

# STATEWIDE MAPPING OF MINERAL HAZARDS IN CALIFORNIA

## A Model for Multiple Applications

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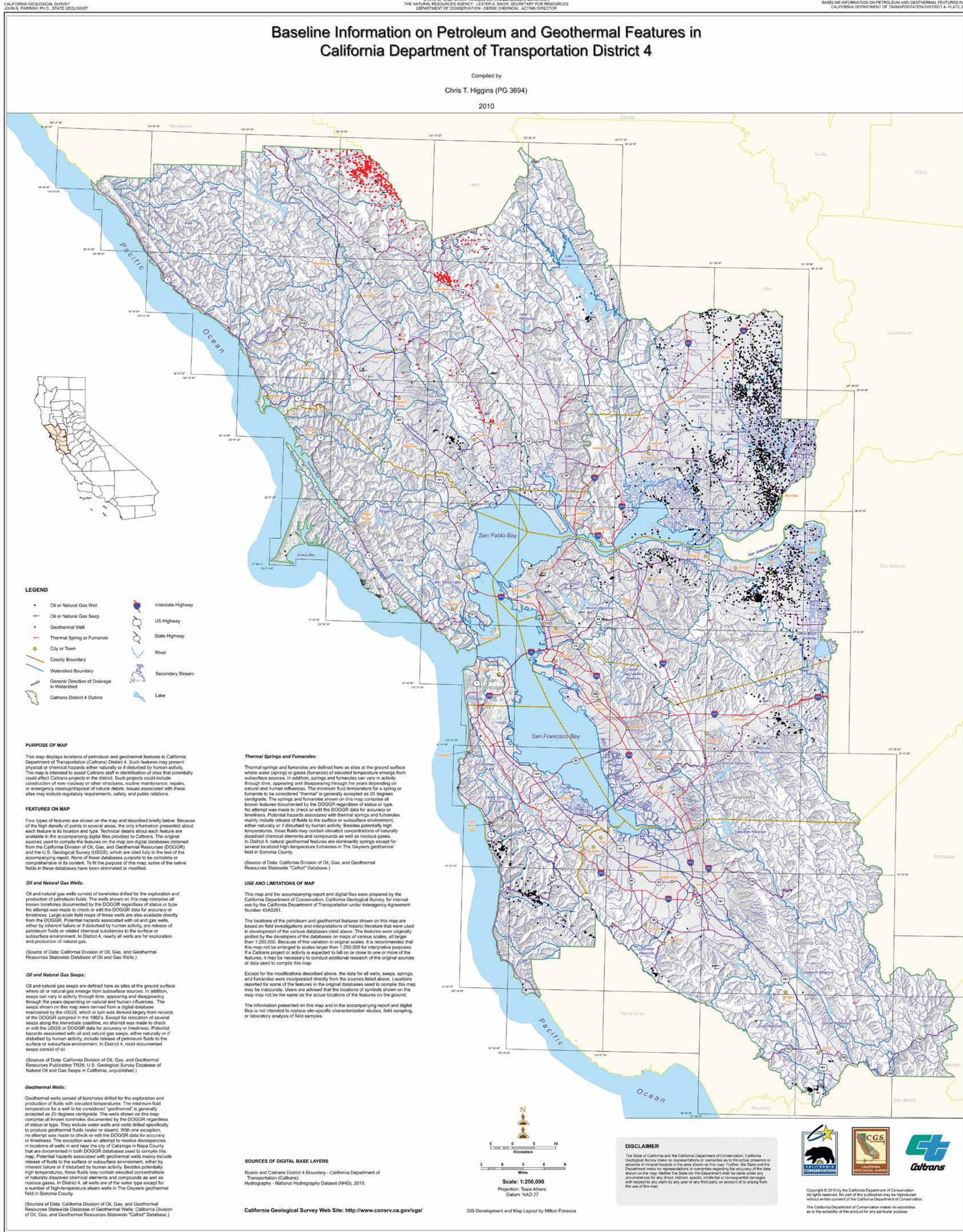
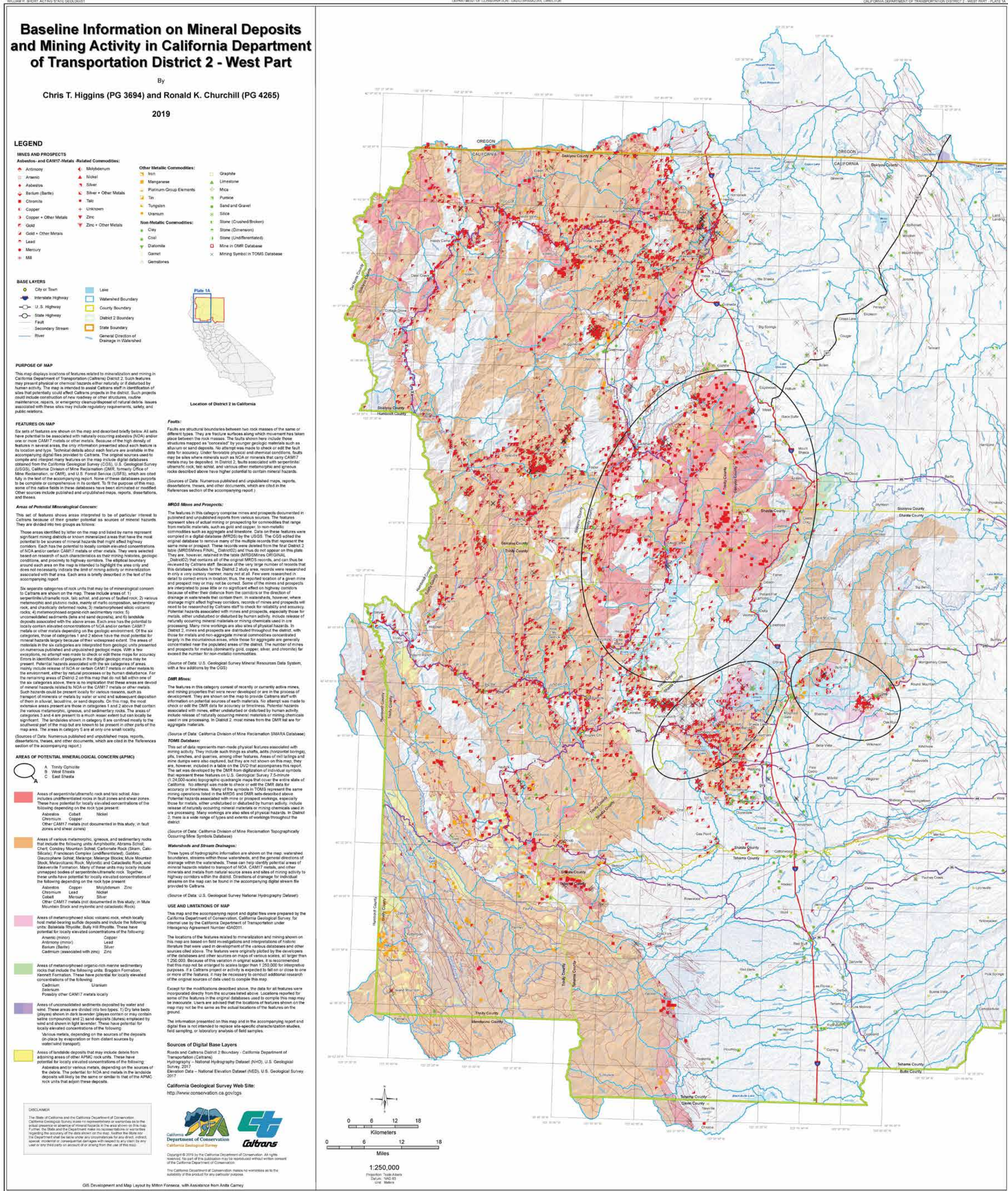
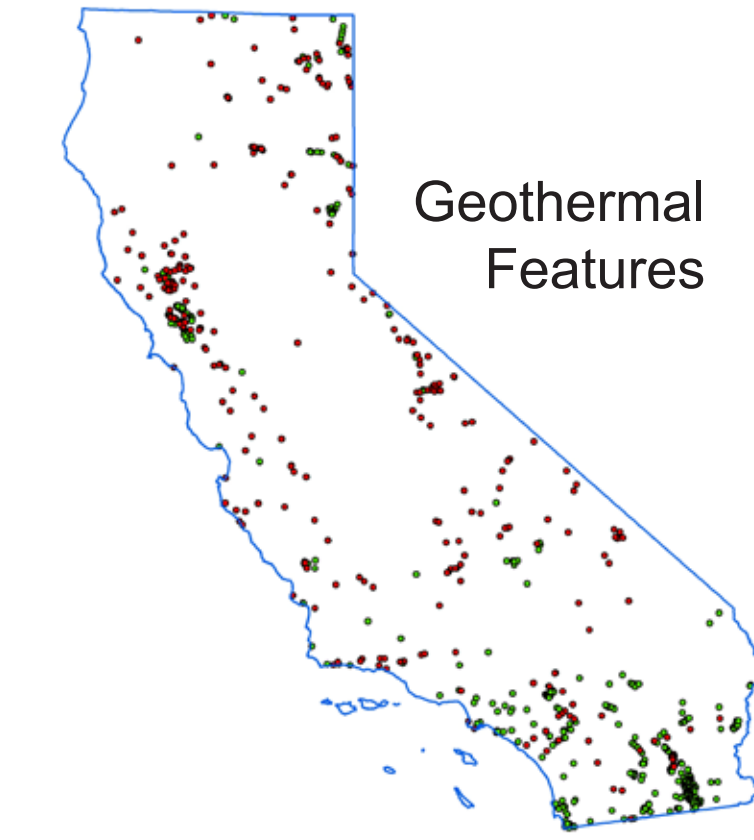
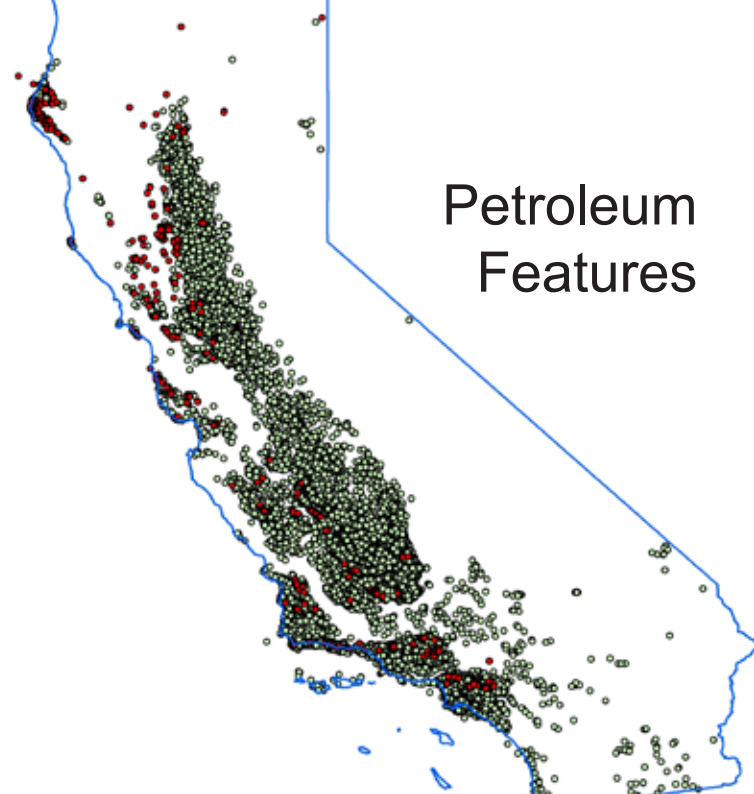
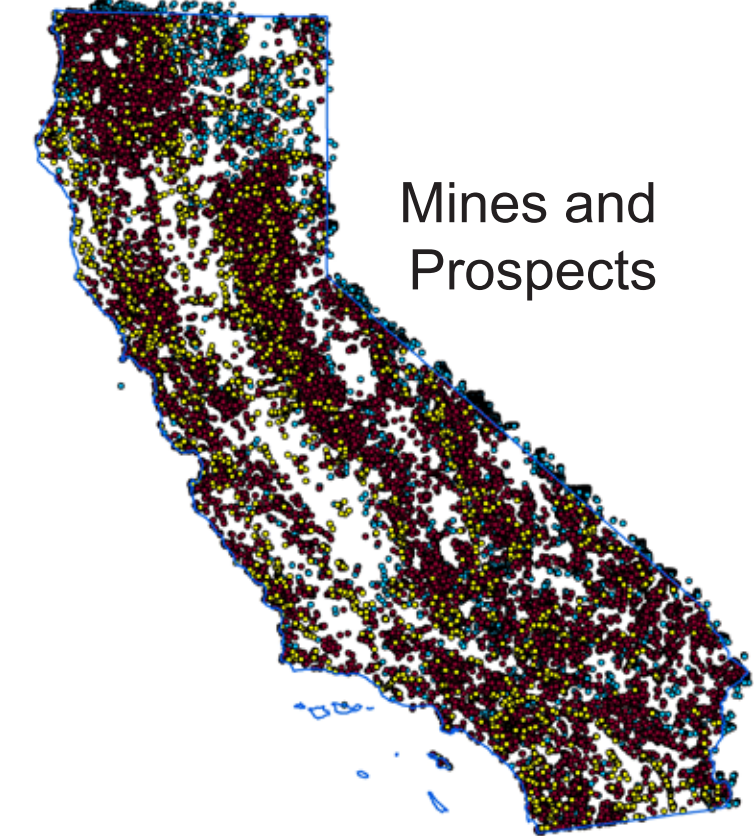
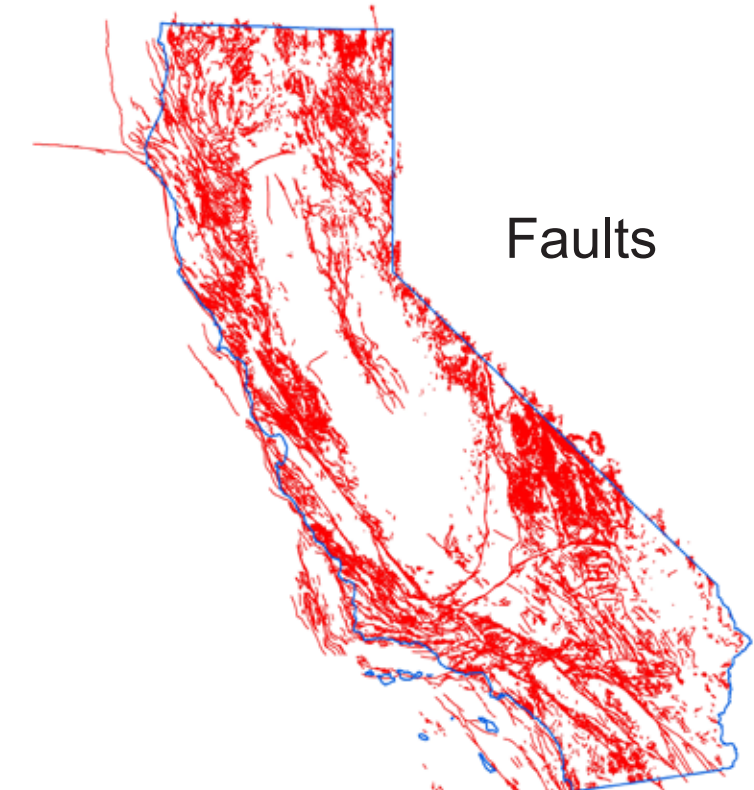
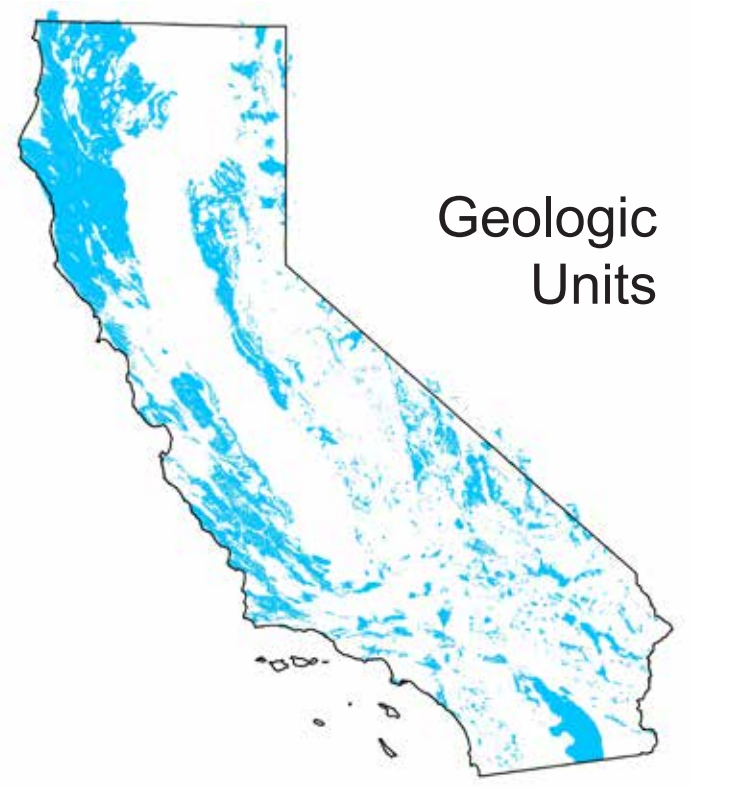
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### OVERVIEW

Mineral hazards are a common yet often less-recognized group of features compared to other types of natural and man-made hazards. We define "mineral hazards" in part as minerals and elements that occur naturally in elevated, potentially harmful, concentrations in rocks, soils, and certain fluids. Also included are features from human activities related to extraction of mineral and energy resources. Along with its large human population, extensive development, and diverse natural environment, California is very complex geologically, thus it contains many areas of mineral hazards that make it appropriate for such a study. Although mineral hazards have been investigated over several decades by the California Geological Survey (CGS), no systematic statewide assessment had been accomplished until recently when, at the request of the California Department of Transportation (Caltrans), the CGS completed a preliminary assessment of potential mineral hazards over the entire state. This work focused on natural and man-made minerals-related features that might adversely affect construction, use, and maintenance of state and federal highways under Caltrans jurisdiction. The features evaluated include: 1) geologic units that may contain naturally-occurring asbestos (NOA), fibrous erionite, or elevated concentrations of regulated metals (Ag, Ba, Be, Cd, Co, Cr, Cu, Hg, Mo, Ni, Pb, Ti, V, Zn) and metalloids (As, Sb, Se); 2) faults, which can be sites of increased potential for certain types of mineralization; 3) mines and prospects, which can be sources of anomalous concentrations of metals and ore-processing chemicals; 4) oil and natural-gas seeps; 5) thermal springs and fumaroles; and 6) oil, natural-gas, and geothermal wells. The methods and products developed during the Caltrans study can be applied worldwide to many other uses besides highways where there are obligations to protect public health and safety and the environment. The products include maps that highlight types and locations of potential mineral hazards, digital data in GIS format, and accompanying reports that provide details and additional information. Although they do not indicate risk or probability, these products can be applied by users from many backgrounds as screening tools to assess potential for the presence of mineral hazards.



### FEATURES OF PRINCIPAL INTEREST



### Naturally-Occurring Asbestos\* and Other Fibrous Minerals

**SERPENTINE**  
Chrysotile\*

**AMPHIBOLES**  
Tremolite\*  
Actinolite\*  
Anthophyllite\*  
Crocidolite\*  
Amosite\*  
Glaucophanes?

**ZEOLITES**  
Erionite  
Mordenite?

### DEVELOPMENT OF THE MAPS

Two primary sets of thematic maps have been prepared for each Caltrans district. One set displays areas and features of potential mineralogical concern, which comprise significant mining districts, localities of known mines and mineralization, certain types of geologic units, and faults, all of which may be of interest to Caltrans for further investigation. Selection of geologic units is based on their likelihood to contain NOA/fibrous minerals or elevated concentrations of the regulated metals/metalloids listed. The second set displays oil and natural-gas seeps, thermal springs and fumaroles, and wells drilled for petroleum and geothermal resources. Watersheds, streams, and the overall directions of flow of the streams in the watersheds are shown because of their potential to transport contaminants to highway corridors.

We have developed the maps from many sources of data. The highlighted geologic units (see table) and faults are interpreted and compiled from basic geologic maps, geochemical data, and fieldwork. The data on mines and mineralization are compiled from technical reports and several digital databases; the U.S. Geological Survey's Mineral Resources Data System (MRDS) is the primary source of data, which we have edited to some degree to improve its utility. The petroleum and geothermal features are compiled from data prepared by the California Division of Oil, Gas, and Geothermal Resources.

The process of developing the maps has evolved as new (and sometimes unanticipated) phenomena, conditions, and sources of data have been discovered. All compilation, analysis, and interpretation of mineral-hazard data are done with GIS tools, which are used to develop products that range from paper maps to digital files for use by Caltrans staff. This range assures that users with different levels of computer experience or available computer resources can access the information.

### GEOLOGIC UNITS HIGHLIGHTED ON MAPS

UNIT	POTENTIAL	COMMENTS
Alkaline Intrusive Complex	NOA, Ba, (other CAM17?), Radioactive Elements	Mountain Pass area; crocidolite; rare-earth elements
Amphibolite	NOA, Co, Cr, Cu, Ni	Mafic protoliths; some ultramafic bodies
Anorthosite Complex	NOA, Be, Co, Cr, Cu, Mn, Ni, V	Bodies of ultramafic, gabbro, actinolite-tremolite schist
Anthophyllite Schist	NOA	Bodies within metavolcanic rock
Balskalia Rhyolite	Cu, Pb, Zn, Ag, Cd, Sb, As	Volcanogenic metal-sulfide deposits
Big Blue Formation	NOA, Co, Cr, Cu, Hg, Ni	Derived from New Iria serpentinite body
Carbonate Rock	NOA, Cu, Mo, Pb, Ag, Zn	Metamorphic terranes with skarn, calc-silicate rock
Catalina Schist	NOA, Co, Cr, Cu, Mn, Ni	Contains serpentine and actinolite
Chert	NOA	Includes metachert; crocidolite
Fault-Zone Rock	NOA, Co, Cr, Cu, Ni	Undifferentiated; serpentine, gabbro, metavolcanic
Franciscan Complex	NOA, Co, Cr, Cu, Hg, Mn, Ni	Undifferentiated; many rock types; mélangé belts
Gabbro	NOA, Co, Cr, Cu, Ni (As)	Includes metagabbro and diabase; As in Sierra
Glaucophanes Schist	NOA, Hg	Includes blueschist; crocidolite; fibrous glaucophanes
Great Valley Complex	NOA, Co, Cr, Cu, Hg, Mn, Ni	Basal mélangé and Coast Range Ophiolite
Hydrothermally Altered Rock	Hg, Ag, As, Cu, Pb, Sb, Zn	Typically siliceous and/or argillaceous; metal sulfides
Kennett Formation	Se, Cd, U (other CAM17 metals locally?)	Shasta area; contains organic-rich siliceous shales
La Panza Pluton	U	U in shear zones and metamorphic inclusions
Landslide Deposits	NOA, fibrous zeolites, and/or various metals	Associated only with the other units on this list
Los Banos Formation	NOA, Co, Cr, Cu, Hg, Mn, Ni	Contains Franciscan Complex, serpentine detritus
Manposit-Rock Complex	NOA, Co, Cr, Cu, Ni, Pb, Ag, Zn, As	Altered serpentinite; complex hydrothermal alteration
Mélangé	NOA, Co, Cr, Cu, Hg, Mn, Mo, Ni, Pb, Ag, Zn (As)	Non-serpentinite matrix only; complex unit
Merced Falls Slate	NOA, Co, Cr, Cu, Ni	Local mafic and ultramafic bodies
Metavolcanic Rock	NOA, Cu, Pb, Zn (As)	Undifferentiated; dominantly mafic; actinolite common
Monterey Formation + Similar Units	Cd, Se, U (other CAM17 metals locally?)	Organic-rich siliceous/phosphatic marine shales
Mylonitic and Cataclastic Rock	NOA	Local sheared zones may be favorable
Oro Loma Formation	NOA, Co, Cr, Cu, Hg, Mn, Ni	Detritus from Franciscan Complex and serpentinite
Orocopia Schist	NOA, Co, Cr, Cu, Mn, Ni	Correlative with Franciscan Complex
Paso Robles Formation	Cd, Se, U (other CAM17 metals locally?)	Abundant detritus from Monterey Formation
Plutonic Rock	NOA	"Fibrous" actinolite in granitic rock
Rand Schist	NOA, Co, Cr, Cu, Mn, Ni	Correlative with Franciscan Complex
Saline Lake Evaporite Deposits	Possible but unspecified CAM17 and other metals	Windblown dust from playas
San Onofre Breccia	NOA, Co, Cr, Cu, Mn, Ni	Detritus from Catalina Schist
Sand Deposits	NOA, fibrous zeolites, and/or various metals	Windblown; dunes, sheets, ramps
Sedimentary Rock	Fibrous zeolites	Erionite in altered lacustrine glass-rich tufts
Serpentinite/Ultramafic Rock	NOA, Co, Cr, Cu, Hg, Ni	Includes serpentinite-matrix mélangé and talc schist
Shear-Zone Rock	NOA, Co, Cr, Cu, Ni	Undifferentiated; sheared and disrupted belts of rock
Shoo Fly Complex	NOA, Cu, Mo, Pb, Ag, Zn, Ba	Local bodies of skarn and calc-silicate rock
Sierra Buttes (Elwell) Formation	Cd, Se, U (other CAM17 metals locally?)	Horizons of phosphate-bearing chert
Silica-Carbonate Rock	NOA, Co, Cr, Cu, Hg, Ni	Alteration product of serpentinite
Spring Deposits	Possible but unspecified CAM17 and other metals	Siliceous and calcareous sinter
Tulare Formation	NOA, Co, Cr, Cu, Hg, Mn, Ni, Cd, Se, U	Franciscan Complex and Monterey Formation detritus

In addition to the individual district maps prepared during the project, the CGS is integrating the features from each of the districts into several thematic layers that cover the entire state. For example, all of the geologic units will be combined into one single seamless map layer.

### EXAMPLES OF OTHER POTENTIAL USERS AND APPLICATIONS OF MINERAL-HAZARD MAPS

#### Users

- Agricultural Industry
- Air Pollution Specialists
- Construction Firms
- Consultants (Engineers/Geoscientists)
- Consultants (Environmental Firms)
- Elected Officials
- Emergency Responders
- General Public
- Hazardous-Waste Specialists
- Highway Departments
- Land-Use Managers and Planners
- Military Facilities
- Public-Health Community
- Real Estate Community
- Recreational-Site Officials
- Timber Industry
- Utility Operators
- Water Specialists

#### Applications

- Crop-uptake of metals from soils derived from underlying or surrounding bedrock
- Establish regulations on control of dust emissions where fibrous minerals may be present
- Employee health at construction sites that may contain mineral hazards
- Technical-project investigations (planning, design, construction)
- Environmental studies, preparation of required environmental documents
- Awareness to aid decision-making (all levels of government)
- Potential hazards from dust related to wildfires, floods, landslides, etc.
- Awareness of potential hazards (e.g., for property sale/purchase or ownership)
- Remediation of mine sites, particularly those that produced metals
- Maintenance, new construction, emergency cleanup, employee and public health
- Improve land-management to protect public and environment
- Remediation of sites; protection of personnel during training exercises
- Medical geology; epidemiological studies of sites with high occurrences of disease
- Awareness of conditions related to sale and purchase of real property
- Protection of public where generation of dust may occur (hiking, biking, camping, etc.)
- Harvesting of timber; employee health
- Siting and maintenance of transmission structures
- Watershed studies related to water quality, pollutants

### California-Regulated Threshold Values for Metals/Metalloids

METAL/METALLOID	STLC (mg/l) <sup>1</sup>	TTLIC (mg/kg) <sup>2</sup>
Antimony (Sb)	15	500
Arsenic (As)	5	500
Barium (Ba)	100	10,000
Beryllium (Be)	0.75	75
Cadmium (Cd)	1	100
Chromium (Cr)	560	None*
	Cr <sup>3+</sup> =560; Cr <sup>6+</sup> =5	Cr <sup>3+</sup> =2,500; Cr <sup>6+</sup> =500
Cobalt (Co)	80	8,000
Copper (Cu)	25	2,500
Lead (Pb)	5	1,000
Mercury (Hg)	0.2	20
Molybdenum (Mo)	350	3,500
Nickel (Ni)	20	2,000
Selenium (Se)	1	100
Silver (Ag)	5	500
Thallium (Tl)	7	700
Vanadium (V)	24	2,400
Zinc (Zn)	250	5,000

<sup>1</sup> Those shown in red are of particular interest because of their distribution in California  
<sup>2</sup> Soluble Threshold Limit Concentration  
<sup>3</sup> Total Threshold Limit Concentration  
\*Not established



#### ACKNOWLEDGMENTS

The CGS appreciates the assistance, guidance, and patience of Scott Nelson, Pete Conn, Rich Bailey, and other staff of Caltrans in the development of these maps. Staff in other State and Federal contributed highly useful data sets that either have been incorporated into the maps or have aided analysis and derivation of new interpretive layers for the maps. Anita Carney of the CGS capably assisted with GIS tasks throughout the project.