DIVISION OF MINES AND GEOLOGY
Ian Campbell, *State Geologist*

STATE OF CALIFORNIA
Edmund G. Brown, *Governor*
THE RESOURCES AGENCY
William E. Warne, *Administrator*

DEPARTMENT OF CONSERVATION
DeWitt Nelson, *Director*

EXPLANATORY DATA

TRONA SHEET

GEOLOGIC MAP OF CALIFORNIA

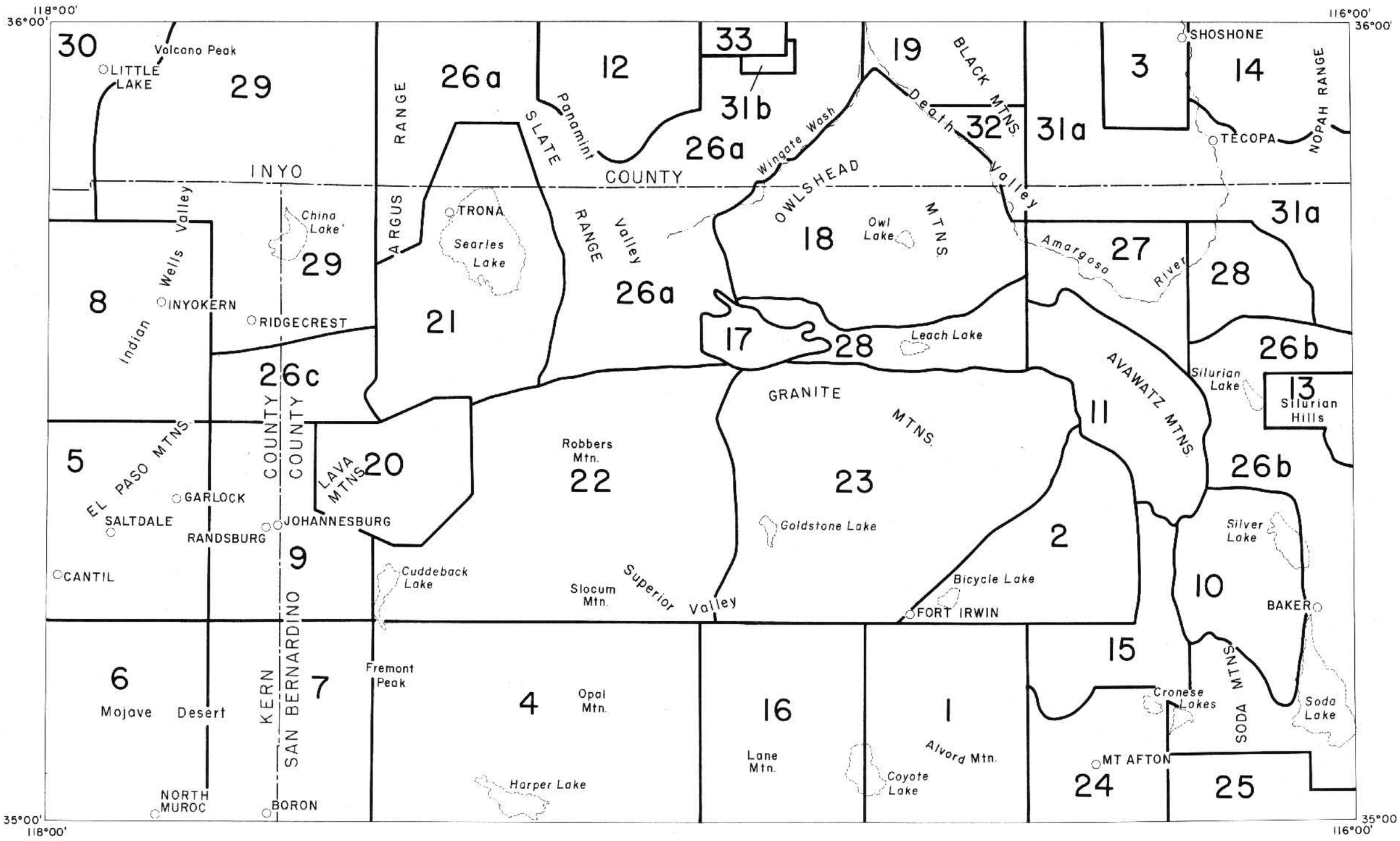
OLAF P. JENKINS EDITION

Compiled by Charles W. Jennings, John L. Burnett, and Bennie W. Troxel, 1962

(Third Printing, 1975)

INDEX TO GEOLOGIC MAPPING

USED IN THE COMPILATION OF THE TRONA SHEET



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For a complete list of published geologic maps of this area see Division of Mines and Geology Special Reports 52 and 52-A.

STRATIGRAPHIC NOMENCLATURE— TRONA SHEET

AGE	STATE MAP SYMBOL	STATE MAP UNIT State Map Units listed here are not necessarily in stratigraphic sequence; the sequence used has been standardized for all sheets of the Geologic Map of California	STRATIGRAPHIC UNITS AND CHARACTERISTIC LITHOLOGIES (The formally named formations grouped within an individual State Map Unit, are listed in stratigraphic sequence from youngest to oldest.)
CENOZOIC — QUATERNARY — Recent	Qs	**RECENT DUNE SAND**	Dune sand and other windblown sand deposits.
CENOZOIC — QUATERNARY — Recent	Qal	**RECENT ALLUVIUM**	Alluvium. Alluvial fan deposits. Includes dissected alluvium of probable Pleistocene age in some areas.
CENOZOIC — QUATERNARY — Recent	Qst	**QUATERNARY SALT DEPOSITS**	Mostly deposits of sodium chloride; some sodium sulphate on surface of Searles Lake.
CENOZOIC — QUATERNARY — Recent	Ql	**QUATERNARY LAKE DEPOSITS**	Clay, silt, and fine sand of lake beds. Recent playas and mud flats exposed in the central parts of basins (mostly undissected); Pleistocene deposits exposed around edges of basins (mostly dissected)—chiefly Manix Lake beds in the Alvord Mountain quadrangle and Searles Lake deposits in the Searles Lake, Trona, and Wingate Pass quadrangles. Includes some tufa masses around Searles Lake.
CENOZOIC — QUATERNARY — Pleistocene	Qc	**PLEISTOCENE NONMARINE SEDIMENTARY DEPOSITS**	Older alluvium. Dissected alluvium and terrace gravels.
CENOZOIC — QUATERNARY — Pleistocene	Qpv^r Qpv^a Qpv^b Qpv^p	**PLEISTOCENE VOLCANIC ROCKS:** **RHYOLITIC** **ANDESITIC** **BASALTIC** **PYROCLASTIC**	Rhyolite flows and cones in the Little Lake quadrangle. Andesite sills, dikes, plugs, and some flows (Lava Mountains). Intrusive plugs of dark gray to red andesite (Panamint Valley). Black Mountain Basalt. Unnamed basalts (some of which may be older or younger than Pleistocene). Basaltic cinders (Cinder Hill northwest of Confidence Hills).
CENOZOIC — QUATERNARY — Pleistocene	QP	**PLIOCENE-PLEISTOCENE NONMARINE SEDIMENTARY DEPOSITS**	Funeral Fanglomerate—*fanglomerate with interbedded basalt flows and fine-grained sedimentary rocks* and China Ranch Beds—*fanglomerate and siltstone* (Tecopa area). Muehlberger's "Upper sedimentary sequence"—*silt and sand* (Quail Mountains). Sedimentary breccia, granitic gravel, and andesite gravel (Alvord Mountain quadrangle). Unnamed gravels probably correlative with the Funeral Fanglomerate. Deformed and uplifted lake and alluvial deposits in the Searles Lake, Wingate Wash, Trona, and Manly Peak quadrangles. Dibblee's member 8 of the Ricardo Formation.
CENOZOIC — QUATERNARY — Pleistocene	✳	**QUATERNARY AND/OR PLIOCENE CINDER CONES**	Pleistocene cinder cones.
CENOZOIC — QUATERNARY — Pliocene	Pc	**UNDIVIDED PLIOCENE NONMARINE SEDIMENTARY ROCKS**	Sedimentary rocks of fluvial and lacustrine origin (upper part of the Tropico Group) in the Boron area (Pliocene age uncertain). Arkosic pebbly sandstone in the Summit Diggings area (Randsburg quadrangle).
CENOZOIC — QUATERNARY — Pliocene	Pmlc	**MIDDLE AND/OR LOWER PLIOCENE NONMARINE SEDIMENTARY ROCKS**	Ricardo Formation—*sandstone, conglomerate, volcanic and granitic gravels, tuff breccia, ash and bentonite* (El Paso Mountains and Boron area); arkosic sandstone, conglomerate, siltstone, tuff, and volcanic breccia in the Randsburg, Cuddeback Lake and Searles Lake quadrangles.
CENOZOIC — QUATERNARY — Pliocene	Pv^r Pv^a Pv^b Pv^p	**PLIOCENE VOLCANIC ROCKS:** **RHYOLITIC** **ANDESITIC** **BASALTIC** **PYROCLASTIC**	Rhyolite and dacite flows and intrusive rocks. Andesite and latite flows within the Ricardo Formation. Andesite and latite flows (Lane Mountain quadrangle). Andesite flows and flow breccias, some volcanic domes and necks (Lava Mountains). Basalt flows within the Ricardo Formation and the Funeral Fanglomerate. Saddleback Basalt—*basalt flows*. Unnamed basaltic flows. Tuffs, volcanic breccias, some massive volcanic rocks intrusive into breccias, some sandstone beds (Lava Mountains). Rhyolitic tuff breccia and tuffaceous sediments (Alvord Mountain quadrangle).
CENOZOIC — TERTIARY — Miocene	Mc	**UNDIVIDED MIOCENE NONMARINE SEDIMENTARY ROCKS**	Sedimentary rock portion of the Tropico Group—*Moderately consolidated sedimentary and pyroclastic rocks, limestone, conglomerate, sandstone, shale, and chert* (Castle Butte and Boron quadrangles). Unnamed Miocene conglomerate in the Cave Mountain quadrangle. Sedimentary rocks of the "Jubilee chaos" (Virgin Springs area).
CENOZOIC — TERTIARY — Miocene	Muc	**UPPER MIOCENE NONMARINE SEDIMENTARY ROCKS**	Barstow Formation—*fanglomerate, sandstone, arkosic sandstone, conglomerate with minor tuff, limestone, basalt and andesite* (middle Miocene in part).
CENOZOIC — TERTIARY — Miocene	Mmc	**MIDDLE MIOCENE NONMARINE SEDIMENTARY ROCKS**	Clews Fanglomerate—*reddish-brown fanglomerate with a lower bentonitic sandstone and siltstone unit and an upper arkosic sandstone and tuff unit* (Alvord Mountain quadrangle). Granitic and dacitic breccia (Lane Mountain quadrangle). Granitic conglomerate and granitic and rhyolitic breccia (Opal Mountain quadrangle).
CENOZOIC — TERTIARY — Miocene	Mv Mv^r Mv^a Mv^b Mv^p	**MIOCENE VOLCANIC ROCKS:** **RHYOLITIC** **ANDESITIC** **BASALTIC** **PYROCLASTIC**	Undifferentiated volcanic rocks. Rhyolite flows, tuff and perlite. Andesite and dacite. Andesitic breccia and dacite of the Tropico Group. Basalt flows in the Barstow Formation; Alvord Peak Basalt—*nonporphyritic basalt*. Unnamed basalt flows. Spanish Canyon Formation—*tuff and tuffaceous sandstone with two olivine basalt flows and interbedded arkosic sandstone* (Alvord Mountain quadrangle). Tuff and tuff breccia of the Tropico Group. Unnamed tuff, tuff breccia, and agglomerate.
CENOZOIC — TERTIARY — Oligocene	Φc	**OLIGOCENE NONMARINE SEDIMENTARY ROCKS**	Conglomerate, sandstone, minor fine-grained sedimentary rocks, and limestone of probable Oligocene age (Shoshone quadrangle).
CENOZOIC — TERTIARY — Oligocene	Φv Φv^a	**OLIGOCENE VOLCANIC ROCKS:** **UNDIFFERENTIATED** **ANDESITIC**	Volcanic flows and pyroclastic rocks of probable Oligocene age (Shoshone quadrangle). Andesite flows and coarse pyroclastic rocks of probable Oligocene age (Avawatz Pass quadrangle)
CENOZOIC — TERTIARY — Paleocene	Epc	**PALEOCENE NONMARINE SEDIMENTARY ROCKS**	Goler Formation[1]—*arkosic sandstone and conglomerate.*
CENOZOIC — TERTIARY — Undivided	Tc	**TERTIARY NONMARINE SEDIMENTARY ROCKS**	Avawatz Formation—*siltstone, sandstone, fanglomerate, and breccia* (early Pliocene and Miocene age; includes rocks which may be as old as Oligocene). Undifferentiated detrital sedimentary rocks and evaporite rocks in the Quail Mountains, Leach Lake, and Confidence Hills quadrangles. Monolithologic breccias which formed during the Tertiary; includes small klippe of Precambrian rock at Bitter Spring (D. F. Hewett, personal communication, 1962). Muehlberger's "Middle and Lower sedimentary sequences"—*siltstone, sandstone, conglomerate, tuff, and agglomerate* in the Quail Mountains. Elsewhere includes undivided Tertiary sedimentary rocks.
CENOZOIC — TERTIARY — Undivided	Ti Ti^r Ti^a Ti^b	**TERTIARY INTRUSIVE (HYPABYSSAL) ROCKS:** **UNDIFFERENTIATED** **RHYOLITIC** **ANDESITIC** **BASALTIC**	Intrusive volcanic rocks and very fine-grained plutonic rocks. Rhyolite and dacite intrusive rocks and volcanic flows. Andesite and latite dikes and plugs. Basalt intrusive rocks (Saltdale quadrangle).
CENOZOIC — TERTIARY — Undivided	Tv Tv^r Tv^a Tv^b Tv^p	**TERTIARY VOLCANIC ROCKS:** **UNDIFFERENTIATED** **RHYOLITIC** **ANDESITIC** **BASALTIC** **PYROCLASTIC**	Volcanic flows, some volcanic necks, dikes, and pyroclastic rocks. Rhyolite and dacite flows, some plugs and dikes. Andesite, and latite flows, some plugs and dikes. Basalt flows, some plugs and dikes. Tuff and volcanic breccia.

STRATIGRAPHIC NOMENCLATURE—Continued

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CENOZOIC — UNDIVIDED	QTc	**CENOZOIC NONMARINE SEDIMENTARY ROCKS**	Undivided nonmarine Cenozoic sedimentary rocks.
CENOZOIC — UNDIVIDED	QTv	**CENOZOIC VOLCANIC ROCKS:** **UNDIFFERENTIATED**	Cenozoic flows, volcanic necks, dikes, and pyroclastic rocks.
	QTv^a	**ANDESITIC**	Andesite.
	QTv^b	**BASALTIC**	Basalt.
	QTv^p	**PYROCLASTIC**	Pyroclastic rocks and tuff.
CENOZOIC — UNDIVIDED	gr	**MESOZOIC GRANITIC ROCKS**	Mainly undivided granitic rocks, but including Teutonia and Atolia Quartz Monzonites, granite, quartz diorite, quartz monzonite, granodiorite, hornblende diorite, pegmatite, aplite, granophyre, and gneissic granite. gr?=Mesozoic (?) hypabyssal rocks, largely porphyritic (Searles Lake quadrangle).
MESOZOIC — UNDIVIDED	bi	**MESOZOIC BASIC INTRUSIVE ROCKS**	Hornblende diorite and gabbro in the Inyokern quadrangle. Amphibolite of probable uralitized pyroxenite origin (Alvord Mountain quadrangle). Hornblende diorite (Opal Mountain, Fremont Peak and Castle Butte quadrangles). Diorite-gabbro (Lane Mountain quadrangle).
MESOZOIC — JURASSIC	JRv	**JURASSIC AND/OR TRIASSIC METAVOLCANIC ROCKS**	Upper member of the Warm Spring Formation[2]—*andesite flows*. Volcanic part of the Soda Mountain Formation[2]—*meta-andesite flow breccia, quartzite, sandstone, and minor pyroclastic rocks*. Rhyolite intrusive rocks, andesite, diorite and granodiorite dikes in the Manly Peak quadrangle. Undifferentiated types of metavolcanic and associated metasedimentary rocks in the Avawatz Mountains and in the area west and south.
MESOZOIC — TRIASSIC	TR	**TRIASSIC MARINE SEDIMENTARY AND METASEDIMENTARY ROCKS**	Upper member of the Soda Mountain Formation—*quartzite, sandstone and minor pyroclastic rocks* (probable Triassic-Jurassic age); Lower member of the Warm Spring Formation—*limestone breccia*; Butte Valley Formation—*calc-silicate hornfels*. Unnamed Lower Triassic sedimentary rocks (Soda Mountains area).
MESOZOIC — UNDIVIDED	m	**PRE-CRETACEOUS METAMORPHIC ROCKS, UNDIFFERENTIATED,**	Quartz-feldspar gneisses and mica schists intruded by granitic dikes (Alvord Mountain quadrangle). Locally unnamed and undifferentiated metamorphic rocks. Includes rocks of possible early Tertiary age in the Leach Lake quadrangle.
	ls	ls = **LIMESTONE AND/OR DOLOMITE**	Coarsely crystalline limestone, dolomite, and tactite.
MESOZOIC — UNDIVIDED	ms	**PRE-CRETACEOUS METASEDIMENTARY ROCKS**	Kernville Series—*mica schist, minor quartzite, hornfels, and limestone* (Inyokern quadrangle). Quartzite conglomerate and hornfels (Saltdale quadrangle). Hornfels, quartzite, and conglomerate (Lane Mountain quadrangle). Limestone, siliceous limestone, slate and phyllite in the Lava Mountains.
MESOZOIC — UNDIVIDED	mv	**PRE-CRETACEOUS METAVOLCANIC ROCKS**	Metamorphosed quartz latite in the Boron quadrangle. Locally unnamed pre-Cretaceous metavolcanic rocks.
MESOZOIC — UNDIVIDED	gr-m	**PRE-CENOZOIC GRANITIC AND METAMORPHIC ROCKS**	Undifferentiated quartzite, marble, talc schist, and meta-igneous rocks in the Cronese Mountains area. Quartzite, phyllite, dolomite, mica schist and meta-andesite in the Quail Mountains. Undifferentiated granitic, dioritic, gneissic and metavolcanic rocks in the Slate Range. Mixed granitic, metavolcanic, and carbonate rocks in the Owlshead Mountains. Includes the western part of Muehlburger's granite-gneiss in the Quail Mountains. Elsewhere, undifferentiated metamorphic-igneous rocks.
PALEOZOIC — PERMIAN	PP	**PALEOZOIC MARINE SEDIMENTARY AND METASEDIMENTARY ROCKS,**	Garlock Series—*tactite, marble, phyllite, schist, hornfels, chert, limestone, and shale* (Permian in part). Unnamed quartzite, schist, hornfels, metaconglomerate, and pure to impure limestone in the Slate Range, Lane Mountains, Silurian Hills quadrangle, Soda Lake quadrangle, Avawatz Mountains, and Goldstone Lake quadrangle.
	ls	ls = **LIMESTONE AND/OR DOLOMITE**	Riggs Formation—*limestone and dolomite* (Silurian Hills). Elsewhere undifferentiated carbonate rocks.
PALEOZOIC — PERMIAN	Pv	**PALEOZOIC METAVOLCANIC ROCKS**	Andesite porphyry, tuff and basaltic greenstone (Saltdale quadrangle). Elsewhere metabasalt, metatuff and other metavolcanic rocks.
PALEOZOIC — PERMIAN	P	**PERMIAN MARINE SEDIMENTARY AND METASEDIMENTARY ROCKS**	Anvil Spring Formation[2]—*limestone, cherty limestone, minor shale and dolomite* (Manly Peak quadrangle). Bird Spring Formation[2]—*limestone and hornfels* (Warm Spring Canyon, Soda Mountains). Unnamed carbonate rocks in the northeast part of the Avawatz Pass quadrangle.
PALEOZOIC — MISSISSIPPIAN CARBONIFEROUS	C	**UNDIVIDED CARBONIFEROUS MARINE SEDIMENTARY AND METASEDIMENTARY ROCKS**	Limestone, hornfels and quartzite in the Soda Mountains.
PALEOZOIC — MISSISSIPPIAN CARBONIFEROUS	CM	**MISSISSIPPIAN MARINE SEDIMENTARY AND METASEDIMENTARY ROCKS**	Monte Cristo Limestone—*limestone with thin layers of bedded chert* (Nopah Range).
PALEOZOIC — CAMBRIAN	€	**CAMBRIAN MARINE SEDIMENTARY AND METASEDIMENTARY ROCKS**	Cornfield Springs Formation—*dolomite*; Bonanza King Formation—*dolomite*; Cadiz Formation—*sandstone, shale and limestone*; Wood Canyon Formation—*sandstone and shale* (lower part may be Precambrian); Lotus Formation[2]—*limestone and dolomitic limestone* (Manly Peak quadrangle).
PALEOZOIC — CAMBRIAN	€?	**CAMBRIAN-PRECAMBRIAN MARINE SEDIMENTARY AND METASEDIMENTARY ROCKS**	Stirling Quartzite—*massive to thin layered quartzite*; Johnnie Formation—*sandy dolomite, quartzite, shale, siltstone and sandstone*; Noonday Dolomite—*dolomite and limestone.*
PRECAMBRIAN	p€g p€s	**UNDIVIDED PRECAMBRIAN METAMORPHIC ROCKS:** **GNEISS** **SCHIST**	Waterman Gneiss—*quartz diorite gneiss with white marble* (may be Paleozoic). Johannesburg Gneiss—*hornblende-biotite-plagioclase-quartz gneiss* (may be Paleozoic). Quartz diorite gneiss in the Boron quadrangle (may be Paleozoic). Unnamed gneiss and quartzite. Mesquite Schist—*chlorite-quartz-sericite schist and limestone* (saltdale quadrangle); Rand Schist—*mica-quartz-albite schist and actinolite schist* (Saltdale and Randsburg quadrangles). Unnamed schist. The age of the rocks shown as p€s is uncertain and may be younger than Precambrian.
PRECAMBRIAN	lp€	**LATER PRECAMBRIAN SEDIMENTARY AND METAMORPHIC ROCKS**—Algonkian on some maps	Kingston Peak Formation—*conglomerate, graywacke, limestone, sandstone, and shale;* Beck Spring Dolomite—*gray dolomite;* Crystal Spring Formation—*dolomite, quartzite, diabase, and shale.* Pahrump Group undifferentiated—*dolomite, hornfels, quartzite, conglomerate, and diabase.*
PRECAMBRIAN	ep€	**EARLIER PRECAMBRIAN METAMORPHIC ROCKS**—Archean on some maps	Gneiss, schist, and metaconglomerate in the Manly Peak quadrangle. Granite gneiss in the Quail Mountains. Quartzite, calc-silicate rocks, gneiss, schist, basic complex of gabbroic and dioritic gneiss, and migmatite in the Soda Mountains area. Diorite, marble and other metasedimentary rocks, diorite gneiss, and granite gneiss in the Avawatz Mountains. Elsewhere undifferentiated earlier Precambrian metamorphic rocks.

NOTES

[1] Paleocene (or older) age. McKenna, M. C., 1955, Paleocene mammal, Goler Formation, Mojave Desert, California: Am. Assoc. Petroleum Geologists Bull., vol. 39, pp. 512-515, and McKenna, M. C., 1960, A continental Paleocene vertebrate fauna from California: Amer. Museum Novitiates, no. 2024, Nov. 29, p. 1-20.

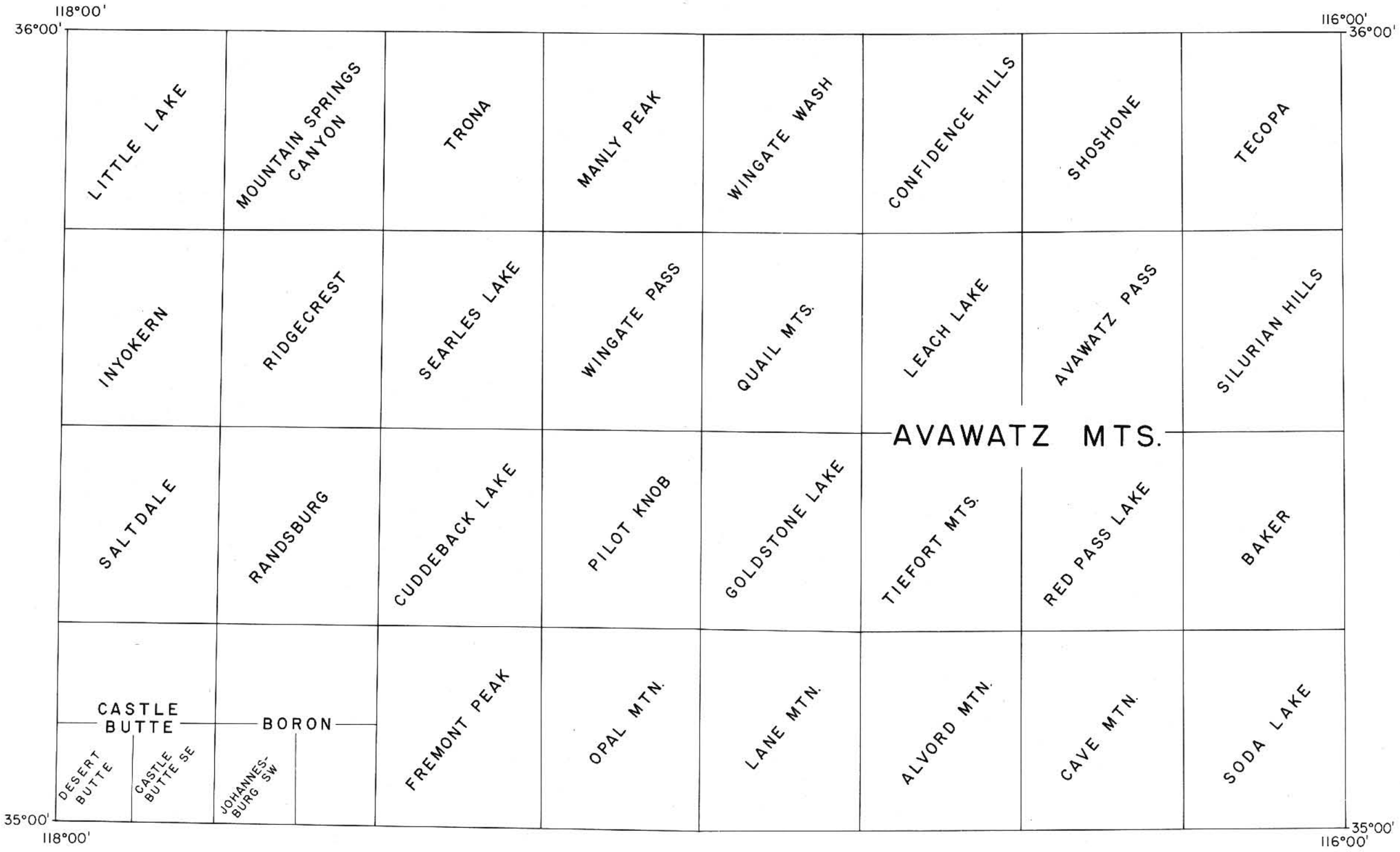
[2] Not necessarily in stratigraphic sequence inasmuch as interrelationships of these formations are not completely understood.

TOPOGRAPHIC QUADRANGLES

WITHIN THE TRONA SHEET

AVAILABLE FROM THE U.S. GEOLOGICAL SURVEY

1962



View north over the Avawatz Mountains toward Death Valley. Prominent white beds in center background are fine-grained sediments deposited by the Amargosa River. White cliffs (center) are steeply dipping beds of Precambrian marble. Avawatz Peak, right foreground, composed of Mesozoic granitic rocks, is bounded on its left flank by the Arrastre Spring fault zone. The distinctly bedded exposure in the left foreground consists of early Tertiary nonmarine strata lying on Jura-Triassic metavolcanic rocks.

Photo by Pacific Air Industries, 1949.

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