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

Navajo National Monument

GRI Ancillary Map Information Document

Produced to accompany the Geologic Resources Inventory (GRI) Digital Geologic Data for Navajo National Monument

nava_geology.pdf

Version: 6/19/2019

Geologic Resources Inventory Map Document for Navajo National Monument

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Geologic Resources Inventory Map Document

Navajo National Monument, Arizona

Document to Accompany Digital Geologic-GIS Data

nava_geology.pdf

Version: 6/19/2019

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

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 Map and Source Map Citation** – A listing of the GRI digital geologic-GIS map produced for this project along with the source used in its completion.

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

5) **Ancillary Source Map Information** – Additional information including index map, explanation of mapping, and the report associated with the source map publication.

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

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

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About the NPS Geologic Resources Inventory Program

Background

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

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

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

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

Products

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

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

For detailed information regarding GIS parameters such as data attribute field definitions, attribute field codes, value definitions, and rules that govern relationships found in the data, refer to the NPS Geology-GIS Data Model document available at: https://www.nps.gov/articles/gri-geodatabase-model.htm

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://go.nps.gov/gri_products

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: https://www.nps.gov/subjects/geology/gri.htm, 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 Navajo National Monument, Arizona (NAVA):

Digital Geologic-GIS Map of Navajo National Monument and Vicinity, Arizona (*GRI MapCode NAVA*)

The map was produced from the following source map.

> Cooley, M.E., et.al., 1969, Regional Hydrogeology of the Navajo and Hopi Indian Reservations, Arizona, New Mexico, and Utah with a Section on Vegetation: U.S. Geological Survey, Professional Paper 521-A, Plate 1, Sheet 3 of 9, scale 1:125,000 (Regional Hydrogeology of the Navajo and Hopi Indian Reservations). (*GRI Source Map ID 825*).

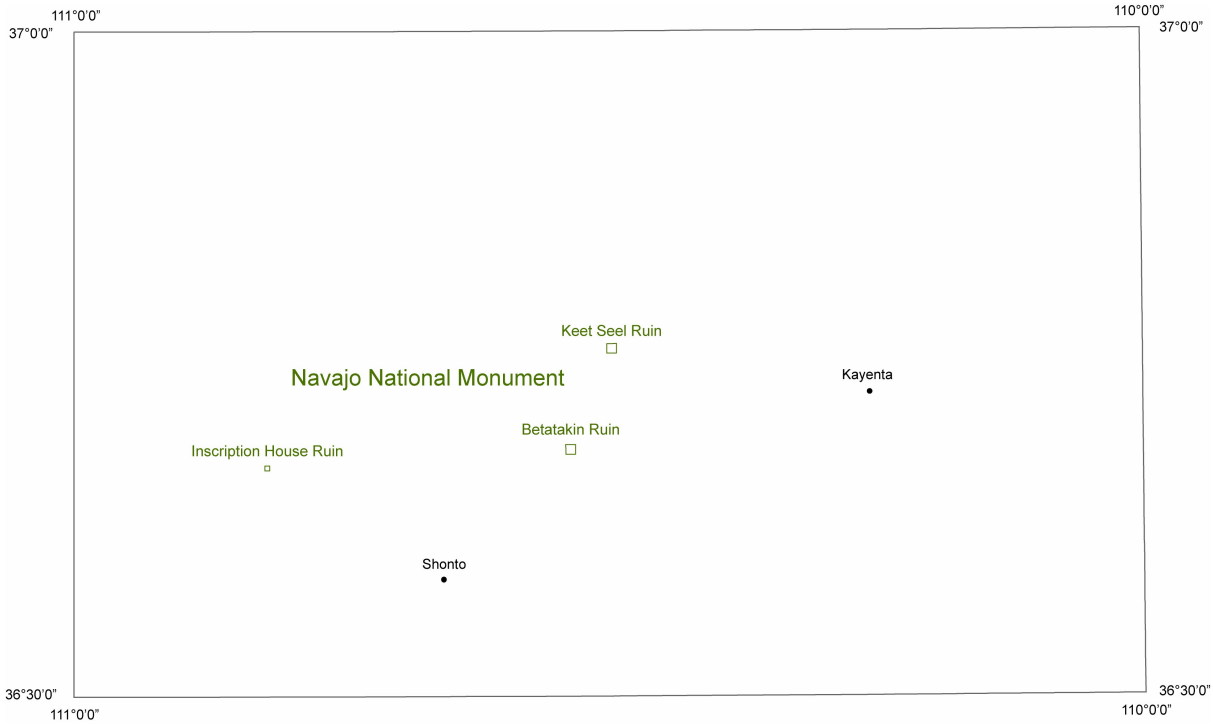
Only a partial extent of the source map, portions of sheet 3, was used, but all geologic features within this extent were captured. Additional information pertaining to the source map is also presented in the GRI Source Map Information (NAVAMAP) table included with the GRI geologic-GIS data.

The citation for the GRI report mentioned in this document is listed below.

Graham, J., 2007, Navajo National Monument Geologic Resources Evaluation Report. Natural Resources Report NPS/NRPC/GRD/NRR - 2007/005. National Park Service, Denver.

Index Map

The following index map displays the extent (in dark gray) of the GRI digital geologic-GIS map for Navajo National Monument, as well as the unit boundaries and unit names of the monument (in dark green, as of June, 2019). The towns of Kayenta and Shonto are also shown.



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

Map Unit List

The geologic units present in the digital geologic-GIS data produced for Navajo National Monument, Arizona (NAVA) 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 (NAVAUNIT) table included with the GRI geologic-GIS data.

Cenozoic Era

Quaternary Period
Qal - Alluvium
Qd - Dune sand

Tertiary Period
Tg - Gravel
Ti - Intrusive igneous rocks

Mesozoic Era

Cretaceous Period
Ky - Yale Point Sandstone
Kw - Wepo Formation
Kt - Toreva Formation
Km - Mancos Shale
Kd - Dakota Sandstone

Jurassic Period
Jmw - Morrison Formation, Westwater Canyon Member
Jmr - Morrison Formation, Recapture Member
Jms - Morrison Formation, Salt Wash Member
Jcs - Cow Springs Sandstone
Jbsu - Summerville Formation, Bluff Sandstone and upper sandy member, undifferentiated
Jsu - Summerville Formation, upper sandy member
Jem - Entrada Sandstone, middle silty member
Jel - Entrada Sandstone, lower sandy member
Jc - Carmel Formation
JTRn - Navajo Sandstone*
TRk - Kayenta Formation, sandy facies*
TRwl - Wingate Sandstone, Lukachukai Member*
TRwr - Wingate Sandstone, Rock Point Member*

** The Navajo Sandstone, Kayenta Formation and Wingate Sandstone are all now recognized to be Jurassic in age. Source map unit symbols for these units that indicates Triassic age (i.e., TR) have been retained as this was also done in the GRI report (Graham, 2007). The change in age of these units is discussed in the report.*

Triassic Period
TRcco - Chinle Formation, Church Rock and Owl Members, undifferentiated
TRcp - Chinle Formation, Petrified Forest Member
TRcm - Chinle Formation, Monitor Butte Member
TRcs - Chinle Formation, Shinarump Member
TRm - Moenkopi Formation
TRmh - Moenkopi Formation, Hoskinnini Member

Paleozoic Era

Permian Period
Pcdc - Cutler Formation, De Chelley Sandstone Member
Pcor - Cutler Formation, Organ Rock Tongue Member
Pccm - Cutler Formation, Cedar Mesa Sandstone Member

Map Unit Descriptions

Descriptions of all geologic map units, generally listed from youngest to oldest, are presented below. All unit descriptions taken from the Regional Hydrogeology of the Navajo and Hopi Indian Reservations source map. If a unit symbol, name and/or age has been changed from the source map in the GRI digital geologic-GIS data, the source map unit symbol, name and/or age is then presented just before that unit's description.

Qal - Alluvium (Recent and Pleistocene)

Qal - Alluvium (Pleistocene and Recent)
Chiefly sand, silt, and gravel. Yields generally small amounts of water to wells along the Little Colorado River, San Juan River and larger tributaries.

Qd - Dune sand (Recent and Pleistocene)

Qd - Dune Sand (Pleistocene and Recent)
Chiefly sand. Yields small amounts of water to a few springs.

Tg - Gravel (Pliocene)

Gravel to silt, may include rocks of Miocene age.

Ti - Intrusive igneous rocks (Pliocene and Miocene (?))

Ti - Intrusive igneous rocks (Miocene? and Pliocene)
Includes, in the Carrizo Mountains, stock-laccoliths that possibly are older than Miocene (?).

Ky - Yale Point Sandstone (Upper Cretaceous)

Tan and brown sandstone. Yields water along southwestern flank of the San Juan basin.

Kw - Wepo Formation (Upper Cretaceous)

Alternating beds of olive-gray siltstone, coal, and yellowish-gray sandstone. Sandstone beds yield small amounts of water to a few wells and springs in central Black Mesa.

Kt - Toreva Formation (Upper Cretaceous)

Sandstone units yield small amounts of water to wells in southern and central Black Mesa; base of formation is a prominent spring zone in the Hopi country. The unit is divided into three members,

Upper Sandstone Member
Yellowish-gray to grayish-orange-pink, fine to very coarse grained.

Middle Carbonaceous Mudstone Member
Varicolored.

Lower Sandstone Member
Light-brown to pale-yellowish-gray, fine- to medium-grained.

Km - Mancos Shale (Upper Cretaceous)

Light- to dark-gray claystone and siltstone containing lesser amounts of tan fine-grained sandstone, limestone, and concretionary limestone. Usually not water bearing. The unit is divided into three members,

Upper Part
No additional description present on source map.

Satan Tongue
No additional description present on source map.

Mulatto Tongue
No additional description present on source map.

Lower Part
Present only in southern part. No additional description present on source map.

Kd - Dakota Sandstone (Upper Cretaceous)

Tan, brown, and gray sandstone, conglomeratic sandstone, and conglomerate; frequently contains partings of brown carbonaceous siltstone and lenses of coal. Unit is chief aquifer of the D multiple-aquifer system; yields small amounts of water to wells in the southern part of Black Mesa basin; some of the wells flow.

Jmw - Morrison Formation, Westwater Canyon Member (Upper Jurassic)

Yellowish-gray sandstone containing conglomeratic lenses and dark-reddish-brown siltstone. Sandstone units yield small amounts of water to wells in Apache and Navajo Counties.

Jmr - Morrison Formation, Recapture Member (Upper Jurassic)

White and brown fine- to medium- grained sandstone, siltstone and conglomerate. Sandstone units yield small amounts of water to wells in Apache and Navajo Counties.

Jms - Morrison Formation, Salt Wash Member (Upper Jurassic)

White and moderate-orange very fine to medium-grained sandstone, grayish-red shale, and gray limestone. Sandstone units yield small amounts of water to wells in Apache and Navajo Counties.

Jcs - Cow Springs Sandstone (Upper Jurassic)

Greenish-gray to light-yellowish-gray fine- to medium-grained cross-bedded sandstone, intertoungues with Morrison Formation and grades into upper units of San Rafael Group. Lower part of Morrison Formation mapped with unit in some areas. Yields small amounts of water in Chinle Valley area and in the southern and eastern parts of the Black Mesa basin.

Jbsu - Bluff Sandstone and Summerville Formation, upper sandy member, undifferentiated (Upper Jurassic)

Bluff Sandstone (Jurassic)
Gray to brown medium- to coarse-grained sandstone. Yields small amounts of water in Chinle Valley area and in the southern and eastern parts of the Black Mesa basin.

Summerville Formation, upper sandy member (Upper Jurassic)
Moderate-reddish-brown fine- to medium-grained sandstone and argillaceous siltstone. Usually not water bearing; sandy facies yields some water to springs in Chuska Mountains.

Jsu - Summerville Formation, upper sandy member (Upper Jurassic)

Moderate-reddish-brown fine- to medium-grained sandstone and argillaceous siltstone. Usually not water bearing; sandy facies yields some water to springs in Chuska Mountains.

Jem - Entrada Sandstone, middle silty member (Upper Jurassic)

Reddish-brown fine-grained sandstone and siltstone. Yields water to a few small springs in the northern part of the Navajo Indian Reservation; yields small amounts to wells in the Chinle Valley area and in the southern part of Black Mesa basin.

Jel - Entrada Sandstone, lower sandy member (Upper Jurassic)

Reddish-brown fine-grained sandstone and siltstone. Yields water to a few small springs in the northern part of the Navajo Indian Reservation; yields small amounts to wells in the Chinle Valley area and in the southern part of Black Mesa basin.

Jc - Carmel Formation (Upper and Middle Jurassic)

Red sandstone and siltstone. Yields water to a few small springs in northeastern Coconino County; forms upper confining bed of the N multiple-aquifer system.

JTRn - Navajo Sandstone (Jurassic*)

Grayish-orange-pink even-grained highly cross-bedded sandstone. Unit is the chief aquifer of the N multiple-aquifer system; yields small to medium amounts of water principally in the northern part of the Navajo Indian Reservation; base of formation is conspicuous spring zone.

** The Navajo Sandstone is now recognized to be Jurassic in age. The source map unit symbol for the unit that indicates Triassic age (i.e., TR) has been retained as this was also done in the GRI report (Graham, 2007). The change in age of this unit is discussed in the report.*

TRk - Kayenta Formation, sandy facies (Jurassic*)

Pale-red, cross-bedded sandstone, northeast. Yields water to a few springs; tongues of the Navajo Sandstone in the upper part of the formation yield small amounts of water to wells near Tuba City; a few of these wells flow.

** The Kayenta Formation is now recognized to be Jurassic in age. The source map unit symbol for the unit that indicates Triassic age (i.e., TR) has been retained as this was also done in the GRI report*

(Graham, 2007). The change in age of this unit is discussed in the report.

TRwl - Wingate Sandstone, Lukachukai Member (Jurassic*)

Reddish-brown, fine-grained cross-bedded sandstone. Yields small and moderate amounts of water to springs and wells in northern Apache and Navajo Counties.

** The Wingate Sandstone is now recognized to be Jurassic in age. The source map unit symbol for the unit that indicates Triassic age (i.e., TR) has been retained as this was also done in the GRI report (Graham, 2007). The change in age of this unit is discussed in the report.*

TRwr - Wingate Sandstone, Rock Point Member (Jurassic*)

Reddish-brown siltstone that grades southward into mudstone. Yields some water to springs; unit generally does not yield sufficient water for drilled wells.

** The Wingate Sandstone is now recognized to be Jurassic in age. The source map unit symbol for the unit that indicates Triassic age (i.e., TR) has been retained as this was also done in the GRI report (Graham, 2007). The change in age of this unit is discussed in the report.*

TRcco - Chinle Formation, Church Rock and Owl Members, undifferentiated (Upper Triassic)

Undifferentiated in Monument Valley-Piute Canyon area. Includes only Owl Rock Member in other parts of the reservation. Church Rock Member, reddish-brown siltstone and silty sandstone and grayish-orange-pink mudstone to silty sandstone in the Monument Valley area. Lateral equivalent of the Rock Point Member of the Wingate Sandstone. Owl Rock Member, mottled light-gray and grayish-pink interbedded limestone and calcareous siltstone. Also includes Hite Bed in Monument Valley area along San Juan River. Hite Bed is a pale-reddish to purple sandstone.

TRcp - Chinle Formation, Petrified Forest Member (Upper Triassic)

Claystone, siltstone, and minor amounts of sandstone. On Defiance Plateau, upper and lower parts, separated by Sonsela Sandstone Bed, recognized but not differentiated. The unit is divided into three parts,

Upper Part
No additional description present on source map.

Sonsela Sandstone Member
Light-gray sandstone and conglomerate.

Lower Part
No additional description present on source map.

TRcm - Chinle Formation, Monitor Butte Member (Upper Triassic)

Siltstone, sandstone and lime-pellet conglomerate; includes lower part of Petrified Forest Member in Monument Valley area.

TRcs - Chinle Formation, Shinarump Member (Upper Triassic)

Light-gray to yellowish-gray sandstone and conglomerate; Monitor Butte Member between Lupton and the canyon of Black Creek, Mesa Redondo Member in southern Defiance Plateau, and sandstone and siltstone member in Cameron-Lees Ferry area mapped with unit. Locally, yields small amounts of water to wells and springs throughout northeastern Arizona; it is connected hydrologically with the Coconino (De Chelly) Sandstone of Permian age in the Defiance uplift area.

TRm - Moenkopi Formation (Lower and Middle (?) Triassic)

Reddish-mudstone, siltstone, and silt sandstone. Moenkopi(?) in the Fort Wingate School area. Yields small amount of water to a few wells.

TRmh - Moenkopi Formation, Hoskinnini Member (Lower and Middle (?) Triassic)

Of Triassic(?) age. Present only in Monument Valley; mapped separately in western and central part.

Pcdc - Cutler Formation, De Chelley Sandstone Member (Lower Permian)

Moderate-reddish-orange to very pale orange thick- to very thick-bedded sandstone. Reddish-orange and pale-orange sandstone.

Pcor - Cutler Formation, Organ Rock Tongue Member (Lower Permian)

Deep-reddish-brown silty sandstone, sandy siltstone, siltstone, and a few beds of impure limestone.

Pccm - Cutler Formation, Cedar Mesa Sandstone Member (Lower Permian)

Light-colored very thick-bedded sandstone, siltstone, and limestone.

GRI Ancillary Source Map Information

The following section present ancillary source map information associated with source map used for this project.

Regional Hydrogeology of the Navajo and Hopi Indian Reservations

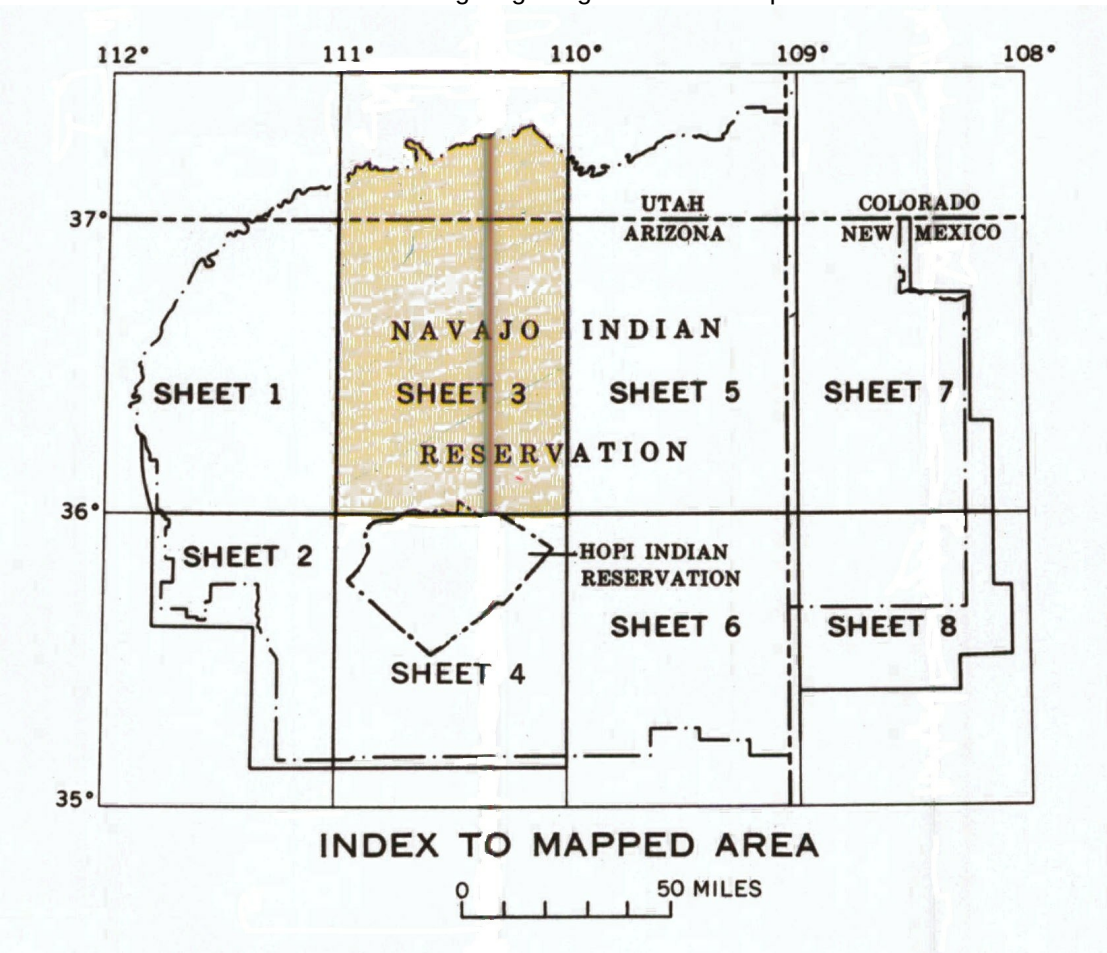
The formal citation for this source.

Cooley, M.E., et.al., 1969, Regional Hydrogeology of the Navajo and Hopi Indian Reservations, Arizona, New Mexico, and Utah with a Section on Vegetation: U.S. Geological Survey, Professional Paper 521-A, Plate 1, Sheet 3 of 9, scale 1:125,000 (*GRI Source Map ID 825*).

Prominent graphics and text associated with this source.

Index Map

The following index map displays the extent of each sheet (map) associated with the source map publication. Only a portion of sheet 3 (denoted in color) was used as a source for the GRI digital geologic-GIS data/map of the monument. As indicated on the Index Map of the GRI Digital Geologic-GIS Map for Navajo National Monument only the extent defined by 111° x 110° longitude, and 37° by 36°30' latitude was used for the GRI digital geologic-GIS data/map.



Graphic from source map: Regional Hydrogeology of the Navajo and Hopi Indian Reservations

Explanation

The explanation of map units, map symbols, unit correlation and sources of geologic data for all eight sheets (maps) associated with the source publication was published as a single sheet (sheet 9). The sheet, as well as all other plates, sheets and documents associated with the source map are available at the map's U.S. Geological Survey publication page, https://pubs.er.usgs.gov/publication/pp521A.

Report

An embedded PDF document of the source map report can be accessed by double-clicking the following document link.

report.pdf

The report contains additional information on the units exposed in the map area, as well as information on the geology and occurrence of groundwater, and the regional hydrogeology. Note that has this report pertains to the full source map publication, and thus all source map sheets, some information within the report may not be relevant to the map area and Navajo National Monument.

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 Stephanie O'Meara.

The information in this document was compiled from GRI source map, and is intended to accompany the digital geologic-GIS map and other digital data for Navajo National Monument, Arizona (NAVA) developed by Stephanie O'Meara and Jake Suri (Colorado State University) (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).

GRI finalization by Stephanie O'Meara (Colorado State University).

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