis of the fibers is parallel to the vein walls.

**talc-chlorite schist**—A metamorphic rock (schist) composed primarily of the minerals talc and chlorite.

**thin-section**—A fragment of rock mechanically ground to 0.03 millimeters in thickness and mounted with epoxy onto a glass slide. Most rocks are transparent at this thickness and the
optical properties of their minerals can be examined with a polarizing-light microscope and used for their identification.

**tremolite**—A white to dark-gray mineral of the amphibole group, principally composed of calcium, magnesium, silica, and hydroxide (Ca$_2$Mg$_3$Si$_8$O$_{22}$(OH)$_2$). It contains varying amounts of iron and may contain manganese and chromium. Tremolite occurs in long blade-shaped or short stout prismatic crystals and in columnar, fibrous (asbestos) or granular masses or compact aggregates, generally in metamorphic rocks such as dolomitic marble and talc schists. Tremolite asbestos is the most common variety of amphibole asbestos. Tremolite asbestos occurs most commonly as slip fiber veins in fault zones. It is found in a variety of host rocks, both igneous and metamorphic, although most of the commercial deposits have been in serpentinite. Historically in California, a commercial deposit consisted of a single steeply dipping vein, typically a few inches wide and less than 100 feet long. Some veins contained pockets up to several feet in width.

**tremolite/actinolite**—Tremolite and actinolite are closely related amphibole minerals and this term is used to jointly refer to them or in situations where it is uncertain which one is present.

**ultramafic rock**—an igneous rock composed chiefly of mafic (dark colored iron-magnesium) minerals such as olivine, augite, or hypersthene. Dunite, peridotite and pyroxenite are examples of ultramafic rock types. Asbestos minerals may form in ultramafic rock when it undergoes metamorphism.

**vein**—The mineral filling in a fracture or fault in a host rock.

**volcanic rock**—A fine-grained rock that formed by the crystallization of magma at or near the surface of the earth (an extrusive igneous rock).

**X-ray diffraction**—A mineral identification method that uses characteristic interference patterns of X-rays. These patterns are obtained when pulverized mineral samples are exposed to X-rays and relate to the three dimensional arrangement of atoms in minerals.

**REFERENCES**


MAP REFERENCES

Anonymous, Undated, Geology Map no. 56 B-4, Garden Valley, California 7.5-minute quadrangle: unpublished geologic map for El Dorado National Forest, plotted at 1:48,000-scale.

Anonymous, Undated, Geology Map no. 56 B-4, Georgetown, California 7.5-minute quadrangle: unpublished geologic map for El Dorado National Forest, plotted at 1:48,000-scale.


Coyle, J., 1993, Map of Bedrock Geology, Slate Mountain, California 7.5 minute quadrangle: unpublished map for El Dorado National Forest, scale 1:24,000.


Nash, J.T., 1988, Geology and Geochemistry of Gold Deposits of the Big Canyon Area, El Dorado County, California: U.S. Geological Survey Bulletin 1854, 40 p., Figure 2.


Springer, R.K., 1971, Geology of the Pine Hill intrusive complex, El Dorado County, California: University of California, Davis, unpublished Ph.D. dissertation, 362 p., Plate 1, scale 1:24,000, and Figure 2.


Wagner, D.L., Jennings, C.W., Bedrossian, T.L., and Bortugno, E.J., 1981, California Division of Mines and Geology, Regional Geologic Map Series, Sacramento Quadrangle, California: Map 1A (Geology), scale 1:250,000.


APPENDIX B.

GEOLOGIC HAZARD ABATEMENT DISTRICTS
(PUBLIC RESOURCES CODE SEC. 26500-26554)

Chapter 1. Definitions

26500. Unless the context otherwise requires, the definitions set forth in this chapter govern the construction of this division.

26501. "Board of directors" means the governing body of the district.

26502. "Bonds" means bonds, notes, or other evidence of indebtedness issued by a district pursuant to this division.

26503. "Local agency" means a city, a city and county, or a county.

26504. "Clerk", where not otherwise modified, means the clerk of the district.

26505. "Improvement" means any activity that is necessary or incidental to the prevention, mitigation, abatement, or control of a geologic hazard, including, but not limited to, all of the following:

(a) Acquisition of property or any interest therein.

(b) Construction.

(c) Maintenance, repair, or operation of any improvement.

(d) Preparation of geologic reports required pursuant to Section 2623 for multiple projects within an earthquake fault zone or zones.

(e) Issuance and servicing of bonds, notes, or debentures issued to finance the costs of the improvements specified in subdivisions (a), (b), (c), and (d).

26506. "District" means a geologic hazard abatement district created pursuant to this division.

26507. "Geologic hazard" means an actual or threatened landslide, land subsidence, soil erosion, earthquake, fault movement, or any other natural or unnatural movement of land or earth.

26508. "Legislative body" means the legislative body of a local agency.

26509. "Plan of control" means a report prepared by an engineering geologist certificated pursuant to Section 7822 of the Business and Professions Code or a firm of engineering
Chapter 2. District Formation

Article 1. Purpose

(a) Prevention, mitigation, abatement, or control of a geologic hazard.

(b) Mitigation or abatement of structural hazards that are partly or wholly caused by geologic hazards.

Article 2. Lands Included

(a) The lands included within a district may be contiguous or noncontiguous.

(b) The lands included within a district may be situated in more than one local agency.

(c) The lands included within a district may be publicly or privately owned.

(d) No parcel of real property shall be divided by the boundaries of the proposed district.

(e) All lands included within a district shall be specially benefited by construction proposed in a plan of control approved by the legislative body.

Article 3. Initiation of Proceedings

(a) The provisions of this chapter shall be inoperative as to a legislative body unless and until the legislative body adopts a resolution declaring that it is subject to its provisions and has forwarded a copy of such resolution to the State Controller.

(b) Proceedings for the formation of a district may be initiated by either of the following methods:
(a) A petition signed by owners of not less than 10 percent of the real property to be included within the proposed district.

(b) By resolution of the legislative body.

26551. If the territory proposed to be included within a district is located in more than one local agency, the legislative body of the local agency wherein lies the greater amount of assessed valuation of real property as shown on the assessment roll last equalized by the county, shall initiate and conduct the proceedings to form a district.

26552. A petition initiating proceedings for formation of a district may be presented to the clerk of the legislative body, and shall contain substantially all of the following:

(a) A statement that the petition is made pursuant to this division.

(b) An indication, opposite each signature, of the lot, tract, and map number or other legal description sufficient to identify such signature as that of the owner of land within the territory included within the proposed district.

(c) An indication, opposite each signature, of the date each signature was affixed to the petition.

(d) A legal description and map of the boundaries of the territory to be included within the proposed district.

26553. A plan of control shall be attached to the petition.

26554. Upon receipt of a petition in the form described in Sections 26550.5, 26551, and 26553, the clerk of the legislative body shall place such petition on the agenda for the regular meeting of the legislative body next following the clerk's determination that such petition is substantially in the form described in Sections 26551 and 26552 and upon verification that the signatures affixed to the petition represent owners of not less than 10 percent of the real property to be included within the proposed district.

26555. No petition shall be accepted by the clerk of the legislative body unless the signatures thereon shall have been secured within 120 days of the date on which the first signature on the petition was affixed and such petition is submitted to the clerk within 30 days after the last signature was affixed.

26556. The clerk of the legislative body shall notify the person whose signature first appears on the petition of any irregularity in the petition. Such notification shall be by certified mail with return receipt requested. Within 10 days of the date of such mailing, a supplemental petition curing any irregularity may be submitted to the clerk.

26557. Upon presentation to the legislative body of a petition in the form prescribed by Sections 26551 and 26552, the legislative body shall adopt a resolution setting a public hearing on such
petition and directing notice thereof to be mailed to all owners of real property to be included within the proposed district as shown on the assessment roll last equalized by the county.

26558. A resolution of the legislative body initiating proceedings for the formation of a district shall contain substantially the following:

(a) A statement that the resolution is made pursuant to this division.

(b) A statement that the legislative body has been presented with and has reviewed a plan of control, and has determined that the health, safety, and welfare require formation of a district.

(c) The setting of a public hearing on such determination and directing that notice be mailed to all owners of real property included within the proposed district.

26559. All activities of a local agency taken pursuant to this division for the formation of a district or the annexation of territory thereto are specific actions necessary to prevent or mitigate an emergency within the meaning of paragraph (4) of subdivision (b) of Section 21080.

26560. Notwithstanding any other provision of law, proceedings for the formation of a district pursuant to this division are exclusive.

Article 4. Notice and Hearing

26561. Notice of the hearing set pursuant to Section 26557 or subdivision (c) of Section 26558 shall be mailed first-class, postage prepaid, in the United States mail, at least 20 days preceding the date of the public hearing, to each owner of real property within the proposed district as shown on the last equalized county assessment roll, or the State Board of Equalization assessment roll, as the case may be.

26562. A copy of the petition described in Section 26552 or the resolution described in Section 26558 shall be attached to the notice.

26563. The notice shall set forth the time, date, and place of the hearing, briefly describe the purpose thereof, and indicate where the plan of control may be reviewed or duplicated, at a cost not to exceed the cost of duplication. The notice shall also set forth the address where objections to the proposed formation may be mailed or otherwise delivered up to and including the time of the hearing.

26564. At any time not later than the time set for hearing objections to the proposed formation, any owner of real property within the proposed district may make a written objection to the formation. Such objection shall be in writing, shall contain a description of the land by lot, tract, and map number, and shall be signed by such owner. Objections shall be mailed or delivered as specified in the notice described in Section 26561. If the person whose signature appears on such objection is not shown on the assessment roll last equalized by the county as the owner of the subject real property, the written objection shall be accompanied by evidence sufficient to indicate that such person is the owner of such property. The determination by the legislative body of ownership for purposes of this section shall be final and conclusive.
26565. At the time set for hearing objections, the legislative body shall be presented with all objections made pursuant to Section 26564. The legislative body may adjourn such hearing from time to time, but not to exceed 60 days from the date specified in the original notice.

26566. If it appears at the hearing that owners of more than 50 percent of the assessed valuation of the proposed district object to the formation thereof, the legislative body shall thereupon close the hearing and direct that proceedings for the formation of a district be abandoned.

26567. At the close of the hearing or within 60 days thereafter, the legislative body may proceed by resolution to order the formation of the proposed district. The resolution shall appoint five owners of real property within the district to the initial board of directors for terms not to exceed four years, or, as an alternative to the appointment of five owners of real property within the district, the legislative body may appoint itself to act as the board of directors. If the legislative body appoints itself as the board of directors, Section 26583 shall not apply. If owners of real property within the district are appointed as the initial board of directors, then following the initial term, the board of directors shall be elected as provided by Section 26583. This section shall apply to all districts formed on or after January 1, 1980.

Chapter 2.3 District Dissolution

26567.1. (a) The legislative body may, by resolution, order the dissolution of a district formed under this division. Any resolution ordering a dissolution is valid only if the legislative body, based on substantial evidence on the record, makes one or more of the following findings:

(1) The corporate powers have not been used, there is a reasonable probability that those powers will not be used in the future, and the district holds no significant liquid assets.

(2) The board of directors, by resolution passed by unanimous vote of the directors, or by a vote of the owners of more than 50 percent of the assessed valuation of the real property in the district, approved the dissolution of the district.

(3) The district has not levied or collected any assessments and holds no significant liquid assets.

(4) The district has not substantially complied with a material condition of the resolution of formation adopted by the legislative body.

(b) If the board of directors is comprised of members of the legislative body, the decision of the board to dissolve a district shall be approved by the owners of more than 50 percent of the assessed valuation of the real property in the district within 90 days after a valid resolution ordering dissolution.

(c) A legislative body or a board of directors shall adopt a resolution setting a public hearing on the proposed dissolution and directing that notice shall be sent to the last known address of each homeowner within the district. The notice shall include the date, time, and place of the hearing and include a copy of the proposed resolution ordering dissolution. The notice shall be mailed
first-class, postage prepaid, in the United States mail and be postmarked no later than 30 days prior to the date of the hearing. The notice shall also set forth the address where written objections to the dissolution of the district may be mailed or otherwise delivered up to and including the time of the hearing.

26567.2. In dissolution proceedings, the legislative body may dispense with the resolution and plan of control required by Sections 26553, 26558, and 26562. After the dissolution of the district, the legislative body shall assume all remaining responsibilities and obligations of the district.

26567.3. Within 90 days after a dissolution, the board of directors shall return any liquid assets of the district to the landowners and local agencies in the same proportion that they have contributed to the revenue of the district, and shall provide by resolution for the distribution for ownership of any capital improvements and assets of the district. Within 90 days of a valid resolution ordering dissolution, any property owner within the district may offer an alternative plan for the distribution for ownership of any capital improvements and real assets of the district which shall be adopted if approved by the owners of more than 50 percent of the assessed valuation of the real property in the district.

Chapter 2.5. Emergency Formation

Article 1. Initiation of Proceedings

26568. The procedures for initiation of proceedings, notice, and hearing and formation of a district under this chapter shall be alternative to the procedures in Articles 3 (commencing with Section 26550) and 4 (commencing with Section 26561) of Chapter 2. Chapter 3 (commencing with Section 26570) does not apply to districts formed under this chapter.

26568.1. Proceedings for the formation of a district for any of the work specified in Section 26525 may be initiated by a petition signed by two-thirds of the property owners of the real property to be included within the proposed district.

26568.2. A petition initiating proceedings for the formation of a district under this chapter shall contain substantially all of the following:

(a) A statement that the petition is made pursuant to this chapter.

(b) An indication, opposite each signature, of the lot, tract, and map number, or other legal description sufficient to identify the signature as that of the owner of land within the proposed district.

(c) The reasons necessitating the creation of the district under this chapter.

(d) A request that the time set for hearings on the formation of the district be on short notice and the reason or reasons for the request.
(c) A description of, or proposal for, work to be done, an estimate of the cost of the work, and proposed assessments.

26568.3. (a) Upon presentation to the legislative body of a petition in the form prescribed by Section 26568.2, the legislative body shall adopt a resolution setting a public hearing on short notice on the petition and directing that notice of the hearing be given as provided in Section 26569. However, notice of the hearing shall be omitted if the hearing of objections is not required as provided in subdivision (b). The hearing shall be set no earlier than 15 days after the adoption of the resolution under this subdivision.

(b) The hearing of objections shall not be required if the legislative body, when considering the passage of a resolution of intention pursuant to a petition presented pursuant to Section 26568.1, finds and determines by a four-fifths vote of all members thereof, that all of the owners of lots or lands liable to be assessed have signed and filed a petition with the clerk on or before the day that the resolution of intention is to be considered for passage, waiving the hearing, declaring that they do not have any objections to the proposed work or the formation of the district, and requesting that the hearings of objections not be required.

Article 2. Notice and Hearing

26569. Notice of the hearing on short notice set pursuant to Section 26568.3 shall be as follows:

(a) Published notice shall be made pursuant to Section 6061 of the Government Code and shall be completed at least 10 days prior to the date of the hearing. Published notice shall include a copy of the petition described in Section 26568.2.

(b) Mailed notice shall be sent by first-class mail, with return receipt requested, and postmarked not less than 10 days preceding the date of the public hearing. A copy of the petition described in Section 26568.2 shall be attached to the notice.

26569.1. At any time no later than the time set for hearing, any owner of real property within the proposed district may file with the clerk, a written protest to the formation of the district. A written protest shall contain a description of the land by lot, tract, and map number and shall be signed by the owner.

26569.2. At the time set for hearing objections, the legislative body shall be presented with all objections made pursuant to Section 26568.1.

26569.3. If it appears at the hearing that the owners of more than one-third of the real property to be included within the proposed district object to the formation thereof, the proceedings for the formation of the district shall be abandoned.

26569.4. If a protest by the owners of more than one-third of the real property to be included in the district has not been filed, the legislative body may adopt a resolution ordering the improvements and the formation of the assessment district. The adoption of the resolution constitutes the levy of an assessment for the fiscal year referred to in the assessment.
Article 3. Nature of the District

26569.5. A district formed under this chapter shall be comprised of an area within a local agency which is specially benefited by, and is subject to a special assessment to pay of the cost of, an improvement. The district is not an entity separate and distinct from the local agency within which it is formed.

26569.6. The legislative body shall appoint itself to act as board of directors of the district.

26569.7. This chapter is applicable only in a city or county which has adopted an ordinance providing that the chapter is applicable in its jurisdiction.


Article 1. Nature of the District

26570. A district is a political subdivision of the state. A district is not an agency or instrumentality of a local agency.

26571. A district is comprised of an area specially benefited by and subject to special assessment to pay the cost of an improvement. While a district performs certain governmental and proprietary functions as a political subdivision of the state, it is not a special district within the meaning of Section 56036 of the Government Code.

26573. The powers of a district are vested in the board of directors.

Article 2. Powers of a District

26574. A district may do all of the following:

(a) Sue and be sued.

(b) Make, amend, and repeal bylaws.

(c) Have a seal.

(d) Exercise all powers necessary or incidental to carry out the purposes of this division.

26575. A district may obtain, hire, purchase, or rent office space and equipment.

26576. Within the territorial limits of the district, or for the purposes set forth in this division, a district may acquire real property or any interest therein by eminent domain.

26577. A district may purchase, lease, obtain an option upon, acquire by gift, grant, bequest, or devise, or otherwise acquire any property or any interest in property.
26578. A district may sell, lease, exchange, assign, encumber, or otherwise dispose of property or any interest in property.

26579. The district may enter into contracts and agreements with the United States, any state or local unit of government, public agency, including any other geologic hazard abatement district or public district, private organization, or any person in furtherance of the purposes of the division.

26580. The district may:

(a) Acquire, construct, operate, manage, or maintain improvements on public or private lands. Such improvements shall be with the consent of the owner, unless effected by the exercise of eminent domain pursuant to Section 26576.

(b) Accept such improvements undertaken by anyone.

26580.1. The district may make improvements to existing public or private structures where the board of directors determines that it is in the public interest to do so.

26581. At any time following the adoption of the resolution pursuant to Section 26567, the board of directors may proceed to annex territory to the district. The proceedings for annexation shall follow the procedure contained in Article 3 (commencing with Section 26550) and Article 4 (commencing with Section 26561) of Chapter 2 of this division. In such instance, the board of directors shall assume the responsibilities of the legislative body. Annexation of territory to a district shall be subject to the approval of the legislative body which ordered formation of the district. Such approval shall be given by resolution, following the order by the board of directors for annexation of territory to the district.

Article 3. Meetings

26582. A district shall keep a record of the proceedings of its meetings. A district is subject to the provisions of the Ralph M. Brown Act (commencing with Section 54950 of the Government Code).

Article 4. Officers

26583. Following the four-year term of the initially appointed board of directors formed pursuant to Section 26567 and composed of owners of real property within the district, the board of directors shall be composed of five elected directors. The term of office of directors shall be four years. The expiration of the term of any director shall not constitute a vacancy and he or she shall hold office until his or her successor has qualified. Elections shall be called and conducted, and the results canvassed, returned, and declared pursuant to the Uniform District Election Law (Part 4 (commencing with Section 10500) of Division 10 of the Elections Code). This section shall not apply to a district where the legislative body has appointed itself as the board of directors.
26584. The board of directors shall appoint a clerk of the district.

26585. The board of directors shall appoint a treasurer of the district.

26586. The board of directors may appoint other officers of the district and delegate thereto such powers of the district as may be appropriate in the circumstances.

Chapter 4. Finances

Article 1. Improvement Act of 1911; Municipal Improvement Act of 1913; Improvement Bond Act of 1915

26587. A district may use the Improvement Act of 1911 (commencing with Section 5000 of the Streets and Highways Code) or the Municipal Improvement Act of 1913 (commencing with Section 10000 of the Streets and Highways Code) or the Improvement Bond Act of 1915 (commencing with Section 8500 of the Streets and Highways Code) to pay the costs of an improvement pursuant to this division.

26588. The powers and duties conferred by the Improvement Act of 1911 or the Municipal Improvement Act of 1913 or the Improvement Bond Act of 1915 on the various boards, officers, and agents of cities shall be exercised by the corresponding boards, officers, and agents of the district.

26589. In the application of the Improvement Act of 1911 or the Municipal Improvement Act of 1913 or the Improvement Bond Act of 1915 to proceedings instituted by a district, the terms used in the Improvement Act of 1911 or the Municipal Improvement Act of 1913 or the Improvement Bond Act of 1915 have the following meanings:

(a) "City council" or "council" or "legislative body" means the board of directors of the district.

(b) "Municipality" or "city" means the district.

(c) "Clerk" or "city clerk" means the clerk of the district.

(d) "Superintendent of streets," "street superintendent," or "city engineer" means any person appointed by the board to perform or effect an improvement.

(e) "Tax collector" means the county tax collector.

(f) "Treasurer" or "city treasurer" means the treasurer of the district.

(g) "Mayor" means the board of directors or an officer of the district to whom such powers and duties are delegated by the board of directors.

(h) "Right-of-way" means any parcel of land in, on, under, or through which a right-of-way or easement has been granted to the district for the purpose of performing or effecting an improvement.
26590. Any certificates or documents required by the Improvement Act of 1911 or the Municipal Improvement Act of 1913 or the Improvement Bond Act of 1915 to be filed or recorded in the office of the superintendent of streets or street superintendent shall be filed or recorded in the office of the clerk of the district.

Article 2. Financial Assistance

26591. A district may accept financial or other assistance from any public or private source and may expend any funds so accepted for any of the purposes of this division.

26592. Contributions by a local agency, the state, or any instrumentality or political subdivision thereof, are hereby declared to be for a public purpose.

26593. A district may borrow money from or otherwise incur an indebtedness to a local agency, the state, or any instrumentality or political subdivision thereof, or the federal government, and may comply with any conditions imposed upon the incurring of such indebtedness.

26594. A district may repay any financial assistance accepted pursuant to Section 26591.

26595. A district may reimburse the local agency for all or any part of the cost and expenses incurred by the local agency in formation of the district.

Chapter 5. Improvements

26600. The board of directors may negotiate improvement contracts or may award such contracts by competitive bidding pursuant to procedures approved by the board of directors.

26601. Improvement caused to be undertaken pursuant to this division, and all activities in furtherance thereof or in connection therewith, shall be deemed to be specific actions necessary to prevent or mitigate an emergency within the meaning of paragraph (4) of subdivision (b) of Section 21080.

Chapter 6. Maintenance

26650. A district may levy and collect assessments pursuant to this chapter to pay for the cost and expenses of the maintenance and operation of any improvements acquired or constructed pursuant to this division.

26651. The board of directors shall adopt a resolution declaring its intention to order that the cost and expenses of maintaining and operating an improvement acquired or constructed pursuant to this division shall be assessed against the property within the district benefited thereby. The resolution shall contain both of the following:

(a) A report prepared by an officer of the district which sets forth the yearly estimated budget, the proposed estimated assessments to be levied each year against each parcel of property, and a description of the method used in formulating the estimated assessments.
(b) The time, date, and place for the hearing of protests to the proposed assessments.

26652. The board of directors shall cause a notice of the adoption of the resolution described in Section 26651 to be mailed by first class mail to each owner of real property within the district as shown on the last equalized assessment roll of the county. The notice shall be mailed not less than 14 days prior to the date set for the hearing and shall contain all of the following:

(a) A statement that the board of directors has adopted the resolution.

(b) The time, date, and place set forth in the resolution for the hearing of protests on the proposed assessments.

(c) A statement of the total yearly estimated budget for the maintenance and operation of the improvements.

(d) A statement that the report described in Section 26651 is available for inspection at the office of the district.

(e) The name and telephone number of a person designated by the board of directors to answer inquiries regarding the proposed assessment.

26653. At the hearing, the board of directors shall hear and consider all protests. At the conclusion of the hearing, the board of directors may adopt, revise, change, reduce, or modify any assessment and shall make its determination upon each assessment described in the report. Thereafter, by resolution, the board of directors may confirm the assessments and order the levy and collection thereof.

26654. Following the order by resolution of the levy and collection of assessments by the board of directors, the clerk shall cause to be recorded a notice of assessment, as provided for in Section 3114 of the Streets and Highways Code, whereupon the assessment shall attach as a lien upon the property, as provided in Section 3115 of the Streets and Highways Code.

Thereafter, the clerk shall collect the assessments as directed by the board of directors, or, in lieu of collection by the clerk, the board of directors may provide that the assessments are payable at the same time and in the same manner as general taxes on real property are payable.

A district board of directors shall reimburse the city or county, as the case may be, for any cost incurred pursuant to this section.
Areas More Likely to Contain Natural Occurrences of Asbestos in Western El Dorado County, California

by Ronald K. Churchill
March 2000

EXPLANATION

The rock exposures in western El Dorado County are predominately metamorphic and are associated with the Precambrian basement rocks of the western Sierra Nevada batholith. The Precambrian basement rocks are primarily gneisses, schists, and quartzites of the eastern Sierran batholith. These basement rocks form the core of the Sierra Nevada batholith, and are composed of a younger granite and older metamorphic rocks. The Precambrian basement rocks are surrounded by younger granitic rocks, which make up the Sierra Nevada batholith. The Sierra Nevada batholith is a large granite body that extends from the western Sierra Nevada to the eastern Sierra Nevada.

The Precambrian basement rocks in western El Dorado County are predominantly metamorphic and are associated with the Precambrian basement rocks of the western Sierra Nevada batholith. The Precambrian basement rocks are primarily gneisses, schists, and quartzites of the eastern Sierran batholith. These basement rocks form the core of the Sierra Nevada batholith, and are composed of a younger granite and older metamorphic rocks. The Precambrian basement rocks are surrounded by younger granitic rocks, which make up the Sierra Nevada batholith. The Sierra Nevada batholith is a large granite body that extends from the western Sierra Nevada to the eastern Sierra Nevada.

The Precambrian basement rocks in western El Dorado County are predominantly metamorphic and are associated with the Precambrian basement rocks of the western Sierra Nevada batholith. The Precambrian basement rocks are primarily gneisses, schists, and quartzites of the eastern Sierran batholith. These basement rocks form the core of the Sierra Nevada batholith, and are composed of a younger granite and older metamorphic rocks. The Precambrian basement rocks are surrounded by younger granitic rocks, which make up the Sierra Nevada batholith. The Sierra Nevada batholith is a large granite body that extends from the western Sierra Nevada to the eastern Sierra Nevada.