

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



Sunset Crater Volcano National Monument

GRI Ancillary Map Information Document

Produced to accompany the Geologic Resources Inventory (GRI) Digital Geologic
Data for Sunset Crater Volcano National Monument

sucr_geology.pdf

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Geologic Resources Inventory Map Document for Sunset Crater Volcano National Monument

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Geologic Resources Inventory Map Document



Sunset Crater Volcano National Monument, Arizona

Document to Accompany Digital Geologic-GIS Data

[sucr_geology.pdf](#)

Version: 2/6/2014

This document has been developed to accompany the digital geologic-GIS data developed by the Geologic Resources Inventory (GRI) program for Sunset Crater Volcano National Monument, Arizona (SUCR).

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.

National Park Service (NPS) Geologic Resources Inventory (GRI) Program staff have assembled the digital geologic-GIS data that accompanies this document.

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About the NPS Geologic Resources Inventory Program

Background

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

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

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

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

Products

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

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

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

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

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

GRI geologic-GIS data is also available online at the NPS Data Store Search Application: <http://irma.nps.gov/App/Reference/Search>. To find GRI data for a specific park or parks select the appropriate park

(s), enter "GRI" as a Search Text term, and then select the Search Button.

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

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

GRI Digital Map and Source Map Citation

The GRI digital geologic-GIS map for Sunset Crater Volcano National Monument, Arizona (SUCR):

Digital Geologic Map of Sunset Crater Volcano National Monument and Vicinity (Eastern San Francisco Volcanic Field), Arizona (*GRI MapCode SUCR*)

Moore, R.B. and Wolfe, E.W., 1976, Geologic Map of the Eastern San Francisco Volcanic Field, Arizona, U.S. Geological Survey, Miscellaneous Investigations Series Map I-953, 1:50,000 scale. ([Eastern San Francisco Volcanic Field Map](#)). (*GRI Source Map ID 1208*).

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

Map Unit List

The geologic units present in the digital geologic-GIS data produced for Sunset Crater Volcano National Monument, Arizona (SUCR) 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. Information about each geologic unit is also presented in the GRI Geologic Unit Information (SUCRUNIT) table included with the GRI geology-GIS data.

Cenozoic Era

Quaternary Period

[Qe](#) - Eolian deposits
[Qal](#) - Alluvium and colluvium
[Qtg](#) - Terrace gravels
[Qsl](#) - Basalt cinders and spatter
[Qsc](#) - Alkali-olivine basalt cinder cone
[Qsp](#) - Basaltic pyroclastic sheet from eruption of Sunset Crater
[Qsb](#) - Bonito and Kana-a flows from Sunset Crater
[Qmc](#) - Basalt conder cones
[Qms](#) - Basalt spatter from vent 127
[Qmp](#) - Basalt pyroclastic sheet
[Qmpv](#) - Basalt of vent 130
[Qmb](#) - Basalt flows
[Qmac](#) - Basaltic andesite cinder and spatter cones
[Qma](#) - Basaltic andesite flows
[Qmr](#) - Vitrophyre plugs of O'Neill Crater (vent 109) and Strawberry Crater (vent 77)
[Qor](#) - Rhyodacite flow of Deadman Mesa
[Qorv](#) - Vent facies of rhyodacite flow of Deadman Mesa
[Qorr](#) - Rhyodacite dome of Robinson Crater
[Qoap](#) - Andesite pyroclastic deposits of O'Leary Peak
[Qoo](#) - Rhyodacite obsidian flow north of O'Leary Peak
[Qoov](#) - Vent facies of rhyodacite obsidian flow north of O'Leary Peak
[Qord](#) - Rhyodacite porphyry dome of O'Leary Peak
[Qoch](#) - Chaotic rock debris
[Qod](#) - Dacite flow north of O'Leary Peak
[Qoaf](#) - Andesite porphyry
[Qtc](#) - Basalt cinder cones
[Qttc](#) - Tuffaceous cinder cones
[Qts](#) - Basalt spatter cones or spatter ramparts
[Qtp](#) - Local basalt pyroclastic deposits
[Qtb](#) - Basalt flows
[Qtac](#) - Basaltic andesite cinder cones
[Qta](#) - Basaltic andesite flow
[Qtad](#) - Basaltic andesite porphyry dome of vent 91
[Qtt](#) - Tuff ring deposits

Quaternary and Tertiary Periods

[QTwc](#) - Basalt spatter and cinder cone
[QTwb](#) - Basalt flows
[QTa](#) - San Francisco Mountain Volcanic Center andesite flows

Mesozoic and Paleozoic Eras

Triassic and Permian Periods

[TRPs](#) - Sedimentary rocks of Triassic and Permian Age

Map Unit Descriptions

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

Qe - Eolian deposits (Holocene)

Reworked, black, derived largely from Sunset Crater cinders; usually occurs as local active dune deposits; not distinguished in areas extensively covered by basalt cinders that originated at Sunset Crater ([Qsp](#)). (*GRI Source Map ID 1208*) ([Eastern San Francisco Volcanic Field Map](#)).

Qal - Alluvium and colluvium (Holocene and Pleistocene)

Consists predominantly of cinders over most of area. In western part unit includes glacial outwash, Sinagua Formation of Updike and Pewe (1970), and dissected alluvial fan deposits on the north side of O'Leary Peak; dissected gravel deposits largely composed of silicic volcanic rock fragments that occur locally in Interflow washes in the northern part of the area. Postdates faults shown as bounding it. (*GRI Source Map ID 1208*) ([Eastern San Francisco Volcanic Field Map](#)).

Qtg - Terrace gravels (Pleistocene)

Gravel terrace remnants that cap mesas (usually underlain by sandstone of Moenkopi Formation) near the Little Colorado River. Pebbles include silicic volcanic rocks, basalt, granite, quartzite, sandstone, petrified wood, chert, limestone, conglomerate, and arkose. (*GRI Source Map ID 1208*) ([Eastern San Francisco Volcanic Field Map](#)).

Qsl - Basalt cinders and spatter (Holocene)

Locally overlies basalt cinder cone of Sunset Crater and the basalt sheet from eruption of Sunset Crater. Consists of alkali olivine basalt with a few ultramafic xenoliths. Probably a late stage of the Sunset Crater eruption. (*GRI Source Map ID 1208*) ([Eastern San Francisco Volcanic Field Map](#)).

Qsc - Alkali-olivine basalt cinder cone (Holocene)

Date of eruption, determined from tree-ring studies, 1064 or 1065 A.D. (Smiley, 1958, p. 190). (*GRI Source Map ID 1208*) ([Eastern San Francisco Volcanic Field Map](#)).

Qsp - Basaltic pyroclastic sheet from eruption of Sunset Crater (Holocene)

Unit occurs as a widespread blanket of fresh black and subordinate red cinders that mantles preexisting landscape. Composition is alkali olivine basalt with locally abundant ultramafic, gabbroic, granulitic, and sedimentary xenoliths. Light stipple where the cinders are present as a thin discontinuous mantle overlying another mapped unit. (*GRI Source Map ID 1208*) ([Eastern San Francisco Volcanic Field Map](#)).

Qsb - Bonito and Kana-a flows from Sunset Crater (Holocene)

Composition is alkali olivine basalt. Flows generally overlie basalt cinder sheet from eruption of Sunset Crater ([Qsp](#)) but are mantled in part by the youngest basalt cinders (part of [Qsp](#)) from Sunset Crater. A few ultramafic xenoliths are present. Flow surfaces consist of very fresh pahoehoe, slab pahoehoe, and aa. Thickness ranges from 2 m near margins to perhaps 30 m or more in the center of the Bonito flow.

Scattered phenocrysts of olivine, clinopyroxene, and rare plagioclase occur in a groundmass of the same minerals, opaque oxides, and residuum. (GRI Source Map ID 1208) ([Eastern San Francisco Volcanic Field Map](#)).

Qmc - Basalt conder cones (Pleistocene)

Includes local spatter and tuff deposits. Composition is generally alkali olivine basalt with minor alkali-rich high-alumina basalt (Moore, 1973). Although significant soil development has occurred, cones have sharp rims and are virtually uneroded. (GRI Source Map ID 1208) ([Eastern San Francisco Volcanic Field Map](#)).

Qms - Basalt spatter from vent 127 (Pleistocene)

Includes little or no cinder material. Composition is alkali olivine basalt. (GRI Source Map ID 1208) ([Eastern San Francisco Volcanic Field Map](#)).

Qmp - Basalt pyroclastic sheet (Pleistocene)

Usually black; smooth, relatively uneroded, continuous over large areas; upper part brown because of soil formation, which distinguishes unit from basalt cinder sheet from eruption of Sunset Crater ([Qsp](#)); lag of black, cinders common on surface. Includes local dune deposits in lee of Woodhouse- and Tappan-age flows east of Merriam Crater (vent 128). Light stipple where the cinders are present as a thin discontinuous mantle overlying another mapped unit. Includes red mantling cinders immediately adjacent to Merriam Crater (vent 128) and basaltic andesite spatter and cinders near O Neill Crater (vent 109) and Strawberry Crater (vent 77). (GRI Source Map ID 1208) ([Eastern San Francisco Volcanic Field Map](#)).

Qmpv - Basalt of vent 130 (Pleistocene)

Pluglike feature composed of approximately horizontal alkali olivine basalt flow units that may have been uplifted after ponding in the vent. (GRI Source Map ID 1208) ([Eastern San Francisco Volcanic Field Map](#)).

Qmb - Basalt flows (Pleistocene)

Flow surfaces are rough, relatively fresh pahoehoe and aa. Composition is generally alkali olivine basalt with minor alkali-rich high-alumina basalt. Scattered phenocrysts of olivine, clinopyroxene, and rare plagioclase occur in a groundmass of the same minerals plus opaque oxides and residuum. Scattered ultramafic nodules occur in some flows. Thickness at flow edges ranges from 2 to 12 m. (GRI Source Map ID 1208) ([Eastern San Francisco Volcanic Field Map](#)).

Qmac - Basaltic andesite cinder and spatter cones (Pleistocene)

Basaltic andesite cinder and spatter cones. (GRI Source Map ID 1208) ([Eastern San Francisco Volcanic Field Map](#)).

Qma - Basaltic andesite flows (Pleistocene)

Flow surfaces consist of large, relatively fresh blocks. Phenocrysts of olivine, clinopyroxene, orthopyroxene, and plagioclase are set in a groundmass of the same minerals plus opaque oxides and residuum. A few gabbroic and ultramafic xenoliths are present. thickness near margins ranges from 3 to

30 m. Flows have breached east sides of Strawberry (vent 77) and O'Neill (vent 109) Craters K-Ar ages (Damon and others, 1974) include 50,000 +/- 14,000 years for the O'Neill flow and 46,000 +/- 46,000 years for the Strawberry flow. (GRI Source Map ID 1208) ([Eastern San Francisco Volcanic Field Map](#)).

Qmr - Vitrophyre plugs of O'Neill Crater (vent 109) and Strawberry Crater (vent 77) (Pleistocene)

Apparently extruded as small viscous spines after breaching of the cones by basaltic andesite flows. Chemically, plug of O'Neill Crater is rhyodacite and Strawberry Crater plug is dacite. Phenocrysts of corroded plagioclase and orthopyroxene are set in a brown glass. Inclusions of basaltic andesite spatter occur in the vitrophyre; inclusions of the vitrophyre found in the spatter suggest the vitrophyre may have existed as a nearly solid segregation in the magma chamber during the eruption of the basaltic andesite. (GRI Source Map ID 1208) ([Eastern San Francisco Volcanic Field Map](#)).

Qor - Rhyodacite flow of Deadman Mesa (Pleistocene)

Plagioclase and orthopyroxene microphenocrysts are scattered in a microcrystalline to cryptocrystalline groundmass. Flow top, which is relatively flat, is largely mantled by alluvium and Sunset Crater cinders. Maximum flow thickness at the margin is 90 m. (GRI Source Map ID 1208) ([Eastern San Francisco Volcanic Field Map](#)).

Qorv - Vent facies of rhyodacite flow of Deadman Mesa (Pleistocene)

Flow erupted along a fissure marked by reddish oxidation of the rhyodacite and, in the southern portion, by a steep narrow ridge. (GRI Source Map ID 1208) ([Eastern San Francisco Volcanic Field Map](#)).

Qorr - Rhyodacite dome of Robinson Crater (Pleistocene)

Obsidian and cryptocrystalline to microcrystalline rhyodacite with scattered microphenocrysts of plagioclase, biotite, and fayalitic olivine. Dome almost totally mantled by pyroclastic material consisting of angular fragments of obsidian, pumice, and flow-banded rhyodacite identical to the underlying dome material, as well as minor altered rhyodacite porphyry of O'Leary Peak. Light stipple shows distribution of the pyroclastic material where it overlies the rhyodacite porphyry of O'Leary Peak and the andesite porphyry flow. Maximum exposed height of dome about 150 m. Age relation to rhyodacite of Deadman Mesa and rhyodacite obsidian flow north of O'Leary Peak unknown. (GRI Source Map ID 1208) ([Eastern San Francisco Volcanic Field Map](#)).

Qoap - Andesite pyroclastic deposits of O'Leary Peak (Pleistocene)

Red scoria with abundant xenoliths of O'Leary rhyodacite porphyry and quartz xenocrysts and scattered xenoliths of the andesite porphyry flow; occurs as crudely bedded deposits on the south and west flanks of O'Leary Peak. (GRI Source Map ID 1208) ([Eastern San Francisco Volcanic Field Map](#)).

Qoo - Rhyodacite obsidian flow north of O'Leary Peak (Pleistocene)

Obsidian is banded and largely devitrified. Flow top consists of frothy, pumiceous material. Scattered microphenocrysts of plagioclase, orthopyroxene, amphibole, and quartz are set in a groundmass of glass or devitrified glass. Flow is heavily mantled with Sunset Crater cinders and some alluvium. Maximum flow thickness, at south margin, is about 90 m. Unit overlies rhyodacite porphyry of O'Leary Peak. (GRI Source Map ID 1208) ([Eastern San Francisco Volcanic Field Map](#)).

Qoov - Vent facies of rhyodacite obsidian flow north of O'Leary Peak (Pleistocene)

Flow erupted along fissure marked by reddish oxidation of the rhyodacite and, in part, by a steep high ridge. (GRI Source Map ID 1208) ([Eastern San Francisco Volcanic Field Map](#)).

Qord - Rhyodacite porphyry dome of O'Leary Peak (Pleistocene)

Phenocrysts and microphenocrysts of sanidine (occasionally mantled with plagioclase), plagioclase, altered amphibole, quartz, allanite, orthopyroxene, and biotite occur in a light-gray to light-brown groundmass of similar minerals plus opaque oxides and residuum. Xenoliths of red or gray hornblende andesite identical to those that occur in the andesite porphyry flow are abundant. Two domes are present. The southeast dome, interpreted as the younger, contains rare xenoliths identical in lithology to the andesite porphyry flow. The higher northwest dome, about 600 m high, is deeply gullied on its north slope, where the porphyry is unusually decomposed, possibly because of hydrothermal alteration. Elsewhere the domes are undissected. Sanidine from the porphyry of the northwest dome has been dated at 233,000 +/- 37,000 years by the K-Ar method (Damon and others, 1974). (GRI Source Map ID 1208) ([Eastern San Francisco Volcanic Field Map](#)).

Qoch - Chaotic rock debris (Pleistocene)

Consists of rocks older than the O'Leary Peak volcanic center that were apparently pushed aside by and spilled from the O'Leary Peak rhyodacite porphyry dome; poorly exposed; includes unconsolidated debris of Mississippian Redwall Limestone, Pennsylvanian Supai Formation, Permian Coconino Sandstone, Permian Kaibab Limestone, and basalt. Debris materials mixed with each other and with fragments of rhyodacite porphyry from O'Leary Peak. Debris of older rocks (e.g. Redwall) tends to be concentrated nearer the dome and debris of younger rocks (e.g. Kaibab Limestone, basalt) farther from the dome. (GRI Source Map ID 1208) ([Eastern San Francisco Volcanic Field Map](#)).

Qod - Dacite flow north of O'Leary Peak (Pleistocene)

Abundant plagioclase and scattered orthopyroxene and quartz phenocrysts in a cryptocrystalline to microcrystalline groundmass with abundant plagioclase and orthopyroxene; poorly exposed; areal extent small; stratigraphic position uncertain but may predate rhyodacite obsidian flow north of O'Leary Peak. (GRI Source Map ID 1208) ([Eastern San Francisco Volcanic Field Map](#)).

Qoaf - Andesite porphyry (Pleistocene)

Underlies the northwest porphyry dome. Phenocrysts of plagioclase, orthopyroxene, amphibole, clinopyroxene, biotite (commonly altered), and rare quartz and alkali feldspar are set in a groundmass of plagioclase, pyroxene, opaque oxides, and brown glass. Abundant xenoliths of hornblende andesite are similar to those found in the rhyodacite porphyry dome of O'Leary Peak. Thickness at the margins ranges from 15 to 60 m. (GRI Source Map ID 1208) ([Eastern San Francisco Volcanic Field Map](#)).

Qtc - Basalt cinder cones (Pleistocene)

Compositions include alkali olivine basalt and alkali-rich high-alumina basalt. Cinders are deeply weathered in soil zone; cones are subdued but little dissected. Ultramafic, gabbroic, granulitic, and Paleozoic sedimentary xenoliths are abundant in many cones. Phenocrysts of olivine, clinopyroxene,

and plagioclase are common, usually set in a very fine grained groundmass of highly oxidized material. Flows and cones of this group are considered comparable in age to the Tappan flow of the SP Mountain quadrangle (Ulrich and Bailey, 1974), for which a K-Ar age of 0.51 +/- 0.08 m.y. has been determined (Damon and others, 1974). (*GRI Source Map ID 1208*) ([Eastern San Francisco Volcanic Field Map](#)).

Qttc - Tuffaceous cinder cones (Pleistocene)

Generally consist of interbedded tuff and alkali olivine basalt or high-alumina basalt cinders. Fragments of ultramafic rocks, gabbros, granulites, and Paleozoic sedimentary rocks are included in the tuff, which, as in the tuff rings, consists of finely comminuted quartz grains and phenocrysts or xenocrysts of clinopyroxene, plagioclase, and olivine in a palagonitic matrix. (*GRI Source Map ID 1208*) ([Eastern San Francisco Volcanic Field Map](#)).

Qts - Basalt spatter cones or spatter ramparts (Pleistocene)

Includes little or no cinder material. Composition is generally alkali olivine basalt, with phenocrysts of olivine, clinopyroxene, and plagioclase in a groundmass of the same materials plus opaque oxides and residual material. (*GRI Source Map ID 1208*) ([Eastern San Francisco Volcanic Field Map](#)).

Qtp - Local basalt pyroclastic deposits (Pleistocene)

Usually closely associated with nearby cinder cones; commonly red, hummocky, brown soil in upper part with cinder lag on surface; locally eroded. Light stipple where cinders are present as a than discontinuous mantle overlying another mapped unit. (*GRI Source Map ID 1208*) ([Eastern San Francisco Volcanic Field Map](#)).

Qtb - Basalt flows (Pleistocene)

Largely alkali olivine basalt; some alkali-rich high-alumina basalt. Ultramafic, gabbroic, granulitic, and Paleozoic sedimentary xenoliths are present in many flows. Textures range from nonporphyritic to porphyritic, with sparse to abundant phenocrysts of olivine, clinopyroxene, and plagioclase in a groundmass of the same minerals, opaque oxides, and residual material. Flow margins, which range from 1 to 60 m thick, are generally well defined and undissected; the upper surfaces of the flows are typically somewhat subdued by weathering and accumulation of alluvial or pyroclastic mantles. A K-Ar age of 0.67 +/- 0.10 m.y. has been determined by Damon, Shafiqullah, and Leventhal, (1974, p 227) for the basalt flow from vent 171. (*GRI Source Map ID 1208*) ([Eastern San Francisco Volcanic Field Map](#)).

Qtac - Basaltic andesite cinder cones (Pleistocene)

Includes subordinate spatter. Weathered cinders and spatter contain rare phenocrysts of olivine, clinopyroxene, orthopyroxene, amphibole, and plagioclase in a groundmass of the same minerals, opaque oxides, and residual material. (*GRI Source Map ID 1208*) ([Eastern San Francisco Volcanic Field Map](#)).

Qta - Basaltic andesite flow (Pleistocene)

Flow margins, 10-50 in high, are well defined, undissected, blocky; upper surfaces are subdued by weathering effects and mantling materials. Phenocrysts of plagioclase and minor olivine, clinopyroxene, amphibole, and orthopyroxene and rare xenocrysts of quartz are set in a fine-grained groundmass of plagioclase, pyroxene, olivine, opaque oxides, and residual material. (*GRI Source Map ID 1208*) ([Eastern](#)

[San Francisco Volcanic Field Map](#)).

Qtad - Basaltic andesite porphyry dome of vent 91 (Pleistocene)

Includes breached spatter rampart and flow. Phenocrysts of plagioclase, orthopyroxene, clinopyroxene, opaque oxides, amphibole, and, rarely, biotite, apatite, and olivine occur in a microcrystalline groundmass of plagioclase, olivine, pyroxene, opaque oxides, and residuum. Similar but highly oxidized rock forms the spatter rampart. The flow, lithologically similar to the dome, apparently breached both the dome and the spatter rampart. (GRI Source Map ID 1208) ([Eastern San Francisco Volcanic Field Map](#)).

Qtt - Tuff ring deposits (Pleistocene)

Crudely sorted, well-bedded tuff containing fine-grained quartz and possibly derived from the Coconino Sandstone, crystals or fragments of plagioclase, clinopyroxene, and olivine, basalt cinders, basalt fragments, and fragments of silicified Kaibab Limestone and, locally, sandstone of the Moenkopi Formation, all in a palagonitic matrix. Where age relations can be determined the tuff rings are younger than Woodhouse-age flows and older than the associated Tappan-age cones and flows. Includes tuff deposits from an unidentified vent in southeastern corner of mapped area. (GRI Source Map ID 1208) ([Eastern San Francisco Volcanic Field Map](#)).

QTwc - Basalt spatter and cinder cone (Pleistocene and Pliocene)

Basalt spatter and cinder cone material of vent 520. Alkali olivine basalt. (GRI Source Map ID 1208) ([Eastern San Francisco Volcanic Field Map](#)).

QTwb - Basalt flows (Pleistocene and Pliocene)

Composition is alkali olivine basalt and minor alkali-rich high-alumina basalt. Commonly cap mesas. Phenocrysts of olivine, clinopyroxene, and plagioclase occur in a fine- to medium-grained matrix of the same minerals, opaque oxides, and residuum. Gabbro xenoliths are occasionally present. Upper flow surfaces are commonly quite flat, and thickness at flow margins ranges from 2 to 15 m. Locally mantled by thin rhyolitic pumice deposit (Ulrich and Bailey, 1974), not shown in northwestern part of mapped area. K-Ar ages of basalt flows of Woodhouse age range from approximately 0.8 to 3.0 m.y. (Damon and others, 1974). (GRI Source Map ID 1208) ([Eastern San Francisco Volcanic Field Map](#)).

QTa - San Francisco Mountain Volcanic Center andesite flows (Pleistocene and Pliocene)

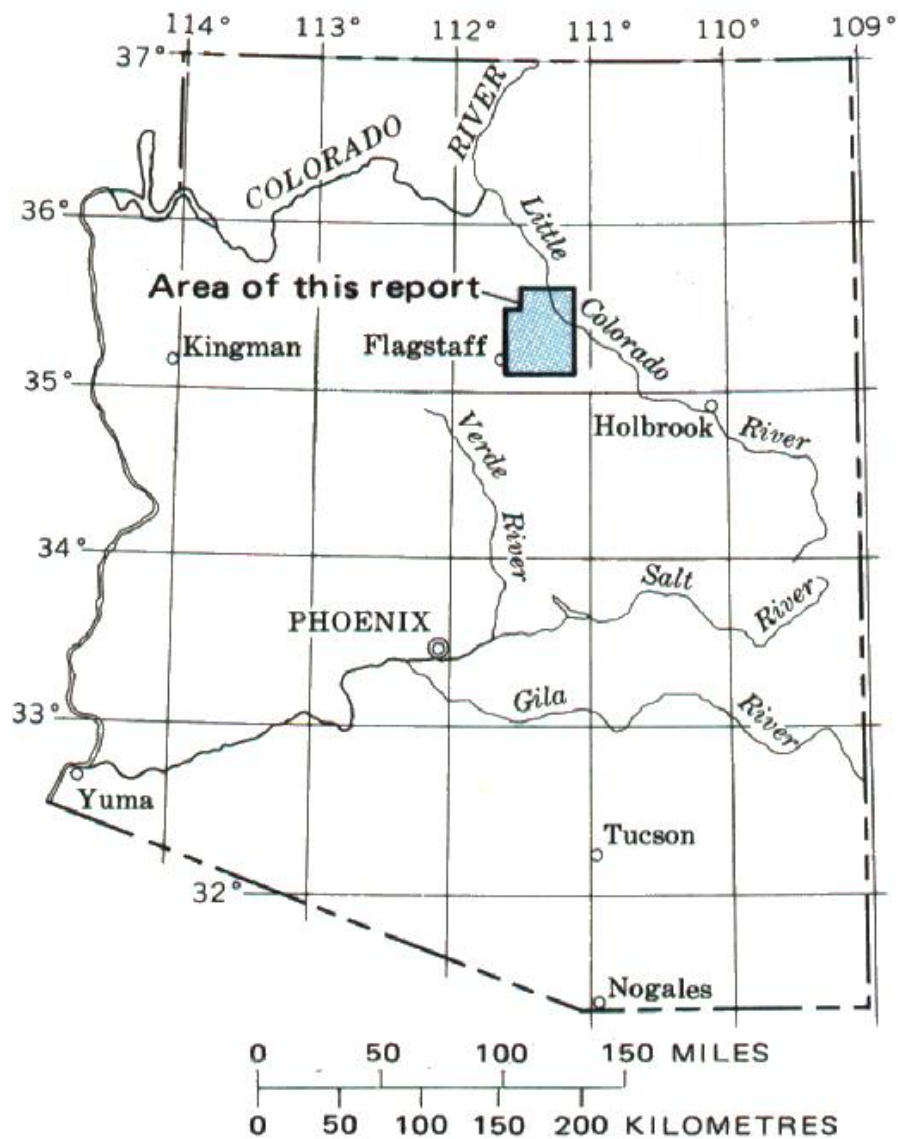
Occurs at west edge of map area north of Black Bill Park. Phenocrysts of plagioclase and orthopyroxene in a groundmass of black, brown, or gray glass. Flow surface is heavily mantled with alluvium; thickness at the flow margins ranges from 6 to 30 m in the mapped area. (GRI Source Map ID 1208) ([Eastern San Francisco Volcanic Field Map](#)).

TRPs - Sedimentary rocks of Triassic and Permian Age (Triassic and Permian)

Sandy dolomitic limestone and minor sandstone and siltstone of the Permian Kaibab Limestone and red sandstone with minor shale and conglomerate of the Triassic Moenkopi Formation, undivided. Includes the Permian Coconino Sandstone and Toroweap Formation in the Little Colorado River valley north of Grand Falls and in a deep canyon north of Doney Crater (vent 80). The Moenkopi Formation is not exposed in the volcanic field south of the Leupp Road except in scattered patches along Interstate

Highway 40 and U.S. Highway 66 in and near Flagstaff. Most of the mesa-capping basalt flows of Woodhouse age ([QTwb](#)) rest on Moenkopi sandstone, as do many of the older terrace gravels ([Qtg](#)). Locally includes unmapped alluvial deposits and some mantling pyroclastic materials. (*GRI Source Map ID 1208*) ([Eastern San Francisco Volcanic Field Map](#)).

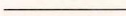
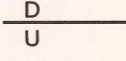
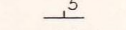
Location Map



INDEX MAP OF ARIZONA

Extracted from: ([Eastern San Francisco Volcanic Field Map](#)).

Map Legend

	Contact — Also distinguishes separate flows within the same age group
	Fault — Dashed where approximately located, dotted where concealed; U upthrown; D downthrown side
	Monocline — Showing trace of axis, dashed where approximately located
	Anticline — Showing trace of axis, dashed where approximately located
	Strike and dip of beds
	Inclined
V235	Vent number — Vent numbers smaller than 500 from Colton (1967); numbers larger than 500 assigned to vents not numbered by Colton
235	Lava flow from vent 235; sources for unnumbered flows are unknown

Extracted from: ([Eastern San Francisco Volcanic Field Map](#)).

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Extracted from: ([Eastern San Francisco Volcanic Field Map](#)).

GRI Digital Data Credits

This document was developed and completed by Derek Witt (Colorado State University) for the NPS Geologic Resources Division (GRD) Geologic Resources Inventory (GRI) Program. Quality control of this document by Stephanie O'Meara (Colorado State University). The initial GRI ancillary map information document/helpfile was produced by Stephanie O'Meara.

The information in this document was compiled from the GRI source map, and is intended to accompany the digital geologic-GIS map and other digital data for Sunset Crater Volcano National Monument, Arizona (SUCR) developed by Derek Witt and Stephanie O'Meara (see the [GRI Digital Map and Source Map Citation](#) section of this document for all sources used by the GRI in the completion of this document and related GRI digital geologic-GIS map). Initial GRI digital data produced by Stephanie O'Meara and Todd Sander (NPS GRD student intern).

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