DEPARTMENT OF THE INTERIOR
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TO ACCOMPANY MAP I-757

REGIONAL GEOLOGIC MAP OF SAN ANDREAS AND RELATED FAULTS IN CARRIZO PLAIN, TEMBLOR, CALIENTE, AND LA PANZA RANGES AND VICINITY, CALIFORNIA

By

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INTRODUCTION

Only basic descriptions of map units are given herein. Stratigraphic terminology and age assignment of each unit are discussed in a separate publication (Dibblee, 1973).

Each map unit of Tertiary age is assigned to established faunal stages and Lyellian epochs of the Pacific Coast standard chronology, as proposed by Weaver and others (1944). Oligocene and Miocene foraminiferal stages to which marine shale units are assigned are those of Kleinpell (1938), and the Eocene stages are those of Mallory (1959).

Lithologies of most marine formations of Late Cretaceous and Tertiary age are generally similar. Unless indicated otherwise, sandstones are generally light gray, weather buff or light brown, are thin to thick bedded, in places crossbedded, semifriable, fine, medium to locally coarse grained, micaceous, and arkosic. Argillaceous rocks (clayey shale, claystone and siltstone) are dark gray, weather lighter gray or brown, are massive to bedded, micaceous, compact, but crumble with ellipsoidal fracture on weathering. Nearly all argillaceous units contain concretions, and lenses and beds of impure dolomite as thick as 2 feet.

Sandstones and argillaceous rocks of terrestrial formations of Late Cretaceous and Tertiary age are similar to those of marine formations but are varicolored with green, pink, red, orange, and buff tints.

DESCRIPTION OF MAP UNITS

SURFICIAL DEPOSITS

Thin surface mantle of unconsolidated, undeformed alluvial deposits of valleys and canyon flood plains; of late Quaternary age.

SURFICIAL SEDIMENTS

Undissected sediments of Holocene age. Units as follows:

Alluvium (Qa).—Light-gray gravel, sand and silt, deposited in present valleys and canyon flood plains. As much as 100 feet thick in valleys.

Playa clay (Qc).—Clay or mud of Soda Lake, Buena Vista Lake, and other small playa lakes. In Soda Lake contains much alkali.

Landslide debris (Qls).—Debris of various sources: mud, sand, gravel, shale, claystone, sandstone or serpentine.

OLDER ALLUVIUM (Qoa)

Gravel, sand, and silt, as thick as 50 feet; much dissected where elevated; eroded to terrace remnants locally. Age, Pleistocene.

VALLEY DEPOSITS

Extensive weakly-consolidated alluvial and some lacustrine deposits; mainly of Pleistocene age, but lowest part may be as old as Pliocene; up to several thousand feet thick; deposited in San Joaquin Valley and in Salinas Valley-Carrizo Plain area. Locally deformed, mostly near San Andreas fault and near margins of valleys of deposition. Unconformity at base along margins of valleys of deposition.

PASO ROBLES FORMATION (QTp)

Valley sediments of upper Salinas Valley-Carrizo Plain area. Mainly light-gray to tan pebble gravel and sand, and interbedded light-reddish to greenish-gray sandy clay. Pebbles mostly of Monterey white siliceous shale; others of sandstone, claystone, granitic rocks, andesitic porphyries, quartzite; in Cholame area a few are of Franciscan rocks. Southeast of Cholame on west side of San Andreas fault includes gray thin-bedded lacustrine clays that contain several beds of marl and gypsum. Formation as much as 1,500 feet in exposed thickness, with as much as 1,500 feet more unexposed. Thins out against unconformably underlying older formations of Caliente, La Panza, Temblor and Diablo Ranges. Top a surface of deposition that forms much of surface of Carrizo Plain and top of old alluvial fans at margin of plain; formation severely dissected to northwest. Age mainly Pleistocene, with lowest part probably Pliocene near Atascadero.

Alluvial valley sediments exposed at southeast end of Caliente Range on southwest side of San Andreas fault assigned to Paso Robles Formation. About 700 feet thick; unconformable on Caliente and older formations. Mainly gravel composed of angular pebbles and cobbles of sandstone, dark shale (Tertiary), granitic and gneissic rocks, schist, and marble, all derived largely from San Emigdio Mountains (southeast of map area) east of San Andreas fault; also contains jumbled landslide masses of those rocks.

TULARE FORMATION (QTt)

Valley sediments on west side of San Joaquin Valley, lithologically similar to Paso Robles Formation. In foothill areas mainly pebble-cobble gravel, grading eastward in Kettleman Hills and Elk Hills to sands and sandy clays.

Most pebbles are of Monterey siliceous shale, others of sandstone, claystone; some of Franciscan rocks in northern exposures, of granitic rocks in southern exposures. Maximum thickness 2,800 feet; top a surface of deposition that forms flat surface of San Joaquin Valley that is covered by alluvium. Conformable on San Joaquin Formation, but in Temblor Range overlaps Etchegoin Formation to become unconformable on Miocene formations against which it thins westward. Age mainly Pleistocene, lowest part may be late Pliocene.

UNNAMED VALLEY SEDIMENTS (QTu)

In Cuyama Valley, unnamed valley sediments form old alluvial fans as much as 700 feet thick, derived from Caliente Range and from Sierra Madre Mountains, and composed of very poorly sorted angular sandstone and shale detritus, unconformable on Morales Formation. Presumably same age as Paso Robles Formation, at least in part.

UPPER TERTIARY SEDIMENTARY SEQUENCE

Sedimentary sequence mainly of Pliocene age, present in two areas separated by Temblor Range and its northwest extension toward Gold Hill. Sequence of northeastern area (San Joaquin Valley and Diablo Range) nearly all marine, as much as 7,000 feet thick. Sequence of southwestern area (from Cuyama Valley to Salinas Valley) terrestrial and marine, as much as 5,700 feet thick. Unconformity at base along margins of depositional areas.

MORALES FORMATION (Tmo)

Terrestrial sedimentary formation exposed around Carrizo Plain, Cuyama Valley, and southwest of La Panza Range; composed mainly of light-gray friable conglomerate and sandstone, and minor interbedded gray- to reddish-gray siltstone; most pebbles and cobbles are of granitic rocks, andesitic porphyry, and quartzite (all probably derived from older conglomerates), sandstone; and few of siliceous shale.

In western Cuyama Valley area, as much as 2,800 feet thick; upper 1,600 feet mostly conglomerate and sandstone, lower 1,200 feet mostly gray lacustrine clay; unconformable on Santa Margarita and older formations.

On south side of eastern Cuyama Valley, composed of about 2,000 feet of friable conglomerate and sandstone, with local angular unconformity near middle, and disconformable on Quatal, Santa Margarita, and Branch Canyon Formations.

East of Cuyama Valley and on north flank of southeastern Caliente Range, composed of about 5,000 feet of friable conglomerate and sandstone conformable on clay of Quatal Formation.

In San Juan Creek area, northwest of Carrizo Plain, composed of 1,300 feet of friable conglomerate and sandstone unconformable below Paso Robles Formation and conformable on clay of Quatal Formation.

On east side of San Andreas fault at east margin of Carrizo Plain, about 2,500 feet of friable conglomerate included in Morales Formation of which lowest beds grade laterally southward into upper part of unnamed (Pliocene) marine sediments; elsewhere conformable on conglomerate of Santa Margarita Formation.

Age, presumably Pliocene, upper part possibly Pleistocene (Blancan age) by vertebrate chronology.

QUATAL FORMATION (Tq)

Lacustrine gypsiferous claystone, as much as 700 feet thick, conformable below Morales Formation southwest of San Andreas fault. In southeastern Caliente Range and vicinity conformable on Caliente Formation. South of Cuyama Valley composed of about 300 feet of reddish claystone and white sandstone disconformable(?) on Santa Margarita Sandstone. Age Pliocene (Hemphillian age).

SAN JOAQUIN FORMATION (Tsj)

Mudstone unit conformable below Tulare Formation and above Etchegoin Formation in Kettleman Hills, Reef Ridge area and San Joaquin Valley subsurface. Composed mainly of gray mudstone, siltstone and minor fine- to medium-grained gray sandstone; in Kettleman Hills and locally in Reef Ridge area, basal 0–50 feet composed of pebbly blue sandstone and pebble conglomerate (Cascajo Conglomerate Member of Woodring and others, 1940). In Kettleman Hills from 1,300 to 1,800 feet thick; in Reef Ridge area as thick as 2,200 feet. Grades upward through interbeds of sandstone and shale-pebble conglomerate into Tulare Formation. Contains marine and brackish water mollusks and echinoids and rare mammalian fossils; age late Pliocene, possibly in part early Pleistocene.

ETCHEGOIN FORMATION (Te)

Marine sandy formation, composed of semifriable locally pebbly arkosic sandstone and interbedded siltstone and mudstone; gray where fresh, weathers brown. In Reef Ridge area about 5,000 feet thick, conformable below San Joaquin Formation and above Reef Ridge Shale. In Gould Hill about 9 miles northwest of McKittrick, only lowest 1,500 feet of Etchegoin Formation exposed unconformably below Tulare Formation and unconformably on Belridge Diatomite Member of Monterey Shale. In exposure 1 mile south of McKittrick, Etchegoin Formation only locally present where it consists of less than 70 feet of fossiliferous pebbly sandstone unconformably between Tulare Formation and Belridge Diatomite Member of Monterey Shale.

Contains numerous mollusks and echinoids diagnostic of Pliocene age.

Blue sandstone (Teb).—In Reef Ridge area upper 1,700 feet of Etchegoin Formation contains several units as thick as 500 feet composed largely of blue sandstone. Blue sandstone highly permeable, grains well sorted, many of andesite. Grains covered with thin blue coating of authigenetic montmorillonoid derived from solution of andesitic volcanic detritus in sandstone (Lerbekmo, 1957). Sandstone locally contains pebbles, mostly of andesite and black chert; commonly fossiliferous. Southeastward from Reef Ridge area blue sandstone beds disappear or become gray laterally along strike. Northwest of McLure Valley, upper 1,500 feet of Etche-

goin Formation composed of unfossiliferous massive blue sandstone, with base about 3,000 feet above base of Etchegoin Formation. In northern Kettleman Hills Etchegoin Formation contains a few thin beds of blue sandstone near top.

UNNAMED MARINE SEDIMENTS (Tu)

On east side of San Andreas fault, about 12 miles east of Soda Lake, unit composed of about 1,500 feet of friable tan fine-grained sandstone that contains shallow-water marine mollusks diagnostic of early Pliocene age. Grades upward and in part laterally northward into Morales(?) Formation; overlies conglomerate of Santa Margarita Formation. May be equivalent to lower part of Etchegoin Formation. Southeastward may intertongue into Bitterwater Creek Shale.

In Shandon area west of San Andreas fault, marine sandstone and siltstone of Pliocene(?) age as thick as 2,000 feet between Paso Robles Formation and Santa Margarita Formation found in several test holes drilled for oil or gas (H. Wagner, oral commun., 1968). Not exposed in map area. Probably correlative with Pancho Rico Formation northwest of map area.

MIDDLE TERTIARY SEDIMENTARY SEQUENCE

Sedimentary sequence of variable lithology, mostly of Miocene age, but ranging into Oligocene and probably into Pliocene, on both sides of San Andreas fault.

West of fault, sequence is marine and terrestrial and includes mafic volcanic rocks; as thick as 10,000 feet in Caliente Range and possibly under Carrizo Plain, but much thinner elsewhere; unconformity at base.

East of fault, sequence is marine; as thick as 14,000 feet in southeastern Temblor Range but thins northwestward to only 700 feet in Reef Ridge-McLure Valley area; unconformity at base in most places.

REEF RIDGE SHALE (Trr)

In Reef Ridge area and southeastward composed of about 500 feet of soft, gray marine claystone; conformable between Etchegoin Formation and Monterey Shale. In McLure Valley area less than 200 feet thick where present. Age late Miocene and possibly early Pliocene. Transitional unit between upper Tertiary and middle Tertiary sedimentary sequences. Arbitrarily placed in latter sequence.

BITTERWATER CREEK SHALE (Tbw)

Exposed on east side of San Andreas fault southeast of Carrizo Plain. Mainly poorly bedded marine semisiliceous silty mudstone; brown, but weathers nearly white; moderately hard, brittle; weathers to small splintery to semiplaty fragments; unit as thick as 2,000 feet. In northwesternmost exposures contains intertongues of unfossiliferous sandstone (unnamed marine sediments, Tu?), with siliceous shale pebbles. Unconformably overlain by Paso Robles Formation, underlain by conglomerate of Santa Margarita Formation.

SANTA MARGARITA FORMATION

Marine clastic sediments on both sides of San Andreas fault. In both areas contains shallow-water marine mollusks and echinoids diagnostic of late Miocene age.

Sandstone (Tsm).—Widespread in areas west of San Andreas fault. Friable, white, thick bedded to massive; locally contains pebbles of granitic rocks and quartzite, also contains hard calcareous bioclastic reefs of shell fragments. In places contains lenses as thick as 150 feet of soft diatomaceous to hard siliceous shale. In places basal part of sandstone and shale contains phosphatic pellets, also several beds of tuff. Formation as thick as 1,500 feet. In Cuyuma Valley area overlain unconformably or disconformably by Morales and Quatal Formations, elsewhere unconformably by Paso Robles Formation; overlies Monterey Shale, unconformably in Pozo area; in Red Hills overlies Caliente(?) Formation, under Carrizo Plain presumably grades laterally eastward into it.

Conglomerate and breccia (Tsg).—Present only in southeastern Temblor Range east of San Andreas fault. Composed of boulders, cobbles, and pebbles of granitic rocks, schist, marble and quartzite in friable gray sandy matrix; poorly bedded; includes some coarse sandstone. Near Fellows upper part contains fragments of Tertiary rhyolitic rocks. As thick as 2,500 feet; in northeastern foothills intertongues northeastward downdip into Belridge Diatomite Member of Monterey Shale. On southwest flank of range unconformable on shale and sandstone unit (Tmi) of Monterey Shale.

Granitic breccia (gb).—Shattered to brecciated mass of granitic rock (mostly granodiorite); forms a probable old landslide in upper part of the conglomerate and breccia in southeastern Temblor Range.

Schist breccia (sb).—Shattered to brecciated mass of dark hard fine-grained biotite schist; forms a probable old landslide in lower part of the conglomerate and breccia in southeastern Temblor Range.

MONTEREY SHALE

Offshore marine predominantly organically deposited siliceous sediments of early, middle and late Miocene age, extensively exposed on both sides of San Andreas fault.

East of San Andreas fault, Monterey Shale as thick as 7,200 feet in southeastern Temblor Range; thins northwestward to about 600 feet in Diablo Range; upper part, of late Miocene age, composed mostly of siliceous shale and diatomite; lower part, of middle Miocene age, composed mostly of siliceous and argillaceous shale; underlies Reef Ridge Shale (conformably) or Etchegoin and Tulare Formations (unconformably), and conformable on Temblor Formation. East of fault, six units mapped.

Belridge Diatomite Member (Tmb).—Uppermost unit of Monterey Shale exposed in eastern foothills of Temblor Range, composed of white-weathering soft porous diatomite and fissile diatomaceous shale, composed largely of diatom debris, contains abundant arenaceous Foraminifera and fish scales. As much as 2,500 feet exposed (in Fellows-Maricopa area); unconformably overlain by Etchegoin and Tulare Formations; gradational downward into McLure Shale Member of Monterey Shale. In exposed sections age late Miocene (Mohnian Stage).

McLure Shale Member (Tm).—Also known locally as "Antelope" and "McDonald" Shale Members in parts of Temblor Range. Composed of hard brittle porcelaneous siliceous shale and softer chalky to fissile semisiliceous shale; brown, weathers white. In Chico Martinez Creek upper part contains beds of cherty shale. Contains abundant diatom impressions. In extreme northwestern Temblor Range middle part contains hard siliceous sandstone lenses. Unit as thick as 4,500 feet in Temblor Range; thins northwestward to 600 feet in Reef Ridge area. Age, late Miocene (Mohnian Stage); lowest part in southeast Temblor Range is middle Miocene (Luisian Stage) at one place.

Sandstone lenses (Tms).—Light tan, hard to semifriable. Forms lenses as thick as 100 feet in McLure Shale Member in southeastern Temblor Range. Unfossiliferous.

Devilwater Shale Member (Tmd).—In northwestern Temblor Range, southwestern foothills of Diablo Range, and Devils Den area, mainly soft clayey to silty shale; includes soft fissile shale, claystone, siltstone and friable sandstone. About 1,000 feet thick; as thick as 1,200 feet. In Temblor Range from Chico Martinez Creek to Packwood Creek, overlies Gould Shale Member, elsewhere overlies Temblor Formation. Age, middle Miocene (Luisian Stage).

Gould Shale Member (Tmg).—Hard brittle porcelaneous siliceous shale and interbedded softer chalky, punky to fissile semisiliceous to argillaceous shale; similar to McLure Shale Member but thinner bedded, commonly laminated, brown but weathers yellowish-buff, contains few or no diatom impressions, common Foraminifera and fish scales. In southeastern Temblor Range (where it is commonly known as Devilwater-Gould Shale Member) as thick as 3,000 feet, underlies McLure Shale Member and overlies Temblor Formation, age, middle Miocene (Relizian and Luisian Stages), except in one place where lowest beds are early Miocene (uppermost Saucesian Stage). In northwestern Temblor Range as thick as 600 feet, pinches out northwest of Packwood Creek; underlies Devilwater Shale Member, overlies Temblor Formation, age, middle Miocene (Relizian Stage).

Shale and sandstone unit (Tmi).—Exposed in southwest margin of southeastern Temblor Range southwest of Recruit Pass fault only. Semisiliceous shale, similar to that of Gould Shale Member, but contains about 50 percent interbedded buff-weathering fine-grained sandstone. As much as 1,500 feet exposed unconformably below conglomerate of Santa Margarita Formation, base buried. Age, middle Miocene (Relizian and Luisian Stages).

West of San Andreas fault, Monterey Shale as thick as 3,000 feet; upper part mainly siliceous shale, lower part mainly argillaceous shale; conformable below sandstone of Santa Margarita Formation and conformable on Vaqueros Formation; intertongues northeastward into Branch Canyon Sandstone; very thin or absent on southwest flank of La Panza Range and in Red Hills. West of fault, four units mapped.

Whiterock Bluff Shale Member (Tmw).—Siliceous shale unit that forms upper part of Monterey Shale between San Andreas and Rinconada faults known as Whiterock Bluff Shale Member (Hill and others, 1958). Hard brittle porcelaneous laminated siliceous shale and interbedded softer thin-bedded fissile to punky semisiliceous to semi-calcareous shale; commonly contains Foraminifera and fish scales. About 1,200 feet thick, as thick as 1,500 feet; grades downward into Saltos Shale Member; also grades laterally northeastward into it in Caliente Range and Sierra Madre Mountains. Age, middle Miocene (mostly Luisian Stage, in part uppermost Relizian Stage). In subsurface area between Paso Robles and Shandon, uppermost 300 feet may be in lower part of Mohnian Stage (late Miocene) (H. C. Wagner, oral commun., 1970).

Saltos Shale Member (Tma).—Argillaceous shale unit of Monterey Shale between San Andreas and Rinconada faults known as Saltos Shale Member (Hill and others, 1958). Composed of soft gray clayey to silty shale, brittle laminated siliceous shale, thin-bedded, punky to fissile semi-siliceous and semi-calcareous shale, siltstone, and thin dolomite beds; member gray to brown, weathers light brown; lowest part composed of clay shale. Member from 1,000 to 2,200 feet thick, conformable on Vaqueros Formation, intertongues northeastward into Branch Canyon Sandstone. Contains Foraminifera and fish scales. Age, mostly middle Miocene, Relizian Stage, in part early Miocene, late Saucesian Stage. In parts of Caliente Range and eastern Sierra Madre Mountains upper part grades laterally westward into Whiterock Bluff Shale Member.

Upper part, siliceous shale (Tmu).—Upper part of Monterey Shale adjacent to and southwest of Rinconada fault mainly hard platy siliceous shale, commonly porcelaneous, brittle; brown, weathers white; in places laminated. Age, presumably Mohnian Stage, late Miocene, possibly in part Luisian Stage, middle Miocene.

Lower part, argillaceous and siliceous shale (Tml).—Lower part of Monterey Shale adjacent to and southwest of Rinconada fault mostly soft thin-bedded to fissile light-brown argillaceous shale, interbedded tan semi-siliceous and hard brittle siliceous shale, and many thin beds of tan dolomite. Contains Foraminifera diagnostic of Relizian and Luisian Stages, middle Miocene.

BRANCH CANYON SANDSTONE (Tbs)

Near-shore marine sandstone facies into which Monterey Shale intertongues and grades laterally eastward in area between Rinconada and San Andreas faults. Sandstone as thick as 3,000 feet. In southeastern Caliente Range intertongues eastward into Caliente Formation. Age, middle Miocene in Caliente Range; middle and late Miocene in Branch Canyon area south of Cuyama Valley.

SANDSTONE LENSES (Tms)

Sandstone west of Rinconada fault similar to Branch Canyon Sandstone. South of Cuyama River as thick as 300 feet and unconformable on Cretaceous shale and sandstone; forms lenses in Monterey Shale elsewhere. Age, probably middle Miocene.

CALIENTE FORMATION

Terrestrial facies of all but lowest part of middle Tertiary sedimentary sequence west of San Andreas fault within about 8 miles of it, possibly throughout mapped segment. Composed of variegated red and green soft mudstone, siltstone, red to buff sandstone, and conglomerate with pebbles, cobbles and boulders of granitic and metamorphic rocks. In Caliente Range as thick as 4,200 feet, conformable below Quatal Formation; intertongues westward into underlying Branch Canyon Sandstone and Vaqueros Formation; age, mainly Miocene, but ranges into Pliocene and perhaps into Oligocene. In Red Hills, Caliente(?) Formation as thick as 3,000 feet; upper part gray to pink sandstone and conglomerate; lower part unbedded gray fanglomerate of unsorted granitic boulders and cobbles; age, Oligocene(?) and Miocene, but mostly Miocene in this area.

BASALT (Tb)

Black very fine grained basalt, composed of palagonitic glass, plagioclase, pyroxene, olivine and iron oxides, amygdaloidal in flows; diabasic texture in sills and dikes. Forms flows and sills as thick as 300 feet, and some dikes, in middle Tertiary sedimentary sequence in Caliente and La Panza Ranges.

TEMBLOR FORMATION

Marine sandstone and claystone that conformably underlie Monterey Shale or its equivalents are called Temblor Formation east of San Andreas fault and Vaqueros Formation west of it. In southeastern Temblor Range, Temblor Formation is as thick as 7,000 feet, base unexposed; in northwestern Temblor Range and Diablo Range, thickness 2,000 feet or less, locally absent, and disconformable or unconformable on older formations, with increasing discordance westward toward San Andreas fault. Age, late Oligocene (Zemorrian), early Miocene (Saucesian), and early middle Miocene (early Relizian).

On northeast flank of northwestern Temblor Range, Devils Den area, and adjacent subsurface area, Temblor Formation differentiated into named local members; elsewhere divided into unnamed lithologic facies units.

Sandstone (Tts).—Mostly semifriable to hard locally calcareous sandstone. In places includes thin interbeds or lenses of siltstone. Contains bioclastic reefs of shell fragments in Diablo Range and northwestern Temblor Range; unfossiliferous elsewhere.

Clay shale (Ttc).—Mostly argillaceous sedimentary rocks composed of clayey to silty shale, claystone and siltstone; commonly contains a few thin lenses of hard tan dolomite. Locally includes thin lenses of hard semisiliceous shale, and others of sandstone.

Basal conglomerate lens (Ttg).—At northwest end of Antelope Valley as thick as 600 feet, at base of Temblor Formation. Dark olive brown, composed of pebbles and cobbles derived from Panoche Formation, Gravelly Flat Formation, and Franciscan rocks, embedded in hard sandy mudstone. Includes layers of sandstone and several hard bioclastic reefs of shell fragments. Age, probably late early Miocene.

Buttonbed Sandstone Member (Ttb).—Uppermost local unit of sandstone; possibly a transgressive basal sandstone of Monterey Shale. Calcareous sandstone, with calcareous bioclastic reefs of shell fragments and pebbles mostly of varicolored jasper. As thick as 100 feet, locally absent. In Devils Den area unconformable on underlying members of Temblor Formation. Age, middle Miocene (Relizian Stage).

Media Shale Member (Ttm).—Upper local unit of clay shale. Mainly claystone, clay shale, and minor semisiliceous shale. At Chico Martinez Creek about 900 feet thick; to northwest at Bitterwater Creek as thick as 2,200 feet. At Devils Den composed of about 350 feet of claystone. Age, mostly early Miocene (Saucesian Stage), but uppermost part is early middle Miocene (Relizian Stage).

Carneros Sandstone Member (Ttr).—Middle local unit of sandstone. Rarely fossiliferous; at Chico Martinez Creek about 230 feet thick; thinner to southeast and northwest, locally absent. At Devils Den, about 200 feet thick and contains interbedded claystone and siliceous shale. Age, early Miocene (Saucesian Stage).

Santos Shale Member (Ttn).—Lower local unit of clay shale; about 400 feet thick or less; age, late Oligocene (Zemorrian Stage) and early Miocene (Saucesian Stage). Surrounds Agua Sandstone Member, a lens up to 48 feet thick (not shown) at Chico Martinez Creek and at mouth of Cedar Creek. Near Devils Den, only upper part of Santos Shale Member shown, about 300 feet thick, where it is early Miocene age (Saucesian Stage). Only upper part of Santos Shale Member (part above Agua Sandstone Member) shown on map.

Undivided lower members (Ttu).—Basal part of Temblor Formation composed of several members rocognized only near Chico Martinez Creek and near Devils Den; too thin to differentiate on map. Members thicken northeastward downdip in subsurface area. Near Chico Martinez Creek unit about 160 feet thick or less, composed of two members: in descending order, the so-called Phacoides sand (Wygal Sandstone Member of Dibblee, 1973), as thick as 100 feet; and the so-called Salt Creek Shale (Cymric Shale Member of Dibblee, 1973), as thick as 80 feet. Near Devils Den, unit as thick as 400 feet, composed of following members: in descending order, Agua Sandstone Member, 60 to 180 feet; Santos Shale Member (lower part), 50 to 100 feet; so-called Phacoides sandstone (Wygal Sandstone Member of Dibblee, 1973), 10 to 70 feet; and Salt Creek shale of drillers (Cymric Shale Member of Dibblee, 1973), 10 to 60 feet. Age of unit in both areas, Oligocene (Zemorrian Stage).

VAQUEROS FORMATION

In Caliente Range as thick as 7,000 feet, and divided into several named members (Hill and others, 1958; Dibblee, 1973). Elsewhere much thinner, in places absent, and divided into two lithologic facies units. Age, late Oligocene (Zemorrian Stage) and early and middle Miocene (Saucesian Stage).

Sandstone (Tvs).—Thick-bedded fine- to medium-grained sandstone; age, early and possibly middle Miocene.

Clay shale (Tvc).—Mostly argillaceous sedimentary rocks similar to those of Temblor Formation in lithology and age.

Painted Rock Sandstone Member (Tvp).—Predominantly sandstone facies of Vaqueros Formation in Caliente Range exclusive of basal sandstone unit in southeastern part. As thick as 5,700 feet. Contains several bioclastic reefs, mostly in upper part. In southeastern Caliente Range contains much interbedded siltstone; lower part of member grades laterally eastward into upper part of Soda Lake Shale Member, and upper part intertongues eastward into lower part of Caliente Formation. In La Panza Range (northeast flank) from 200 to 1,200 feet thick; upper part fine- to medium-grained fossiliferous sandstone; lower part nearly white thick-bedded sandstone. Age, early Miocene (Saucesian Stage), possibly in part middle Miocene (Relizian Stage) in northern exposures.

Soda Lake Shale Member (Tvl).—Predominantly clay shale facies of Vaqueros Formation in Caliente Range. Mainly dark-gray silty to argillaceous shale and siltstone. Age, late Oligocene (Zemorrian Stage) and early Miocene (Saucesian Stage). In northwestern Caliente Range member about 1,200 feet thick; includes stratum of tan cherty siliceous shale as thick as 150 feet, with base about 350 feet above base of member. In southeastern Caliente Range stratigraphically equivalent claystone about 900 feet thick. Included in Soda Lake Shale Member of this area by Vedder and Repenning (1965) and herein is a stratigraphically higher interval, as thick as 1,500 feet, of siltstone and minor interbedded sandstone (base of this interval indicated by dashed line on map).

Quail Canyon Sandstone Member (Tvq).—Basal sandstone unit of Vaqueros Formation in southeastern Caliente Range; hard crossbedded to massive sandstone, as thick as 200 feet, underlies Soda Lake Shale Member. Age, probably late Oligocene (Zemorrian Stage).

SIMMLER FORMATION

Stream-laid sedimentary deposits that conformably underlie Vaqueros Formation and unconformably overlie older rock units west of San Andreas fault. Age, Oligocene (Zemorrian, possibly in part Refugian Stage).

Conglomerate (Tsc).—Ranges from coarse unbedded boulder conglomerate to bedded pebble conglomerate and sandstone. In northwestern La Panza Range as thick as 2,000 feet, light-gray boulder conglomerate and coarse arkosic sandstone of granitic detritus. In southeastern La Panza Range, Sierra Madre Mountains, and Pine Ridge as thick as 3,000 feet, reddish to greenish-gray conglomerate and sandstone derived from underlying Upper Cretaceous and lower Tertiary marine sedimentary sequence. Southwest of Garcia Mountain and Rinconada fault as thick as 300 feet, reddish to greenish-gray mudstone and pebbly sandstone.

Sandstone (Tsi).—Exposed only in Caliente Range, where it is about 3,000 feet thick. Mainly hard reddish-brown to gray well-bedded sandstone; includes some interbedded reddish-brown micaceous siltstone and mudstone. Locally contains as much as 30 feet of conglomerate at base, with cobbles and pebbles of granitic rocks, andesitic porphyry and quartzite.

LOWER TERTIARY MARINE SEDIMENTARY SEQUENCE

Sequence of marine miogeosynclinal clastic sedimentary rocks, as thick as 3,000 feet, of Eocene and Oligocene age, east of San Andreas fault; disconformable or unconformable on the Jurassic(?) and Cretaceous marine sedimentary sequence.

WAGONWHEEL FORMATION

Marine claystone and sandstone in Devils Den area. About 500 feet thick, but as thick as 640 feet. Overlain disconformably by Temblor Formation; underlain by Kreyenhagen Shale. Age, early Oligocene (Refugian Stage).

Clay shale unit (Tw).—Clay shale; about 400 feet thick but as thick as 540 feet; upper part contains several thin beds of glauconite; middle part contains several strata of ochre-yellow dolomite and hard semisiliceous shale; lower part contains thin strata of fossiliferous sandstone.

Sandstone unit (Tws).—About 100 feet thick, at base of formation. Composed of several strata of sandstone seperated by thin beds of siltstone.

KREYENHAGEN SHALE

Marine clay shale and claystone. Age, late Eocene (Narizian Stage), but basal part possibly middle Eocene (Ulatisian Stage), and uppermost part possibly early Oligocene (Refugian Stage).

Undifferentiated shale (Tk).In Reef Ridge area (type area) 1,000 to 1,250 feet thick, upper part slightly siliceous; lowest 50 to 100 feet (called Canoas Siltstone Member but too thin to differentiate) greenish gray, foraminiferal, locally overlain by thin sandstone bed.

Welcome Shale Member (Tkw).—Exposed at Devils Den; poorly exposed gray clay shale, about 700 feet thick; forms upper member of formation, seperated from lower member by Point of Rocks Sandstone.

Gredal Shale Member (Tkg).—Exposed near Devils Den, and at head of Media Agua Creek in northwestern Temblor Range. Composed of gray, greenish- to reddish-gray locally foraminiferal claystone and siltstone; as thick as 700 feet; forms lower member of formation, overlain by Point of Rocks Sandstone and underlain by Avenal Sandstone.

POINT OF ROCKS SANDSTONE (Tpr)

Marine thick-bedded sandstone, with thin partings of micaceous siltstone. In Devils Den area about 2,350 feet thick, lies between Gredal and Welcome Shale Members of Kreyenhagen Shale. In Diablo Range about 1,230 feet thick, overlies Avenal Sandstone. In northwestern Temblor Range about 2,000 feet thick or less; upper part locally contains two units of claystone each as thick as 100 feet; disconformably overlain by Temblor Formation, overlies Gredal Shale Member of Kreyenhagen Shale or Lodo Formation where present, unconformably overlies Panoche Formation elsewhere. Age, major part late Eocene (Narizian Stage), basal part middle Eocene (Ulatisian Stage).

AVENAL SANDSTONE (Ta)

Marine sandstone at base of lower Tertiary marine sedimentary sequence, unconformity at base. In Reef Ridge is fine grained, fossiliferous, 300 to 500 feet thick. West of McLure Valley locally calcareous, as thick as

400 feet. In Devils Den area 30 to 200 feet thick. In northwestern Temblor Range sandstone lens as thick as 200 feet. Age, middle Eocene (Ulatisian Stage), in part early Eocene (Penutian Stage).

UNNAMED SANDSTONE (Tus)

Unnamed marine sandstone of probable Eocene age exposed in two areas. One near Gold Hill east of Cholame Valley composed of about 1,000 feet of massive sandstone that overlies hornblende quartz gabbro between San Andreas and Gold Hill faults. Age, middle Eocene(?).

Other area is on Big Pine Mountain on southwest side of Rinconada fault near south corner of map area. More than 1,000 feet of sandstone and interbedded micaceous siltstone; age, middle Eocene(?); disconformably(?) overlies sandstone and shale of Late Cretaceous age.

LODO FORMATION (Tl)

Marine claystone, soft, poorly exposed only in central part of Temblor Range, as thick as 200 feet, disconformably below Avenal Sandstone and Kreyenhagen Shale and disconformably on Panoche Formation. Age, Paleocene and early Eocene.

LOWER TERTIARY AND UPPER CRETACEOUS MARINE SEDIMENTARY SEQUENCE

Very thick sequence of miogeosynclinal mainly marine clastic sedimentary rocks of very Late Cretaceous to Eocene age, unconformable on the crystalline plutonic and metamorphic rocks between San Andreas and Rinconada faults.

MARINE CLASTIC SEDIMENTARY ROCKS

Continuously deposited sequence present east of Rinconada fault, about 25,000 feet thick, of marine conglomerate, sandstone, and claystone; in a few places non-marine. In eastern Caliente Range called Pattiway Formation (Hill and others, 1958). Age, Eocene (in Sierra Madre Mountains), Paleocene (in eastern Caliente Range, La Panza Range and Garcia Mountain), and very Late Cretaceous (in northernmost exposures in La Panza Range).

Sandstone, clay shale, and minor conglomerate (Tss).—Mostly hard sandstone, and lesser amounts of interbedded siltstone, micaceous clay shale, and local lenses of conglomerate. Conglomerate similar to lowest conglomerate unit described below. About 20,000 feet of strata exposed, with no definite sequence because of intergradation and intertonguing of rock types. Age, Paleocene and Eocene. Includes Pattiway Formation, Paleocene, in eastern Caliente Range.

Conglomerate (Tcg).—Similar to lowest conglomerate described below. Forms lens as thick as 500 feet, as long as 2 miles, at base of unit described above. Age, probably Paleocene, possible Late Cretaceous.

Sandstone, clay shale, and minor conglomerate (Kss).—Similar to that described above, but mostly if not entirely of very Late Cretaceous age as indicated from fossils.

Conglomerate (Kcg).—Olive gray, weathers brown, composed of rounded cobbles of quartzite, andesitic porphyry, and hard granitic rocks embedded in matrix of hard muddy sandstone. As thick as 1,500 feet at base of marine clastic sedimentary rocks. Age, Late Cretaceous(?).

CRETACEOUS AND JURASSIC(?) MARINE SEDIMENTARY SEQUENCE

Sequence of miogeosynclinal marine clastic sedimentary rocks, commonly known as "Great Valley sequence," as thick as 10,500 feet, mainly of Cretaceous age, east of San Andreas fault. Also present west of Rinconada fault, more than 7,000 feet thick. In both areas overlies or is possibly in fault contact with the eugeosynclinal sedimentary and igneous rocks. Following units mapped.

MOSTLY MARINE SEDIMENTARY ROCKS

Series of clastic sedimentary rocks exposed west of Rinconada fault. Lithologically similar to marine clastic sedimentary rocks east of that fault, but contains somewhat more clay shale and siltstone, and in one place terrestrial lenses. Many thousands of feet thick, overlies Franciscan rocks. Age, Late Cretaceous as inferred from fossils. Composed of following units.

Sandstone and clay shale (Ks).—Interbedded sandstone, siltstone and micaceous clay shale. In places contains thin lenses of cobble conglomerate, similar to those in marine clastic sedimentary rocks east of Rinconada fault.

Red conglomerate and mudstone (Kcr).—Terrestrial red conglomerate with cobbles of quartzite, andesitic porphyries and hard granitic rocks; in places includes red to greenish-gray pebbly sandstone and siltstone. Exposed only in upper Sisquoc River area, where it forms lenses as thick as 1,000 feet within marine clastic sedimentary rocks.

Conglomerate (Kco).—Similar to those in marine clastic sedimentary rocks east of Rinconada fault, forms lenses as thick as 500 feet within the sandstone and clay shale.

PANOCHE FORMATION

Marine sedimentary rocks of Late Cretaceous age east of San Andreas fault. In Diablo Range north of Cottonwood Creek about 4,800 feet thick, in Orchard Peak to south as thick as 6,800 feet; in northwest Temblor Range about 2,000 feet or less, gradational downward into Gravelly Flat Formation.

Clay shale and claystone (Kp).—Dark-gray highly micaceous clayey to silty shale; in places contains few thin beds of hard micaceous sandstone. Forms lenticular units as thick as 900 feet.

Sandstone and clay shale (Kps).—Sandstone and clay shale or claystone form interbeds generally a few feet thick but some as thick as 200 feet. Sandstone hard, commonly biotite-rich; some beds contain many dark-brown spheroid to discoid concretions as much as 3 feet in longest dimension. Clay shale or claystone dark gray, highly micaceous. On Orchard Peak Ridge unit contains six beds 10 to 35 feet thick of white tuffaceous sandstone and bentonite in interval 600 to 1,500 feet above base of formation.

Conglomerate (Kpg).—Dark gray, composed of pebbles and cobbles of black chert, green jasper, andesitic

porphyry, quartzite, granitic rocks, and locally tan dolomite and sandstone, in matrix of hard muddy sandstone. Forms lenses as thick as 300 feet, mostly at base of formation.

HEX CLAYSTONE (Kh)

Pervasively sheared and crushed bentonitic claystone, named by Marsh (1960), exposed southeast of Orchard Peak. Bluish to brownish gray, composed of montmorillonitic clay; contains veinlets of gypsum, also tan-weathering calcareous nodules and lenses, and few blocks of sandstone. Claystone devoid of bedding, is plastic and shear-foliated throughout; prevasively sheared and is injected into Panoche Formation. May be largely upper part of Gravelly Flat Formation. Age, Early Cretaceous on basis of fossils.

GRAVELLY FLAT FORMATION (gf)

Marine predominantly shale unit east of San Andreas fault. Mainly dark olive-gray to brown thin-bedded micaceous clayey to silty shale; contains laminae and in places thin interbeds of olive-gray fine-grained arkosic sandstone or graywacke, also thin hard tan calcareous layers or nodules. Near Orchard Peak contains two strata of white tuffaceous sandstone and bentonite, one as thick as 50 feet and 1,000 feet above base, the other as thick as 70 feet and 1,250 feet above base of formation (Marsh, 1960). In Diablo Range-Orchard Peak area formation as thick as 4,000 feet, in depositional if not in fault contact with Franciscan rocks and serpentine. In Temblor Range possibly 5,000 feet exposed, but contact with Panoche Formation very gradational and only arbitrarily located. Assigned a Late Jurassic(?) and Early Cretaceous age.

JOLLO FORMATION OF HALL AND CORBATÓ (1967) (jo)

Dark shale unit exposed near Alamo Creek west of Rinconada fault, lithologically similar to Gravelly Flat Formation; contains thin beds of dark-gray pebble conglomerate. Overlies graywacke of Franciscan Formation; overlapped eastward by Upper Cretaceous marine clastic sedimentary rocks; as thick as 1,000 feet at border of map area. Age, Early Cretaceous, probably in part Late Jurassic.

EUGEOSYNCLINAL SEDIMENTARY AND IGNEOUS ROCKS

Complex of eugeosynclinal marine sedimentary and mafic volcanic rocks and ultramafic intrusive rocks, all pervasively (tectonically?) sheared and mixed; of late Mesozoic age; exposed below the Jurassic(?) and Cretaceous marine sedimentary sequence northeast of San Andreas and Gold Hill faults, and also southwest of Rinconada fault.

SERPENTINE AND SERPENTINIZED PERIDOTITE (sp)

Serpentine and partly serpentinized peridotite intermixed. Serpentine bluish green to greenish black, composed mainly of antigorite (hydrous magnesium silicate) and disseminated magnetite, severely slickensided and brecciated. Peridotite greenish black, composed of pyroxene (largely altered to antigorite) and disseminated magnetite. Both rocks contain minute fibrous veinlets of asbestos. Form many injected pod- or sill-like masses in Franciscan rocks and just below Gravelly Flat Formation. Age, Jurassic and (or) Cretaceous.

FRANCISCAN ROCKS OF BAILEY AND OTHERS (1964)

Pervasively sheared and brecciated assemblage of marine eugeosynclinal rocks; assemblage probably very thick, but only small part exposed. Age, late Mesozoic, either Late Jurassic or Cretaceous, or both.

Mixed rocks, undifferentiated (f).—Mainly sandstone (graywacke) and claystone, and local occurrences of chert and limestone. Sandstone greenish gray, hard, massive; much brecciated and recemented. Claystone dark gray, poorly bedded, severely sheared, gouged and slickensided. Chert red, brown, green, thin bedded, much contorted. Limestone bluish gray to pink, much brecciated, present only east of Cholame Valley. Sandstone, chert, limestone, and other rocks (greenstone, jasper and blue schist) from lenses, cataclastic fragments, and large monoliths in matrix largely of pervasively sheared claystone.

Greenstone (fg).—Slightly metamorphosed from extrusive and intrusive(?) basalt; greenish black, moderately hard, aphanitic, massive, displays pillow structures locally; composed mainly of chlorite, pumpellyite, and disseminated iron oxides. Much shattered, in places partly silicified to varicolored jasper.

CRYSTALLINE PLUTONIC AND METAMORPHIC ROCKS

Plutonic and gneissoid metamorphic rocks that form crystalline basement complex of area between San Andreas and Gold Hill faults and Rinconada fault.

GRANITIC ROCKS (gr)

Mostly granitic rocks that range from granodiorite to quartz monzonite in La Panza Range; light gray, massive, medium grained; composed of one-third quartz, two-thirds feldspar, 2 to 10 percent biotite, and a total less than 1 percent hornblende, sphene, zircon and iron oxides. One-half to two-thirds of feldspar is plagioclase (andesine), remainder is potassic feldspar; some of latter occurs as phenocrysts (D. C. Ross, oral commun., 1967). Age, Mesozoic; reported about 80.5 million years or Cretaceous (Hay, 1963, p. 113). These rocks and gneissic rocks intruded by local small masses of white fine-grained granite or alaskite.

HORNBLENDE QUARTZ GABBRO (hg)

Unusual amphibolite rock exposed at and near Gold Hill in Cholame Valley on east side of San Andreas fault. Dark gray, massive to rarely gneissoid, medium to coarse grained; average of eight samples contains 48 percent hornblende, 39 percent plagioclase (mostly labradorite, but ranges from andesine to bytownite), about 13 percent quartz, and traces of potassic feldspar and biotite (D. C. Ross, oral commun., 1968). Includes a small outcrop of white marble at Gold Hill. Age of gabbro Mesozoic or older; about 143 million years old or Jurassic (Hay, 1963, p. 113–115).

GNEISSIC ROCKS

At Barrett Ridge (about 7 miles west of Soda Lake) mainly gray banded gneiss composed of quartz, feldspar

and biotite; gneiss includes small bodies of dark-gray biotite schist, light-gray quartzite, and (adjacent to San Juan fault) white marble (not shown). At Red Hills mainly gray gneissoid quartz diorite, with about 11 percent biotite; ranges from massive quartz diorite to banded gneiss; includes several very small bodies of white marble (not shown). Age, Mesozoic or older. Presumably part of Sur Series of Trask (1926).

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