

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



# National Park of American Samoa

## *GRI Ancillary Map Information Document*

Produced to accompany the Geologic Resources Inventory (GRI) Digital Geologic Data for National Park of American Samoa

npsa\_geology.pdf

Version: 2/5/2021

# Geologic Resources Inventory Ancillary Map Information Document for National Park of American Samoa

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## Geologic Resources Inventory Map Document



# National Park of American Samoa

## Document to Accompany Digital Geologic-GIS Data

[npsa\\_geology.pdf](#)

Version: 2/5/2021

This document has been developed to accompany the digital geologic-GIS data developed by the Geologic Resources Inventory (GRI) program for National Park of American Samoa (NPSA).

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

This document contains the following information:

- 1) **About the NPS Geologic Resources Inventory Program** – A brief summary of the Geologic Resources Inventory (GRI) Program and its products. Included are web links to the GRI GIS data model, and to the GRI products page where digital geologic-GIS datasets, scoping reports and geology reports are available for download. In addition, web links to the NPS Data Store and GRI program home page, as well as contact information for the GRI coordinator, are also present.
- 2) **GRI Digital Maps and Source Citations** – A listing of all GRI digital geologic-GIS maps produced for this project along with sources used in their completion. In addition, a brief explanation of how each source map was used is provided. An index map displaying the park extent and the prominent islands of American Samoa, each of whom is covered in extent by a digital geologic-GIS map, is also presented.
- 3) **Map Unit Listing** – A listing of all geologic map units present on maps for this project, generally listed from youngest to oldest.
- 4) **Map Unit Descriptions** – Descriptions for all geologic map units.
- 5) **Geologic Cross Sections** – Geologic cross section graphics.
- 6) **Ancillary Source Map Information** – Additional source map information presented by source map. For each source map this may includes a unit listing and map legend. The "Geology of the Samoan Islands", which accompanies the source maps, is also presented.
- 7) **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. Learn more about I&M and the 12 baseline inventories at the I&M webpage: <https://www.nps.gov/im/inventories.htm>.

## GRI Digital Maps and Source Map Citations

The GRI digital geologic-GIS maps for National Park of American Samoa (NPSA):

The GRI compiled park extent and vicinity map (sources are listed with the individual island component maps below),

### **Digital Geologic Map of National Park of American Samoa (*GRI MapCode NPSA*)**

Individual GRI digital geologic-GIS (island) maps with source publication(s).

#### **Digital Geologic Map of Ofu and Olosega, American Samoa (*GRI MapCode OFOL*)**

Theroux, J.P. and others (geology after Stice, Gary D. and McCoy, Floyd, W. Jr., 1968), 1981, A Coastal Zone Management Atlas of American Samoa: Page 16, Geology: Ofu/Olosega: University of Hawaii, Cartographic Laboratory, Atlas, plate 4, scale 1:24,000 (*GRI Source Map ID 4377*).

#### **Digital Geologic Map of Tau, American Samoa (*GRI MapCode TAU*)**

Theroux, J.P. and others (geology after Stice, Gary D. and McCoy, Floyd, W. Jr., 1968), 1981, A Coastal Zone Management Atlas of American Samoa: Page 17, Geology: Tau: University of Hawaii, Cartographic Laboratory, Atlas, plate 5, scale 1:24,000 (*GRI Source Map ID 4378*).

#### **Digital Geologic Map of Tutuila, American Samoa (*GRI MapCode TUTU*)**

Theroux, J.P. and others (geology after Stearns, Harold T., 1944), 1981, A Coastal Zone Management Atlas of American Samoa: Page 13, Geology: Western Tutuila: University of Hawaii, Cartographic Laboratory, Atlas, plate 1, scale 1:24,000 (*GRI Source Map ID 4374*).

Theroux, J.P. and others (geology after Stearns, Harold T., 1944), 1981, A Coastal Zone Management Atlas of American Samoa: Page 14, Geology: Central Tutuila: University of Hawaii, Cartographic Laboratory, Atlas, plate 2, scale 1:24,000 (*GRI Source Map ID 4375*).

Theroux, J.P. and others (geology after Stearns, Harold T., 1944), 1981, A Coastal Zone Management Atlas of American Samoa: Page 15, Geology: Eastern Tutuila: University of Hawaii, Cartographic Laboratory, Atlas, plate 3, scale 1:24,000 (*GRI Source Map ID 4376*).

The full extent of each source map was used and all geologic features were captured.

The three Tutuila source map plates state the data source (for geology mapping) is: Stearns, Harold T., 1944, Geology of the Samoan Islands: Bulletin of the Geological Society of America, Vol. 55, p. 1279-1332, scale approximately 1:63,000.

For Ofu/Olosega and Tau, each source map plate states the data source (for geology mapping) is: Stice, Gary D. and McCoy, Floyd, W. Jr., 1968, The Geology of the Manu'a Islands, Samoa: Pacific Science, Vol. XXII, scale of source map approximately 1:56,000.

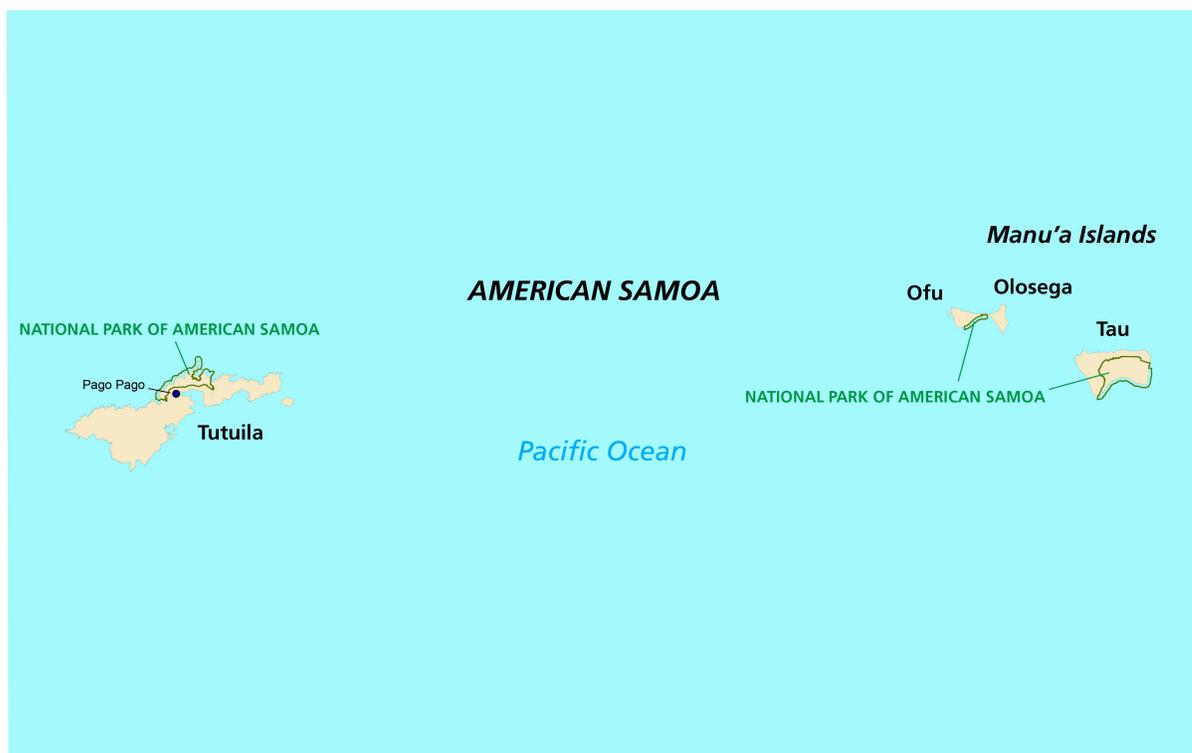
Of special note, shoreline present on the source maps, published at 1:24,000 scale, appears to have been generalized as it displays less detail than shoreline observed on 2001 U.S. topographic 1:24,000 scale base maps. All shoreline has thus been attributed as "water or shoreline, approximate". Also, in numerous areas throughout the Tutuila map the shoreline appears shifted and off when compared with the 2001 U.S. topographic base maps, as well as more recent ESRI World aerial imagery. Users should question the spatial location of shoreline on the Tutuila map. There are also many small islands of calcareous sand and alluvium (unit [Ra](#)) on the Tutuila map, however, many these areas are no longer visible on the 2001 U.S. topographic base maps or on ESRI World aerial imagery.

For mapped geologic features (i.e., contacts, dikes, faults, outcrop localities and observation localities) there was a strong correlation between topographic index contour lines present on source base maps and more recent 2001 U.S. topographic base maps of the islands. When georeferencing a source map to a 2001 U.S. topographic map most georeferencing control points were produced from distinct index topographic contour lines, and with an even distribution of control points across each island map index contour lines on the source map and the 2001 US Topo map aligned very well. This hopefully ensures that the inland mapped geology is accurate and is at least less than the 12.2 meters or 40 feet (U.S. National Map Accuracy Standards) for a source map scale of 1:24,000.

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

## Index Map

The following index map displays the prominent islands that comprise American Samoa. The boundary for National Park of American Samoa (NPSA) (as of January, 2021), present on each prominent island of American Samoa, is outlined in green. The GRI digital geologic-GIS maps for National Park of American Samoa cover the full extent of each prominent island: Tutuila, Ofu and Olosega, and Tau.



Index map by Stephanie O'Meara (Colorado State University).

## Map Unit List

The geologic units present in the digital geologic-GIS data produced for National Park of American Samoa (NPSA) are listed below. Units are listed with their assigned unit symbol and unit name (e.g., Ra - Calcareous sand and alluvium). Units are listed from youngest to oldest, and have been revised from the first release of this dataset. Information about each geologic unit is also presented in the GRI Geologic Unit Information (NPSAUNIT) table included with the GRI geologic-GIS data.

### Cenozoic Era

#### Quaternary Period

##### Recent, and Recent and Pleistocene Epoch

[water](#) - Water (and shoreline)

[landfill](#) - Landfill

[plug](#) - Plug

[Ra](#) - Calcareous sand, talus and alluvium

[Qb](#) - Calcareous sediments

[Qa](#) - Noncalcareous sediments, alluvium

[Qm](#) - Noncalcareous sediments, marshes

[Rll](#) - Leone Volcanics, pahoehoe flow

[Rlc](#) - Leone Volcanics, cinder cone at upper end of source fissure

[Rla](#) - Leone Volcanics, stony ash cone along fissure

[Rlt](#) - Leone Volcanics, lithic-vitric tuff

[Rat](#) - Aunu'u Tuff, lithic vitric tuff

[Qfl](#) - Fiti'Uta Formation, lava flows

[Qfc](#) - Fiti'Uta Formation, cinder cone

[Qft](#) - Faleasao Formation, undifferentiated tuff complex

[Qnt](#) - Nu'u Formation, palagonitized lapilli tuff

[Qnl](#) - Nu'u Formation, basalt flows

##### Pleistocene Epoch

[Qlp](#) - Luatele Formation, pahoehoe flows

[Qlc](#) - Luatele Formation, ponded lavas

[Qte](#) - Tunoa Formation, lava flows

[Qtec](#) - Tunoa Formation, cinder cone

[Qtc](#) - Tunoa Formation, volcanic deposits

[Qtcc](#) - Tunoa Formation, cinder cone

[Qle](#) - Lata Formation, post-caldera volcanics

[Qlec](#) - Lata Formation, post-caldera cinder cone

[Qlel](#) - Lata Formation, post-caldera lava flows

[Qli](#) - Lata Formation, intra-caldera dense flows

[Qlic](#) - Lata Formation, intra-caldera cinder cone

[Qlii](#) - Lata Formation, intra-caldera lava flows

#### Quaternary and Tertiary Periods

##### Pleistocene? and Pliocene Epochs

[Pt](#) - Trachyte plugs and dikes

[Ptp](#) - Trachytic pumice deposits

[Po](#) - Taputapu Volcanics

[Ppe](#) - Pago Volcanic Series, extra-caldera volcanics

[Ppi](#) - Pago Volcanic Series, intra-caldera volcanics

[Ppt](#) - Pago Volcanic Series, lithic-vitric tuff

[Pa](#) - Alofau Volcanics

[Pol](#) - Olomoana Volcanics

[Pm](#) - Masefau Dike Complex

### **Tertiary Period**

#### **Pliocene Epoch**

[Tle](#) - Lata Formation, pre-caldera member

[Ttae](#) - Tuafanua Formation, A'ofa shield

[Tts](#) - Tuafanua Formation, Sili shield

[Ttai](#) - Tuafanua Formation, ponded flows

[Tafb](#) - Asaga Formation, breccia cone at Fatuaga Point

[Tafi](#) - Asaga Formation, plug at Fatuaga Point

[Tat](#) - Asaga Formation, composite cone at Toaga

[Tam](#) - Asaga Formation, tuff cone at Lemaga Point

[Tas](#) - Asaga Formation, tuff cone at the west end of Samoa

[Tac](#) - Asaga Formation, cinder cone at Tauga Point

## Map Unit Descriptions

Descriptions of all geologic map units, generally listed from youngest to oldest, are presented below. In some cases unit descriptions, derived from the source map, are nothing more than simple descriptive text on the type of feature and locality (e.g., "cinder cone at Tauga Point"). The source map plate, and therefore the island (Ofu-Olosego or Tau) or portion of Tutuila island (i.e., eastern, central or western), a unit is present on is also denoted.

### **water - Water (and shoreline)**

Shoreline was derived from the 1:24,000 scale source maps, and no date was provided on any source map for shoreline and the map's topographic base map. The date of the source publications (Wingert and Pereira, 1981: see [GRI Digital Map and Source Citations](#)) is 1981, and thus the topographic base and shoreline pre-dates this date. Shoreline on the source maps appears to have been generalized as it displays less detail than shoreline observed on 2001 U.S. topographic 1:24,000 scale base maps. All shoreline has been attributed as "water or shoreline, approximate". On the Tutuila map there are numerous areas throughout the map where shoreline appears shifted and off when compared with 2001 U.S. topographic base maps of the islands, as well as more recent ESRI World aerial imagery. Users should question the spatial location of shoreline on this map. There are also many small islands of calcareous sand and alluvium (unit [Ra](#)) on the Tutuila map, however, many these areas are no longer visible on the 2001 U.S. topographic base maps or on ESRI World aerial imagery.

### **landfill - Landfill (Recent)**

No additional unit description present on source map. (*GRI Source Map ID 4374*) ([Tutuila Island: Western map](#)).

### **plug - Plug (Recent)**

No additional unit description present on source map. (*GRI Source Map ID 4374*) ([Tutuila Island: Western map](#)).

### **Ra - Calcareous sand, talus and alluvium (Recent)**

Loose calcareous beach sand along the coast, talus at the foot of the valley walls, and alluvium on valley floors. (*GRI Source Map ID 4374, 4375 and 4376*) ([Tutuila Island: Central, Eastern and Western maps](#)).

Of special note, there are many small islands of calcareous sand and alluvium (unit [Ra](#)) on the Tutuila map, however, many these areas are no longer visible on the 2001 US Topo maps or on ESRI World aerial imagery.

### **Qb - Calcareous sediments (Recent- Pleistocene)**

Modern beaches composed of unconsolidated fragments of marine organisms. Beachrock is frequently present. (*GRI Source Map ID 4377 and 4378*) ([Ofu and Olosega Islands](#) and [Tau Island](#)).

### **Qa - Noncalcareous sediments, alluvium (Recent- Pleistocene)**

Alluvium, talus, and stream deposits. (*GRI Source Map ID 4377 and 4378*) ([Ofu and Olosega Islands](#) and [Tau Island](#)).

**Qm - Noncalcareous sediments, marshes (Recent- Pleistocene)**

Marshes sometimes occur in areas behind constructional benches. (*GRI Source Map ID 4377 and 4378*) ([Ofu and Olosega Islands](#) and [Tau Island](#)).

**Rll - Leone Volcanics, pahoehoe flow (Recent)**

Olivine pahoehoe basalt flow. (*GRI Source Map ID 4374, 4375 and 4376*) ([Tutuila Island: Central, Eastern and Western maps](#)).

**Rlc - Leone Volcanics, cinder cone at upper end of source fissure (Recent)**

Cinder cone at upper end of source fissure. (*GRI Source Map ID 4374, 4375 and 4376*) ([Tutuila Island: Central, Eastern and Western maps](#)).

**Rla - Leone Volcanics, stony ash cone along fissure (Recent)**

Stony ash cone along fissure. (*GRI Source Map ID 4374, 4375 and 4376*) ([Tutuila Island: Central, Eastern and Western maps](#)).

**Rlt - Leone Volcanics, lithic-vitric tuff (Recent)**

Lithic-vitric tuff from Vailoatai, Fagatele, and Fogâma´a Craters. The tuff from Fogâma´a Crater overlies the tuff from Fagatele Crater unconformably. (*GRI Source Map ID 4374, 4375 and 4376*) ([Tutuila Island: Central, Eastern and Western maps](#)).

**Rat - Aunu'u Tuff, lithic vitric tuff (Recent)**

Lithic-vitric tuff forming ´Aunu´u Island. (*GRI Source Map ID 4374, 4375 and 4376*) ([Tutuila Island: Central, Eastern and Western maps](#)).

**Qfl - Fiti'Uta Formation, lava flows (Recent)**

Lava flows of basalt and olivine basalt forming the bench at Fiti´uta. (*GRI Source Map ID 4378*) ([Tau Island](#)).

**Qfc - Fiti'Uta Formation, cinder cone (Recent)**

Associated cinder cone. (*GRI Source Map ID 4378*) ([Tau Island](#)).

**Qft - Faleasao Formation, undifferentiated tuff complex (Recent)**

Undifferentiated tuff complex of palagonitized vitric-crystal lapilli tuff, breccia, and occasional horizontal lava flows from at least three main cones centered at Faleâsao, To´a, and Fa´asamene Coves. (*GRI Source Map ID 4378*) ([Tau Island](#)).

**Qnt - Nu'u Formation, palagonitized lapilli tuff (Recent-Pleistocene)**

Palagonitized lapilli tuff forms Nu´utele and Nu´usilaelae islets. (*GRI Source Map ID 4377*) ([Ofu and Olosega Islands](#)).

**Qnl - Nu'u Formation, basalt flows (Recent-Pleistocene)**

Hawaiite and olivine basalt flows may fill former deeply eroded stream valleys on western Ofu. (*GRI Source Map ID 4377*) ([Ofu and Olosega Islands](#)).

**Qlp - Luatele Formation, pahoehoe flows (Pleistocene)**

Thin pahoehoe flows of olivine basalt and picrite-basalt have built Luatele shield on the northeastern portion of the island. (*GRI Source Map ID 4378*) ([Tau Island](#)).

**Qlc - Luatele Formation, ponded lavas (Pleistocene)**

Ponded lavas which partly fill the depression. (*GRI Source Map ID 4378*) ([Tau Island](#)).

**Qte - Tunoa Formation, lava flows (Pleistocene)**

Lava flows of basalt and olivine basalt have built Tunoa shield on the northwestern portion of the island. (*GRI Source Map ID 4378*) ([Tau Island](#)).

**Qtcc - Tunoa Formation, cinder cone (Pleistocene)**

Associated cinder cone. (*GRI Source Map ID 4378*) ([Tau Island](#)).

**Qtc - Tunoa Formation, volcanic deposits (Pleistocene)**

Volcanic deposits of red vitric-crystal ash, lapilli tuff, and olivine basalt lavas. These partly fill the depression formed by the collapse of the shield. (*GRI Source Map ID 4378*) ([Tau Island](#)).

**Qtcc - Tunoa Formation, cinder cone (Pleistocene)**

Associated cinder cone. (*GRI Source Map ID 4378*) ([Tau Island](#)).

**Qle - Lata Formation, post-caldera volcanics (Pleistocene)**

Post-caldera volcanics consisting of olivine basalt, picrite-basalt, basalt, and hawaiite. (*GRI Source Map ID 4378*) ([Tau Island](#)).

**Qlec - Lata Formation, post-caldera cinder cone (Pleistocene)**

Post-caldera cinder cone. (*GRI Source Map ID 4378*) ([Tau Island](#)).

**Qlel - Lata Formation, post-caldera lava flows (Pleistocene)**

Associated lava flows. (*GRI Source Map ID 4378*) ([Tau Island](#)).

**Qli - Lata Formation, intra-caldera dense flows (Pleistocene)**

Intra-caldera member consisting of dense flows of olivine basalt, picrite-basalt, basalt, and hawaiite with numerous thin beds of vitric-crystal ash. (*GRI Source Map ID 4378*) ([Tau Island](#)).

**Qlic - Lata Formation, intra-caldera cinder cone (Pleistocene)**

Intra-caldera cinder cone. (GRI Source Map ID 4378) ([Tau Island](#)).

**Qlil - Lata Formation, intra-caldera lava flows (Pleistocene)**

Associated lava flows. (GRI Source Map ID 4378) ([Tau Island](#)).

**Pt - Trachyte plugs and dikes (Pleistocene? and Pliocene)**

Dense cream-colored trachyte plugs and dikes. The plugs are eroded bulbous domes and are younger than the surrounding volcanics. (GRI Source Map ID 4374, 4375 and 4376) ([Tutuila Island: Central, Eastern and Western maps](#)).

**Ptp - Trachytic pumice deposits (Pleistocene? and Pliocene)**

Trachytic pumice deposits associated with Vatia Plug. (GRI Source Map ID 4374, 4375 and 4376) ([Tutuila Island: Central, Eastern and Western maps](#)).

**Po - Taputapu Volcanics (Pleistocene? and Pliocene)**

Olivine basalts, chiefly thin bedded, and associated cinder cones, dikes, and thin vitric tuff beds. (GRI Source Map ID 4374, 4375 and 4376) ([Tutuila Island: Central, Eastern and Western maps](#)).

**Ppe - Pago Volcanic Series, extra-caldera volcanics (Pleistocene? and Pliocene)**

Extra-caldera volcanics consist of an upper member of basaltic and andesitic flows with their associated cones, dikes and plugs that are later than the caldera and a lower member of thin-bedded primitive basalt flows and their associated cones and dikes that are older than the caldera. The two members are not separated. (GRI Source Map ID 4374, 4375 and 4376) ([Tutuila Island: Central, Eastern and Western maps](#)).

**Ppi - Pago Volcanic Series, intra-caldera volcanics (Pleistocene? and Pliocene)**

Intra-caldera volcanics consists of massive andesitic and basaltic flows, and their associated cones and dikes. (GRI Source Map ID 4374, 4375 and 4376) ([Tutuila Island: Central, Eastern and Western maps](#)).

**Ppt - Pago Volcanic Series, lithic-vitric tuff (Pleistocene? and Pliocene)**

An interbedded lithic-vitric tuff member confined within the Pago Caldera. (GRI Source Map ID 4374, 4375 and 4376) ([Tutuila Island: Central, Eastern and Western maps](#)).

**Pa - Alofau Volcanics (Pleistocene? and Pliocene)**

Thin-bedded basalts, mostly olivine-bearing and associated cones, vitric tuff beds, and dikes. (GRI Source Map ID 4374, 4375 and 4376) ([Tutuila Island: Central, Eastern and Western maps](#)).

**Pol - Olomoana Volcanics (Pleistocene? and Pliocene)**

Thin-bedded primitive olivine basalts, capping andesites and associated cones, vitric tuff beds, and plugs. (*GRI Source Map ID 4374, 4375 and 4376*) ([Tutuila Island: Central, Eastern and Western maps](#)).

**Pm - Masefau Dike Complex (Pleistocene? and Pliocene)**

Thin basaltic flows cut by hundreds of narrow basaltic dikes and associated intra-formational talus breccia. (*GRI Source Map ID 4374, 4375 and 4376*) ([Tutuila Island: Central, Eastern and Western maps](#)).

**Tle - Lata Formation, pre-caldera member (Pliocene)**

Pre-caldera member consisting of lava flows of olivine basalt, picrite-basalt, basalt, feldspar-phyric basalt, and hawaiite with occasional beds of tuff. (*GRI Source Map ID 4378*) ([Tau Island](#)).

**Ttae - Tuafanua Formation, A'ofa shield (Pliocene)**

A'ofa coalescing shield comprised of olivine basalt, basalt, picrite-basalt, and hawaiite flows with a few intercalated beds of ash, tuff, and breccia. The shield and the Fatuaga breccia cone are intruded by numerous dikes. (*GRI Source Map ID 4377*) ([Ofu and Olosega Islands](#)).

**Tts - Tuafanua Formation, Sili shield (Pliocene)**

Sili coalescing shield comprised of olivine basalt, basalt, picrite-basalt, and hawaiite flows with a few intercalated beds of ash, tuff, and breccia. The shield and the Fatuaga breccia cone are intruded by numerous dikes. (*GRI Source Map ID 4377*) ([Ofu and Olosega Islands](#)).

**Ttai - Tuafanua Formation, ponded flows (Pliocene)**

Thick ponded flows of olivine basalt, hawaiite, and ankaramite within the A'ofa caldera volcanic deposits. (*GRI Source Map ID 4377*) ([Ofu and Olosega Islands](#)).

**Tafb - Asaga Formation, breccia cone at Fatuaga Point (Pliocene)**

Breccia cone at Fatuaga Point. (*GRI Source Map ID 4377*) ([Ofu and Olosega Islands](#)).

**Tafi - Asaga Formation, plug at Fatuaga Point (Pliocene)**

Associated volcanic plug at Fatuaga point. (*GRI Source Map ID 4377*) ([Ofu and Olosega Islands](#)).

**Tat - Asaga Formation, composite cone at Toaga (Pliocene)**

Composite cone at Toaga. Older cones are approximately aligned along the regional rift zone. (*GRI Source Map ID 4377*) ([Ofu and Olosega Islands](#)).

**Tam - Asaga Formation, tuff cone at Lemaga Point (Pliocene)**

Tuff cone at Lemaga Point. Older cones are approximately aligned along the regional rift zone. (*GRI Source Map ID 4377*) ([Ofu and Olosega Islands](#)).

**Tas - Asaga Formation, tuff cone at the west end of Samoa (Pliocene)**

Tuff cone at the west end of Samoa. Older cones are approximately aligned along the regional rift zone. (*GRI Source Map ID 4377*) ([Ofu and Olosega Islands](#)).

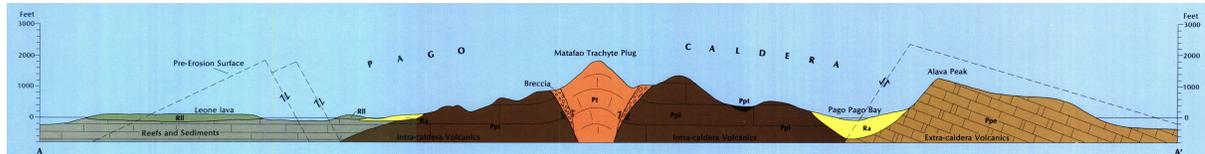
**Tac - Asaga Formation, cinder cone at Tauga Point (Pliocene)**

Cinder cone at Taugâ Point. Older cones are approximately aligned along the regional rift zone. (*GRI Source Map ID 4377*) ([Ofu and Olosega Islands](#)).

## Geologic Cross Sections

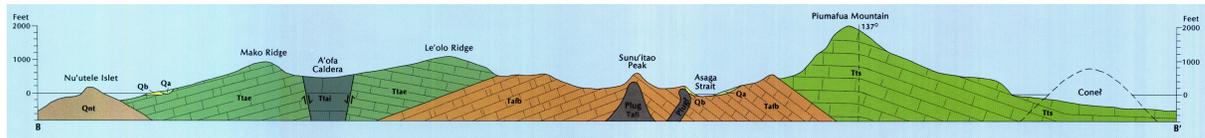
The geologic cross sections present in the GRI digital geologic-GIS data produced for National Park of American Samoa (NPSA) are presented below. Cross section graphics were scanned at a high resolution and can be viewed in more detail by zooming in (if viewing the digital format of this document).

### Geologic Cross Section A-A'



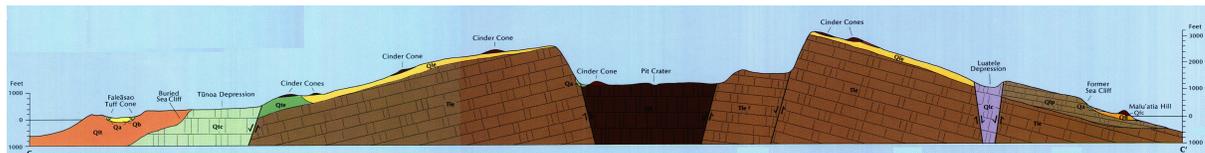
Graphic from [Tutuila Island: Central, Eastern and Western maps](#).

### Geologic Cross Section B-B'



Graphic [Ofu and Olosega Islands](#).

### Geologic Cross Section C-C'



Graphic from [Tau Island](#).

## Ancillary Source Map Information

Additional or ancillary map information present on source geologic maps used by the Geologic Resources Inventory (GRI) Program in the production of digital geologic-GIS data for National Park of American Samoa (NPSA) are presented below.

### Geology of the Samoan Islands

The Samoan archipelago is located along the crest of the Samoan Ridge, which extends over 485 km (300 mi) from Savai'i eastward to Rose Atoll. The Samoan Ridge consists of four major volcanic piles trending about N 70° W with an apparent offset in the deep ocean floor between Tutuila and Manu'a. It is possible that such a displacement could have been caused by fault movements associated with the Tonga Trench, a major geologic feature of the Pacific Ocean floor located 200 km (124 mi) south (Stice and McCoy 1968). However, the volcanoes of Tonga, being more typical of other Pacific island arc-trench systems such as the Aleutians, Japan and the Marianas, are quite different from their Samoan neighbors residing on the Pacific plate. Tongan volcanoes usually have much more explosive eruptions because of their higher silica content and lower magma temperatures. In contrast, the Samoan volcanoes have been built up primarily of gently flowing, less explosive basaltic lavas. Many geologists attribute the origin of island chains to the westward movement of the Pacific plate over a plume or "hot spot" located approximately 60-100 km (40-65 mi) below the ocean floor. However, recent investigations (Malahoff, et al. 1981) indicate that a former northern extension of the Tonga trench has been rotated about 90° during the past 7 million years by the westward movement of the Pacific plate. The Samoan islands, located near the oceanic plate boundary, may have been generated by shearing along lateral faults related to the subduction of the oceanic plate in the Tonga Trench.

The Samoan Ridge itself is made up of thin-bedded, billowy basalt pahoehoe flows (pillow lavas) like those found on deep ocean ridges. Magma from rifts on the ocean floor built up 3-5 km (2-3 mi), to rise above sea level as islands. As these volcanic piles came within about a hundred meters of the surface, the eruptions were probably more explosive because of gases created following the formation of steam when the magma came in contact with sea water. Surface outpourings of magma in Samoa typically built large, gently sloping shields rather than steep-sided ash cones. Once the islands extended above sea level, the eruptions again became quiet, and shield building by thin-bedded pahoehoe flows continued. After several million years, volcanic activity gradually declined and the islands (representing a large volcanic pile built up more than 5 km on the ocean floor) began to subside.

Many of the volcanic centers that built up above sea level formed broad, gently sloping (5-10°) shields. Typically, the summits of these shields collapsed to form central depressions called calderas. After caldera formation, more erosion between successive flows is evidence of longer intervals of volcanic quiescence.

Some of the volcanic centers did not have a caldera-forming stage, however, and cones with small or no visible craters were formed, examples being the older volcanoes on Ofu and Olosega islands. After the post-caldera activity, volcanism virtually ceased and was followed by a long period of erosion, slow subsidence, and coral reef formation. Sea cliffs, in places more than a hundred meters high, were formed around Tutuila and the Manu'a islands. Drowned barrier reefs on Tutuila indicate a rapid 60 m (200 ft) rise in sea level (probably due to melting of glaciers formed during the Wisconsin stage, about 20,000 years ago) which may have continued to 2 m above the present sea level. Stream valleys developed flat floors due to alluvial filling, and on Tutuila, bays were formed by drowned river valleys.

This period of volcanic quiescence and extensive erosion was followed by renewed activity, especially in the northwest (Faleâsao formation) and northeast (Fiti'uta formations) portions of Ta'û, the Nu'u formation on Ofu, and Leone volcanics (including 'Aunu'u) on Tutuila. Fringing reefs (usually less

than 350 m offshore) are now being formed around most of the coastlines of Tutuila and Manu'a.

## Geology of Tutuila

### History

According to Stearns (1944), Tutuila was formed by five volcanoes aligned along two or three parallel rifts trending N 70° E, along the axis of the Samoan Ridge. The oldest shield exposed on the island appears to have been nearly obliterated by swarms of dikes forming the Masefau dike complex. This volcano may have formed a caldera centered offshore north of the present Masefau village. The vesicles or gas bubbles in the dikes indicate that they were injected 300–600 m (1000–2000 ft) below the former surface, which has since been eroded away.

At the eastern end of the island, several dense plugs and crater fills indicate another volcanic center in the area around Olomoana Peak. The Olomoana volcanics include typical shield-building, thin-bedded basalt lavas dipping about 10° north. There are several graded domes formed by low temperature, viscous trachyte lava, which was slowly squeezed up to the surface to form a dome because of its high silica content. The loose material of the trachyte dome and associated pumice are easily removed by erosion, exposing the denser underlying plug. Trachyte is probably formed by differentiation in the magma chamber within the volcano, by crystal settling, and other processes. After a long period of erosion and volcanic quiescence the lighter high silica portion of the magma migrates toward the upper part of the chamber resulting in andesites and trachytes instead of basalts. The sticky trachyte oozes out onto the surface late in the volcano's caldera-filling stage.

The Alofau volcanics include basalt lavas that were erupted near the present Alofau village at about the same time as similar eruptions in the Olomoana area. The caldera of this shield is now eroded and mostly submerged, and its lavas are also cut by numerous dikes formed by magma being injected through the older flows to form the later overlying flows now removed by erosion.

The Pago volcanic series represents lavas, dikes, cinder cones, and tuff cones of the largest volcanic shield forming Tutuila. After building a gently sloping shield with frequent outpourings of thin-bedded basalt lava flows, the volcano collapsed to form a caldera approximately 10 km (6 mi) across. Subsequently, a thick series of tuffs and ponded lavas partly filled the caldera. Numerous trachyte plugs, including Matafau, Pioa, and Papatele were extruded within the caldera and the Afono, Vatia, Ta'u, and Leila trachyte plugs formed elsewhere about the same time.

With a decline in volcanic activity, accompanied by prolonged gradual subsidence of the volcano, erosional forces carved a deep valley into the rocks within the Pago caldera. These rocks were softer and more readily removed by erosion than the less altered lavas outside the caldera, because of the sulfuric gases and more explosive eruptions associated with formation and filling of the caldera. Pago Pago Harbor and other bays were formed as sea level rose with subsidence.

The western end of Tutuila contains basalt lava flows dipping only 5-10° from a rift zone parallel to the Samoan Ridge and lined with cinder cones such as Oloava and Taputapu Island. Flows from Taputapu volcano overlap those of Pago volcano and are therefore younger and less deeply eroded. With slow subsidence a fringing reef gradually developed into a barrier reef.

During a long period of volcanic quiescence, probably lasting several hundred thousand years, deep valleys (such as Pago Pago) and high sea cliffs were incised into the island. Later, sea level fluctuations associated with the formation and melting of ice caps caused the drowning of these valleys and the barrier reef. A resurgence of volcanic activity created the Leone volcanics, which formed cinder cones on land and tuff cones like 'Aunu'u Island where lava erupted beneath the sea and generated steam explosions. Basalt lava flows poured out over the submerged barrier reef and added about 21 sq km (8 sq mi) of land in the Leone area.

A fringing reef once again began to form around the present coastline of Tutuila. The beaches are composed of sand-sized material from this reef, primarily foraminiferal, algal, shell, and coral fragments. In embayments formed by drowned river valleys, villages are often located on beach areas that may have been formed at slightly higher (up to 8 m/25 ft) stands of the sea. Wave action will continue to supply the beaches with calcareous material as long as the coral reefs are protected from dredging and pollution. However, many of the corals in Pago Pago Harbor have already been destroyed by human activities, resulting in serious coastal erosion problems. The future of beach areas in other parts of the island depends on maintaining an adequate supply of sand from a healthy coral reef.

### Rock Units

A geologic map of Tutuila was produced by Harold T. Stearns (1944), who grouped the rocks of the island in order of decreasing age:

- Masefau dike complexes ([Pm](#))
- Olomoana volcanics ([Pol](#))
- Alofau volcanics ([Pa](#))
- Pago volcanic series ([Ppe](#), [Ppi](#), [Ppt](#))
- Taputapu volcanics ([Po](#))
- 'Aunu'u tuff ([Rat](#))
- Leone volcanics ([Rll](#), [Rlc](#), [Rla](#), [Rlt](#))
- Sedimentary rocks ([Ra](#))

Descriptions of these groups are given in accompanying map legends. The trachyte plugs ([Pt](#) / [Ptp](#)) are mapped separately and are not included with intracaldera or upper extracaldera volcanics because they are easily distinguished topographically and, because they are about the same age, are more meaningfully separated by their trachyte rock type than whether they are inside or outside the caldera.

## Geology of the Manu'a Islands

### History

According to Stice and McCoy (1968), the three islands of the Manu'a group—Ofu, Olosega, and Ta'ū—were built by volcanic activity along the crest of the easternmost portion of the Samoan Ridge. Ta'ū represents the largest volcanic center, where a'ā and pahoehoe flows constructed a volcanic shield more than 900 m (3000 ft) above sea level. The present-day total thickness of this volcanic pile is over 3600 m (12,000 ft), as measured from the ocean floor to the summit of Ta'ū—Lata Mountain, 931 m (3056 ft). Dips of the lava flows frequently exceed 30°, but average 20-25°. Summit collapse formed a caldera that was later partially filled with ponded lavas and pyroclastic deposits to a thickness of over 300 m (1000 ft). From the summit area, two rift zones radiate to the northeast and northwest—the latter coinciding with the trend of the Samoan Ridge—and contain two smaller shield volcanoes. Following a period of extensive erosion, the northeast corner of the island, upon which the village of Fiti'uta now stands, was built outward by dunite-bearing lava flows. Near the village of Faleāsao, a tuff complex containing large dunite xenoliths and coral blocks extended the northwest corner of the island burying a former sea cliff.

Ofu and Olosega islands represent a complex of at least six volcanic cones aligned along the regional rift of the Samoan Ridge. Two of these cones developed as shields that later coalesced and buried older cones of largely pyroclastic material. The shields are composed mainly of a'ā and pahoehoe flows of nonporphyritic basalt, olivine basalt, and picrite basalt, with hawaiites occurring in the uppermost portion of the shield on Ofu. More than 3300 m (11,000 ft) of volcanic material are represented by these shields, as measured from the ocean floor to the present-day summits of Ofu at Tumutumumu (494 m/1621 ft) and of Olosega at Piumafua (638 m/2095 ft), which appear to be the approximate former summits of both shields. Average dips of the lava flows are 10–20° locally,

becoming considerably steeper when they move into valleys, over sea cliffs or other uneven topography created by erosion or faulting. Summit collapse of both shields produced calderas, one on northern Ofu and another off northwestern Olosega, near Sili village. The caldera on northern Ofu was partly filled by the ponding of olivine basalt, hawaiite, and ankaramite lava flows. The floor of Sili caldera lies offshore and may never have been exposed above sea level. Following a period of quiescence and erosion, probably contemporaneous with that on Ta'û, recent volcanism built a lapilli tuff cone, the remnants of which form Nu'utele and Nu'usilaelae islets. Volcanism has continued into the present era with a submarine eruption reported between Olosega and Ta'û in 1868.

Narrow fringes of calcareous beach deposits and coral reefs nearly surround each of the three islands. The high cliffs around them are the result of marine erosion. Benches at +4 m and +1.5 m above present sea level may indicate former higher eustatic stands of the sea.

### Rock Units

Stice and McCoy (1968) produced geologic maps that grouped the rocks of Manu'a into the following formations in order of decreasing age (see accompanying map legends):

#### Ta'û

Lata formation ([Tle](#), [Qle](#), [Qli](#))  
 Tûnoa formation ([Qte](#), [Qtc](#))  
 Luatele formation ([Qlp](#), [Qlc](#))  
 Faleâsao formation ([Qft](#))  
 Fiti'uta formation ([Qfi](#))  
 Noncalcareous sediments ([Qa](#), [Qm](#))  
 Calcareous sediments ([Qb](#))

#### Ofu/Olosega

Asaga formation ([Tafb](#), [Tat](#), [Tam](#), [Tas](#), [Tac](#))  
 Tuafoa formation ([Ttae](#), [Tts](#), [Ttai](#))  
 Nu'u formation ([Qnt](#), [Qnl](#))  
 Noncalcareous sediments ([Qa](#), [Qm](#))  
 Calcareous sediments ([Qb](#))

### Field Methods

Stearns plotted geologic formations from field observations he made in 1941 and 1943 on an early topographic map of Tutuila. The inaccuracy of the topographic map has made some boundary adjustments necessary and these delineations are not as precise as later work by Stice and McCoy, who were able to use aerial photographs. Stearns made measurements of strike and dip of bedding, faults, and dikes with a Brunton field compass and translated them visually to the base map. Numerous rock samples were collected and studied under a microscope by G. A. Macdonald (Macdonald 1944). Chemical analyses of approximately 20 rock samples collected by Stice on Tutuila in 1963 were reported later (Macdonald 1968).

As on Tutuila, field mapping in Manu'a was done only with the aid of a Brunton compass. However, use of aerial photographs enhanced the mapping project, especially where dense vegetation and lack of access trails into the interior of the islands would have greatly hampered accuracy and completeness. Prior to completion of the geologic mapping, US Geological Survey topographic maps (1:24,000) based on the same aerial photographs were published. With the availability of both the aerial photographs and the more precise topographic map, the accuracy of boundaries of the geological formations should be much more accurate on the Manu'a maps. Chemical analyses and thin-section studies of the Manu'a rocks have been described elsewhere (see Stice 1968).

On the map of Manu'a, the symbols and system of naming formations differ somewhat from those used on Tutuila because of attempts by Stice to conform with guidelines established by the Committee on Stratigraphic Nomenclature of the Geological Society of America and the World

Geological Congress. Formation names are therefore used for separate rock units instead of the "volcanic series" terminology employed by Stearns prior to the establishment of international guidelines. This system of nomenclature would be roughly equivalent to grouping the formations of Manu'a into the "Ta'û volcanic series", or the "Ofu-Olosega volcanic series".

Gary D. Stice

All text from source publication, Wingert, Everett A. (compiler) and Pereira, Joseph M. (prefacer), 1981, A Coastal Zone Management Atlas of American Samoa: Geological Society of America Bulletin Volume 55

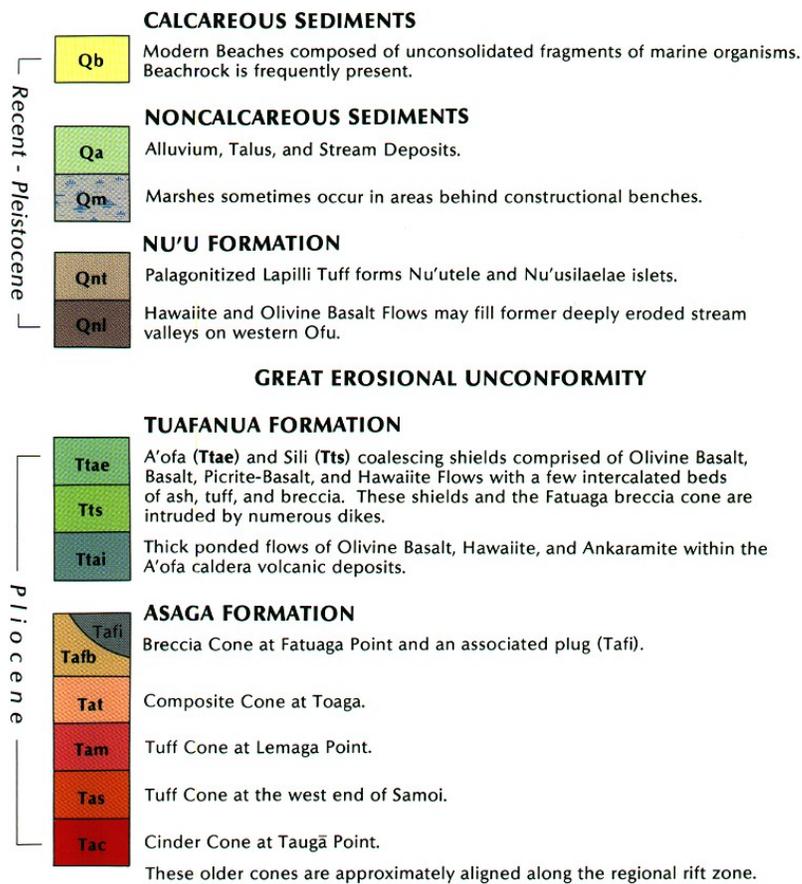
## Ofu and Olosega Islands Map

The formal citation for this source.

Theroux, J.P. and others (geology maps after Stearns, Harold T.), 1981, A Coastal Zone Management Atlas of American Samoa: Page 16, Geology: Ofu/Olosega: University of Hawaii, Cartographic Laboratory, Atlas, plate 4, scale 1:24,000 (*GRI Source Map ID 4377*).

Data Source (for geologic mapping): Stice, Gary D. and McCoy, Floyd, W. Jr., 1968, The Geology of the Manu'a Islands, Samoa: Pacific Science, Vol. XXII, scale of source map approximately 1:56,000.

## Unit Listing



Graphic from source map [Ofu and Olosega Islands](#).

## Legend

STRUCTURAL SYMBOLS	
	Normal Fault. Hachures on downthrown side.
	Eroded Fault Scarp, approximately located. Hachures on downthrown side.
	Buried Fault Scarp, location inferred.
	Contact. Dashed where approximately located.
	Dike.
	Dip and Strike of Beds.
	Horizontal Beds.

Graphic from source map [Ofu and Olosega Islands](#).

## Tau Island Map

The formal citation for this source.

Theroux, J.P. and others (geology maps after Stearns, Harold T.), 1981, A Coastal Zone Management Atlas of American Samoa: Page 17, Geology: Tau: University of Hawaii, Cartographic Laboratory, Atlas, plate 5, scale 1:24,000 (*GRI Source Map ID 4378*).

Data Source (for geologic mapping): Stice, Gary D. and McCoy, Floyd, W. Jr., 1968, The Geology of the Manu'a Islands, Samoa: Pacific Science, Vol. XXII, scale of source map approximately 1:56,000.

## Unit Listing

		<b>CALCAREOUS SEDIMENTS</b>
		Modern Beaches composed of unconsolidated fragments of marine organisms. Beachrock is frequently present.
R e c e n t		<b>NONCALCAREOUS SEDIMENTS</b> Alluvium, Talus, and Stream Deposits.
		Marshes sometimes occur in areas behind constructional benches.
		<b>FITI'UTA FORMATION</b> Lava flows of Basalt and Olivine Basalt forming the bench at Fiti'uta. Qfc - associated Cinder Cone.
		<b>FALEĀSAO FORMATION</b> Undifferentiated Tuff Complex of Palagonitized Vitric-Crystal Lapilli Tuff, Breccia, and occasional horizontal lava flows from at least three main cones centered at Faleāsao, To'a, and Fa'asamene Coves.
		<b>GREAT EROSIONAL UNCONFORMITY</b>
		<b>LUATELE FORMATION</b>
P l e i s t o c e n e		Thin pahoehoe flows of Olivine Basalt and Picrite-Basalt have built Luatele shield on the northeastern portion of the island.
		Ponded Lavas which partly fill the depression.
		<b>TŪNOA FORMATION</b> Lava flows of Basalt and Olivine Basalt have built Tūnoa shield on the northwestern portion of the island. Qtec - associated Cinder Cone.
		Volcanic deposits of red Vitric-Crystal Ash, Lapilli Tuff, and Olivine Basalt lavas. These partly fill the depression formed by the collapse of the shield. Qtcc - associated Cinder Cone.
		<b>LATA FORMATION</b>
		Post-Caldera Volcanics consisting of Olivine Basalt, Picrite-Basalt, Basalt, and Hawaiite. Qlec - post-caldera Cinder Cone. Qlel - associated Lava Flows.
Pliocene		Intra-Caldera Member consisting of dense flows of Olivine Basalt, Picrite-Basalt, Basalt, and Hawaiite with numerous thin beds of vitric-crystal ash. Qlic - intra-caldera Cinder Cone. Qlil - associated Lava Flows.
		Pre-Caldera Member consisting of lava flows of Olivine Basalt, Picrite-Basalt, Basalt, Feldspar-Phyric Basalt, and Hawaiite with occasional beds of tuff.

Graphic from source map [Tau Island](#).

## Legend

### STRUCTURAL SYMBOLS

-  Normal Fault. Hachures on downthrown side.
-  Eroded Fault Scarp, approximately located.  
Hachures on downthrown side.
-  Buried Fault Scarp, location inferred.
-  Contact. Dashed where approximately located.
-  Dike.
-  Dip and Strike of Beds.
-  Horizontal Beds.

Graphic from source map [Tau Island](#).

## Tutuila Island Map

The formal citations for these sources.

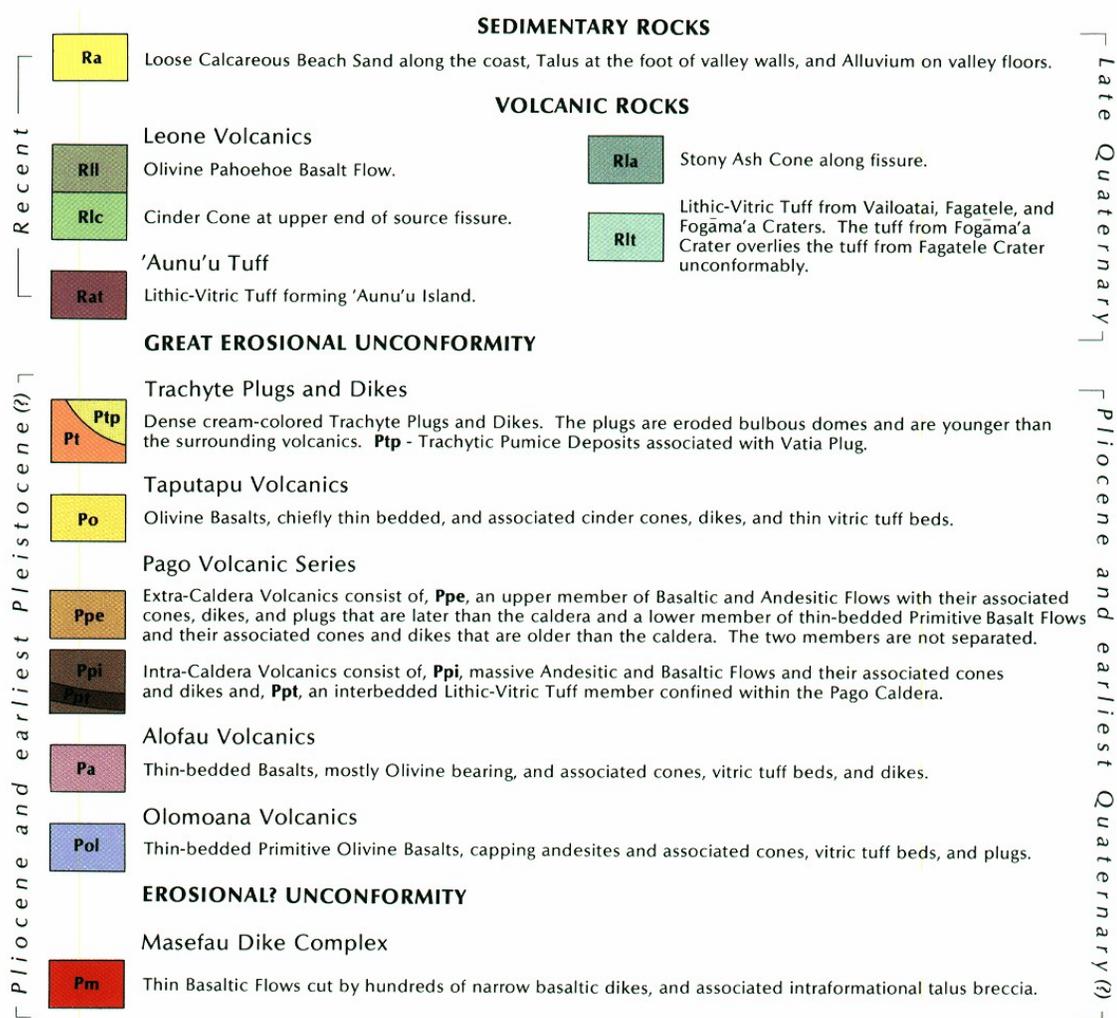
Theroux, J.P. and others (geology maps after Stearns, Harold T.), 1981, A Coastal Zone Management Atlas of American Samoa: Page 13, Geology: Western Tutuila: University of Hawaii, Cartographic Laboratory, Atlas, plate 1, scale 1:24,000 (*GRI Source Map ID 4374*).

Theroux, J.P. and others (geology maps after Stearns, Harold T.), 1981, A Coastal Zone Management Atlas of American Samoa: Page 14, Geology: Central Tutuila: University of Hawaii, Cartographic Laboratory, Atlas, plate 2, scale 1:24,000 (*GRI Source Map ID 4375*).

Theroux, J.P. and others (geology maps after Stearns, Harold T.), 1981, A Coastal Zone Management Atlas of American Samoa: Page 15, Geology: Eastern Tutuila: University of Hawaii, Cartographic Laboratory, Atlas, plate 3, scale 1:24,000 (*GRI Source Map ID 4376*).

Data Source (for geologic mapping): Stearns, Harold T., 1944, Geology of the Samoan Islands: Bulletin of the Geological Society of America, Vol. 55, p. 1279-1332, scale approximately 1:63,000.

### Unit Listing



Graphic from source map [Tutuila Island: Central, Eastern and Western maps.](#)

## Legend

STRUCTURAL SYMBOLS	
	Normal Fault. Hachures on downthrown side.
	Eroded Fault Scarp, approximately located. Hachures on downthrown side.
	Buried Fault Scarp, location inferred.
	Contact. Dashed where approximately located.
	Dike.
	Dip and Strike of Beds.
	Outcrop of Vitric Tuff or Cinders.
	Plug.

Graphic from source map [Tutuila Island: Central, Eastern and Western maps.](#)

## GRI Digital Data Credits

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

The information in this document was compiled from GRI source maps and intended to accompany the digital geologic-GIS map(s) and other digital data for National Park of American Samoa, (NPSA) developed by Stephanie O'Meara and Jim Chappell (Colorado State University) (see the [GRI Digital Maps and Source Map Citations](#) section of this document for all sources used by the GRI in the completion of this document and related GRI digital geologic-GIS maps.

GRI finalization by Stephanie O'Meara.

GRI program coordination and scoping provided by Bruce Heise (NPS GRD, Lakewood, Colorado).