DIGITAL MAPPING TECHNIQUES 2014

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Showcasing Geologic Resources Inventory Digital Map Products: Grand Canyon National Park

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The Geologic Resources Inventory

The Geologic Resources Inventory (GRI) is one of twelve inventories funded under the National Park Service (NPS) Natural Resource Challenge and is administered by the Geologic Resources Division (GRD) of the Natural Resource Stewardship and Science Directorate (NRSS). The goal of the GRI is to increase understanding of the geologic processes at work in parks and provide accurate geologic information for use in park decision-making. Sound park stewardship relies on understanding natural resources and their role in the ecosystem, of which geology is the foundation. The GRI program is a partnership between the NPS and Colorado State University (CSU), and the program relies heavily upon the U.S. Geological Survey, individual state geological surveys, and other organizations in developing its source map products. CSU research associates work side-by-side with NPS GRD GRI staff to facilitate a scoping meeting that identifies park mapping needs, as well as park-specific geologic issues, features, and processes. For each park the GRI then creates a summary of the scoping meeting, produces digital geologic-GIS map products, and writes a comprehensive geologic report, all for use by park staff.

Introduction

The GRI produces digital geologic-GIS data in several data formats to meet the varying needs and GIS skills of our data users. These product formats presently are: (1) an ESRI 10.0 file geodatabase and accompanying 10.0 ArcMap document for use with ESRI ArcGIS software, (2) a KML/KMZ file for use with Google Earth, and (3) an ESRI 10.1 map service for use with online map viewers.

The focus of this poster is to present GRI digital geologic-GIS products for Grand Canyon National Park (GRCA), and to display this data with high-resolution elevation data to showcase some of the park's spectacular geology. Photographs produced by Ron Karpilo provide excellent visual representation of some of the Grand Canyon's most notable geologic features. These photographs, taken along the Colorado River, are tied into the map using river mile markers.

The GRI produced the digital geologic-GIS map products for Grand Canyon National Park by converting1:24,000 scale digital source data from eight 30' by 60' quadrangle maps, produced by the U.S. Geological Survey (Billingsley, et. al., 2000 to 2012) to the GRI geology-GIS file geodatabase data model format version 2.1. These maps were converted and compiled using ArcGIS Desktop along with custom python and .NET tools developed by the GRI. Each map is cartographically presented with map unit colors and symbology that follows conventional geologic map standards.

GRI Digital Geologic-GIS Maps for Grand Canyon National Park

The GRI digital geologic-GIS maps for Grand Canyon National Park include a compiled park extent map, as well as individual 30' x 60' quadrangle maps. These maps are listed below, and are available online from the NPS GRI Publications page, http://go.nps.gov/gripubs. The source map for each individual 30' x 60' quadrangle map is listed in *italic*, and a 30' x 60' quadrangles index map is also provided (see the 30' x 60' Quadrangle Index Map).

GRI Digital Geologic Map of Grand Canyon National Park, Arizona
The compiled park map has been limited to 7.5' quadrangles that include or that are immediately adjacent to the park. See individual 30' x 60' quadrangle maps (below) for source publications.

GRI Digital Geologic Map of the Fredonia 30' x 60' Quadrangle, Arizona
Billingsley, G.H., Priest, S.S., and Felger, T.J., 2008, Geologic Map of the Fredonia 30' x 60' Quadrangle, Mohave and Coconino Counties, Northern Arizona: U.S. Geological Survey, Scientific Investigations Map SIM-3035, scale 1:100,000 (digital data scale 1:24,000).

GRI Digital Geologic Map of the Glen Canyon Dam 30' x 60' Quadrangle, Arizona
Billingsley, G.H., and Priest, S.S., 2013, Geologic Map of the Glen Canyon Dam 30' x 60' Quadrangle, Coconino County, Arizona: U.S. Geological Survey, Scientific Investigations Map SIM-3268, scale 1:100,000 (digital data scale 1:24,000).

GRI Digital Geologic Map of the Grand Canyon 30' X 60' Quadrangle, Arizona
Billingsley, G.H., and Hampton, H.M., 2000, Geologic Map of the Grand Canyon 30' X 60' Quadrangle, Coconino and Mohave Counties, Northwestern Arizona: U.S. Geological Survey, Geologic Investigations Series Map I-2688, scale 1:100,000 (digital data scale 1:24,000).

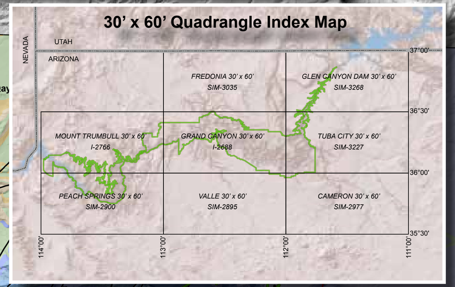
GRI Digital Geologic Map of the Mount Trumbull 30' X 60' Quadrangle, Arizona
Billingsley, G.H., and Wellmeyer, J.L., 2004, Geologic Map of the Mount Trumbull 30' X 60' Quadrangle, Mohave and Coconino Counties, Northwestern Arizona: U.S. Geological Survey, Geologic Investigations Series Map I-2766, scale 1:100,000 (digital data scale 1:24,000).

GRI Digital Geologic Map of the Peach Springs 30' x 60' Quadrangle, Arizona
Billingsley, G.H., Block, D.L., and Dyer, H.C., 2006, Geologic Map of the Peach Springs 30' x 60' Quadrangle, Mohave and Coconino Counties, Northwestern Arizona: U.S. Geological Survey, Scientific Investigations Map SIM-2900, scale 1:100,000 (digital data scale 1:24,000).

GRI Digital Geologic Map of the Tuba City 30' x 60' Quadrangle, Arizona
Billingsley, G.H., Stoffer, P.W., and Priest, S.S., 2012, Geologic Map of the Tuba City 30' x 60' Quadrangle, Coconino County, Arizona: U.S. Geological Survey, Scientific Investigations Map SIM-3227, scale 1:50,000 (digital data scale 1:24,000).

GRI Digital Geologic Map of the Valle 30' x 60' Quadrangle, Arizona
Billingsley, G.H., Felger, T.J., and Priest, S.S., 2006, Geologic Map of the Valle 30' x 60' Quadrangle, Coconino County, Northern Arizona: U.S. Geological Survey, Scientific Investigations Map SIM-2895, scale 1:100,000 (digital data scale 1:24,000).

GRI Digital Geologic Map of Wupatki National Monument and Vicinity, Arizona
Billingsley, G.H., Priest, S.S., and Felger, T.J., 2007, Geologic Map of the Cameron 30' x 60' Quadrangle, Coconino County, Northern Arizona: U.S. Geological Survey, Scientific Investigations Map SIM-2977, scale 1:100,000.

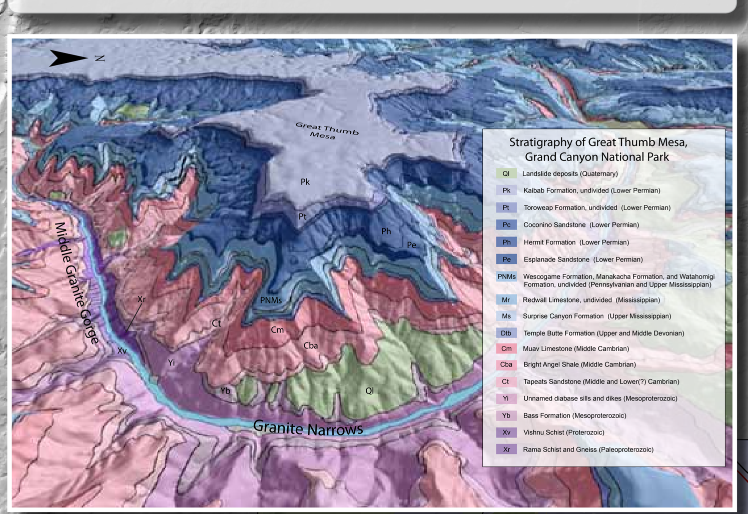


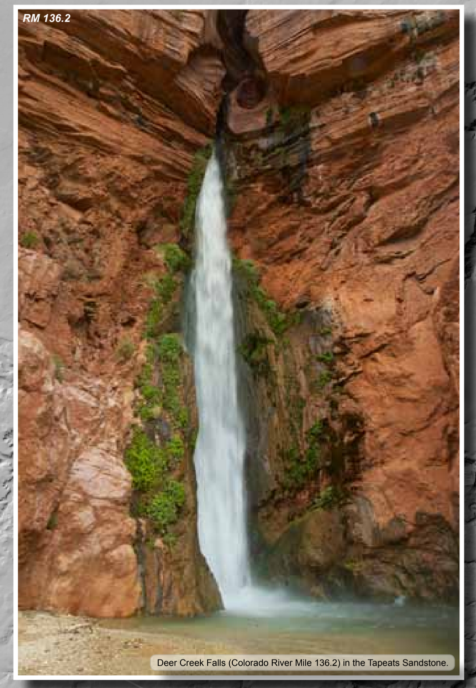
Uinkaret Volcanic Field and Lava Dams

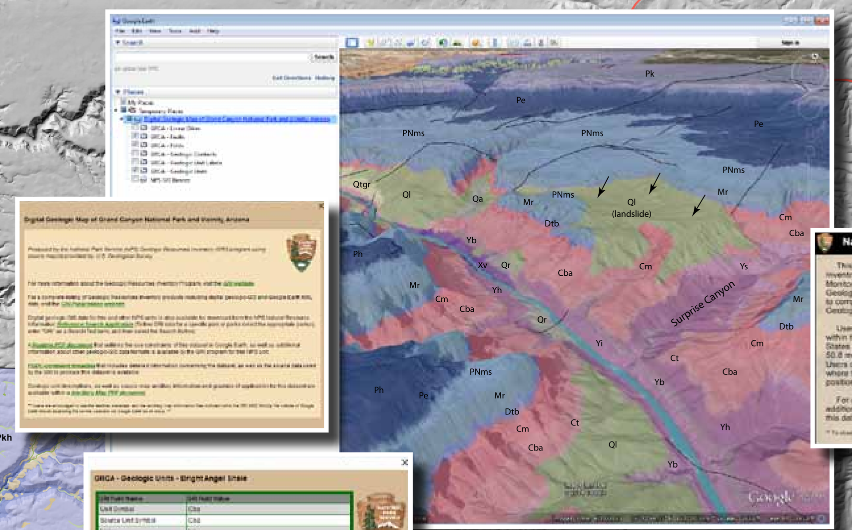
Over 150 lava flows have erupted from volcanic vents in this area and flowed into the Grand Canyon creating spectacular "frozen" lava falls (see River Mile 179.5 photo). These events occurred over the last 2 million years with some of the flows impounding upstream river water, which resulted in increased water levels that extended beyond the present shoreline of Lake Powell (Hamblin, 1994). The image below, produced with ArcGlobe and Adobe Illustrator, shows the Uinkaret Volcanic Field from the southwest, dotted with pyroclastic cinder cones, and a probable lava dam location.

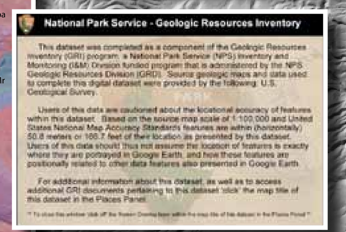
Great Thumb Mesa

The Grand Canyon contains one of the most complete and exposed rock records in the world. The canyon walls can be viewed as a stratigraphic section showing rocks increasing in age as you descend down to the Colorado River. The image below, produced with ArcGlobe and Adobe Illustrator, shows the stratigraphy for Great Thumb Mesa (see also River Mile 127.5 photo), viewed from across the canyon to the east, using 10 meter elevation data for a backdrop. Starting with the Permian Kaibab Formation (Pk) at the top of the mesa, with an age of approximately 250 million years old, the rocks on this wall record almost continuous depositional environments down through the Paleozoic Era and ending in the Precambrian Era with some of the oldest rocks in the park; the Vischnu Schist (Xv) and the Rama Schist and Gneiss (Xr), both roughly 2.5 billion years old.









Surprise Canyon Landslide

The graphic to the left shows geologic units and faults draped over 3-D topography and imagery in Google Earth. Presented in the figure is a massive composite Pleistocene-age landslide, shown here as unit Ql. This massive landslide was possibly caused by (1) downstream lava dams (see Uinkaret Volcanic Field text and figure) impounding the Colorado River, (2) resulting in saturation of the shale at the base of the landslide block, that then (3) failed, slumping and rotating the landslide block.

Panorama taken from the entrance of Stanton's Cave (Colorado River Mile 31.7) of the Colorado River and cliffs composed of Redwall Limestone.

Legend

The legend below displays a subset of the 262 units present on the GRI Digital Geologic Map of Grand Canyon National Park. This subset makes up nearly the entire stratigraphic sequence from the canyon rim down to the Colorado River. Mesozoic and Cenozoic units, represented by yellows, oranges and greens, although present on the map, are not present in the legend.

Grand Canyon National Park Boundary

Roads

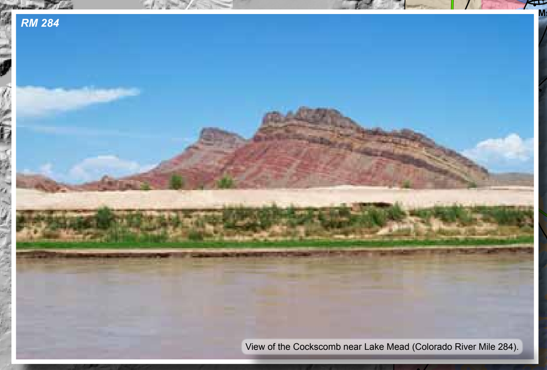
Faults
- reverse fault or high-angle fault
- normal fault - bar and ball on downthrown side

Folds
- anticline, arrow indicates direction of plunge

Zgd Galeros Formation, Duppa Member (Neoproterozoic)
Zgcc Galeros Formation, Carbon Canyon Member (Neoproterozoic)
Zgj Galeros Formation, Jupiter Member (Neoproterozoic)
Zgt Galeros Formation, Tanner Member (Neoproterozoic)
YZn Nankoweap Formation, undivided (Neoproterozoic to latest Mesoproterozoic)
Yi Unnamed diabase sills and dikes (Mesoproterozoic)

Middle Granite Gorge (Colorado River Mile 127.5) and Great Thumb Mesa.

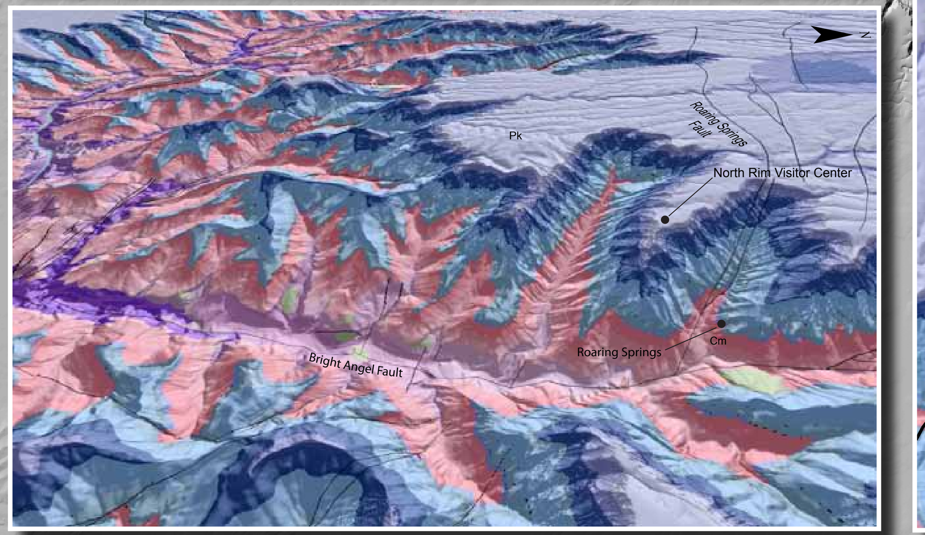
Bass Canyon (C

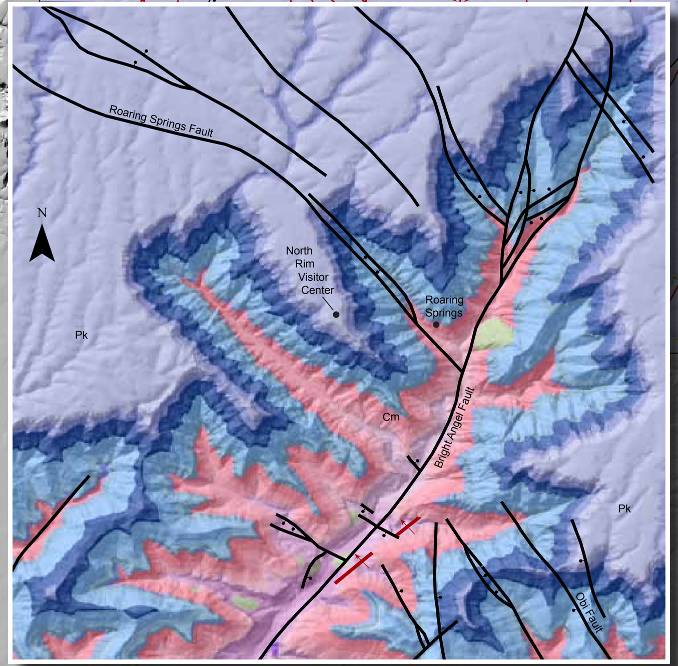


View of the Cockscomb near Lake Mead (Colorado River Mile 284).

North Rim Visitor Center and Roaring Springs

The North Rim Visitor Center is one of the main visitor destinations within the park and is connected, via footpath down the north side of the canyon, across the Colorado River, and up the south side of the Canyon to the South Rim Visitor Center, which is the other main visitor destination within the park. A lesser known fact about this area is that the park draws all of its water from Roaring Springs which is in the canyon below the North Rim Visitor Center. Roaring Springs is located in the Muav Limestone (Cm). Water from this spring is piped both up to the North Rim Visitor Center, and down to the canyon and then up the other side to supply water to the South Rim Visitor Center. While ground water is present in this area, the Roaring Springs Fault provided the fracturing necessary to release ground water at this location. The images right and above, created using ArcMap, ArcGlobe and Adobe Illustrator, show the North Rim Visitor Center area and Roaring Springs from above and from the east. See River Mile photo 87.5 for view of Bright Angel Canyon intersecting the Colorado River.





Geologic Resources Inventory Map Team Members

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- **Ronald Karpilo** (Geologist/GIS Specialist) – Project Manager, Colorado State University
- **Derek Witt** (Geologist/GIS Specialist) – Project Manager, Colorado State University

Software:
Adobe Creative Suite 5.X, Adobe Systems Inc., http://www.adobe.com/products/cs6.html?promoid=JOLIS
ArcGIS 10.X, Environmental Systems Research Institute (ESRI) Inc., 380, New York St., Redlands, CA 92373, http://www.esri.com
Google Earth, Google Inc., http://www.google.com/earth/index.html

Data:
10-meter DEM(s), National Elevation Dataset, U.S. Geological Survey, http://ned.usgs.gov/
ESRI USA Topo Web Map Service, 2014, Topographic base map of USGS scanned topographic maps using National Geographic Society, i-cubed, http://www.arcgis.com/home/webmap/viewer.html?webmap=931d892ac7a843d7ba29d085e0433465

Literature:
W.K. Hamblin, 1994, Late Cenozoic lava dams in the western Grand Canyon: Boulder, Colorado, Geological Society of America Memoir 183, 139 p.

Photos: