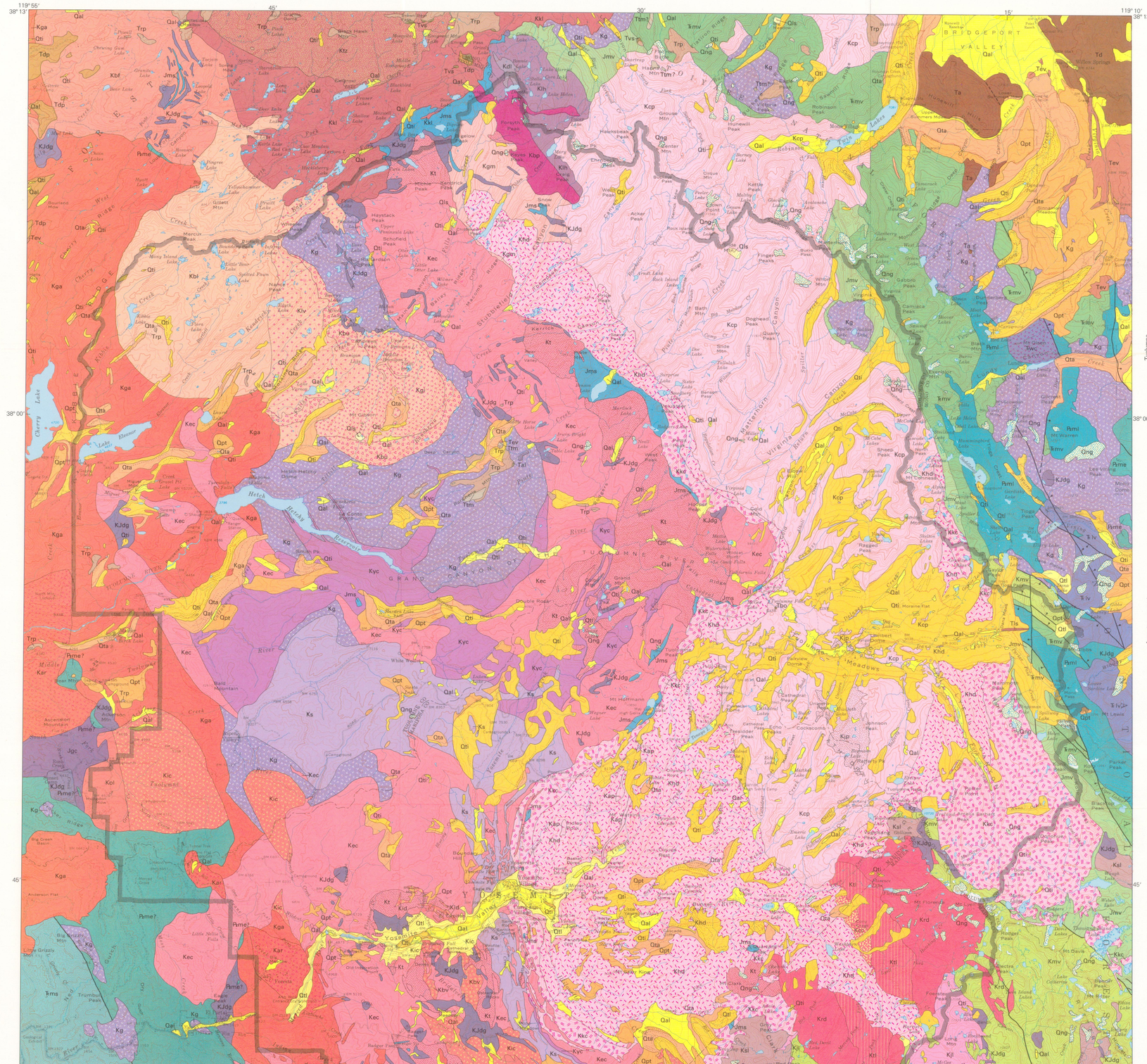
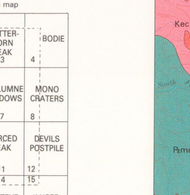
DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

MISCELLANEOUS INVESTIGATIONS SERIES
MAP I–1874



Area of geologic map



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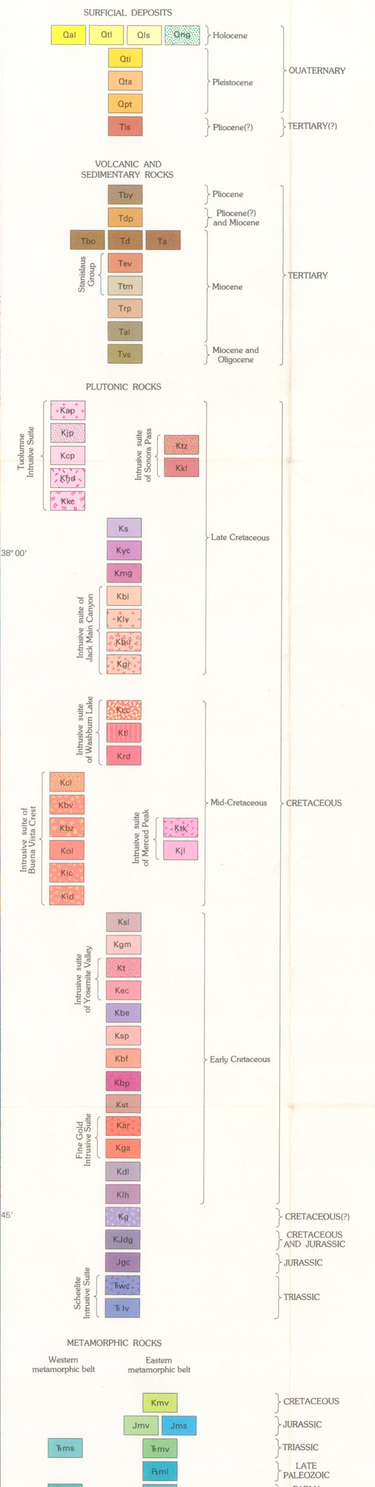
GENERAL
Wahrhaftig, Clyde, glacial geology (this compilation)
Matthes (1930), glacial geology
Bateman (1988a,b)

GEOLOGIC MAP OF YOSEMITE NATIONAL PARK AND VICINITY, CALIFORNIA

Compiled by
N. King Huber, Paul C. Bateman, and Clyde Wahrhaftig
1989

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

[Radiometric age determinations in millions of years (Ma) are indicated where available, as well as the method of dating (U-Pb, Rb-Sr, K-Ar, or fission track)]

SURFICIAL DEPOSITS

Qal **Alluvium (Holocene)**—Stream deposits in major valleys and upland meadow areas; locally includes alluvial fan deposits on the margins of major valleys and glacial outwash deposits

Qtl **Talus (Holocene)**—Rock waste derived from cliffs. Only especially extensive areas shown

Qls **Landslide (Holocene)**—On Slide Mountain at north boundary of park; at Tilill Creek east of Mount Gibson; and at Big Meadow on Buckeye Creek (north edge of map)

Qmg **Neoglacial and periglacial deposits (Holocene)**—Includes cirque moraines and rock glaciers

Qts **Tioga Till (Pleistocene)**—Moraines usually sharp-crested with abundant boulders at surface

Qta **Tahoe Till (Pleistocene)**—Moraines usually crested, but subdued, with scattered, weathered boulders at surface. Includes till mapped by some as Tenaya Till and Mono Basin Till east of the Sierra Nevada crest

Qpt **Pre-Tahoe Till (Pleistocene)**—Moraines hummocky and dissected. Includes till mapped by some as Sherwin Till east of the Sierra Nevada crest

Tis **Indurated landslide deposit (Pliocene?)**—Deposit of unsorted debris in ravine near head of Dana Fork of Tuolumne River

VOLCANIC AND SEDIMENTARY ROCKS

Tby **Younger basalt (Pliocene)**—Alkalic basalt lava flows and necks in southern part of map area; age about 3.5 Ma

Tdp **Disaster Peak Formation (Pliocene(?) and Miocene)**—Andesitic lahars (volcanic mud flows) in northwestern part of map area; age about 6 Ma (K-Ar)

Tvs **Dacite (Miocene)**—Dacitic plugs, lava flows, and tuff in northeast corner of map area; age about 8 Ma (K-Ar)

Tbo **Older basalt (Miocene)**—Small basalt plug northwest of Tuolumne Meadows along Tuolumne River (Little Devils Postpile); age about 9 Ma (fission track)

Ta **Andesite (Miocene)**—Andesitic and basaltic lava flows and breccia in northeast corner of map area

Tev **Stanislaus Group (Miocene)**
Eureka Valley Tuff—Biotite-bearing, welded latite tuff; age about 9 Ma (K-Ar)

Ttm **Table Mountain Latite**—Dark gray to black, porphyritic latite lava flows characterized by platy plagioclase phenocrysts; age about 9 Ma (K-Ar)

Trp **Relief Peak Formation (Miocene)**—Andesitic lahars

Tr **Indurated alluvium (Miocene)**—Stream deposits in an ancient channel buried by lahar on the east slope of Rancheria Mountain

Tvc **Valley Springs Formation (Miocene and Oligocene)** —Rhyolitic tuff, partially to densely welded; age about 25 Ma (K-Ar)

PLUTONIC ROCKS

[The igneous rock formed by solidification of magma beneath the Earth's surface occurs as individual intrusive bodies—plutons—that collectively make up the Sierra Nevada batholith. These plutonic units are the basic geologic map units in granitic terrane. On this map some plutons of similar composition and age have been grouped under the name of one of them; thus El Captain Granite and similar rocks includes what has been mapped as the granodiorite of Mount Hoffmann, the granodiorite of Double Rock, and the granite of Gray Peak on larger-scale geologic source maps. Units thus grouped have the same map color and pattern. Some plutons (or groups of plutons) interpreted as genetically-related sequences of intrusions are placed in named intrusive suites. Units designated as "mid-Cretaceous" are too close to the Early-Late Cretaceous boundary to properly designate with available age data]

Tuolumne Intrusive Suite (Late Cretaceous)

Ktp **Aplite and pegmatite**—Dikes and small masses; mostly late differentiates of the Tuolumne Intrusive Suite

Kjp **Johnson Granite Porphyry**—Fine-grained equigranular granite, locally containing sparse potassium-feldspar phenocrysts

Kcp **Cathedral Peak Granodiorite**—Medium-grained biotite granodiorite containing conspicuous large, blocky phenocrysts of potassium feldspar; quartz grains also conspicuous. Age about 86 Ma (U-Pb)

Kfd **Half Dome Granodiorite**—Medium-grained biotite-hornblende granodiorite with conspicuous sphene. Locally porphyritic with abundant large phenocrysts of potassium feldspar

Kgo **Granodiorite of Kuna Crest and similar rocks**—Dark-colored, fine- to medium-grained, biotite-hornblende granodiorite with minor tonalite. Age about 88 Ma (U-Pb)

Intrusive suite of Sonora Pass (Late Cretaceous)

Ktz **Granodiorite of Topaz Lake**—Medium-grained biotite granodiorite with conspicuous large, blocky phenocrysts of potassium feldspar. Age about 87 Ma (Rb-Sr)

Kkl **Granodiorite of Kinney Lakes**—Medium-grained hornblende-biotite granodiorite. Age about 90 Ma (Rb-Sr)

Ks **Sentinel Granodiorite (Late Cretaceous)**—Coarse-grained, dark-gray, biotite-hornblende granodiorite with abundant sphene. Age about 93 Ma (K-Ar)

Kyc **Yosemite Creek Granodiorite (Late Cretaceous)**—Medium- to coarse-grained, dark-gray, biotite-hornblende granodiorite

Kmg **Mount Givens Granodiorite (Late Cretaceous)**—Medium- to coarse-grained hornblende-biotite granodiorite and granite. Locally porphyritic with tabular potassium-feldspar phenocrysts; abundant sphene. Age about 90 Ma (U-Pb)

Intrusive suite of Jack Main Canyon (Late Cretaceous)

Kbl **Granodiorite of Boundary Lake**—Light-colored, medium-grained biotite granodiorite and granite. Locally porphyritic. Age about 91 Ma (Rb-Sr)

Kiv **Granodiorite of Lake Vernon**—Hornblende-biotite granodiorite characterized by a "spotted" appearance

Kbu **Granodiorite of Beaurup Lake**—Medium-grained hornblende-biotite granodiorite

Kgr **Quartz diorite of Mount Gibson**—Coarse-grained, dark-gray to black, hornblende-biotite quartz diorite; pyroxene bearing

Intrusive suite of Washburn Lake (mid-Cretaceous)

Kdc **Granite porphyry of Cony Crags**—Biotite granite porphyry. Contains sparse phenocrysts of plagioclase, quartz, and potassium feldspar in a fine-grained matrix

Kil **Granite of Turner Lake**—Medium-grained biotite granite and felsic granodiorite

Krd **Granodiorite of Red Devil Lake**—Dark hornblende-biotite granodiorite and biotite granite. Age about 98 Ma (U-Pb)

Intrusive suite of Buena Vista Crest (mid-Cretaceous)

Kcl **Granite of Chilnualna Lakes**—Fine-grained biotite granite and granodiorite

Kbv **Bridalveil Granodiorite and similar rocks**—Fine-grained hornblende-biotite granodiorite and biotite granite

Kbz **Granodiorite of Breeze Lake**—Light-gray, fine-grained biotite granodiorite with abundant plagioclase phenocrysts

Kol **Granodiorite of Ostrander Lake**—Medium-grained, hornblende-biotite granodiorite and biotite granite. Locally contains potassium-feldspar phenocrysts

Kic **Granodiorite of Illiouette Creek and similar rocks**—Medium- to coarse-grained mafic hornblende-biotite granodiorite, tonalite, and granite. Age about 100 Ma (U-Pb)

Kid **Quartz diorite**—Dark fine-grained rock rich in hornblende. Occurs as irregular intrusive masses cross-cutting El Capitan and Taft Granites on north side of Yosemite Valley and as dikes of quartz diorite containing conspicuous phenocrysts of quartz east of Turner Ridge

Intrusive suite of Merced Peak (mid-Cretaceous)

Kmp **Granite of Timber Knob**—White to very light-gray fine- to medium-grained biotite granite

Kjt **Granodiorite of Jackass Lakes**—Medium-grained biotite granodiorite, but extremely variable in composition. Age about 98 Ma (U-Pb)

Ksl **Gray porphyry of Shellenbarger Lake and similar rocks (Early Cretaceous)**—Fine- to medium-grained, light-gray granite and granodiorite containing sparse to abundant phenocrysts of plagioclase and quartz. Age about 100 Ma (U-Pb)

Kgm **Granite of Grace Meadow (Early Cretaceous)**—Medium- to fine-grained, light-pink to white granite with sugary texture

Intrusive suite of Yosemite Valley (Early Cretaceous)

Kt **Taft Granite and similar rocks**—Fine- to coarse-grained white to gray biotite granite and biotite granodiorite. Locally porphyritic with phenocrysts of potassium feldspar. Age about 96 Ma (U-Pb)

Kec **El Capitan Granite and similar Rocks**—Coarse-grained, white to light-gray biotite granite and biotite granodiorite. Commonly porphyritic with blocky phenocrysts of potassium feldspar and conspicuous quartz grains. Age about 102 Ma (U-Pb)

Kbe **Granodiorite of Beasore Meadow and similar rocks (Early Cretaceous)**—Mafic hornblende-biotite granodiorite and tonalite

Ksp **Granite of Shuteye Peak (Early Cretaceous)**—Very light gray granite and biotite granite containing sparse to abundant tabular phenocrysts of potassium feldspar as long as 1 cm. Age about 102 Ma (U-Pb)

Kbf **Granodiorite of Bummers Flat (Early Cretaceous)**—Medium-grained biotite granodiorite with conspicuous large, blocky phenocrysts of potassium feldspar; quartz grains also conspicuous. Age about 101 Ma (Rb-Sr)

Kbg **Granite of Bond Pass (Early Cretaceous)**—Moderately foliated granite and granodiorite

Kst **Granite porphyry of Star Lakes (Early Cretaceous)**—Granite porphyry and granodiorite porphyry. Typically contains abundant small plagioclase phenocrysts in a medium- to fine-grained groundmass. Age about 108 Ma (Rb-Sr)

Fine Gold Intrusive Suite (Early Cretaceous)[1]

Kar **Granodiorite of Arch Rock and similar rocks**—Medium-grained, biotite granodiorite, commonly with poikilitic potassium feldspar. Age about 116 Ma (U-Pb)

Kga **Tonalite of the Gateway and similar rocks**—Medium-grained, biotite-hornblende tonalite. Varies to granodiorite and quartz diorite. Age about 114 Ma (U-Pb)

Kdl **Granite of Dorothy Lake (Early Cretaceous)**—Light-pink, Tourmaline-bearing granite

Kth **Granodiorite of Lake Harriet (Early Cretaceous)**—Dull-gray, biotite-hornblende granodiorite. Age about 133 Ma (Rb-Sr)

Kg **Granitic rocks, undivided (Cretaceous?)**—Miscellaneous bodies of granitic rock of unknown age and affinity, but probably all of Cretaceous age

Kddg **Diorite and gabbro (Cretaceous and Jurassic)**—Occurs as generally small, irregular-shaped bodies throughout map area. Some bodies older and some younger than the plutonic rocks with which they are in contact

Jgc **Tonalite of Granite Creek (Jurassic)**—Medium-grained, biotite-hornblende tonalite and granodiorite and minor gabbro. Age about 163 Ma (U-Pb)

Scheelite Intrusive Suite (Triassic)[1]

Twc **Wheeler Crest Granodiorite**—Medium-grained, biotite-hornblende granite, commonly porphyritic with potassium-feldspar phenocrysts. Age about 210 Ma (U-Pb)

Ttr **Granite of Lee Vining Canyon**—Medium-grained granite, commonly porphyritic. Age about 210 Ma (U-Pb)

METAMORPHIC ROCKS

Western metamorphic belt

Ktms **Metasedimentary rock, undivided (Triassic, at least in part)**—Metachert and phyllite derived chiefly from chert and shale; minor limestone. At west edge of map area along Merced River

Pzme **Metasedimentary rock, undivided (Early? Paleozoic)**—Quartzite and argillite derived from quartz-rich sedimentary rocks

Eastern metamorphic belt

Kmv **Metavolcanic rock, undivided (Cretaceous)**—Hornfels and other metamorphic rocks derived chiefly from pyroclastic rocks—tuff and tuff breccia—and lesser lava flows; includes minor metasedimentary rocks. Occurs in southeast quadrant of map area and on Mount Dana and Gaylor Peak. Outcrop near south-central edge of map area questionably assigned to this unit

Jmv **Metavolcanic rock, undivided (Jurassic)**—Hornfels and other metamorphic rocks derived chiefly from pyroclastic rocks—tuff and tuff breccia— and lesser lava flows; includes some metasedimentary rocks chiefly derived from impure sandstone and limestone. Occurs in a discontinuous belt extending northwest from the Thousand Island Lake area to near Matterhorn Peak

Jms **Metasedimentary rock, undivided (Jurassic?)**—Hornfels and other metamorphic rocks derived chiefly from sandstone, siltstone, shale, limestone, and conglomerate. Known to be of Jurassic age in Strawberry Tungsten Mine area near southeast corner of map area. Other bodies of rock assigned to this map unit are of questionable age

Trmv **Metavolcanic rock, undivided (Triassic?)**—Hornfels and other metamorphic rocks derived chiefly from pyroclastic rocks—tuff and tuff breccia—and lesser lava flows; includes minor metasedimentary rocks. Occurs in a discontinuous belt extending northwest along the range crest from the Alger Lakes area on the east edge of the map to the Twin Lakes area

Pzmt **Metasedimentary rock, undivided (Late Paleozoic)**—Hornfels and other metamorphic rocks derived chiefly from sandstone, siltstone, limestone, and conglomerate. Occurs in a discontinuous belt near the range crest from Alger Lakes to Dunderberg Peak

Pzms **Metasedimentary rock, undivided (Early Paleozoic)** —Hornfels and other metamorphic rocks derived chiefly from sandstone, siltstone, and limestone. Occurs in small masses northeast and southeast of Lee Vining Peak

[1]Bateman (in press)

Contact

Fault—Dashed where approximately located; ball and bar on downthrown side

Crest of glacial moraine

INTRODUCTION

This map summarizes the distribution of geologic units in the area of Yosemite National Park; these units are briefly described in the explanation. More detailed descriptions and additional information on the relations between units can be found in the referenced source materials, particularly the geologic quadrangle maps. In the Yosemite area, structural details, such as attitudes of bedding and foliation, are of local interest but add little to the depiction of regional geology at the scale of this compilation, and they have been omitted for clarity. Such details are shown on the individual geologic quadrangle maps and have been summarized for most of the Yosemite area on a compilation of pre-Tertiary bedrock geology by Bateman (1988,b) The pre-Tertiary bedrock geology is further described in a detailed technical report by Bateman (1988, a), and the overall geologic story of Yosemite National Park is presented in a less technical volume by Huber (1987). Calkins and others (1985) provide a large-scale detailed geologic map of the Yosemite Valley area.

GEOLOGIC SUMMARY

Yosemite National Park sits astride the central Sierra Nevada, a mountain range stretching generally north-south for more than 300 mi. Topographically, the Sierra Nevada is asymmetric, with a broad, gentle west slope and a narrow, steep east escarpment that culminates in the highest peaks. It is 50 to 80 mi wide and ranges in altitude from near sea level along its west edge to more than 13,000 ft along the crest in the Yosemite area. Geologically, the Sierra Nevada is a huge block of the Earth's crust that has broken free on the east along a bounding fault system and been uplifted and tilted westward relative to the desert basin to the east; it is still undergoing uplift. In response to this uplift, the major streams draining the western slope of the Sierra have incised deep canyons into what is otherwise a gently rolling upland. Past glaciers have created an alpine topography in the High Sierra and profoundly modified the stream valleys down which they flowed. The bare glaciated terrane in eastern Yosemite and the deep canyons in western Yosemite provide abundant geologic vistas of great variety.

Surficial Deposits

Of the limited areas of surficial deposits shown on the map, glacial deposits are the most extensive. The exact number of glaciations that occurred in the Sierra during the Pleistocene (about 1.7 to 0.01 Ma) is uncertain. For simplicity on this map, Pleistocene glacial till is grouped into three map units, from youngest to oldest, Tioga, Tahoe, and pre-Tahoe Till. The distinction is based, in part, on morainal form and degree of dissection, and is somewhat arbitrary.

East of the Sierra Nevada crest, the Tioga and Tahoe Tills are shown as mapped by others, except that the till mapped by some as Tenaya Till and Mono Basin Till in the Bridgeport Valley area is here included in the Tahoe. Till mapped by others as Sherwin Till is here included in the pre-Tahoe. West of the Sierran crest, till here shown as the Tioga and Tahoe is generally equivalent to till of the Wisconsinan Stage of Matthes (1930). Till of Matthes' El Portal Stage is here shown as pre-Tahoe.

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GRANITIC ROCKS

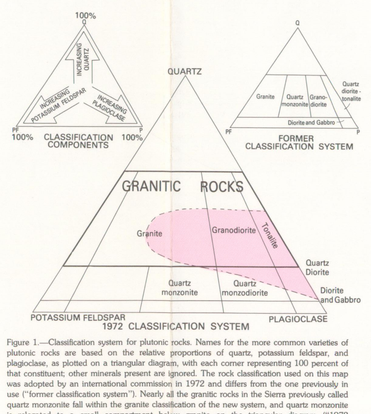

Figure 1.—Classification system for plutonic rocks. Names for the more common varieties of plutonic rocks are based on the relative proportions of quartz, potassium feldspar, and plagioclase, as plotted on a triangular diagram, with each corner representing 100 percent of that constituent; other minerals present are ignored. The rock classification used on this map was adopted by an international commission in 1972 and differs from the one previously in use ("former classification system"). Nearly all the granitic rocks in the Sierra previously called quartz monzonite fall within the granite classification of the new system, and quartz monzonite is relegated to a small compartment below granite on the triangular diagram ("1972 classification system"). In some cases, rock units previously called quartz monzonite are now called granodiorite because of better knowledge of their average mineral composition. The colored area on the diagram indicates the general range in composition for most plutonic rocks in the Yosemite National Park area.

The plutonic rock units shown on the geologic map represent discrete intrusive bodies usually bounded by sharp contacts with adjacent rocks. Generally, in small plutons, the rock is compositionally and texturally much the same, but within larger plutons composition and texture are more variable. The rock name applied to a given plutonic unit is based on an average composition for that unit. Some well-studied plutonic rock units have been given formal names (Cathedral Peak Granodiorite, Tuolumne Intrusive Suite) while others bear informal names (granodiorite of Kuna Crest, intrusive suite of Buena Vista Crest); usage here follows that of reference sources.

Certain field relations help determine the relative ages of individual bodies of plutonic rock. For example, younger magma often penetrates into cracks in older rock forming thin sheets, or dikes, of younger rock. Additionally, younger plutons commonly contain inclusions, or fragments, of older rock, which were embedded in the younger rock while it was still molten. Determining the absolute age of a given rock in millions of years requires measurement of the amount of radioactive decay of elements such as uranium, thorium, potassium, or rubidium. From such measurements, and the known rates of decay, one can approximate the amount of time elapsed since the rock crystallized or cooled below a temperature that permitted the rock to retain the decay products. Where available, such radiometric ages are given in the description of map units; all ages are approximate and there are some discrepancies between calculated ages and relative ages determined from cross-cutting geologic relations.

Some plutonic rock units are grouped into intrusive suites. The units in each suite are interpreted as resulting from the same magma-producing event. The most firmly established suites are those in which the different units that make up the suite grade into each other. Such suites commonly are zoned, both compositionally and texturally, and generally exhibit partial or complete nested patterns in which relatively dark rock in the margins gives way inward to younger, lighter colored rock. Formal names have been given to this type of suite. The Tuolumne Intrusive Suite, the first intrusive suite to be identified in the Sierra Nevada, is an example of this kind of intrusive suite.

Some of the intrusive suites shown on the map are composed of rocks that are thought to be of similar age, but which show no evidence of gradation to one another. Such suites may have been produced during a single intrusive event but not necessarily from the same parent magma. Assignment of plutonic units to such suites involves considerable uncertainty, and informal names have been applied, such as the intrusive suite of Yosemite Valley.

Metamorphic Rocks

The country rocks into which the Sierra Nevada batholith was emplaced are weakly to strongly metamorphosed, mildly to complexely deformed strata of Paleozoic (about 570 to 240 Ma) and Mesozoic (about 240 to 66 Ma) age. In the Yosemite area these metamorphic rocks occur in two northwest-trending belts situated largely west and east of the park proper and in isolated bodies scattered throughout the park.

Fossils, which generally provide much of the age information for rocks, are rare in metamorphic rocks, but limited age control in the metamorphosed volcanic rocks is provided by isotopic-dating methods. The map units for metamorphic rocks are defined largely on the basis of inferred age; rock composition is a secondary consideration. Because these map units are so generalized and encompass rocks of different metamorphic grade in different areas, only the predominant parent rock types are indicated for each unit.

Rocks of the western metamorphic belt, in the southwest part of the map area, are here divided into two map units. The western unit (Ꞓrms), predominantly bedded chert and argillite, is considered to be of Triassic (about 240 to 205 Ma) age, at least in part, based on conodont fossils recently discovered in a limestone bed in the Merced River canyon just west of the map area. The eastern unit (Pzme), predominantly quartzite and quartz-mica schist, is assigned to the early Paleozoic, based on tentative correlation with similar rocks farther north.

Rocks of the eastern metamorphic belt more or less parallel the Sierra Nevada crest and include both Paleozoic metasedimentary rocks and Mesozoic rocks predominantly of metavolcanic origin. Much of this belt, particularly in the northeast corner of the map, has not been studied in detail, and the distribution shown for individual units is tentative.

The Paleozoic rocks of the eastern belt are chiefly metamorphosed sedimentary rocks and include quartzite, metaconglomerate, and marble; the most common rock, however, is hornfels—a catch-all term for a fine-grained metamorphic rock composed of a mosaic of equidimensional grains formed by recrystallization of fine-grained sedimentary and volcanic rocks of various compositions. These Paleozoic rocks are well exposed along Highway 120 near Ellery Lake northeast of Tioga Pass.

The Mesozoic rocks of the eastern metamorphic belt are chiefly of pyroclastic origin—tuff and other explosively ejected fragmental volcanic rock—with lesser amounts of sedimentary rock. These Mesozoic rocks, which lie generally west of the Paleozoic rocks in the eastern metamorphic belt, make up the Ritter Range and the southeast margin of the park. Such rocks also form much of the Sierran crest northward through Kuna Peak, Mount Dana, and Gaylor Peak and continue north of the park beyond Twin Lakes.

Of particular interest are the little-deformed metamorphic rocks of Cretaceous (about 138 to 66 Ma) age. Metavolcanic rocks near the summit of Mount Dana have a radiometric age of about 118 million years, and similar rocks in the Ritter Range and the Clark Range have an age of about 100 million years, which makes them contemporaneous with some of the major intrusive suites. In the Ritter Range a thick deposit of volcanic breccia may have resulted from the collapse of an ancient volcanic caldera located immediately to the west and now occupied in part by the granodiorite of Jackass Lakes.

Age assignments are tenuous for other scattered bodies of metamorphic rock, such as those near the north-central and south-central borders of the map and those near May Lake and Benson Lake.

Volcanic Rocks

During the Tertiary, from about 20 million years ago to about 5 million years ago, vast volumes of volcanic material were erupted from a belt of volcanoes extending along what is now the northern Sierran crest. The Sierra Nevada north of Yosemite was virtually buried by lava flows, volcanic tuff, and lahars (volcanic mud flows). The volcanic material traveled great distances. Much of it reached the edge of the Central Valley of California, and some of it traveled as far south as the northern part of Yosemite. Three separate units of this volcanic sequence—the lahars of the Relief Peak Formation, the Table Mountain Latite, and the Eureka Valley Tuff—successively flowed down the valley of a south-flowing tributary of the ancestral Tuolumne River and into the main river channel in the vicinity of Rancheria Mountain northeast of Hetch Hetchy. Erosional remnants of the lahars indicate that they then flowed as far west as Groveland, about 18 mi west of the Yosemite map area. Other erosional remnants of the lahars indicate that they were so thick that they actually flowed upstream along the ancestral Tuolumne River at least 5 mi above the junction of the south-flowing tributary. An indurated stream gravel exposed on the east slope of Rancheria Mountain, facing Piute Creek, defines this ancient channel of the Tuolumne River. The gravel's Miocene age (about 24 to 5 Ma) is indicated by its burial by lahars of the Relief Peak Formation of that age.

Other volcanic rocks in the map area represent local eruptive events. One such event is recorded by a basalt plug—a solidified remnant of lava in a volcanic conduit—located on the south side of the Tuolumne River several miles northwest of Tuolumne Meadows. The outcrop, easily reached by the Glen Aulin trail, exhibits crudely developed columnar joints. The youngest volcanic rocks in the map area, about 3½ million-years old, are found along the south boundary of the park and in the southeast corner of the map. These basaltic lava flows and necks are unusually rich in potassium for rocks with such a low silica content.

Surficial Deposits

Of the limited areas of surficial deposits shown on the map, glacial deposits are the most extensive. The exact number of glaciations that occurred in the Sierra during the Pleistocene (about 1.7 to 0.01 Ma) is uncertain. For simplicity on this map, Pleistocene glacial till is grouped into three map units, from youngest to oldest, Tioga, Tahoe, and pre-Tahoe Till. The distinction is based, in part, on morainal form and degree of dissection, and is somewhat arbitrary.

East of the Sierra Nevada crest, the Tioga and Tahoe Tills are shown as mapped by others, except that the till mapped by some as Tenaya Till and Mono Basin Till in the Bridgeport Valley area is here included in the Tahoe. Till mapped by others as Sherwin Till is here included in the pre-Tahoe. West of the Sierran crest, till here shown as the Tioga and Tahoe is generally equivalent to till of the Wisconsinan Stage of Matthes (1930). Till of Matthes' El Portal Stage is here shown as pre-Tahoe.

INDEX MAP

GEOLOGIC TIME CHART

Terms and boundary ages used by the U.S. Geological Survey in this report

ERA	PERIOD	AGE ESTIMATES OF BOUNDARIES IN Ma
Cenozoic	Quaternary	0.010
	Tertiary	1.7
		24
		38
		54
		66
Mesozoic	Cretaceous	96
		138
	Jurassic	205
	Triassic	240
Paleozoic	Permian	290
	Pennsylvanian	330
	Mississippian	360
	Devonian	410
	Silurian	435
	Ordovician	500
	Cambrian	570
Precambrian		4550

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