

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



Channel Islands National Park

GRI Ancillary Map Information Document

Produced to accompany the Geologic Resources Inventory (GRI) Digital Geologic
Data for Channel Islands National Park

chis_geology.pdf

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Geologic Resources Inventory Map Document for Channel Islands National Park

Table of Contents

Geologic Resources Inventory Map Document.....	1
About the NPS Geologic Resources Inventory Program.....	3
GRI Digital Maps and Source Map Citations.....	5
Index Map	7
GRI Digital Geologic-GIS Maps of Santa Cruz, San Miguel and Santa Rosa Islands	8
Map Unit List.....	8
Map Unit Descriptions.....	9
Qal - Alluvium (Quaternary).....	9
Qfg - Fanglomerate (Quaternary).....	10
Qls - Landslide (Quaternary).....	10
Qt - Terrace deposits (Quaternary).....	10
Qma - Middle Anchorage Alluvium (Pleistocene).....	10
Qph - Potato Harbor Formation (Pleistocene).....	10
Tm - Monterey Shale, undifferentiated (Miocene).....	11
Tmsh - Monterey Shale, Shale Member (Miocene).....	11
Tmbt - Monterey Shale, Beechers Bay Member (Miocene).....	11
Tmbc - Monterey Formation, Beechers Bay Member, black volcanic conglomerate and tuffaceous sandstones (Miocene).....	11
Tmbs - Monterey Formation, Beechers Bay Member, rhythmically bedded sandstones and shale (Miocene).....	12
Tmbt - Monterey Formation, Beechers Bay Member, tuff and tuffaceous sandstones (Miocene).....	12
Tb - Blanca Volcaniclastics, undifferentiated (Miocene).....	12
Tbu - Blanca Volcaniclastics, Upper Member (Miocene).....	12
Tbm - Blanca Volcaniclastics, Middle Member (Miocene).....	12
Tbl - Blanca Volcaniclastics, Lower Member (Miocene).....	13
Tsc - Santa Cruz Island Volcanics, undifferentiated (Miocene).....	13
Tscp - Santa Cruz Island Volcanics, Prisoner's Harbor Member (Miocene).....	13
Tscd - Santa Cruz Island Volcanics, Devil's Peak Member (Miocene).....	13
Tscs - Santa Cruz Island Volcanics, Stanton Ranch Member (Miocene).....	13
Tscg - Santa Cruz Island Volcanics, Griffith Canyon Member (Miocene).....	13
Ti - Intrusive, undifferentiated (Miocene).....	14
Tic - Intrusive, C Member (Miocene).....	14
Tib - Intrusive, B Member (Miocene).....	14
Tia - Intrusive, A Member (Miocene).....	14
Tsm - San Miguel Volcanics, undifferentiated (Miocene and/or Oligocene).....	14
Tsmu - San Miguel Volcanics, Upper Member (Miocene and/or Oligocene).....	14
Tsmi - San Miguel Volcanics, Lower Member (Miocene and/or Oligocene).....	15
Tsmf - San Miguel Volcanics, basaltic flows (Miocene and/or Oligocene).....	15
Tsmi - San Miguel Volcanics, basaltic intrusives (Miocene and/or Oligocene).....	15
Tsmc - San Miguel Volcanics, volcaniclastics (Miocene and/or Oligocene).....	15
Tso - San Onofre Breccia (Miocene and/or Oligocene).....	15
Tr - Rincon Shale, undifferentiated (Miocene and/or Oligocene).....	16
Tru - Rincon Shale, Upper Member (Miocene and/or Oligocene).....	16
Trm - Rincon Shale, Middle Member (Miocene and/or Oligocene).....	16
Trl - Rincon Shale, Lower Member (Miocene and/or Oligocene).....	16

Tv - Vaqueros Sandstone, undifferentiated (Oligocene).....	17
Tvu - Vaqueros Sandstone, Upper Member (Oligocene).....	17
Tvsh - Vaqueros Sandstone, Shale Member (Oligocene).....	17
Tvl - Vaqueros Sandstone, Lower Member (Oligocene).....	17
Ts - Sepe Formation (Oligocene).....	17
Tcd - Cozy Dell Shale (Eocene).....	17
Tsp - South Point Sandstone (Eocene).....	18
Tjv - Jolla Vieja Formation (Eocene).....	18
Tc - Canada Formation (Eocene).....	18
Tcp - Canada and Pozo Formations, undifferentiated (Eocene and Paleocene).....	18
Tp - Pozo Formation (Paleocene).....	18
Kj - Jalama Formation (Upper Cretaceous).....	19
Jap - Alamos Plutonite (Upper Jurassic).....	19
Jwd - Willow s Diorite (Upper Jurassic).....	19
Jwdsci - Willow s Diorite and Santa Cruz Island Schist, undifferentiated (Upper Jurassic and pre-Late Jurassic).....	19
Jsci - Santa Cruz Island Schist (pre-Late Jurassic).....	19
Ancillary Source Map Information.....	20
AAPG Field Trip Guidebook No. 12.....	20
AAPG Correlation Chart.....	20
AAPG Structural Setting Map.....	21
AAPG Cross Sections.....	21
San Miguel Island Geologic Map.....	22
San Miguel Island Correlation of Map Units.....	22
San Miguel Island Map Legend.....	23
San Miguel Island Block Sections Map.....	24
Block Section 1.....	25
Block Section 2.....	25
Block Section 3.....	26
Block Section 4.....	26
Block Section 5.....	27
Block Section 6.....	28
Block Section 7.....	29
Block Section 8.....	30
Block Section 9.....	31
Santa Cruz Island Geologic Map.....	32
Santa Cruz Island Map Correlation of Map Units.....	32
Santa Cruz Island Map Legend.....	33
Santa Cruz Island Complete List of Source Authors and Contributors.....	33
Santa Rosa Island Geologic Map.....	34
Santa Rosa Island Map Correlation of Map Units.....	34
Santa Rosa Island Map Legend.....	35
GRI Digital Quaternary Surficial Geologic-GIS Maps of Channel Islands National Park.....	36
Map Unit List.....	36
Map Unit Descriptions.....	37
Anthropogenic deposits.....	38
Qml - Modified land or artificial fill (latest Holocene).....	38
Alluvial deposits.....	38
Qaa - Active alluvial deposits (latest Holocene).....	38
Qya - Young alluvial fan deposits (Holocene and latest Pleistocene).....	39
Qia - Intermediate alluvial fan deposits (late and middle Pleistocene).....	39
QiaY - Younger intermediate alluvial fan deposits (late and middle Pleistocene).....	39
Qiao - Older intermediate alluvial fan deposits (late and middle Pleistocene).....	39

Qoa - Old alluvial fan deposits (middle and early Pleistocene).....	40
Fluvial deposits	40
Qaf - Active fluvial deposits (latest Holocene).....	40
Qyf - Young fluvial deposits (Holocene and latest Pleistocene).....	41
Qyfy - Younger young fluvial deposits (Holocene).....	41
Qyfo - Older young fluvial deposits (early Holocene and latest Pleistocene).....	41
Qif - Intermediate fluvial deposits (late and middle Pleistocene).....	41
Qify - Younger intermediate fluvial deposits (late and middle Pleistocene).....	42
Qifo - Older intermediate fluvial deposits (late and middle Pleistocene).....	42
Qof - Old fluvial deposits (middle and early Pleistocene).....	42
Colluvial channel deposits.....	42
Qac - Active colluvial deposits (historic to latest Holocene).....	42
Eolian deposits.....	43
Qaed - Active eolian sand dune deposits (latest Holocene).....	43
Qaer - Active eolian sand ramp deposits (latest Holocene).....	44
Qaes - Active eolian sand sheet deposits (latest Holocene).....	44
Qye - Young eolian sand deposits (Holocene and latest Pleistocene).....	44
Qyed - Young eolian sand dune deposits (Holocene and latest Pleistocene).....	45
Qyer - Young eolian sand ramp deposits (Holocene and latest Pleistocene).....	45
Qyes - Young eolian sand sheet deposits (Holocene and latest Pleistocene).....	45
Qie - Intermediate eolian sand deposits (late and middle Pleistocene).....	45
Qied - Intermediate eolian sand dune deposits (late and middle Pleistocene).....	46
Qier - Intermediate eolian sand ramp deposits (late and middle Pleistocene).....	46
Qoe - Old eolian sand deposits (middle and early Pleistocene).....	46
Qoec - Old eolian cemented sand deposits (middle and early Pleistocene).....	47
Qoed - Old eolian sand dune deposits (middle and early Pleistocene).....	47
QTe - Very old eolian sand deposits (early Pleistocene and Pliocene?).....	47
Mixed eolian and alluvial deposits.....	48
Qyea - Young mixed eolian and alluvial deposits (Holocene and latest Pleistocene).....	48
Qyae - Young mixed alluvial and eolian deposits (Holocene and latest Pleistocene).....	48
Qyeao - Older young mixed eolian and alluvial deposits (early Holocene and latest Pleistocene).....	48
Qiea - Intermediate mixed eolian and alluvial deposits (late and middle Pleistocene).....	48
Qiae - Intermediate mixed alluvial and eolian deposits (late and middle Pleistocene).....	49
Qoea - Old mixed eolian and alluvial deposits (middle and early Pleistocene).....	49
Qoae - Old mixed alluvial and eolian deposits (middle and early Pleistocene).....	49
Beach deposits.....	50
Qab - Active beach deposits (latest Holocene).....	50
Qabs - Active sandy beach deposits (latest Holocene).....	50
Qabf - Active beach fringe deposits (latest Holocene).....	51
Qybf - Young beach fringe deposits (Holocene and latest Pleistocene).....	51
Lagoonal deposits.....	51
Qal - Active lagoon deposits (latest Holocene).....	51
Qil - Intermediate lagoon deposits (late and middle Pleistocene).....	52
Paludal deposits.....	52
Qyp - Young paludal or marsh deposits (Holocene and latest Pleistocene).....	52
Groundwater discharge deposits.....	52
Qag - Active groundwater-discharge deposits (latest Holocene).....	52
Qyg - Young groundwater-discharge deposits (Holocene and latest Pleistocene).....	53
Hillslope deposits	53
Qha - Abundant hillslope deposits of entisol order soil (Holocene and late? Pleistocene).....	53
Qhav - Abundant hillslope deposits of vertisol order soil (Holocene and late? Pleistocene).....	53
Qhs - Sparse hillslope deposits of entisol order soil (Holocene and late? Pleistocene).....	54
Colluvial deposits	54
Qyc - Young colluvial deposits (Holocene and latest Pleistocene).....	54

Qic - Intermediate colluvial deposits (late and middle Pleistocene).....	54
Mass wasting deposits.....	55
Qls-SS - Shallow-seated landslide deposits and scarps (Holocene).....	55
Qls-DS - Deep-seated landslide deposits and scarps (Holocene and Pleistocene).....	55
Marine terrace deposits.....	56
QTmt - Marine paleontologic marker bed (Pleistocene to late Pliocene?).....	56
Bedrock.....	56
Tb - Bedrock substrate materials (Tertiary).....	56
Ts - Sedimentary rocks (Miocene).....	57
Tso - San Onofre Breccia (Miocene).....	57
Tv - Volcanic rocks (Miocene).....	57
Tt - Tuffaceous sedimentary rocks (Miocene).....	58
Erosional Surfaces.....	58
Active marine wave-cut platform (historic).....	59
Marine wave-cut platform (Pleistocene to late Pliocene?).....	59
Eolian deflation hollow (historic to Holocene).....	60
Gully (historic to Holocene).....	60
Surface erosion (historic to Holocene).....	61
Ancillary Source Map Information.....	62
Quaternary Surficial Geologic Maps of the Channel Islands (SIM-xxxx).....	62
SIM-xxxx Correlation of Map Units.....	62
Abstract and Introduction.....	63
Geologic History	64
Structure and Tectonics of Quaternary Deposits.....	64
Faults	65
Locational Uncertainty.....	66
Mapping Methods.....	66
Map Unit Classification and Feature Attribution.....	67
Existence and Identity Confidence.....	70
References Cited.....	71
GRI Digital Data Credits.....	76

Geologic Resources Inventory Map Document



Channel Islands National Park, California

Document to Accompany Digital Geologic-GIS Data

[chis_geology.pdf](#)

Version: 9/16/2020

This document has been developed to accompany the digital geologic-GIS data developed by the Geologic Resources Inventory (GRI) program for Channel Islands National Park, California (CHIS).

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 and an index map displaying location and extents of GRI map data are both provided.
- 3) **GRI Digital Geologic-GIS Maps of San Miguel, Santa Cruz and Santa Rosa Islands** – Unit listing, unit descriptions, and additional (ancillary) source map information relevant to the digital geologic-GIS maps for the park.
- 4) **GRI Digital Quaternary Surficial Geologic-GIS Maps of Anacapa and Santa Barbara Islands** – Unit listing, unit descriptions, and additional (ancillary) source map information relevant to the Quaternary surficial geologic-GIS maps for the park.
- 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

The Geologic Resources Inventory (GRI) provides geologic map data and pertinent geologic information to support resource management and science-informed decision making in more than 270 natural resource parks throughout the National Park System. 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 GRI is one of 12 inventories funded by the National Park Service (NPS) Inventory and Monitoring Program. The Geologic Resources Division of the NPS Natural Resource Stewardship and Science Directorate administers the GRI. The NPS Geologic Resources Division partners with the Colorado State University Department of Geosciences to produce GRI products. Many additional partners participate in the GRI process by contributing source maps or reviewing products.

The GRI team undertakes three tasks for each park in the Inventory and Monitoring program: (1) conduct a scoping meeting and provide a summary document, (2) provide digital geologic map data in a geographic information system (GIS) format, and (3) provide a GRI report. These products are designed and written for nongeoscientists.

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: <https://www.nps.gov/articles/gri-geodatabase-model.htm>

Geologic Reports: GRI reports synthesize discussions from the original scoping meeting, follow up conference call(s), and subsequent research. Chapters of each report discuss the geologic setting of the park, distinctive geologic features and processes within the park, highlight geologic issues facing resource managers, and describe the geologic history leading to the present-day landscape. Each report also includes a poster illustrating these GRI digital geologic-GIS data.

For a complete listing of GRI products visit the GRI publications webpage: <https://go.nps.gov/gripubs>. GRI digital geologic-GIS data is also available online at the NPS Data Store: <https://irma.nps.gov/DataStore/Search/Quick>. 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: <https://www.nps.gov/subjects/geology/gri.htm>. At the bottom of that webpage is a "Contact Us" link if you need additional information. You may also directly contact the program coordinator:

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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

GRI digital maps produced for Channel Islands National Park, California (CHIS) include two sets of geologic maps. The first set of maps are geologic maps based upon older 1:24,000 scale mapping within a 1969 American Association of Petroleum Geologists Field Trip Guidebook. These maps provide geologic map coverage for three of the park's five islands, Santa Cruz, San Miguel and Santa Rosa. These maps, as well as their source maps, are listed below.

Digital Geologic-GIS Map of San Miguel Island, California (*GRI MapCode SMIS*)

Weaver, D.W., and Doerner, D.P., 1969, Geologic Map of San Miguel Island, in Geology of the Northern Channel Islands, Southern California Borderland: American Association of Petroleum Geologists, Field Trip Guidebook no. 12, scale 1:24,000. ([San Miguel Island Geology](#)). (*GRI Source Map ID 75157*).

The full extent of the source map was used, and all geologic features within this extent were captured from this source.

Digital Geologic-GIS Map of Santa Cruz Island, California (*GRI MapCode SCIS*)

University of California, Santa Barbara Geological Survey, 1969, Geology of Santa Cruz Island, in Geology of the Northern Channel Islands, Southern California Borderland: American Association of Petroleum Geologists, Field Trip Guidebook no. 12, scale 1:24,000. ([Santa Cruz Island Geology](#)). (*GRI Source Map ID 75158*).

The full extent of the source map was used, and all geologic features within this extent were captured from this source.

Digital Geologic-GIS Map of Santa Rosa Island, California (*GRI MapCode SRIS*)

Sonneman, Howard et. al., 1969, Geology of Santa Rosa Island, in Geology of the Northern Channel Islands, Southern California Borderland: American Association of Petroleum Geologists, Field Trip Guidebook no. 12, scale 1:24,000. ([Santa Rosa Island Geology](#)). (*GRI Source Map ID 75156*).

The full extent of the source map was used, and all geologic features within this extent were captured from this source.

The second set of geologic maps focuses on Quaternary surficial mapping, and were produced from newer 1:12,000 scale mapping provided by the U.S. Geological Survey. These maps, along with the source maps used, are listed below.

Digital Quaternary Surficial Geologic-GIS Map of Anacapa Island, California (*GRI MapCode ANAC_surficial*)

Schmidt, K. M., Minor, S. A., and Bedford, D. R., 2018, Quaternary Surficial Geologic Map of Anacapa Island, Channel Islands National Park, California: U.S. Geological Survey, unpublished Scientific Investigations Map SIM-xxxx, scale 1:12,000. ([Channel Islands Quaternary Surficial Geology](#)). (*GRI Source Map ID 76115*).

The full extent of the source map was used, and all geologic features within this extent were captured from this source.

Digital Quaternary Surficial Geologic-GIS Map of San Miguel Island, California (GRI MapCode SMIS_surficial)

Schmidt, K. M., Minor, S. A., and Bedford, D. R., 2020, Quaternary Surficial Geologic Map of San Miguel Island, Channel Islands National Park, California: U.S. Geological Survey, unpublished Scientific Investigations Map SIM-xxxx, scale 1:12,000. ([Channel Islands Quaternary Surficial Geology](#)). (GRI Source Map ID 76283).

The full extent of the source map was used, and all geologic features within this extent were captured from this source.

Digital Quaternary Surficial Geologic-GIS Map of Santa Barbara Island, California (GRI MapCode SABA_surficial)

Schmidt, K. M., Minor, S. A., and Bedford, D. R., 2018, Quaternary Surficial Geologic Map of Santa Barbara Island, Channel Islands National Park, California: U.S. Geological Survey, unpublished Scientific Investigations Map SIM-xxxx, scale 1:12,000. ([Channel Islands Quaternary Surficial Geology](#)). (GRI Source Map ID 76114).

The full extent of the source map was used, and all geologic features within this extent were captured from this source.

Digital Quaternary Surficial Geologic-GIS Map of Santa Cruz Island, California (GRI MapCode SCIS_surficial)

Schmidt, K. M., Minor, S. A., and Bedford, D. R., 2019, Quaternary Surficial Geologic Map of Santa Cruz Island, Channel Islands National Park, California: U.S. Geological Survey, unpublished Scientific Investigations Map SIM-xxxx, scale 1:12,000. ([Channel Islands Quaternary Surficial Geology](#)). (GRI Source Map ID 76115).

The full extent of the source map was used, and all geologic features within this extent were captured from this source.

Digital Quaternary Surficial Geologic-GIS Map of Santa Rosa Island, California (GRI MapCode SRIS_surficial)

Schmidt, K. M., Minor, S. A., and Bedford, D. R., 2019, Quaternary Surficial Geologic Map of Santa Rosa Island, Channel Islands National Park, California: U.S. Geological Survey, unpublished Scientific Investigations Map SIM-xxxx, scale 1:12,000. ([Channel Islands Quaternary Surficial Geology](#)). (GRI Source Map ID 76116).

The full extent of the source map was used, and all geologic features within this extent were captured from this source.

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

Index Map

The following index map displays the extent of the GRI digital geologic-GIS maps for Channel Islands National Park. The extent of each island's data is coincident with its shoreline. The national park boundary for each island (as of September, 2020) is shown in green. Prominent cites and the park visitor center in Ventura are also shown.



Index map produced by Sarah Lowe, Jakob Suri, and James Winter (Colorado State University).

GRI Digital Geologic-GIS Maps of Santa Cruz, San Miguel and Santa Rosa Islands

Map Unit List

The geologic units present in the digital geologic-GIS maps for Channel Islands National Park, California (CHIS) are listed below. Units are listed with their assigned unit symbol and unit name (e.g., Qal - Alluvium). 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 (CHISUNIT) table included with the GRI digital geologic-GIS data. In some cases source unit symbols have been modified to fit adopted GRI GIS data standards concerning unit symbols and naming conventions.

Cenozoic Era

Quaternary Period

- [Qal](#) - Alluvium
- [Qfg](#) - Fanglomerate
- [Qls](#) - Landslide
- [Qt](#) - Terrace deposits
- [Qma](#) - Middle Anchorage Alluvium
- [Qph](#) - Potato Harbor Formation

Tertiary Period

- [Tm](#) - Monterey Shale, undifferentiated
- [Tmsh](#) - Monterey Shale, Shale Member
- [Tmbt](#) - Monterey Shale, Beechers Bay Member
- [Tmbc](#) - Monterey Formation, Beechers Bay Member, black volcanic conglomerate and tuffaceous sandstones
- [Tmbs](#) - Monterey Formation, Beechers Bay Member, rhythmically bedded sandstones and shale
- [Tmbt](#) - Monterey Formation, Beechers Bay Member, tuff and tuffaceous sandstones
- [Tb](#) - Blanca Volcaniclastics, undifferentiated
- [Tbu](#) - Blanca Volcaniclastics, Upper Member
- [Tbm](#) - Blanca Volcaniclastics, Middle Member
- [Tbl](#) - Blanca Volcaniclastics, Lower Member
- [Tsc](#) - Santa Cruz Island Volcanics, undifferentiated
- [Tscp](#) - Santa Cruz Island Volcanics, Prisoner's Harbor Member
- [Tscd](#) - Santa Cruz Island Volcanics, Devil's Peak Member
- [Tscs](#) - Santa Cruz Island Volcanics, Stanton Ranch Member
- [Tscg](#) - Santa Cruz Island Volcanics, Griffith Canyon Member
- [Ti](#) - Intrusive, undifferentiated
- [Tic](#) - Intrusive, C Member
- [Tib](#) - Intrusive, B Member
- [Tia](#) - Intrusive, A Member
- [Tsm](#) - San Miguel Volcanics, undifferentiated
- [Tsmu](#) - San Miguel Volcanics, Upper Member
- [Tsmi](#) - San Miguel Volcanics, Lower Member
- [Tsmf](#) - San Miguel Volcanics, basaltic flows
- [Tsmi](#) - San Miguel Volcanics, basaltic intrusives
- [Tsmc](#) - San Miguel Volcanics, volcaniclastics
- [Tso](#) - San Onofre Breccia
- [Tr](#) - Rincon Shale, undifferentiated
- [Tru](#) - Rincon Shale, Upper Member

[Trm](#) - Rincon Shale, Middle Member
[Trl](#) - Rincon Shale, Lower Member
[Tv](#) - Vaqueros Sandstone, undifferentiated
[Tvu](#) - Vaqueros Sandstone, Upper Member
[Tvsh](#) - Vaqueros Sandstone, Shale Member
[Tvl](#) - Vaqueros Sandstone, Lower Member
[Ts](#) - Sepe Formation
[Tcd](#) - Cozy Dell Shale
[Tsp](#) - South Point Sandstone
[Tjv](#) - Jolla Vieja Formation
[Tc](#) - Canada Formation
[Tcp](#) - Canada and Pozo Formations, undifferentiated
[Tp](#) - Pozo Formation

Mesozoic Era

Cretaceous Period

[Kj](#) - Jalama Formation

Jurassic Period

[Jap](#) - Alamos Plutonite

[Jwd](#) - Willows Diorite

Jurassic Period and pre-Late Jurassic Period

[Jwdsci](#) - Willows Diorite and Santa Cruz Island Schist, undifferentiated

pre-Late Jurassic Period

[Jsci](#) - Santa Cruz Island Schist

Map Unit Descriptions

Descriptions of all geologic map units, generally listed from youngest to oldest, are presented below.

Qal - Alluvium (Quaternary)

Qal - Alluvium (Quaternary)

No additional description present on source map. Description from source map: [San Miguel Island Geology](#)

Qal - Alluvium (Quaternary)

Unconsolidated alluvium; marine and terrestrial. Description from source map: [Santa Cruz Island Geology](#)

Qal - Alluvium (Recent)

No additional description present on source map. Description from source map: [Santa Rosa Island Geology](#)

Unit is present on San Miguel Island, Santa Cruz Island and Santa Rosa Island.

Qfg - Fanglomerate (Quaternary)

Terrestrial. Description from source map: [Santa Cruz Island Geology](#)

Unit is present on Santa Cruz Island.

Qls - Landslide (Quaternary)**Qls - Landslide (Quaternary)**

No additional description present on source map. Description from source map: [San Miguel Island Geology](#)

Qls - Landslides (Quaternary)

Landslide blocks and debris. Description from source map: [Santa Cruz Island Geology](#)

Qls - Landslide (Recent)

No additional description present on source map. Description from source map: [Santa Rosa Island Geology](#)

Unit is present on San Miguel Island, Santa Cruz Island and Santa Rosa Island.

Qt - Terrace deposits (Quaternary)**Qt - Terrace (Quaternary)**

No additional description present on source map. Description from source map: [San Miguel Island Geology](#)

Qtg - Terrace gravels (Quaternary)

Unconsolidated marine terrace gravels. Description from source map: [Santa Cruz Island Geology](#)

Qtg - Terrace sands and gravels (Pleistocene)

No additional description present on source map. Description from source map: [Santa Rosa Island Geology](#)

Unit is present on San Miguel Island, Santa Cruz Island and Santa Rosa Island.

Qma - Middle Anchorage Alluvium (Pleistocene)

Sandy pebble conglomerate and breccia. Description from source map: [Santa Cruz Island Geology](#)

Unit is present on Santa Cruz Island.

Qph - Potato Harbor Formation (Pleistocene)

White, organic clastic limestones and volcanic sandstone. Mollusks. Description from source map: [Santa Cruz Island Geology](#)

Unit is present on Santa Cruz Island.

Tm - Monterey Shale, undifferentiated (Miocene)**Tm - Monterey Shale (Miocene)**

No additional description present on source map. Description from source map: [San Miguel Island Geology](#)

Tm - Monterey Shale (Miocene)

No additional description present on source map. Description from source map: [Santa Cruz Island Geology](#)

Tm - Monterey Formation (Miocene)

No additional description present on source map. Description from source map: [Santa Rosa Island Geology](#)

Unit is present on San Miguel Island, Santa Cruz Island and Santa Rosa Island.

Tmsh - Monterey Shale, Shale Member (Miocene)**Tm-sh - Monterey Shale, Shale Member (Miocene)**

Buff punky and siliceous shale; foraminifera. Description from source map: ([San Miguel Island Geology](#))

Tm-sh - Monterey Shale, Shale Member (Miocene)

Buff to white, chalky and siliceous shales with bedded chert and bentonite; foraminifers. Description from source map: [Santa Cruz Island Geology](#)

Tm-sh - Monterey Formation, Shale Member (Miocene)

Siliceous and organic shales, foraminiferal. Description from source map: [Santa Rosa Island Geology](#)

Unit is present on San Miguel Island, Santa Cruz Island and Santa Rosa Island.

Tmbt - Monterey Shale, Beechers Bay Member (Miocene)**Tm-bt - Monterey Shale, Beechers Bay Member (Miocene)**

Light Gray tuffaceous volcanic sandstones and conglomerates; mollusca. Description from source map: [San Miguel Island Geology](#)

Tm-bb - Monterey Shale, Beechers Bay Member (Miocene)

Light buff laminated shale, siltstone, sandstone, and conglomerate. Corrugated bedding. Foraminifers. Description from source map: [Santa Cruz Island Geology](#)

Unit is present on San Miguel Island and Santa Cruz Island.

Tmbc - Monterey Formation, Beechers Bay Member, black volcanic conglomerate and tuffaceous sandstones (Miocene)**Tm-bc - Monterey Formation, Beechers Bay Member, black volcanic conglomerate and tuffaceous sandstones (Miocene)**

Black volcanic conglomerate and tuffaceous sandstones. Description from source map: [Santa Rosa](#)

[Island Geology](#)

Unit is present on Santa Rosa Island.

Tmbs - Monterey Formation, Beechers Bay Member, rhythmically bedded sandstones and shale (Miocene)

Tm-bs - Monterey Formation, Beechers Bay Member, rhythmically bedded sandstones and shale (Miocene)

Rhythmically bedded sandstones and shales. Description from source map: [Santa Rosa Island Geology](#)

Unit is present on Santa Rosa Island.

Tmbt - Monterey Formation, Beechers Bay Member, tuff and tuffaceous sandstones (Miocene)

Tm-bt - Monterey Formation, Beechers Bay Member, tuff and tuffaceous sandstones (Miocene)

Tuffs and tuffaceous sandstones. Description from source map: [Santa Rosa Island Geology](#)

Unit is present on Santa Rosa Island.

Tb - Blanca Volcaniclastics, undifferentiated (Miocene)

No additional description present on source map. Description from source map: [Santa Cruz Island Geology](#)

Unit is present on Santa Cruz Island.

Tbu - Blanca Volcaniclastics, Upper Member (Miocene)

Tb-u - Blanca Volcaniclastics, Upper Member (Miocene)

Brown, pink or gray, thick-bedded tuff-breccias with cobble to boulder conglomerates and basalt sills. Description from source map: [Santa Cruz Island Geology](#)

Unit is present on Santa Cruz Island.

Tbm - Blanca Volcaniclastics, Middle Member (Miocene)

Tb-m - Blanca Volcaniclastics, Middle Member (Miocene)

White, massive tuff breccia with volcanic sandstones and siltstone. Description from source map: [Santa Cruz Island Geology](#)

Unit is present on Santa Cruz Island.

Tbl - Blanca Volcaniclastics, Lower Member (Miocene)**Tb-I - Blanca Volcaniclastics, Lower Member (Miocene)**

Buff, volcaniclastic and metamorphic conglomerates, sandstones and siltstones. Description from source map: [Santa Cruz Island Geology](#)

Unit is present on Santa Cruz Island.

Tsc - Santa Cruz Island Volcanics, undifferentiated (Miocene)**Tsc - Santa Cruz Island Volcanics (Miocene)**

No additional description present on source map. Description from source map: [Santa Cruz Island Geology](#)

Unit is present on Santa Cruz Island.

Tscp - Santa Cruz Island Volcanics, Prisoner's Harbor Member (Miocene)**Tsc-P - Santa Cruz Island Volcanics, Prisoner's Harbor Member (Miocene)**

Dark gray, dacitic andesite flows with interbedded light bluish-green, tuffaceous sandstones. Description from source map: [Santa Cruz Island Geology](#)

Unit is present on Santa Cruz Island.

Tscd - Santa Cruz Island Volcanics, Devil's Peak Member (Miocene)**Tsc-D - Santa Cruz Island Volcanics, Devil's Peak Member (Miocene)**

Dark gray and red, scoriaceous andesite flows and flow breccias. Description from source map: [Santa Cruz Island Geology](#)

Unit is present on Santa Cruz Island.

Tscs - Santa Cruz Island Volcanics, Stanton Ranch Member (Miocene)**Tsc-S - Santa Cruz Island Volcanics, Stanton Ranch Member (Miocene)**

Massive, red flow breccias with greenish-gray tuffs and tuff breccias. Description from source map: [Santa Cruz Island Geology](#)

Unit is present on Santa Cruz Island.

Tscg - Santa Cruz Island Volcanics, Griffith Canyon Member (Miocene)**Tsc-G - Santa Cruz Island Volcanics, Griffith Canyon Member (Miocene)**

Olive gray, vesicular basalt flows and flow breccias with tuffaceous volcanic breccias. Description from source map: [Santa Cruz Island Geology](#)

Unit is present on Santa Cruz Island.

Ti - Intrusive, undifferentiated (Miocene)

No additional description present on source map. Description from source map: [Santa Cruz Island Geology](#)

Unit is present on Santa Cruz Island.

Tic - Intrusive, C Member (Miocene)**Ti-c - Intrusive, C Member (Miocene)**

Buff and reddish gray leucandesitic intrusive. Description from source map: [Santa Cruz Island Geology](#)

Unit is present on Santa Cruz Island.

Tib - Intrusive, B Member (Miocene)**Ti-b - Intrusive, B Member (Miocene)**

Black, porphyritic to glassy andesitic intrusive. Description from source map: [Santa Cruz Island Geology](#)

Unit is present on Santa Cruz Island.

Tia - Intrusive, A Member (Miocene)**Ti-a - Intrusive, A Member (Miocene)**

Dacitic intrusive. Description from source map: [Santa Cruz Island Geology](#)

Unit is present on Santa Cruz Island.

Tsm - San Miguel Volcanics, undifferentiated (Miocene and/or Oligocene)**Tsm - San Miguel Volcanics (Miocene and/or Oligocene)**

No additional description present on source map. Description from source map: [San Miguel Island Geology](#)

Tsm - San Miguel Volcanics (Miocene and/or Oligocene)

No additional description present on source map. Description from source map: [Santa Rosa Island Geology](#)

Unit is present on San Miguel Island and Santa Rosa Island.

Tsmu - San Miguel Volcanics, Upper Member (Miocene and/or Oligocene)**Tsm-u - San Miguel Volcanics, Upper Member (Miocene and/or Oligocene)**

Massive dacitic intrusives, flows and clastics. Description from source map: [San Miguel Island Geology](#)

Unit is present on San Miguel Island.

Tsml - San Miguel Volcanics, Lower Member (Miocene and/or Oligocene)

Tsm-l - San Miguel Volcanics, Lower Member (Miocene and/or Oligocene)

Basaltic flows with pillow structure (?) and dikes; volcanic sandstones and conglomerates. Description from source map: [San Miguel Island Geology](#)

Unit is present on San Miguel Island.

Tsmf - San Miguel Volcanics, basaltic flows (Miocene and/or Oligocene)

Tsm-f - San Miguel Volcanics, basaltic flows (Miocene and/or Oligocene)

No additional description present on source map. Description from source map: [Santa Rosa Island Geology](#)

Unit is present on Santa Rosa Island.

Tsmi - San Miguel Volcanics, basaltic intrusives (Miocene and/or Oligocene)

Tsm-i - San Miguel Volcanics, basaltic intrusives (Miocene and/or Oligocene)

No additional description present on source map. Description from source map: [Santa Rosa Island Geology](#)

Unit is present on Santa Rosa Island.

Tsmc - San Miguel Volcanics, volcanoclastics (Miocene and/or Oligocene)

Tsm-c - San Miguel Volcanics, volcanoclastics (Miocene and/or Oligocene)

Volcanoclastics, sparsely foraminiferal. Description from source map: [Santa Rosa Island Geology](#)

Unit is present on Santa Rosa Island.

Tso - San Onofre Breccia (Miocene and/or Oligocene)

Tso - San Onofre Breccia (Miocene and/or Oligocene)

Glaucophane schist, dacite, diorite conglomerate with sandstones and siltstones. Mollusks. Description from source map: [Santa Cruz Island Geology](#)

Tso - San Onofre Breccia (Miocene and/or Oligocene)

Volcanic and glaucophane schist conglomerate. Description from source map: [Santa Rosa Island Geology](#)

Unit is present on Santa Cruz Island and Santa Rosa Island.

Tr - Rincon Shale, undifferentiated (Miocene and/or Oligocene)**Tr - Rincon Shale (Oligocene)**

No additional description present on source map. Description from source map: [San Miguel Island Geology](#)

Tr - Rincon Member (Miocene and/or Oligocene)

Gray or brown shales and mudstones with dolomitic interbeds. Foraminifers. Description from source map: [Santa Cruz Island Geology](#)

Tr - Rincon Shale (Miocene and/or Oligocene)

No additional description present on source map. Description from source map: [Santa Rosa Island Geology](#)

Unit is present on San Miguel Island, Santa Cruz Island and Santa Rosa Island.

Tru - Rincon Shale, Upper Member (Miocene and/or Oligocene)**Tr-u - Rincon Shale, Upper Member (Oligocene)**

Cream colored, chalky, foraminiferal shale. Description from source map: [San Miguel Island Geology](#)

Tr-u - Rincon Shale, Upper Member (Miocene and/or Oligocene)

Brown shales, foraminiferal. Description from source map: [Santa Rosa Island Geology](#)

Unit is present on San Miguel Island and Santa Rosa Island.

Trm - Rincon Shale, Middle Member (Miocene and/or Oligocene)**Tr-m - Rincon Shale, Middle Member (Miocene and/or Oligocene)**

Blue-gray shales, foraminiferal. Description from source map: [Santa Rosa Island Geology](#)

Unit is present on Santa Rosa Island.

Trl - Rincon Shale, Lower Member (Miocene and/or Oligocene)**Tr-l - Rincon Shale, Lower Member (Oligocene)**

Brown and gray and greenish-buff shales, siltstones, sandstones and pebble conglomerates with mollusca. Description from source map: [San Miguel Island Geology](#)

Tr-l - Rincon Shale, Lower Member (Miocene and/or Oligocene)

Brown and green mudstones and siltstone, mollusks. Description from source map: [Santa Rosa Island Geology](#)

Unit is present on San Miguel Island and Santa Rosa Island.

Tv - Vaqueros Sandstone, undifferentiated (Oligocene)**Tv - Vaqueros Sandstone (Oligocene)**

Conglomerate. Dioritic, metamorphic, and volcanic clasts, with volcanic sandstone. Mollusks.

Description from source map: [Santa Cruz Island Geology](#)

Tv - Vaqueros Sandstone, undifferentiated (Oligocene)

Mollusks. Description from source map: [Santa Rosa Island Geology](#)

Unit is present on Santa Cruz Island and Santa Rosa Island.

Tvu - Vaqueros Sandstone, Upper Member (Oligocene)**Tv-u - Vaqueros Sandstone, Upper Member (Oligocene)**

Fine to medium grained sandstone and siltstone. Description from source map: [Santa Rosa Island Geology](#)

Unit is present on Santa Rosa Island.

Tvsh - Vaqueros Sandstone, Shale Member (Oligocene)**Tv-sh - Vaqueros Sandstone, Shale Member (Oligocene)**

Rincon like brown shales and siltstones, mollusks. Description from source map: [Santa Rosa Island Geology](#)

Unit is present on Santa Rosa Island.

Tvl - Vaqueros Sandstone, Lower Member (Oligocene)**Tv-l - Vaqueros Sandstone, Lower Member (Oligocene)**

Coarse grained sandstones and conglomerates. Description from source map: [Santa Rosa Island Geology](#)

Unit is present on Santa Rosa Island.

Ts - Sepe Formation (Oligocene)

Buff, green and red sandstones and conglomerates. Description from source map: [Santa Rosa Island Geology](#)

Unit is present on Santa Rosa Island.

Tcd - Cozy Dell Shale (Eocene)**Tcd - Cozy Dell Shale (Eocene)**

Gray to blue-gray siltstones and shale with flaggy limestone interbeds. Foraminifers. Description from source map: [Santa Cruz Island Geology](#)

Tcd - Cozy Dell (Eocene)

Blue-gray shale and siltstones, foraminiferal. Description from source map: [Santa Rosa Island Geology](#)

Unit is present on Santa Cruz Island and Santa Rosa Island.

Tsp - South Point Sandstone (Eocene)**Tsp - South Point Sandstone (Eocene)**

Micaceous buff sandstones, siltstones and interbedded shales; occasional corrugated bedding. Description from source map: [San Miguel Island Geology](#)

Tsp - South Point Sandstone (Eocene)

Gray sandstone with interbedded shale, foraminiferal. Description from source map: [Santa Rosa Island Geology](#)

Unit is present on San Miguel Island and Santa Rosa Island.

Tjv - Jolla Vieja Formation (Eocene)

Buff, medium-grained, massive or thick bedded sandstone and volcanic conglomerate. Description from source map: [Santa Cruz Island Geology](#)

Unit is present on Santa Cruz Island.

Tc - Canada Formation (Eocene)

Greenish gray and bluish gray shales and siltstones, thin interbedded sandstones, basal conglomerate. Foraminifers and mollusks. Description from source map: [Santa Cruz Island Geology](#)

Unit is present on Santa Cruz Island.

Tcp - Canada and Pozo Formations, undifferentiated (Eocene and Paleocene)**Tp-c - Pozo-Canada Formations (Paleocene to Eocene)**

Rhythmically bedded siltstones and shales; foraminiferal; micaceous buff sandstones; cobble conglomerate. Description from source map: [San Miguel Island Geology](#)

Unit is present on San Miguel Island.

Tp - Pozo Formation (Paleocene)

Buff and gray sandy siltstones and shales, interbedded sandstones. Foraminifers and mollusks. Description from source map: [Santa Cruz Island Geology](#)

Unit is only present on Santa Cruz Island.

Kj - Jalama Formation (Upper Cretaceous)

Foraminiferal gray shales; gray and buff flaggy sandstones, siltstones and shales; and gray massive sandstones. Description from source map: [San Miguel Island Geology](#)

Unit is present on San Miguel Island.

Jap - Alamos Plutonite (Upper Jurassic)**JRap - Alamos Plutonite (Upper Jurassic)**

Dark to light gray quartz diorite. Description from source map: [Santa Cruz Island Geology](#)

Unit is present on Santa Cruz Island.

Jwd - Willows Diorite (Upper Jurassic)**JRwd - Willows Diorite (Upper Jurassic)**

Deeply weathered, fine to coarse-grained, hornblende diorite, gray when fresh, weathers to salmon pink. Description from source map: [Santa Cruz Island Geology](#)

Unit is present on Santa Cruz Island.

Jwdsci - Willows Diorite and Santa Cruz Island Schist, undifferentiated (Upper Jurassic and pre-Late Jurassic)**JRwd/JRsci - Willows Diorite and Santa Cruz Island Schist, undifferentiated (pre-Late Jurassic to Upper Jurassic)**

See descriptions for units [Jwd](#) and [Jsci](#). Description from source map: [Santa Cruz Island Geology](#)

This unit doesn't appear on the source map correlation. One mapped area on the Santa Cruz source map indicates both Jwd and Jsci are present. This area is considered to be both units undifferentiated.

Unit is present on Santa Cruz Island.

Jsci - Santa Cruz Island Schist (pre-Late Jurassic)**pJRsci - Santa Cruz Island Schist (pre-Late Jurassic)**

Actinolite chlorite schist and phyllite, green when fresh, weathers to red. Description from source map: [Santa Cruz Island Geology](#)

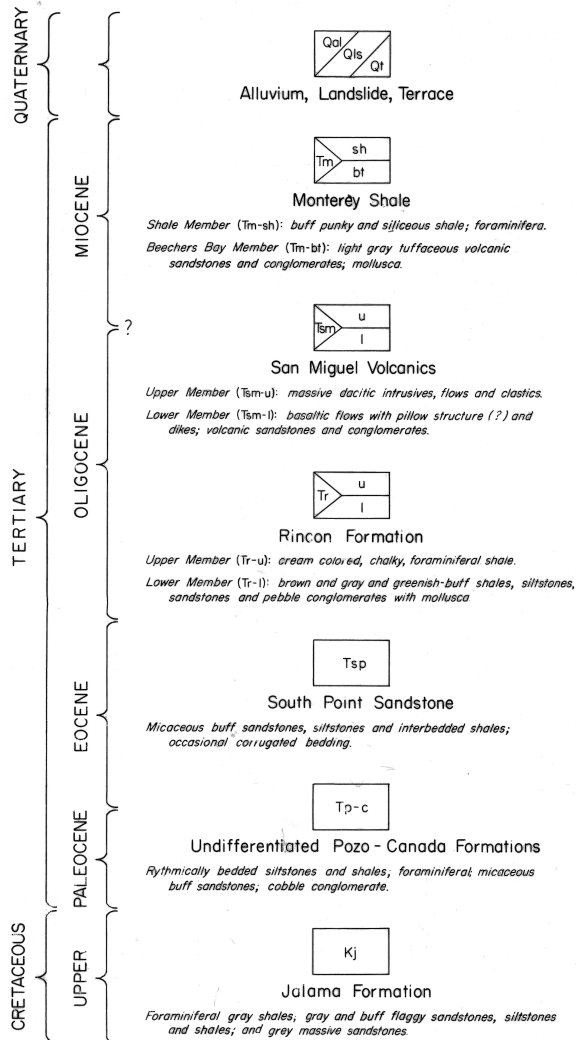
Unit is present on Santa Cruz Island.

San Miguel Island Geologic Map

Source map for the GRI San Miguel digital geologic-GIS map.

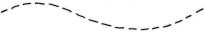
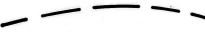
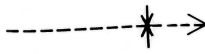
Weaver, D.W., and Doerner, D.P., 1969, Geologic Map of San Miguel Island, in *Geology of the Northern Channel Islands, Southern California Borderland*: American Association of Petroleum Geologists, Field Trip Guidebook no. 12, scale 1:24,000. (GRI Source Map ID 75157).

San Miguel Island Correlation of Map Units



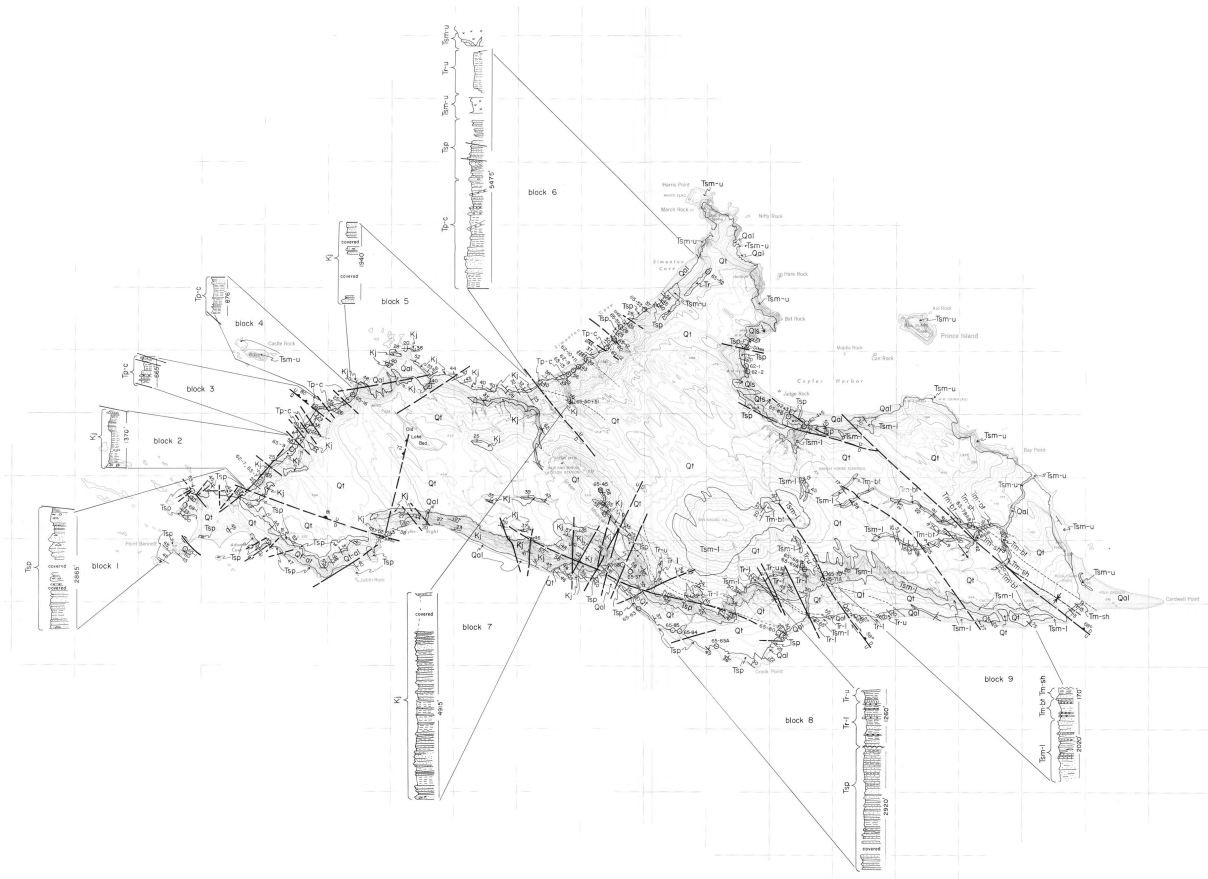
Graphic from source map: [San Miguel Island Geology](#)

San Miguel Island Map Legend

	Contact, formational
	Contact, inferred
	Conglomerate bed
	Fault, showing movement
	Fault, concealed
	Strike and dip
	Axis of syncline, showing plunge
	Foraminifer locality

Graphic from source map: [San Miguel Island Geology](#)

San Miguel Island Block Sections Map

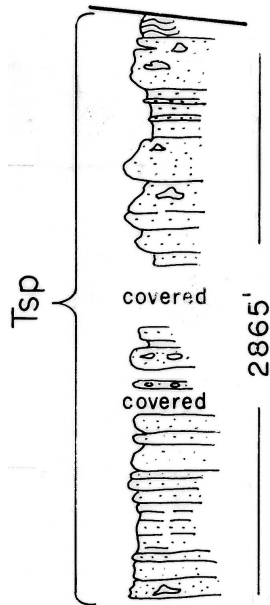


Graphic from source map: [San Miguel Island Geology](#)

The above graphic was scanned at a high resolution and can be viewed in more detail by zooming in (if viewing the digital format of this document).

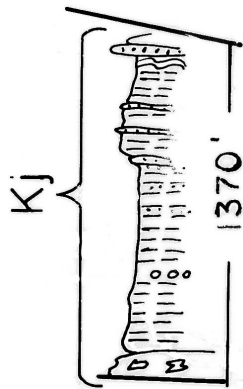
Block sections shown on the previous page are presented below as individual graphics.

Block Section 1

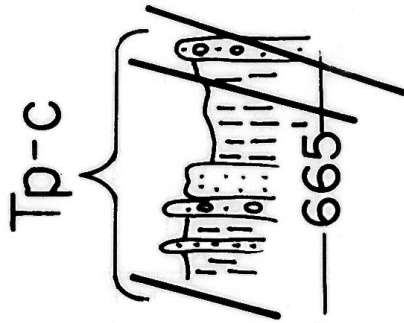


Graphic from source map: [San Miguel Island Geology](#)

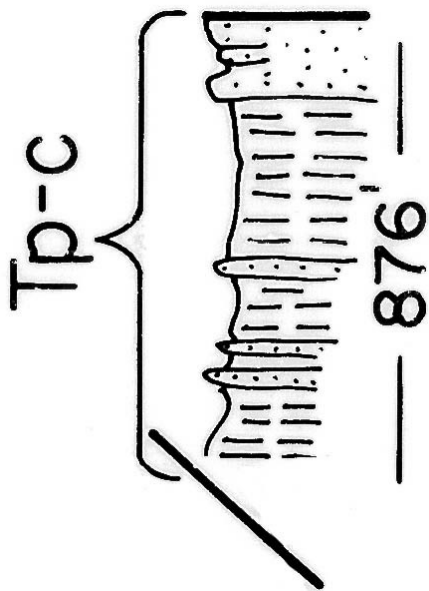
Block Section 2



Graphic from source map: [San Miguel Island Geology](#)

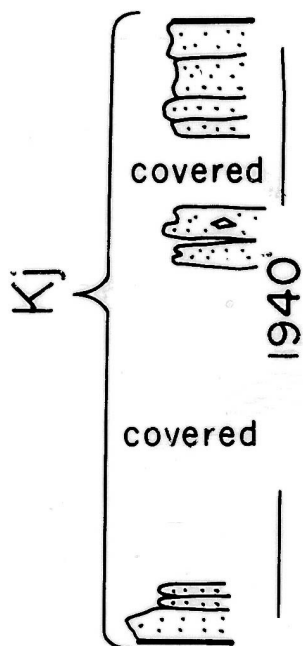
Block Section 3

Graphic from source map: [San Miguel Island Geology](#)

Block Section 4

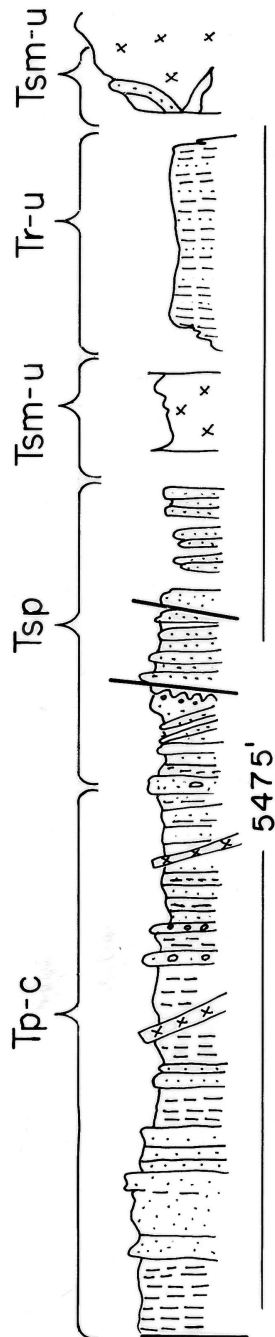
Graphic from source map: [San Miguel Island Geology](#)

Block Section 5



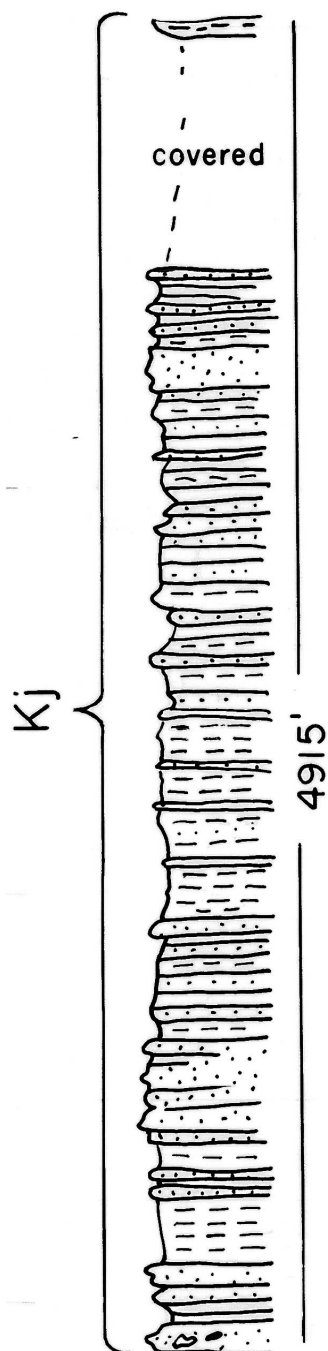
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Block Section 6



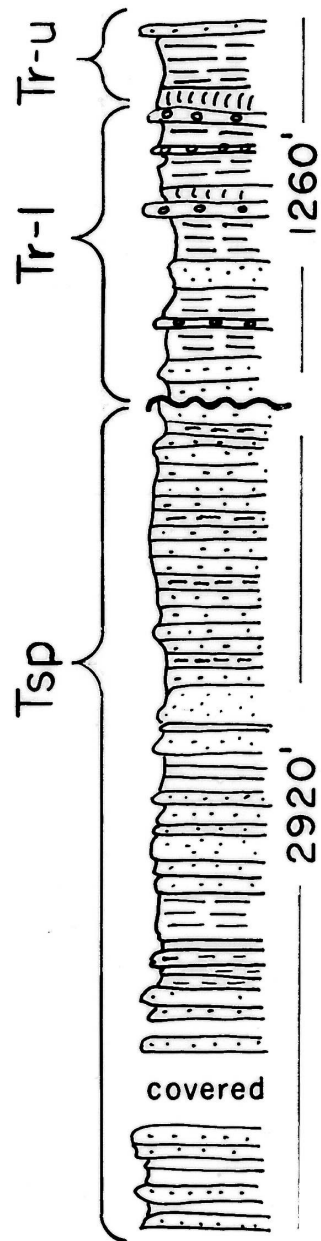
Graphic from source map: [San Miguel Island Geology](#)

Block Section 7



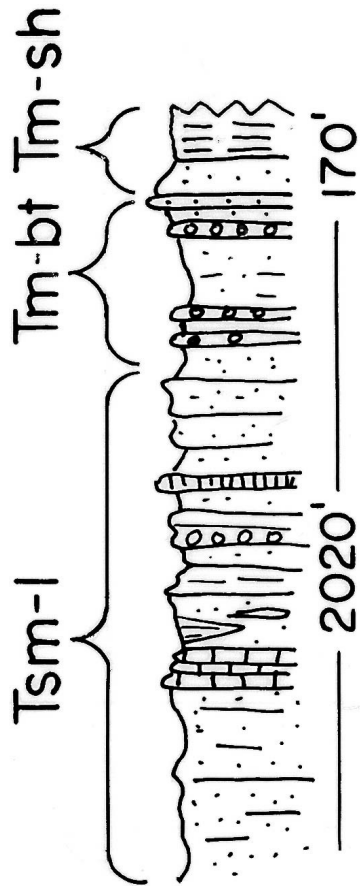
Graphic from source map: [San Miguel Island Geology](#)

Block Section 8



Graphic from source map: [San Miguel Island Geology](#)

Block Section 9



Graphic from source map: [San Miguel Island Geology](#)

Santa Cruz Island Geologic Map

Source map for the GRI Santa Cruz digital geologic-GIS map.

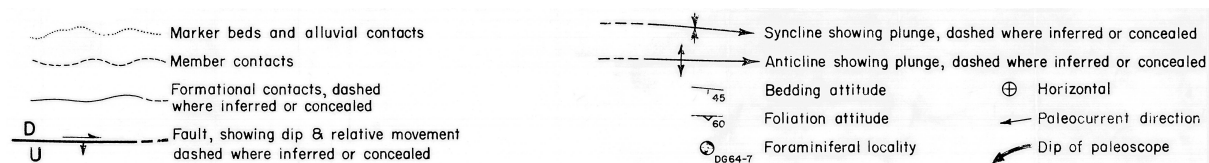
University of California, Santa Barbara Geological Survey, 1969, Geology of Santa Cruz Island, in Geology of the Northern Channel Islands, Southern California Borderland: American Association of Petroleum Geologists, Field Trip Guidebook no. 12, scale 1:24,000. (*GRI Source Map ID 75158*).

Santa Cruz Island Map Correlation of Map Units

QUATERNARY	RECENT	Qal	QUATERNARY ALLUVIUM Unconsolidated alluvium; marine & terrestrial.
		Qfg	QUATERNARY FANGLOMERATES Terrestrial.
		Qls	QUATERNARY LANDSLIDES Landslide blocks and debris.
		Qtg	QUATERNARY TERRACE GRAVELS Unconsolidated marine terrace gravels.
	PLEISTOCENE	Qma	MIDDLE ANCHORAGE ALLUVIUM Sandy pebble conglomerate & breccia.
		Qph	POTATOE HARBOR FORMATION White, organic clastic limestone and volcanic sandstone. Mollusks.
	MIOCENE	Tmshbb	MONTEREY FORMATION Shale Member: Buff to white, chalky and siliceous shales with bedded chert and bentonite. Foraminifers. Beechers Bay Member: Light buff laminated shale, siltstone, sandstone, and conglomerate. Corrugated bedding. Foraminifers.
		Tbtum	BLANCA VOLCANICLASTICS Upper Member: Brown, pink or gray, thick-bedded tuff-breccias with cobble to boulder conglomerates and basalt sills. Middle Member: White, massive tuff breccia with volcanic sandstones & siltstone. Lower Member: Buff, volcanoclastic & metamorphic conglomerates, sandstones & siltstones.
		TscpdsG	SANTA CRUZ ISLAND VOLCANICS Prisoner's Harbor Member: Dark gray, dacitic andesite flows with interbedded light bluish-green, tuffaceous sandstones. Devil's Peak Member: Dark gray and red, scoriaceous andesite flows and flow breccias. Stanton Ranch Member: Massive, red flow breccias with greenish-gray tuffs and tuff breccias. Griffith Canyon Member: Olive gray, vesicular basalt flows and flow breccias with tuffaceous volcanic breccias.
	TERTIARY	OLIGOCENE	Tso
Tr			RINCON MEMBER Gray or brown shales and mudstones with dolomitic interbeds. Foraminifers.
Tv			VAQUEROS SANDSTONE Conglomerate-dioritic, metamorphic, and volcanic clasts, with volcanic sandstone. Mollusks.
Eocene		Tcd	COZY DELL SHALE Gray to blue-gray siltstones and shales with flaggy limestone interbeds. Foraminifers.
		Tjv	JOLLA VIEJA FORMATION Buff, medium-grained, massive or thick bedded sandstone and volcanic conglomerate.
		Tc	CAÑADA FORMATION Greenish gray and bluish gray shales and siltstones, thin interbedded sandstones, basal conglomerate. Foraminifers and mollusks.
PALEOCENE		Tp	POZO FORMATION Buff and gray sandy siltstones and shales, interbedded sandstones. Foraminifers and mollusks.
		TRap	ALAMOS PLUTONITE Dark to light gray quartz diorite
UPPER JURASSIC		TRwd	WILLOWS DIORITE Deeply weathered, fine to coarse-grained, hornblende diorite, gray when fresh, weathers to salmon pink.
		pRsci	SANTA CRUZ ISLAND SCHIST Actinolite-chlorite schist and phyllite, green when fresh, weathers to red.
PRE-LATE JURASSIC			

Graphic from source map: [Santa Cruz Island Geology](#)

Santa Cruz Island Map Legend



Graphic from source map: [Santa Cruz Island Geology](#)

Santa Cruz Island Complete List of Source Authors and Contributors

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1964

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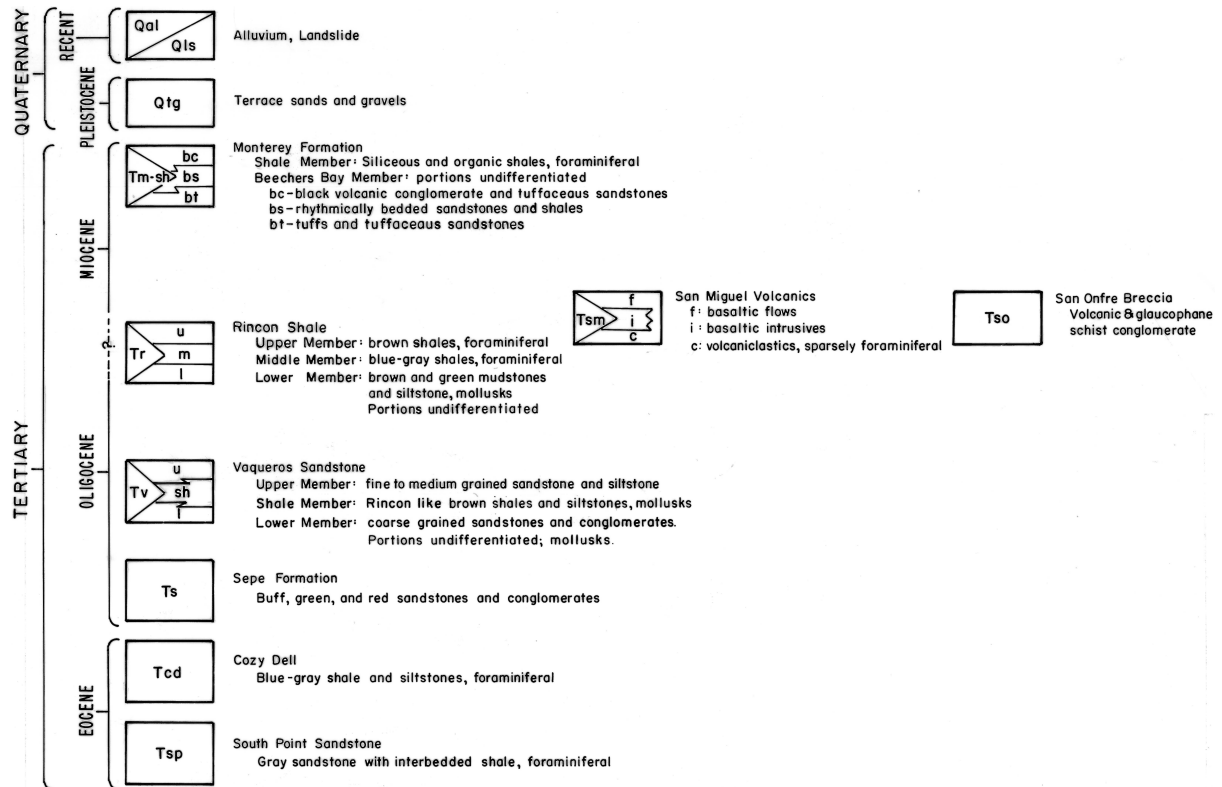
Graphic from source map: [Santa Cruz Island Geology](#)

Santa Rosa Island Geologic Map

Source map for the GRI Santa Rosa digital geologic-GIS map.

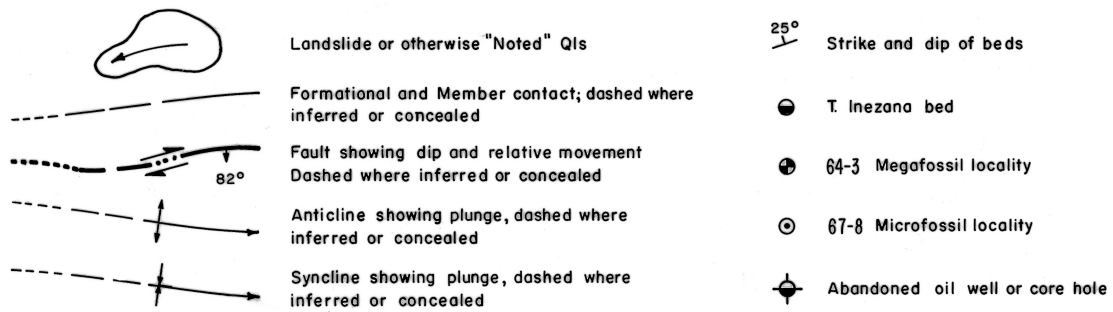
Sonneman, Howard et. al., 1969, Geology of Santa Rosa Island, in Geology of the Northern Channel Islands, Southern California Borderland: American Association of Petroleum Geologists, Field Trip Guidebook no. 12, scale 1:24,000. (GRI Source Map ID 75156).

Santa Rosa Island Map Correlation of Map Units



Graphic from source map: [Santa Rosa Island Geology](#)

Santa Rosa Island Map Legend



Graphic from source map: [Santa Rosa Island Geology](#)

GRI Digital Quaternary Surficial Geologic-GIS Maps of Channel Islands National Park

Map Unit List

The geologic units present in the digital Quaternary surficial geologic-GIS data produced for Channel Islands National Park, California (CHIS) are listed below. Units are listed with their assigned unit symbol and unit name (e.g., Qml - Modified land or 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 (CHISUNIT_surficial) table included with the GRI geologic-GIS data.

Cenozoic Era

Quaternary Period

Holocene Epoch

[Qac](#) - Active colluvial deposits
[Qml](#) - Modified land or artificial fill
[Qaa](#) - Active alluvial deposits
[Qaf](#) - Active fluvial deposits
[Qaed](#) - Active eolian sand dune deposits
[Qaer](#) - Active eolian sand ramp deposits
[Qaes](#) - Active eolian sand sheet deposits
[Qal](#) - Active lagoon deposits
[Qab](#) - Active beach deposits
[Qabs](#) - Active sandy beach deposits
[Qabf](#) - Active beach fringe deposits
[Qag](#) - Active groundwater-discharge deposits

Holocene and Pleistocene Epochs

[Qha](#) - Abundant hillslope deposits of entisol order soil
[Qhav](#) - Abundant hillslope deposits of vertisol order soil
[Qhs](#) - Sparse hillslope deposits of entisol order soil
[Qyc](#) - Young colluvial deposits
[Qls-SS](#) - Shallow-seated landslide deposits and scarps
[Qls-DS](#) - Deep-seated landslide deposits and scarps
[Qya](#) - Young alluvial fan deposits
[Qyf](#) - Young fluvial deposits
[Qyfy](#) - Younger young fluvial deposits
[Qye](#) - Young eolian sand deposits
[Qyed](#) - Young eolian sand dune deposits
[Qyer](#) - Young eolian sand ramp deposits
[Qyes](#) - Young eolian sand sheet deposits
[Qyea](#) - Young mixed eolian and alluvial deposits
[Qyae](#) - Young mixed alluvial and eolian deposits
[Qybf](#) - Young beach fringe deposits
[Qyp](#) - Young paludal or marsh deposits
[Qyg](#) - Young groundwater-discharge deposits
[Qyfo](#) - Older young fluvial deposits
[Qyeao](#) - Older young mixed eolian and alluvial deposits

Pleistocene Epoch

[Qia](#) - Intermediate alluvial fan deposits
[QiaY](#) - Younger intermediate alluvial fan deposits
[Qiao](#) - Older intermediate alluvial fan deposits
[Qif](#) - Intermediate fluvial deposits
[QifY](#) - Younger intermediate fluvial deposits
[Qifo](#) - Older intermediate fluvial deposits
[Qie](#) - Intermediate eolian sand deposits
[Qied](#) - Intermediate eolian sand dune deposits
[Qier](#) - Intermediate eolian sand ramp deposits
[Qiea](#) - Intermediate mixed eolian and alluvial deposits
[Qiae](#) - Intermediate mixed alluvial and eolian deposits
[Qil](#) - Intermediate lagoon deposits
[Qic](#) - Intermediate colluvial deposits
[Qoa](#) - Old alluvial fan deposits
[Qof](#) - Old fluvial deposits
[Qoe](#) - Old eolian sand deposits
[Qoec](#) - Old eolian cemented sand deposits
[Qoed](#) - Old eolian sand dune deposits
[Qoea](#) - Old mixed eolian and alluvial deposits
[Qoae](#) - Old mixed alluvial and eolian deposits

Quaternary and Tertiary Periods

Pleistocene and Pliocene Epochs

[QTmt](#) - Marine paleontologic marker bed
[QTe](#) - Very old eolian sand deposits

Tertiary Period

[Tb](#) - Bedrock substrate materials

Miocene Epoch

[Ts](#) - Sedimentary rocks
[Tso](#) - San Onofre Breccia
[Tv](#) - Volcanic rocks
[Ti](#) - Tuffaceous sedimentary rocks

Map Unit Descriptions

Note: The following Quaternary surficial unit descriptions were extracted from unpublished Quaternary Surficial Geologic Maps of the Channel Islands ([Channel Islands Quaternary Surficial and Bedrock Geology](#)). Descriptions are listed by deposit type, and not in order of youngest to oldest. Unit descriptions are from draft data and in some cases may be incomplete or unclear.

Unit descriptions of surficial deposits are listed in order of the following taxonomic features: (1) sediment grain size and roundness, color, and composition; (2) sedimentary structure and consolidation; (3) deposit surface morphology; (4) soil development; (5) inset relations with other units; (6) characteristic landforms and position in landscape, with particular attention to imagery; (7) vegetation characteristics, and (8) any other diagnostic features (or) implications for evaluating existence or age of fault ground rupture. Primary unit categories are grouped by depositional transport process, with constituent units listed in order of increasing age. Quaternary unit ages are assumed to be roughly correlative across all islands mapped. Bedrock data was evaluated from several sources, primarily Dibblee et al. (1998),

Weaver et al. (1969) as well as new field observations.

Erosional surfaces that are denoted in the data are described below in the section titled [Erosional Surfaces](#).

Information about [geologic classification and feature attribution](#) can be found in the source map section of the this document.

Text from source map: [Channel Islands Quaternary Surficial Geology](#)

Anthropogenic deposits

Qml - Modified land or artificial fill (latest Holocene)

Natural or man-made materials emplaced for various purposes, including construction, military operations, and ranching. Also includes areas where surface sediments have been removed by grading or quarrying. Modified land typically alters patterns and rates of drainage, infiltration, soil erosion, and soil development. Locally includes engineered drainage structures. Sedimentary structures, surface morphology, and soils inherited from original deposit typically are altered or destroyed. Often visible on aerial photographs as simple geometric patterns and areas of consistent, characteristically high albedo. Vegetation is typically sparse and dominated by first-succession species dominated by grasses and small shrubs. Grass species are composed largely of nonnative ephemeral grasses such as oats (*Avena* spp.), bromes (*Bromus* spp.), barleys (*Hordeum* spp.), and ryegrasses (*Lolium* spp.). Shrubs are dominated by Coyote Brush (*Baccharis pilularis*). Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This unit appears on Anacapa, San Miguel, Santa Barbara, Santa Cruz and Santa Rosa Islands.

Alluvial deposits

Alluvial deposits of generally non-cohesive material where water flow is poorly confined by channel walls resulting in outspread gently sloping masses where tributary valleys issue from narrow canyons to broader valley floors with ample accommodation space. Deposits can reflect fan, cone, or splay morphology.

Text from source map: [Channel Islands Quaternary Surficial Geology](#)

Qaa - Active alluvial deposits (latest Holocene)

Poorly to moderately sorted fine sand to boulders deposited by ephemeral streams that actively receive or have received sediments on annual basis or within the last few years or decades. Typically unconsolidated and uncemented, thus easily eroded. Surface undulates with rounded microtopography common to braided streams and pronounced bar and swale topography; incised channels are shallow or absent. Active fan channels originate from the mountain front, incised in the proximal fan and tending to diffuse in the distal fan. Soil development is minimal but fine grained eolian sediment may be abundant, especially in distal piedmont areas. Surfaces are prone to seasonal flooding. Main proximal fan channels are sharply defined on aerial photographs as long, bright, sinuous features and grade down-fan into complex braided-channel networks. Vegetation typically reflects age of exposure, with recently active surfaces having sparse annuals, and older surfaces supporting a patchwork of shrubs on surfaces active

only decadally. Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This unit appears on Santa Cruz and Santa Rosa Islands.

Qya - Young alluvial fan deposits (Holocene and latest Pleistocene)

Poorly to moderately sorted fine sand to boulders deposited by ephemeral streams; deposits have surfaces that have received little or no deposition in the last several hundred years. Poorly cemented: loose to slightly compact. Microtopography fairly rough in much of fan consisting of remnants of bar-and-swale topography, with largest clasts concentrated in the elevated bars. Poorly developed soil, expressed as incipient sandy A horizon; no significant B or C horizon development in soil profile. Surfaces either permanently abandoned or flooded infrequently by channel avulsions in distributary streams at centennial to millennial intervals. Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This unit appears on San Miguel, Santa Cruz and Santa Rosa Islands.

Qia - Intermediate alluvial fan deposits (late and middle Pleistocene)

Poorly to moderately sorted fine sand to boulder gravel; deposits have surfaces that have been abandoned for tens of thousands of years. Clasts mostly subangular to subrounded, coarsening uphill toward mountain fronts. Deposits typically compact, but may be loose where bioturbated. Bar-and-swale topography replaced via diffusive processes with broad, flat, surfaces, that contain exposed clasts. Top of unit is incised by low to moderately dense channel networks; younger surfaces are locally inset along channel margin. Moderately well-developed A horizon (>5 cm thick), composed of silt, very fine sand, and clay. Repeated sequences of dark brown to black organic paleosols cm to decimeters thick. Sparsely to moderately vegetated, abundance and species diversity increasing with elevation. Dominant species are grasses (stipa and rye), saltgrass (*Distichlis spicata*), coyote bush (*Baccharis pilularis*), and California sagebrush (*Artemisia californica*). Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This unit appears on Anacapa, San Miguel, Santa Barbara, Santa Cruz and Santa Rosa Islands.

Qiay - Younger intermediate alluvial fan deposits (late and middle Pleistocene)

Younger subdivision of Qia with terraces inset within Qiao. Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This unit appears on Santa Cruz Island.

Qiao - Older intermediate alluvial fan deposits (late and middle Pleistocene)

Older subdivision of Qia with inset terraces of Qiay terraces. Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This unit appears on Santa Cruz and Santa Rosa Islands.

Qoa - Old alluvial fan deposits (middle and early Pleistocene)

Poorly to moderately sorted fine sand to boulders; deposits have surfaces that have been abandoned for several tens to hundreds? of thousands of years. Clasts mostly subangular to subrounded, coarsening uphill toward mountain fronts. Well-indurated soils with poorly imbricated gravel graded to previous base level. Compact and partially cemented near surface. Commonly forms high, stranded surfaces standing a few meters to tens of meters above active washes in the proximal alluvial fan environment; little or no remnant depositional geomorphology. Original upper soil horizons are largely eroded, but locally younger soils may be superimposed directly on well-developed B horizon. In general, the old alluvial deposits are not extensive, forming somewhat isolated relict surfaces near mountain fronts. Moderately vegetated with dominant species of grasses (stipa and rye), coyote bush (*Baccharis pilularis*), and California sagebrush (*Artemisia californica*). Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This unit appears on San Miguel, Santa Cruz and Santa Rosa Islands.

Fluvial deposits

Fluvial deposits from streams and rivers, where water flow is largely confined by channel walls, with a bed composed of a range of materials from cohesive clay and silt to non-cohesive granular material and overbank deposits composed of cohesive clay and silt. Such deposits have geometries, or bed forms, that reflect complex interactions between water flow, channel boundaries, and the deposit itself. Sorting into coarser and finer facies corresponds to different modes of transport including bed and suspended loads. Coarser bed loads, mostly sand and gravel, accumulate in the valley floor whereas finer wash-load sediment, mostly silt and clay, accumulate primarily on flood plains where flows exceed channel confinement.

Text from source map: [Channel Islands Quaternary Surficial Geology](#)

Qaf - Active fluvial deposits (latest Holocene)

Moderately to poorly sorted, fine sand to boulder gravel deposited by ephemeral streams that actively receive or have received sediments on an annual basis or within the last few decades. Similar in character to unit Qaa but generally better sorted and stratified locally with strong imbrication. Typically forms wider, longer, more gently sloping channels that drain small valleys; thus flows more frequently than alluvial fan channels. Mapped unit width may be accentuated in small drainage area watersheds and hence may include inner gorge of valley walls. Deposits loose and unconsolidated, easily disturbed. Locally abrupt channel boundaries between coarse cobbles, gravel, and sand against fine-grained slack-water deposits. Abundant cut and fill stratigraphic contacts. Characteristically inset into Qyf and Qif. No soil development. As much as several meters of active sediments commonly have accumulated within the past few decades. Surfaces are prone to seasonal flooding. Appears on imagery as long, bright, somewhat sinuous features commonly trending perpendicular to the base of distal fans. Recently active surfaces contain sparse vegetation. Typified by “fjordland” canyons draining to north on north side of Santa Rosa Island. Channels active at decadal intervals are moderately vegetated on surfaces. Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This unit appears on San Miguel, Santa Cruz and Santa Rosa Islands.

Qyf - Young fluvial deposits (Holocene and latest Pleistocene)

Poorly to moderately sorted, mixed clastic sediment ranging from fine sand to boulders; deposits have surfaces that have been abandoned for several hundred years. Poorly cemented and poorly consolidated. Loose to slightly compact. Some buried, repeated sequences of dark paleosols. Surfaces largely inactive, forming terraces decimeters to generally less than 1 m above active fluvial deposits, Qaf. Locally sourced by seepage erosion forming theater shaped headwalls. Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This unit appears on San Miguel, Santa Cruz and Santa Rosa Islands.

Qyfy - Younger young fluvial deposits (Holocene)

Fluvial deposits characterized by surfaces that have been abandoned or receive materials during large flood events every few hundred years. Commonly contains remnants of bar and swale topography. Poorly developed soil, expressed as incipient to weak sandy A horizon and weak Bw horizon. Surfaces largely inactive, forming terraces decimeters to generally less than one meter above active fluvial deposits, Qaf. Inset within Qyfo. Forms wide channels, concentrating drainage from, and roughly perpendicular to, local alluvial fan drainages. Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This unit appears on Santa Cruz Island.

Qyfo - Older young fluvial deposits (early Holocene and latest Pleistocene)

Fluvial deposits characterized by surfaces that have been abandoned or receive materials during large flood events every few hundred to thousands? of years. Deposits are typically inset into intermediate fluvial deposits (Qif) and incised by active channels. Surface has moderate to subdued bar-and-swale topography and shows an overall flattening. On imagery, appears as moderate to moderately low-albedo patches; intermediate alluvial deposits with slightly dark varnish may appear similar, but are cut by fewer actively incising channels. Moderately vegetated to well-vegetated. Includes well-stratified, moderately sorted channel gravel, poorly sorted sandy crevasse splay deposits, muddy to finely sandy floodplain deposits, and muddy marsh deposits with organic materials and groundwater-discharge carbonate blebs. Surface of the plain is undulatory and has inverted topography, with high areas consisting of anastomosing former gravel-filled channels, which have been exposed by erosion of finer-grained sediments. Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This unit appears on Santa Cruz Island.

Qif - Intermediate fluvial deposits (late and middle Pleistocene)

Poorly to moderately sorted fine sand to cobble gravel; deposits have surfaces that have been abandoned for roughly 1-16 ka (Schumann and Pigati, 2018; Schumann and others, 2016). Clasts mostly subangular to subrounded, coarsening uphill toward mountain fronts. Deposits typically compact but may be loose where bioturbated. Bar-and-swale topography replaced via diffusive processes with broad, flat, surfaces. Unit is similar to Qia, but forms wider lower gradient characteristic terrace surfaces, typically fine grained. Top of unit is incised by low to moderately dense channel networks; younger surfaces are locally inset along channel margin. Poor to moderately well-developed A horizon (>5 cm thick) and weak to moderate Bt. Locally formed upslope of valley constrictions or dams formed by deep-seated landsliding. Sparsely to moderately vegetated; abundance and species diversity increasing with

elevation. Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This unit appears on San Miguel, Santa Cruz and Santa Rosa Islands.

Qify - Younger intermediate fluvial deposits (late and middle Pleistocene)

Younger subdivision of Qif with terraces inset within Qifo. Present within Cañada Poso, Cañada del Puerto, and in the Central Valley of Santa Cruz Island. Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This unit appears on Santa Cruz and Santa Rosa Islands.

Qifo - Older intermediate fluvial deposits (late and middle Pleistocene)

Older subdivision of Qif with inset terraces of Qify terraces. Present within Cañada Poso, Cañada del Puerto, and in the Central Valley of Santa Cruz Island. Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This unit appears on Santa Cruz and Santa Rosa Islands.

Qof - Old fluvial deposits (middle and early Pleistocene)

Poorly to moderately sorted fine sand to boulder gravel; deposits have surfaces that have been abandoned for tens of thousands of years. Largely disconnected from modern drainage systems, preserved high on hillslopes. Well developed B horizon. Present on Santa Rosa Island in Jolla Vieja, Whetstone, and Arlington Canyons, as well as near the Santa Rosa Island fault in Cañada Garañon. Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This unit appears on Santa Rosa Island.

Colluvial channel deposits

Accumulations of sediment along valley margins and within low-order, narrow drainage networks extending up hillsides above valley bottoms. Accumulates via unconcentrated and poorly channelized hillslope processes of slope wash, mass wasting, and downhill soil creep in response to gravity.

Text from source map: [Channel Islands Quaternary Surficial Geology](#)

Qac - Active colluvial deposits (historic to latest Holocene)

Unsorted to poorly sorted, fine sand to boulder gravel deposited by highly ephemeral channels that actively receive or have received sediment on an annual basis or within the last few decades. Deposits confined to bedrock and colluvial channels; partly formed by small headwater streams at the tips of a channel network that flow over a colluvial valley fill and exhibit weak or ephemeral fluvial and gravitational transport (Montgomery and Buffington, 1997). Deposits generated by shallow concentrations of surface water flow largely insufficient to transport available sediment load downslope of hollows. Hillslope

processes such as gully erosion, debris flows, and rock slides dominate sediment transport and distribution. Although fluvial scour and deposition may occur on a local scale, transport capacity is the limiting factor. Similar in character to unit Qaf but less sorted and poorly stratified generally devoid of imbrication. Typically present in narrow, long, unconfined to confined, moderate to steep gradient channels that drain small drainage area valleys including gullies. Mapped unit width accentuated in small drainage area watersheds and hence may include inner gorge of valley walls. Deposits loose and unconsolidated, easily disturbed. Locally abrupt boundaries between coarse cobbles, gravel, and sand against fine-grained slack water deposits. Abundant cut and fill stratigraphic contacts. Characteristically inset into Qha and Qhs. No soil development. Deposits largely less than 0.5 – 1 m thick. Appears on imagery as long, bright, linear to somewhat sinuous features trending perpendicular to contours with polygon boundaries in finger, hourglass, or tear drop shape. Locally contains gully erosional features. Recently active erosional/depositional surfaces contain sparse vegetation, commonly including Coyote Brush (*Baccharis pilularis*). Colluvial channels active at decadal intervals display moderately vegetated surfaces. Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This unit appears on Anacapa, San Miguel, Santa Barbara, Santa Cruz and Santa Rosa Islands.

Eolian deposits

Sequences derived from sediment transport by wind in suspension or by saltation of grains. Characteristic erodible material is fine grained; clay to medium sand particle size range. Physical composition of deposits varies with distance and height of transport. Transport distance from source is variable, such that finer silt and clay particles travel farther, concentrating the proximal coarser fractions into well-sorted deposits. Entrained grains are subject to sorting, rounding, and etching or frosting by grain-to-grain abrasion visible with loupe. Eolian transport of sediment generally results in finer, better sorted, and more rounded grains than similar localized wave-deposited beach deposits. Deposits are common on more western and northern land masses, such as across San Miguel Island (Johnson, 1972; Muhs and others, 2018) and at Sandy, Carrington, and Skunk Points on Santa Rosa Island (Muhs and others, 2014). During prior glacial stades, paleo-open shelves were likely typified by large eolian packages with carbonate-rich sediment derived from marine fauna exposed on wave-cut platforms where such marine shelf sediments provided ample sediment supply to adjacent islands (e.g., Muhs and others, 2018).

Text from source map: [Channel Islands Quaternary Surficial Geology](#)

Qaed - Active eolian sand dune deposits (latest Holocene)

White to pale-gray and -brown, moderately sorted to well-sorted fine to medium sand mobile on a monthly to annual basis. Loose and subject to migration with moderate cross lamination, containing few larger clasts. Present in areas of abundant sand supply, a prevailing northwesterly wind, and depositional accommodation space. Asymmetric surface ripples are composed of well-sorted medium- to fine-grained sand with long axes oriented orthogonal to prevailing wind direction. Has pronounced dune morphology, typically seif or longitudinal dunes, with steeply sloped, primarily southeasterly migrating lobes. Locally domal and quasi-parabolic dunes exist. Gradational contacts with neighboring units as deposits taper in thickness. No soil development. On imagery appears with very high-albedo spectra. Vegetation is absent to moderate cover of dominantly yellow sand-verbena (*Abronia latifolia*), ragweed (*Ambrosia chamissonis*), silver lupine (*Lupinus albifrons*), and coastal goldenbush (*Isocoma menziesii*). Iceplant, or sea fig, in the form of naturalized, invasive *Carpobrotus chilensis* is a dominant herb, and prostrate crystalline ice plant, *Mesembryanthemum crystallinum*, generally covered with large, glistening bladder cells or water vesicles may also dominate. Description from source map: [Channel Islands](#)

[Quaternary Surficial Geology](#)

This unit appears on San Miguel, Santa Cruz and Santa Rosa Islands.

Qaer - Active eolian sand ramp deposits (latest Holocene)

Ramp of inclined fine to medium sand on windward or lee side of mountains or hills (climbing and falling dunes) active on a monthly to annual basis (Bateman and others, 2012; Lancaster and Tchakerian, 1996). Dominantly eolian but receives minor contribution of coarser grained sediment transported from adjacent hillslopes by gravity and sheetwash. Commonly expresses wedge-shaped planform shape. Locally contains low-amplitude seif dunes typified by Qaed. Locally sourced eolian sediment from nearby Qab and Qabs. Vegetation includes desert saltgrass (*Distichlis spicata*), silver lupine (*Lupinus albifrons*), and coastal goldenbush (*Isocoma menziesii*). Gradational contacts with neighboring units. Distinguished from sand sheets (Qaes) by presence on topographically inclined surfaces. Downwind from parabolic Qaed field on San Miguel near Cuyler Harbor. Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This unit appears on San Miguel and Santa Rosa Islands.

Qaes - Active eolian sand sheet deposits (latest Holocene)

Low-gradient sheet and low-relief dunes of silt and fine to coarse sand covering gently inclined surfaces (Fryberger and others, 1979) transported on a monthly to annual basis. Fine to coarse grained with ripples, gently dipping, poorly laminated horizons, traces of bioturbation, and small-scale cut-and-fill structures. Although small, sand-sheet veneer deposits are widespread through map area, most are too thin and small to depict at map scale. No soil development. High-albedo on imagery. Differentiated from Qaer by presence on low angle, generally horizontal gently undulatory ground surfaces. Thinner with more diffuse boundaries than Qaed. Fills pre-existing topographic lows, generally inset within older eolian deposits. Sparse vegetation. Contacts with neighboring units are characteristically gradational. Occurs primarily downwind of Qaer east of Green Mountain on San Miguel Island. Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This unit appears on San Miguel Island.

Qye - Young eolian sand deposits (Holocene and latest Pleistocene)

Pale brown, moderately sorted to well-sorted, fine- to medium-sand deposits range from active on a decadal to century basis to presently stabilized and inactive. Moderately cross-laminated, containing few clasts. Loose to slightly compacted. On imagery has slightly darker albedo than unit Qae. Locally contains remains of most recent human occupation middens. Roughly equivalent to older range of unit Qeh of Muhs and others (2018). Sparsely vegetated with grasses, yellow bush lupine (*Lupinus arboreus*), saltgrass (*Distichlis spicata*), and coastal goldenbush (*Isocoma menziesii*). Gradational contacts with neighboring units. Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This unit appears on San Miguel, Santa Cruz and Santa Rosa Islands.

Qyed - Young eolian sand dune deposits (Holocene and latest Pleistocene)

Dune deposits, locally including coppice dunes transported on a decadal to century basis. Commonly strongly cross-laminated. Steep, with lee and stoss slopes poorly to moderately well defined. Sparse vegetation. Gradational contacts with neighboring units. Deposits are common on San Miguel Island, and near Sandy and Carrington Points on Santa Rosa Island. Qyed supports denser growth of coyote bush (*Baccharis pilularis*) than Qoe. Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This unit appears on San Miguel, Santa Cruz and Santa Rosa Islands.

Qyer - Young eolian sand ramp deposits (Holocene and latest Pleistocene)

Ramp deposits on inclined ground surface, locally including coppice dunes transported on a decadal to century basis. Commonly strongly cross-laminated. Steep, with lee and stoss slopes poorly to moderately well defined. Dominantly eolian with minor component of coarser grained sediment transported from adjacent hillslopes by gravity and sheetwash. Commonly expresses wedge-shaped planform shape. Sparse to scattered vegetation. Gradational contacts with neighboring units. Deposits are common on northwest facing hillslopes along the coast of San Miguel Island west of Simonton Cove and east of Cuyler Harbor, as well as east of Sandy point at the northwestern tip of Santa Rosa Island. Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This unit appears on San Miguel and Santa Rosa Islands.

Qyes - Young eolian sand sheet deposits (Holocene and latest Pleistocene)

Low-gradient sheet and low-relief dunes of silt and fine to coarse sand covering gently inclined surfaces (Fryberger and others, 1979) transported on a decadal to century basis. Fine to coarse grained with ripples, gently dipping, poorly laminated horizons, traces of bioturbation, and small-scale cut-and-fill structures. Although small, sand-sheet veneer deposits are widespread through map area, most are too thin and small to depict at map scale. No soil development. Contrary to Qaes, occurs as low to moderate albedo on imagery. Differentiated from Qyer by presence on low angle, generally horizontal gently undulatory ground surfaces. Thinner with more diffuse boundaries than Qyed. Fills pre-existing topographic lows, generally inset within older eolian deposits. Generally covered by vegetation. Contacts with neighboring units are characteristically gradational. Occurs primarily as expansive sheets on Santa Rosa Island east of Cañada Lobos towards Carrington Point and as spatially limited sheets south of Cuyler Harbor on San Miguel Island southeast, downwind, of Qyer deposits. Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This unit appears on San Miguel Island.

Qie - Intermediate eolian sand deposits (late and middle Pleistocene)

Moderately to well cemented, well sorted, laminar to cross bedded, white to brown eolian silt and sand. Deposits range from 0.5 to 10's m thick. Upper section contains cumulic A horizon, midden remains, rhizoliths and minor calcified tree trunks. Contains carbonate-cemented eolianite in middle of sequence. Locally, basal 1 m composed of weakly cemented, brown and grey sands with multiple polygonal joint patterns. Includes deep, yellowish brown to reddish brown Bt horizon locally containing terrestrial snail shells (*Helimithoglypta ayresiana*). In some areas below Bt are characteristic rhizoliths of unknown tree

species with calcareous exterior and sand-rich core, and laminar, stage III Bk calcretes. Deposits conspicuously lack pisoliths of Qoea. Northwest paleo-winds generated high-angle foreset beds and top-set beds. Orientations of foreset beds locally indicate paleo-dune source that is presently nonexistent resulting from past sea-level fluctuations. Conspicuous throughout San Miguel Island with broad undulating surfaces and locally near Cañada Lobo on Santa Rosa Island. Incised by gullies indicative of seepage erosion with abrupt theater-shaped heads. Local, thin fire-oxidized horizons. Vegetation includes desert saltgrass (*Distichlis spicata*), sand dune sedge (*Carex pansa*), chemise (*Adenostema fasciculata*), and scrub oak (*Quercus dumosa*). Contacts with older neighboring units gradational. Temporally overlaps with units Qey and Qes of Muhs and others (2018), with Qes being the inland facies of the lower part of Qey sequence. Locally hosts older human-derived shell middens in upper sequence. Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This unit appears on San Miguel, Santa Cruz and Santa Rosa Islands.

Qied - Intermediate eolian sand dune deposits (late and middle Pleistocene)

Dune-shaped deposits of moderately to well cemented, well sorted, laminar to cross bedded, white to brown eolian silt and sand with characteristics similar to Qie. Dunal morphologies include limited barchan and parabolic forms, more commonly sief or longitudinal. Present as moderate-relief mounds on Santa Rosa Island near Pocket Field, Cañada Soledad, Dry Canyon, and Skunk Point. Present on San Miguel Island west of Simonton Cover and Cuyler Harbor and at higher elevations on the flanks of San Miguel Hill. Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This unit appears on San Miguel and Santa Rosa Islands.

Qier - Intermediate eolian sand ramp deposits (late and middle Pleistocene)

Ramp deposits on inclined ground surface of moderately to well cemented, well sorted, laminar to cross bedded, white to brown eolian silt and sand with characteristics similar to Qie. Primarily present on Santa Rosa Island from Sandy Point to Arlington Canyon and between Castle Rock and Simonton Cove and San Miguel Island. Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This unit appears on San Miguel, Santa Cruz and Santa Rosa Islands.

Qoe - Old eolian sand deposits (middle and early Pleistocene)

Deeply weathered, highly oxidized sand and silt. Sub-rounded to rounded quartz grains in degraded carbonate cement. Near ground surface, expresses A/Bt/Bk/C soil profile. Bt horizon of soils have well-developed clay films and Bk has stage III+ to V laminar K horizons. Stage V horizons include extensive brecciation and recementation, where Bk horizon is near present ground surface, deposit supports little vegetation growth. Does not contain Fe-rich spherical pisoliths. Generally, deposited upon marine bedrock platforms, b-p, underlies Qoea and may be partly coeval with unit, and can be capped by Qhav. Forms lower-relief mounds and broader expanses. Vegetation dominated by grasses, annuals, coyote bush (*Baccharis pilularis*), saltgrass (*Distichlis spicata*), coastal goldenbush (*Isocoma menziesii*), and chamise (*Adenostoma fasciculatum*). At basal contact unit can contain centimeter to decimeter thick coquina of Marine Paleontologic Marker Bed including shell hash with some intact, articulated bivalve shells. Possibly correlative, over unknown time interval, with QToe. Deposits generally occur at elevations above ~100 m with notable presence south of Sandy and Carrington Points on Santa Rosa Island and on Santa Cruz Island. Description from source map: [Channel Islands Quaternary Surficial](#)

[Geology](#)

This unit appears on Anacapa, San Miguel, Santa Barbara, Santa Cruz and Santa Rosa Islands.

Qoec - Old eolian cemented sand deposits (middle and early Pleistocene)

Strongly cross-bedded, highly cemented sub-rounded to rounded sand comprising erosionally resistant eolianite. Composition ranges from i) quartz grains in carbonate cement devoid of macroscopic marine shell fragments to ii) dominantly composed of cemented calcium carbonate sand forming (Bee Canyon, South Road between Wreck and San Augustin Canyons, and Carrington Point on Santa Rosa Island). Appears as high albedo spectra on remotely sensed imagery. Does not contain pisoliths. Typically observed directly overlying basal marine platform forming erosional unconformities (b-p). Generally underlies Qoea and may be partly coeval with unit. Forms resistant coastal cliffs and steep QIs-DS headscarps. Vegetation dominated by grasses, annuals, coyote bush (*Baccharis pilularis*), saltgrass (*Distichlis spicata*), coastal goldenbush (*Isocoma menziesii*), and chamise (*Adenostoma fasciculatum*). At basal contact unit commonly contains centimeter to decimeter thick coquina of Marine Paleontologic Marker Bed including shell hash with some intact, articulated bivalve shells. Possibly correlative, over unknown time interval, with QToe. Eolianites generally occur at elevations above ~100 m. High degree of cementation is primary characteristic to differentiate from Qoe. Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This unit appears on San Miguel Island.

Qoed - Old eolian sand dune deposits (middle and early Pleistocene)

Dune-shaped deposits of strongly cross-bedded, highly cemented sub-rounded to rounded sand in erosionally resistant eolianite with characteristics similar to Qoe. Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This unit appears on Santa Cruz Island.

QTe - Very old eolian sand deposits (early Pleistocene and Pliocene?)

Cross-bedded eolianite with massive to thinly bedded whitish micritic eolianite, sandy biomicrite, and sandy biomicroparite, well-cemented with carbonate, with low proportions of quartz grains. Eolianite is typically capped by pronounced vertisol (Qhav). Stratigraphically below eolianite lies a very fine to coarse facies coquina (Marine Paleontologic Marker Bed) including shell hash with some intact, articulated bivalve shells and rounded gravel and cobble gravel diagnostic of shallow water marine and nearshore environment. The coquina has generally medium to coarse sand sized carbonate fragments and shell fragments; friable with low to moderate density. Previously identified as the Potato Harbor Formation (Weaver and Meyer, 1969). Limited to exposures in a few locations on the northeast tip of Santa Cruz Island between Potato Harbor and Cavern Point (Muhs and others, 2018). Possibly correlative, over unknown time interval, with Qoe. Mapped outcrops have an aerial extent totaling ~1km² at elevations of ~100 m overlaying steep sea cliffs. Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This unit appears on Santa Cruz Island.

Mixed eolian and alluvial deposits

Qyea - Young mixed eolian and alluvial deposits (Holocene and latest Pleistocene)

Young deposits of eolian sand interstratified with lenses of alluvial fan deposits transported on a decadal to century basis. Lithologically and morphologically similar to unit Qye, mainly consisting of loose, fine to medium sand with faintly defined to well-defined, thin cross bedding; sparse gravel. Forms broad, undulating surfaces with indistinct bar-and-swale topography. Prone to surface modification by eolian sediment transport and bioturbation. Generally occurs in distal depositional environment. Soil development absent to poorly developed. On aerial photographs appears slightly less bright than unit Qye. Sparsely vegetated, mainly with grasses and annuals. Gradational contacts with neighboring units. Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This unit appears on San Miguel, Santa Cruz and Santa Rosa Islands.

Qyae - Young mixed alluvial and eolian deposits (Holocene and latest Pleistocene)

Young alluvial deposits interstratified with lesser amounts of eolian sand transported on a decadal to century basis. Lithologically and morphologically similar to unit Qya, consisting of loose to moderately compact gravelly sand with faintly defined to well-defined thin bedding. Forms broad, undulating surfaces with subdued bar-and-swale topography. Soil development absent to poorly developed, with sandy A horizon and Bw horizon. On aerial photographs appears slightly darker than Qae surfaces. Moderately vegetated, generally supporting grasses, annuals, California sagebrush (*Artemisia californica*), saltbush (*Atriplex semibaccata*), and coyote brush (*Baccharis pilularis*). Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This unit appears on San Miguel, Santa Cruz and Santa Rosa Islands.

Qyeao - Older young mixed eolian and alluvial deposits (early Holocene and latest Pleistocene)

Older young deposits of eolian sand interstratified with lenses of coarser alluvial deposits transported on a decadal to century basis. Lithologically and morphologically similar to unit Qye, mainly consisting of loose, fine to medium sand with silt and clay, locally with faintly defined to well-defined, thin cross bedding; sparse gravel. Forms broad, undulating surfaces with indistinct bar-and-swale topography. Prone to surface modification by eolian sediment transport. Soil development absent to poorly developed. Locally oxidized. On aerial photographs appears slightly less bright than unit Qye. Sparsely vegetated, mainly with grasses, annuals, and creeping, mat-forming succulent species. Contacts with neighboring units are typically gradational. Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This unit appears on Anacapa and San Miguel Islands.

Qiea - Intermediate mixed eolian and alluvial deposits (late and middle Pleistocene)

Moderately sorted to well-sorted eolian sand with minor lenses of alluvial, poorly sorted to moderately sorted silt, gravel, cobbles transported on a century to millennial basis. Surface composed of moderately sorted to well-sorted sand with dispersed subangular to subrounded clasts that coarsen up valley. Locally contains low concentrations of pisoliths, with sandy matrix support, redeposited from nearby

eroded Qoea deposits. Somewhat loose from accumulation of eolian sand. Alluvial deposition on surfaces abandoned for thousands of years; flattened by diffusive processes and devoid of bar and swale topography. Partly incised by narrow channels, with younger surfaces inset into the edges. Moderately developed to well-developed soil profile. Moderately vegetated, typically supporting grasses, annuals, coyote brush (*Baccharis pilularis*), and California sagebrush (*Artemisia californica*). Contacts with older neighboring units gradational. Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This unit appears on San Miguel, Santa Barbara, Santa Cruz and Santa Rosa Islands.

Qiae - Intermediate mixed alluvial and eolian deposits (late and middle Pleistocene)

Alluvium interstratified with lesser amounts of eolian sand transported on a century to millennial basis. Poorly to moderately sorted mixtures of silt, gravel, cobbles, and boulders, interstratified with moderately sorted to well-sorted sand. Outcrop surfaces light grey-brown, shade varying with sediment composition and thickness of varnish. Clasts mostly subangular to subrounded, and coarser toward mountain fronts. Typically compact but can be somewhat loose from influx of eolian sand. Lithologically and morphologically similar to unit Qia, with the addition of eolian sand throughout. Sparse coppice mounds and small dunes, locally producing hummocky terrain. Channel density is low to moderate, with younger surfaces inset into the edges. Moderately developed to well-developed soil profile, with sandy A, Bt and Btk. Calcic accumulation in the Bk horizon stage I+ to II. High-albedo on imagery. Moderately vegetated, generally supporting grasses such as *Distichlis spicata*, and *Stipa* as well as annuals and coastal goldenbush (*Isocoma menziesii*). Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This unit appears on Anacapa, San Miguel, Santa Barbara, Santa Cruz and Santa Rosa Islands.

Qoea - Old mixed eolian and alluvial deposits (middle and early Pleistocene)

Deeply weathered, highly oxidized sand and silt. Well-developed pedogenic development exhibiting an A/E/Bt/Bk/C profile that where intact can be up to 2-3 m thick. Referred to as the "Green Mountain Soil" by Johnson (1972) and unit Qeo of Muhs and others (2018). Fe-rich, roughly spherical, gravel-sized pisolites characteristically present in the lower A horizon as well as parts of the E and upper Bt horizons. Bt horizon exhibits well-developed clay films on prismatic or columnar peds. Bk horizons can be as advanced as stage III to IV with laminar calcium carbonate formations. As unit is present over much of San Miguel Island, but does not occur on lower pre-last interglacial complex (MIS 5) marine terrace, dated to ~120,000 yr by Muhs and others (2014a), the unit is likely older than ~120,000 yr. Presence of in situ pisolites in upper ~0.5-1 m of deposit is diagnostic. Pisolites are locally present as lag deposit on ground surface where unit is being eroded. Possibly correlative, over unknown time interval, with QToe. On San Miguel Island near Tyler Bight and the western flank of San Miguel Mountain, Qoea is observed to rest stratigraphically above Qoe. Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This unit appears on San Miguel, Santa Cruz and Santa Rosa Islands.

Qoae - Old mixed alluvial and eolian deposits (middle and early Pleistocene)

Pale grey to reddish brown, moderately cemented, crudely stratified cobbly gravelly sand. Clasts moderately to well rounded present in concentrated discrete horizons to matrix support. Well-developed

pedogenic development exhibiting an A/E/Bt/Bk/C profile that where intact can be up to 2-3 m thick. Deeply weathered and highly oxidized within soil profile with abundant reddish brown sandy clayey silt. Darker color likely results from abundant input of terrigenous material. Locally present over b-p with no underlying older eolian stratigraphy. Exposures generally limited except in badlands-like gullies. Possibly correlative, over unknown time interval, with QToe. Distributed over San Miguel Island and northern half of Santa Rosa Island. Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This unit appears on Anacapa, Santa Cruz and Santa Rosa Islands.

Beach deposits

Beach deposits are unconsolidated sediments located in the zone that extends from the uppermost limit of wave action to the low-tide line. An abrupt change in surface gradient and material composition commonly occurs at the landward limit. Map extents perpendicular to the shoreline are inherently narrow, meters to tens of meters, but form long, semi-continuous pocket beaches to continuous beaches. Transport processes are dominated by tidal fluctuations, currents, and waves, but are accompanied by wind, storm surges, and biogenic processes. Materials range greatly in size, shape, and composition with seasonal temporal variations. Sediment sources range from locally derived to extralimital transported long distances by long-shore currents. Sand fractions tends to be composed of quartz and feldspar whereas coarser grains express a range of rock types but are dominated by island-sourced rocks. Marine biogenic or skeletal material generally accounts for a small volumetric contribution.

Text from source map: [Channel Islands Quaternary Surficial Geology](#)

Qab - Active beach deposits (latest Holocene)

Weakly bedded, well-sorted, well-rounded, undifferentiated grain sizes but commonly includes compact sand with clasts up to boulder in size. Locally salt rich. Transported on a daily to annual basis. Forms broad, extensive, slightly graded edges of marine tidal zones that have received water and sediment from marine and terrestrial sources on a bi-diurnal cycle. Deposits have undergone seasonal flooding and drying cycles, with associated sediment expansion and shrinkage; locally may also show displacive growth of salt crystals. Subject to eolian erosion, reworking, and deposition when dry. Thin to thick subhorizontal bedding. High to very high-albedo in imagery. Generally lacks or has sparse vegetation. Within roughly 2 m vertically of mean sea level. Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This unit appears on Anacapa, San Miguel, Santa Barbara, Santa Cruz and Santa Rosa Islands.

Qabs - Active sandy beach deposits (latest Holocene)

Sandy facies of beach that typically supports sparse vegetation, generally near upslope margin of beach slightly above mean sea level where sediments are reworked on a monthly to annual basis by eolian transport when dry. Locally exhibits symmetric ripples at surface. Plan view profiles may exhibit a smooth "sine curve" to peaked giant cusps at the apex protuberances with intervening areas smoothly curved. Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This unit appears on Anacapa, San Miguel, Santa Barbara, Santa Cruz and Santa Rosa Islands.

Qabf - Active beach fringe deposits (latest Holocene)

Poorly sorted to moderately sorted sand and silt, with minor amounts of cobbles, gravel, and clay in the back-beach area. Loose and unconsolidated. Surface is undulating, with indistinct bar-and-swale topography. Locally inclined as sand ramp is blown by eolian transport onto adjacent hillslopes and sea cliffs. Can display asymmetric ripples on surface. Prone to frequent surface modification by eolian sediment transport; less frequent high tide, flooding, and alluvial modification. May include groundwater-discharge and salt deposits. No soil development. High-albedo on imagery. Locally mud-cracked; may have linear fissures or mounds that support vegetation. Vegetation dominated by grasses, with few shrubs and accompanying coppice mounds. Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This unit appears on San Miguel, Santa Cruz and Santa Rosa Islands.

Qybf - Young beach fringe deposits (Holocene and latest Pleistocene)

Poorly sorted to moderately sorted sand and silt, with minor amounts of cobbles, gravel, and clay. Loose and unconsolidated. Surface is undulating, with indistinct bar-and-swale topography. Has not received flooding or alluvial deposition in hundreds of years. May include mass wasting deposits derived from upslope erosion of adjacent cliffs. Prone to frequent surface modification by tidal sediment transport. Minor dissection of surface by stream channels. Little to no soil development. Mixed low to high albedo spectra on aerial photography. Moderately well vegetated; typically supporting grass. Present as narrow bands under other units near Cuyler Harbor on San Miguel Island. Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This unit appears on San Miguel, Santa Cruz and Santa Rosa Islands.

Lagoonal deposits

A lagoon is a semi-enclosed coastal body of water that is openly connected with the ocean within which sea water is measurably diluted with fresh water derived from upslope terrigenous drainage. Water is typically shallow and low energy resulting in organic-rich fine-grained deposits transported by wind, currents, storm surges, and bioturbation including worms, gastropods, and arthropods. Sediment sources are fine-grained material composed of aggregated organic and inorganic particles sourced from both land and sea. Sedimentary structures include discontinuous wavy to parallel laminations to continuous laminations and thin bedding with local biogenic structures.

Text from source map: [Channel Islands Quaternary Surficial Geology](#)

Qal - Active lagoon deposits (latest Holocene)

Interbedded supratidal mud, silt, and fine sand, including evaporite, carbonate, and siliciclastic material. Formed near coastal dune fields and in embayments. Organic rich with dark color. Deposited in a swampy environment accumulating abundant silt and fine sand transported by wind and trapped by previously deposited sediment and vegetation moistened by groundwater discharge in an area experiencing mixing of fresh and salt water. Located just up gradient of, and within, area inundated by mean sea level. Adjacent salt marshes are spatially limited. Generally contains sparse marine fossils,

local tidal vegetation, fish, shellfish, and shorebirds. Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This unit appears on Santa Cruz and Santa Rosa Islands.

Qil - Intermediate lagoon deposits (late and middle Pleistocene)

Interbedded supratidal mud and fine sand and siliciclastic material. Organic rich with dark color. If Qal depositional environment is diagnostic, likely deposited in swampy area with abundant silt and sand transported by wind, groundwater discharge, and waves in an area experiencing mix of fresh and salt water. Lone mapped deposit located near Abalone Rocks on east coast of Santa Rosa Island, just upslope of area inundated by present Qal. Deposit dated at ~37ka by luminescence techniques. Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This unit appears on Santa Rosa Island.

Paludal deposits

Qyp - Young paludal or marsh deposits (Holocene and latest Pleistocene)

A minimum of 2m of sub-mm to mm scale laminations of silt and clay with abrupt horizontal contacts to fining upward sequence of silty sand and sandy silt to homogenous silt and clay. Charcoal grey to brownish root beer in color with pronounced mottling and oxidization. Abundant ped faces in upper silt and clay. Low to high organic content. Where organic rich, present as thinly bedded horizons. Sharp boundary between cumulic A horizon and underlying weak Bt. Polygonal structure from shrink swell of clays. Locally contains floating fragments of underlying bedrock in fine matrix. Locally capped by Qhav. Likely very shallow water, not massive clay or mud, deposited in wetland or meadow environment with denser veg and wet ground surface with frequent annual wet and dry cycles. Adjacent to Santa Cruz Island fault, contains oxidized fire horizon with abundant charcoal at ~1m depth. Exposure south of Smuggler's Cove on Santa Cruz Island contains ungulate bones. Exposure on western San Miguel Island, used as a dirt airstrip, gave a minimum radiocarbon age of 1636±40 yrs cal BC (sample KSSMI-18-1a). Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This unit appears on San Miguel and Santa Cruz Islands.

Groundwater discharge deposits

Qag - Active groundwater-discharge deposits (latest Holocene)

Poorly to moderately consolidated, white, gray, and very pale brown calcareous, siliceous, and gypsiferous deposits; slightly domal, lacking identifiable spring craters. Commonly contains minor amounts of eolian sand or silt and finely disseminated organic matter. Nodular calcite, authigenic silica, and gypsum in sediments. Authigenic gypsum generally consists of scattered, sand-sized lenticular grains set in a cryptocrystalline matrix. Cylindrical casts and molds derived from the roots and stems of in-situ plants, such as vines, are locally abundant. Local moss and lichen. Locally forms broad, flat deposits with some algal mats. Deposits overlie valley floor alluvium and (or) bedrock. Well vegetated. Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This unit appears on Anacapa, San Miguel, Santa Cruz and Santa Rosa Islands.

Qyg - Young groundwater-discharge deposits (Holocene and latest Pleistocene)

Poorly to well consolidated, white, gray, and very pale brown to yellow calcareous, siliceous, and/or gypsiferous deposits; slightly domal, generally lacking identifiable spring craters. On steeper ground, slope parallel deposits. Thin travertine-like to sheets with iridescent sheen common. Commonly contains minor amounts of eolian sand or silt and finely disseminated organic matter in addition to denser, more hydrophilic vegetation. Appears light to dark green on imagery. Incorporated rounded clasts from nearby alluvium common. Authigenic gypsum generally consists of scattered, sand-sized lenticular grains set in a cryptocrystalline matrix. Deposits overlie valley floor alluvium and (or) bedrock. Cement can be rooted into fractures of underlying bedrock. Numerous rhizoliths consistent with near surface deposit. Present in northern Cuyler Harbor associated with palm trees and along Santa Rosa Island fault. Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This unit appears on Santa Cruz Island.

Hillslope deposits

Hillslopes deposits are detached rock fragments, regolith, and other surficial deposits, generally <2 m, underlain by rock and saprolite. Deposits consist of zones of mechanically and chemically weathered rock or materials transported short distances by gravity and flowing water. They cover mountainous regions where slopes are steep (usually >3° degrees), significant sediment has not accumulated, and bedrock typically crops out. Thicker, aerially consistent units were distinguished as colluvium.

Text from source map: [Channel Islands Quaternary Surficial Geology](#)

Qha - Abundant hillslope deposits of entisol order soil (Holocene and late? Pleistocene)

Miscellaneous poorly dated hillslope materials (colluvium, talus, regolith, and landslide deposits) that are generally <2 m thick but cover more than half of the areal bedrock surface. Composed dominantly of mineral soils with few organics and no or poorly formed soil horizons characteristic of entisol order soil where material is largely unaltered from parent material, forming only an A horizon. Locally contains minor inceptisols in areas of relative stability such as topographic concavities. Typically well mixed from bioturbation and gravitational transport, especially on slopes greater than 20°. More widely prevalent on slopes less than 20° with a northerly aspect. Minor continuous deposition of new parent material by wind and water. Clasts derived from shale bedrock generally smaller in diameter and more subangular compared to other bedrock types. Locally has meter-scale sinkholes when overlying erodible bedrock. Patchy bedrock outcrops are exposed in remainder of area. Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This unit appears on Anacapa, San Miguel, Santa Barbara, Santa Cruz and Santa Rosa Islands.

Qhav - Abundant hillslope deposits of vertisol order soil (Holocene and late? Pleistocene)

Poorly dated, lower gradient hillslope materials generally <2 m thick but cover more than half of the areal bedrock surface. Characterized by dark organic vertisolic soils with abundant swelling clays. Forms soft, fluffy soils, with conspicuous, through-going sub-vertical cracks, when dry and highly plastic when wet.

Annual shrink/swell action prevents formation of well-developed soil horizons, resulting in a deep A horizon and no B horizon. As cracks likely stay open for at least 90 cumulative days per year, soil classified as ustert sub order. Most common in areas of fine-grained parent materials such as dark, organic-rich loess deposits, or fine-grained bedrock such as marine mudstone, shales, and siltstones. May also develop by dissolution of underlying carbonate-rich material such as QTe. Common in grasslands. Organic vertisol soils typically less than 1 m thick. Patchy bedrock outcrops are exposed in remainder of area. Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This unit appears on San Miguel, Santa Cruz and Santa Rosa Islands.

Qhs - Sparse hillslope deposits of entisol order soil (Holocene and late? Pleistocene)

Miscellaneous poorly dated hillslope materials (colluvium, talus, regolith, and landslide deposits) that are generally <2 m thick but cover less than half of the areal bedrock surface. Composed of mineral soils with no or poorly formed genetic soil horizons. Material is largely unaltered from parent material forming an A horizon. Locally contains minor inceptisols in areas of relative stability such as topographic concavities. Typically well mixed from bioturbation and gravitational transport, especially on slopes greater than 20°. More prevalent on slopes with a southerly aspect. Clasts derived from shale bedrock generally smaller in diameter and more subangular compared to other bedrock types. Patchy bedrock outcrops are exposed in remainder of area. Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This unit appears on Anacapa, San Miguel, Santa Barbara, Santa Cruz and Santa Rosa Islands.

Colluvial deposits

Accumulations of sediment along valley margins and within low-order, narrow drainage networks extending up hillsides above valley bottoms. Accumulates via unconcentrated and poorly channelized hillslope processes of slope wash, mass wasting, and downhill soil creep in response to gravity.

Text from source map: [Channel Islands Quaternary Surficial Geology](#)

Qyc - Young colluvial deposits (Holocene and latest Pleistocene)

Poorly sorted, sand and gravel containing clasts as large as boulders, derived from nearby areas upslope, that are typically angular. Deposits massive to very poorly bedded and loose to moderately compact. Mapped colluvial deposits mostly thicker than 2 m and covering a wide area; exact age undetermined. Poor to moderate soil development, generally increasing with abundance of fine-grained sediment and weathering products including clay. Landforms range from steep talus slopes to concave-up colluvial aprons that grade into alluvial fans (Qya). Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This unit appears on San Miguel, Santa Cruz and Santa Rosa Islands.

Qic - Intermediate colluvial deposits (late and middle Pleistocene)

Poorly sorted, silt and clay-rich sand and gravel containing clasts as large as boulders, derived from nearby areas upslope, that are typically angular. Deposits massive to very poorly bedded and loose to

moderately compact. Locally includes accumulations of weathering products including clay. Mapped colluvial materials thicker than 2 m and covering a wide area; exact age undetermined. Generally smooth deposit surfaces that are sharply incised by gullies. Soil development appears to be greatest where original deposit contains abundant silt and clay. Clast composition reflects that of rocks and sediments lying directly uphill. In some areas, deposits form steep slopes. Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This unit appears on Anacapa, Santa Cruz and Santa Rosa Islands.

Mass wasting deposits

QIs-SS - Shallow-seated landslide deposits and scarps (Holocene)

Material transported downslope under the influence of gravity less than 5-m, typically 0.5-1.5 m, thick composed dominantly of regolith. Unit encompasses both short-travelled debris slides and long-travelled debris flows that entrained material residing in the downslope valley drainage network. Planform shapes are tear-dropped to long and narrow. Ages are likely <100 years to modern and activity levels tied to large magnitude storm hydrology such as those occurring in 1969, 1977/1978, and 1997/1998 (e.g., Campbell, 1975; Renwick and others, 1982; Pinter and Vestal, 2005). Commonly located on steep slopes near drainage divides at tips of channels networks and are locally included within Qac polygons where too small to map individually. Actual numbers and distribution of features not accurately represented as individual slides are small in size. Where mapped, source and deposit are not distinguished individually; locally mapped as assimilation of multiple slides. Scattered location on Santa Cruz and Santa Rosa Islands. Typically little to no vegetation excluding grasses. Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This unit appears on Anacapa, San Miguel, Santa Barbara, Santa Cruz and Santa Rosa Islands.

QIs-DS - Deep-seated landslide deposits and scarps (Holocene and Pleistocene)

Material transported downslope under the influence of gravity greater than 5-m thick composed of both regolith and bedrock. Transport displaces original surface morphology into large, steep scarps at the top, back-rotated blocks in the body, and transverse ridges and radial cracks in the distal toe. Scarps depicted as individual or en echelon arcs. In the zone of accumulation, material displaced by landslide over-rides original ground surface (Cruden and Varnes, 1996). Horizontal transport distances typically less than vertical height. Mode of sliding ranges from rotational, with a concave-upward profile in the body and convex-upward profile in the toe, to translational with a more linear upward longitudinal profile. Prominent internal scarps depicted as hachured curvilinear line. Planform shapes are roughly circular to oblate. Ages and activity levels variable with failure induced by both hydrology (e.g., Renwick and others, 1982; Pinter and Vestal, 2005) and earthquake strong-ground motions (e.g., Woolley, 1994). Some mapped slides have deeply incised gullies aligned parallel with lateral landslide margins. A dense concentration exists along the shoreline on the isthmus east of Prisoners Harbor on Santa Cruz Island, above Cuyler Harbor on San Miguel Island, as well as numerous inner-gorge translational landslides located between Arlington and Verde Canyons on Santa Rosa Island. In addition, numerous deep-seated landslides are preferentially located along the Santa Rosa Island fault where hillslopes have been steepened and material likely weakened by tectonic fracturing and other fault-related damage. Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This unit appears on Anacapa, San Miguel, Santa Barbara, Santa Cruz and Santa Rosa Islands.

Marine terrace deposits

QTmt - Marine paleontologic marker bed (Pleistocene to late Pliocene?)

Largely marine-facies sediment consisting of generally light-gray to whitish calcareous clay to coarse sand and gravel containing invertebrate and vertebrate fossils. Locally includes conspicuous coquina beds, weakly to moderately well-cemented with carbonate, generally < 1m thick. Species include bivalves (*Epilucina californica*) and gastropods (*Callianax biplicata*)(formerly *Olivella biplicata*). Deposits directly overlie varying age wave-cut platforms (b-yp and b-op) that extend from the exposed outer edge (typically cliff face or seacliff) landward to the back edge (shoreline angle). Mapped active wave-cut platforms (b-ap), present along the modern shorelines, generally lack any significant marine deposits due to stripping by wave and surf action. Marine deposits, at most a few centimeters to decimeters thick, denoted as red marker bed associated with marine bedrock platform (b-yp and b-op), not distinct polygons. Deposits unconformably overly eroded bedrock with low-angle planar surface representing the surf-cut terrace but are conformable with overlying terrestrial (mostly alluvial) deposits. Locally marine deposits adjacent to shoreline angles commonly interspersed with coarse colluvial talus aprons from adjacent paleo seacliffs. Clasts are more well-rounded than fluvial deposits, with coarse boulder lag of extra-limital rock types commonly at termination of wave-cut terrace at back edge defining shoreline angle. Characteristically grades upwards into calcareous eolianite (Qie). Ichnofossils are common in the form of pholad-like borings in gravel clasts, shells, and basal bedrock platform, roughly a centimeter or to up to many cm in diameter. Different Mollusca species form various-shaped holes in rock with tear-drop shaped holes formed by pholads (family Pholadidae) and more elongate holes likely made by Lithophagids (family Mytilidae). Some rounded depressions in the rock could also be generated by sea-urchins (phylum Echinodermata). Present echinoderms, observed in unit b-ap, generate depressions in the intertidal zone include *Strongylocentrotus purpuratus* and *S. franciscanus*. Presence, elevation, and magnitude of marine deposits and platforms related to global eustatic changes in sea level as well as local and regional tectonic base-level adjustments (e.g., Muhs and others, 2004; Muhs and Groves, 2018). Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This unit appears on Santa Barbara, Santa Cruz and Santa Rosa Islands.

Bedrock

Tb - Bedrock substrate materials (Tertiary)

Bedrock substrate materials that are shallowly buried. Includes partly consolidated sedimentary materials that underlie surficial deposits and pediment and hillslope veneers. Ages range from Pliocene to Eocene. Bedrock data derived from several sources, primarily Dibblee (1982, 1998), Nuccio (1977), Nuccio and Wooley (1998), Orr (1960), Weaver (1968), Woolley (1994, 1998a, 1998b). Combined, simplified unit includes: Beechers Bay "Formation" composed of volcanic andesitic and basaltic clasts, intermediate to basic in composition, from marine volcanism and marine sediments. Synchronous with deposition of Monterey Formation sediments, but typically much coarser facies proximal to volcanic source. Magnetic susceptibility of enclosed basaltic clasts generally < 1, up to 2.5 10⁻³ SI. Also composed of erosionally resistant sandstone beds that form broad topographic knolls, locally with Island oaks. San Onofre Breccia characterized by diagnostic blue schist clasts in dark gray, bedded conglomeratic sedimentary deposit. Other clasts include basalt, andesite, dacite, greenschist, and lesser amounts of diorite and mafic amphibolite and gneiss. Monterey Shale composed of shale and sandstone beds that may display tafoni weathering structures of ellipsoidal, pan- to bowl-shaped, natural rock cavities common along coastal environments where salt weathering is accentuated. Typically found on inclined or vertical surfaces and occur in groups. San Miguel Volcanics dominated by vesicle-rich andesite likely representing sub-aerial or low-water depth eruptions. Locally resembles dirty well-sorted greywacke with slightly oxidized buff color. Some soils derived from unit are mollisols reflecting greater proportion of fine material and more organic content. Rincon Shale with marine clastic poorly to

moderately lithified clay shale and siltstone. Some beds are fossiliferous with large oyster shells. Highly susceptible to erosion with dense concentration of deeply incised gullies. Some large deep-seated landslides at contact with Vaqueros sandstone. Vaqueros sandstone is shallow marine clastic that includes fine-grained gray sandstone with local claystone, siltstone, and pebbly fossiliferous strata including large oyster shells. Is more resistant to erosion than Rincon Shale. Sespe Formation is terrestrial fluvial sandstone with diagnostic, contrasting colors of brown, red, pinkish to greenish. Weakly lithified with high susceptibility to erosion. Cozy Dell Shale is marine clastic bedded gray clay. South Point Sandstone is marine, well-lithified clastic hard, fine-to-medium grained arkosic sandstone. Correlative with Coldwater Formation on mainland. White, well-sorted, massive sandstone beds with thin siltstone horizons. Local hard concretions of sandstone. Resistant to erosion. Forms rocky Carrington Point. Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This unit appears on San Miguel, Santa Cruz and Santa Rosa Islands.

Ts - Sedimentary rocks (Miocene)

Marine(?) tuffaceous(?) siltstone and shale; locally calcareous(?) on Santa Barbara Island. Finer grained than unit Tt. Sedimentary rocks are whitish to light gray in color. Unit forms inter-volcanic flow layers and lenses, locally contorted, as much as about 5-10 m thick within map unit Tv. Exposed in sea cliffs on Santa Barbara Island to north between Shag Rock and East Mound 2 and at the southern tip of the island is truncated by northeast striking fault. Mapped separately only where thick and continuous enough to depict at map scale. Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This unit appears on Santa Barbara Island.

Tso - San Onofre Breccia (Miocene)

Conglomerate and sedimentary breccia on Anacapa Island. Pale grayish green and bedded. Clasts, angular to subrounded, range from pebbles to boulders. Compositionally clasts are exotic, including conspicuous blue schist and glaucophane schist that are diagnostic of the San Onofre. Breccia and conglomerate have been correlated with the San Onofre Breccia of Norris (1995) by Scholl (1960) and Dibblee (2001). Unit forms interflow layers and lenses as much as about 10 m thick within stratigraphically higher part of map unit Tv, mapped separately only on south rim of Middle Anacapa Island and above Cathedral Cove on East Anacapa Island where thick and continuous enough to depict at map scale. Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This unit appears on Anacapa Island.

Tv - Volcanic rocks (Miocene)

Intermediate-composition (basaltic to andesitic) lava flows and breccias with subordinate lenses and layers of volcanoclastic and tuffaceous sedimentary rocks. Lavas are gray, weather to shades of tannish-, brownish-, and reddish-gray, phyrlic to aphyric, partly vesicular, massive to flow-foliated, and locally intensely brecciated and (or) fractured. Phenocrysts are dominantly plagioclase. Some lava intervals are pervasively brecciated. Interflow volcanoclastic layers are generally composed of angular, locally derived clasts and debris of lava in a gravelly, sandy to silty matrix. Interflow tuffaceous sedimentary layers in unit are the same as described for map units Tt and Ts but are too thin and localized to map separately. Lavas and breccias commonly exhibit cavernous weathering and form caves at the base of sea cliffs,

especially where cut by faults. Unit mainly exposed and mapped in sea cliffs on island perimeters. Lavas presumably erupted in a submarine environment. Lavas exposed on East Anacapa Island have $^{40}\text{Ar}/^{39}\text{Ar}$ ages ranging from about 15.8 to 16.3 Ma (Luyendyk and others, 1998). Unit is equivalent to the Santa Cruz Island Volcanics and/or Conejo Volcanics (Scholl, 1960; Dibblee, 2001). Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This unit appears on Anacapa and Santa Barbara Islands.

Tt - Tuffaceous sedimentary rocks (Miocene)

Marine(?) tuffaceous sandstones and siltstones with subordinate beds and intervals of conglomerate and sedimentary breccia on Anacapa Island. Tuffaceous sedimentary rocks are pale tan to grayish green and locally micaceous. Conglomerate and breccia are the same as described for the San Onofre Breccia map unit (Tso), but are included in the tuffaceous sedimentary unit where undifferentiated. Unit forms inter-volcanic flow layers and lenses as much as about 10 m thick within map unit Tv, mapped separately in sea cliffs only where thick and continuous enough to depict at map scale. Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This unit appears on Anacapa Island.

Erosional Surfaces

Along high-energy rocky coasts, marine terraces form as a result of coastal attack at the shoreline, local sea level, in times of relative stability (e.g., Dietz, 1963; Bradley and Griggs, 1976; Muhs and others, 2003). During sea-level high stands, coastal erosion by wave and surf action cut bedrock platforms and deposit marine sediment and fossils. Emergent terraces are comprised of inshore, steeply inclined sea cliffs and adjacent offshore low-gradient, planar marine bedrock platforms. The shoreline angle, located at the intersection of the former sea cliff base and the landward boundary of the wave- and surf-cut platform, denotes the paleo-sea level (Muhs and others, 2003; Muhs and Groves, 2018). Thin veneers of marine sediments, deposited directly upon bedrock platforms, are characterized by sequences of basal gravel, cobbles, and boulders fining upward to sand-supported granules, likely the infill zone of a paleo-gravel beach (Bluck, 1967; Postma and Nemec, 1990; Hart and Flint, 1995). Marine deposits typically grade upward into terrigenous alluvial and colluvial deposits. Inter-tidal marine faunal assemblages near the bedrock platform and well-sorted eolian sequences are locally present. As coastal California has a tectonically uplifting coast, terrace flights have differing elevations reflecting spatially and temporally variable uplift rates.

In map expression, the inner edge, upper elevation of bedrock platform boundary generally corresponds with the observed or inferred shoreline angle. Alternatively, the outer edge, lower elevation boundary is located some unknown distance downslope of the shoreline angle. Between inner and outer extents, areas incised by younger erosion denoted by units such as Tb, Tb (gullied), and Qls-DS. Areas topographically higher than inner edge of shoreline angle denote older landscapes above influence of marine erosion. Where composite map units denote an underlying Tb-yp (young marine wave-cut platform) or Tb-op (old marine wave-cut platform), those overlying units are generally thinner than 2 m, locally supported by field observations of Marine Paleontologic Marker Bed. Where overlying units are thick (> 2 m), bedrock platform not included in the composite map unit.

Terrigenous erosional surfaces are generally topographically steep and rugged where, in the extreme case, hillslope deposits are not preserved. In locations with more gentle topography hillslope deposits form abundant, thick cover. The detachment of sediment on inclined erosional surfaces occurs through a variety of processes including the kinetic energy of raindrop impact and by tractive forces of flowing

water, wind, or waves. Erosion, the entrainment or dissolving and subsequent removal of surficial or rock material, also occurs by wind, water, and biologic agents. Hillslope deposits are largely gravitationally transported, heterogenous assemblages of rock and soil, that have not been transported through any well-defined channel network system. They are typically located on lower gradient portions of the landscape and at base of eroding slopes.

Text from source map: [Channel Islands Quaternary Surficial Geology](#)

Active marine wave-cut platform (historic)

Planar, generally horizontal to gently inclined (0-5°) surface, actively beveled by marine wave and surf erosion, that is currently at or near modern mean sea level. Typically bounded on the landward side by a steeply ascending slope at the shoreline angle, indicating maximum sea ingression, and a gently descending slope on the seaward side. Platform erosion is active daily with a width is typically much narrower than Tb-yp (young marine wave-cut platform) units, ranging from meters to tens of meters. Only mapped in the intermittently exposed intertidal zone, therefore width much narrower than actual extent. May contain sparse, very thin (but unmappable) marine deposits composed of silt and sand to boulders with abundant to sparse marine fossils. Pholad and pholad-like borings within fine grained underlying bedrock or wave-abraded rounded clasts common to absent. Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This erosional surface appears on Anacapa, Santa Barbara, Santa Cruz and Santa Rosa Islands.

Marine wave-cut platform (Pleistocene to late Pliocene?)

Flat, gently inclined (< 5°) abandoned surface, beveled by marine wave erosion, that is currently meters to several hundred meters above modern mean sea level. Typically bounded on the landward side by a steeply ascending slope at the shoreline angle, indicating the shoreline location at time of maximum sea ingression, and a gently descending slope on the seaward side. Preserved platform width is variable from <1 to several kilometers. Older platforms covered by marine and/or alluvial or colluvial deposits and soils in various stages of maturity. In places directly overlain by sparse, thin marine deposits composed of fine-grained micritic (microcrystalline limestone) silt and sand with abundant to sparse well-rounded pebbles, cobbles, and boulders and marine fossils. Pholad and pholad-like borings within fine grained underlying bedrock or wave-abraded rounded clasts common to absent. Lower, younger marine platforms are common locations for archeologic sites.

On San Miguel Island, marine wave-cut platforms are subdivided into young and old platforms.

Young marine wave-cut platform (late Pleistocene) - Planar, gently inclined (0-5°) abandoned surface, beveled by marine wave and surf erosion, currently meters to tens of meters above modern mean sea level forming b-ap. Units correspond with marine isotope substage (MIS) 5 with ages of ~80, 100, and ~120 ka (Muhs and Groves, 2018). Typically bounded on the landward side above shoreline angle by a steeply ascending slope of b or Qhs/b, Preserved platform width is variable from tens to several hundred meters. Characteristically covered by mixed eolian, alluvial, and/or colluvial deposits that locally exceed 2 m thickness including soils in various stages of maturity. Deposits mantling unit range from active to intermediate. Upper extent extrapolated from observed locations using planar, gently inclined topography, hence uncertainty in the presence of a buried marine platform throughout the polygon's extent can be moderate. In places directly overlain by sparse, thin marine deposits composed of fine-grained micritic (microcrystalline limestone) silt and sand with abundant to sparse well-rounded pebbles, cobbles, and boulders and marine fossils mapped as Marine Paleontologic Marker Bed. Pholad

and pholad-like borings within fine grained underlying bedrock or wave-abraded rounded clasts common to absent. Common locations for archeologic sites including middens.

Old marine wave-cut platform (middle Pleistocene to late Pliocene?) - Planar, gently inclined (< 5°) abandoned surface, beveled by marine wave and surf erosion, that is currently meters to several hundred meters above modern mean sea level. Ages older than MIS 5.5 exceeding 130 ka (Muhs and Groves, 2018). Unit extent likely incorporates numerous generations of paleo-sea level highstands with insufficient evidence to map each individually. Preserved platform width is variable from <1 to several kilometers. Older platforms characteristically covered by marine and/or alluvial or colluvial deposits including soils in various stages of maturity that locally exceed 2 m thickness. Mantling deposits are dominantly intermediate and old in age. Majority of b-op extent extrapolated from observed locations using flat, gently inclined topography, hence uncertainty in the presence is great. Locally directly overlain by sparse, thin marine deposits composed of fine-grained micritic (microcrystalline limestone) silt and sand with abundant to sparse well-rounded pebbles, cobbles, and boulders and marine fossils mapped as Marine Paleontologic Marker Bed. Pholad and pholad-like borings within fine grained underlying bedrock or wave-abraded rounded clasts common to absent.

Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This erosional surface appears on Santa Barbara, Santa Cruz Islands.

Eolian deflation hollow (historic to Holocene)

Hemispherical erosional feature formed by wind concentrated on a portion of the landscape with entrainment and removal of substrate material. The resulting hollow or pit may be topographically closed or open along the downslope extent. Features range from meters to tens of meters in diameter with similar dimensions of vertical relief. Generally positioned in aligned clusters. Surfaces may be mantled by coarse lag detritus. Characteristically located within Qha and Qae/Qye/Qie deposits, but also incised into mechanically weak bedrock (Tb). Likely result from optimal topographic orientation of landscapes relative to prevailing wind patterns and changes in vegetation cover. Present in Pocket Field and east of Lobo Canyon on Santa Rosa Island as well as locally on San Miguel Island. Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This erosional surface appears on Santa Cruz and Santa Rosa Islands.

Gully (historic to Holocene)

Linear erosional feature of local scour and incision concentrated within well-defined channels formed by running water and entrainment of grains oriented parallel to the steepest hillslope gradient. Depth of incision ranges from small rills at centimeter to decimeter scale to large gullies up to many meters wide and deep. Valley walls are steep that may be incised into underlying bedrock. Although the cross-sectional shape of the incision is influenced by relative strength of the material, most gullies exhibit a sharp V-shaped profile. Gullies in cohesive material (e.g., Qie and Qiea) tend to develop near vertical walls resulting from undermining and collapse of banks, assuming a more U-shaped profile. Characteristically located within Qha, but also in areas of concentrated incision into mechanically weak bedrock (b). Within hillslope deposits, primarily formed within entisols, but also vertisols. Upslope extent may correlate with either severe sheet erosion or within slight topographic concavities or hollows where both surface and subsurface water flow is focused. Map unit Qhag present on steep, locally rocky hillslopes and is distinguished from Qac by a lack of continuity with downslope valley fluvial network as well as a more linear outcrop pattern. Likely promoted by pronounced grazing pressures, changes in

vegetation cover, and infiltration capacity of surface deposits. Pronounced on Santa Rosa Island near Clapp Springs and between China Camp and Jolla Vieja Canyon, as well as, on Santa Cruz Island i) between Kinton Point and Rugged Mountain and ii) north of the Santa Cruz Island fault near Christy Ranch and locally on San Miguel Island at Simonton Cove and between Crook and Cardwell Points. Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This erosional surface appears on Anacapa, Santa Barbara, Santa Cruz and Santa Rosa Islands.

Surface erosion (historic to Holocene)

Planar to tear-shaped erosional scour feature formed by flowing surface water and entrainment of grains oriented parallel to the steepest hillslope gradient. Generally forms by unchannelized sheet flow over both cohesive and non-cohesive materials on steeper topography. Characteristically located within Tb, but also present in areas of concentrated incision into more competent surficial materials. Planform shape may resemble Qls, but source area is not formed by landsliding and no landslide deposit exists. Differs from Qhs in planform shape and reflects concentrated transport and removal of surface units. Differs from Qhag and Qhsg as erosion results in more surface lowering than channelized gully incision. Thin to no cover by surficial sediment. Likely promoted by pronounced grazing pressures, changes in vegetation cover, and infiltration capacity of surface deposits. Bedrock surface erosion (Tb with surface erosion) present on steep, south flanks of West Anacapa Island, Santa Rosa Island near South Point and west of East Point, and Santa Cruz Island between Alberts and Middle Anchorages and in southwest part of island. Description from source map: [Channel Islands Quaternary Surficial Geology](#)

This erosional surface appears on Anacapa, Santa Barbara, Santa Cruz and Santa Rosa Islands.

Ancillary Source Map Information

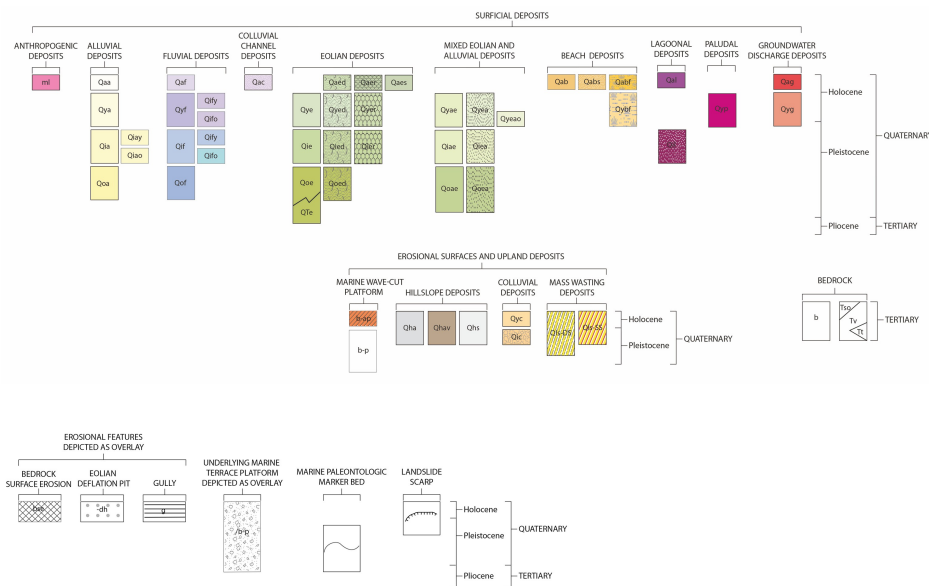
Quaternary Surficial Geologic Maps of the Channel Islands (SIM-xxxx)

Source map for the GRI surficial digital geologic-GIS maps.

Schmidt, K. M., Minor, S. A., and Bedford, D. R., 2017, Draft Quaternary Surficial Geologic Maps of the Channel Islands, Santa Barbara and Ventura Counties, California: U.S. Geological Survey, unpublished Scientific Investigations Map SIM-xxxx, scale 1:12,000.

Note: A surficial digital geologic-GIS map for each island in Channel Islands National Park (Anacapa, Santa Miguel, Santa Barbara, Santa Cruz and Santa Rosa) was provided with this publication.

SIM-xxxx Correlation of Map Units



The above graphics were scanned at a high resolution and can be viewed in more detail by zooming in (if viewing the digital format of this document).

Of note, units colors in the GRI digital geologic-GIS data differ slightly than colors indicated on this correlation. In addition, units represented by patterns (e.g., Qyeo) have been changed to an age-appropriate color with no pattern.

Graphics from source map: [Channel Islands Quaternary Surficial Geology](#)

Abstract and Introduction

Abstract

The Quaternary surficial deposits and structures of Channel Islands National Park (CHIS), CA record the young (post-2.58-Ma) geologic and landscape evolution of insular coastal southern California. The northern Channel Islands (San Miguel, Santa Rosa, Santa Cruz, and Anacapa Islands) plus Santa Barbara Island to the south are all embodied within CHIS. The area is situated in the Santa Barbara Channel south Big Bend area near the intersection of the Garlock the San Andreas fault zones. The purpose of this report is to present Quaternary surficial geologic maps of the five islands comprising CHIS at a nominal scale of 1:12,000, summarize the Quaternary geologic history of those islands, describe the geologic units depicted on the maps, and highlight some of the island's natural hazard susceptibilities.

Introduction

This text and associated maps describe and depict the Quaternary geology encompassing all five islands within Channel Islands National Park (CHIS) covering roughly 509 km² (196 mi²) in both Ventura and Santa Barbara Counties in southern California (figure 1) (<https://www.nps.gov/chis>). Map boundaries are not tied to specific quadrangle boundaries, but rather by extent of each of the northern Channel Islands (San Miguel, Santa Rosa, Santa Cruz, and Anacapa) as well as Santa Barbara Island to the south. These islands are regularly visited (~300,000 people/yr) for viewing of insular landscapes, birds, pinnipeds, and island fox, outdoor recreation, and other interests in natural and human history. CHIS was designated as a National Monument in 1938, a National Biosphere Reserve in 1976, and a National Park in 1980. The surrounding offshore waters are part of the Channel Islands National Marine Sanctuary (<https://channelislands.noaa.gov/>). This synthesis embodies new mapping by the U. S. Geological Survey (USGS) beginning in 2012, shortly following the comprehensive conversion of Santa Rosa Island from private to public management by the NPS.

Natural History

Even though the climate of CHIS is similar to that of the nearby mainland, the islands' size and physical separation have a considerable influence on the ecosystems present. As sea level (Muhs and others, 2012; 2014a; 2014b; and 2015) and tectonic deformation rates (Berryman, 1987; Shaw and Suppe, 1994; Niemi and others, 2008) have interacted over geologic time, the width of the Santa Barbara Channel has greatly fluctuated (Muhs, 2015). During sea level low stands, for instance, the distance between the islands and the mainland was as little as ~7 kilometers (Johnson, 1978; Muhs and others, 2015). The isolation effects of changing marine and terrestrial configurations over geologic time have generated unique flora and fauna on the Channel Islands (Schoenherr and others, 2003).

Charles Darwin's voyage on the HMS Beagle inspired insightful observations between tectonic deformation of the earth's crust and the unique flora and fauna of the Galápagos Islands (Darwin, 1851). Such pivotal research has applicability to the map area, as the Channel Islands have been deemed, by analogy, "California's Galápagos".

Diverse landscapes, stretching west to east along rough latitudinal alignment. Mediterranean climate. History of mixed land use in private property domain. Chumash occupation. Pioneers to North America, dating back at least 13 ka. Following the Chumash, European explorers, Chinese fisherman, sea mammal hunters, ranchers, sport hunters, petroleum companies, and the military left imprints on the landscape. The most pronounced of which are the legacy of ranching. Restoration efforts. Maps provide template to evaluate spatial distribution of surficial materials, natural hazards, surface-water availability and ecosystem functions. Island dwarfism with *Mammuthus exilis* and the Columbian mammoth (*M. columbi*) (Stock, 1935; Madden, 1981) and island fox (*Urocyon littoralis*) (Wayne and others, 1991).

Human History

Cabrillo

Orr and Arlington Springs discovery

Maritime based society (Erlandson and others, 2011)
Ranching era

Geography and Geomorphology

Although the northern Channel Islands are a seaward extension of the Santa Monica Mountains with respect to having similar bedrock geology, the Santarosae block has remained isolated from the mainland since it began transrotating away from the San Diego terrane in the Miocene. Elevations range from sea level to the highest Devils Peak 753 m (2470 ft) on Santa Cruz Island.

Text from source map: [Channel Islands Quaternary Surficial Geology](#)

Geologic History

The area is located within the California Borderlands and the extension of the Western Transverse Range offshore of Santa Barbara and Ventura. Part of larger Western Transverse Range tectonic domain reflecting geology from farther south transported by larger San Andreas Fault system including the complexities of deformation associated with the Big Bend of the San Andreas fault. The map area also lies to the south of the Santa Barbara-Ventura fault and fold belt.

The western Transverse Ranges consist mainly of variably deformed marine and nonmarine sedimentary rocks and deposits that range in age from Jurassic to the present. These strata record a long history of continental-margin sedimentation, and deposits as young as middle Pleistocene record considerable protracted deformation that includes Neogene and Quaternary transtensional-to-transpressional faulting, folding, and large (75-90 degrees) clockwise vertical-axis rotations of crustal blocks (for example, Dibblee, 1966, 1982; Hornafius and others, 1986; Namson and Davis, 1988; Luyendyk, 1991; Dickinson, 1995; Gurrola and others, 2001).

Prior geologic mapping (Weaver and others, 1969; Dibblee and Ehrenspeck, 1998; Dibblee and others, 1998; Dibblee, 2001a,b,c) focused on the bedrock units and their structure with only simplified Quaternary surficial details.

Orr (1960, 1968) conducted the first comprehensive research on marine terraces on Santa Rosa Island was field based examining terraces 7-23 m above msl.

Text from source map: [Channel Islands Quaternary Surficial Geology](#)

Structure and Tectonics of Quaternary Deposits

San Miguel Island

Repeated sequences of eolian deposition and erosion.
No apparent Quaternary faulting

Santa Rosa Island

Pronounced influence of Quaternary movement on Santa Rosa Island fault on character of rocks and surficial deposits. Sinistral deflection of stream drainages crossing fault trace. The northern portion of the island is exemplified by low elevation, moderate relief with intact bedrock stratigraphy underlying early to middle Pleistocene marine wave-beveled platforms mantled by extensive, eolian and alluvial deposits of wide age range. South of the island spanning fault the landscape is rugged with much greater dissection and relief.

Santa Cruz Island

Rugged, also pronounced influence of Santa Cruz Island fault on character of rocks and surficial deposits. Similar sinistral deflection of stream drainages and differential rock uplift and erosion across fault.

Anacapa Island

Narrow profile with little accommodation space for surficial deposits. Also has an island-spanning fault system.

Santa Barbara Island

Relatively simple uplifted bedrock marine platform.

No apparent Quaternary faulting

Pinniped scour along southeastern margin.

Quaternary Faults

The island maps depict faults that are primarily Quaternary in age, but some may be pre-Quaternary. Quaternary faults commonly have faint to strong geomorphic expression, including linear fault scarps, differential erosion ("fault-line scarps"), offset and deflected stream channels, linear sags and valleys, and pressure and shutter ridges, as well as forming aligned springs and vegetation lineaments. Quaternary age is implied for faults that cut Quaternary surficial deposits, even if such faults continue along strike into underlying bedrock. Faults located entirely in bedrock or that cut Quaternary deposits only along branching strands or on distant segments may be pre-Quaternary in age. Such structures are restricted to bedrock landscapes with sparse Quaternary deposit cover with which to gage potential age of fault offset, and hence a conservative approach was adopted with respect to designating age. In this report bedrock faults were mapped only if they are: (1) well expressed at the surface and easily delineated on aerial photo imagery and (or) LiDAR hillshades, and (2) they were not previously delineated on published bedrock geologic maps of Weaver and others (1969), Dibblee and Ehrenspeck (1998), Dibblee and others (1998) and Dibblee (2001a, b, c). In general, such faults were not assigned an age (see below) in the arc attribute table due to uncertainty in the timing of their most recent movement.

Text from source map: [Channel Islands Quaternary Surficial Geology](#)

Faults**Fault Type**

The orientation (i.e., strike and dip) and primary mode of slip (i.e., kinematics) of faults were measured and accessed in the field where fault principal slip surfaces were exposed. The fault kinematics were mostly determined from the rake of slickenside striae and slip-sense determinations using offset beds or other features, or using other structural criteria (Petit, 1987; Doblas, 1998). One of four primary fault types was assigned based on these observations: (1) normal; (2) reverse; (3) sinistral strike slip; or (4) dextral strike slip. Faults with dominantly dip-slip components of slip (i.e., rake values $>45^\circ$) were assigned a normal fault type if their hanging-wall block is displaced downward relative to their footwall block, and a reverse fault type if the sense of movement is opposite. Faults with dominantly strike-slip components of slip (i.e., rake values $<45^\circ$) were assigned a sinistral strike slip fault type if the block on one side of the fault is displaced to the left relative to the block on the other side, and a dextral strike slip fault type if the sense of relative block movement is to the right. In the case of fault principal slip surfaces that exhibit multiple sets of slickenside striae, the slip direction and sense that is most consistent with the fault's geomorphic features (e.g., scarp facing direction) and (or) stratigraphic separation was used for assigning fault type. The certainty of the fault's kinematic determination factored into the identity confidence assigned to the fault arc. Faults lacking any direct kinematic observations were not assigned a fault type (i.e., assigned a null value).

Fault Age

The age of most recent ground rupture for a given fault strand was constrained from the displacement of deposits of known age or age range as determined by previously reported or newly acquired geochronologic data. Age descriptions range from Holocene, Pleistocene, Quaternary, and pre-Quaternary(?). Faults with unknown movement age were assigned a null value. The general temporal descriptor of Quaternary was used where strands traverse Quaternary deposits, but the specific timing relations were typically unclear. Where Quaternary units are not present, such as in the bedrock uplands, the age of most recent rupture can be ambiguous. Where it was difficult to distinguish bedrock faults that might have been active in the Quaternary because of the scarcity of Quaternary deposits to preserve records of recent movements, we use the term Pre-Quaternary(?) or null values. Faults that clearly appear to have only been active prior to the Quaternary, such as in the Miocene volcanic units, are only depicted on the maps for Anacapa and Santa Barbara Islands.

Text from source map: [Channel Islands Quaternary Surficial Geology](#)

Locational Uncertainty

Source map locational accuracy, stored in the GRI NOTES field is based on the relation between a mapped feature's field location and its position as represented on the base map. The field is populated by one of three possible numeric values measured in meters. Although many features and boundaries observed were constrained by GPS control of field observations and have fine-scale resolution of features, most arcs are not constrained by direct field measurements. Rather, boundaries identified through examination of remotely sensed data, depending on the type and clarity of feature, will have coarser-resolution locational accuracy. Location confidence includes locational accuracies of ~10, 20, and 40 m for San Miguel, Santa Rosa, and Santa Cruz Islands. For Anacapa and Santa Barbara Islands, accuracies are 5, 10, and 20 m because of the small aerial extent of the islands and respective more detailed mapping. Eolian gradational contacts, present where eolian or mixed eolian-alluvial units share common boundaries, or where eolian units are in contact with hillslope units (Qha and Qhs), have high locational uncertainty. If eolian units are younger than, and share boundaries with, adjacent non-eolian units, the contacts are depicted as gradational. If, however, eolian units are older than adjacent non-eolian units, the contacts are non gradational.

Text from source map: [Channel Islands Quaternary Surficial Geology](#)

Mapping Methods

Mapping Methods

The maps presented here emphasize the Quaternary surficial geology of the Channel Islands with simplified bedrock geology. The surficial geology for the five islands of CHIS was mapped at a scale of ~1:12,000. The maps are newly derived and hence have no compilation sources. For Anacapa and Santa Barbara Islands, the maps represent a combination of Quaternary surficial and bedrock geology. Bedrock mapping was compiled from available maps and by new field mapping.

Mapping methods utilized interpretation of remote-sensing images, including: i) varying scales aerial stereo-photography with overlap, ii) 0.6-m resolution orthorectified DigitalGlobe imagery (Imagery 2012-2019 DigitalGlobe, Inc.) and iii) ESRI online World Imagery data from a variety of sources including: 0.3 and 0.5 m resolution DigitalGlobe and 1-m 4-band resolution NAIP (USDA-FSA Aerial Photography Field Office). Hillshade and slopeshade derivatives from helicopter-based, airborne LiDAR DEMs (1-m resolution) were used in conjunction with imagery to elucidate map unit boundaries and fault strand locations. Remotely sensed data provided invaluable sources of information for the types and spatial

extents of surficial geology. In order, though, to accurately identify unit types, we employed planned integration of remotely sensed data with field and laboratory investigations. Extensive fieldwork allowed for identification of properties of parent material, degree of weathering within parent material, structure of deposit, stratigraphic position, color and reflectivity of deposit, maturity of overlying pedogenic soil development, soil thickness, vegetation assemblages, and site-specific geomorphology; features typically difficult to identify solely from remote sensing. Faults were identified and characterized based upon image interpretation and field observations of fault gouge, slickenlines, slickensides, and damage-zone fractures of varying degrees of development, linear zones of carbonate and/or silica veins and cements, linear valleys (locally perpendicular to regional drainage patterns), scarps, ridges, and benches, wind gaps, offset and deflected valley drainages, shutter ridges, and vegetation lineaments. All field observations were geo-located using handheld global positioning systems (GPS) with a NAD83 datum and a Universal Transverse Mercator (UTM) zone 10 and 11 projection. Typical GPS locational accuracies associated with field observations were ± 3 m. Although some observations were logged in a notebook, most were collected on tablet computers running geospatial programs loaded with user-configured, site-specific base maps. Some tablets were augmented with external wireless, higher accuracy, GPS units connected via Bluetooth. Most ground-based field photographs were geo-tagged using GPS. Relating the field observations with high-resolution imagery and topography allowed for the heads up digitizing of geology utilizing field observations and a variety of available base maps at screen scales of 1:2,000 to 1:5,000 to provide high-resolution locational accuracy. This scale range, supported by the imagery and topographic input data, was essential to identify the geologic unit boundaries. Augmenting the variations in color, tone, and shading provided by imagery with the topographic qualities of relief, slope, and curvature generated from lidar-based DEMs offered added interpretive criteria for the office-based heads up digitizing.

Text from source map: [Channel Islands Quaternary Surficial Geology](#)

Map Unit Classification and Feature Attribution

Map Unit Classification

The Quaternary surficial units presented on the maps represent the geologic record of the inter-related geomorphic transport processes of erosion and deposition. Agents of erosional processes such as water, waves, wind, gravity, and bioturbation inherently remove material. Such sediment removal, entrainment, and transport typically do not leave behind a direct record. There is an absence of Quaternary deposits proximal to where material is eroded, in the extreme case exposing the underlying bedrock. In contrast, where sediment transport results in material deposition and subsequent compaction, there can be a mappable unit characteristic of a given geomorphic transport process. Hence, the correlation of map units is divided into broad categories of i) erosional surfaces and hillslopes deposits typically located in the uplands on steeper topography and ii) surficial deposits of alluvial and eolian processes, for example, typically located in the valleys and relatively lower elevation areas.

Relative ages of Quaternary deposits were differentiated by examining a combination of diagnostic criteria including: the geomorphic or landscape position, deposit surface roughness, drainage patterns, depth of channel incision, pedogenic development, degree of physical and chemical weathering in matrix, source lithology and degree of clast weathering, degree of consolidation and (or) cementation, vegetation assemblages, and relative elevation (e.g., Christenson and Purcell, 1985; Bull, 1991). For a small number of locations, samples were taken to determine ^{14}C , cosmogenic radionuclide, and luminescence numeric ages of key deposits. The chronosequence methodology adopted here is similar to Christenson and Purcell (1985) and Yount et al. (1994) with further refinements by the framework of Schmidt and McMackin (2006) and Miller et al. (2009; 2010). We determined pedogenic maturity by examining hand-dug shallow holes as well as targeting available channel, sea cliff, and road cut exposures to estimate relative degrees of weathering and translocation of material. We evaluated the thickness of soil horizons such as the Av, and strength of the argillic (Bt) or calcic (Btk or Bkm)

horizons. Undergoing primarily progressive development, over time soils tend to become better differentiated by horizons, the horizon contrasts become greater, and the profile thickness tends to increase. Time-dependent processes such as pedogenic maturity, surface roughness, and the vertical separation between units were best judged from field relations.

Quaternary units are segregated into four primary age groups: active (a), young (y), intermediate (i), and old (o). Within these primary groups, where possible, select young and intermediate units are subdivided into secondary younger (y) and older (o) subclasses.

Active units received sediment in the past few years or decades. Active fluvial units, for example, received traction-transported sediments deposited in valley floors and overbank areas in the past few years or decades. Active deposits are characterized by loose to slightly compact sediment and are prone to inundation and aggradation or stripping by erosion. Soils in active units are thin and weakly developed. They are characteristically unvegetated or sparsely vegetated with hydrophobic plants and have rough surface microtopography such as bar and swale morphology. Although active units typically are small in areal extent and narrow and long in planform, they are most likely to affect human activity since they are geomorphically transient features susceptible to flooding and reworking.

Young units received sediment in the Holocene, but not in the past century or two. On young units, diffusive processes, such as sheet flow, rain splash, bioturbation, and eolian deposition, tend to flatten abandoned surfaces over time, muting any primary geomorphic surface expression such as bar and swale topography. Soil development begins with the advent of these diffusive processes, particularly the input of eolian fines. Young units within the area include deposits of alluvial, fluvial, eolian, mixed eolian, and beach origin. Deposit surfaces are moderately vegetated, especially with shrubs. Fault-scarp preservation is typically poor in young units because such youthful deposits tend to be granular and poorly consolidated with little pedogenic cement. Fault offset of young units was evaluated by identifying laterally offset or deflected deposit surfaces, shutter ridges.

Intermediate units are interpreted to be primarily late Pleistocene to Holocene in age, from ~X ka to ~Y ka (Pinter and Sorlien, 1991; Pinter and others, 1998; Schumann and others, 2016; Schumann and Pigati, 2018; Schumann and Pigati, 2019). These units had sufficient time to develop mature soils displaying overlying vesicular A horizons, or Av. Intermediate units are subdivided on the basis of pedogenic features, abundance of buried soils, and structure of the soil. Varying amounts of red to brown clay accumulation and iron oxidation alter the B-horizon soil color (Bw to Bt horizon). The vertical separation between deposit surfaces and differences in gradient with respect to younger inset surfaces vary with timing of incision and the relative age of the deposit. Intermediate units are particularly important diagnostics of Quaternary fault activity because they are the youngest units that reliably preserve fault scarps in addition to laterally offset deposit surfaces, shutter ridges, and presence of sub-vertical carbonate-and silica cemented fault gouge.

Deposits classified as old are estimated to be early to middle Pleistocene in age, from ~1 Ma to ~50 ka (??). These units are not aerially extensive and typically are at higher topographic positions than younger units, often by several meters to tens of meters.

In addition to age, distinctions of process, environment, and source lithology are used to further refine map unit designation. The major processes and environments, listed by decreasing aerial extent, are (associated map-unit sublabel in parentheses): alluvial (a), fluvial (f), colluvial (c), eolian (e), mixed eolian and alluvial (e & a), beach (b), lagoonal (l), paludal (p), and groundwater (g). If possible, processes are further subdivided as: eolian deposits with dune (d), ramp (r), and sheet (s) morphologies. Older, uplifted marine terrace deposits, locally containing marine fauna, typically do not form large enough exposures to map as separate polygons and hence are denoted by a red-colored marker bed.

Composite Map Unit Symbols

Note: Source map composite map unit information is conveyed in the GRI NOTES field.

Surficial geologic units commonly occur as thin (<2 m) veneers over older units including bedrock.

The lateral extent of individual smaller-sized deposits is commonly too small to be depicted individually at the database map scale. Where the patchwork of deposits is too complicated to be represented, composite units are indicated in the GRI NOTES field. For example, Qyf with subordinate map unit Qif indicates where both Qyf and Qif fluvial deposits of different ages are present, where Qyf is spatially dominant over Qif; other deposits in the area compose less than 20%. As a general rule, the first unit listed covers >50% of the area, and the second covers <50%, but >20%. Units that cover <20% are generally discounted.

Morphologic expressions of older, uplifted marine terrace platforms beveled into bedrock, where specific evidence for marine fossils, pholad-bored clasts or bedrock, or shoreline angles exist are denoted by a suffix for platform (-p). Active wave-cut platforms present along the modern shorelines are denoted by a suffix for active platform (-ap). Marine terrace platforms are depicted cartographically with a unique overlay to denote their presence under surficial deposits.

Eolian deflation pits, or blowouts, are hollows characterized by somewhat circular, closed depressions where loose, eolian sediments have been removed by wind. They are typically meters to tens of meters in diameter for an individual pit. Such deflation hollows are denoted by the suffix (dh) in addition to a dotted overlaying cartographic pattern.

Gullied hillslope deposits or bedrock are denoted by the suffix (g) in addition to a horizontal-ruled overlaying cartographic pattern. Bedrock exposures having undergone pronounced surface erosion are denoted with the suffix (se). Such surface erosion takes place not as a concentrated landslide, but rather as transport of individual particles over a rock surface.

Although letters in map-unit labels may repeat, their order and relation to each other makes the labels unambiguous. For additional information regarding the system for generating composite unit names see Schmidt and McMackin (2006).

Feature Attribution

Line feature attribution includes geologic unit contact, eolian gradational contact, fault, lineament, shoreline, waterline, marker bed, and map boundary. The spatial juncture between mappable geologic units is represented by a contact embodying characteristics intrinsic to the genesis of the units it separates. That is, for Quaternary erosional and depositional units, the process and age of the adjoining features impart different characteristics that influence the ability to identify and interpret the existence, identity, and locational accuracy of the contact. Most contacts can be identified in the field, however, some are not field distinguishable and were interpreted through analysis of remote sensing data. Unless otherwise stated, contacts are discrete and abrupt. Eolian gradational contacts, though, are designated separately because of their nature of being spatially diffuse and transitional.

Faults are planar or curvilinear rupture surfaces along which geologic units have been displaced and deformed. Where a fault cuts the unit or units they traverse, it is younger than those units. All faults represented in this database correlate to the category of fault 'class A' from the U.S. Geological Survey online database of Quaternary faults and folds. Class A definition: geologic evidence demonstrates the existence of a Quaternary fault of tectonic origin, whether the fault is confirmed by direct observation of the fault surface or inferred indirectly from liquefaction or other associated deformational features. Lineaments depict linear surface features of regional extent, likely reflecting crustal structure not readily identifiable as a through-going fault. Besides faults, lineaments may originate from such factors as differential rock resistance to erosion or regional joints. Lineament identification includes linear

alignments of valley networks, vegetation, and ridges, but caution was exercised to not include anthropogenic features such as roads, fence lines, or domestic animal tracks.

Other arc types include shorelines that approximate mean sea level inferred from the zero contour generated from the airborne lidar data and imagery depicting the Pacific Ocean marine-terrestrial interface. Where possible, the intertidal zone is demarcated by a low and high tide couplet for units subject to intertidal fluctuations and storm surges such as Qab and b-ap. Where steep cliffs are adjacent to the Pacific Ocean only one shoreline is depicted. Waterlines in comparison bound terrestrial fresh water features. Marker beds identify stratigraphic horizons of significance within a geologic unit. Marker beds are represented as an arc, not a polygon, as they are too thin and discontinuous to depict at the map scale. Marine fossiliferous sediments associated with marine terraces (depicted by red marker bed) are mostly depicted as marker beds labeled Marine Paleontologic Marker Bed. Map boundaries denote the limit of features mapped.

Exposure Concealment

Concealed feature attribution denotes whether a contact or fault is not observable in imagery, or in the field, because of concealment by overlying map unit, body of water, or dense vegetation. An exposed contact or fault has evidence visible at ground surface. A concealed contact or fault is contact not visible at ground surface. In some instances concealed faults separate two different types of units in the database. For arcs to be labeled concealed, they must be continuously buried by relatively thick deposits, such as alluvial or eolian units. Contacts and faults are not labeled concealed where they traverse through many hillslope deposits, as the latter are generally thin and spatially discontinuous.

Text from source map: [Channel Islands Quaternary Surficial Geology](#)

Existence and Identity Confidence

Note: Source map existence and identity confidence is stored in the NOTES field of feature classes in the GRI geodatabase.

Source map "existence confidence" stored in the NOTES field describes the scientific confidence regarding the level of certainty of a feature, separating geologic units, does indeed exist and can be spatially traced with continuity.

Source map "identity confidence" stored in the NOTES field describes the scientific confidence regarding the level of certainty that a feature embodies the stated nature, origin, or geometry of the feature(s) mapped.

The identity confidence is also expressed by "location confidence" in the NOTES field; a numeric value in meters as a locational uncertainty described below.

In contrast to the two-tier certainty level of the FGDC standard (FGDC, 2006) of certain and questionable, here we adopt the term certain, but separate questionable into probable and possible categories to provide more additional levels of description:

Certain-

Reserved for features that can be unambiguously identified with a known existence and/or identity that can be traced spatially through the landscape. These arcs are mapped by geomorphic features traceable by imagery or were observed in outcrop, such as in a valley wall aligned at a high angle to a fault, or in a cliff exposure. Correlates with FGDC standard (FGDC, 2006) of certain.

Probable-

Features lacking an unambiguous observed surface exposure, but multiple lines of indirect evidence were identified to support feature's existence or identity. For example, somewhat ambiguous fault features include lineaments, topographic scarps, offset streams, shutter ridges, pop ups, sag ponds or depressions, and depositional or lithologic contrasts. Correlates with FGDC standard (FGDC, 2006) of questionable.

Possible-

Features with one or two indirect-evidence features, possibly also clues such as an orientation consistent with the structure of more certain contacts or faults in the area. Lower level of certainty typically reflects lack of direct field observation with inferences derived from remote sensing or field observations where direct evidence is obscured by vegetation. Correlates with FGDC standard (FGDC, 2006) of questionable.

Text from source map: [Channel Islands Quaternary Surficial Geology](#)

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