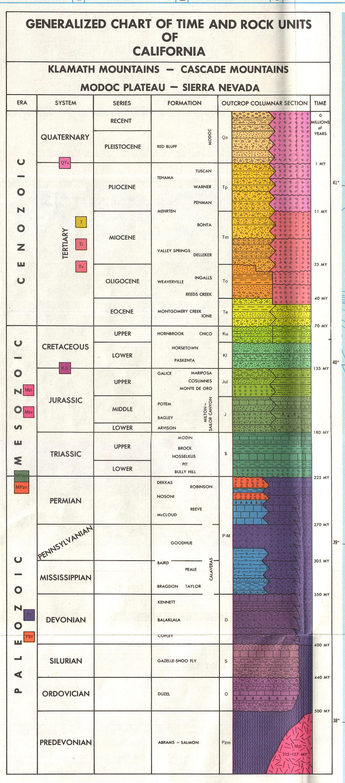
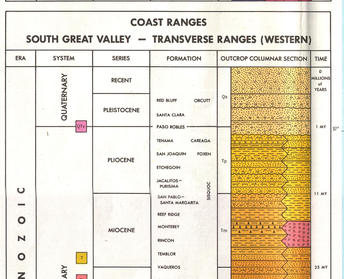
GENERALIZED CHART OF TIME AND ROCK UNITS OF CALIFORNIA

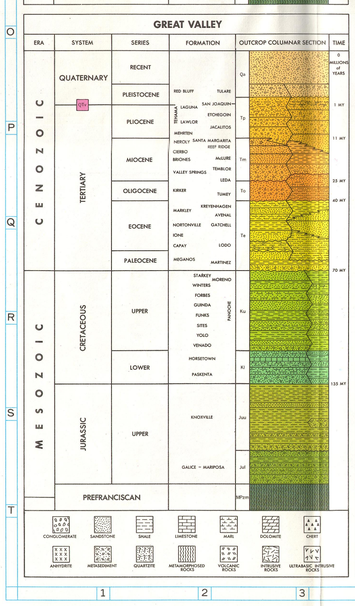
KLAMATH MOUNTAINS — CASCADE MOUNTAINS MODOC PLATEAU — SIERRA NEVADA



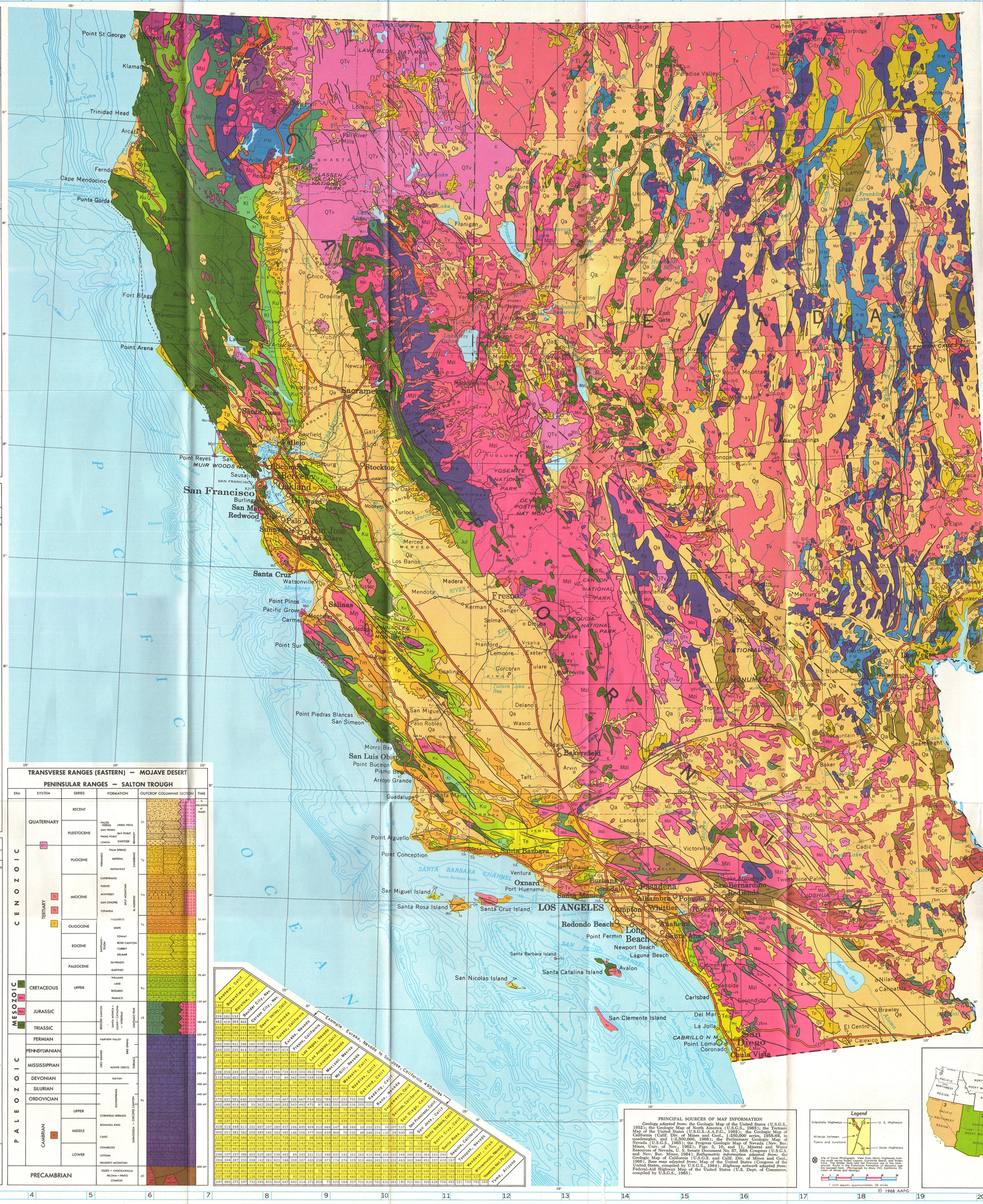
COAST RANGES SOUTH GREAT VALLEY — TRANSVERSE RANGES (WESTERN)



GREAT VALLEY



TRANSVERSE RANGES (EASTERN) — MOJAVE DESERT PENINSULAR RANGES — SALTON TROUGH



EXPLANATORY NOTES

The objective of the *Geological Highway Map* of the *Pacific Southwest Region* is to present the general geology of California and Nevada in an interesting and colorful manner sufficiently generalized to make it clearly understandable to the general public, but detailed enough to be useful to the science student and the professional geologist.

This is the third of a series of eleven regional maps being prepared to cover the conterminous states of the United States (see index map). It is hoped that these publications will be a valuable source of geological information that will be used by the traveling public to help explain the variations seen in rocks, soils, and land forms. All landforms, such as rivers, valleys, hills, plains, canyons, and mountains, result from geological processes and take on new beauty and fascination when they are observed with some understanding of their origin and history.

Each of the illustrations in this publication presents a particular type of geological information, and each is in part related to the other. The *Geological Highway Map* shows, by different colors, the age and outcrop pattern of the surface rocks. The *Generalized Chart of Time and Rock Units* illustrates the kinds of rocks that comprise the map units and their relative and radiometric ages (determined from decay of radioactive elements in the rocks). The positions of the principal structural features are presented on the *Tectonic Map*. The rocks and structures below the surface are shown in the *Geological Cross Sections*. The principal landforms are illustrated on the *Physiographic Map*.

All colors on the *Geological Highway Map*, the *Generalized Chart of Time and Rock Units*, and the *Geological Cross Sections* are coordinated: the same color is used for rocks of the same age. The long-established color designations of the United States Geological Survey for the various geological systems of rocks have been followed. The darker shades of color within each system represent the older rock units of that system: the lighter shades are the younger units.

Geological information concerning a particular area can be assembled by reference to the various map elements. For example, if Lake Tahoe, Mount Whitney, and Death Valley are the areas of interest, the following can be determined:

1. *Geological Highway Map*

Lake Tahoe is situated on rocks whose age and outcrop pattern are shown by the two colors of red and the letter symbols Mzi and Tv.

2. *Generalized Chart of Time and Rock Units*

The two colors of red and the letter symbols indicate that these rocks are of the Mesozoic Era (Mzi) and the Tertiary System (Tv) of the Cenozoic Era. The lithologic symbols show that the surface rocks are primarily igneous intrusive rocks such as granite (Mzi) and igneous volcanic rocks such as lava (Tv). The time column places the age of these rocks at approximately 135 million years (Mzi) and 25 million years (Tv).

3. *Geological Cross Sections*

Cross section C-C' passes through Death Valley (200 feet below sea level) and Mount Whitney (14,495 feet above sea level), the lowest and highest elevations in the conterminous United States. The cross section shows that Death Valley is located on alluvium of Quaternary age (Qa) and that Mount Whitney consists of intrusive igneous rock (granite) of Mesozoic age (Mzi). The alluvium in Death Valley is approximately 9,000 feet thick. The granite of Mount Whitney extends to depths in excess of 10,000 feet below sea level.

4. *Physiographic Map*

Mount Whitney is located in the Sierra Nevada Mountains.

5. *Tectonic Map*

Mount Whitney is situated on the Sierra Nevada batholith.

Similarly, geological information can be obtained for any area in the two-state region.

GEOLOGICAL HIGHWAY MAP

This map is a combination of a geological map which shows the location and surface distribution of rocks of various geological ages, and a base map that locates the highways, rivers, counties, cities, and towns. The configuration of a part of the ocean floor to a depth of 10,000 feet is shown by contour lines. Areas of the same color are underlain by rocks of the same age. Color is the identification of the color rocks on the map: letter symbols such as Ka are used. The first letter of the symbol is capitalized and designates the rock system or era (K for Cretaceous), and the second letter, which is lower case, denotes the series (u for upper). Sometimes a second small letter is added to show further subdivision of a series (example: Jsl which refers to the lower part of the Upper Jurassic). In addition to denoting series, small letters are added as needed to avoid confusion with another system or era (example: M indicates Mississippian and Mz indicates Mesozoic). Small letters are used on occasion to show rock type (example: Mzss is used to show metamorphic rocks of Mesozoic age). In some areas more than one system of rocks is mapped in the same unit, resulting in a letter symbol of more than one capital letter (example: QT denoting Quaternary-Tertiary; D-C which includes Devonian, Silurian, Ordovician, and Cambrian).

Igneous rocks (formed by the cooling of molten material) are shown in red. Five different hues of red are used on the regional maps, each indicative of specific intervals of time (Precambrian, Paleozoic, Mesozoic, Tertiary, and Quaternary). Sometimes the igneous rocks may be divided into two categories. Those cooled on the earth's surface are volcanic, or extrusive. Those cooled below the surface are plutonic, or intrusive. The lower-case letter of the letter symbol indicates the rock origin (Tv, Tertiary-volcanic, and Ti, Tertiary-intrusive). A sixth hue of red is used on this map to delineate certain ultrabasic intrusive igneous rocks, occurring in California, of Cretaceous-Jurassic age (symbol KJi).

The locations of the larger faults (fractures along which the rock layers have been displaced) are shown as heavy black lines.

The shape and width of outcrop areas are controlled by (1) dip or attitude of the rock layers, (2) thickness of the beds, (3) resistance to erosion of these rocks and layers, and (4) slope of the surface. This is illustrated on the cross sections.

GENERALIZED CHART OF TIME AND ROCK UNITS

Five charts are used to show the kinds of rocks in the California-Nevada region. The rocks are arranged according to relative age. The approximate ages, in millions of years as determined by radiometric (isotopic) dating methods, appear in the time column (right side of chart). Isotopic age determinations also appear (where available) with the lithologic symbols representing igneous rocks. Igneous basement rocks appear at the bottom of the columnar section. Other igneous rocks are shown in the chart as separate boxes, each placed in the appropriate time subdivision.

All rocks are classified into four major units of time called *eras*. The oldest rocks known are Precambrian, the next younger rocks are Paleozoic and Mesozoic, and the most recent rocks are Cenozoic. Rock layers may be classified into units that can be identified at widely separated places. In the usual course of events, these rock units are mapped as *formations*. From studies of fossils and by other means, the relative ages of these formations are determined and they are combined into time-rock units referred to as *series* (the time-equivalent term of a series is an *epoch*). Series are subdivisions of rock *systems* (the time-equivalent term of a system is a *period*). Not all series are represented in each system. Thus it may be said that the Mentone Formation is part of the Miocene Series of the Tertiary System of rocks. However, the fossils found in those rocks lived during the Miocene Epoch of time and the Tertiary Period of time. The subdivisions of the rock sequence into various units of time are based on mountain-building activities and major changes in animal and plant life as shown by fossil remains.

The types of rocks in the various map units are shown in the columnar section by lithologic symbols which indicate the type of rock-forming material, and its appearance. An explanation of the lithologic symbols appears at the base of each chart. No map unit on the geological map has the same lithology in all places on the map, and the rock-forming units are not necessarily time units. For example, the Oligocene Series of the Tertiary System (yellow color—letter symbol To) is sandstone and shale in northern California, whereas in western Nevada the same series consists of volcanic rocks (red color—included in letter symbol Tv). The many variations of this kind in the Pacific Southwest Region emphasize the need for including five localized charts of time and rock units. Some rock units are easily recognizable across hundreds of square miles, but others change lithology and appearance within relatively short distances. In the outcrop columnar section, the lithology presented is that of the type locality—the place at which the rocks of the particular unit are typically exposed and from which the unit was named.

PRINCIPAL SOURCES OF MAP INFORMATION

Geology adapted from: the Geologic Map of the United States (U.S.G.S., 1932); the Geologic Map of North America (U.S.G.S., 1965); the Tectonic Map of the United States (U.S.G.S.-A.A.P.G., 1962); the Geologic Map of California (Calif. Div. of Mines and Geol., 1958), scale 1:250,000, 10 quadrangles, and 1:2,500,000, 1966); the Preliminary Geologic Map of Nevada (U.S.G.S., 1965); the Progress Geologic Map of Nevada (Nev. Bur. Mines, Univ. of Nev., 1962); Figs. 8, 10, and 11, Mineral and Water Resources of Nevada, U. S. Senate Document No. 87, 88th Congress (U.S.G.S. and Nev. Bur. Mines, 1964). *Bathymetric information adapted from:* the Geologic Map of California (U.S.G.S. and Calif. Div. of Mines and Geol., 1958); the State map adapted from: Map of the United States (Congress of the United States, U.S.G.S., 1964). *Highway network adapted from:* Federal-Aid Highway Map of the United States (U.S. Dept. of Commerce, compiled by U.S.G.S., 1965).

Legend

Interstate Highways — U. S. Highways
Mileage between Towns and Junctions — State Highways

Use of Color Photography: View from Misty Highlands looking toward Point Reyes Peninsula, Tomales Bay, Bolinas Lagoon, The Golden Gate and San Francisco are in the background. Photo taken at 2,000 feet elevation looking down. Trees are exposed here. (Photograph by Mary Hill, California Div. of Mines and Geology)

1 inch equals approximate 30 miles

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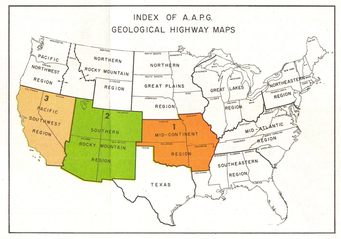
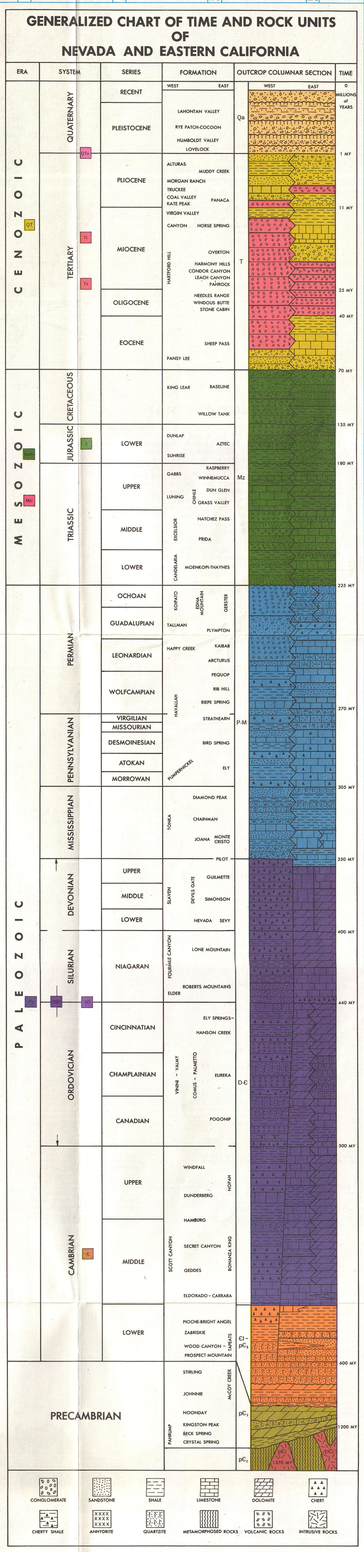
INDEX OF A.A.P.G. GEOLOGICAL HIGHWAY MAPS



GENERALIZED CHART OF TIME AND ROCK UNITS OF NEVADA AND EASTERN CALIFORNIA



MAP NO. 3
UNITED STATES GEOLOGICAL HIGHWAY MAP SERIES

Geological Highway Map OF THE PACIFIC SOUTHWEST REGION

CALIFORNIA NEVADA

COMPILED BY
DAN E. FERAY
TEXAS TECHNOLOGICAL COLLEGE

PHILIP OETKING
SOUTHWEST RESEARCH INSTITUTE

H. B. RENFRO
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