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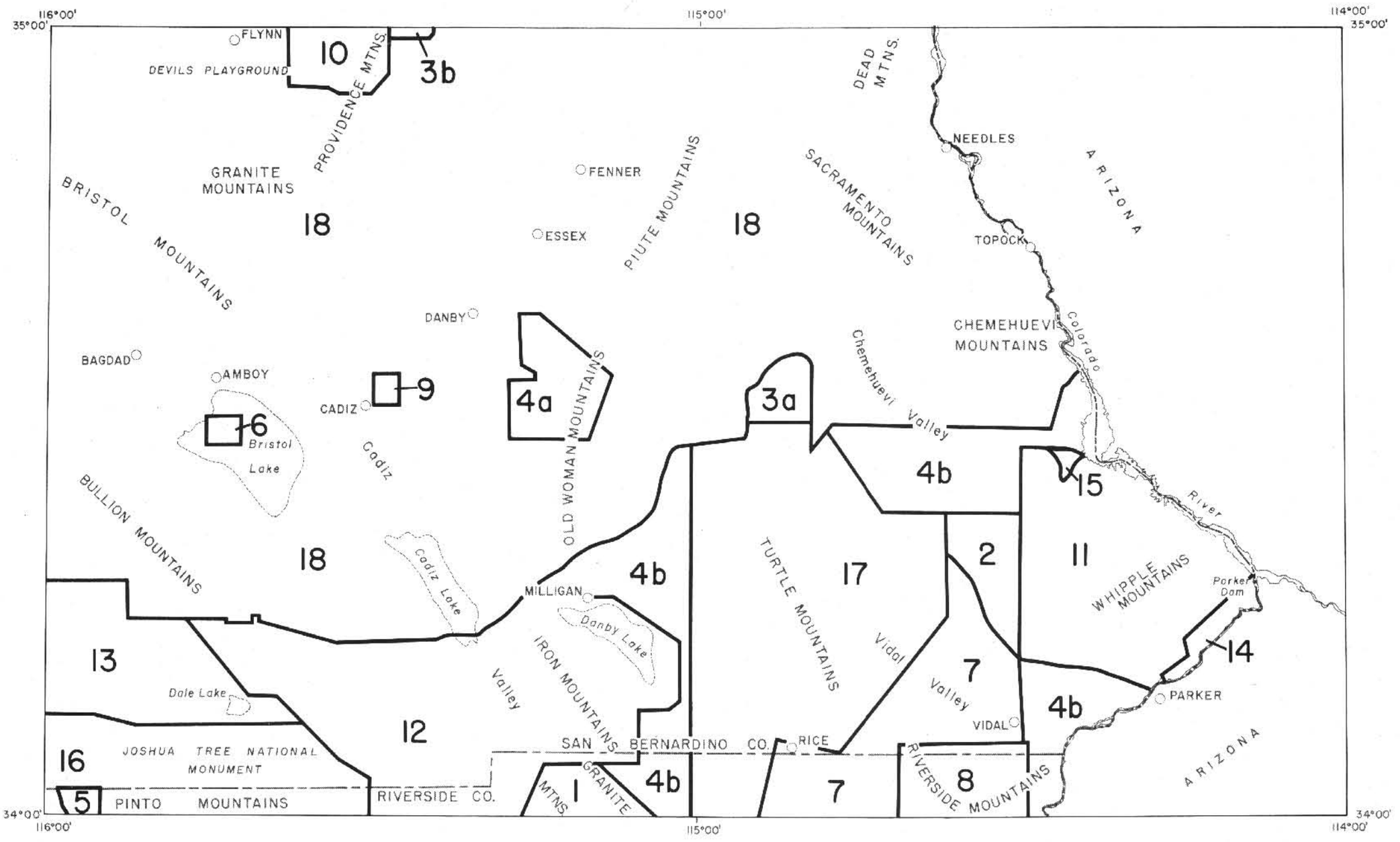
EXPLANATORY DATA
NEEDLES SHEET
GEOLOGIC MAP OF CALIFORNIA
OLAF P. JENKINS EDITION

Compiled by Charles C. Bishop, 1963

Second printing, 1973

INDEX TO GEOLOGIC MAPPING
USED IN THE COMPILATION OF THE NEEDLES SHEET



1. Anonymous, Reconnaissance geology of the Granite Mountains area, scale 1:62,500, unpublished, 1958.

2. Anonymous, Reconnaissance geology of the Whipple Mountains area, scale 1:62,500, unpublished, 1961-62.

3a. Bishop, Charles C., Photogeologic interpretation of part of the Stepladder Mountains quadrangle, California, scale 1:62,500, California Div. Mines and Geology reconnaissance mapping for the State Geologic Map, 1963.

3b. Bishop, Charles C., Photogeologic interpretation of the northern part of the Colton Well quadrangle, California, scale 1:62,500, California Div. Mines and Geology reconnaissance mapping for the State Geologic Map, 1963.

4a. Bishop, Charles C. and Jennings, Charles W., Reconnaissance geologic map and photogeologic interpretation of parts of the Milligan, Essex, Cadiz Lake and Danby quadrangles, California, scale 1:62,500, California Div. Mines and Geology reconnaissance mapping for the State Geologic Map, 1963.

4b. Bishop, Charles C. and Jennings, Charles W., Reconnaissance geologic map and photogeologic interpretation of alluvial and adjacent bedrock areas, scale 1:62,500, California Div. Mines and Geology reconnaissance mapping for the State Geologic Map, 1963.

5. Evans, James R., Xenotime mineralization in the southern Music Valley area, Riverside County, California: California Div. Mines and Geology Special Rept. 79, 24 pp., in press, 1963, Map I: Geologic map of the southern Music Valley, scale 4 inches = 1 mile.

6. Gale, H. S., 1951, Geology of the saline deposits of Bristol Dry Lake, San Bernardino County, California: California Div. Mines and Geology, Special Rept. 13, 21 pp., pl. 1, scale 1:62,500.

7. Giessner, F. W., Map of the Rice and Vidal Valley areas, California (showing reconnaissance geology and location of wells and springs) scale 1:62,500, U. S. Geol. Survey, Ground Water Branch, work in progress, 1962; to be published by Calif. Dept. Water Resources in Bull. 91-8, 1963.

8. Hamilton, Warren B., Geologic map of the Riverside and West Riverside Mountains, scale 1:24,000, U. S. Geol. Survey work in progress, 1963.

9. Hazzard, John C., 1933, Notes on the Cambrian rocks of the eastern Mojave Desert, California: California Univ. Dept. Geol. Sci. Bull., v. 23, no. 2, Map 1, scale 1:187,500.

Southern Pacific Company, Land Dept., Regional geologic mapping program, geologic map of part of T5N R14E SBBM, scale 1:24,000, unpublished, 1959-60.

Lanphere, M. A., Geochronologic studies in the Death Valley-Mojave Desert region, California, Pl. 8; Geologic map of part of the Marble Mountains, scale 1:24,000, Calif. Inst. of Tech., unpublished Ph.D. thesis, 1962.

Lanphere, M. A., Geochronologic studies in the eastern Mojave Desert, California: Jour. Geol., in press, 1964.

10. Hazzard, John C., 1954, Rocks and structure of the northern Providence Mountains, San Bernardino County, California, in California Div. Mines and Geology, Bull. 170, Geology of Southern California, Chpt. IV, contr. 4, Pl. 2, scale 1:31,680.

11. Kemnitzer, Luis E., Structural studies in the Whipple Mountains, southeastern California, scale 1:62,500, Calif. Inst. of Tech., unpublished Ph.D. thesis, 1937.

12. Kupfer, Donald H. and Bassett, Allen M., 1962, Geologic reconnaissance map of part of the southeastern Mojave Desert, California: U. S. Geol. Survey Mineral Investigations, Field Studies Map MF-205, scale 1:125,000.

13. Moyle, W. R., Jr., 1961, Data on water wells in the Dale Valley area, San Bernardino and Riverside Counties: California Dept. Water Resources, Bull. 91-5, 55 pp., fig. 2, scale 1:62,500, prepared by U. S. Geol. Survey, Ground Water Branch.

14. Noble, J. A., Reconnaissance geologic map and photogeologic interpretation of a part of the Whipple Mountains along the Colorado River, scale 1 in. = 880 feet and 1 in. = 1080 feet, unpublished 1963.

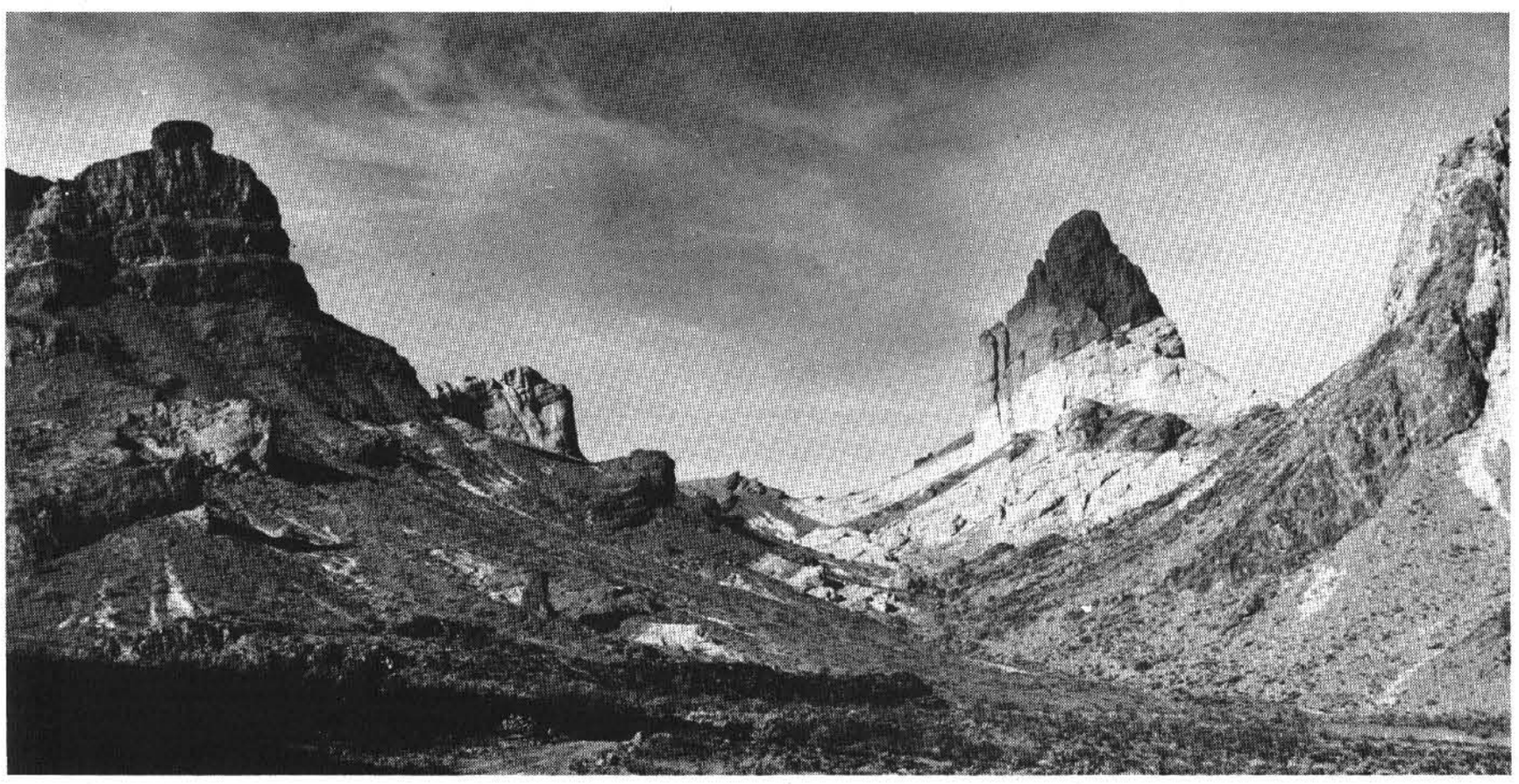
15. Noble, L. F., 1931, Nitrate deposits in southeastern California: U. S. Geol. Survey Bull. 820 (information concerning Quaternary lake bed deposits on p. 39, no map).

16. Rogers, Thomas H. and Jennings, Charles W., Reconnaissance geologic map and photogeologic interpretation of the southern part of the Valley Mountain and Dale Lake quadrangles, California, scale 1:62,500, California Div. Mines and Geology reconnaissance mapping for the State Geologic Map, 1964. (In part after anonymous mining company reconnaissance geologic map of the Pinto-Sheephole Mountains area, scale 1:62,500, unpublished, 1957).

17. Saul, Richard B., Reconnaissance geology and photogeologic interpretation of the Turtle Mountain quadrangle and parts of the Vidal, Savahia Park, and Rice quadrangles, California, scale 1:62,500, California Div. Mines and Geology reconnaissance mapping for the State Geologic Map, 1963.

18. Southern Pacific Company, Land Dept., Regional geologic mapping program, geologic maps of all or parts of T3-11N, R9-18E; T2N, R11-16E; T5-11N, R19-24E SBBM by R. Anctil; H. F. Bonham, Jr.; J. T. Collier; J. W. Cooksley; W. L. Coonrad; A. B. Cunningham; E. A. Danchy; James Gamble; R. T. Laird; Max Schafer; W. H. Spurck; M. S. Tischler, scale 1:24,000, unpublished, 1958-1960. Field checked and modified in part by California Div. Mines and Geology, 1963.

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



View west from Coffin Spring in the northern part of the Turtle Mountains showing typical exposures of Tertiary volcanic rocks. Light colored pyroclastic material is interbedded with darker andesitic flow rocks. *Photo by Richard B. Saul, 1963*

STRATIGRAPHIC NOMENCLATURE—NEEDLES 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**	Wind blown sand, including dune sand.
	✳	**QUATERNARY CINDER CONES**	Recent and Pleistocene(?) cinder cones in the Amboy area.
	Qrv^{b}	**RECENT VOLCANIC ROCKS:** **BASALTIC**	Recent basaltic flows from Amboy Crater.
	Qal	**RECENT ALLUVIUM**	Valley and stream fill, fan deposits; may be locally overlain by thin veneer of eolian sand.
	Qst	**QUATERNARY SALT DEPOSITS**	Salt crystal bodies at or near the surface in Bristol and Danby Lakes.
	Ql	**QUATERNARY LAKE DEPOSITS**	Playa deposits. Lake beds bordering the Colorado River north of the Whipple Mountains, referred to as the Chemehuevi Formation (C. R. Longwell personal communication 11/9/63); may be Pliocene in part.
— Pleistocene	Qc	**PLEISTOCENE NONMARINE SEDIMENTARY DEPOSITS**	Older alluvium, local terrace deposits, dissected fans. Alluvial material bordering the Colorado River dissected by present drainage. "Qc-Qal" indicates undifferentiated older and younger alluvium. Qc_o = older fan deposits in the Pinto Mountains.
		PLEISTOCENE VOLCANIC ROCKS:	
	Qpv^{b}	**BASALTIC**	Basaltic flows and minor amounts of related andesitic and pyroclastic rocks.
	Qpvp	**PYROCLASTIC**	Pyroclastic rocks.
— Pliocene	QP	**PLIOCENE-PLEISTOCENE NONMARINE SEDIMENTARY DEPOSITS**	Silt, sand, gravel and conglomerate (conglomerate commonly of volcanic composition). May be weakly indurated and tilted or deformed. Includes lake beds in Vidal Valley of probable Pliocene or early Pleistocene age.
CENOZOIC — TERTIARY — Miocene		**MIOCENE VOLCANIC ROCKS:**	
	Mv	**UNDIFFERENTIATED**	Undifferentiated volcanic flows, flow breccia, agglomerates, tuffs and tuff breccias of variable composition. Probably Miocene or Mio-Pliocene age.
	Mv^{a}	**ANDESITIC**	Andesite flows and flow breccia with small amounts of rhyolite. Locally may be intrusive. Probable Miocene or Mio-Pliocene age.
	Mv^{b}	**BASALTIC**	Basalt and basaltic andesite flows and flow breccia, including minor pyroclastic deposits and minor intrusive rocks. Probable Miocene or Mio-Pliocene age.
	Mvp	**PYROCLASTIC**	Tuff, tuff breccia, welded tuff, and minor perlite, perlitic rhyolite and conglomerate. Includes a small body of fresh water limestone in the Lava Hills. Probable Miocene or Mio-Pliocene age.
— Undivided	Tc	**TERTIARY NONMARINE SEDIMENTARY ROCKS**	Continental clastic deposits, minor fresh water limestone, and siliceous dolomitic limestone in the Sacramento Mountains.[1] Monolithologic breccias of possible tectonic origin in the Sacramento-Chemehuevi Mountains area. Tertiary continental clastic rocks with interbedded pyroclastic and volcanic flow rocks in the eastern Whipple Mountains. Elsewhere undifferentiated conglomerate and sandstone, with minor amounts of siltstone and tuffaceous deposits. Southern Pacific Company mapping indicates these rocks and the related volcanics in the Piute, Dead, Sacramento and Chemehuevi Mountains are thrust over the underlying basement rocks.
		TERTIARY INTRUSIVE (HYPABYSSAL) ROCKS:	
	Ti^{r}	**RHYOLITIC**	Rhyolite, rhyodacite, and dacite intrusive rocks. Fountain Peak Rhyolite—*biotite rhyolite forming the intrusive mass at Fountain Peak* (Providence Mountains). Perlite in the Bristol Mountains. Rhyolitic intrusive plugs in the Turtle Mountains.
	Ti^{a}	**ANDESITIC**	Andesite, basaltic andesite and latite intrusive rocks.
		TERTIARY VOLCANIC ROCKS:	
	Tv	**UNDIFFERENTIATED**	Volcanic rocks (including flows, and pyroclastic rocks) of varied composition ranging from Oligocene to Mio-Pliocene age. Includes thin undifferentiated continental beds.
	Tv^{a}	**ANDESITIC**	Andesite flows and flow breccia.
	Tv^{b}	**BASALTIC**	Basalt and andesitic basalt flows with minor related pyroclastic rocks.
	Tvp	**PYROCLASTIC**	Pyroclastic deposits of rhyolite, rhyodacite and dacite composition. Tuff and welded tuff (in part water laid); includes minor related flow rocks and clastic material.
MESOZOIC — CRETACEOUS		**MESOZOIC GRANITIC ROCKS:**	
	gr	**UNDIFFERENTIATED**	Granitic rocks ranging in composition from true granite to diorite, of known or probable Mesozoic age.[2] Includes dikes and other small intrusions of varied composition too small to delineate. Also includes pediment areas.
	gr^{a}	**ADAMELLITE (QUARTZ MONZONITE)**	Quartz monzonite and some quartz monzonite porphyry in the Pinto Mountains.(Possible Precambrian re W. J. Miller, 1938, Bull. Geol. Soc. Amer., pp. 417-446).
	gr^{t}	**TONALITE (QUARTZ DIORITE)**	Quartz diorite and diorite in the Pinto Mountains. (Possible Precambrian re W. J. Miller, 1938).
— JURASSIC	bi	**MESOZOIC BASIC INTRUSIVE ROCKS**	Hornblende and biotite gabbro in the Bullion Mountains. Hornblende gabbro in the Gold Park area of the Pinto Mountains. (Possible Precambrian re W. J. Miller, 1938, Bull. Geol. Soc. Amer., pp. 417-446).
	JTRv	**JURASSIC AND/OR TRIASSIC METAVOLCANIC ROCKS**	Flow breccia, dacite and tuff (in part epidotized), possibly including some plutonic rocks in the northern Bristol Mountains. Flows and flow breccia (locally amygdaloidal and possibly locally intruded by Mesozoic plutonic rocks) in Hidden Hill area. Age of these rocks uncertain.
— TRIASSIC	TR	**TRIASSIC MARINE SEDIMENTARY AND METASEDIMENTARY ROCKS**	Moenkopi Formation—*limestone, in part nodular; shale; brown sandstone; and limestone pebble conglomerate* (Providence Mountains).

STRATIGRAPHIC NOMENCLATURE—Continued

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.)
MESOZOIC — UNDIVIDED	ls	**PRE-CRETACEOUS METAMORPHIC ROCKS:** **UNDIFFERENTIATED** **ls = LIMESTONE AND/OR DOLOMITE**	Metasedimentary to meta-igneous rock complex including hornfels, granophyre, phyllite, metadiorite, gneiss, and quartzite, with some Mesozoic intrusive rocks. Greenschist, greenstone, metamorphosed clastic sediments and subordinate metacarbonate rocks (Riverside Mountains). Metacarbonate rocks of the Bristol Mountains, locally include tactite, aplite, and other intrusive rocks. Dolomite marble and tactite in the Pinto Mountains.
	ms	**PRE-CRETACEOUS METASEDIMENTARY ROCKS**	White, buff, and gray quartzite in the Pinto Mountains.
	mv	**PRE-CRETACEOUS METAVOLCANIC ROCKS**	Undifferentiated metavolcanic rocks in Valley Mountain northeast of Twentynine Palms.
	gr-m	**PRE-CENOZOIC GRANITIC AND METAMORPHIC ROCKS**	Migmatites of Precambrian complex rocks and Mesozoic plutonic rocks (Calumet Mountains, Fenner Hills, and Piute Mountains). Undifferentiated plutonic and metamorphic rocks.
PALEOZOIC — PERMIAN UNDIVIDED	$\mathbb{P}$ $\mathbb{P}_{ls}$	**PALEOZOIC MARINE SEDIMENTARY AND METASEDIMENTARY ROCKS** **ls = LIMESTONE**	Metasedimentary rocks of probable Paleozoic age, including metadolomite, white marble, varicolored marble and quartzite (Riverside Mountains and Arica Mountains). Marble, locally cherty and fossiliferous (crinoid stems and brachipods) in the Marble Mountains.
PERMIAN	$\mathbb{P}_m$	**PERMIAN MARINE SEDIMENTARY AND METASEDIMENTARY ROCKS**	Bird Spring Formation—*fossiliferous limestone with minor amounts of calcareous shale and chert* (Providence Mountains); lower part composed of rocks of Pennsylvanian age; however, in Providence Mountains, Bird Spring Formation is largely composed of the upper unit of Permian age. Limestone with minor calcareous shale (Ship Mountains).
CARBONIFEROUS	CP	**PENNSYLVANIAN MARINE SEDIMENTARY AND METASEDIMENTARY ROCKS**	Limestone and minor black chert (northwestern part of the Ship Mountains).
	CM	**MISSISSIPPIAN MARINE SEDIMENTARY AND METASEDIMENTARY ROCKS**	Monte Cristo Limestone—*includes: Yellow Pine, Anchor, Bullion, and Dawn Limestone members and a basal sandstone member* (Providence Mountains).
DEVONIAN	D	**DEVONIAN MARINE SEDIMENTARY AND METASEDIMENTARY ROCKS**	Sultan Limestone—*limestone and dolomite with local thin sandstone beds* (Providence and southern Marble Mountains).
CAMBRIAN	$\mathbb{C}$	**CAMBRIAN MARINE SEDIMENTARY AND METASEDIMENTARY ROCKS**	Cambrian sedimentary section in the Providence and southern Marble Mountains including: Upper Cambrian "Cornfield Springs" Formation—*dolomite and shale;* Middle Cambrian Bonanza King Formation—*dolomite and partially dolomitized limestone, locally cherty and sandy;* Cadiz Formation—*muddy limestone, shale and quartzite;* Lower Cambrian Chambless Limestone—*limestone with algal nodules;* Latham Shale—*platy shale with thin sandy limestone layers.* Also includes small outcrop area of Prospect Mountain Quartzite of probable Cambrian age.
PRECAMBRIAN	p€ p€s p€g	**UNDIVIDED PRECAMBRIAN METAMORPHIC ROCKS:** **UNDIFFERENTIATED** **SCHIST** **GNEISS**	Essex Series (in part)[3]—*quartzite, marble, dolomite, and interbedded schists.* p€ls = marble in the Old Woman Mountains. Chlorite schists of the Essex Series[3] (Old Woman Mountains). Augen gneiss, granite to dioritic gneiss[3], Fenner Gneiss[3], Kilbeck Gneiss[3], Essex Series[3], and Pinto Gneiss[3]; includes meta-igneous intrusive rocks.
	p€gr	**UNDIVIDED PRECAMBRIAN GRANITIC ROCKS**	Plutonic igneous rocks[4] varying in composition from granite to diorite and gabbro.[3] Generally slightly to highly foliated or gneissic.
	p€c	**PRECAMBRIAN IGNEOUS AND METAMORPHIC ROCK COMPLEX**	Intimate mixture of Precambrian plutonic rocks (diorites to granites) and Precambrian metamorphic rocks, including migmatites.[3]
	ep€	**EARLIER PRECAMBRIAN METAMORPHIC ROCKS**	Augen gneiss (western Providence Mountains and southern Homer Mountains).

NOTES

1. Fossil vertebrates found in the Sacramento Mountains are of a fairly primitive species of *Merychippus* and are probably middle Miocene according to John F. Lance, personal communication 12/18/1963.

2. Radiometric dates of granite rocks from the following areas indicate:
   Marble Mountains (central part)
   165 million years (minimum), Pb^{206}/U^{238}, L. T. Silver, personal communication, 2/5/1964.
   Ship Mountains
   150 million years (minimum), Pb^{206}/U^{238}, L. T. Silver, personal communication, 2/5/1964.
   Piute Mountains
   70.3 million years (± 3.0 m.y.), K/A, Geochron Laboratories, for Calif. Div. Mines and Geology, Sept. 1963.
   West Riverside Mountains
   98.5 million years (± 4.0 m.y.), K/A, Geochron Laboratories, for Calif. Div. Mines and Geology, Sept. 1963.
   Pinto Mountains
   163 million years (± 7 m.y.), K/A, Geochron Laboratories, for Calif. Div. Mines and Geology, Oct. 1963.

3. The age of some of these rocks is uncertain and actually may be younger than Precambrian.

4. Radiometric dates of granitic rocks from the following area indicate:
   Marble Mountains (southern part)
   1450 million years (± 20 m.y.), Pb^{206}/U^{238}, Silver, L. T. and McKinney, C. R., 1963, U/Pb isotopic age studies of a Precambrian granite, Marble Mountains: Geol. Soc. Amer. Spec. Papers, No. 73 (1962 meetings), p. 65 (abstract).
   1250 million years (± 20 m.y.), K/A, and 1300 million years (± 30 m.y.) Rb-Sr, Lanphere, M. A., 1964, Geochronologic studies in the eastern Mojave Desert, California: Jour. Geol., in press.
   1190 million years (± 20 m.y.), K/A, and 1215 million years (± 30 m.y.), Rb-Sr., Lanphere, M. A., 1964, Geochronologic studies in the eastern Mojave Desert, California: Jour. Geol., in press.
   1150 million years (± 30 m.y.), K/A, and 1410 million years (± 30 m.y.), Rb-Sr, Lanphere, M. A., 1964, Geochronologic studies in the eastern Mojave Desert, California: Jour. Geol., in press.

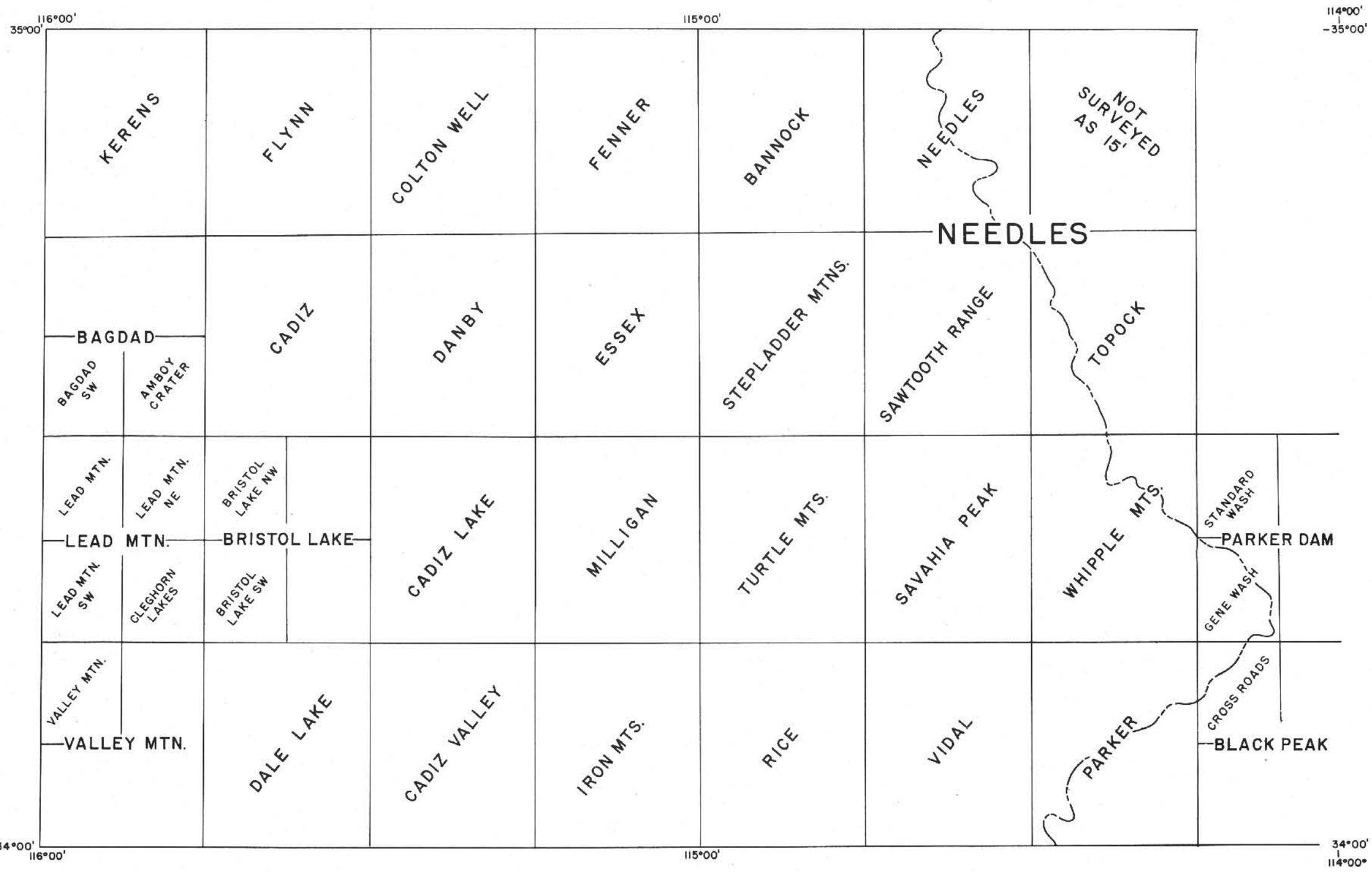
TOPOGRAPHIC QUADRANGLES

WITHIN THE NEEDLES SHEET

AVAILABLE FROM THE U.S. GEOLOGICAL SURVEY

FEDERAL CENTER, DENVER, COLORADO 80225

1963



View northwest of Amboy Crater, a very recent cone composed of volcanic ejecta, surrounded by dark basaltic flow rocks. A thin veneer of wind blown sand gives the basalt a light appearance; thicker sand deposits are white. The Bristol Mountains, composed of dark Precambrian complex rocks and lighter granitic rocks are seen in the upper right, with the Granite Mountains on the skyline behind. The Lava Hills, in the upper left, are composed of Tertiary volcanic rocks underlain by Mesozoic granitic rocks and pre-Cenozoic granitic and metamorphic rocks. *Photo by R. C. Frampton and J. S. Shelton, Claremont, California.*

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