U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science Directorate
Geologic Resources Division

Santa Monica Mountains National Recreation Area

GRI Ancillary Map Information Document

Produced to accompany the Geologic Resources Inventory (GRI) Digital Geologic Data for Santa Monica Mountains National Recreation Area

samo_geology.pdf

Version: 6/1/2016

Geologic Resources Inventory Ancillary Map Information Document for Santa Monica Mountains National Recreation Area

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Geologic Resources Inventory Map Document

Santa Monica Mountains National Recreation Area, California

Document to Accompany Digital Geologic-GIS Data

samo_geology.pdf

Version: 6/1/2016

This document has been developed to accompany the digital geologic-GIS data developed by the Geologic Resources Inventory (GRI) program for Santa Monica Mountains National Recreation Area, California (SAMO).

Attempts have been made to reproduce all aspects of the original source products, including the geologic units and their descriptions, geologic cross sections, the geologic report, references and all other pertinent images and information contained in the original publication.

This document contains the following information:

1) **About the NPS Geologic Resources Inventory Program** – A brief summary of the Geologic Resources Inventory (GRI) Program and its products. Included are web links to the GRI GIS data model, and to the GRI products page where digital geologic-GIS datasets, scoping reports and geology reports are available for download. In addition, web links to the NPS Data Store and GRI program home page, as well as contact information for the GRI coordinator, are also present.

2) **GRI Digital Maps and Source Citations** – A listing of all GRI digital geologic-GIS maps produced for this project along with sources used in their completion. In addition, a brief explanation of how each source map was used is provided.

3) **Digital Geologic Map of Santa Monica Mountains National Recreation Area**

a) **Map Unit Listing** – A listing of all geologic map units present on maps for this project, generally listed from youngest to oldest.

b) **Map Unit Descriptions** – Descriptions for all geologic map units. If a unit is present on multiple source maps the unit is listed with its source geologic unit symbol, unit name and unit age followed by the unit's description for each source map.

c) **Ancillary Source Map Information** – Additional source map information presented by source map. For each source map this may include a stratigraphic column, index map, map legend and/or map notes.

4) **Digital Geohazards Map of Santa Monica Mountains National Recreation Area**

a) **Ancillary Source Map Information** – Additional source map information presented by source map.

5) **GRI Digital Data Credits** – GRI digital geologic-GIS data and ancillary map information document production credits.

For information about using GRI digital geologic-GIS data contact:

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About the NPS Geologic Resources Inventory Program

Background

Recognizing the interrelationships between the physical (geology, air, and water) and biological (plants and animals) components of the earth is vital to understanding, managing, and protecting natural resources. The Geologic Resources Inventory (GRI) helps make this connection by providing information on the role of geology and geologic resource management in parks.

Geologic resources for management consideration include both the processes that act upon the Earth and the features formed as a result of these processes. Geologic processes include: erosion and sedimentation; seismic, volcanic, and geothermal activity; glaciation, rockfalls, landslides, and shoreline change. Geologic features include mountains, canyons, natural arches and bridges, minerals, rocks, fossils, cave and karst systems, beaches, dunes, glaciers, volcanoes, and faults.

The Geologic Resources Inventory aims to raise awareness of geology and the role it plays in the environment, and to provide natural resource managers and staff, park planners, interpreters, researchers, and other NPS personnel with information that can help them make informed management decisions.

The GRI team, working closely with the Colorado State University (CSU) Department of Geosciences and a variety of other partners, provides more than 270 parks with a geologic scoping meeting, digital geologic-GIS map data, and a park-specific geologic report.

Products

Scoping Meetings: These park-specific meetings bring together local geologic experts and park staff to inventory and review available geologic data and discuss geologic resource management issues. A summary document is prepared for each meeting that identifies a plan to provide digital map data for the park.

Digital Geologic Maps: Digital geologic maps reproduce all aspects of traditional paper maps, including notes, legend, and cross sections. Bedrock, surficial, and special purpose maps such as coastal or geologic hazard maps may be used by the GRI to create digital Geographic Information Systems (GIS) data and meet park needs. These digital GIS data allow geologic information to be easily viewed and analyzed in conjunction with a wide range of other resource management information data.

For detailed information regarding GIS parameters such as data attribute field definitions, attribute field codes, value definitions, and rules that govern relationships found in the data, refer to the NPS Geology-GIS Data Model document available at: http://science.nature.nps.gov/im/inventory/geology/GeologyGISDataModel.cfm

Geologic Reports: Park-specific geologic reports identify geologic resource management issues as well as features and processes that are important to park ecosystems. In addition, these reports present a brief geologic history of the park and address specific properties of geologic units present in the park.

For a complete listing of Geologic Resource Inventory products and direct links to the download site visit the GRI publications webpage http://www.nature.nps.gov/geology/inventory/gre_publications.cfm

GRI geologic-GIS data is also available online at the NPS Data Store Search Application: http://irma.nps.gov/App/Reference/Search. To find GRI data for a specific park or parks select the appropriate park (s), enter “GRI” as a Search Text term, and then select the Search Button.

For more information about the Geologic Resources Inventory Program visit the GRI webpage: http://www.nature.nps.gov/geology/inventory, or contact:

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The Geologic Resources Inventory (GRI) program is funded by the National Park Service (NPS) Inventory and Monitoring (I&M) Division.

GRI Digital Maps and Source Map Citations

The GRI digital geologic-GIS maps for Santa Monica Mountains National Recreation Area, California (SAMO):

Digital Geologic Map of Santa Monica Mountains National Recreation Area, California (*GRI MapCode SAMO*)

The map was produced from the following California Geological Survey and U.S. Geological Survey source maps and digital data:

Campbell, Russell H., Wills, Chris J., Irvine, Pamela J., and Swanson, Brian J. (digital preparation by Gutierrez, Carlos, I., and O'Neal, Matt D.), 2014, Preliminary Geologic Map of the Los Angeles 30' x 60' Quadrangle, California (version 2.0): California Geological Survey and the U.S. Geological Survey, scale 1:100,000. (*GRI Source Map ID 76065*)

Only a portion of the full extent of this map was used. The extent used was limited to the following 7.5' quadrangles: Beverly Hills, Burbank, Calabasas, Canoga Park, Hollywood, Malibu Beach, Moon Park, Newbury Park, Point Dume, Simi Valley West, Thousand Oaks, Topanga, Triunfo Pass, and Van Nuys. All geologic features within the extent of these quadrangles were captured from this source.

Tan, S.S., Clahan, K.B., Hitchcock, C.S., Gutierrez C.I.and Mascorro M.T., 2004, Geologic Map of the Camarillo 7.5-minute Quadrangle, Ventura County, California version 1.0: California Geological Survey, Preliminary Geologic Maps, scale 1:24,000. (*GRI Source Map ID 74950*)

Only folds and related fold map symbology was captured from this source.

Wills, C.J., Campbell, R.H. and Irvine, P.J., 2012, Geologic Map Database of the Santa Monica Mountains Region, Los Angeles and Ventura Counties, California: California Geological Survey, unpublished, scale 1:24,000. (*GRI Source Map ID 75634*)

Only a portion of the full extent of this map was used. The extent used was limited to the following 7.5' quadrangles: Camarillo and Point Mugu. All geologic features within the extent of these quadrangles were captured from this source.

Digital Geohazards Map of Santa Monica Mountains National Recreation Area, California (*GRI MapCode SAMO_GEOHAZARDS*)

The map was produced from the following California Geological Survey source digital data:

Irvine, P.J. and McCrink, T.P., 2012, Landslide Inventory of the Santa Monica Mountains Region, Los Angeles and Ventura Counties, California: California Geological Survey, unpublished, scale 1:24,000. (*GRI Source Map ID 75623*).

The full extent of the source was used.

Additional information pertaining to each source map is also presented in the GRI Source Map Information (SAMOMAP) table included with the GRI geologic-GIS data.

Digital Geologic Map of Santa Monica Mountains National Recreation Area

Map Unit List

The geologic units present in the digital geologic-GIS data produced for Santa Monica Mountains National Recreation Area, California (SAMO) are listed below. Units are listed with their assigned unit symbol and unit name (e.g., Qaf - Artificial fill). Units are listed from youngest to oldest. No description for water is provided. Information about each geologic unit is also presented in the GRI Geologic Unit Information (SAMOUNIT) table included with the GRI geology-GIS data. Some source unit symbols, names and/or ages may have been changed in this document and in the GRI digital geologic-GIS data. This was done if a unit was considered to be the same unit as one or more units on other source maps used for this project, and these unit symbols, names and/or ages differed. In this case a single unit symbol and name, and the unit's now recognized age, was adopted. Unit symbols, names and/or ages in a unit descriptions, or on a correlation of map units or other source map figure were not edited. If a unit symbol, name or age was changed by the GRI the unit's source map symbol, name and/or age appears with the unit's source map description.

Cenozoic Era

Quaternary Period
Qaf - Artificial fill
Qa - Alluvium
Qw - Wash deposits
Qb - Beach deposits
Qe - Eolian deposits
Qf - Alluvial fan
Qes - Active coastal estuarine deposits
Qf3 - Late Holocene alluvial fan deposits of the Oxnard Plain associated with unit Qw3
Qw2 - Holocene wash deposits of the Oxnard Plain
Qa2 - Holocene alluvial deposits of the Oxnard Plain
Qf2 - Late Holocene alluvial fan deposits of the Oxnard Plain associated with unit Qw2
Qw1 - Holocene wash deposit of the Oxnard Plain
Qf1 - Holocene alluvial fan deposits of the Oxnard Plain associated with unit Qw1
Qyff - Holocene alluvial deposits
Qls - Landslide deposits
Qya - Young alluvium, undivided
Qya4 - Young alluvium, Unit 4
Qya3 - Young alluvium, Unit 3
Qya2 - Young alluvium, Unit 2
Qya1 - Young alluvium, Unit 1
Qyf - Young alluvial-fan deposits, undivided
Qyf3 - Young alluvial-fan deposits, Unit 3
Qyf2 - Young alluvial-fan deposits, Unit 2
Qyf1 - Young alluvial-fan deposits, Unit 1
Qoft - Alluvial fan deposits on wave-cut surface
Qoa - Old alluvium, undivided
Qoa2 - Old alluvium, Unit 2
Qoa1 - Old alluvium, Unit 1
Qof - Old fan deposits, undivided
Qof4 - Old fan deposits, Unit 4
Qof3 - Old fan deposits, Unit 3

Qof2 - Old fan deposits, Unit 2
Qof1 - Old fan deposits, Unit 1
Qom - Old shallow marine deposits on wave-cut surface
Qs - Saugus Formation, younger

Tertiary to Quaternary Periods
QTs - Saugus Formation, older

Quaternary Period
Qsc - Saugus Formation, Camarillo member
Qsv - Saugus Formation, volcaniclastic breccia-conglomerate
Qvoa - Very old alluvium, undivided
Qvoa1 - Very old alluvium, Unit 1
Qsp - San Pedro Formation
Qlp - Las Posas Formation
QTp - Pico Formation, undivided
QTpg - Pico Formation, Grimes Canyon deltaic facies
QTpcu - Pico Formation, coarse-grained upper facies
QTpc - Pico Formation, sandstone and conglomerate
Qi - Inglewood Formation

Tertiary to Quaternary Periods
QTms - Sedimentary rocks of the Pacific Palisades area

Tertiary Period
QTfl - Fernando Formation, Lower Member
Tpn - Puente Formation, undivided
Tpsl - Puente Formation, siltstone
Tpsh - Puente Formation, siliceous shale
Tpds - Puente Formation, diatomaceous shale
Tpss - Puente Formation, sandstone
Tm - Modelo Formation, undivided
Tmsu - Modelo Formation, upper sandstone unit at Laskey Mesa
Tm4 - Modelo Formation, member 4
Tm3 - Modelo Formation, member 3
Tm2 - Modelo Formation, member 2
Tm1 - Modelo Formation, member 1
Tmd - Modelo Formation, diatomaceous shale
Tms - Modelo Formation, sandstone
Tmb - Modelo Formation, "burnt shale"
Tmt - Monterey Shale, undivided
Tmtd - Monterey Shale, deformed
Tcb - Calabasas Formation, undivided
Tcbvc - Calabasas Formation, volcanic conglomerate
Tcbs - Calabasas Formation, Stokes Canyon Breccia Member
Tcbmp - Calabasas Formation, Mesa Peak Breccia Member
Tcbn - Calabasas Fromation, Newell Sandstone Member
Tcbd - Calabasas Formation, Dry Canyon Sandstone Member
Tcbl - Calabasas Formation, Latigo Canyon Breccia Member
Tcbe - Calabasas Formation, Escondido Canyon Shale Member
Tr - Trancas Formation, undivided
Tra - Trancas Formation, quartz-bearing calcarenites
Tz - Zuma Volcanics

Tt - Topanga Group, undivided
Ttss - Topanga Group, sandstone
Ttsl - Topanga Group, siltstone
Ttcg - Topanga Group, conglomerate
Ttb - Topanga Group, intrusive and extrusive volcanic rocks
Tco - Conejo Volcanics, undivided
Tcode - Conejo Volcanics, dacite-bearing epiclastic lenses
Tcod - Conjeo Volcanics, dacite-bearing upper zone
Tcoa - Conejo Volcanics, andesitic central zone
Tcoaf - Conejo Volcanics, andesitic central zone, andesitic flows
Tcoaa - Conejo Volcanics, andesitic central zone, andesitic agglomerate
Tcoab - Conejo volcanics, andesitic central zone, andesite breccia
Tcob - Conejo Volcanics, basaltic lower zone, basalt and andesitic basalt
Tcoadb - Conejo Volcanics, mixture of andesitic and dacitic flow breccias with some flows
Tcodb - Conejo Volcanics, dacitic flow breccias with some flows
Tcobf - Conejo Volcanics, basaltic lower zone, basalt and andestic basalt, basalt flows
Tcobb - Conejo Volcanics, basaltic lower zone, basalt and andesitic basalt, basaltic breccia
Tcop - Conejo Volcanics, basaltic lower zone, pillow basalt
Tcobz - Conejo Volcanics, basaltic lower zone, basaltic sand
Tcom - Conejo Volcanics, Malibu Bowl Tongue
Tcos - Conejo Volcanics, Solstice Canyon Tongue
Tcor - Conejo Volcanics, Ramera Canyon Tongue
Ti - Intrusive rocks, undivided
Tid - Intrusive rocks, dacite
Tia - Intrusive rocks, andesitic
Tib - Intrusive rocks, basaltic
Tim - Mixed rocks
Ttc - Topanga Canyon Formation, undivided
Ttcc - Topanga Canyon Formation, Cold Creek Member
Ttcf - Topanga Canyon Formation, Fernwood Member
Ttcs - Topanga Canyon Formation, Saddle Peak Member
Ttcb - Topanga Canyon Formation, Big Sycamore Member
Ttcbs - Topanga Canyon Formation, Big Sycamore Member, prominent sandstone bed
Ttce - Topanga Canyon Formation, Encinal Member
Tv - Valqueros Formation, undivided
Tvn - Vaqueros Formation, San Nicholas Member
Tvd - Vaqueros Formation, Danielson Member
Ts - Sespe Formation, undivided
Tsp - Sespe Formation, Piuma Member
Tl - Llajas Formation
Tss - Santa Susana Formation
Tssl - Santa Susana Formation, limestone
Tlv - Las Virgenes Sandstone
Tsi - Simi Conglomerate, undivided

Mesozoic Era

Cretaceous Period
Kc - Chatsworth Formation
Kt - Tuna Canyon Formation, undivided
Kte - Tuna Canyon Formation, informal member 'e'
Ktd - Tuna Canyon Formation, informal member 'd'

Ktc - Tuna Canyon Formation, informal member 'c'
Ktb - Tuna Canyon Formation, informal member 'b'
Ktr - Trabuco Formation
Kgr - Granitic rocks

Jurassic Period
Jsm - Santa Monica Slate, undivided
Jsms - Santa Monica Slate, spotted slate
Jsmp - Santa Monica Slate, phyllite

Mesozoic Era
MZqdb - Biotite-quartz diorite
MZhd - Hornblende diorite
MZdg - Diorite gneiss

Map Unit Descriptions

Descriptions of all geologic map units, generally listed from youngest to oldest, are presented below. All unit descriptions were derived from the following sources: Preliminary Geologic Map of the Los Angeles 30' x 60' Quadrangle, California (version 2.0) (*GRI Source Map ID 76065*), and/or the Geologic Map Database of the Santa Monica Mountains Region, Los Angeles and Ventura Counties, California (*GRI Source Map ID 75634*). See the GRI Digital Maps and Source Map Citations section of this document for complete source citations.

Qaf - Artificial fill (late Holocene)

af - Artificial Fill (Holocene)
Deposits of sand silt and gravel resulting from human construction, mining or quarrying activities; includes compacted engineered and noncompacted nonengineered fill. Only large deposits are shown. Fills emplaced after source maps were completed are generally not shown. (*GRI Source Map ID 76065*)

Qaf - Artificial Fill (late Holocene)
Deposits of sand silt and gravel resulting from human construction, mining or quarrying activities; includes compacted engineered and noncompacted nonengineered fill. Only large deposits are shown. (*GRI Source Map ID 75634*)

Qa - Alluvium (late Holocene)

Qa - Alluvium (late Holocene)
Unconsolidated gravel, sand and silt in active or recently active floodplains, locally including related alluvial fans and streambeds where those are not mapped separately; chiefly stream deposited, but includes some debris-flow deposits. Locally corresponds with or encompasses areas of historic flooding, including deposits behind flood-control structures. (*GRI Source Map ID 76065*)

Qa - Alluvium (late Holocene)
Unconsolidated gravel, sand and silt in active or recently active streambeds; chiefly stream deposited, but includes some debris-flow deposits; episodes of bank-full stream flow are frequent enough to inhibit growth of vegetation. (*GRI Source Map ID 75634*)

Qw - Wash deposits (late Holocene)

Qw - Wash deposits (late Holocene)
Unconsolidated gravel, sand and silt in active or recently active streambeds; chiefly stream deposited, but includes some debris-flow deposits; episodes of bank-full stream flow are frequent enough to inhibit growth of vegetation. (*GRI Source Map ID 76065*)

Qw - Wash deposits (late Holocene)
Unconsolidated gravel, sand and silt in active or recently active streambeds; chiefly stream deposited, but includes some debris-flow deposits; episodes of bank-full stream flow are frequent enough to inhibit growth of vegetation. (*GRI Source Map ID 75634*)

Qb - Beach deposits (late Holocene)

Qb - Beach deposits (late Holocene)
Loose fine- and medium-grained sand of active beaches chiefly between elevations of lower-low water and storm strands. (*GRI Source Map ID 76065*)

Qb - Beach deposits (late Holocene)
Loose fine- and medium-grained sand of active beaches chiefly between elevations of lower-low water and storm strands. (*GRI Source Map ID 75634*)

Qe - Eolian deposits (late Holocene)

Qe - Eolian deposits (late Holocene)
Loose, fine- to medium- grained sand, silty sand and silt; forms transitory dunes against beach-facing cliff. (*GRI Source Map ID 76065*)

Qe - Eolian (dune) deposits (late Holocene)
Loose, fine- to medium- grained sand, silty sand and silt; forms transitory dunes against beach-facing cliff. (*GRI Source Map ID 75634*)

Qf - Alluvial fan (Holocene)

Qf - Alluvial fan (Holocene)
Unconsolidated bouldery, cobbly, gravelly, sandy, or silty alluvial deposits on active and recently active alluvial fans and in some connected headward channel segments. (*GRI Source Map ID 76065*)

Qf - Alluvial fan (Holocene)
Unconsolidated bouldery, cobbley, gravelly, sandy, or silty alluvial deposits on active and recently active alluvial fans and in some connected headward channel segments. (*GRI Source Map ID 75634*)

Qes - Active coastal estuarine deposits (Holocene)

Composed of submerged/saturated silty clay. (*GRI Source Map ID 75634*)

Qf3 - Late Holocene alluvial fan deposits of the Oxnard Plain associated with unit Qw3 (Holocene)

Youngest of three subunits of Qyf that can be distinguished in some areas. (*GRI Source Map ID 75634*)

Qw2 - Holocene wash deposits of the Oxnard Plain (Holocene)

Composed of unconsolidated sand, silt and gravel. (*GRI Source Map ID 75634*)

Qa2 - Holocene alluvial deposits of the Oxnard Plain (Holocene)

Deposited as overbank material associated with unit Qw2 , recognized by scour and incised channeling features; composed of unconsolidated, poorly sorted, clayey sand with some gravel. (*GRI Source Map ID 75634*)

Qf2 - Late Holocene alluvial fan deposits of the Oxnard Plain associated with unit Qw2 (Holocene)

Recognized by scour and incised channeling features; composed of unconsolidated, poorly sorted, clayey sand with some gravel. Unit distinguished by geomorphic expression of alluvial fan. (*GRI Source Map ID 75634*)

Qw1 - Holocene wash deposit of the Oxnard Plain (Holocene)

Composed of unconsolidated sand, silt and gravel. (*GRI Source Map ID 75634*)

Qf1 - Holocene alluvial fan deposits of the Oxnard Plain associated with unit Qw1 (Holocene)

Recognized by scour and incised channeling features; composed of unconsolidated, sandy clay with some gravel. Unit distinguished by geomorphic expression of alluvial fan. (*GRI Source Map ID 75634*)

Qyff - Holocene alluvial deposits (Holocene)

Composed of unconsolidated, poorly sorted, clayey sand with some gravel depending on source area of stream, material may be the same as wash or alluvial fan deposits. (*GRI Source Map ID 75634*)

Qls - Landslide deposits (Holocene and late Pleistocene?)

Only selected landslide deposits shown on this map as described below. Deposits represent rock detritus from bedrock and surficial materials, broken in varying degrees from relatively coherent large blocks to disaggregated small fragments, deposited by landslide processes. Most deposits are Holocene, some dissected landslides may be as old as late Pleistocene. Landslide deposits shown on this map were compiled primarily from landslide inventories prepared by CGS for the Seismic Hazard Zonation Program. For this map, only landslides described as definite or probable and larger than 50,000 square meters are shown to preserve the clarity of the underlying bedrock geology. Selected historically active landslides between 10,000 and 50,000 square meters are shown, but no landslides smaller than 10,000 square meters are shown on this map. Exceptions to these rules include small or questionable landslides surrounded by larger probable or definite landslides. (*GRI Source Map ID 76065*)

Qya - Young alluvium, undivided (Holocene and late Pleistocene)

Qya - Young alluvium, undivided (Holocene and late Pleistocene)
Unconsolidated, generally friable, stream-deposited silt, sand and gravel on flood plains, locally including related alluvial fans and streambeds where those are not mapped separately. Deposits are clearly related to depositional processes that are still on-going. Subunits are distinguished by relative ages based on geomorphic relationships, relative degree of surface dissection and soil formation. (*GRI Source Map ID 76065*)

Qya - Young alluvium, undivided (Holocene and late Pleistocene)
Unconsolidated, generally friable, stream-deposited silt, sand and gravel on canyon floors. Deposits are clearly related to depositional processes that are still on-going. Surfaces may show slight to moderate pedogenic soil development. Subunits are distinguished by relative ages based on geomorphic relationships, relative degree of surface dissection and soil formation. (*GRI Source Map ID 75634*)

Qya4 - Young alluvium, Unit 4 (Holocene)

Youngest of as many as 4 subunits of Qya that can be distinguished in some areas. (*GRI Source Map ID 76065*)

Qya3 - Young alluvium, Unit 3 (Holocene and late Pleistocene)

Older young alluvium, older than Unit 4, younger than Unit 2. (*GRI Source Map ID 76065*)

Qya2 - Young alluvium, Unit 2 (late Pleistocene)

Older young alluvium, older than Unit 3, younger than Unit 1. (*GRI Source Map ID 76065*)

Qya1 - Young alluvium, Unit 1 (late Pleistocene)

Oldest young alluvium. (*GRI Source Map ID 76065*)

Qyf - Young alluvial-fan deposits, undivided (Holocene and late Pleistocene)

Qyf - Young fan deposits, undivided (Holocene and late Pleistocene)
Unconsolidated gravel, sand and silt, bouldery along mountain fronts; deposited chiefly from flooding streams and debris flows. Deposits are clearly related to depositional processes that are still on-going. Subunits are distinguished by relative ages based on geomorphic relationships, relative degree of surface dissection and soil formation. (*GRI Source Map ID 76065*)

Qyf - Young alluvial-fan deposits, undivided (Holocene and late Pleistocene?)
Unconsolidated gravel, sand and silt, bouldery near mountain fronts; deposited chiefly from flooding streams and debris flows. Deposits are clearly related to alluvial fan depositional processes that are still on-going. Surfaces can show slight to moderate pedogenic soil development. Subunits are distinguished by relative ages based on geomorphic relationships, relative degree of surface dissection and soil formation. (*GRI Source Map ID 75634*)

Qyf3 - Young alluvial-fan deposits, Unit 3 (late Pleistocene to Holocene)

Young fan deposits, older than Unit 5, younger than Unit 2. (*GRI Source Map ID 76065*)

Qyf2 - Young alluvial-fan deposits, Unit 2 (late Pleistocene to Holocene)

Qyf2 - Young alluvial-fan deposits, Unit 2 (Holocene to late Pleistocene)
Older young fan deposits, older than Unit 3, younger than Unit 1. (*GRI Source Map ID 76065*)

Qyf2 - Young alluvial-fan deposits, Unit 2 (Holocene and late Pleistocene)
Older young fan deposits, older than Unit 3, younger than Unit 1. (*GRI Source Map ID 75634*)

Qyf1 - Young alluvial-fan deposits, Unit 1 (late Pleistocene to Holocene)

Oldest of as many as four subunits of Qyf that can be distinguished in some areas. (*GRI Source Map ID 76065*)

Qoft - Alluvial fan deposits on wave-cut surface (late Pleistocene to Holocene)

Unconsolidated to moderately indurated, clay, silt, sand, and angular gravel including clasts to boulder size; chiefly debris-flow deposits, but probably includes some stream-deposited material; surfaces can show slight to moderate pedogenic soil development. Overlies elevated wave-planed bedrock and marine terrace deposits along the coast. (*GRI Source Map ID 76065*)

Qoa - Old alluvium, undivided (middle to late Pleistocene)

Qoa - Old alluvium undivided (late to middle Pleistocene)
Unconsolidated to moderately indurated gravel, sand and silt deposited on flood plains, locally including related alluvial fans and streambeds where those are not mapped separately. Deposits have been uplifted or otherwise removed from the locus of recent sedimentation. Surfaces may be dissected in varying degrees; and can show moderately to well-developed pedogenic soils. Subunits are distinguished by relative ages based on geomorphic relationships, relative degree of surface dissection and soil formation. (*GRI Source Map ID 76065*)

Qoa - Old alluvium, undivided (middle to late Pleistocene)
Unconsolidated to moderately indurated gravel, sand and silt. Deposits have been uplifted or otherwise removed from the locus of recent sedimentation. Environment of deposition may include axial valley, floodplain or alluvial fan, but morphology of original deposit may not be preserved. Surfaces can show moderate to well-developed pedogenic soil, including a distinctive reddish "B"soil horizon and may be moderately to well dissected. Subunits are distinguished by relative ages based on geomorphic relationships, relative degree of surface dissection and soil formation. (*GRI Source Map ID 75634*)

Qoa2 - Old alluvium, Unit 2 (late Pleistocene)

Intermediate of as many as three subunits of Qoa that can be distinguished in some areas. (*GRI Source Map ID 76065*)

Qoa1 - Old alluvium, Unit 1 (middle Pleistocene)

Oldest of as many as three subunits of Qoa that can be distinguished in some areas. (*GRI Source Map ID 76065*)

Qof - Old fan deposits, undivided (middle to late Pleistocene)

Qof - Old fan deposits, undivided (late to middle Pleistocene)
Slightly to moderately consolidated silt, sand and gravel deposits on alluvial fans. Deposits have been uplifted or otherwise removed from the locus of recent sedimentation. Morphology of original alluvial fan surface usually well preserved, though dissected in varying degrees; surfaces can show moderately to well-developed pedogenic soils. Subunits are distinguished by relative ages based on geomorphic relationships, relative degree of surface dissection and soil formation. (*GRI Source Map ID 76065*)

Qof - Old alluvial-fan deposits, undivided (middle to late Pleistocene)
Slightly to moderately consolidated silt, sand and gravel deposits on alluvial fans. Deposits have been uplifted or otherwise removed from the locus of recent sedimentation. Morphology of original alluvial fan surface preserved to some extent. Surfaces dissected in varying degrees and can show moderately to well-developed pedogenic soils. Subunits are distinguished by relative ages based on geomorphic relationships, relative degree of surface dissection and soil formation. (*GRI Source Map ID 75634*)

Qof4 - Old fan deposits, Unit 4 (late Pleistocene)

Youngest of as many as four subunits of Qof that can be distinguished in some areas. (*GRI Source Map ID 76065*)

Qof3 - Old fan deposits, Unit 3 (late Pleistocene)

Qof3 - Old fan deposits, Unit 3 (late Pleistocene)
Intermediate subunit of Qof that can be distinguished in some areas, older than Qof4 and younger than Qof2. (*GRI Source Map ID 76065*)

Qof3 - Old alluvial-fan deposits, Unit 3 (late Pleistocene)
Intermediate of as many as four subunits of Qof that can be distinguished in some areas. (*GRI Source Map ID 75634*)

Qof2 - Old fan deposits, Unit 2 (late Pleistocene)

Qof2 - Old fan deposits, Unit 2 (late Pleistocene)
Intermediate subunit of Qof that can be distinguished in some areas, older than Qof3 and younger than Qof1. (*GRI Source Map ID 76065*)

Qof2 - Old alluvial-fan deposits, Unit 2 (late Pleistocene)
Intermediate of as many as four subunits of Qof that can be distinguished in some areas. (*GRI Source Map ID 75634*)

Qof1 - Old fan deposits, Unit 1 (late Pleistocene)

Oldest of at least four subunits of Qof that can be distinguished in some areas. (*GRI Source Map ID 76065*)

Qom - Old shallow marine deposits on wave-cut surface (late Pleistocene)

Unconsolidated (but with small areas locally calcite-cemented) sand, silty sand and gravel; commonly overlies wave-cut bedrock surfaces at two or more altitudes above present sea level; surfaces can show slight to moderate pedogenic soil development; locally carries molluscan fauna referred to the late Pleistocene (Addicott, 1964). (*GRI Source Map ID 76065*)

Qs - Saugus Formation, younger (late? Pleistocene)

Weakly to moderately cemented, medium- to coarse-grained, light-gray to yellowish-gray sandstone and pebble conglomerate and light greenish-gray sandy siltstone deposited in the Ventura basin; moderately sorted; commonly cross bedded and channeled; interbedded with moderate-brown to reddish-brown poorly sorted sandy mudstone and local claystone seams in the type area and other portions of the eastern Ventura basin, reflecting overbank deposits and paleosols; fluvial near the basin axis, transitioning to alluvial fan environment near the basin margins; interfingers with shallow marine sands to the west. The Saugus Formation is chiefly nonmarine as defined by Hershey (1902b) and Winterer and Durham (1962), but mapping compiled herein may locally include shallow marine interbeds. Transitional to brackish water deposits at the base of the section observed in the eastern Ventura basin are assigned to the Sunshine Ranch Member. This formation has a gradational to interfingering conformable contact with underlying shallow marine strata of the Pico Formation near the axis of the Ventura basin, but the contact is time transgressive and is progressively younger to the west. Near the basin margins, the base is unconformable with the Pico Formation and locally overlaps older strata and basement rock. The upper contact shows distinct angular discordance with the overlying Pacoima Formation in most areas, but discordance is more subtle west of Valencia and middle Pleistocene deposition in this area may be nearly continuous. The thickness varies greatly across the Ventura basin; Kew (1924) reports a thickness of 2,000 ft. (610 m) but Winterer and Durham (1962) report that up to 12,000 ft. (3,660 m) of Saugus strata were encountered in a well southeast of San Fernando Pass; a thickness of 2,000 m is reported in the western Ventura basin below the Santa Clara River, but DeVecchio and others (2012b) report a thickness of only 40 to 60 m in the Camarillo area near the southwest margin of the basin. In the eastern Ventura basin, the base of the Saugus is estimated at about 2.3 Ma west of Valencia and in the Mission Hills (Levi and Yeats, 1993) to about 2.6 Ma near Gold Canyon in the northern San Fernando Valley (Beyer and others, 2009). Unfossiliferous deltaic deposits mapped as Saugus in the Elsmere Canyon area by Dibblee (1991d, 1992c) and Squires (2012) may be significantly older based on their position below Sunshine Ranch strata and mapped interfingering relationships with older Pico and Towsley Formation strata. The top of the Saugus in the eastern Ventura basin is estimated at about 0.5 Ma by Levi and Yeats (1993) and is younger to the west. North of Ventura, Lajoie and others (1982) report an age of 0.2 Ma in marine sands underlying the Saugus and an age of 85 ka in overlying marine terrace deposits. In the Moorpark area, Wagner and others (2007) report an age of 780 to 850 ka at a Mammoth fossil site. In the Camarillo and Las Posas Hills area, DeVecchio and others (2012a, 2012b) report that Saugus strata overlie marine sands as young as about 125 ka and may be as young as 25 ka south of the Camarillo Hills based on OSL dating. Based on reported ages, Saugus strata west of Fillmore and west of the Tapo Canyon area are considered post-Pliocene in age and therefore mapped as Qs rather than QTs. Clasts within the Saugus Formation are typically plutonic, metamorphic and volcanic rocks, derived primarily from the San Gabriel Mountains, and transported westward by the ancestral Santa Clara River; however, distinctive clast assemblages have locally been recognized and mapped as informal members or facies by various workers. These include upper Saugus (QTsu); volcaniclastic breccia-conglomerate (Qsv) and Camarillo member (Qsc); additional facies are defined by Weber (1982) in the Santa Clarita area based on the presence or absence of San Francisquito Formation sandstone, Pelona Schist, or anorthosite clasts. The Saugus Formation was initially defined by Hershey (1902b) as the “Saugus division” for continental strata exposed in railroad cuts east of Bouquet Junction near Saugus (type area). These deposits were subsequently lumped into the Fernando

Formation by Eldridge and Arnold (1907). Kew (1923, 1924) formally adopted the term Saugus Formation for the upper section of the Fernando Group and extended usage into the western Ventura basin. Kew generally followed Hershey's nonmarine definition except that he also included underlying coarse-grained shallow marine deposits within the Saugus Formation. The unit was redefined and remapped by Winterer and Durham (1962) in the eastern Ventura basin, who reassigned most of the shallow marine strata to the Pico Formation, conforming to Hershey's nonmarine definition of the Saugus. This nonmarine definition has been adopted by most workers in the eastern Ventura basin (e.g. Saul, 1975, 1979; Weber, 1982; Yeats and others, 1985; Saul and Wootton, 1983; Treiman, 1986, 1987a; Dibblee Foundation maps; Squires and others, 2006; Squires, 2012). Maps covering areas south and west of the area mapped by Winterer and Durham commonly include marine deposits as part of the Saugus based on Kew's definition (e.g. Weber and others, 1973; White, 1985; Squires and White, 1983; Groves, 1991). The restricted usage of Winterer and Durham (1962) in the type area is adopted herein and shallow marine strata formerly assigned to the Saugus Formation in the Santa Susana Mountains and Oak Ridge located east of, and down section of, the Grimes deltaic unit (QTpg) are reassigned as an upper informal member of the Pico Formation (QTpcu) (see Appendix A for details). Nonmarine strata of similar age are mapped as the La Habra Formation in the Los Angeles basin (Eckis, 1934), and as the Casitas Formation in the Santa Barbara basin (Upson, 1951). (*GRI Source Map ID 76065*)

QTs - Saugus Formation, older (late Pliocene to late? Pleistocene)

QTs/Qs - Saugus Formation, undivided (late? Pleistocene to late Pliocene)
Weakly to moderately cemented, medium- to coarse-grained, light-gray to yellowish-gray sandstone and pebble conglomerate and light greenish-gray sandy siltstone deposited in the Ventura basin; moderately sorted; commonly cross bedded and channeled; interbedded with moderate-brown to reddish-brown poorly sorted sandy mudstone and local claystone seams in the type area and other portions of the eastern Ventura basin, reflecting overbank deposits and paleosols; fluvial near the basin axis, transitioning to alluvial fan environment near the basin margins; interfingers with shallow marine sands to the west. The Saugus Formation is chiefly nonmarine as defined by Hershey (1902b) and Winterer and Durham (1962), but mapping compiled herein may locally include shallow marine interbeds. Transitional to brackish water deposits at the base of the section observed in the eastern Ventura basin are assigned to the Sunshine Ranch Member. This formation has a gradational to interfingering conformable contact with underlying shallow marine strata of the Pico Formation near the axis of the Ventura basin, but the contact is time transgressive and is progressively younger to the west. Near the basin margins, the base is unconformable with the Pico Formation and locally overlaps older strata and basement rock. The upper contact shows distinct angular discordance with the overlying Pacoima Formation in most areas, but discordance is more subtle west of Valencia and middle Pleistocene deposition in this area may be nearly continuous. The thickness varies greatly across the Ventura basin; Kew (1924) reports a thickness of 2,000 ft. (610 m) but Winterer and Durham (1962) report that up to 12,000 ft. (3,660 m) of Saugus strata were encountered in a well southeast of San Fernando Pass; a thickness of 2,000 m is reported in the western Ventura basin below the Santa Clara River, but DeVecchio and others (2012b) report a thickness of only 40 to 60 m in the Camarillo area near the southwest margin of the basin. In the eastern Ventura basin, the base of the Saugus is estimated at about 2.3 Ma west of Valencia and in the Mission Hills (Levi and Yeats, 1993) to about 2.6 Ma near Gold Canyon in the northern San Fernando Valley (Beyer and others, 2009). Unfossiliferous deltaic deposits mapped as Saugus in the Elsmere Canyon area by Dibblee (1991d, 1992c) and Squires (2012) may be significantly older based on their position below Sunshine Ranch strata and mapped interfingering relationships with older Pico and Towsley Formation strata. The top of the Saugus in the eastern Ventura basin is estimated at about 0.5 Ma by Levi and Yeats (1993) and is younger to the west. North of Ventura, Lajoie and others (1982) report an age of 0.2 Ma in marine sands underlying the Saugus and an age of 85 ka in overlying marine terrace deposits. In the Moorpark area, Wagner and others (2007) report an age of 780 to 850 ka at a Mammoth fossil site. In the Camarillo and Las Posas Hills area, DeVecchio and others (2012a, 2012b) report that Saugus strata overlie marine sands as young as about 125 ka and may be as young as 25 ka south of the Camarillo Hills based on OSL dating. Based on reported ages, Saugus strata west of

Fillmore and west of the Tapo Canyon area are considered post-Pliocene in age and therefore mapped as Qs rather than QTs. Clasts within the Saugus Formation are typically plutonic, metamorphic and volcanic rocks, derived primarily from the San Gabriel Mountains, and transported westward by the ancestral Santa Clara River; however, distinctive clast assemblages have locally been recognized and mapped as informal members or facies by various workers. These include upper Saugus (QTsu); volcaniclastic breccia-conglomerate (Qsv) and Camarillo member (Qsc); additional facies are defined by Weber (1982) in the Santa Clarita area based on the presence or absence of San Francisquito Formation sandstone, Pelona Schist, or anorthosite clasts. The Saugus Formation was initially defined by Hershey (1902b) as the “Saugus division” for continental strata exposed in railroad cuts east of Bouquet Junction near Saugus (type area). These deposits were subsequently lumped into the Fernando Formation by Eldridge and Arnold (1907). Kew (1923, 1924) formally adopted the term Saugus Formation for the upper section of the Fernando Group and extended usage into the western Ventura basin. Kew generally followed Hershey’s nonmarine definition except that he also included underlying coarse-grained shallow marine deposits within the Saugus Formation. The unit was redefined and remapped by Winterer and Durham (1962) in the eastern Ventura basin, who reassigned most of the shallow marine strata to the Pico Formation, conforming to Hershey’s nonmarine definition of the Saugus. This nonmarine definition has been adopted by most workers in the eastern Ventura basin (e.g. Saul, 1975, 1979; Weber, 1982; Yeats and others, 1985; Saul and Wootton, 1983; Treiman, 1986, 1987a; Dibblee Foundation maps; Squires and others, 2006; Squires, 2012). Maps covering areas south and west of the area mapped by Winterer and Durham commonly include marine deposits as part of the Saugus based on Kew’s definition (e.g. Weber and others, 1973; White, 1985; Squires and White, 1983; Groves, 1991). The restricted usage of Winterer and Durham (1962) in the type area is adopted herein and shallow marine strata formerly assigned to the Saugus Formation in the Santa Susana Mountains and Oak Ridge located east of, and down section of, the Grimes deltaic unit (QTpg) are reassigned as an upper informal member of the Pico Formation (QTpcu) (see Appendix A for details). Nonmarine strata of similar age are mapped as the La Habra Formation in the Los Angeles basin (Eckis, 1934), and as the Casitas Formation in the Santa Barbara basin (Upson, 1951). (*GRI Source Map ID 76065*)

QTs - Saugus Formation, undivided (late Pliocene? to middle Pleistocene)
Slightly consolidated, moderately to poorly sorted, light-gray to yellowish-gray sandstone and conglomerate with variably abundant interbeds of reddish-brown to greenish-gray siltstone and mudstone. This unit was deposited in a dominantly nonmarine, fluvial to alluvial environment, with many of the fine-grained beds representing overbank deposits and paleosols. In the central portion of the basin, the contact with marine strata of the underlying Pico Formation is time transgressive and generally conformable and/or laterally gradational or interfingering as a result of basin filling and associated westward migration of the paleoshoreline over time, but may be locally unconformable near the basin margins. The Saugus Formation is unconformably overlain by younger units and this contact is generally marked by angular discordance. Rocks of this formation in the type area were first assigned to the Saugus "Division" by Hershey (1902) and subsequently included in the upper portion of the Fernando Formation by Eldridge and Arnold (1907). Kew (1923 & 1924) raised the Fernando to group status and assigned the Saugus strata of Hershey (1902) to the Saugus Formation. He reported that nonmarine strata in the type area grade westward into marine strata and included these rocks in the Saugus Formation, and this convention was subsequently followed by many workers in the central and western Ventura basin. However, subsequent workers in the eastern Ventura basin such as Oakeshott (1958), Winterer and Durham (1958 and 1962), Saul (1975 & 1979), Squires and others (2006), and Dibblee (various Dibblee Foundation maps of the Ventura basin) restricted the Saugus Formation to nonmarine or associated transitional marine deposits, and this usage is followed in this study. (*GRI Source Map ID 75634*)

Qsc - Saugus Formation, Camarillo member (late Pleistocene)

Thickly bedded, reddish, pebble-bearing siltstone; paleosols with carbonate-cemented rhizoliths common; clasts are dominantly composed of locally derived Miocene shale and volcanic clasts, with subordinate granitic and metamorphic clasts. Defined informally by DeVecchio and others (2012b) for their chronostratigraphic units Qs2 and Qs3 exposed in the Camarillo and Las Posas Hills area; locally derived clast assemblage distinguishes this member from older sections of the Saugus Formation to the north and is interpreted by DeVecchio and others (2012b) to indicate that uplift of South Mountain and Oak Ridge had diverted the ancestral Santa Clara River to the north, thereby preventing crystalline clasts derived from the San Gabriel Mountains from reaching this area; DeVecchio and others (2012b) report IRSL dates of 78 ± 6 ka to 125 ± 9 ka for this member; thickness 40 to 60 m. (*GRI Source Map ID 76065*)

Qsv - Saugus Formation, volcaniclastic breccia-conglomerate (Pleistocene)

Massive to crudely bedded, breccia-conglomerate composed of angular to subrounded, pebble- to boulder-size, weathered and fresh clasts of Conejo Volcanics in a poorly consolidated matrix of caliche, clay, silt and sand. Amount of matrix material is variable; some exposures consist only of angular, monolithologic volcanic clasts coated with caliche and contain little or no other matrix material. Previously mapped as part of the Conejo Volcanics. May represent remnants of debris shed from Conejo Volcanics highland into local basin during deposition of Saugus Formation (T. F. Blake, pers. com., 1993). (Dibblee, 1992a and 1992b; Irvine, 1995). (*GRI Source Map ID 76065*)

Qvoa - Very old alluvium, undivided (early to middle Pleistocene)

Qvoa - Very old alluvium, undivided (middle to early Pleistocene)
Slightly to moderately consolidated silt, sand and gravel deposits. Deposits have been uplifted or otherwise removed from the locus of recent sedimentation. Environment of deposition may include axial valley, floodplain or alluvial fan, but morphology of original deposit may not be preserved. Surfaces may be significantly dissected and show well-developed pedogenic soils. Subunits are distinguished by relative ages based on geomorphic relationships, relative degree of surface dissection and soil formation. (*GRI Source Map ID 76065*)

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Qvoa1 - Very old alluvium, Unit 1 (early to middle Pleistocene)

Older subunit of Qvoa that can be distinguished in some areas. (*GRI Source Map ID 76065*)

Qsp - San Pedro Formation (middle Pleistocene)

Unconsolidated sand with local gravelly sand, silty sand and silt interbeds; shallow marine invertebrate fossils common. Woodring and others (1946) report a maximum stratigraphic thickness of about 300 ft. (90 m). The San Pedro Formation has an estimated age range of 200 to 500 ka, as summarized in Jacobs, (2007). The San Pedro Formation was defined at San Pedro Hill (Palos Verdes Peninsula) and extended to other portions of the Los Angeles basin. Fossils were noted at San Pedro Hill by early workers (e.g. Trask, 1855b; Lawson, 1893) but Dall (1898) is credited as the first to use the term “San Pedro beds” (Wilmarth, 1938). Arnold and Arnold (1902) and Arnold (1903) distinguished a “lower” and "upper" San Pedro series and the "lower series" was subsequently assigned the name San Pedro "formation" by Kew in Tieje (1926). Terminology for the San Pedro Formation was formalized by Woodring and others (1946) and their usage is adopted herein. This term was extended into the subsurface by Poland and others (1956, 1959) and additional background is summarized by Powell and Ponti (2007). The term San Pedro has also been extended by some workers in the past to granular Pleistocene strata in the western Ventura basin based on molluscan fauna (e.g. Grant and Gale, 1931; Bailey, 1935); however, this extended usage is not used here, as suggested by Ponti (pers. comm., 2012), based on the presence of an intervening depositional basin boundary. (*GRI Source Map ID 76065*)

Qlp - Las Posas Formation (late early to middle Pleistocene)

Qlp - Las Posas Formation (middle to late early Pleistocene)
Shallow marine, light-gray to light yellowish-gray, fine- to locally coarse-grained sandstone, silty sandstone and pebbly sandstone with greenish-gray mudstone and subordinate conglomerate interbeds in the type area; invertebrate fossils and bivalve-dominated hash beds locally common; sands commonly quartz rich; pebbles composed of well-rounded plutonic, metamorphic and volcanic clasts derived primarily from the San Gabriel Mountains; moderately well sorted; medium bedded to locally laminated; poorly cemented. The Las Posas Formation crops out on either side of the Las Posas Valley in the Las Posas Hills and on the south side of South Mountain/Oak Ridge west of Long Canyon, and west of Fillmore on the north side of the Santa Clara River (western Ventura basin). A prominent basal conglomerate is commonly present in the South Mountain area (Lung, 1958) and northwest of the Santa Clara River at Adams Canyon (basal Saugus of Driver, 1928; Irvine, unpublished mapping 1991). It overlies or interfingers with the Mudpit shale north of the Santa Clara River. In the South Mountain area, it conformably overlies or locally interfingers with upper Pico Formation siltstone and is distinguished from older shallow marine strata of the upper Pico Formation (QTpcu) to the east by its stratigraphic position above the Grimes Canyon deltaic unit (QTpg), whereas QTpcu is generally below QTpg; to the south, it unconformably overlies the Sespe Formation and Conejo Volcanics in the Las Posas Hills. The Las Posas Formation is up to 300 m thick below Las Posas Valley (Dibblee, 1992g). Its age is estimated at 450 ka to 750 ka based on amino acid racemization (Wehmiller, 2010 in DeVecchio and others, 2012b), but DeVecchio and others (2012b) report an OSL date of 141 ± 10 ka near the base of the section in the Las Posas Hills. Sarna-Wojcicki and others (1984) estimate the base of the shallow marine sands (their "San Pedro") is at about 1.0 Ma in the South Mountain area, but also report an age of about 0.4 Ma in the Ventura area. This unit was originally mapped as Fernando Formation by McLaughlin and Waring (1914) after the definition of Eldridge and Arnold (1907) and subsequently assigned to the Saugus Formation by Kew (1924). The Las Posas "formation" was coined by Pressler (1929) for sands in the Las Posas Hills type area, and nearby South Mountain, Oak Ridge and Camarillo Hills that are stratigraphically above the "Santa Barbara horizon" and contain warm water "Saugus" fauna of Kew (1924) and Waterfall (1929). Pressler subdivided this unit into a lower Kalorama member (which Bailey, 1935 subsequently included in his Santa Barbara Formation) and an upper Long Canyon member. Subsequent workers referred to this section either as a marine member of the Saugus following Kew, 1924 (e.g. Pasta, 1958; Lung, 1958; Jakes, 1979), as the San Pedro Formation (e.g. Grant and Gale, 1931; Bailey, 1943, 1951;State Water Resources Board, 1953; Weber and others, 1973), or as the Las Posas Sand or Formation (e.g. Dibblee Foundation Maps; DeVecchio and others, 2012a and b); the term Las Posas Formation is adopted because the term San Pedro is restricted to the Los Angeles basin and the term Saugus Formation is restricted to nonmarine deposits following the original definitions of Hershey (1902b) and Winterer and Durham (1962). (*GRI Source Map ID 76065*)

Qlp - Las Posas Formation (early to middle Pleistocene)
Shallow marine deposits in the western and central Ventura basin composed primarily of poorly consolidated, folded sandstone and conglomerate that commonly contain invertebrate megafossils. This unit was originally defined by Pressler (1929) for exposures in the Las Posas Hills area and is assigned herein generally following the usage of Dibblee on various Dibblee Foundation maps of the Ventura basin. Rocks of this unit have previously been assigned by some workers either as the lower marine portion of

the Saugus Formation based primarily on mapping by Kew (1924) or as the San Pedro Formation based on interpreted faunal similarities with exposures in the type area (northern portions of the Camarillo and Newbury Park quadrangles). (*GRI Source Map ID 75634*)

QTp - Pico Formation, undivided (Pliocene to middle Pleistocene)

Thick marine sequence composed of siltstone, sandstone and subordinate conglomerate deposited in the Ventura basin; coarser-grained sediments deposited primarily by turbidity currents and are commonly the dominant lithology along the axis of the basin, in feeder channels on the adjacent basin slopes (Yeats, 1979a; Sylvester and Brown, 1988), and at the eastern margin of the basin south of Newhall (Winterer and Durham, 1962); hemipelagic clayey siltstone is interbedded or interfingering with the turbidity deposits and is locally the dominant lithology; deposited primarily at bathyal depths exceeding 4,500 ft. (1400 m) at the base of the section (Natland, 1967), but grades or interfingers up section into upper bathyal to neritic mudstone (see Mudpit shale - QTpms) and shallow water shelf and delta sandstone, conglomerate, and siltstone, with locally prominent fossil hash beds (see QTpcu and QTpg). The siltstone is typically bluish gray where fresh and olive gray with limonite stains or nodules where weathered; coarse-grained units range from light olive gray to light gray and light brown; compact but typically not well cemented. Siltstone beds typically contain abundant foraminifers and local invertebrate fossils. The upper shallow water deposits also contain locally abundant molluscan fossils and ostracodes. The Pico Formation is widely exposed in the eastern Ventura basin; it is exposed in the central Ventura basin on either side of the Santa Clara River Valley, but is thickest below this valley along the Ventura basin axis, where it is largely concealed by alluvium and faulting. Winterer and Durham (1962) report a maximum thickness of about 5,000 to 6,000 ft. (1500 to 1800 m) in the eastern Ventura basin; however, Bailey (1952) reports a thickness of about 13,900 to 15,400 ft. (4200 to 4700 m) west of the map area in the Ventura area. The lower basinal section pinches out to the south and Pico deposits along the northern margin of the Ventura basin are missing in the upper reaches of the mountains on the north due to uplift and erosion. The basal portion of the formation was reportedly deposited during the Repettian stage in both the western and eastern Ventura basin (e.g. Dibblee, 1988; Beyer and others, 2009), and overlies the Modelo Formation to the west and overlies or interfingers with the Towsley Formation to the east in the type area. The top of the formation is time transgressive and is progressively younger to the west. Near the type section west of Valencia, the Pico Formation is reportedly older than about 2.5 Ma, the age of the base of the Saugus Formation estimated by Levi and others (1986). However, Winterer and Durham (1962) report the presence of the benthic foraminifera Uvigerina peregrina and Bulimina subacuminata within Pico siltstone, which characterize the early Pleistocene Wheelerian and Venturian stages respectively (Natland, 1952; Squires and others, 2006). McDougall and others (2012) report that these species also occur in the upper Repettian stage. In the western Ventura basin the upper Pico Formation includes early to middle Pleistocene ash beds, and alternatively underlies or includes the 0.6 Ma Lava Creek ash (see QTpms). This section was initially assigned to the Fernando Formation as defined by Eldridge and Arnold (1907) and as mapped by McLaughlin and Waring (1914). Kew (1924) subsequently assigned the lower, marine strata of the Fernando to the Pico Formation (except for coarse-grained shallow marine deposits), with the type section at Pico Canyon. Winterer and Durham (1962) remapped and redefined the formation in the type area and assigned the coarse-grained shallow marine units to the Pico Formation. This usage has been adopted by most workers in the eastern Ventura basin and is adopted here and extended to the Santa Susana Mountains and Oak Ridge. Strata in the Ventura basin containing Repettian-age fauna that are lithologically similar to the type Pico section are included within the Pico Formation. The term Repetto is abandoned entirely as a lithologic formation per the recommendation of Durham and Yerkes (1964). The term Pico is abandoned as a lithologic formation in the Los Angeles basin following the recommendation of Durham and Yerkes (1959, 1964). The term Fernando Formation is not used in the Ventura basin based on differences in lithologic facies reported between the type Pico section and Pliocene strata in the Los Angeles basin (Durham and Yerkes, 1959, 1964) (see Appendix A for details). (*GRI Source Map ID 76065*)

QTpg - Pico Formation, Grimes Canyon deltaic facies (Pliocene to middle Pleistocene)

Medium- to coarse-grained sandstone, pebbly sandstone, and pebble conglomerate; cross bedding common to pervasive and foreset beds locally apparent; channeling common as well; weakly cemented to uncemented, clasts typically crystalline and derived from the San Gabriel Mountains, and rounded to well-rounded and smooth; moderately to well sorted; conglomerate locally clast supported; typically light gray; light-brown iron-oxide staining varies from local to prominent; generally unfossiliferous; uncommon greenish-gray sandy siltstone to rare thin claystone interbeds with local invertebrate fossils. This unit is well exposed along Grimes Canyon road and at quarries to the east and west of the road (Moorpark and Simi Valley West quadrangles). It is equivalent to a unit interpreted by Dibblee (1992b) as a delta deposit from west-flowing streams and expanded eastward into Happy Camp Canyon on this map based on additional field mapping. It interfingers with and is underlain by Pico siltstone to the west; underlain by and likely grades into or interfingers with fossiliferous shallow marine sands to the east that are assigned here to the upper coarse-grained marine member of the Pico Formation (QTpcu). Overlain by Las Posas Formation or undifferentiated Saugus Formation. Maximum thickness is about 315 m per Dibblee (1992b) cross section. This section historically assigned either to the Saugus or San Pedro Formations; designated herein as an informal member of the Pico Formation based on the definition of Winterer and Durham (1962) and the interpretation that most of this unit is marine; This interpretation is based on mapped interfingering relationships with offshore marine siltstone of the Pico Formation to the west, the presence of uncommon fossiliferous interbeds, the presence of marine sands up section of this unit near Grimes Canyon Road, the prevalence of wellrounded and nearly polished clasts indicative of extensive abrasion in a littoral environment, and foreset bedding suggestive of a delta front environment; however, differentiation of unfossiliferous marine sands from nonmarine sands is problematic in some areas and some nonmarine paralic strata are likely included in the unit as currently mapped. This unit stratigraphically separates and distinguishes older, shallow marine sands to the east, assigned herein as an informal upper facies of the Pico Formation (QTpcu), from younger, shallow marine sands to the west assigned herein to the Las Posas Formation. (*GRI Source Map ID 76065*)

QTpcu - Pico Formation, coarse-grained upper facies (Pliocene to middle Pleistocene)

Sandstone, conglomerate and locally prominent fossil hash/coquina beds overlying Pico offshore deposits; locally cross bedded and channeled; gradational with or underlying the Grimes deltaic unit (QTpg); onlaps older formations to the south; overlain conformably or unconformably by nonmarine Saugus or transitional Sunshine Ranch Member strata in most areas; invertebrate fossils locally common. This facies is interpreted as shallow marine shelf, delta or embayment deposits (White, 1983, 1985; Groves, 1991). This section was initially mapped as the lower portion of the Saugus Formation by Kew (1924), but was reassigned to the upper Pico Formation in the eastern Ventura basin by Winterer and Durham (1962). Shallow marine strata previously assigned to the lower marine Saugus Formation in the Santa Susana Mountains are reassigned here to this facies following the usage of Winterer and Durham and subsequent workers in the type localities of the Saugus and Pico Formations (see Appendix A for details). (*GRI Source Map ID 76065*)

QTpc - Pico Formation, sandstone and conglomerate (Pliocene to middle Pleistocene)

Sandstone and conglomerate interbeds within typical Pico siltstone (Val Verde quadrangle and Moorpark 7.5’ quadrangles). (*GRI Source Map ID 76065*)

Qi - Inglewood Formation (early Pleistocene)

Shallow marine, well-consolidated clay-siltstone and interbedded very fine-grained sandstone, commonly with calcareous, limonitic concretions; relatively dense and moderately expansive where weathered. This unit is now recognized as one from which most of the landslides in the Baldwin Hills are derived (Hsu and others, 1982). (*GRI Source Map ID 76065*)

QTms - Sedimentary rocks of the Pacific Palisades area (late Pliocene to early Pleistocene)

A few small exposures of marine siltstone and very fine-grained silty sandstone; very soft and slightly indurated, locally very fossiliferous, fossils referred to the late Pliocene or early Pleistocene; maximum thickness about 120 m (Hoots, 1931; McGill, 1989). (*GRI Source Map ID 76065*)

QTfl - Fernando Formation, Lower Member (Pliocene)

Interbedded silty sandstone and massive pebble conglomerate of the Los Angeles basin. Includes Fernando Formation member 1 of Lamar (1970). See QTfu above and Appendix A for discussion of nomenclature QTflc—conglomerate. (*GRI Source Map ID 76065*)

Tpn - Puente Formation, undivided (early Pliocene and late Miocene)

Marine siltstone, sandstone, and shale; mostly a Los Angeles basin temporal equivalent of the Modelo Formation, but partly younger; named by Eldridge (in Eldridge and Arnold, 1907) from exposures in the Puente Hills; strata are associated with the Los Angeles basin (El Monte, Los Angeles and Hollywood 7.5’ quadrangles) as contrasted with Modelo strata, which are associated with the eastern Ventura basin. In the Los Angeles and Hollywood 7.5’ quadrangles Lamar (1970) mapped four non-sequential, interbedded, informal lithologic subunits, which have not been specifically correlated with the formal members recognized by Shoellhamer and others (1954). (*GRI Source Map ID 76065*)

Tpsl - Puente Formation, siltstone (early Pliocene)

Well-bedded, light gray siltstone; thickest beds at top of section, also interbeds lower in section (Lamar, 1970, fig. 14). (*GRI Source Map ID 76065*)

Tpsh - Puente Formation, siliceous shale (early Pliocene)

Well-bedded, light gray, siliceous shale and siltstone; regularly interbedded with thin, fine- to coarse-grained sandstone beds; most common in a few discontinuous zones, chiefly in upper-central part of formation (Lamar, 1970, fig. 14). (*GRI Source Map ID 76065*)

Tpds - Puente Formation, diatomaceous shale (early Pliocene)

Well-bedded, dull white diatomaceous shale; a discontinuous single zone in central part of formation (Lamar, 1970, fig. 14). (*GRI Source Map ID 76065*)

Tpss - Puente Formation, sandstone (late Miocene)

Well-bedded, very fine- to very coarse-grained sandstone; medium to light brown and light gray; mostly well cemented but less so in uppermost parts; local discoidal concretions; most abundant in lower part of formation (Lamar, 1970, fig. 14). (*GRI Source Map ID 76065*)

Tm - Modelo Formation, undivided (late and middle Miocene)

Predominantly gray to brown thin-bedded mudstone, diatomaceous clay shale, or siltstone, with interbeds of very fine-grained to coarse-grained sandstone; proportion and thickness of sandstone interbeds allows lithofacies to be mapped in some areas; generally unconformable on older rocks around northern, eastern and southern margins of the Ventura basin. The base of the Modelo is generally unconformable on middle Miocene and older rocks. The name, Modelo, was introduced by Eldridge and Arnold (1907) for strata exposed in the Topatopa Mountains, north of Piru and further described in the Santa Susana Mountains and San Fernando Pass areas by Winterer and Durham (1962); extended to the eastern Santa Monica Mountains and described in detail by Hoots (1931) where further noted for turbidite features indicating submarine fan deposition (Sullwold, 1960); Along the north flank of the Santa Monica Mountains the unconformity mapped by Hoots (1931) in the eastern part of the range, where Modelo locally overlies Santa Monica Slate, has been mapped continuously westward (Yerkes and Campbell, 1980; Weber, 1984; and unpublished 1:12,000-scale mapping by Yerkes and Campbell, 1965-1974, in the Canoga Park and Calabasas 7.5’ quadrangles) as far as the north side of the Ventura Freeway (U.S. 101) at the west side of Las Virgenes Creek, to the west of which it becomes accordant with (and apparently conformable on) subjacent strata of the Calabasas Formation (Weber, 1984); further west, the Modelo and subjacent parts of the Calabasas appear to grade progressively westward into more diatomaceous, clayey, Monterey-like lithofacies. Many of the sandstone and shale beds below (south of) the unconformity (and its westward conformable extension) and above (north) of the Conejo Volcanics are lithologically similar to the Modelo but more intensely folded and faulted; these have been assigned to the Calabasas Formation by Yerkes and Campbell (1979). Fellbaum and Fritsche (1993) include them in the Modelo Formation; however, their stratigraphic position below the unconformity mapped by Hoots (1931) as the base of the Modelo, and the predominance of middle Miocene foraminifera (Luisian or Relizian?) in the Calabasas, suggests their correlation with Modelo strata is questionable. In the eastern Santa Monica Mountains the Modelo was mapped and described in detail by Hoots (1931), and Kleinpell (1938) used the unconformity at the base, well exposed near Mohn Springs in Topanga Canyon, where it is underlain by predominantly middle Miocene Topanga strata, as the base for his type Mohnian (foraminiferal) Stage (late Miocene). Widespread in eastern Ventura basin; locally extended to include some strata along the south flank of the Santa Monica Mountains in the Pacific Palisades-Westwood area. Five members were described by Cemen (1977) in the Topatopa Mountains and four of them have been mapped as far south as the north flanks of Oak Ridge and the Santa Susana Mountains. Age-correlative strata in the Los Angeles basin are generally referred to the Puente Formation or, west of the Newport-Inglewood zone, to the Monterey Shale. (*GRI Source Map ID 76065*)

Tmsu - Modelo Formation, upper sandstone unit at Laskey Mesa (late and middle Miocene)

Weber (1984) assigned strata at Laskey Mesa to the Towsley Formation, as shown by Yerkes and Campbell (2005); Truex and Hall (1969) previously assigned most of this section to the Modelo Formation and the uppermost portion to the Santa Margarita Formation, and Brown (1957) mapped it as Modelo Formation; Dibblee (1992b) mapped this section as Tertiary unnamed shale and sandstone; Yeats (1979) reported that Towsley Formation does not occur south of the Santa Susana Fault. Field review of this area did not reveal any brown mudstone or coarse-grained turbidite beds typical of the Towsley Formation and this unit has been reassigned to the upper Modelo Formation herein based on lithologic similarity to Modelo strata to the west and previous usage. (*GRI Source Map ID 76065*)

Tm4 - Modelo Formation, member 4 (late and middle Miocene)

Upper sandstone unit; white to gray, fine to coarse-grained arkosic sandstone, with subordinate thin partings and lenticular interbeds of silty clay shale, locally siliceous; thickness variable, locally as much as 825 m. (Cemen, 1977). (*GRI Source Map ID 76065*)

Tm3 - Modelo Formation, member 3 (late and middle Miocene)

Middle shale unit; porcelaneous and calcareous shale and porcelaneous mudstone, brown to buff, thin-bedded to laminated, moderately to well indurated, with thick lenses of gray calcareous sandstone locally; thickness variable but may exceed 763 m.; foraminifera referred to lower part of the Mohnian Stage of Kleinpell (1938) (Cemen, 1977). (*GRI Source Map ID 76065*)

Tm2 - Modelo Formation, member 2 (late and middle Miocene)

Lower sandstone unit; grayish white to dark brown, fine to medium-grained sandstone, locally interbedded with dark brown siltstone and claystone; locally as much as 915 m. thick, thins westward and pinches out between the middle and lower shale units (Cemen, 1977). (*GRI Source Map ID 76065*)

Tm1 - Modelo Formation, member 1 (late and middle Miocene)

Lower shale unit; cherty to porcelaneous shale and mudstone, locally calcareous, locally diatomaceous, moderately to well indurated, thin-bedded to laminated, generally dark gray to brown; contains foraminifera referred to the Relizian and Luisian Stages of Kleinpell (1938), indicating the unit is age-correlative with the Calabasas Formation and, possibly the upper part of the Topanga Canyon Formation in the Santa Monica Mountains; thickness 214-794 m. (Cemen, 1977). (*GRI Source Map ID 76065*)

Tmd - Modelo Formation, diatomaceous shale (late and middle Miocene)

Diatomaceous shale; includes outcrops on the south side of the San Fernando Valley at Pierce College shown as Pico Formation by Yerkes and Campbell (2005), based on the presence of Repettian stage benthic foraminifers (Ingle, 1967; Yerkes and Campbell, 1993); previously assigned to the Modelo Formation by Hoots (1931). Review of these exposures indicates that much of this unit is lithologically more consistent with the Modelo Formation than the Pico Formation. This section is assigned here to the Modelo Formation based on the noted lithology and presence of Modelo Formation mapped on strike to the east and west, but is queried based on the reported presence of Repettian stage fauna. (*GRI Source Map ID 76065*)

Tms - Modelo Formation, sandstone (late and middle Miocene)

Sandstone and conglomerate. (*GRI Source Map ID 76065*)

Tmb - Modelo Formation, "burnt shale" (late and middle Miocene)

Unusual slag and scoriaceous- to obsidian-like material found within the upper part of the Modelo Formation in the Grimes Canyon area, Big Mountain/Happy Camp Canyon, and upper Las Virgenes Canyon area. It is composed of red, yellowish-orange, purple, brown, and black mudstone, siltstone, and diatomite that has been altered by in-situ combustion of natural gas in layers containing abundant organic material, as described and mapped by Irvine (1995), Brown (1957), and Jestes (1958). (*GRI Source Map ID 76065*)

Tmt - Monterey Shale, undivided (late, middle, and early Miocene)

Marine clay shale, thin interbedded siltstone, minor sandstone and pebble conglomerate, and glassy tuff; siltstone is commonly diatomaceous, locally bituminous, siliceous, or dolomitic; sandstone is commonly quartz arenite; some conglomerates contain clasts of glaucophane schist. Shale is gray to dark brownish gray where fresh, weathers quickly to chalky white; contains foramifera referred to the Relizian, Luisian, or Mohnian Stages (early middle, late middle, or early late Miocene respectively) of Kleinpell (1938). Monterey strata are exposed only south of the Malibu Coast Fault and west of the Newport-Inglewood zone of faulting and folding; rocks of equivalent age north of the Malibu Coast Fault are referred to the Topanga Group and the Modelo Formation; east of the Newport Inglewood zone, strata of equivalent age are referred to the Puente Formation and the Topanga Group. The Monterey is generally considered a distal, deep-basin facies of the more-proximal Modelo, Puente and other formations of the equivalent age range. Name extended into southern California from type area in Monterey County, central California (Woodring and others, 1936). The upper part of the unit in some areas (chiefly along the Pacific Coast Highway) is late Mohnian in age and locally overlies the early Miocene Trancas Formation unconformably; its relation to middle Miocene Monterey strata on Point Dume is obscured, but could be an intraformational unconformity. The (mostly middle Miocene) section exposed on Point Dume is about 1000 m thick. The Monterey Shale in the northern Los Angeles basin is unconformably overlain by unconsolidated Pliocene, Pleistocene and Holocene deposits. (*GRI Source Map ID 76065*)

Tmtd - Monterey Shale, deformed (middle and early Miocene)

Intensely deformed shale, siltstone, and sandstone, commonly dolomitic, locally siliceous, locally very cherty; contains foraminifera referred to the Relizian or Luisian (middle Miocene) Stages of Kleinpell (1938). In upper plate of Escondido thrust fault beds are tightly folded, with vertical limbs and gently east-plunging axes; thickness across folded beds is at least 650 m. (*GRI Source Map ID 76065*)

Tcb - Calabasas Formation, undivided (early late Miocene and late middle Miocene)

Interbedded impure, clayey to silty sandstone and silty shale, with local beds of sedimentary breccia; sandstone is thin-, medium- and thick-bedded, mostly medium to coarse grained, poorly sorted, commonly with wacke texture, commonly shows graded bedding; shale, locally diatomaceous; may have small phosphatic pellets, locally abundant fish scales, sparse Foraminifera and rust-colored plant casts, some thicker beds contain zones of large ovoid dolomitic concretions; sedimentary breccia, olistostromes incorporating cobble- to large boulder-size clasts of recognizable older Tertiary strata, some as fossil-bearing clasts of Paleocene, Eocene, early Miocene, and middle Miocene strata. Many of the sandstones are lithologically similar to those in the overlying, less-deformed Modelo Formation. Total thickness is about 1,200 m in the type area. The Modelo is unconformable on the Calabasas in the name area, however, west of Malibu Junction and north of the Ventura Freeway the two formations are accordant, the Calabasas is greatly thinned, and grades westward into finer-grained clayey siltstone and shale much like that of the Modelo in the area, and the two formations are distinguished only by differences in foraminiferal fauna. (The Calabasas there contains foraminifera referred to the Luisian Stage of Kleinpell, 1938; the Modelo contains foraminifera referred to the Mohnian Stage of Kleinpell, 1938). The contact relationships with the underlying Conejo Volcanics are marked by extreme variability, ranging from unconformable to accordant and intertonguing, apparently reflecting marine sedimentation, at least partly contemporaneous with the development of a submarine volcanic edifice and associated tectonic disturbance. Intraformational deformation west of Liberty Canyon, the angular unconformity east of Medea Creek, and the abruptly thinner Calabasas section near and west of Agoura reflect local tectonic activity during deposition; and the volcanic conglomerate is probably significantly younger than most of the Calabasas section to the east. In the west-central Santa Monica Mountains the Calabasas

Formation and older strata are involved in major pre-Modelo deformation that includes detachment faulting. Well-defined upper-plate ramps in Trancas and Topanga Canyons show offsets exceeding many hundreds of feet on faults that bend to follow bedding planes, along which intervening beds are missing or thinned, and establish a style of younger-over-older faulting as a significant structural feature. Outcrops where contact relations can be observed in macroscopic detail, and confirm depositional or shear-surface relations, are extremely rare, but where found indicate little discordance at stratigraphic hiatus or local unconformity contacts between pre-Conejo Tertiary Formations. The Paleogene sequence is similar to that in the adjacent Simi Hills and the more distant Santa Ana Mountains, where variations in depositional environments appear to represent epeiric transgressions and regressions. Therefore, we conclude that contacts lacking local exposures of diagnostic depositional character, where significant parts of the section are missing or dramatically thinned, are one or more of a set of detachment faults. The alternative is to infer Paleogene orogenic deformation on a scale not recognized elsewhere in southern California. (*GRI Source Map ID 76065*)

Tcbvc - Calabasas Formation, volcanic conglomerate (late middle Miocene)

Volcanic conglomerate, mapped by Weber (1984) as basal Calabasas Formation where it rests unconformably on the Chatsworth Formation (Cretaceous) along the south flank of the Simi Hills, and extends northwestward across the Cretaceous-Paleogene sequence at the west end of the Simi Hills. This conglomerate is probably correlative with volcanic conglomerates that locally forms the base of the Calabasas Formation sandstone and shale exposed along and north of the Ventura Freeway in the Agoura area (Blackerby, 1965), and overlying volcanic strata in the Thousand Oaks area (Weber, 1984). In addition to the informal volcanic conglomerate member, five members were named by Yerkes and Campbell (1979). (*GRI Source Map ID 76065*)

Tcbs - Calabasas Formation, Stokes Canyon Breccia Member (late middle Miocene)

Sedimentary breccia consisting of angular boulders and cobbles of redeposited well-cemented sandstone with molluscan faunas diagnostic of the "Martinez" (Paleocene) and "Domengine" (middle Eocene) Stages; the breccia bed is locally as thick as 60 m; underlain and overlain conformably by Calabasas sandstone and siltstone; locally overlain unconformably by basal conglomerate of the Modelo Formation. Thinner, less continuous breccia beds are present at two other horizons nearby. (Stokes Canyon area, northern Malibu Beach and southern Calabasas 7.5’ quadrangles; Yerkes and Campbell, 1979, p. E22; Yerkes and Campbell, 1980). (*GRI Source Map ID 76065*)

Tcbmp - Calabasas Formation, Mesa Peak Breccia Member (late middle Miocene)

Sedimentary breccia consisting of angular boulders and cobbles of volcanic rock in a very coarse-grained sandstone matrix; maximum thickness approximately 288 m. Overlies the Newell Sandstone Member of the Calabasas Formation in the upper plate of the Malibu Bowl Detachment Fault, west central Malibu Beach 7.5’ quadrangle (Yerkes and Campbell, 1979, p. E23; Yerkes and Campbell, 1980). (*GRI Source Map ID 76065*)

Tcbn - Calabasas Fromation, Newell Sandstone Member (late middle Miocene)

Poorly sorted turbidite sandstone and interbedded shaly siltstone with large dolomitic concretions; overlies and wedges out westward into Malibu Bowl Tongue of the Conejo Volcanics; maximum thickness approximately 244 m. (Yerkes and Campbell, 1979, p. E23; Yerkes and Campbell 1980). (*GRI Source Map ID 76065*)

Tcbd - Calabasas Formation, Dry Canyon Sandstone Member (late middle Miocene)

Sandstone (proximal turbidites) and subordinate interbedded siltstone, many thin turbidites, locally prominent dolomitic concretions in siltstone; overlies and tongues eastward into Solstice Canyon Tongue of the Conejo Volcanics; underlies and intertongues westward into Escondido Canyon Shale Member of the Calabasas Formation; overlain by, and locally intertongues with, the Malibu Bowl Tongue of the Conejo Volcanics, and locally overlain by the Newell Sandstone member of the Calabasas Formation; locally overlain by Latigo Canyon Breccia Member of the Calabasas Formation; underlain by Ramera Canyon Tongue of Conejo Volcanics; approximate maximum thickness 686 m (Campbell and others, 1996; Yerkes and Campbell, 1979, p. E24; Yerkes and Campbell, 1980). (*GRI Source Map ID 76065*)

Tcbl - Calabasas Formation, Latigo Canyon Breccia Member (late middle Miocene)

Sedimentary breccia, large angular boulders of Sespe Sandstone and fossiliferous Vaqueros sandstone in sandy, tuffaceous or volcanic breccia; intertongues with epiclastic volcanic breccia; approximate maximum thickness 91 m; underlies the Solstice Canyon Tongue of the Conejo Volcanics and overlies the Escondido Canyon shale member of the Calabasas formation (Yerkes and Campbell, 1979, p. E23; Campbell and others, 1996). (*GRI Source Map ID 76065*)

Tcbe - Calabasas Formation, Escondido Canyon Shale Member (late middle Miocene)

Siltstone, mudstone, shale and minor interbedded thin sandstone turbidites; locally prominent dolomitic concretions; tongues eastward into Dry Canyon Sandstone Member of the Calabasas Formation; westward laps onto and intertongues with Ramera Canyon Tongue of the Conejo Volcanics; approximate maximum thickness 276 m; (Yerkes and Campbell, 1979, p. E24; Campbell and others, 1996). (*GRI Source Map ID 76065*)

Tr - Trancas Formation, undivided (middle and early Miocene)

Marine mudstone, silty shale, claystone, sandstone, and locally prominent sedimentary breccia on Lechusa Point and Point Dume; the breccias are distinctive for their abundant detritus of the Mesozoic Catalina Schist, including glaucophane schist (San Onofre breccia of Woodford and Bailey, 1928). The Trancas has been much deformed in the zone south of the Malibu Coast Fault, and no complete section is known. The Sovereign Oil Company Malibu 1 exploratory well on Point Dume drilled through 290 m of marine sandstone, mudstone, claystone, and sedimentary breccia (San Onofre Breccia) between the base of the Monterey Shale and the underlying Zuma Volcanics, assigned to the Trancas formation by Yerkes and Campbell (1979); (Point Dume and Triunfo Pass 7.5’ quadrangles; Campbell and others, 1996; Campbell, 1965-1975, unpublished 1:12,000-scale mapping). The siltstones locally contain abundant foraminiferal assemblages assigned to the Saucesian (lower Miocene) and Relizian or Luisian (middle Miocene) stages of Kleinpell (1938). (*GRI Source Map ID 76065*)

Tra - Trancas Formation, quartz-bearing calcarenites (middle and early Miocene)

In the western part of the Point Dume 7.5’ quadrangle and eastern part of the Triunfo Pass 7.5’ quadrangle are distinctive for the pervasive intergranular disruption that causes original bedding to be completely masked; further west, at Sequit Point, the sandstones are seen to be coarse-grained, cross-laminated calcarenites, composed chiefly of barnacle plates and oyster fragments, with significant areas intruded by sandstone of similar composition but in which the original fabric is no longer visible (inferred to be a result of liquefaction). An exposure of San Onofre Breccia overlying Zuma Volcanics on the tip of Point Dume, south of the Point fault, is assumed to represent the base of the Trancas Formation in that area. The Trancas may intertongue with both the Zuma Volcanics and the lower part of the Monterey Shale, but is locally unconformably overlain by upper (late Miocene) beds of the Monterey Shale. (*GRI Source Map ID 76065*)

Tz - Zuma Volcanics (middle and early Miocene)

Basaltic, andesitic and dacitic flows, flow breccias, pillow lavas, aquagene tuffs, mudflow breccias, volcanic sand and interbedded mudstone, siltstone, sandstone, minor breccia-conglomerate; all probably deposited in a marine environment; no igneous rocks south of the Malibu Coast Fault are recognizably intrusive into the associated sedimentary rocks; sedimentary interbeds carry foraminifera referred to the Relizian or Luisian Stages (middle Miocene) of Kleinpell (1938). Weigand and Savage (1993), from a study of major element analyses, showed that most of the analyzed samples of Zuma Volcanics fall in the dacite field of the classification of LeBas and others (1986). Plagioclase phenocrysts from basalt near the tip of Point Dume have been dated at 14.6 ± 1 my (Berry and others, 1976). Base not exposed, but an equivalent section in the exploratory well, Sovereign Malibu 1 on Point Dume, is about 430 m (stratigraphic) thick above probable metamorphic basement (Catalina Schist). Although the Zuma and Conejo Volcanics fall within the same range of ages, the overlying and underlying sedimentary strata, and the basement rocks, are significantly different, suggesting that they could be related to different extrusive centers. (Campbell and others, 1970, 1996; Yerkes and Campbell, 1980; and Campbell, unpublished 1:12,000-scale mapping, 1967-1971). (*GRI Source Map ID 76065*)

Tt - Topanga Group, undivided (middle and early Miocene)

First called the Topanga Formation by Kew (1923) for exposures in the central Santa Monica Mountains that include the type locality for the "Topanga Canyon fauna" (about 50 molluscan species) of Arnold (1907a). Durrell (1954) recognized that the three subdivisions identified by Kew (1923) are contiguous westward with extensive units of formation rank, labeling them the Lower Topanga, Middle Topanga and Upper Topanga Formations. Subsequent publication of the North American Stratigraphic Code led Yerkes and Campbell (1979) to change the names to conform, and designated the set of three formations as the Topanga Group, consisting of the Calabasas Formation, the Conejo Volcanics, and the Topanga Canyon Formation, each with two or more members. Elsewhere, middle Miocene strata with similar lithologic and biologic facies have been informally divided: in the eastern Ventura basin and the northern Los Angeles basin beds containing Luisian BFZ foraminifera (late middle Miocene), that are labeled Tt are chiefly age-equivalent to the Calabasas Formation; beds containing a "Temblor" or "Topanga" molluscan fauna have also been labeled Tt. Middle Miocene volcanic rocks that may be related to the Conejo Volcanics, but are spatially separated, are labeled Ttb. The distribution and nomenclature history of the Topanga Group has been reviewed by Campbell and others (2007). (*GRI Source Map ID 76065*)

Ttss - Topanga Group, sandstone (middle and early Miocene)

Sandstone, medium- to coarse-grained, well-bedded, light brown and gray (Lamar, 1970). (*GRI Source Map ID 76065*)

Ttsl - Topanga Group, siltstone (middle and early Miocene)

Siltstone, well bedded, medium to dark brown, with interbedded sandstone, shale and chert (Lamar, 1970). (*GRI Source Map ID 76065*)

Ttcg - Topanga Group, conglomerate (middle and early Miocene)

Conglomerate, massive- to well-bedded, light brown; includes basal breccia locally (Lamar, 1970). (*GRI Source Map ID 76065*)

Ttb - Topanga Group, intrusive and extrusive volcanic rocks (middle and early Miocene)

Chiefly basaltic, interlayered with sandstone and shale assigned to the Topanga Group. In part, may be correlative with Conejo Volcanics of central and western Santa Monica Mountains and adjacent areas to the northwest; but includes rocks that are dated as older than the oldest contiguous Conejo (McCulloh and others, 2002). (eastern Santa Monica Mountains, Hoots, 1931; Santa Susana Mountains, Evans and Miller, 1978; northeastern Verdugo Mountains, Oakeshott, 1958). (*GRI Source Map ID 76065*)

Tco - Conejo Volcanics, undivided (middle Miocene)

Basalt, andesitic basalt, basaltic andesite, andesite, and dacite in a thick sequence of extrusive volcanic flows, flow-breccias, agglomerates, and epiclastic volcanic breccias, volcanic sandstones and siltstones; thickest (probably in excess of 3 km) where it underlies the north flank of the western Santa Monica Mountains, and thinning eastward to as little as 200 m of interbedded flows and volcaniclastic sedimentary rocks on the nose of the Topanga Anticline; further east the volcanic rocks are thin and discontinuous, and the name has not been extended eastward for more than a mile east of Topanga Canyon Road. The thick sequence shows a crude compositional layering: pillow basalts, pillow breccias, aquagene tuffs, black volcanic sandstones and interbedded black siltstones are common in the basal part of the Conejo, associated with basalt, andesitic basalt, and basaltic andesite flows, breccias, and agglomerates; andesite and basaltic andesite predominate in the central part of the sequence with interlayered andesitic basalt; and an upper zone, dominated by andesitic and basaltic andesite but including dacite flows in some areas as well as epiclastic volcanic conglomerates containing andesite and dacite clasts. The map by Durrell (1954) called the volcanics that intervene between lower Miocene and upper-middle Miocene sedimentary strata the “Middle Topanga Formation”; but his students Sonneman (1956) and Blackerby (1965) adopted the name "Conejo Formation” and “Conejo Volcanics", following the usage of Taliaferro (1924) for rocks in the Conejo Mountain area. This usage was formalized by Yerkes and Campbell (1979). In the vicinity of boundary between the Triunfo Pass and Point Dume quadrangles the contact with the upper part of the underlying Topanga Canyon and Vaqueros Formations is a buttress unconformity against a degraded half graben or caldera wall that laps eastward conformably onto shelf sediments at a higher stratigraphic level. Weigand and Savage (1993) have summarized the geochemistry of the Conejo Volcanics, comparing them with other southern California Miocene volcanic suites. The range in initial 87Sr/86Sr is reported as 0.60294-0.70320, indicating parent magmas derived from the upper mantle without important crustal rock contamination (Weigand and Savage, 1993, p. 105,106). K-Ar ages on plagioclases from basalt and andesite, reported by Turner and Campbell (1979), range from 15.5±0.8 m.y. near the base of the Conejo to 13.9±0.4 m.y. near the top. McCulloh and others (2002, p. 3) have recalculated the older date using updated decay constants to yield a 15.9±0.8 m.y. age. (*GRI Source Map ID 76065*)

Tcode - Conejo Volcanics, dacite-bearing epiclastic lenses (middle Miocene)

Epiclastic volcanic rocks, but including basalt, andesite and dacite pyroclastic flows and flow breccia; forms relatively thin layers and lenses interbedded in lower part of Calabasas Formation, which locally includes volcanic sandstone and volcanic conglomerate (north of Ventura Freeway, Thousand Oaks 7.5' quadrangle; after Blackerby, 1965). (*GRI Source Map ID 76065*)

Tcod - Conjeo Volcanics, dacite-bearing upper zone (middle Miocene)

Interlayered dacite (including trachytic dacite), andesite and basalt flows and pyroclastics; minor volcanic sandstone. Malibu Junction Member of Conejo Volcanics of Blackerby (1965) (south of Ventura Freeway, Thousand Oaks 7.5' quadrangle). (*GRI Source Map ID 76065*)

Tcoa - Conejo Volcanics, andesitic central zone (middle Miocene)

Interlayered porphyritic and microporphyritic andesite, andesitic basalt, and basaltic andesite flows, agglomerates and flow breccias; includes some crystal tuff, vesicular andesite, pyroclastics and volcanic sandstone; includes Ladyface Member and Medea Member of Blackerby (1965), as well as Potrero and Triunfo Members of Sonneman (1956) and Guynes (1959). (Blackerby, 1965 and unpublished mapping 1965-1973; Campbell and others, 1996, and unpublished mapping 1962-1976; Sonneman, 1956; Guynes, 1959; and Weber, 1984). (*GRI Source Map ID 76065*)

Tcoaf - Conejo Volcanics, andesitic central zone, andesitic flows (middle Miocene)

Andesite flows, mapped as Potrero Member of the Conejo Formation by Sonneman (1956) and Guynes (1959). (*GRI Source Map ID 76065*)

Tcoaa - Conejo Volcanics, andesitic central zone, andesitic agglomerate (middle Miocene)

Andesite agglomerate and tuff, mapped as part of Potrero Member of the Conejo Formation by Guynes (1959). (*GRI Source Map ID 76065*)

Tcoab - Conejo volcanics, andesitic central zone, andesite breccia (middle Miocene)

Tcoab - Conejo volcanics, andesitic central zone, andesite breccia (middle Miocene)
Andesitic and basaltic breccia and some agglomerate; mostly equivalent to rocks mapped as the Triunfo Member by Sonneman (1956) and Guynes (1959), and includes rocks mapped as Medea Member by Blackerby (1965). (Yerkes and Campbell, 1980; Campbell and others, 1970; Sonneman, 1956; Guynes, 1959; Weber, 1984; and unpublished 1:12,000-scale mapping by R. H. Campbell and B. A. Blackerby, 1967-1972). (*GRI Source Map ID 76065*)

Tcoab - Conejo Volcanics, andesitic central zone, andesite breccia (middle Miocene)
Andesitic and basaltic breccia and some agglomerate; mostly equivalent to rocks mapped as Triunfo Member by Sonneman (1956) and Guynes (1959); includes rocks mapped as Medea Member by Blackerby (1965). (Topanga, Malibu Beach, Point Dume, Triunfo Pass, Newbury Park and Thousand Oaks 7.5' quadrangles; Yerkes and Campbell, 1980; Campbell and others, 1970; Sonneman, 1956; Guynes, 1959; Weber, 1984; and unpublished 1:12,000-scale mapping by R. H. Campbell and B. A. Blackerby, 1967-1972). (GRI Source Map ID 75634)

Tcob - Conejo Volcanics, basaltic lower zone, basalt and andesitic basalt (middle Miocene)

Tcob - Conejo Volcanics, basaltic lower zone, basalt and andesitic basalt
Chiefly basalt, olivine basalt, basaltic andesite, and andesitic basalt; ranges from trachytic olivine basalt to porphyritic quartz andesite; as flows, breccias, agglomerates, pillow basalts, pillow breccias, and basaltic sand and silt; includes Olivine Basalt and Seminole Members of Blackerby (1965); (Malibu Beach, Point Dume, Triunfo Pass, and Thousand Oaks 7.5’ quadrangles; Yerkes and Campbell, 1980; Campbell and others, 1996; Blackerby, 1965; Sonneman, 1956; Guynes, 1959; Weber, 1984; and unpublished 1:12,000-scale mapping by R. H. Campbell and B. A. Blackerby, 1962-1976). Lithologically recognized subunits (flows and breccias) are interlayered at various stratigraphic levels in the upper part of the zone, and do not form a consistent stratigraphic sequence; however pillow basalt, pillow breccia, and volcanic sand predominate in the lower part of the zone. (*GRI Source Map ID 76065*)

Tcob - Conejo Volcanics, basaltic lower zone, basalt and andesitic basalt (middle Miocene)
Chiefly basalt, olivine basalt, basaltic andesite, and andesitic basalt; ranges from trachytic olivine basalt to porphyritic quartz andesite; as flows, breccias, agglomerates, pillow basalts, pillow breccias, and basaltic sand and silt; includes Olivine Basalt and Seminole Members of Blackerby (1965). (Malibu Beach, Point Dume, Triunfo Pass, and Thousand Oaks 7.5‘ quadrangles; Yerkes and Campbell, 1980; Campbell and others, 1996; Blackerby, 1965; Sonneman, 1956; Guynes, 1959; Weber, 1984; and unpublished 1:12,000-scale mapping by R. H. Campbell and B. A. Blackerby, 1962-1976). Lithologically recognized subunits (flows and breccias) are interlayered at various stratigraphic levels in upper part of zone, and do not form a consistent stratigraphic sequence; however pillow basalt, pillow breccia, and volcanic sand predominate in lower part of zone. (*GRI Source Map ID 75634*)

Tcoadb - Conejo Volcanics, mixture of andesitic and dacitic flow breccias with some flows (middle middle Miocene)

No additional unit description provided. (Tan et al, 2004, Point Mugu quadrangle). (*GRI Source Map ID 75634*)

Tcodb - Conejo Volcanics, dacitic flow breccias with some flows (middle middle Miocene)

No additional unit description provided. (Tan et al, 2004, Point Mugu quadrangle). (*GRI Source Map ID 75634*)

Tcobf - Conejo Volcanics, basaltic lower zone, basalt and andestic basalt, basalt flows (middle Miocene)

Basalt, andesitic basalt and basaltic andesite flows (Blackerby, 1965; Yerkes and Campbell, 1979, 1980; Campbell and others, 1996; Weber, 1984). (*GRI Source Map ID 76065*)

Tcobb - Conejo Volcanics, basaltic lower zone, basalt and andesitic basalt, basaltic breccia (middle Miocene)

Tcobb - Conejo Volcanics, basaltic lower zone, basalt and andesitic basalt, basaltic breccia (middle Miocene)
Basalt, andesitic basalt and basaltic andesite breccias; can include some pillow breccia; in part, mapped as Serrano member of Conejo Volcanics by Sonneman (1956) and Guynes (1959). (Sonneman, 1956; Guynes, 1959; Blackerby, 1965; Yerkes and Campbell, 1980; Weber, 1984; Campbell and others, 1996). (*GRI Source Map ID 76065*)

Tcobb - Conejo Volcanics, basaltic lower zone, basalt and andesitic basalt, basaltic breccia (middle Miocene)
Basalt, andesitic basalt and basaltic andesite breccias; includes some pillow breccia; in part, mapped as Serrano member of Conejo Volcanics by Sonneman (1956) and Guynes (1959). (Malibu Beach, Point Dume, Triunfo Pass and Thousand Oaks 7.5' quadrangles; Sonneman, 1956; Guynes, 1959; Blackerby, 1965; Yerkes and Campbell, 1980; Weber, 1984; Campbell and others, 1996). (*GRI Source Map ID 75634*)

Tcop - Conejo Volcanics, basaltic lower zone, pillow basalt (middle Miocene)

Basalt pillow lavas, pillow breccias and probable aquagene tuffs; included in Seminole Member mapped by Blackerby, 1965, and Serrano Member mapped by Sonneman, 1956, and by Guynes, 1959. (Sonneman, 1956; Guynes, 1959; Blackerby, 1965; Yerkes and Campbell, 1980; Campbell and others, 1996). (*GRI Source Map ID 76065*)

Tcobz - Conejo Volcanics, basaltic lower zone, basaltic sand (middle Miocene)

Tcobz - Conejo Volcanics, basaltic lower zone, basaltic sand (middle Miocene)
Black basaltic sand and siltstone; included in Seminole Member of Blackerby, 1965. (Blackerby, 1965; Yerkes and Campbell, 1980; Campbell and others, 1996). (*GRI Source Map ID 76065*)

Tcobz - Conejo Volcanics, basaltic lower zone, basaltic sand (middle Miocene)
Black basaltic sand and siltstone; included in Seminole Member of Blackerby, 1965 (Point Dume and Malibu Beach 7.5' quadrangles; Blackerby, 1965; Yerkes and Campbell, 1980; Campbell and others, 1996). (*GRI Source Map ID 75634*)

Tcom - Conejo Volcanics, Malibu Bowl Tongue (middle Miocene)

Andesitic and basaltic flows and flow breccias; underlies and tongues eastward into the Newell Sandstone Member of the Calabasas Formation and overlies the Dry Canyon Sandstone Member of the Calabasas Formation; as much as 143 m thick (Yerkes and Campbell, 1979; Yerkes and Campbell, 1980). (*GRI Source Map ID 76065*)

Tcos - Conejo Volcanics, Solstice Canyon Tongue (middle Miocene)

Basaltic and andesitic flows, breccias, and tuffs; local water-laid volcanic sandstone; underlies and intertongues eastward into the upper part of the Dry Canyon Sandstone Member of the Calabasas Formation, overlies Latigo Canyon Breccia Member of the Calabasas Formation; as much as 143 m thick (Campbell and others, 1970; Yerkes and Campbell, 1979; Yerkes and Campbell, 1980; Campbell and others, 1996). (*GRI Source Map ID 76065*)

Tcor - Conejo Volcanics, Ramera Canyon Tongue (middle Miocene)

Basaltic and andesitic breccias, tuff-breccias, and flows(?); minor volcanic sandstone; underlies, and upper part intertongues with lower part of Escondido Canyon Shale Member of the Calabasas Formation; underlain in some areas by shallow marine strata of the Topanga Canyon Formation which is cut out locally by the Malibu Bowl Detachment Fault; as much as 518 m thick. (Campbell and others, 1970; Yerkes and Campbell, 1979; Yerkes and Campbell, 1980; Campbell and others, 1996). (*GRI Source Map ID 76065*)

Ti - Intrusive rocks, undivided (middle Miocene)

Ti - Intrusive rocks, undivided (middle Miocene)
Dikes, sills and irregularly shaped intrusive bodies of diabase, basalt, and andesite; commonly pervasively altered and easily eroded, undercutting slopes and, therefore, commonly spatially associated with toes of landslides; sills are larger and more abundant in the Topanga Canyon Formation at shallow stratigraphic depths below the base of the Conejo Volcanics; intrusive along the Malibu Bowl Detachment Fault only where Topanga Canyon Formation and younger strata are carried in the upper plate; (widespread in central and western Santa Monica Mountains; Yerkes and Campbell, 1980; Campbell and others, 1996; Yerkes and Campbell, 1994. In the central and western Santa Monica Mountains these are related to the Conejo Volcanics; however, in the eastern Santa Monica Mountains and elsewhere they may be related to other volcanic centers of roughly the same age (for example, small dikes mapped by Saul (1976) in the Mount Wilson 7.5’ quadrangle). (*GRI Source Map ID 76065*)

Ti - Intrusive rocks, undivided (middle Miocene)
Dikes, sills and irregularly shaped intrusive bodies of diabase, basalt, and andesite; commonly pervasively altered and easily eroded, undercutting slopes and, therefore, commonly spatially associated with toes of landslides; sills are larger and more abundant in Topanga Canyon Formation at shallow stratigraphic depths below base of Conejo Volcanics; intrusive along Malibu Bowl Detachment Fault only where Topanga Canyon Formation and younger strata are carried in upper plate (widespread in central and western Santa Monica Mountains; Yerkes and Campbell, 1980; Campbell and others, 1996). (*GRI Source Map ID 75634*)

Tid - Intrusive rocks, dacite (middle Miocene)

Dacite dikes, irregular intrusive bodies in older Conejo rocks, and a plug intrusive into Topanga Canyon Formation; (Dibblee and Ehrenspeck, 1993, p. 89). (*GRI Source Map ID 76065*)

Tia - Intrusive rocks, andesitic (middle Miocene)

Tia - Intrusive rocks, andesitic (middle Miocene)
Andesitic dikes, sills and irregular intrusive bodies, chiefly sills in Topanga Canyon and Vaqueros Formations, and dikes in older rocks. (*GRI Source Map ID 76065*)

Tia - Intrusive rocks, andecite (middle Miocene)
Andesitic plug and hypabyssal intrusive rocks into Topanga Canyon Formation (Camarillo, Point Mugu, Triunfo Pass and Newbury Park 7.5‘ quadrangles; Dibblee and Ehrenspeck, 1993). (*GRI Source Map ID 75634*)

Tib - Intrusive rocks, basaltic (middle Miocene)

Tib - Intrusive rocks, basaltic (middle Miocene)
Basaltic, diabasic, and gabbroic dikes, sills and irregular intrusive bodies, chiefly sills in Topanga Canyon Formation and following detachment faults, and dikes in older rocks. (*GRI Source Map ID 76065*)

Tib - Intrusive rocks, basaltic (middle Miocene)
Diabase and mafic hypabyssal intrusive rocks into Topanga Canyon Formation (Point Mugu, Triunfo Pass and Newbury Park 7.5‘ quadrangles; Dibblee and Ehrenspeck, 1993). (*GRI Source Map ID 75634*)

Tim - Mixed rocks (middle Miocene and early or early middle Miocene)

Very fine- to fine-grained basalt, pervasively intrusive into black siltstone and very fine-grained sandstone of the Topanga Canyon Formation on a spacing too intimate to map separately at 1:12,000-scale; (Campbell, unpublished mapping, 1967-1976). (*GRI Source Map ID 76065*)

Ttc - Topanga Canyon Formation, undivided (middle and early Miocene)

Marine sandstone, commonly arkosic, with interbedded siltstone, pebbly sandstone and pebble-cobble conglomerate; generally well indurated; recognized only in the central and western Santa Monica Mountains, where it is overlain unconformably by the Conejo Volcanics, and conformably overlies lithologically similar older Miocene and Oligocene strata of the Vaqueros Formation; elsewhere, correlative strata are included in the undivided Topanga Group, Tt. Yerkes and Campbell (1979) formalized the name “Topanga Canyon Formation” and described as members lithologic facies that indicate an eastward shoaling of depositional environments from deeper shelf on the west to shoreface, estuarine, and fluvial deposits, wedging out just east of Santa Ynez Canyon. (Note that the deposition precedes post-volcanic tectonic rotation, so in early middle Miocene time the direction of shoaling was nearly north). North of Castro Peak, where the formation is undivided (Ttc), it is as much as 1,070 m thick. West of Santa Ynez Canyon to Malibu Canyon three members are recognized: the Cold Creek (Ttcc), Fernwood (Ttcf), and Saddle Peak (Ttcs) Members (Yerkes and Campbell, 1960). The Fernwood Member represents an estuarine and fluvial depositional environment, and separates shelf marine strata of the underlying Saddle Peak and overlying Cold Creek Members, both of which pinch out west of Topanga Canyon. The Fernwood Member wedges out westward and the two nearshore marine members coalesce just east of Malibu Canyon; therefore, the Formation is undivided from Malibu Canyon west to Zuma Canyon. Interbeds of siltstone and mudstone, suggestive of deepening offshore shelf depositional environments, become progressively thicker westward, and siltstone strata of the Encinal Canyon Member (Ttce) predominate west of Zuma Canyon. In and west of Arroyo Sequit some thick sandstone beds become prominent in the upper part of the Topanga Canyon Formation, and are here called the Big Sycamore Member (Ttcb). (*GRI Source Map ID 76065*)

Ttcc - Topanga Canyon Formation, Cold Creek Member (middle and early Miocene)

Marine sandstone, siltstone, and minor pebbly sandstone; sandstone commonly medium grained, moderately to well sorted arkosic arenite, in laminated and graded beds as much as two meters thick, and locally biotitic. About 707 m thick in the northeast corner of the Malibu Beach 7.5’ quadrangle. Locally abundant molluscan fauna referred to "Temblor Stage" of Weaver and others (1944), including the locality for the “Topanga Canyon fauna” (about 50 molluscan species) of Arnold (1907a); named as a member of the Topanga Canyon Formation by Yerkes and Campbell (1979). Conformably overlies the Fernwood member of the Topanga Canyon formation; overlain, in most places conformably, by Conejo

Volcanics. In a few localities in upper Topanga Canyon the Conejo is missing and the Cold Creek Member is accordantly overlain by the Calabasas Formation. Foraminifera from siltstone in upper part assigned to Relizian BFZ. (Yerkes and Campbell, 1980; Campbell, unpublished 1:12,000-scale mapping, 1965-1972). (*GRI Source Map ID 76065*)

Ttcf - Topanga Canyon Formation, Fernwood Member (middle and early Miocene)

Paralic, fluvial, estuarine, and marine sandstone, pebbly sandstone, and mudstone, with minor tuff and limestone; interbedded with grayish-red or olive-gray mudstone and, locally, minor vitric rhyolite tuff and algal(?) limestone; fluvial sandstone forms thick lenticular ledge-forming beds and is complexly channeled and crossbedded; locally abundant closely spaced borings normal to sandstone bedding (ophiomorpha?), and rare fragments of bone occur; the shallow-water gastropod Melongena, known only from the provincial middle Miocene, occurs in sandstone on a ridge west of Topanga Canyon (in the Fernwood area) (Yerkes and Campbell, 1979; Yerkes and Campbell, 1980). The Fernwood is overlain conformably by and intertongues into the Cold Creek Member of the Topanga Canyon Formation. The Fernwood overlies the Saddle Peak Member conformably and may intertongue with it. In several parts of the Topanga Canyon drainage area Fernwood strata are cut off down dip by Sespe Formation redbeds along the Malibu Bowl Detachment Fault or by basalt and diabase intrusive into the fault. Fritsche (1993) and Flack (1993) propose that the Fernwood member should be assigned to the Sespe Formation. However, the Fernwood has nowhere been observed to be in direct depositional contact with Sespe strata (even though short segments of approximately located contact are shown on the map, there is no outcrop exposure of unfaulted contact relationships). Nor does the Fernwood contain any red sandstone, which is characteristic of (though not always present in) the Sespe Formation. Therefore, the usage of the source maps is retained. (Yerkes and Campbell, 1979; Yerkes and Campbell, 1980; Yerkes and Campbell, 1994). (*GRI Source Map ID 76065*)

Ttcs - Topanga Canyon Formation, Saddle Peak Member (middle and early Miocene)

Thick-bedded to massive, medium-to coarse grained marine sandstone, pebbly sandstone, and hackly fracturing sandy siltstone, over a 1/2-m-thick basal pebble conglomerate; conformably overlain by the Fernwood Member of the Topanga Canyon Formation; conformably overlies the Piuma Member of the Sespe Formation or its’ marine correlative Vaqueros Formation; in places faulted against Sespe and older rocks, or strata of the Calabasas Formation, chiefly along the Malibu Bowl Detachment Fault. A resistant sandstone near the base of the Saddle Peak Member contains an abundant "Temblor" megafauna that includes the gastropod Antillophos dumbleanus (Anderson), that is apparently restricted to the middle Miocene; immediately above this bed is a 10-cm thick layer of well-preserved, in part articulated valves of the giant pectinid Vertipecten nevadanus (Conrad) (also called V. bowersi); the entire fauna is referred to the middle Miocene "Temblor" provincial Stage. Fritsche (1993) has proposed that the Saddle Peak Member be included with the Vaqueros Formation because some elements of the fauna are long ranging and are also found in the Vaqueros, and because closely similar lithofacies are found in both units. However, detailed mapping can carry continuous and overlapping stratigraphic horizons in most areas where the Saddle Peak Member is in contact with underlying Vaqueros, and the two units are mappable separately. Therefore, the usage of the source maps is retained. The unit is about 220 m thick along Piuma Road on the west shoulder of Saddle Peak. (Yerkes and Campbell, 1979; Yerkes and Campbell, 1980). (*GRI Source Map ID 76065*)

Ttcb - Topanga Canyon Formation, Big Sycamore Member (middle and early Miocene)

Ttcb - Topanga Canyon Formation, Big Sycamore Member (middle and early Miocene)
Alternating gray sandstone and dark gray siltstone or silty mudstone, commonly platy to shaly; chiefly mudstone with interbedded thin- to thick-bedded lenticular sandstone in sets that locally coalesce to massive beds; sandstone grain size variable, with local rip-up clasts of shale, and pebbly sandstone with polished, rounded chert pebbles; mudstone interbeds commonly thin-bedded to shaly. A rare occurrence of detrital glaucophane in sandstone is the earliest known north of the Malibu Coast Fault. Sonneman (1954) estimated a total thickness of 2,400 ft. (732 m) to 3,500 ft. (1,066 m). Mapped as the “Upper Member of the Sycamore Formation” by Sonneman (1956); mapped as individual sandstone beds in the “Undivided Topanga Canyon Formation” by Dibblee and Ehrenspeck (1990); here called “Big Sycamore Member of the Topanga Canyon Formation” to follow rules of the North American Code. Fossils include: locally common Vertipectin Nevandus at Point Mugu; rare Turritella Temblorensis (Sonneman, 1954); and Relizian foraminifera (Sonneman, 1954). (*GRI Source Map ID 76065*)

Ttcb - Topanga Canyon Formation, Big Sycamore Member (early middle Miocene)
Marine sandstone, commonly arkosic, with interbedded siltstone and pebbly mudstone; generally well indurated; sandstone predominates, probably shelf and nearshore depositional environments; equivalent to the informal "Upper Sycamore Formation" of Sonneman (1956). Prominent sandstone interbeds designated Ttcbs. (*GRI Source Map ID 75634*)

Ttcbs - Topanga Canyon Formation, Big Sycamore Member, prominent sandstone bed (early middle Miocene)

See previous description. (*GRI Source Map ID 75634*)

Ttce - Topanga Canyon Formation, Encinal Member (middle and early Miocene)

Chiefly dark gray siltstone or silty mudstone, commonly platy to shaly, but at many localities bedding fissility is obscured by a dominant conchoidal fracture, possibly indicating bioturbation; lenticular dolomitic concretions locally abundant, particularly along locally restricted stratigraphic zones as thick as 60 cm; rare medium-and fine-grained sandstone beds in the Encinal Canyon area (western Point Dume 7.5’ quadrangle) increase in abundance somewhat westward in the Triunfo Pass 7.5’ quadrangle. The siltstone rests conformably on sandstone of the underlying San Nicholas Member of the Vaqueros Formation, but there is apparent discordance in some places where lack of exposure prevents clear discrimination. The Encinal Canyon Member intertongues with and is overlapped conformably by the Big Sycamore Member of the Topanga Canyon Formation, and unconformably overlain by Conejo Volcanics (see discussion of base of Conejo, above). Poorly preserved foraminifera in two collections from the Encinal Canyon Road exposures reported by Yerkes and Campbell (1979) are assigned to the Relizian (?) stage and Saucesian or Relizian stages of Kleinpell (1938), respectively. Further west, in the Triunfo Pass and Point Mugu quadrangles Sonneman (1956) reports that the “Lower Member of the Sycamore Formation”, which is contiguous with the Encinal Canyon Member of the Topanga Canyon Formation (Yerkes and Campbell, 1980), also contained foraminifera assignable to the Relizian Stage. A subsequent collection reported by Flack (1993) is also assigned a late Saucesian to early Relizian age. Flack (1993, p. 46) considers the Encinal Member, as well as the entire Topanga Canyon Formation, to be late early Miocene rather than early middle Miocene. (Campbell and others, 1996; Campbell, unpublished 1:12,000-scale mapping, 1965-1975; Sonneman, 1956; Dibblee and Ehrenspeck, 1990). (*GRI Source Map ID 76065*)

Tv - Valqueros Formation, undivided (early Miocene and Oligocene)

Tv - Vaqueros Formation, undivided (early Miocene and Oligocene)
A heterogeneous sequence of thick- and medium-bedded sandstone and interbedded siltstone and mudstone; sandstone ranges from coarse- to very fine-grained, chiefly biotitic arkosic arenites and wackes; siltstone and mudstone interbeds commonly dark gray, but can be greenish or reddish in color; commonly carries Turritella inezana and other elements of the "Vaqueros fauna". Although the name was first used in central California (Hamlin, 1904) and subsequently extended on the basis of faunal elements, it has long been used in coastal Southern California, and is used consistently throughout intervening areas, to refer to a well-recognized and widespread, predominantly marine sequence that contains a distinctive molluscan fauna (Loel and Corey, 1932). Since Addicott (1972) noted that the range of the Temblor fauna included the range of the Vaqueros fauna in the Temblor Range type area, some authors (Fritsche, 1993; Dibblee, 1989a) have proposed abandoning the name, Vaqueros, and combining the pre-Conejo post-Sespe strata into a single unit. However, in nearly all the problematical areas there are sufficient continuous or overlapping beds, as well as differences in fauna, to provide a realistic basis for mapping separate formations. In the Santa Monica Mountains a complete section in the vicinity of Castro Peak, where the Vaqueros accordantly overlies the nonmarine Sespe formation, is as much as 760 m thick; east of Malibu Canyon however, shoreface facies intertongue with nonmarine strata of the Sespe Formation, and Vaqueros strata are not present in and east of Topanga Canyon. Along the north side of Simi Valley, Vaqueros strata about 600 m thick lie accordantly above Sespe redbeds and are overlain by Conejo Volcanics; the Vaqueros wedges-out to the east in the Simi Valley West 7.5’ quadrangle. In the Simi Valley area, Squires and Filewicz (1983, Fig. 2) show the Vaqueros as approximately 310 m in thickness, intertonguing with and overlying the Sespe Formation; it pinches out eastward beneath the unconformably overlying Conejo Volcanics. North of Fillmore, the easternmost Vaqueros is about 183 m thick. (Cemen, 1977; Eschner, 1969; Bailey, 1951). Oborne (1993) has described the several interbedded lithofacies that are present to the west of Topanga Canyon and interprets them to represent deposition during a rapid marine transgression from west to east over nonmarine strata of the Sespe. This compilation retains the usage and nomenclature of Yerkes and Campbell, 2005. (western Santa Monica Mountains, western Topatopa Mountains, and north side of Simi Valley; Yerkes and Campbell, 1979; Yerkes and Campbell, 1980; Campbell and others, 1996; Eschner, 1969; Bailey, 1951; Cemen, 1977; Squires, 1983a; Sonneman, 1956; Durrell, 1954). (*GRI Source Map ID 76065*)

Tv - Vaqueros Formation, undivided (early Miocene)
Heterogeneous sequence of thick- and medium-bedded sandstone and interbedded siltstone and mudstone. Sandstone ranges from coarse- to very fine-grained, chiefly biotitic arkosic arenites and wackes; siltstone and mudstone interbeds commonly dark gray, but can be greenish or reddish in color. Commonly carries Turritella inezana and other elements of "Vaqueros fauna". Although name was first used in central California (Hamlin, 1904) and subsequently extended on basis of faunal elements, it has long been used in coastal Southern California, and is used consistently throughout intervening areas, to refer to a well-recognized and widespread, predominantly marine sequence that contains a distinctive molluscan fauna (Loel and Corey, 1932). North of Fillmore, easternmost Vaqueros is about 183 m thick (Cemen, 1977; Eschner, 1969; Bailey, 1951) In the Simi Valley area, Squires and Filewicz (1983, Fig. 2) show the Vaqueros as approximately 310 m in thickness, intertonguing with and overlying the Sespe Formation; it pinches out eastward beneath the unconformably overlying Conejo Volcanics. In Santa Monica Mountains a complete section in vicinity of Castro Peak, where Vaqueros accordantly overlies nonmarine Sespe Formation, is as much as 760 m thick. East of Malibu Canyon, shoreface facies intertongue with nonmarine strata of Sespe Formation, and Vaqueros strata are not present in and east of Topanga Canyon. Oborne (1993) described several interbedded lithofacies west of Topanga Canyon and interprets them to represent deposition during rapid marine transgression. Fritsche (1993) proposed lumping Vaqueros and Topanga Canyon Formations into a single "Unnamed Sandston" unit because both contain similar lithofacies and locally lack their typical distinctive faunal elements. However, in nearly all problematical areas there are sufficient continuous or overlapping beds to provide a realistic

basis for mapping separate formations. Therefore, this compilation retains usage and nomenclature of source maps (western Santa Monica Mountains, western Topatopa Mountains, and north side of Simi Valley; Yerkes and Campbell, 1979; Yerkes and Campbell, 1980; Campbell and others, 1996; Eschner, 1969; Bailey, 1951; Cemen, 1977; Squires, 1983a; Sonneman, 1956; Durrell, 1954). (*GRI Source Map ID 75634*)

Tvn - Vaqueros Formation, San Nicholas Member (early Miocene and Oligocene)

Tvn Vaqueros Formation, San Nicholas Member (early Miocene and Oligocene)
Very thick bedded to massive cliff- and ledge-forming marine sandstone, generally very light gray to pale bluish gray; rare interbeds and partings of siltstone and shale, commonly dark gray. Sandstone, very fine- to very coarse-grained arenite, locally pebbly; thick beds show internal cross lamination, parallel, lamination, and disturbed (burrowed?), laminations; local common barnacle detritus. Generally conformably underlain by the Danielson Member of the Vaqueros Formation; however, locally thinned where it rests on older rocks beneath the Zuma Detachment Fault, as in Encinal Canyon. Conformably overlain by the Encinal Member of the Topanga Canyon Formation. Mapped as “Nicholas Formation” by Sonneman (1956), named for exposures in the vicinity of San Nicholas Canyon (Triunfo Pass 7.5’ quadrangle); formalized as a member of the Vaqueros Formation by Yerkes and Campbell (1979). (Campbell and others, 1996; Campbell, unpublished 1:12,000-scale mapping, 1967-1975). (*GRI Source Map ID 76065*)

Tvn - Vaqueros Formation, San Nicholas Member (early Miocene)
Very thick bedded to massive cliff- and ledge-forming marine sandstone, generally very light gray to pale bluish gray; rare interbeds and partings of siltstone and shale, commonly dark gray. Sandstone, very fine- to very coarse-grained arenite, locally pebbly; thick beds show internal cross lamination, parallel lamination, and disturbed (burrowed?) laminations; local abundant barnacle detritus. Generally conformably underlain by Danielson Member of the Vaqueros Formation; however, locally thinned where it rests on older rocks beneath Zuma Detachment Fault, as in Encinal Canyon. Conformably overlain by Encinal Member of Topanga Canyon Formation. Mapped as "Nicholas Formation" by Sonneman (1956) named for exposures in vicinity of San Nicholas Canyon (Triunfo Pass 7.5‘ quadrangle); formalized as member of Vaqueros Formation by Yerkes and Campbell (1979). (Triunfo Pass and Point Dume 7.5‘ quadrangles; Campbell and others, 1996; Campbell, unpublished 1:12,000-scale mapping, 1967-1975). (*GRI Source Map ID 75634*)

Tvd - Vaqueros Formation, Danielson Member (early Miocene and Oligocene)

Tvd Vaqueros Formation, Danielson Member (early Miocene)
Grayish black, very fine-grained, marine sandy siltstone or mudstone, in medium and thin beds, generally with indistinct parallel lamination; fractures commonly conchoidal or irregularly subparallel to bedding, but locally platy or shaly. In San Nicholas Canyon, several prominent interbeds, 1/3 to 1 m thick, of calcareous very fine-grained sandstone and sandy mudstone contain fossil remains of Turritella inezana Conrad in such numbers as to locally form biostromes (Yerkes and Campbell, 1979, p. E12). Mapped as “Danielson Formation” by Sonneman (1956), named for exposures on the Danielson Ranch in Big Sycamore Canyon (Triunfo Pass 7.5’ quadrangle); formalized as a member of the Vaqueros Formation by Yerkes and Campbell (1979). (Sonneman, 1956; Campbell and others, 1996; Campbell, unpublished 1:12,000-scale mapping, 1967-1975). (*GRI Source Map ID 76065*)

Tvd - Vaqueros Formation, Danielson Member (early Miocene)
Grayish black, very fine-grained, marine sandy siltstone or mudstone, in medium and thin beds,

generally having indistinct parallel lamination; fractures commonly conchoidal or irregularly subparallel to bedding, but locally platy or shaly. In San Nicholas Canyon, several prominent interbeds, 1/3 to 1 m thick, of calcareous very fine-grained sandstone and sandy mudstone contain Turritella inezana Conrad in such numbers as to locally form biostromes (Yerkes and Campbell, 1979, p. E12). Mapped as "Danielson Formation" by Sonneman (1956) named for exposures on Danielson Ranch in Big Sycamore Canyon (Triunfo Pass 7.5‘ quadrangle); formalized as member of Vaqueros Formation by Yerkes and Campbell (1979) (Triunfo Pass and Point Dume 7.5‘ quadrangles; Sonneman, 1956; Campbell and others, 1996; Campbell, unpublished 1:12,000-scale mapping, 1967-1975). (*GRI Source Map ID 75634*)

Ts - Sespe Formation, undivided (early Miocene, Oligocene, and late Eocene)

A nonmarine "redbed" sequence of sandstone, pebbly sandstone, varicolored mudstone, and pebble-cobble conglomerate; sandstone beds commonly very thick to massive, with strong internal cross lamination; and rare thin interbeds varicolored reddish, greenish and grayish mudstone. The sandstone beds are characteristically red in color, chiefly as a result of intergranular hematized biotite; several sections include beds that lack the characteristic red color. The only complete section of the Sespe exposed in the Santa Monica Mountains is in the Solstice Canyon-Castro Peak area, where about 1000 m of the nonmarine strata are in depositional contact on (and accordant with) the underlying marine Llajas Formation, and accordantly beneath the overlying marine Vaqueros Formation. Elsewhere in the Santa Monica Mountains, both to the east and to the west, the Sespe is in fault contact with underlying older strata, chiefly along the Zuma Detachment Fault. At the west end of the Simi Hills about 1365 m of Sespe strata lie accordantly above the marine Llajas and unconformably below Conejo Volcanics. Along the north side of Simi Valley, Sespe exposures total as much as 1656 m in thickness in the west (Simi Valley West 7.5’ quadrangle), but wedges out to the east, north of Santa Susana Pass (Simi Valley East 7.5’ quadrangle). Along the north flank of Oak Ridge the Sespe can be as much as 2135 m thick, based in part on drill-hole data. In the western Topatopa Mountains, north of Fillmore, the Sespe is about 430 m thick between the underlying marine Coldwater Formation and overlying marine strata assigned to the Vaqueros Formation (Fillmore 7.5’ quadrangle). The name, Sespe Formation, was introduced by Watts (1897) and further described by Bailey (1947) for exposures in the vicinity of Sespe Creek, north of Fillmore, and has been extended over large parts of coastal southern California by various workers. Generally, it has been applied to a thick nonmarine sandstone, conglomeratic sandstone and siltstone sequence that is underlain by marine Eocene strata and overlain by marine Miocene beds. (*GRI Source Map ID 76065*)

Tsp - Sespe Formation, Piuma Member (early Miocene)

In contrast to the thicker bedded, more coarsely grained sandstone and conglomerate of the undivided Sespe Formation below, the Piuma Member is distinguished by thinner individual beds, sandstone of generally finer grain size, absence of pebble and cobble conglomerate, and greater abundance of interbedded lacustrine or lagoonal siltstone. The member name was formalized by Yerkes and Campbell (1979) for the upper of two tongues of the Sespe that can be easily distinguished where strata of the marine Vaqueros Formation separate them; the Vaqueros wedges out eastward, but the contact between the Piuma Member and the undivided Sespe below can be carried some distance eastward beyond the Vaqueros wedge-out. (Yerkes and Campbell, 1980). (*GRI Source Map ID 76065*)

Tl - Llajas Formation (early to middle Eocene)

Shallow marine, light-gray to yellowish-gray, very fine- to medium-grained sandstone, laminated siltstone and local mollusk coquina beds; interfingers with alluvial conglomerate (Tlc) at the base; sandstone is laminated to bioturbated; moderately indurated (Irvine, 1990, 1991; Squires, 1983b); section is about 1,800 ft. (550 m) thick. Locally contains fossil mollusks assigned to the “Domengine Stage” (Weaver and others, 1944); Figure 3 of Squires (1983b) suggests the basal portion corresponds to the upper “Capay Stage”. As summarized by Squires (1983b), the Llajas section in the Simi Valley area was originally assigned to the “Tejon” or “Meganos” Formations (e.g. Kew, 1919, 1924); subsequently assigned informally to the Llajas Formation by Schenck (1931) and McMasters (1933); more formally named by Cushman and McMasters (1936) for surface outcrops at the type section on the northwest side of the north branch of Llajas Canyon (now known as Chivo Canyon and formerly known as “Oil Canyon”), and from corehole data obtained from the nearby Tapo No. 42 oil well, all located on the northeast side of Simi Valley) (Simi Valley East, Oat Mountain, Thousand Oaks 7.5’ quadrangles, and correlative strata in the Point Dume, Malibu Beach, and Topanga 7.5’ quadrangles). (*GRI Source Map ID 76065*)

Tss - Santa Susana Formation (late Paleocene to early Eocene)

Marine clay shale and conchoidally fractured mudstone and siltstone with interbeds of fine- to medium-grained sandstone and lenses of pebble-cobble conglomerate; gray limestone concretions common in shale; locally contains foraminifera; locally abundant mollusks diagnostic of the “Meganos” and “Martinez” Stages (Saul, 1983); thickness as much as 1,000 m in the Simi Hills; unit thickness varies laterally and rapid lateral facies changes are common across map area. Named by Nelson (1925) for exposures in the Simi Hills near the town of Santa Susana. As summarized by Parker (1983, 1985), lower Tertiary strata in the Simi Hills were originally correlated and assigned to the “Martinez and/or Meganos Formations” by early workers, including Waring (1914, 1917), Kew (1919, 1924), and Clark (1921). Nelson (1925) raised the “Martinez Formation” to group status and subdivided it into the Simi Conglomerate, Las Virgenes Sandstone, and the Martinez marine member, overlain by the Santa Susana Formation. Most literature published to date follows some form of Nelson’s terminology, but the placement of contacts varies considerably among different authors. Parker (1983, 1985) modified Nelson’s Santa Susana Formation to include the underlying Martinez marine member, thereby encompassing all strata above the Simi Conglomerate and Las Virgenes Sandstone and below the Llajas Formation in the Simi Hills and northeastern Simi Valley. Parker and other authors abandoned “Martinez Group” and “Martinez marine member” because “Martinez” is a molluscan Stage name, imported from a central California type locality, and no longer considered appropriate to use as a formation name for this interval. Colburn and others (1988) and Colburn and Novak (1989) extended Parker’s nomenclature to correlative rocks in the Santa Monica Mountains and included beds mapped as Coal Canyon Formation by Yerkes and Campbell (1979, 2005) in the Santa Susana Formation. Distribution of lower Tertiary strata in the Simi Valley area on this map is based on Squires (1983a), which includes Parker’s nomenclature and contacts. Parker described the lower Tertiary units in terms of western and eastern facies based on the location of the stratigraphic sections relative to the “Runkle Canyon fault” (Squires, 1983a). The western facies of the Santa Susana Formation in the Simi Valley area (Simi Valley East, Calabasas and Thousand Oaks 7.5’quadrangles) overlies the Las Virgenes Sandstone with a gradational to sharp contact and is disconformably overlain by the Llajas Formation. It generally consists of a lower unit of densely bioturbated, fossiliferous, fine- to medium-grained sandstone and an upper unit dominated by poorly fossiliferous fractured mudstone and siltstone interbedded with subordinate sandstone and minor conglomerate. The lower unit represents transition zone and offshore to shelf deposits and the upper unit represents deposition within a slope environment. The eastern facies overlies the Simi Conglomerate with a gradational or sharp contact and is overlain disconformably by the Llajas Formation. The eastern facies is more variable, but generally consists of fractured mudstone and siltstone similar to the western facies with discontinuous interbeds of sandstone and conglomerate. East of Meier Canyon, mudstone and siltstone are present in the lower half and sandstone and conglomerate present in the upper half. Sandstone occurs as discontinuous lenses in conglomerate and in beds up to 20 meters thick. Near Runkle Canyon, sandstone occurs as thin interbeds within the mudstone and siltstone and in tongues up to 150 m with locally abundant megafossils occurring in layers within concretionary beds. Northeast of Simi Valley in Poison Oak Canyon, beds are dominantly mudstone interbedded with minor sandstone above two tongues of Simi Conglomerate. These beds represent inner fan deposits. Interbedded sandstone and conglomerate near Meier Canyon represent the coarse portion of an inner fan and slope deposits. The uppermost portion of the Santa Susana Formation in both the western and eastern facies consists of sandstone with megafossils and microfauna indicative of a shelf environment and may record a basin filling and shoaling event prior to the deposition of the nonmarine basal Llajas conglomerate., In the Santa Monica Mountains, Santa Susana strata include marine sandstone, pebble conglomerate, siltstone and algal limestone. Sandstone is very fine to medium grained, poorly to well sorted, consisting of subrounded quartz and feldspar grains in a sparse clay matrix, locally biotitic; locally contains abundant mollusks; beds commonly are thick and locally have graded upper parts and sharp upper contacts. Siltstone and silty claystone are present locally in the upper part of the formation; closely jointed, conchoidal fracture, and containing abundant biotite; local partings of fine-grained silty biotitic sandstone, and calcareous beds or concretions as thick as 15 cm and as long as 1 m. Pebble-cobble conglomerate forms resistant steep slopes in Carbon and Topanga Canyons; in beds as much as 7 m thick with scattered pebbles, boulders, slabs, and interbeds of mudstone and medium-to coarse-grained sandstone. The Yerkes and Campbell (2005) map shows the Coal Canyon Formation to be about 335 m thick in Solstice Canyon, the only complete section exposed in the Santa Monica Mountains. The thickness summed from incomplete sections in the Carbon Canyon-Topanga Canyon area is as much as 450 m. Commonly carries a molluscan fauna that includes the Martinez-Stage gastropods Turitella pachecoensis and Mesalia martinezensis (Gabb, 1869). Colburn and others (1988) and Colburn and Novak (1989) prepared five stratigraphic columns and detailed geologic maps of the section localities along the axis of the Santa Monica Mountains from Solstice Canyon in the west to Runyon Canyon near Hollywood and correlated Simi Conglomerate, Las Virgenes Sandstone, and Santa Susana Formation strata. The Las Virgenes Sandstone and Simi Conglomerate are not separately delineated on the current version of the Los Angeles compilation map in the central and eastern Santa Monica Mountains (Malibu Beach, Topanga, Beverly Hills, and Hollywood 7.5' quadrangles) and Simi Conglomerate and Las Virgenes Sandstone strata mapped by Colburn and Novak (1989) are included in Santa Susana Formation in these areas. Yerkes and Campbell (1979) mapped the Simi Conglomerate in Solstice Canyon (Point Dume 7.5' quadrangle), but did not recognize the Las Virgenes Sandstone in the Solstice Canyon section, and included most of that interval in the Simi Conglomerate. In the Santa Monica Mountains, the Santa Susana Formation overlies and interfingers with the nonmarine Las Virgenes Sandstone (included in Simi Conglomerate on this map) or overlies the late Cretaceous Tuna Canyon Formation; the relations are generally accordant but locally unconformable. In Solstice Canyon, the Santa Susana Formation is overlain disconformably(?) by marine strata of Eocene age. (Squires, 1983a; Yerkes and Campbell, 1980; Campbell and others, 1996). (*GRI Source Map ID 76065*)

Tssl - Santa Susana Formation, limestone (late Paleocene to early Eocene)

Algal limestone occurs as scattered lenses and pods in siltstone sequences east of Topanga Canyon, most prominently in the eastern wall of Santa Ynez Canyon. (*GRI Source Map ID 76065*)

Tlv - Las Virgenes Sandstone (early(?) Paleocene)

Nonmarine to marine light-gray to yellowish orange, predominantly medium- to coarse-grained weakly to moderately indurated sandstone with green interbedded mudstone and red-bed mudstone, and minor pebble conglomerate; megafossils and burrows are present in the upper part of the section at Bus Canyon; thin sequence, locally as thick as 195 m near Bus Canyon in the Simi Hills, but thins westward to zero; originated as sandy, braided alluvial and meandering stream deposits on a coastal plain; upper part represents nearshore marine deposits (Parker, 1983); conformably overlies Simi Conglomerate and is overlain by and interfingers with the Santa Susana Formation. Named by Nelson (1925) for exposures near Las Virgenes Canyon in the Simi Hills. Colburn and others (1988) and Colburn and Novak (1989) correlated Las Virgenes Sandstone from the Simi Hills to five localities in the Santa Monica Mountains. These strata are included in the Santa Susana Formation on the current Los Angeles compilation map in the central and eastern Santa Monica Mountains (Malibu Beach, Topanga, Beverly Hills, and Hollywood 7.5' quadrangles). Yerkes and Campbell (1979, 2005) did not recognize the Las Virgenes Sandstone in the Solstice Canyon section (Point Dume 7.5’ quadrangle), and included most of that interval in the Simi Conglomerate, including distinctive pisolite-bearing beds that Colburn assigned to the Las Virgenes Sandstone. Pisolite-bearing red beds are also mapped in the Bus Canyon section in the Simi Hills by Parker (1985), but he included the beds in the Simi Conglomerate. (Squires, 1983a). (*GRI Source Map ID 76065*)

Tsi - Simi Conglomerate, undivided (Paleocene)

Thin, predominantly nonmarine cobble-boulder conglomerate mapped at the base of the Tertiary sequence in the Simi Hills, the Santa Monica Mountains, and northeast of Simi Valley. The conglomerate is poorly bedded, weakly to moderately indurated and contains abundant well-rounded, polished cobbles and boulders of quartzite, granitic, rhyolitic, and gneissic rocks in conglomeratic, coarse-grained sandstone. Distribution of lower Tertiary strata in the Simi Valley area shown on this map is based on Squires (1983a), which includes Parker’s (1983, 1985) nomenclature and contacts. Parker described the lower Tertiary units in terms of western and eastern facies based on the location of the stratigraphic sections relative to the “Runkle Canyon fault” (Squires, 1983a). According to Parker, Simi Conglomerate west of the Runkle Canyon fault (Squires, 1983a) represents alluvial fan and braided river deposits and Simi Conglomerate east of the Runkle Canyon fault in Runkle and Meier Canyons and northeast of the Simi Valley represents channel and inner fan facies of a deep-sea fan, based on observed sedimentary structures and microfaunal studies summarized by Parker (1983, 1985). The marine conglomerate included by Parker in the Simi Conglomerate is considered by other authors to be part of the Santa Susana Formation or an unnamed Paleocene marine unit (Hanson, 1981).Yerkes and Campbell (1979) tentatively correlated beds described in the Simi Hills by Nelson (1925) as the Simi Conglomerate with lithologically similar beds in the Solstice Canyon area of the Santa Monica Mountains, and the correlation is supported in subsequent detailed petrographic work by Colburn and Novak (1989). In Solstice Canyon (eastern Point Dume 7.5’ quadrangle) the conglomerate includes a 1-m-thick bed of brick-red pisolitic clayey sandstone, which Colburn and Novak (1989) include in the Las Virgenes Sandstone. Simi Conglomerate beds mapped by Colburn and Novak (1989) in the central and eastern Santa Monica Mountains (Malibu Beach, Topanga, Beverly Hills, and Hollywood 7.5’ quadrangles) are included in the Santa Susana Formation on the current Los Angeles compilation map. Correlative strata in the Santa Susana Mountains, mapped as “Martinez Formation” by Evans and Miller (1978), are here included with the Simi Conglomerate. Evans and Miller (1978) recognized three local lithologic members. (*GRI Source Map ID 76065*)

Kc - Chatsworth Formation (Late Cretaceous)

Dominantly turbidite sandstone, massive, thick-bedded, medium- to coarse-grained, well-cemented; conglomeratic sandstone with rounded, polished clasts of quartzite, porphyry and granitic rocks; with minor siltstone and conglomerate. Molluscan faunas include the ammonite Metaplacenticeras californicum and the gastropod Tuttitella pescaderosensis, referred to the Campanian or Maestrictian (late Cretaceous) Stages (Popenoe, 1973; Saul and Alderson, 1981); benthic foramifera from mudstones in the lower-middle part of the sequence are referred to the late Campanian. Exposed thickness exceeds 1830 m; base not exposed nor drilled; overlain with slight unconformity by Paleocene strata along north side of the Simi Hills, elsewhere, as along the south flank of the Simi Hills, unconformably overlain by Miocene beds. The name, Chatsworth Formation was introduced and defined by Colburn and others (1981) for rocks in the eastern Simi Hills near Chatsworth, that were previously mapped as “Chico Formation” or as unnamed “Upper Cretaceous Rocks” (“Chico” is a molluscan Stage name imported from central California). (Weber, 1984). (*GRI Source Map ID 76065*)

Kt - Tuna Canyon Formation, undivided (Late Cretaceous)

Marine sandstone, siltstone and conglomerate. Sandstone, thick-bedded to very thick-bedded, laminated and graded arkosic wacke (turbidite); locally containing abundant fragments of black slate(?); convolute lamination in some beds, load casts, low-angle cross-lamination, or concentrations of carbonized plant fragments or mica. Fossiliferous sandstone and siltstone are present locally as interbeds or thick lenses; in Las Flores Canyon, contains several beds of olive-gray siltstone that locally contain foramifera. The Tuna Canyon Formation is nowhere completely exposed in the Santa Monica Mountains; the maximum exposed thickness, in the Pena Canyon-Tuna Canyon area, is nearly 800 m. East of Santa Ynez Canyon rests on nonmarine red conglomerate (Trabuco Formation, late Cretaceous) and the Santa Monica Slate (late Jurassic). The formation is overlain disconformably (?) by the Simi Conglomerate in Solstice Canyon, and elsewhere by a basal conglomerate of the Coal Canyon Formation (Paleocene). In several places it contains the Campanian ammonite Metaplacenticeras sp.; foramifera faunas are referred to zones D-2, E, and F-1 (Maestrictian or Campanian - late Cretaceous) of Goudkoff (1945). Named by Yerkes and Campbell (1979) to replace the name “Chico”, which was imported from central California and used on earlier maps in the Santa Monica Mountains. (central and eastern Santa Monica Mountains; Campbell and others, 1996; Yerkes and Campbell, 1980; Alderson, 1988; Hoots, 1931). East of Santa Ynez Canyon the formation was subdivided by Alderson (1988) into four informal members. (*GRI Source Map ID 76065*)

Kte - Tuna Canyon Formation, informal member 'e' (Late Cretaceous)

Greenish-gray shale with interbedded coarse-grained sandstone in the upper part. (*GRI Source Map ID 76065*)

Ktd - Tuna Canyon Formation, informal member 'd' (Late Cretaceous)

Fine-grained, thick-bedded, fossiliferous sandstone. (*GRI Source Map ID 76065*)

Ktc - Tuna Canyon Formation, informal member 'c' (Late Cretaceous)

Pebble-cobble conglomerate and minor sandstone. (*GRI Source Map ID 76065*)

Ktb - Tuna Canyon Formation, informal member 'b' (Late Cretaceous)

Sandstone with minor conglomerate and black shale, carrying Turonian and Coniacian ammonites. (*GRI Source Map ID 76065*)

Ktr - Trabuco Formation (Late Cretaceous)

Conglomerate with well-rounded, polished pebbles, cobbles and boulders of varicolored quartzite, porphyry, granite, basalt, and with angular chips of black slate in a matrix of soft, clayey, coarse-grained to pebbly grit. Thickness estimated at 225 m; unconformably overlies Santa Monica Slate. Name applied by Durrell (1954) for rocks of similar composition and stratigraphic position in the type area in the Santa Ana Mountains, where it was named by Packard (1916); correlation reiterated by Colburn (1973). (Yerkes and Campbell, 1980; Hoots, 1931). (*GRI Source Map ID 76065*)

Kgr - Granitic rocks (Late Cretaceous)

Includes a variety of plutonic igneous rocks ranging from quartz monzonite and granodiorite to tonalite, quartz diorite, and diorite; chiefly quartz diorite: intrudes Santa Monica Slate in the eastern Santa

Monica Mountains (Durrell, 1954). (*GRI Source Map ID 76065*)

Jsm - Santa Monica Slate, undivided (Late Jurassic)

Black slate, sheared metasiltstone, and fine-grained metagraywacke; intensely jointed, isoclinally(?) folded; intruded by Cretaceous granitic pluton forming contact auriole zones of phyllite and spotted cordierite slate; rare pelecypod fragments indicate a late Jurassic age in part (Imlay, 1963). Named by Hoots (1931, p. 88) (Hoots, 1931). (*GRI Source Map ID 76065*)

Jsms - Santa Monica Slate, spotted slate (Late Jurassic)

Spotted with large crystals of cordierite; outer zone of contact aureole with nearby granitic intrusive rocks; grades to unspotted slate through a zone in which individual spots become progressively smaller outward (Hoots, 1931). (*GRI Source Map ID 76065*)

Jsmp - Santa Monica Slate, phyllite (Late Jurassic)

Chiefly mica schist and dark gray phyllite; forms inner zone of contact aureole with adjacent granitic intrusive (Hoots, 1931). (*GRI Source Map ID 76065*)

MZqdb - Biotite-quartz diorite (Mesozoic?)

Medium- to dark gray, medium grained quartz diorite; slightly gneissic. Locally contains inclusions of coarse-grained quartz diorite a few m across, and small elongate bodies of marble, quartzite, and schist of Paleozoic (?) age (Smith, 1986). (*GRI Source Map ID 76065*)

MZhd - Hornblende diorite (Mesozoic)

Gray, medium- to coarse-grained hypidiomorphic granular diorite. (Smith, 1986). (*GRI Source Map ID 76065*)

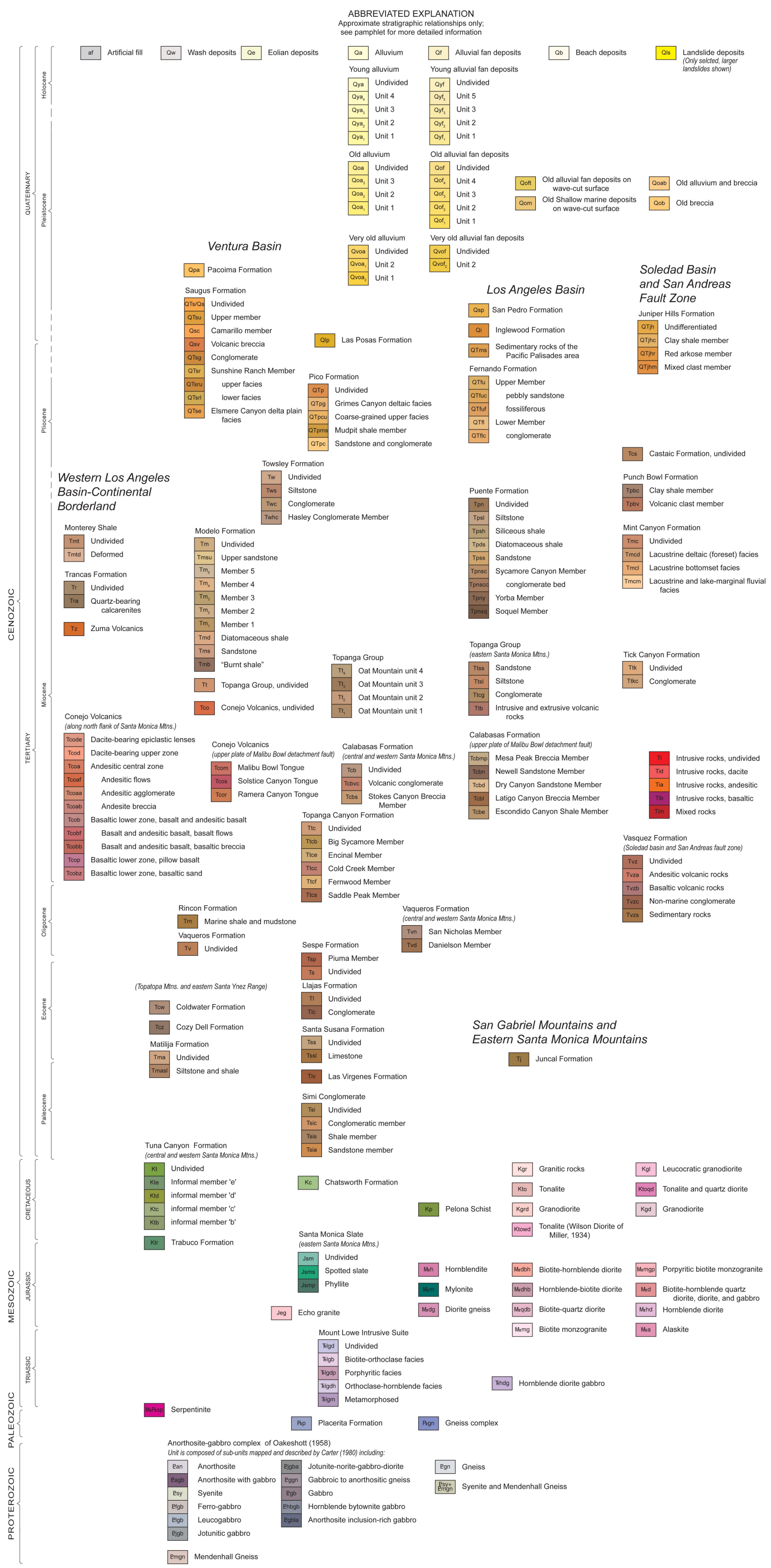
MZdg - Diorite gneiss (Early to Middle Mesozoic)

Dark-colored gneisses including metadiorites, massive hornblende diorite, and amphibolite and biotite schists (60-80% plagioclase, 5-15% quartz, 5% or less potassium feldspar, locally as much as 30% biotite and locally as much as 10% brown hornblende); intrudes the Placerita Formation and intruded by Cretaceous granitic rocks; (Oakeshott, 1958). (*GRI Source Map ID 76065*)

Ancillary Source Map Information

Campbell, Russell H., Wills, Chris J., Irvine, Pamela J., and Swanson, Brian J. (digital preparation by Gutierrez, Carlos, I., and O'Neal, Matt D.), 2014, Preliminary Geologic Map of the Los Angeles 30' x 60' Quadrangle, California (version 2.0): California Geological Survey and the U.S. Geological Survey, scale 1:100,000. (*GRI Source Map ID 76065*)

Correlation of Map Units

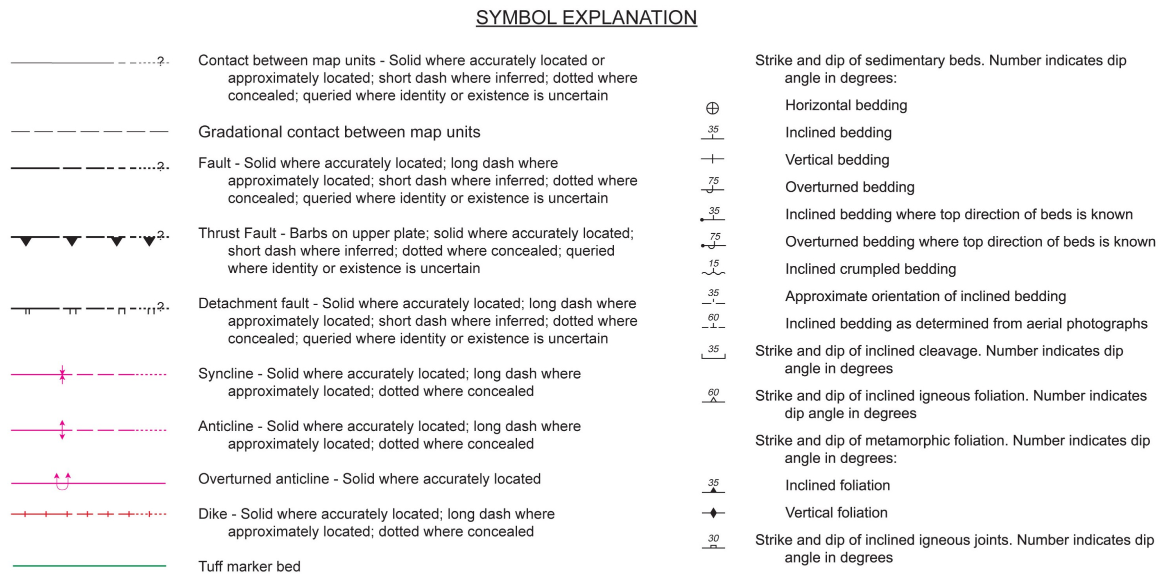


Extracted from: (*GRI Source Map ID 76065*) (Preliminary Geologic Map)

Location Map

Extracted from: (*GRI Source Map ID 76065*) (Preliminary Geologic Map)

Map Legend



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Map Pamphlet

The report that accompanied the the Preliminary Geologic Map of the Los Angeles 30' x 60' Quadrangle is embedded in this document and can be accessed by double-clicking the following link, losangeles_100k_v2.0_Pamphlet.pdf

Digital Geohazards Map of Santa Monica Mountains National Recreation Area

Irvine, P.J. and McCrink, T.P., 2012, Landslide Inventory of the Santa Monica Mountains Region, Los Angeles and Ventura Counties, California: California Geological Survey, unpublished, scale 1:24,000. (*GRI Source Map ID 75623*).

Ancillary Source Map Information

Landslide Inventory Report

The California Geological Survey report component of the Landslide Inventory of the Santa Monica Mountains Region, Los Angeles and Ventura Counties, California map is embedded in this document and can be accessed by double-clicking the following link, Landslide Inventory Report.

Landslide Classifications

Rock Slide

ROCK SLIDE: A landslide involving bedrock in which the rock that moves remains largely intact for at least a portion of the movement. Rock slides can range in size from small and thin to very large and thick, and are subject to a wide range of triggering mechanisms. The sliding occurs at the base of the rock mass along one to several relatively thin zones of weakness, which are variably referred to as “slide planes,” “shear surfaces,” “slip surfaces,” “rupture surfaces,” or “failure surfaces.” The sliding surface may be curved or planar in shape. Rock slides with curved sliding surfaces are commonly called “slumps” or “rotational slides,” while those with planar failure surfaces are commonly called “translational slides,” “block slides,” or “block glides.” Rock slides that occur on intersecting planar surfaces are commonly called “wedge failures.” Rock slides commonly occur on relatively steep slopes in competent rocks. Slope gradients are commonly from 35% to as steep as 70%. Movement of an intact rock mass along a curved slide plane leads to a steep, arcuate headscarp at the upper boundary of the slide. Immediately below the headscarp is a block that is commonly rotated so that it is less steep than the surrounding hill slopes. Below the bench, the slide mass may be intact with a similar gradient to the surrounding slopes or may have additional scarps and benches. The lower parts of the slopes may bulge outward and be steeper that the surrounding slopes.

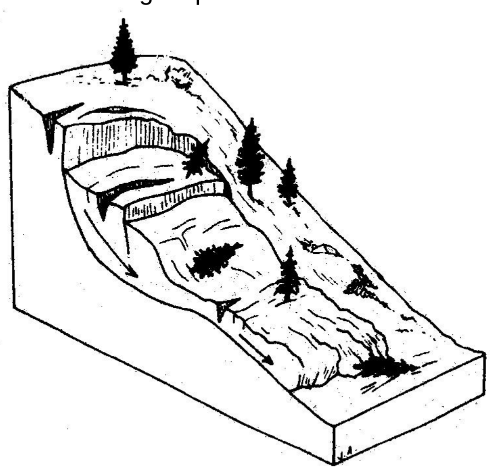


Diagram by J. Appleby, R. Kilbourne, and T. Spittler after Varnes, 1978

Earth Flow

EARTH FLOW: A specific type of Soil Flow landslide where the majority of the soil materials are fine-grained (silt and clay) and cohesive. The material strength is low through much of the slide mass, and movement occurs on many discontinuous shear surfaces throughout the landslide mass. This movement along numerous internal slide planes disrupts the landslide mass leading to cumulative movement that resembles the flow of a viscous liquid characterized by a lumpy, or “hummocky” slope morphology. The lower parts of an earth flow usually bulge outward and are steeper than adjacent slopes. Earth flows commonly occur on moderately steep slopes. Slope gradients are commonly from 10% to as steep as 30%, although steeper slopes may be found in headscarp and toe areas. Earth flows typically are initiated by periods of prolonged rainfall and sometimes don’t initiate until well after a storm or the rainy season has passed. They are characteristically slow moving, in the millimeters or centimeters per day range, and may continue to move for a period of days to weeks after initiating.

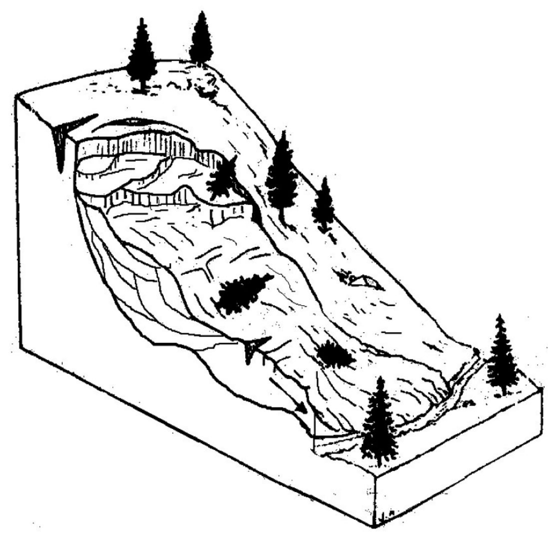


Diagram by J. Appleby, R. Kilbourne, and C. Wills after Varnes, 1978

Debris Slide

DEBRIS SLIDE: A slide of coarse-grained soil, most common in unconsolidated sandy or gravelly units, but also are common in residual soils that form from in-place weathering of relatively hard rock. Owing to the granular constituents, overall strength of the debris slide mass generally is higher than that of earth flows, but there may be a very low strength zone at the base of the soil or within weathered bedrock. Debris slides typically move initially as shallow intact slabs of soil and vegetation, but break up after a short distance into falls and flows. Movement of the slide mass as a shallow slab leads to a smooth, steep, commonly curved scar. The debris is deposited at the base as a loose hummocky mass, although the deposit may be rapidly removed by erosion. Debris slides commonly occur on very steep slopes, as steep as 60% to 70%, usually in an area where the base of a slope is undercut by erosion. Debris slides form steep, unvegetated scars which are likely to remain unvegetated for years. Revegetated scars can be recognized by their even steep slopes, and a shallow amphitheater morphology. A single heavy rainstorm or series of storms may deliver enough rain to trigger debris slides. Individual debris slides may move at rates ranging from meters per day to meters per minute. Debris slide scars are extremely steep and therefore are very sensitive to renewed disturbance. Natural erosion at the base of debris slide scars may trigger additional slides. Cutting into the base of a debris slide scar may also trigger renewed slides. Even without additional disturbance, debris slide scars tend to ravel and erode, leading to small rock falls and debris slides from the same slope.

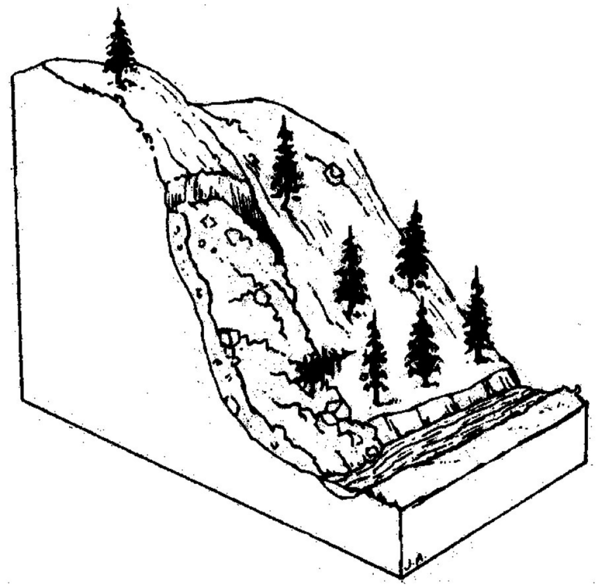


Diagram by J. Appleby, and R. Kilbourne, after Varnes, 1978

Debris Flow

DEBRIS FLOW: A Soil Flow where the majority of the materials are coarse-grained (fine sand to boulder size particles) and non-cohesive. Debris flows are most often triggered by intense rainfall following a period of less intense precipitation or by rapid snow melt. High pore water pressures cause the soil and weathered rock to rapidly lose strength and flow downslope. Debris flows can move very rapidly, at rates ranging from meters per hour to meters per second and travel relatively long distances, making them a significant threat to life and property.Debris flows commonly begin as a slide of a shallow mass of soil and weathered rock. Their most distinctive landform is the scar left by the original shallow slide. The path of the debris flow may be marked by a small drainage that has been stripped of vegetation. The debris flow may not leave any deposit if it flows directly into a larger creek and is immediately eroded away. Many debris flow deposits are ephemeral, but in some cases successive debris flows may deposit material in the same area thereby forming a debris fan, which resembles a small, steep alluvial fan. Individual debris flows typically are small in areal extent and their deposits are relatively thin. Evidence of past debris flow movements often is masked by vegetation growth which can cover the surface rapidly, sometimes within a few years, making them difficult to identify using aerial photographic and field reconnaissance methods. Therefore, only the larger and more recent debris flows typically are identified and included on landslide inventory maps prepared at a scale of 1:24,000.

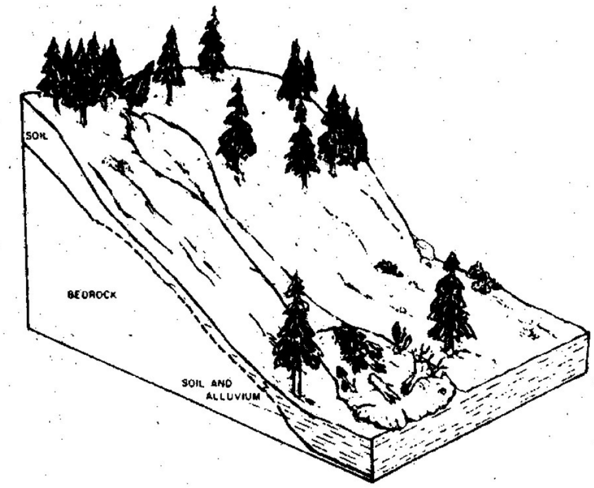


Diagram by J. Appleby, and R. Kilbou rne, CGS

Rock Fall

ROCK FALL: A landslide where a mass of rock detaches from a steep slope by sliding, spreading or toppling and descends mainly through the air by falling, bouncing or rolling. Intense rain, earthquakes or freeze-thaw wedging may trigger this type of movement. Rockfalls occur on steep slopes of hard, fractured rock. The scar left by a rockfall on the slope may be no more apparent than an area of rock that is less weathered than the surrounding rocks. Rockfall deposits are loose piles of rubble that may be easily removed by erosion. Because neither the scar nor the deposit are distinctive, and because the most frequently occurring rockfalls are typically small, individual rock falls are usually not shown on regional-scale (1:24,000 and smaller) landslide maps. Though infrequent, moderate to large volume rockfalls can be extremely dangerous and sometimes fatal. Large slabs of rock impacting a hard ledge after a long drop can rapidly break apart, leading to air entrainment and long runouts, induced airblasts, airborne projectiles (flyrock) and severe dust clouds.

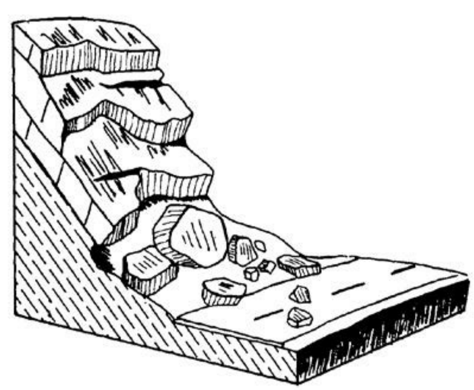
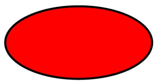
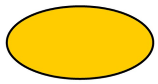
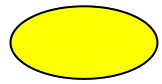
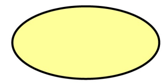


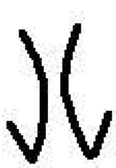
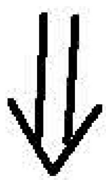
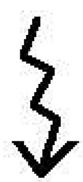
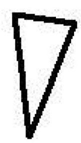
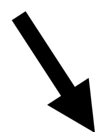
Diagram after Colorado Geological Survey, 1989

Source Map Landslide Symbology

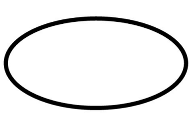
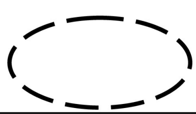
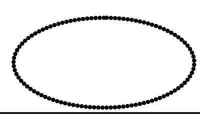
Landslide Activity: CGS landslide inventory maps use color to show the activity, with the hottest color indicating the most recent landslide movement.

ACTIVE OR HISTORIC	DORMANT – YOUNG	DORMANT – MATURE	DORMANT – OLD
			

Landslide Material and Type of Movement: CGS landslide inventory maps use arrow styles to depict the two-part classification of the type of landslide material and type of landslide movement. The direction of the arrow depicts the direction of movement of the slide mass.

ROCK SLIDE	SOIL SLIDE	EARTH FLOW	DEBRIS FLOW	ROCK FALL
				

Confidence of Interpretation: CGS landslide inventory maps use line styles of the outline of the landslide polygon to the relative confidence of our interpretation that the geomorphology of the area is due to landsliding.

DEFINITE:	PROBABLE	QUESTIONABLE
		

**The landslide classification and landslide symbology figures and descriptions were extracted from the Landslide Inventory of the Santa Monica Mountains Region pdf. The CGS Landslide Inventory pdf, including the references, can be viewed by accessing the embedded document from the CGS Landslide source's citation topic. Note that in the GRI digital geologic-GIS data only landslide material and type of movement features, features present in the Hazards Point Features data layer, are symbolized as per the source map. Information on landslide activity and confidence of interpretation, although not displayed via symbology, is present in the Hazards Point Features data layer GIS attribution.

GRI Digital Data Credits

This document was developed and completed by James Winter and Stephanie O'Meara (Colorado State University) for the NPS Geologic Resources Division (GRD) Geologic Resources Inventory (GRI) Program. Quality control of this document by Stephanie O'Meara.

The information in this document was compiled from GRI source maps, and intended to accompany the digital geologic-GIS map(s) and other digital data for Santa Monica Mountains National Recreation Area, California (SAMO) developed by James Winter and Stephanie O'Meara (see the GRI Digital Maps and Source Map Citations section of this document for all sources used by the GRI in the completion of this document and related GRI digital geologic-GIS map(s)). Initial GRI data conversion of the geohazards data by Andrea Croskrey (NPS Geologic Resources Division).

GRI finalization by Stephanie O'Meara.

GRI program coordination and scoping provided by Bruce Heise and Jason Kenworthy (NPS GRD, Lakewood, Colorado), and Katie KellerLynn (Colorado State University).