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

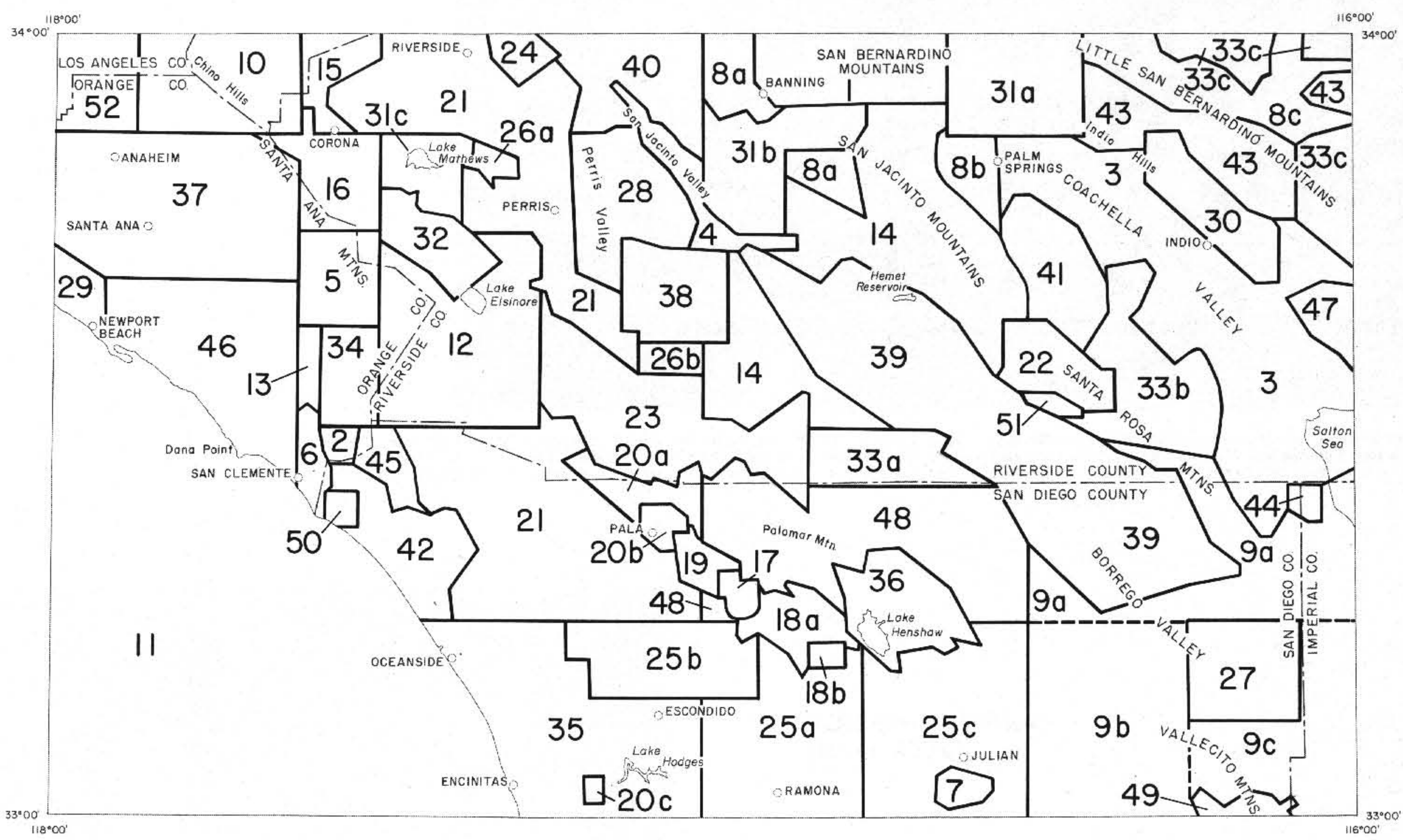
STATE OF CALIFORNIA
Edmund G. Brown, *Governor*
THE RESOURCES AGENCY
Hugo Fisher, *Administrator*

DEPARTMENT OF CONSERVATION
DeWitt Nelson, *Director*

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

Complied by Thomas H. Rogers, 1965

INDEX TO GEOLOGIC MAPPING
USED IN THE COMPILATION OF THE SANTA ANA SHEET



1. Allen, C. R., 1957, San Andreas fault zone in San Gorgonio Pass, southern California: Geol. Soc. America Bull. vol. 68, no. 3, pp. 315–350, Pl. 1, scale 1:63,360; Pl. 2, scale 1:31,680; Pl. 3, scale 1:15,840; Pl. 4, scale 1:15,840. Also *in* Geology of southern California: California Div. Mines Bull. 170, 1954, map sheet 20: Geology of the north side of San Gorgonio Pass, scale 1:62,500 (local additions to faulting in northern part of area from T. W. Dibblee, Jr., ref. no. 8a).

2. Ball, A. R., Geology of the northern and western parts of the San Clemente quadrangle, Orange County, California, scale 1:24,000, University Southern California, unpublished M.A. thesis,.1961.

3. California Dept. Water Resources, 1964, Coachella Valley Investigation: Bull. 108, Pl. 3A, 3B, 3C, scale 1:63,360, compiled by J. R. Cummings (in part after T. W. Dibblee, Jr., 1954, ref. no. 9; modifications of high shoreline of ancient Lake Coahuila from studies of prehistoric lakes of the Salton Sea basin by G. M. Stanley, Fresno State College, faculty research, personal communication, 11/23/64; for discussion of calcareous tufa see J. C. Jones, 1914, The tufa deposits of the Salton Sink, *in* Carnegie Institute Washington, Pub. no. 193, pp. 79–83).

4. California Div. Water Resources, 1959, Santa Ana River Investigation: State Water Resources Board Bull. 15, Appendix B, Geology of San Jacinto and Elsinore basins, Pl. 1A, scale 1:31,680.

5. Carson, M. V., Geology of Santiago Peak quadrangle, Orange and Riverside Counties, California, scale 1:24,000, University Southern California, M.A. thesis in progress, 1964.

6. Cleveland, G. B. and Blanc, R. P., Slope stability related to geology, San Clemente area, Orange and San Diego Counties, California, scale 1:12,000, California Div. Mines and Geology, work in progress, 1964 (locally from A. R. Ball, ref. no. 2).

7. Creasey, S. C., 1946, Geology and nickel mineralization of the Julian-Cuyamaca area, San Diego County, California: California Jour. Mines and Geol., vol. 42, no. 1, pp. 15–29, Pl. 2, scale 1:24,000 mapped by S. C. Creasey and R. M. Hutchinson.

8a. Dibblee, T. W., Jr., Geologic map of part of the Banning quadrangles, scale 1:62,500, unpublished (surficial deposits in San Gorgonio Pass from California Dept. Water Resources, ref. no. 3).

8b. Dibblee, T. W., Jr., Geologic map of part of the Palm Springs quadrangle, scale 1:62,500, unpublished, 1957–1963.

8c. Dibblee, T. W., Jr., Geologic maps of the Edom (Thousand Palms) and Lost Horse Mountain (Pinyon Well) quadrangle, scale 1:62,500, unpublished, 1944–1965.
Hope, Roger A., Geologic mapping along the Eagle Mountain fault zone, Riverside County, California, scale 1:62,500, University California, Los Angeles, Ph.D. thesis in progress, 1965.

*9. Dibblee, T. W., Jr., 1954, *in* Geology of southern California: California Div. Mines Bull. 170, Chap. II, Contrib. 2: Geology of the Imperial Valley region, California, Pl. 2, scale 1:375,000; also used the following unpublished geologic quadrangles mapped by T. W. Dibblee, Jr.: a) Rabbit Peak and Clark Lake quadrangles, scale 1:62,500 (additions in Clark Lake quadrangle by F. H. Weber, Jr., 1963, ref. no. 48); b) Borrego quadrangle, scale 1:62,500 (additions by F. H. Weber, Jr., 1963, ref. no. 48; Gastil, R. G. and Bushee, J., 1961, Geology and geomorphology of eastern San Diego County *in* Field trip guidebook, 57th Annual Meeting, Cordilleran Section, Geol. Soc. of America, San Diego State College, maps nos. 5 and 6, scale 1:62,500; M. W. Hart, geology of an area including the Elsinore fault between Banner Grade and Vallecito Valley, scale 1:24,000, San Diego State College, unpublished senior report, 1964; and R. F. Mueller and K. C. Condie, 1964, Stability relations of carbon mineral assemblages in the southern California batholith: Jour. Geol. vol. 72, no. 4, Fig. 2, scale 1 inch = 1000 feet); c) Borrego Mountain quadrangle, scale 1:62,500 (in part after W. E. Ver Planck, 1952, Gypsum in California, California Div. Mines Bull. 163, Pl. 20, scale 1:31,680; modifications of high shoreline of ancient Lake Coahúila from studies on prehistoric lakes of the Salton Sea basin by G. M. Stanley, Fresno State College, faculty research, personal communication, 11/23/64).

10. Durham, D. L. and Yerkes, R. F., 1964, Geology and oil resources of the eastern Puente Hills area, southern California: U. S. Geol. Survey Prof. Paper 420-B, Pl. 1, scale 1:24,000.

11. Emery, K. O. and Shepard, F. P., 1945, Lithology of the sea floor off southern California: Geol. Soc. America Bull., vol. 56, no. 4, pp. 431–478. (In addition, unpublished offshore geologic data collected by K. O. Emery, personal communication, 1961.)
Fowler, G. A., Submarine topography and geology of Lasuen Seamount, southern California: University Southern California unpublished report in marine geology, 11 pp., 1958.
Buffington, E. C. and Moore, D. G., 1963, Geophysical evidence on the origin of gullied submarine slopes, San Clemente, California: Jour. Geol. vol. 71, no. 3, Fig. 3, scale 1 inch = approx. 9500 feet.

12. Engel, R., 1959, Geology of the Lake Elsinore quadrangle, California: California Div. Mines Bull. 146, Pl. 1, scale 1:62,500.
Jahns, R. H., 1954, ref. no. 20a, maps nos. 5 and 6, scale 1:96,000.

13. Fernandez, A. P., Geology of a portion of the Capistrano basin, California, scale 1:12,000, University California, Los Angeles, unpublished M. A. thesis, 1959.

*14. Fraser, D. M., 1931, Geology of San Jacinto quadrangle south of San Gorgonio Pass, California: California Div. Mines, Mining in California, vol. 27, no. 4, pp. 494–540, map p. 540, scale 1:125,000, (modified in northwest corner by Southern Pacific Company, ref. no. 43 and California Dept. Water Resources, 1964, ref. no. 3; additions in southern part by T. H. Rogers and D. M. Morton, Reconnaissance geologic mapping and photogeologic interpretation in parts of Sage, Bachelor Mountain, Hemet, and Idyllwild quadrangles, scale 1:24,000 and 1:62,500, California Div. Mines and Geology, reconnaissance mapping for the State Geologic Map, 1964).

15. Garrett, A. A. and Thomasson, H. G., Jr., 1949, Groundwater outflow from the Chino basin, California and the controlling geologic and hydrologic conditions: U. S. Geol. Survey open file report, Pl. 102, scale 1:62,500.

16. Gray, C. H., Jr., 1961, Geology of the Corona South quadrangle and the Santa Ana Narrows area, Riverside, Orange, and San Bernardino Counties, California: California Div. Mines Bull. 178, Pls. 1 and 3, scale 1:24,000 (in part after E. H. Pampayen, Geology of the Cajalco area, Riverside County, California, scale 1:31,250, Pomona College, unpublished M.A. thesis, 1952).

17. Hanley, J. B., 1951, Economic geology of the Rincon pegmatites, San Diego County, California: California Div. Mines Special Rept. 7-B, Pl. 1, scale 1:24,000.

18a. Hanley, J. B., unpublished geologic mapping in the Palomar Mtn. and Ramona quadrangles, scale 1:24,000, 1946–1948.

18b. Hanley, J. B., Geology of the Pala-Rincon-Mesa Grande pegmatite belt of southern California: U. S. Geol. Survey (manuscript in preparation, 1957).

19. Howes, T. B., A brief study of the geology and ground water conditions in the Pauma Valley area, San Diego County, California, scale 1:24,000, California Institute Technology, unpublished M.S. thesis, 1955 (local additions within the Quaternary deposits by F. H. Weber, Jr., ref. no. 48; and within the bedrock by J. B. Hanley, ref. no. 18a).

20a. Jahns, R. H., 1954, *in* Geology of southern California: California Div. Mines Bull. 170, Guidebook no. 5: Northern part of the Peninsular Range Province, map no. 7, scale 1:96,000 (local additions from J. B. Hanley, ref. no. 18a).

20b. Jahns, R. H. and Wright, L. A., 1951, Gem- and lithium-bearing pegmatites of the Pala district, San Diego County, California: California Div. Mines Special Rept. 7-A, Pl. 1, scale 1:20,000 (Pala Conglomerate, Qc, after F. H. Weber, Jr., 1963, ref. no. 48).

20c. Jahns, R. H. and Lance, J. F., 1950, Geology of the San Dieguito pyrophyllite area, San Diego County, California: California Div. Mines Special Rept. 4, Pl. 1, scale 1:6,000. (See ref. 35 for Pleistocene marine deposits.)

21. Larsen, E. S., Jr., 1948, Batholith and associated rocks of Corona, Elsinore, and San Luis Rey quadrangles, southern California: Geol. Soc. America Memoir 29, Pl. 1, scale 1:125,000; also published in California Div. Mines Bull. 159, Pl. 1. Modifications and additions as follows:
I. In Riverside County:
(i) Gray, C. H., Jr., Geologic map of the Corona North quadrangle, scale 1:24,000, California Div. Mines and Geology, work in progress, 1964 (local modifications within granitic and metamorphic rocks by R. J. Proctor, Met. Water Dist. of So. Calif., unpub. geologic map, 1960).
(ii) Proctor, R. J., Geologic map of the Riverside West quadrangle, scale 1:24,000, Met. Water Dist. of So. Calif., unpub. geologic map, 1960.
(iii) Banks, P. O., Some systematics of uranium and lead distribution in relation to the petrology of the Mt. Rubidoux granites, Riverside Co., scale 1:7,920, Calif. Inst. Tech., unpub. Ph.D. thesis, 1963.
(iv) Irving, E. M., The geology of a portion of the Corona and Riverside quadrangles, near Corona, scale 1:20,800, Univ. Calif., Los Angeles, unpub. M.A. thesis, 1935.
(v) Gray, C. H., Jr., 1954, Geology of the Corona-Elsinore-Murrieta area, Riverside County *in* Geology of southern California: California Div. Mines Bull. 170, map sheet 21, scale 1:187,500.
II. In San Diego County:
(i) Weber, F. H., Jr., ref. no. 48.
(ii) Hanley, J. B., ref. no. 18a.

22. Lockwood, J. P., Geology of an area in the western Santa Rosa Mountains of southern California, with special emphasis on a previously unreported mylonite belt, scale 1:48,000, University California, Riverside, unpublished senior thesis, 1961.

23. Mann, J. F., Jr., 1955, Geology of a portion of the Elsinore fault zone, California: California Div. Mines Special Rept. 43, Pl. 1, scale 1:62,500.
Jahns, R. H., 1954, ref. 20a, map no. 6 and 7, scale 1:96,000.

24. Menzie, T. E., The geology of the Box Spring Mountains, Riverside County, California, scale 1:24,000, Stanford University, unpublished M.S. thesis, 1962.

25a. Merriam, R. H., 1946, Igneous and metamorphic rocks of the southwestern part of the Ramona (30′) quadrangle, San Diego County, California: Geol. Soc. of America Bull. vol. 57, no. 3, pp. 223–260, Pl. 1, scale 1:160,000. Later revisions by R. H. Merriam, 1954, *in* Geology of southern California: California Div. Mines Bull. 170, Geologic Guide no. 5, map no. 10, scale 1:203,000 and R. H. Merriam, unpublished mapping in the Ramona quadrangle, 1951–1953 (additions by F. H. Weber, Jr., ref. no. 48 and G. L. Anderson, soil studies in the Cleveland National Forest, U. S. Dept. Agriculture, Forest Service, work in progress, 1964).

25b. Merriam, R. H., 1954, A typical portion of the southern California batholith, San Diego County, *in* Geology of southern California: California Div. Mines Bull. 170, map sheet no. 22, scale 1:62,500 (modifications and additions from San Diego State College student mapping under direction of R. G. Gastil, scale 1:24,000, 1954–1964).

*25c. Merriam, R. H., 1958, Geology of the Santa Ysabel quadrangle, San Diego County: California Div. Mines Bull. 177, Pl. 1, scale 1:62,500 (additions from R. H. Jahns, 1954, ref. no. 20a, map no. 9, scale 1 inch = 1.6 miles; M. W. Hart, Geology of an area including the Elsinore fault between Banner Grade and Vallecito Valley, San Diego County, California, scale 1:24,000, San Diego State College, unpublished senior report, 1964; and G. C. Copenhaver, Structural and mining geology of the Julian schist, Julian, San Diego County, California, scale 1 inch = 200 feet, San Diego State College, unpublished senior report, 1963).

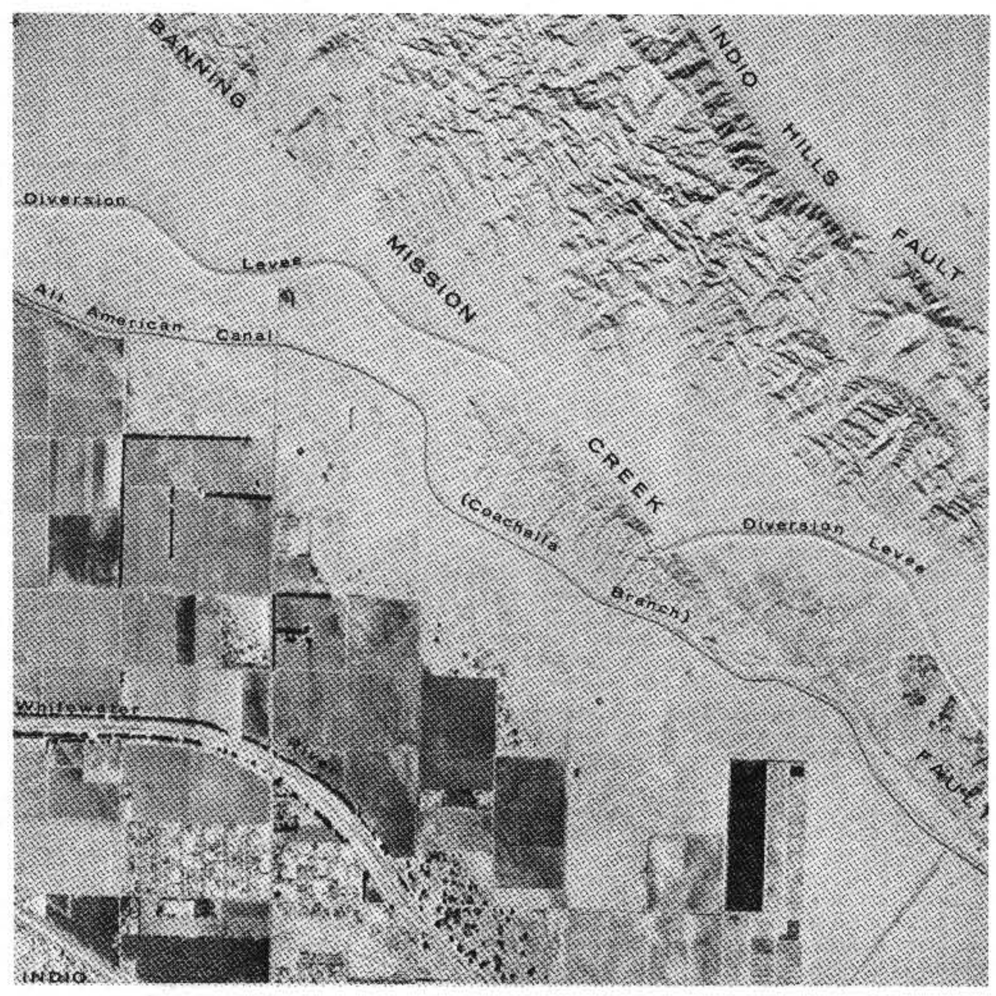
26a. Metropolitan Water District of Southern California, unpublished report no. 533, Final geological report on the Bernasconi and Val Verde tunnel lines, Colorado River Aqueduct, by F. L. Ransome, 1932; and unpublished report no. 657, Geophysical survey no. 14, bedrock location, Val Verde tunnel vicinity, by L. H. Henderson and W. W. Aultman, 1934, (compiled by R. J. Proctor on Steele Peak quadrangle, scale 1:24,000).

continued on page 5

WHITTIER FAULT ZONE

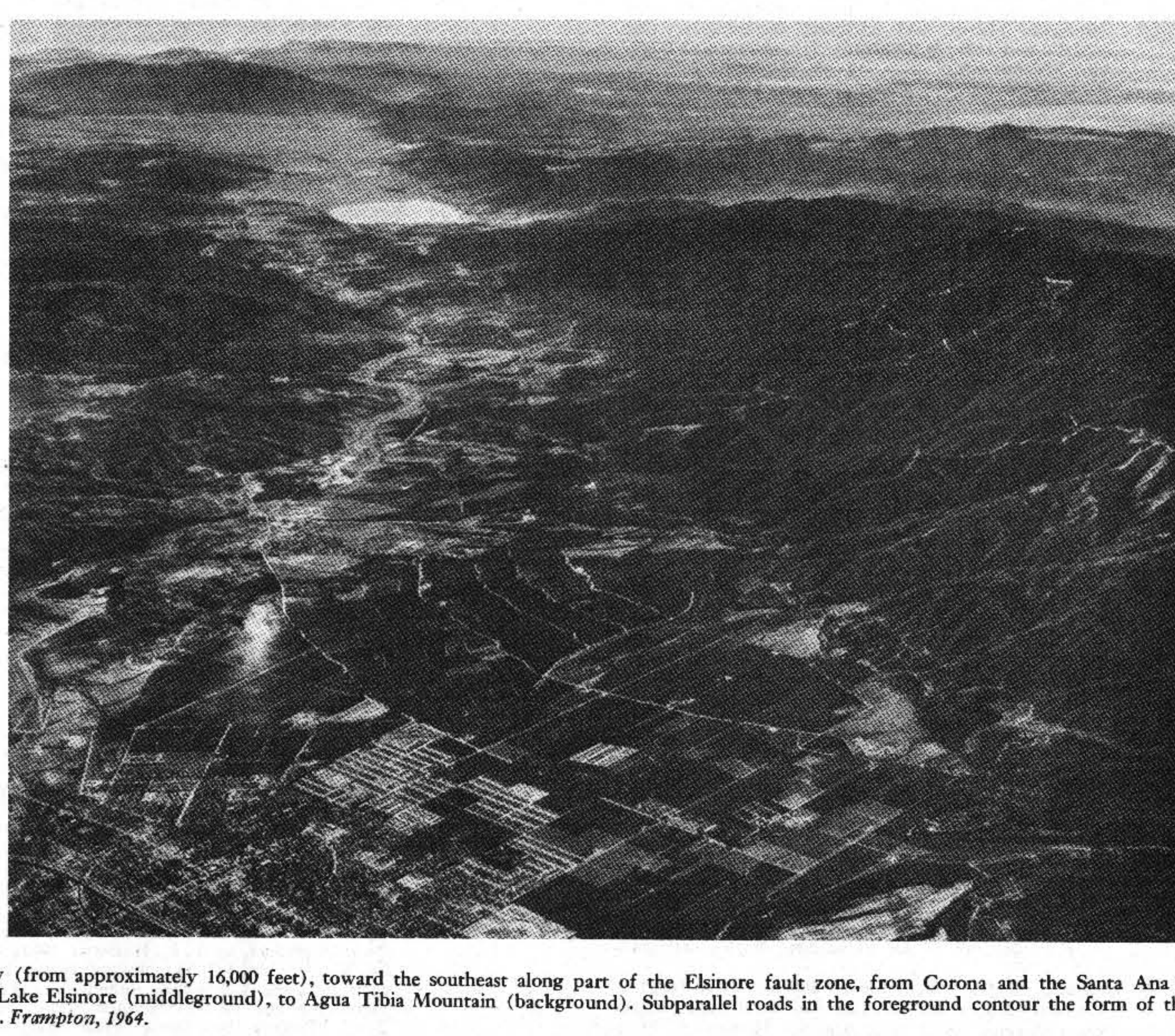
View southeast along the Puente-Chino Hills, toward the Santa Ana Mountains (right skyline). The Whittier fault zone, left of the rectangular reservoir (top of ridge, middleground), slices through Pliocene and Miocene marine sedimentary rocks, and is the dominant structural feature in the Brea-Olinda oil field area. Production from this field has amounted to more than 295,000,000 barrels (12th largest producing field in California), from more than 1,000 wells. *Photo by R. C. Frampton and J. S. Shelton, 1949.*

BANNING-MISSION CREEK FAULT



Vertical aerial photograph of the fault-bounded Indio Hills, in the Coachella Valley. The Banning-Mission Creek fault, part of the San Andreas fault zone, is exceptionally linear and marked by well developed scarps. Extensively deformed sedimentary rocks in the Indio Hills include well-bedded Plio-Pleistocene sandstone and shale and poorly-bedded Pleistocene conglomerate. *Photo from U. S. Department of Agriculture, 1953.*

ELSINORE FAULT ZONE



High altitude view (from approximately 16,000 feet), toward the southeast along part of the Elsinore fault zone, from Corona and the Santa Ana Mountains (foreground), across Lake Elsinore (middleground), to Agua Tibia Mountain (background). Subparallel roads in the foreground contour the form of the Corona alluvial fan. *Photo by R. C. Frampton, 1964.*

STRATIGRAPHIC NOMENCLATURE

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.)
	Qs	**RECENT DUNE SAND**	Wind blown sand, local dunes.
Recent	Qal	**RECENT ALLUVIUM**	Unconsolidated stream, river channel, and alluvial fan deposits. Includes interbedded peat and lagoonal sediments along the coast, decomposed granite in Lost Horse Mountain quadrangle, local eolian sand in Coachella Valley and San Gorgonio Pass, and prominent rock slide in the Palm Desert quadrangle.
	Ql	**QUATERNARY LAKE DEPOSITS**	Deposits of Lake Coahuila (Coahuilla)—*clay, silt, sand, and beach gravel* (contains fossil fresh water fauna and fossiliferous calcareous tufa along west side Coachella Valley, see J. C. Jones, 1941, under reference 3). Lake beds of probable Pleistocene age and younger playa deposits in eastern ¼ of Santa Ana sheet. Interbedded lacustrine sediments and peat near Julian.
	Qt	**QUATERNARY NONMARINE TERRACE DEPOSITS**	Local stream terrace deposits. Extensively dissected and locally folded terrace deposits in Borrego Valley. Thin nonmarine red-brown deposits on coastal marine terraces north of Newport Bay area (locally includes the late Pleistocene marine Palos Verdes Sand).
	Qg	**QUATERNARY GLACIAL DEPOSITS**	Deposits of questionable glacial origin on San Jacinto Peak (described by R. P. Sharp, et al., 1959, Amer. Jour. Sci., vol. 257, p. 93).
QUATERNARY	Qm	**PLEISTOCENE MARINE DEPOSITS AND MARINE TERRACE DEPOSITS**	Elongate beach ridge sand deposits containing abundant ironstone concretions (ref.: K. O. Emery, 1950, Ironstone concretions and beach ridges of San Diego Co.: California Jour. Mines and Geol. vol. 46, no. 2, pp. 213-221); Sweitzer Formation (?)—*well indurated sandstone and conglomerate* (south of Oceanside); Lindavista Formation—*sandstone and conglomerate terrace deposits, in part nonmarine* (south of Oceanside; contains late Pleistocene fauna). Unnamed marine-nonmarine terrace deposits between Oceanside and Newport Bay. San Pedro Formation—*clay with interbedded thick sand and gravel lenses, local fluviatile and lagoonal sediments* (north of Newport Bay).
Pleistocene	Qc	**PLEISTOCENE NONMARINE SEDIMENTARY DEPOSITS**	Qc: undeformed or slightly deformed dissected alluvial fan deposits: Burnt Canyon Breccia and Heights Fanglomerate in San Gorgonio Pass. Pauba Formation—*dominantly boulder gravel and fanglomerate* and Dripping Springs Formation—*coarse fanglomerate* in Temecula Valley and Warner Springs area. Pala Conglomerate in Pauma Valley. Unnamed silt, sand, and gravel elsewhere (locally includes alluvial terrace deposits in Santa Ana Mountains and Puente Hills and decomposed granite in the Corona-Riverside area). Qc_0: extensively folded, faulted, and dissected alluvial fan deposits: Cabezon Fanglomerate and deformed gravels of Whitewater River in San Gorgonio Pass. Bautista Beds—*interbedded gray fine-grained sandstone and shale grading southeastward into coarse gravel* along San Jacinto fault zone (contains vertebrate fauna of Pleistocene age). Ocotillo Conglomerate—*gray unconsolidated boulder conglomerate* along margins of Coachella Valley. Temecula Arkose in Temecula Valley and Warner Springs area. La Habra Formation—*interbedded conglomerate, sandstone, and mudstone* south of Whittier fault zone.
	 Qpv^b	**PLEISTOCENE VOLCANIC ROCKS:** **BASALTIC**	 Nigger Canyon Volcanics—*basaltic tuff, agglomerate, dikes, and flows* (Temecula Valley). Santa Rosa Basalt—*olivine basalt* in the Temecula Valley area and adjacent Santa Ana Mountains (may be late Pliocene, J. F. Mann, 1955).
	✳	**QUATERNARY CINDER CONES**	Parasitic cinder cone on Vail Mountain (Temecula Valley area).
	QP	**PLIOCENE-PLEISTOCENE NONMARINE SEDIMENTARY DEPOSITS**	Gray to brown conglomerate, arkosic sandstone, siltstone, and red claystone (Indio Hills and Mecca Hills); correlated by some geologists with the Palm Spring Formation (Pc?) and Canebrake Conglomerate (Pc?).
	Pc	**UNDIVIDED PLIOCENE NONMARINE SEDIMENTARY ROCKS**	Canebrake Conglomerate (Pc?) [1]—*conglomerate and fanglomerate, local red and green shale, fine-grained sandstone, and claystone* (this unit is interpreted as being the lateral equivalent of the Imperial and Palm Spring Formations as well as overlying the Palm Spring Formation in part); Palm Spring Formation (Pc?)[1]—*interbedded conglomerate, arkosic sandstone, red to gray siltstone and claystone, commmonly with silicified ironwood fragments;* grades laterally into lake beds of Borrego Formation (Tl) and coarse sediments of Canebrake Conglomerate; considered to be Pleistocene in part by T. Downs and G. D. Woodard, 1961: Geol. Soc. Amer. Spec. Paper 68, p. 21, in Borrego Valley and Vallecito Badlands. Mecca Formation (Pc?)—*gray basal conglomerate overlain by continental red sandstone and claystone* (may correlate either with Upper Miocene Split Mountain Formation or Pliocene Canebrake Conglomerate according to T. W. Dibblee, Jr., 1954, California Div. Mines Bull. 170, Chap. II, p. 24). San Timoteo Formation—*interbedded sandstone, siltstone, and conglomerate* in San Gorgonio Pass area (contains a late Pliocene vertebrate fauna near base; upper part considered to be Pleistocene); Upper Member of the Mt. Eden Formation—*interbedded gray to buff sandstone and shale* (contains middle Pliocene flora and vertebrate fauna, D. I. Axelrod, 1938, Carnegie Inst. of Wash. Pub. #476, p. 128); Mt. Eden Red Beds Member (of the Mt. Eden Formation)—*red beds grading up into gray sandstone and shale.* Painted Hill Formation—*interbedded conglomerate and sandstone of predominantly granitic and volcanic detritus* (overlies Imperial Formation, and included in middle (?) Pliocene by C. R. Allen, 1957).
	Pu	**UPPER PLIOCENE MARINE SEDIMENTARY ROCKS**	Niguel Formation—*sandstone and siltstone with local conglomerate* (San Juan Capistrano area). Fernando Formation, Upper Member (upper Pliocene rocks heretofore called Pico Formation [2])—*sandstone, siltstone, and conglomerate* (Los Angeles basin).
CENOZOIC Pliocene	 Pv^r Pv^b	**PLIOCENE VOLCANIC ROCKS:** **RHYOLITIC** **BASALTIC**	 Truckhaven Rhyolite—*varicolored rhyolite and rhyolitic tuff* (Rabbit Peak 15′ quadrangle). Olivine basalt flows and associated dikes within the Painted Hill Formation (Palm Springs 15′ and Banning quadrangles).
	Pml	**MIDDLE AND/OR LOWER PLIOCENE MARINE SEDIMENTARY ROCKS**	Imperial Formation—*interbedded claystone, siltstone, and sandstone,* abundant oyster shell "reefs" (Coachella and Borrego Valleys; considered to be early Pliocene, J. W. Durham, 1954, California Div. Mines Bull. 170, Chap. 3, p. 24). Fernando Formation, Lower Member (lower Pliocene rocks heretofore called Repetto Formation [3])—*interbedded sandstone, pebble conglomerate, and siltstone, local intraformational breccia* (Los Angeles basin).
	Pmlc	**MIDDLE AND/OR LOWER PLIOCENE NONMARINE SEDIMENTARY ROCKS**	Hathaway Formation—*interbedded conglomerate, breccia, sandstone, and siltstone with numerous clasts of augen and flaser gneiss* (underlies Imperial Formation and included in early (?) Pliocene by C. R. Allen, 1957). Unnamed fluviatile and lacustrine green sandstone and siltstone in Lake Mathews and Steele Peak quadrangles (contains early Pliocene vertebrate fauna, R. J. Proctor and T. Downs, 1962, Geol. Soc. Amer. Special Paper 73, p. 59, abstract).
	Mu	**UPPER MIOCENE MARINE SEDIMENTARY ROCKS**	Capistrano Formation—*siltstone, fine sandstone, and shale with local limestone concretions, conglomerate and breccia lenses* (in part early Pliocene). Oso Member of Capistrano Formation—*white massive sandstone.* Puente Formation—*interbedded massive sandstone, conglomerate, siltstone, shale and diatomite, local phosphatic nodules and buff andesite tuff* (subdivided into Sycamore Canyon Member; Yorba Member; Soquel Member; and La Vida Member). Marine member of the upper Split Mountain Formation—*olive-green drab sandstone and shale* and Fish Creek Gypsum Member of the upper part of the Split Mountain Formation—*white interbedded gypsum and anhydrite* (probably marine [4]).
TERTIARY	Muc	**UPPER MIOCENE NONMARINE SEDIMENTARY ROCKS**	Nonmarine part of the upper Split Mountain Formation—*gray conglomerate* (composed of two members, one above and one below the marine member (Mu) of the Split Mountain Formation). Coachella Fanglomerate—*massive conglomerate and red-brown sandstone, basal breccia of gray schist fragments* (unconformably overlain by the early Pliocene Imperial Formation, San Gorgonio Pass area).
Miocene	 Mv^a Mv^p Mv^b	**MIOCENE VOLCANIC ROCKS:** **ANDESITIC** **PYROCLASTIC** **BASALTIC**	 Upper member of El Modeno Volcanics—*andesite flows and flow breccia.* Middle member of El Modeno Volcanics—*palagonite tuff and tuff breccia.* Lower member of El Modeno Volcanics—*vesicular olivine basalt* (the El Modeno Volcanics are middle Miocene in age; Santa Ana Mountains area). Unamed pale red to purple olivine basalt flow within the upper Miocene Coachella Fanglomerate.
	Mc	**UNDIVIDED MIOCENE NONMARINE SEDIMENTARY ROCKS**	Lower part of the Split Mountain Formation—*reddish-brown arkosic sandstone, conglomerate, and sedimentary breccia.*
	Mm	**MIDDLE MIOCENE MARINE SEDIMENTARY ROCKS**	Monterey Formation—*light-colored siliceous and diatomaceous shale and siltstone; local sandstone, limy beds, and andesite tuff* (in part late Miocene; includes rocks mapped as Modelo Formation in Canada Gobernadora quadrangle); San Onofre Breccia—*blue-gray to red schist breccia, interbedded grit and sandstone;* Topanga Formation—*sandstone, conglomerate, siltstone, and shale; local andesite flows, flow-breccia, and tuff.*
	Ml	**LOWER MIOCENE MARINE SEDIMENTARY ROCKS**	Vaqueros Formation—*interbedded marine siltstone and sandstone* in San Joaquin Hills; elsewhere included with Sespe Formation as Sespe-Vaqueros Formations undifferentiated (Φc).
Oligocene (?)	Φc	**OLIGOCENE NONMARINE SEDIMENTARY ROCKS**	Sespe and Vaqueros Formations undifferentiated—*marine and nonmarine vari-colored sandstone, conglomerate, siltstone, and sandy claystone* (upper part contains early to middle Miocene marine fauna). Sespe Formation—*buff, red, white, and green sandstone, grit, clay, and conglomerate* in San Joaquin Hills (lower part may be late Eocene).
	Ec	**EOCENE NONMARINE SEDIMENTARY ROCKS**	Poway Conglomerate—*sandstone and siltstone, basal red to tan conglomerate* (Rancho Santa Fe quadrangle). "Ballena Gravels" in Ramona 15′ quadrangle (may be in part younger than Eocene).
Eocene	E	**EOCENE MARINE SEDIMENTARY ROCKS**	Santiago Formation—*interbedded white, massive, friable sandstone, siltstone, and conglomerate, locally tuffaceous, in part nonmarine* (north of Oceanside area). Unnamed Eocene sandstone, siltstone, and mudstone; Torrey Formation—*light-colored massive sandstone and local siltstone* (formerly considered a member of the La Jolla Formation); Delmar Formation—*interbedded varicolored fine sandstone, siltstone, and mudstone, numerous biostromal units* (in part Paleocene; south of Oceanside area; formerly considered a member of the La Jolla Formation).
Paleocene	Ep	**PALEOCENE MARINE SEDIMENTARY ROCKS**	Silverado Formation—*upper part consists of marine sandstone, conglomerate, siltstone, and shale; lower part consists of nonmarine to brackish sandstone, conglomerate, red and white mottled clay, minor lignite and basal residual claystone breccia* (Santa Ana Mountains). "Martinez (?) Formation"—*conglomerate, arkose, local thin fossiliferous limestone and shale* (nonmarine in part, containing Eocene flora, Engel, R., 1959, p. 48).

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.)
CENOZOIC — TERTIARY — Undivided	Tc	**TERTIARY NONMARINE SEDIMENTARY ROCKS**	Unnamed stream channel (?) deposits in Steele Peak quadrangle. Unnamed gravel deposits in Rancho Santa Fe quadrangle. Unnamed granitic conglomerate, coarse sandstone, and white and green claystone in the Morro Hill quadrangle (Tc?), possibly correlative with Silverado Formation.
	Tm	**TERTIARY MARINE SEDIMENTARY ROCKS**	Thick-bedded Pliocene (?) sandstone and conglomerate, minor siltstone and shale (Corona South quadrangle). San Mateo Formation—*white coarse-grained sandstone and conglomerate* (southern coastal area; Pliocene (?) age, ref.: A. O. Woodford, 1925; J. G. Vedder, U. S. Geol. Survey, suggests that the "San Mateo Formation" at the type locality may be within the Miocene part of the Capistrano Formation, written communication 2/13/64).
	Tl	**TERTIARY LAKE DEPOSITS**	Borrego Formation—*interbedded fossiliferous shale and sandstone* in Borrego Valley (probably upper Pliocene; considered by T. W. Dibblee, Jr., 1954, to be the lacustrine equivalent of the Pliocene (?) Palm Spring Formation; locally overlies the Palm Spring Formation).
		TERTIARY INTRUSIVE (HYPABYSSAL) ROCKS:	
	Ti^r	**RHYOLITIC**	Dacite stock of Cerro de la Calavera (southeast of Oceanside; probably a volcanic neck). Tridymite dacite of Morro Hill (northeast of Oceanside; a small volcanic neck). Quartz latite stock of San Onofre Creek.
	Ti^a	**ANDESITIC**	Andesitic intrusive rocks in Laguna Beach quadrangle.
	Ti^b	**BASALTIC**	Diabase dikes and sills (Tustin and Laguna Beach quadrangles). Diabase sills intruding the La Vida Member of the Puente Formation (La Habra quadrangle). Intrusive olivine basalt in Joshua Tree National Monument. including Basalt of Malapai Hill
		TERTIARY VOLCANIC ROCKS:	
	Tv^r	**RHYOLITIC**	Tridymite dacite flows and pyroclastic beds associated with the stock of Morro Hill (Pre-Tertiary according to G. A. Waring and C. A. Waring, 1917, Amer. Jour. Sci. 4th Series, vol. 44, pp. 98-104, but believed to be Tertiary by E. S. Larsen, Jr., 1948).
MESOZOIC — CRETACEOUS	Ku	**UPPER CRETACEOUS MARINE SEDIMENTARY ROCKS**	Ku: Williams Formation—*interbedded sandstone, conglomerate, minor shale and limestone concretions;* Ladd Formation—*interbedded shale, conglomerate and sandstone.* Rosario Formation—*interbedded sandstone, siltstone, claystone, and conglomerate.* Ku_c: Trabuco Formation—*red, buff, and gray-green boulder conglomerate; minor sandstone* (generally considered to be nonmarine).
		MESOZOIC GRANITIC ROCKS	
	gr	**UNDIFFERENTIATED**	Undifferentiated types of granite, alaskite, quartz monzonite (adamellite), granodiorite, quartz diorite (tonalite), diorite, aplite and pegmatite dikes, as well as some syenite and gabbro (includes gem-bearing pegmatites of the Pala, Rincon, Mesa Grande, Ramona, and Coahuilla districts, and the tin-bearing quartz-tourmaline veins of the Cajalco district). Bradley "Granodiorite" and San Jacinto "Granodiorite"—*gray, medium- to coarse-grained granitic rock ranging from quartz diorite to granite, weathers to boulders of disintegration.*
	gr^a	**GRANITE AND ADAMELLITE (QUARTZ MONZONITE)**	Leucogranites of Rubidoux Mountain—*white fine-grained, and greenish-gray coarse-grained granite, deeply weathered to boulders of disintegration* (Riverside quadrangle). Roblar Leucogranite—*flesh-colored angular-weathering granite* (Margarita Peak 15′ quadrangle). Cajalco Quartz Monzonite—*light-gray to pink porphyritic quartz monzonite, weathers to boulders of disintegration* (Corona and Riverside quadrangles). Home Gardens Quartz Monzonite Porphyry—*light-gray porphyritic quartz monzonite, includes pink micropegmatite granite, weathers to angular masses* (Corona quadrangle). Cactus (?) Quartz Monzonite—*medium-grained biotite quartz monzonite, weathers to boulders of disintegration* (Banning quadrangle). White Tank Quartz Monzonite and Palms Quartz Monzonite—*light brown to gray biotite quartz monzonite, weathers along joints to spectacular spheroidal boulders* (especially well developed in Joshua Tree National Monument).
	gr^g	**GRANODIORITE**	Woodson Mountain Granodiorite—*light-colored coarse-grained granodiorite with scattered, small dark inclusions, weathers to large boulders of disintegration* (widespread in west half Santa Ana sheet). Lake Wolford Leucogranodiorite—*light-colored, fine-grained, angular-weathering granodiorite* (Escondido and Valley Center quadrangles). Domenigoni Valley Granodiorite—*light-colored granodiorite with abundant oriented dark inclusions, weathers to boulders of disintegration* (Murrieta 15′ quadrangle). Indian Mountain Leucogranodiorite—*nearly white, fine-grained, angular-weathering granodiorite, local oriented dark inclusions* (Sitton Peak and Wildomar quadrangles). Escondido Creek Leucogranodiorite—*light-colored angular-weathering granodiorite with abundant dark inclusions erratically distributed, locally a leucotonalite* (Rancho Santa Fe quadrangle). Mt. Hole Granodiorite—*light-colored porphyritic granodiorite, weathers to boulders of disintegration* (Corona quadrangle). Corona Hornblende Granodiorite Porphyry—*dark-gray granodiorite porphyry* (east of Corona).
	gr^t	**TONALITE (QUARTZ DIORITE) AND DIORITE**	Bonsall Tonalite—*light- to dark-gray tonalite with abundant large oriented inclusions locally drawn out into thin streaks, weathers to boulders of disintegration* (widespread in west half Santa Ana sheet). Green Valley Tonalite—*gray tonalite with small scattered inclusions, weathers to boulders of disintegration* (Ramona-Escondido area). Lakeview Mountain Tonalite—*light-colored coarse-grained tonalite, abundant schlieren in Perris-Hemet area, weathers to boulders of disintegration* (widespread from Perris to Santa Ysabel quadrangles). Estelle Tonalite—*light-gray uniform tonalite, weathers to boulders of disintegration* (Riverside quadrangle). La Sierra Tonalite—*light gray, porphyritic tonalite, weathers to boulders of disintegration* (Corona quadrangle). Stonewall Quartz Diorite—*massive granitoid portion of mixed rock unit in Santa Ysabel quadrangle* (older than San Marcos Gabbro; may be Jurassic). Fargo Canyon "Diorite"—*medium-gray locally foliated quartz diorite, weathers to boulders of disintegration* (Lost Horse Mountain quadrangle).
	bi	**MESOZOIC BASIC INTRUSIVE ROCKS**	San Marcos Gabbro and/or Cuyamaca Gabbro—*highly variable assemblage of hornblende and olivine gabbro, quartz-biotite and olivine norite, and hypersthene and quartz-bearing gabbro; local peridotite, pyroxenite, troctolite, and anorthosite; includes fine-grained lamprophyre dikes* (weathers to deep reddish-brown residual soil). Gold Park Gabbro-Diorite—*highly variable hornblende gabbro and diorite* in Joshua Tree National Monument (possibly Precambrian, ref.: W. J. Miller, 1938, Bull. Geol. Soc. Amer. p. 438). Hornblende diorite in Palm Springs quadrangle.
	ub	**MESOZOIC ULTRABASIC INTRUSIVE ROCKS**	Pyroxenite, hornblendite, metaperidotite, and metapyroxenite (Winchester and Lost Horse Mountain quadrangles). Serpentine (Corona South and Winchester quadrangles).
JURASSIC	JR̄v	**JURASSIC AND/OR TRIASSIC METAVOLCANIC ROCKS**	Santiago Peak Volcanics—*predominantly dark-colored flows, tuff, breccia, and agglomerate of predominantly andesitic composition; includes associated hypabyssal porphyry and intrusive breccia ranging from diabase to microgranite; locally includes a basal conglomerate* (in the area south of Oceanside, the volcanic rocks shown by the symbol JR̄v are predominantly rhyolitic with interbedded tuffaceous sandstone, shale, and conglomerate; these rocks have been correlated by some geologists with the Early Cretaceous Alisitos Formation of Baja California). Temescal Wash Quartz Latite Porphyry—*angular-weathering quartz latite to dacite* (may be related to Santiago Peak Volcanics). Amphibolites in Winchester quadrangle (considered to be metabasalt flows and sills by H. P. Schwarcz, 1960).
	Ju	**UPPER JURASSIC MARINE SEDIMENTARY AND METASEDIMENTARY ROCKS**	Bedford Canyon Formation——*interbedded black to dark-gray argillite (metashale), slate, quartzite, graywacke, local conglomerate and dark-colored recrystallized limestone* (limestone lenses contain a Late Jurassic fauna previously interpreted as Triassic, see N. J. Silberling, et al., 1961, Amer. Assoc. Petr. Geol. Bull. vol. 45, no. 10, p. 1746). Similar rocks to the east and southeast of the Santa Ana Mountains, mapped as Bedford Canyon Formation, are progressively more metamorphosed and include phyllites, schists, and locally gneisses (A. O. Woodford, 1960, Amer. Jour. Sci. Bradley Vol. p. 412). Unnamed schist, gneiss, quartzite, meta-arkose, and metaconglomerate in the Winchester quadrangle (considered to lie conformably above the Bedford Canyon Formation by H. P. Schwarcz, 1960; formerly considered to be Paleozoic in age, E. S. Larsen, Jr., 1948).
TRIASSIC (?)	ms	**PRE-CRETACEOUS METASEDIMENTARY ROCKS**	Julian Schist [5]—*interbedded quartz-mica schist and quartzite, local amphibolite schist and quartz-biotite gneiss,* Santa Ysabel and Ramona quadrangles (fragmentary evidence near Julian suggests a Triassic age according to F. S. Hudson, 1922, Univ. Calif. Dept. Geol. Sci. Bull., vol. 13, pp. 175-252). Unnamed quartzite, metaconglomerate, meta-arkose, and quartz-mica schist in Pechanga, Pala, and Palomar Mountain quadrangles (possibly part of the Julian Schist sequence to the southeast [5]). Palm Canyon Complex [8]—*interbedded crystalline limestone, quartzite, quartz-mica schist, and granitic gneiss; in many places intruded lit-par-lit by granitic rocks* (San Jacinto and Santa Rosa Mountains). Unnamed well-foliated gneiss and schist, quartzite, calc-silicate rocks, marble, phylite, and amphibolite elsewhere in eastern and northern parts of the Santa Ana sheet [7].
	mv	**PRE-CRETACEOUS METAVOLCANIC ROCKS**	Amphibolite in Ramona quadrangle.
	m	**PRE-CRETACEOUS METAMORPHIC ROCKS, UNDIFFERENTIATED**	Cataclastic zone in Clark Lake 7½′ quadrangle consisting of adamellitic and tonalitic cataclasite, marble-rich metamorphic rocks, and mylonite. Cataclastic zone in Santa Rosa and San Jacinto Mountains consisting of mylonite gneiss, cataclastic gneiss, marble, quartzite, and schist. Highly sheared metasediments and gneiss in the Borrego quadrangle. Amphibolitic quartzite in Winchester quadrangle.
	ls	**ls = LIMESTONE AND/OR DOLOMITE**	Coarsely crystalline limestone in the San Jacinto and Santa Rosa Mountains.
	gr-m	**PRE-CENOZOIC GRANITIC AND METAMORPHIC ROCKS**	Mixed rocks consisting of strongly foliated migmatites including bodies of schist and quartz diorite (an intimate mixture of Julian Schist and Stonewall Quartz Diorite). Migmatite and migmatitic breccia in Lakeview Mountain area. Migmatitic gneiss and local quartzite, calc-silicate rocks, marble, metaconglomerate, phyllite, and amphibolite, locally intruded by gabbro, granite pegmatite, quartz monzonite, granodiorite, and quartz diorite (along San Jacinto Fault zone). Undifferentiated granitic and metamorphic rocks elsewhere.
PRECAMBRIAN (?)	p€c	**PRECAMBRIAN IGNEOUS AND METAMORPHIC ROCK COMPLEX**	Chuckawalla Complex [8]—*dark-colored strongly foliated quartz-biotite gneiss and biotite schist intruded lit-par-lit by light-colored slightly foliated granitic rocks, locally contorted and crenulated* (Little San Bernardino Mountains). San Gorgonio Igneous-Metamorphic Complex [8]—*migmatitic gneiss, flaser gneiss, and piemontite-bearing gneiss; intruded by pegmatite dikes.*
	p€gr	**UNDIVIDED PRECAMBRIAN GRANITIC ROCKS**	Light colored foliated granitic rocks of possible Precambrian age associated with the Pinto Gneiss in Lost Horse Mountain quadrangle.
		UNDIVIDED PRECAMBRIAN METAMORPHIC ROCKS:	
	p€g	**GNEISS**	Pinto Gneiss [8]—*dark-colored strongly foliated quartz-biotite gneiss* (Little San Bernardino Mountains).

NOTES

1. Pliocene age of the Canebrake Conglomerate and Palm Spring Formation according to T. W. Dibblee, Jr., 1954, California Div. Mines Bull. 170, Chap. II, pp. 23, 24.
2. The type locality of the Pico Formation is in the Ventura basin; however, upper Pliocene strata in the Los Angeles basin commonly have been assigned to the Pico Formation on the basis of foraminiferal correlation; the U. S. Geological Survey has now abandoned the usage of Pico for the Los Angeles basin and assigns these rocks to the Upper Member of the Fernando Formation (D. L. Durham and R. F. Yerkes, 1964, U. S. Geol. Survey Prof. Paper 420-B).
3. The "Repetto" is defined and properly used only as a stage designation; the U. S. Geological Survey has now abandoned the name "Repetto Formation" and assigns these rocks to the Lower Member of the Fernando Formation (D. L. Durham and R. F. Yerkes, 1964, U. S. Geol. Survey Prof. Paper 420-B).
4. The gypsum and anhydrite may have formed "in desiccated marginal gulf areas with restricted circulation or in saline lakes" (D. L. Durham, E. C. Allison, Syst. Zoo., vol. 9, no. 2, p. 63, June 1960).
5. A tentative correlation of part of these rocks with the less metamorphosed Bedford Canyon Formation to the northwest has been suggested (R. H. Jahns, 1954, *in* Geology of southern California: California Div. Mines Bull. 170, Chap. II, Contrib. 3: Geology of the Peninsular Range Province, p. 33, and by R. H. Merriam, 1958, p. 11). Location of the boundary between the Julian Schist (ms) and the Bedford Canyon Formation (Ju) is uncertain and locally arbitrary.
6. The age and distribution of these rocks is highly uncertain. W. J. Miller, 1944 (Calif. Jour. Mines and Geol., vol. 40, no. 1, p. 25), has suggested a Paleozoic age.
7. A tentative Mississippian age has been suggested for certain metasedimentary rocks south of Borrego Valley (R. F. Mueller and K. C. Condie, 1964, Jour. Geol., vol. 72, no. 4, p. 404). Location of the boundary between these unnamed metasedimentary rocks (ms) and the Bedford Canyon Formation (Ju) in the northern part of the map sheet is uncertain and locally arbitrary.
8. The Precambrian age designation for these rocks is uncertain and is based on lithologic comparison with similar rocks of probable Precambrian age to the east.

INDEX TO GEOLOGIC MAPPING—Continued

26b. Metropolitan Water District of Southern California, unpublished report no. 609, Engineering geology of Auld Valley Reservoir site, by R. J. Proctor, 1962, scale 1:24,000.

27. Morley, E. R., Jr., Geology of the Borrego Mountain quadrangle and the western portion of the Shell Reef quadrangle, San Diego County, California, scale 1:24,000, University Southern California, unpublished M.A. thesis, 1963.
Dibblee, T. W., Jr., 1954, ref. no. 9c.

28. Morton, D. M., Geologic map of the Lakeview Mountains area, scale 1:24,000, University California, Los Angeles, Ph.D. thesis in preparation, 1964.

29. Poland, J. F., et al., 1956, Groundwater geology of the coastal zone, Long Beach-Santa Ana area, California: U. S. Geol. Survey Water-Supply Paper 1109, Pl. 3, scale 1:31,680 (same map published in U. S. Geol. Survey Water-Supply Paper 1471).
California Dept. Water Resources Bull. 147-1, Salinity barrier studies, Santa Ana Gap, Orange County, in press, scale 1:63,360; geology by K. H. Wiebe, et al.

30. Popenoe, F. W., Geology of the southeastern portion of the Indio Hills, Riverside County, California, scale 1:31,680, University California, Los Angeles, unpublished M.A. thesis, 1959.

31a. Proctor, R. J., Geology of the Desert Hot Springs area, Little San Bernardino Mountains, California, scale 1:24,000, University California, Los Angeles, unpublished M.A. thesis, 1958. (NW-trending fault in northeast corner of area from T. W. Dibblee, Geologic map of Thousand Palms quadrangle, scale 1:62,500, unpublished 1944–55).

31b. Proctor, R. J., Geologic map of the northwest portion of the San Jacinto Mountains, compiled on San Jacinto, Beaumont, and Cabazon quadrangles, scale 1:24,000, from unpublished maps of the Metropolitan Water District of Southern California by F. L. Ransome (1932) and L. H. Henderson (1939), and from D. M. Fraser, (1931) ref. no. 14 (additions from N. R. Larsen and P. M. Blacet, see under ref. no. 40; and from California Div. Water Resources, 1955, ref. no. 4).

31c. Proctor, R. J., Geologic map of the Lake Mathews quadrangle and northwest part of Steele Peak quadrangle, scale 1:24,000, compiled from unpublished maps of the Metropolitan Water District of Southern California by R. J. Proctor, 1960–61, and from E. H. Pampayen, M.A. thesis, Pomona College, 1952; E. M. Irving, M.A. thesis, University California, Los Angeles, 1935; and various Pomona College senior theses, 1937–1954.

32. Rogers, B. L., 1959, Mineral deposits of the Lake Elsinore quadrangle: California Div. Mines Bull. 146, Pl. 5, scale 1 inch = about 1750 feet (additional faults from R. H. Jahns, 1954, ref. no. 20a, map no. 5, scale 1:96,000, and other additions by R. J. Proctor, ref. no. 31c).

33a. Rogers, T. H. and Weber, F. H., Jr., Reconnaissance geologic mapping and photogeologic interpretation in parts of Palomar Mountain and Warner Springs quadrangles, scale 1:62,500, California Div. Mines and Geology, reconnaissance mapping for the State Geologic Map, 1963–1964.

33b. Rogers, T. H. and Beach, D. H., Reconnaissance geologic mapping and photogeologic interpretation in parts of Palm Desert, Coachella, Clark Lake, and Rabbit Peak quadrangles, scale 1:62,500, California Div. Mines and Geology, reconnaissance mapping for the State Geologic Map, 1963–1964 (in part after T. W. Dibblee, Jr., 1954, ref. no. 9; and B. L. Geyer, Geology of the Palm Desert region, Riverside County, California, ref. no. 41).

33c. Rogers, T. H., Reconnaissance geologic mapping and photogeologic interpretation in parts of Lost Horse Mountain, Coachella, and Thousand Palms quadrangles, scale 1:62,500, California Div. of Mines and Geology, reconnaissance mapping for the State Geologic Map, 1963–1964 (in part after T. W. Dibblee, Jr., 1954, ref. no. 9; various Metropolitan Water District of Southern California unpublished reports by F. L. Ransome; and J.J.W.Rogers, 1961, Igneous and metamorphic rocks of the western part of the Joshua Tree National Monument, Riverside and San Bernardino Counties, California: California Div. Mines Special Rept. 68, Pl. 1, scale 1:250,000).

34. Roth, J. C., Geology of a portion of the southern Santa Ana Mountains, Orange County, California, scale 1:14,400, University California, Los Angeles, unpublished M.A. thesis, 1958.

35. San Diego State College student mapping under the direction of R. G. Gastil, 1954–1964; includes Oceanside, San Luis Rey (also mapped by B. F. Jones, University Southern California, M.S. thesis, 1959), Encinitas, San Marcos, Valley Center, Rancho Santa Fe, and Escondido 7½′ quadrangles (local additions and modifications from J. C. Taylor, Geologic map of parts of the Oceanside, San Luis Rey, and Morro Hill quadrangles, unpublished map, 1950, on file Pomona College).

36. Scheliga, J. T., Jr., Geology and water resources of Warner basin, San Diego County, California, scale 1:24,000, University Southern California, unpublished M.A. thesis, 1963.

37. Schoellhamer, J. E., Kinney, D. M., Yerkes, R. F., and Vedder, J. C., 1954, Geologic map of the northern Santa Ana Mountains, Orange and Riverside Counties, California: U. S. Geol. Survey Oil and Gas Investigation 154, scale 1:24,000.
Woodford, A. O., et al., 1954, *in* Geology of southern California: California Div. Mines Bull. 170, Chap. II: Geology of the Los Angeles basin, Contrib. 5, Pl. 1, scale 1:96,000.
Yerkes, R. F., 1957, Volcanic rocks of the El Modeno area, Orange County, California: U. S. Geol. Survey Prof. Paper 274-L, Pl. 46, scale 1:10,800.
Richmond, J. F., 1952, Geology of Burruel Ridge, northwestern Santa Ana Mountains, California: California Div. Mines Special Rept. 21, Pl. 1, scale 1:24,000.

38. Schwarcz, H. P., Geology of the Winchester-Hemet area, Riverside County, California, scale 1:24,000, California Institute Technology, unpublished Ph.D. thesis, 1960.

39. Sharp, R. V., Geology of the San Jacinto fault zone in the Peninsular Ranges of Southern California, scale 1:62,500, California Institute Technology, unpublished Ph.D. thesis, 1965.

40. Shuler, E. H., Geology of a portion of the San Timoteo Canyon Badlands near Beaumont, California, scale 1:48,000, University Southern California, unpublished M.S. thesis, 1953.
English, H. D., The geology of the San Timoteo Badlands, Riverside County, scale 1:24,000, Pomona College, unpublished M.A. thesis, 1953 (additions from N. R. Larsen, Geology of the Lamb Canyon area, Beaumont, California, scale 1:12,000, Pomona College, unpublished M.A. thesis, 1962; and P. M. Blacet, Geology of the Lamb Canyon area north of San Jacinto, California, scale 1:12,000, University California, Riverside, unpublished senior thesis, 1960).

41. Sims, S. J., Geology of part of the Santa Rosa Mountains, Riverside County, California, scale 1:24,000, Stanford University, unpublished Ph.D. thesis, 1960.
Geyer, B. L., Geology of the Palm Desert region, Riverside County, California, scale 1:24,000, San Diego State College, unpublished senior report, 1962.

42. Smith, W. S. T., Morse, R. R., and Woodford, A. O., Geologic maps of the San Juan Capistrano region, scales 1:125,000 and approx. 1:250,000, unpublished geologic investigations, 1930 (modifications in northwest part by F. H. Weber, Jr., ref. no. 48).

43. Southern Pacific Company, Land Department, Regional geologic mapping program; geologic maps of T2-4S R3-9E, T6S R9E, SBB&M (parts of Palm Springs, Thousand Palms, Lost Horse Mountain, and Coachella quadrangles) by W. A. Oesterling, G. W. Olcott, and D. E. Pruss, scale 1:24,000, unpublished, 1957–1958 (local additions from D. D. MacLellan, Geology of the east Coachella tunnel of the Metropolitan Water District of Southern California, scale 1 inch = 1000 feet, California Institute Technology, unpublished Ph.D. thesis, 1936; T. W. Dibblee, Jr., ref. no. 8c; various Metropolitan Water District of Southern California unpublished reports by F. L. Ransome; and J. E. Weir, 1963, Groundwater and related geology of Joshua Tree National Monument, U. S. Geol. Survey open file report, Fig. 3, scale 1:62,500).

44. Southern Pacific Company, Land Department, Regional geologic mapping program; geologic map of T9S R9E, SBB&M (part of Rabbit Peak quadrangle) by M. C. Gardner, scale 1:24,000, unpublished, 1961.

45. Stevenson, R. E., The Cretaceous stratigraphy of the southern Santa Ana Mountains, California, scale 1:62,500, University California, Los Angeles, unpublished M.A. thesis, 1948.

46. Vedder, J. G., Yerkes, R. F., and Schoellhamer, J. E., 1957, Oil possibilities of San Joaquin Hills-San Juan Capistrano area, California: U. S. Geol. Survey Oil and Gas Investigations Map OM-193, scale 1:24,000.

47. Ware, G. C., Jr., The geology of a portion of the Mecca Hills, Riverside County, California, scale 1:24,000, University California, Los Angeles, unpublished M.A. thesis, 1958.
Hays, W. H., Geology of the central Mecca Hills, Riverside County, California, scale 1:14,400, Yale University, unpublished Ph.D. thesis, 1957.
Dibblee, T. W., Jr., 1954, ref. no. 9.

*48. Weber, F. H., Jr., 1963, Geology and mineral resources of San Diego County, California: California Div. Mines and Geol. County Report 3, Pl. 1, scale 1 inch = 3 miles, including subsequent revisions by F. H. Weber, Jr. and T. H. Rogers, 1964 (local additions from J. B. Hanley, ref. no. 18a, G. L. Anderson, Soil studies in the Cleveland National Forest, U. S. Dept. Agriculture, Forest Service, work in progress, 1964, and J. C. Taylor, Geologic map of parts of Morro Hill, Oceanside, and San Luis Rey quadrangles, unpublished map 1950, on file Pomona College).

49. Woodard, G. D., The Cenozoic succession of the west Colorado Desert, San Diego and Imperial Counties, Southern California, scale 1:24,000, University of California, Berkeley, Ph.D. thesis, 1963.

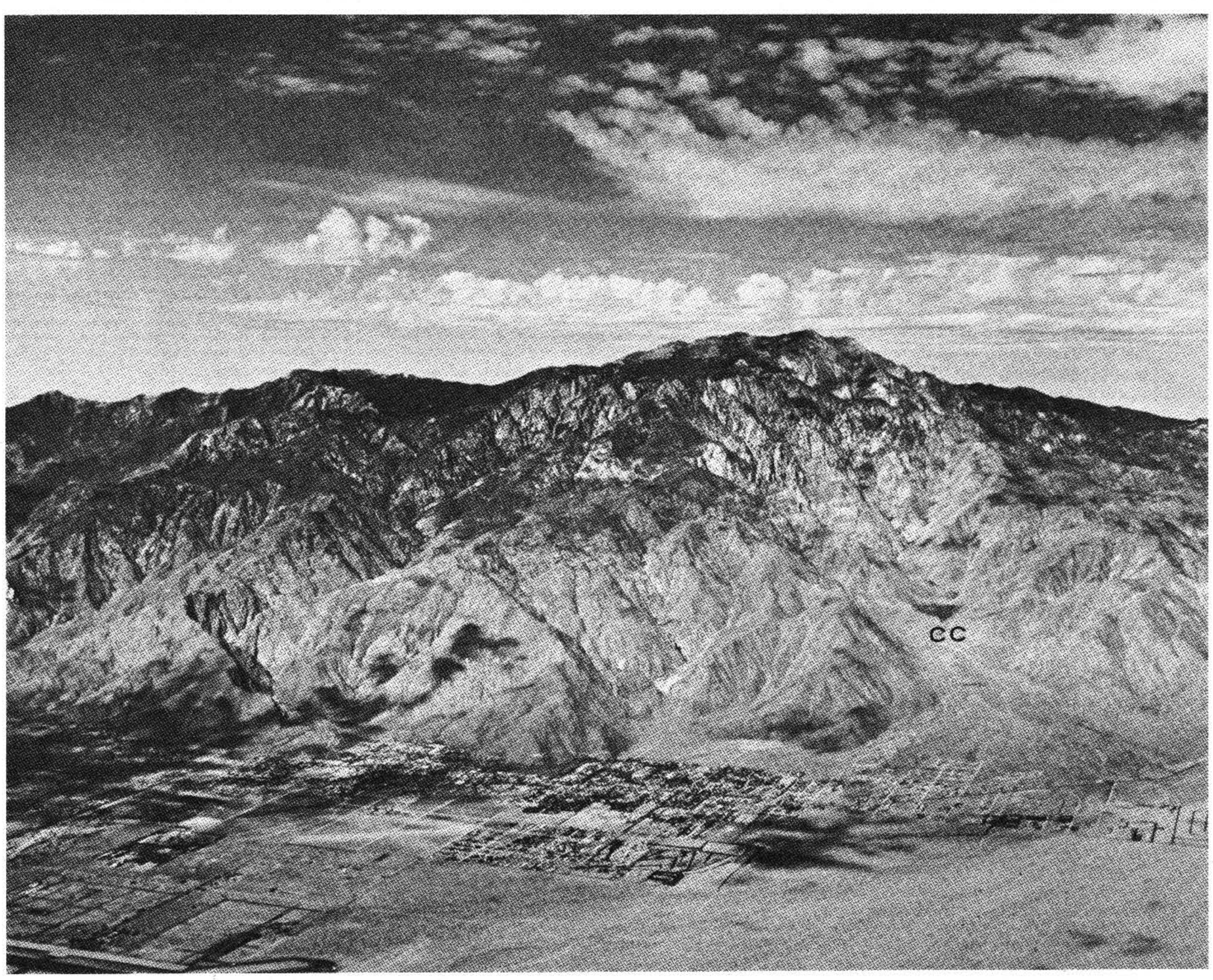
50. Woodford, A. O., 1925, The San Onofre Breccia, its nature and origin: University California Dept. Geol. Sci. Bull. vol. 15, no. 7, pp. 159–280, Pl. 24, scale 1:42,240.

51. Wright, L. B., 1946, Geology of Santa Rosa Mountain area, Riverside County, California: California Jour. Mines and Geol., vol. 42, no. 1, pp. 9–13, Pl. 1, scale 1:30,000.

52. Yerkes, R. F., 1960, Preliminary geologic map of the La Habra quadrangle, Los Angeles basin, California: U. S. Geol. Survey open file report, map scale 1:24,000.

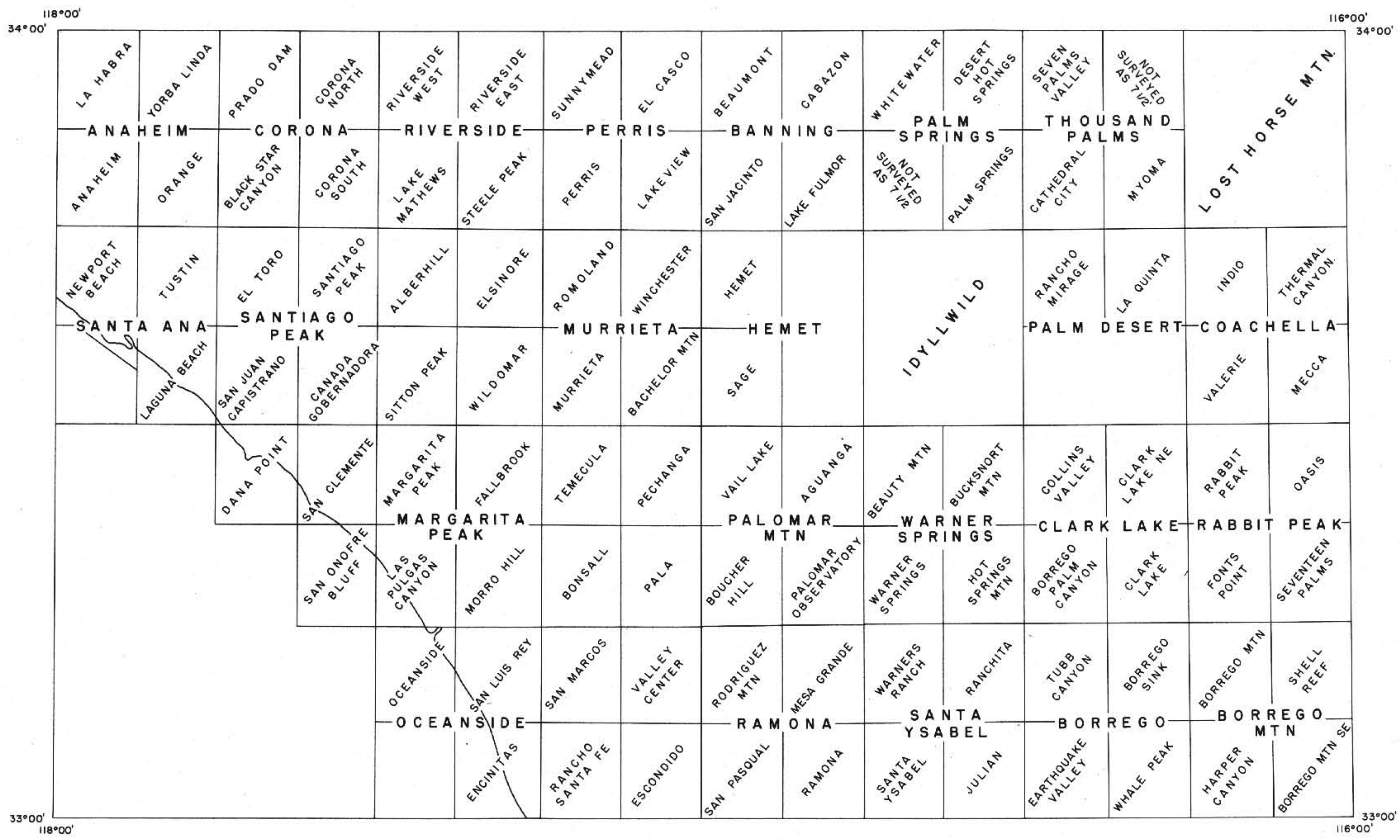
* Local additions from Geologic map of Peninsular Range Province by R. H. Jahns in Geology of southern California: California Div. Mines Bull. 170, Chap. II, Pl. 3, scale 1:375,000.

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 toward the San Jacinto Mountains with San Jacinto Peak (elev. 10,831′) towering more than 10,000 feet above Palm Springs and the Coachella Valley. Mesozoic granitic rocks of the southern California batholith constitute the higher parts of this range with older metamorphic rocks forming the lower slopes. The Palm Springs aerial tramway now extends from the head of Chino Canyon (CC) to a point (elev. 8,516 feet) about 2 miles east of the peak. *Photo by R. C. Frampton, 1952.*

TOPOGRAPHIC QUADRANGLES
WITHIN THE SANTA ANA SHEET
AVAILABLE FROM THE U.S. GEOLOGICAL SURVEY
FEDERAL CENTER, DENVER, COLORADO 80225
1965



ANCIENT SHORELINES

View north from Encinitas (foreground), across Batiquitos Lagoon, toward Oceanside and the Santa Margarita Mountains (skyline). Elongate ridges parallel to the shoreline indicate former positions of the shore as the sea receded in relatively recent geologic time. The ridges occur discontinuously for 40 miles from Oceanside to Mexico. *Photo by R. C. Frampton and J. S. Shelton, 1949.*

39674-C-650 1-76 2M △ OSP