Interested in a National Park's Geology?

(We have Something for Everyone from Geo-Tourists to Serious Scientists!)

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Geologic Resources Inventory

The Geologic Resources Inventory (GRI) is one of twelve inventories funded under the National Park Service (NPS) Natural Resource Challenge. 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 relies heavily upon mapping organizations such as the U.S. Geological Survey and individual state geological surveys in developing its products.

This poster presents the suite of GIS, report and map products produced by the GRI and suggests four potential use cases from the perspective of different potential interests in a park: geo-tourist, educator, researcher and park resource manager. The four use cases were designed to highlight the use of different components of the GRI suite of products based on expertise, software availability and/or a specific need. Each GRI product is defined below along with required software. To find these products go to the GRI Publications page at: http://go.nps.gov/gripubs.

Digital Geologic-GIS Data

Digital geologic map product designed to reproduce all aspects of traditional paper maps in a GIS.

Download File Contains:
1) ESRI Geodatabase holding thematic layers of geologic data along with unit information and source map tables. 2) ESRI map document (mxd) and layer files containing map symbology and other display parameters. 3) Ancillary map information document (see below). 4) FGDC Compliant Metadata in FAQ format. 5) GIS Readme File introducing the GRI and serving as an entry point for using GRI digital geololgic-GIS data.

Required Software: A current version of ArcGIS

Geologic Report

The GRI Geologic Report is a comprehensive report that provides an in depth discussion about the geology of a specific park.

Report Contains:
1) Identification and description of key geologic resource management issues. 2) Discussion of geologic features and processes important to park ecosystems and management. 3) A map unit properties table that identifies characteristics of geologic map units. 4) A brief geologic history of the park area. 5) An overview of the digital geologic map data.

Required Software: An internet browser or PDF viewer like Adobe Acrobat.

Google Earth KML

A lightweight KMZ file that provides a basic visualization of GRI digital geologic-GIS data draped over Google Earth imagery and elevation data.

Download File Contains:
1) GRI digital geologic-GIS data with custom balloons showing GIS data attribution and links to important NPS websites. 2) Ancillary Map Information Document (see below). 3) FGDC Compliant Metadata in FAQ format. 4) GIS Readme File introducing the GRI and serving as an entry point for using GRI digital geologic-GIS data.

Required Software: Google Earth

Map Layout

The GRI Geologic Layout is a print quality map showing features from the GRI digital geologic-GIS data.

Layout Contains:
1) Geologic data draped over hill shaded relief and geographic base map information such as roads and major water bodies. 2) Relevant park locations of interest such as park entrances, visitor centers, campgrounds and other popular park attractions.

Required Software: An internet browser or PDF viewer like Adobe Acrobat.

Ancillary Map Information Document

A PDF document that contains source map surround information and supplements the GIS product.

Document Contains:
1) Source map citation information. 2) An Index map showing NPS boundaries and the extent of GRI digital geologic-data. 3) Geologic unit ages and descriptions. 4) Geologic Cross Sections. 5) Correlation of map units. 6) All other pertinent images and information contained in the source publications used by the GRI. This document is found in the GIS download zip file, the Google Earth KML download zip file, and is available online through links in the GRI Google Earth KMZ map.

Required Software: An internet browser or PDF viewer like Adobe Acrobat.

Map References:
BRCA - Bowers, W.E., 1990, Geologic Map of Bryce Canyon National Park and Vicinity, Southwestern Utah: U.S. Geological Survey, Miscellaneous Investigations Series Map I-2108, scale 1:24,000.
DINO - Rowley, P.D., Kinney, D.M., and Hansen, W.R., 1979, Geologic Map of the Dinosaur Quarry Quadrangle, Uintah County, Utah: U.S. Geological Survey, Geologic Quadrangle Map GQ-1513, scale 1:24,000.
DINO - Rowley, P.D., and Hansen, W.R., 1979, Geologic Map of the Split Mountain Quadrangle, Uintah County, Utah: U.S. Geological Survey, Geologic Quadrangle Map GQ-1515, scale 1:24,000.
FLFO - Evanoff, E., Brill, R., de Toledo, P., Murphy, P., and Cushman, R., 1992, Surficial Geologic Map of Florissant Fossil Beds National Monument, Colorado: University of Colorado, unpublished map, scale 1:10,000.
GLAC - Carrara, P.E., 1990, Surficial Geologic Map of Glacier National Park, Montana: U.S. Geological Survey, Miscellaneous Investigations Series Map I-1508-D, scale 1:100,000.
GLAC - Whipple, James W., 1992, Geologic Map of Glacier National Park, Montana: U.S. Geological Survey, Miscellaneous Investigations Series Map I-1508-F, scale 1:100,000.

Software References:
Adobe Acrobat Pro DC, Adobe Systems Incorporated, San Jose, CA, https://www.adobe.com/
ArcGIS 10.4, Environmental Systems Research Institute (ESRI) Inc., http://www.esri.com
Google Earth Pro, Google Inc., http://www.google.com/earth/index.html

Geo-Tourist: Are you a park visitor with an interest in the rocks around you?

Figure GT1. View eastward from Highline Trail by Trista L. Thornberry-Ehrlich.

Profile: I am a tourist and an amateur geology enthusiast planning a visit to Glacier National Park (GLAC). I am particularly interested in the geologic features I will see along Going-to-the-Sun Road—one of the park's main attractions.

Skills: I am a casual user of Google, Google Earth, and Adobe Reader. I am an amateur rockhound with instinctive curiosity, and a basic knowledge of geologic terms and concepts. I can read most basic maps.

Approach: I go to the visitor center at the park and ask about Google Earth KML data that include geologic information. The park ranger/interpreter points me to the Geologic Resources Inventory.

GRI Recommendations:
1. Download the GLAC GRI Google Earth KML data from the GRI Publications page.
2. Download the GLAC GRI Report from the GRI Publications page.

Step 1: I downloaded the GLAC GRI Report first and browsed the Geologic History, and Geologic Features and Processes chapters for some background information (see figures GT1 - GT5). The easy-to-read text and illustrative graphics helped me to understand the geologic story of the park before embarking on my own tour.

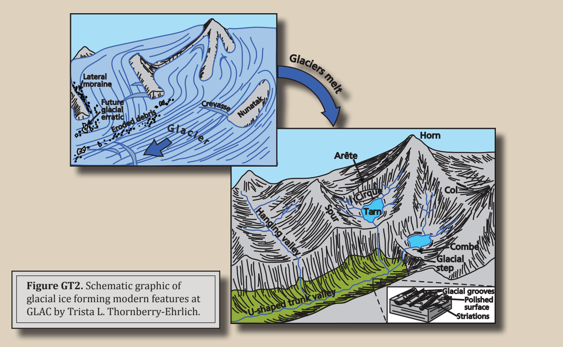


Figure GT2. Schematic graphic of glacial ice forming modern features at GLAC by Trista L. Thornberry-Ehrlich.

Figure GT3. View over Grinnell Glacier by Trista L. Thornberry-Ehrlich.

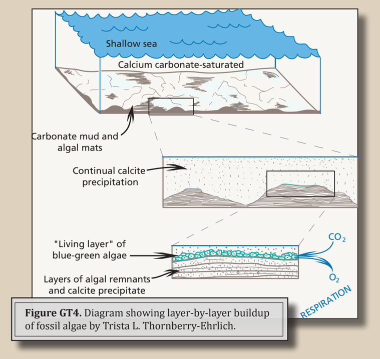


Figure GT4. Diagram showing layer-by-layer buildup of fossil algae by Trista L. Thornberry-Ehrlich.

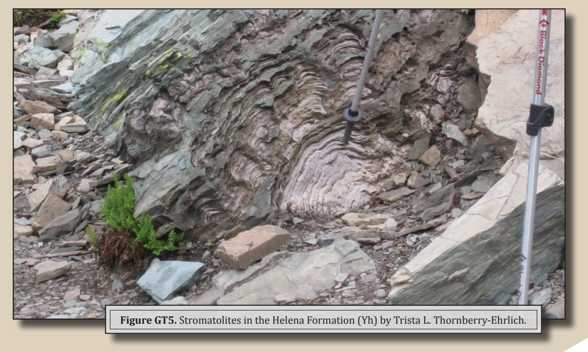


Figure GT5. Stromatolites in the Helena Formation (Yh) by Trista L. Thornberry-Ehrlich.

Step 2: I then downloaded GLAC GRI Google Earth KML data. Upon unzipping this file, I double-clicked on the glac_geology.kmz file in Google Earth. Below is what I saw (see figure GT6):

Figure GT6. The GLAC GRI Google Earth KML data.

Step 3: Zooming in with the roads layer on (see figure GT7), I could see the trace of Going-to-the-Sun Road beneath the geologic units draped over the 3-D aerial image of the park. This allowed me to identify prominent landmarks and views along the route.

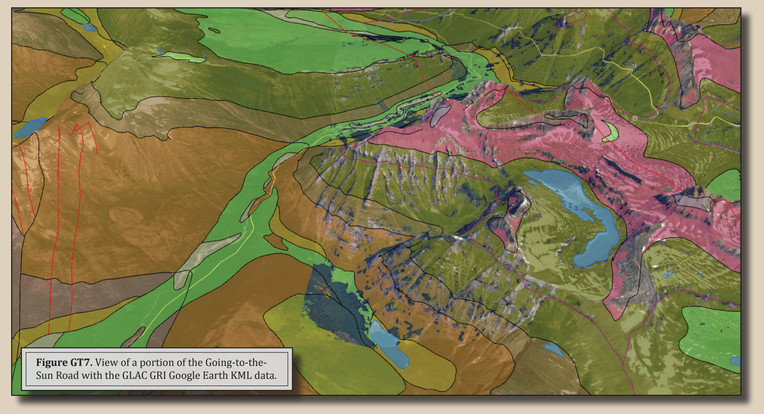
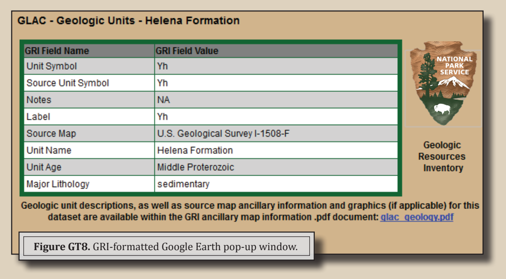


Figure GT7. View of a portion of the Going-to-the-Sun Road with the GLAC GRI Google Earth KML data.

Step 4: I then placed the mouse cursor on a particular color on the map and clicked, and a pop-up containing information about that unit appeared (see figure GT 8). This information provided a bare minimum of information. I would like to know more and I notice there is a link to a GLAC GRI Ancillary Map Information Document so I open that. This link brings me to a PDF that had very detailed information about the unit (see figure GT9). I may not understand ALL the vocabulary, but at least I know more about what I see out the car window. I decide to make a little road guide for myself with screen shots and accompanying text.

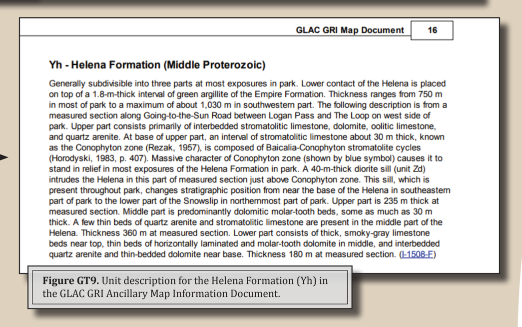


GLAC - Geologic Units - Helena Formation

GRI Field Name	GRI Field Value
Unit Symbol	Yh
Source Unit Symbol	Yh
Notes	NA
Label	Yh
Source Map	U.S. Geological Survey I-1508-F
Unit Name	Helena Formation
Unit Age	Middle Proterozoic
Major Lithology	sedimentary

Geologic unit descriptions, as well as source map ancillary information and graphics (if applicable) for this dataset are available within the GRI ancillary map information .pdf document: glac_geology.pdf

Figure GT8. GRI-formatted Google Earth pop-up window.



GLAC GRI Map Document 16

Yh - Helena Formation (Middle Proterozoic)

Generally subdivisible into three parts at most exposures in park. Lower contact of the Helena is placed on top of a 1.8-m-thick interval of green argillite of the Empire Formation. Thickness ranges from 750 m in most of park to a maximum of about 1,030 m in southwestern part. The following description is from a measured section along Going-to-the-Sun Road between Logan Pass and The Loop on west side of park. Upper part consists primarily of interbedded stromatolitic limestone, dolomite, oolitic limestone, and quartz arenite. At base of upper part, an interval of stromatolitic limestone about 30 m thick, known as the Conophyton zone (Rezak, 1957), is composed of Baicalia-Conophyton stromatolite cycles (Horodyski, 1983, p. 407). Massive character of Conophyton zone (shown by blue symbol) causes it to stand in relief in most exposures of the Helena Formation in park. A 40-m-thick diorite sill (unit Zd) intrudes the Helena in this part of measured section just above Conophyton zone. This sill, which is present throughout park, changes stratigraphic position from near the base of the Helena in southeastern part of park to the lower part of the Snowslip in northernmost part of park. Upper part is 235 m thick at measured section. Middle part is predominantly dolomitic molar-tooth beds, some as much as 30 m thick. A few thin beds of quartz arenite and stromatolitic limestone are present in the middle part of the Helena. Thickness 360 m at measured section. Lower part consists of thick, smoky-gray limestone beds near top, thin beds of horizontally laminated and molar-tooth dolomite in middle, and interbedded quartz arenite and thin-bedded dolomite near base. Thickness 180 m at measured section. (I-1508-F)

Figure GT9. Unit description for the Helena Formation (Yh) in the GLAC GRI Ancillary Map Information Document.

Educator: Are you an educator interested in teaching your students about the geology of a park?

Teacher Use Example: The NPS Geologic Resources Inventory team is regularly approached by teachers looking for ideas and resources to aid in teaching their students about the geology of the U.S. National Parks. This example uses a hypothetical inquiry letter (Figure ED1) from a high school earth science teacher to demonstrate a potential classroom exercise using GRI products: Google Earth product (Figures ED5 and ED6), ancillary map information document (Figure ED3), and report (Figures ED2 and ED4) to learn about the geology of Dinosaur National Monument.

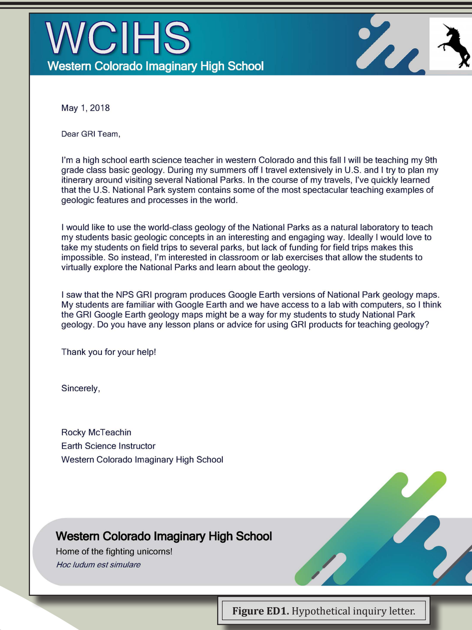


Figure ED1. Hypothetical inquiry letter.

GRI Recommendations: The GRI Google Earth Product along with the Geologic Report, Ancillary Map Information Document, and Map Layout are excellent tools that allow students to virtually explore a park and learn about geologic features and processes. There are many possible ways to use the products in the classroom. Here's one idea that encourages students to use the GRI products to go on a virtual scavenger hunt and explore a park and learn about the geology.

Sample Exercise:
Geologic scavenger hunt exercise (classroom lab or homework assignment)
Example Park: Dinosaur National Monument (DINO)

Assumptions: Students have access to computers with Google Earth, ability to view PDFs, internet access, and basic understanding of Google Earth. Teacher has basic understanding of geologic concepts and Google Earth.

Instructions: 1. Download the DINO GRI Report from the GRI Publications page.

2. Download the DINO Google Earth KML data from the GRI Publications page.

3. Extract files from dinokml.zip, then double click on "dino_geology.kmz"

In Google Earth, create new folder in "My Places" in the Places Table of Contents (left hand side of screen) by right clicking "My Places>Add>Folder" Name folder: DINO_StudentName

For each of the questions explore the GRI Google Earth Product and use the GRI Report (dino_gre_rpt_view.pdf) and the GRI Ancillary Map Information Document (dino_geology.pdf found in dinokml.zip) to answer the questions below.

When asked to find a location, use the "Add Placemark" tool (looks like push pin on the Google Earth tool bar at top of screen) and name it an appropriate name such as "StudentName - Q1: Sandstone" and save it to the folder you created (DINO_StudentName). For questions where you are asked to trace a feature, use the "add path" tool and save it to the same folder.

At end of exercise, save your marked locations by right clicking on the folder you created "DINO_StudentName>Save Place As" and created a .kmz file named DINO_StudentName.kmz
Submit saved .kmz file to teacher for discussion/evaluation/grading.

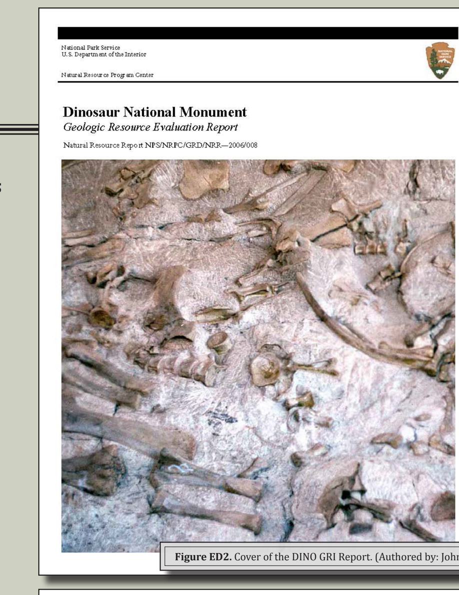


Figure ED2. Cover of the DINO GRI Report (Authored by John Graham).

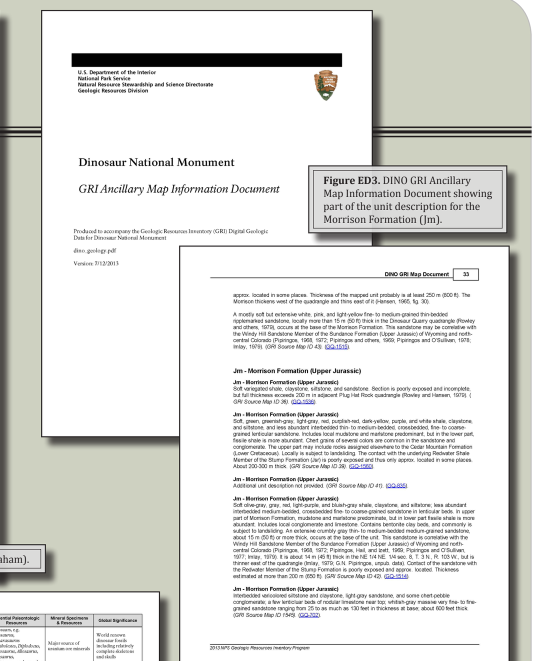


Figure ED3. DINO GRI Ancillary Map Information Document showing part of the unit description for the Morrison Formation (Jm).

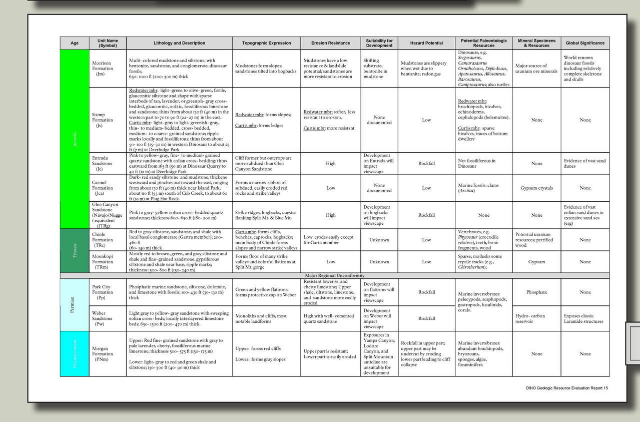


Figure ED4. A portion of the Map Unit Properties Table from the DINO GRI Report.

Example Questions:

Question 1 - Find and mark (with "Add Placemark" tool) locations where you would find:

a) Sandstone b) Limestone c) Shale

Question 2 - Find and mark (with "Add Placemark" tool) locations of geologic units of following ages (Type Unit Name in Description Field when you create Placemark):

a) Quaternary b) Cretaceous c) Jurassic

Question 3 - Find and mark (with "Add Placemark" tool) locations where fault crosses:

a) Road b) River

Question 4 - Find and mark (with "Add Placemark" tool) location where you might find landslide deposits

Question 5 - Find and mark (with "Add Placemark" tool) location where you might find an alluvial fan

Question 6 - Find and mark (with "Add Placemark" tool) a location where you might find a fossil

Question 7 - Find the Split Mountain Anticline (Trace with "add path" tool)

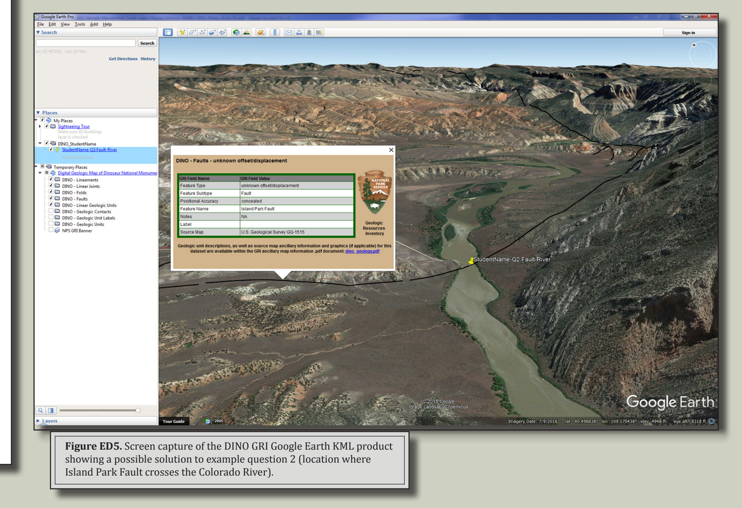


Figure ED5. Screen capture of the DINO GRI Google Earth KML product showing a possible solution to example question 2 (location where Island Park Fault crosses the Colorado River).

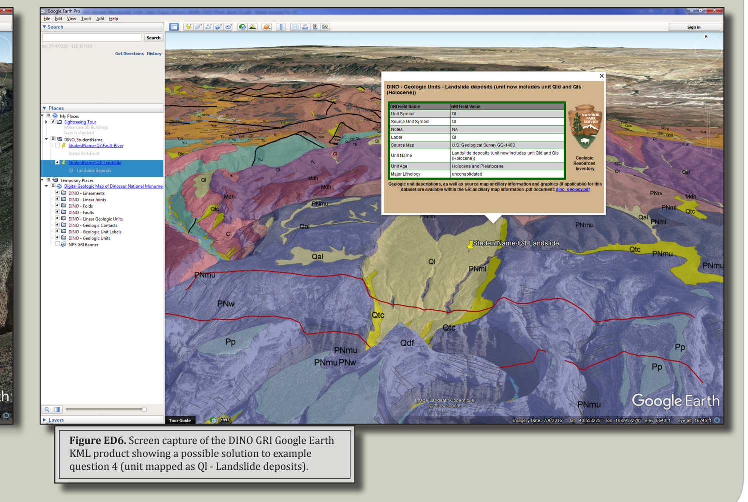


Figure ED6. Screen capture of the DINO GRI Google Earth KML product showing a possible solution to example question 4 (unit mapped as Ql - Landslide deposits).

Researcher: Are you a researcher interested in conducting geologic research in a park?

Profile: I am a graduate student interested in prehistoric ecosystems. I know a number of different organisms are preserved (see figure RS3) at Florissant Fossil Beds National Monument (FLFO), and have chosen this park as a study area to begin gathering data.

Skills: I am well versed in reading scientific literature, and have pre-existing familiarity with both general geologic concepts as well as more specific familiarity with my study focus. I am at least moderately capable with ArcGIS and have access to it on school computers.

Preliminary Research: I began by downloading and reading the FLFO GRI Report to get a better sense of both the park's geology and the history of fossil collection (see figure RS1). Citations in the report lead me to paleontological publications that could be useful in my research.

Planning: I planned my fieldwork with the Google Earth KML (see figures RS2 and RS4) by tracing a path leading me by exposures of the fossil-rich Florissant Formation (Tf) (see figure RS3 and RS5). From those locations I could walk sections of the geology to better understand the paleoenvironment.

Paleontological Resources

The incredible fossil record at Florissant, which consists of organisms that are not ordinarily fossilized, has enabled paleontologists and geologists to reconstruct a relatively brief moment of time at the end of the Eocene Epoch (about 34 million years ago). The fossils at Florissant are of five types:

1. Plants- redwood stumps; palynomorphs (pollen and spores); leaves, fruits, seeds, and flowers
2. Diatom mats (see "Sedimentation and Fossilization" section)
3. Spiders, insects, and myriapods (multi-legged arthropods)
4. Mollusks (clams and snails) and ostracods (microscopic crustaceans)
5. Vertebrates- fish, birds, and mammals

Figure RS1. Section of GRI FLFO report detailing paleontological resoruces (Authored by: Katie KellerLynne).

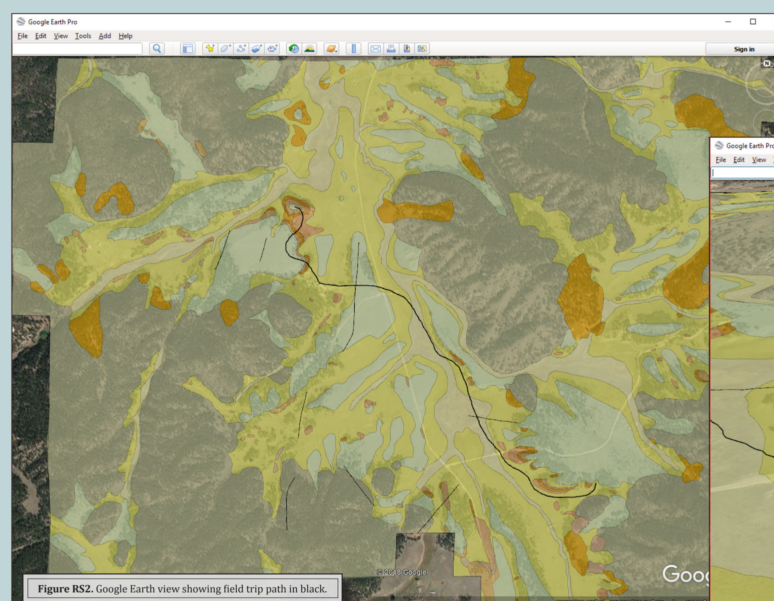
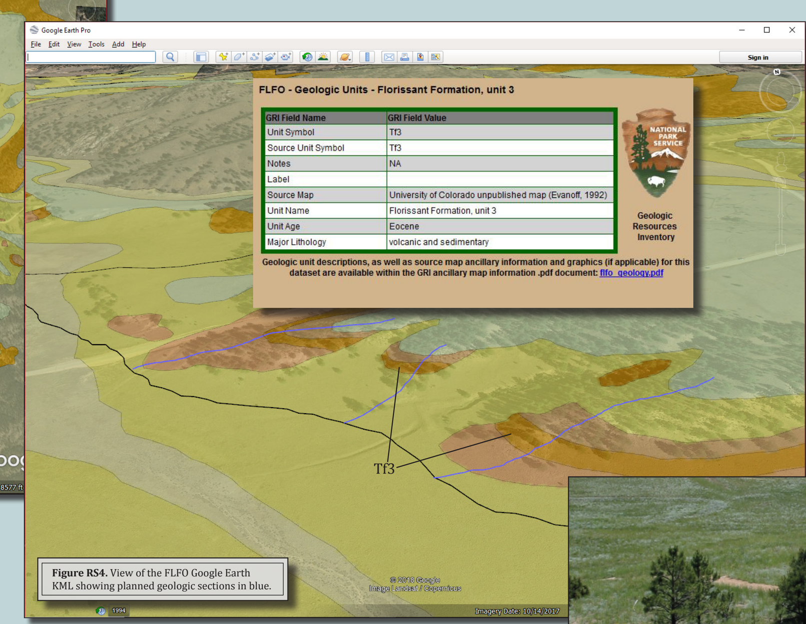


Figure RS2. Google Earth view showing field trip path in black.



FLFO - Geologic Units - Florissant Formation, unit 3

GRI Field Name	GRI Field Value
Unit Symbol	Tf3
Source Unit Symbol	Tf3
Notes	NA
Label	
Source Map	University of Colorado unpublished map (Evanoff, 1992)
Unit Name	Florissant Formation, unit 3
Unit Age	Eocene
Major Lithology	volcanic and sedimentary

Geologic unit descriptions, as well as source map ancillary information and graphics (if applicable) for this dataset are available within the GRI ancillary map information .pdf document: fflo_geology.pdf

Figure RS4. View of the FLFO Google Earth KML showing planned geologic sections in blue.

Figure RS3. Fossilized butterfly from FLFO (courtesy NPS).

Future Work: I found that I could also easily import the path I created in Google Earth into an ArcMap project along with the GIS data and my stations. From there I plan to import elevation data and georeferenced aerial photos taken from a drone to better define my field area. Having all this data in one place will be very useful in managing future fieldwork and for creating map graphics for publications. Additionally, I can use this collection of data to perform more sophisticated spatial and statistical analysis to aid my research.

Execution: After collecting field data I added it to the FLFO GRI Digital Geologic-GIS Data in ArcMap (see figure RS6) which allowed me to visualize the distribution of various fossil species in the park. Additionally, I created a series of points from my field stops which represented various paleoenvironments, with which I was able to analyze the frequency at which particular species were found in particular environments.

Figure RS5. Fossilized tree stump within the Eocene-age Florissant Formation (Tf) (courtesy NPS).

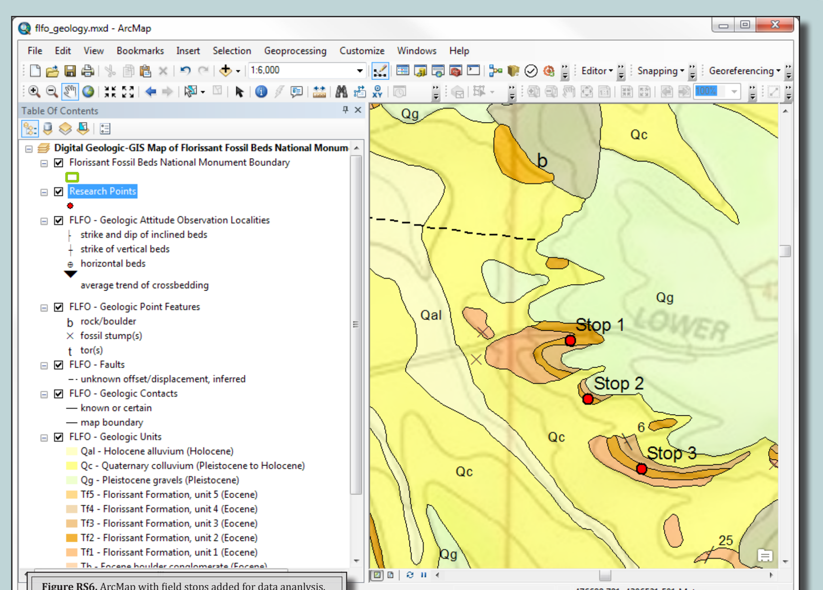


Figure RS6. ArcMap with field stops added for data ananlysis.

Park Manager: Are you a park manager seeking geologic information for resource management decisions?

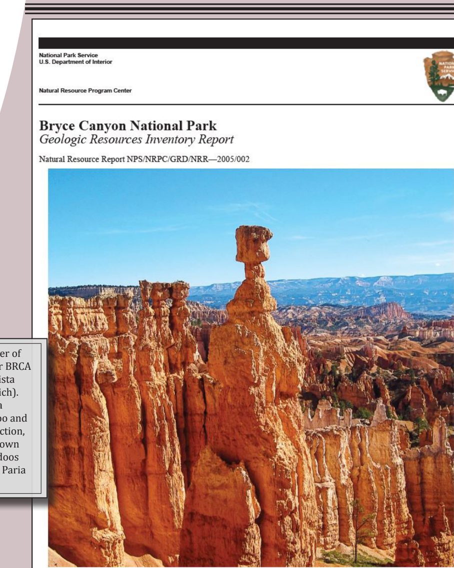


Figure PM1. Cover of the GRI report for BRCA (Authored by: Trista Thornberry-Ehrlich). Thor's Hammer, a prominent hoodoo and park visitor attraction, is majestically shown with nearby hoodoos within the scenic Paria Amphitheatre.

Profile and Goals: I recently started my job as a park resource manager at Bryce Canyon National Park (BRCA) in southern Utah. I have a scientific (biology) background, but I'm not a geologist. I also have some familiarity with GIS software, and working with geospatial data. As I start my new job I'd like to quickly and efficiently learn about my park's geology and how this can help me better manage my park. Specifically, how can I learn about my park's geology and its geologic issues, features and processes, and what are the special and unique geologic resources, if any, I need to be aware of to protect and manage?

While searching online for geologic information about my new park I first came upon a geologic article that briefly discussed the erosion of Bryce Canyon's spectacular geologic hoodoos, and that the amphitheater rim which provides an incredible panoramic view of the hoodoos is receding. Both issues directly affect park management and a park visitor's experience. How can I learn more about these issues, as well as other potential geologic issues and resources at Bryce Canyon, and how can I incorporate geologic and other geospatial (GIS) information to better understand, manage, plan and communicate these issues?

Approach: While browsing my park's library I came upon a hardcopy of the BRCA GRI Report that discusses in detail the geologic history, issues, features and processes the park, and addresses these in a manner intended for a park resource manager such as me.

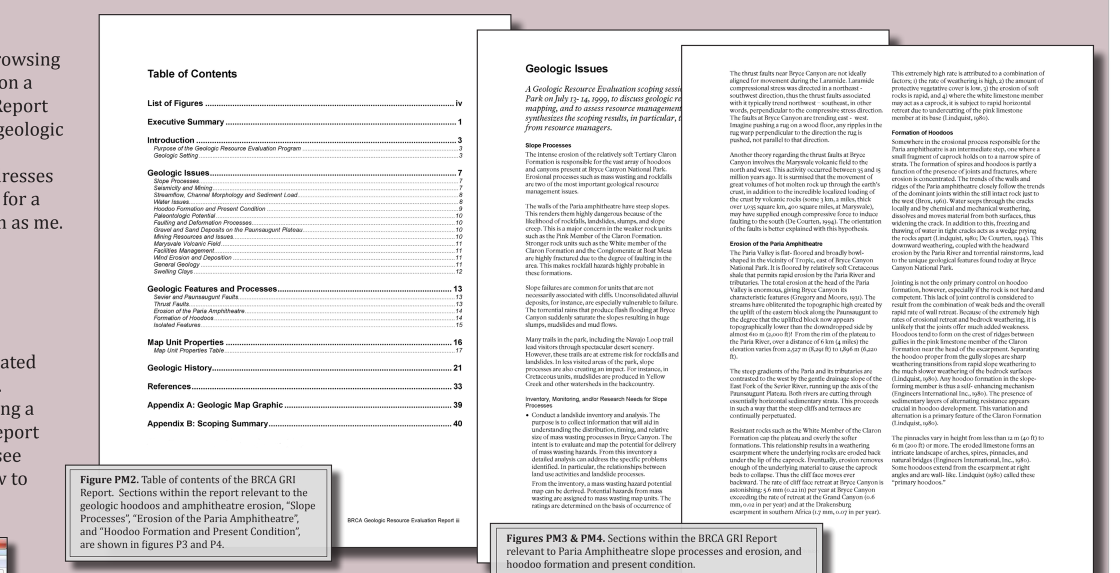


Figure PM2. Table of contents of the BRCA GRI Report. Sections within the report relevant to the geologic hoodoos and amphitheatre erosion, "Slope Processes", "Erosion of the Paria Amphitheatre", and "Hoodoo Formation and Present Condition", are shown in figures P3 and P4.

Figures PM3 & PM4. Sections within the BRCA GRI Report relevant to Paria Amphitheatre slope processes and erosion, and hoodoo formation and present condition.

Step 1: The BRCA GRI Report (see figures PM1 and PM2) provided detailed information pertaining to the slope processes that created the present Paria Amphitheatre, as well as active processes that continue to erode the amphitheatre and the park's amazing landscape. The report also made several suggestions pertaining to the inventorying and monitoring of the Paria Amphitheatre, including conducting a landslide inventory and analysis, producing a rockfall susceptibility map, and performing a trail stability study (see figure PM3). The report also addressed the formation of the geologic hoodoos, as well identified several processes that cause and/or accelerate their erosion (see figure PM4). As with the amphitheatre erosion, the report also listed several inventory, monitoring and research considerations on how to best study, manage and preserve the hoodoos.

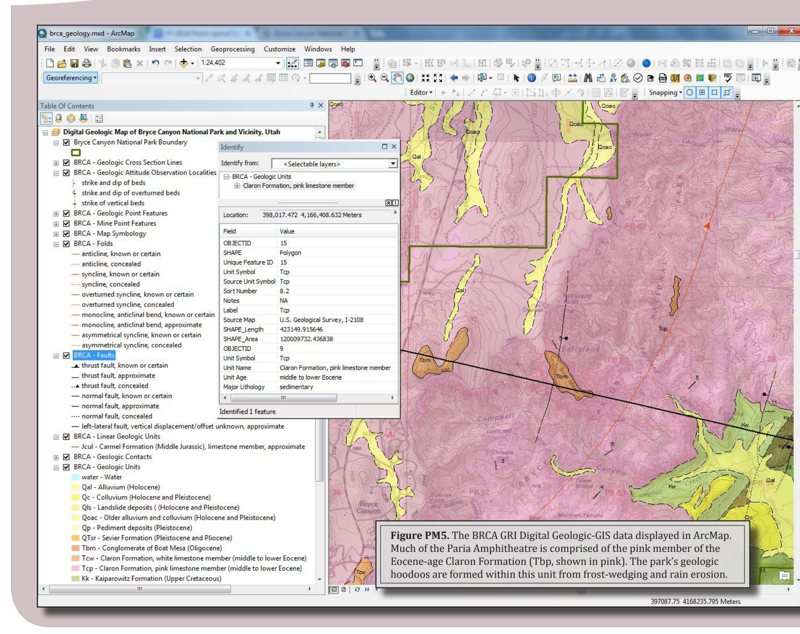


Figure PM5. The BRCA GRI Digital Geologic-GIS data displayed in ArcMap. Much of the Paria Amphitheatre is comprised of the pink member of the Eocene-age Claron Formation (Tcp, shown in pink). The park's geologic hoodoos are formed within this unit from frost-wedging and rain erosion.

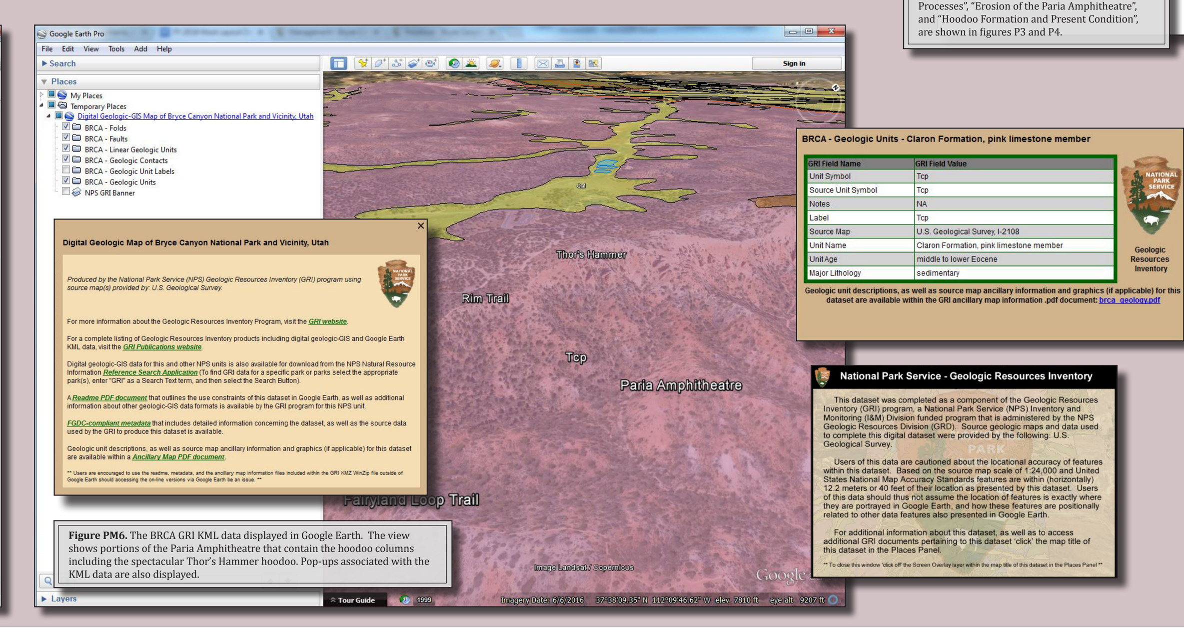


Figure PM6. The BRCA GRI KML data displayed in Google Earth. The view shows portions of the Paria Amphitheatre that contain the hoodoo columns including the spectacular Thor's Hammer hoodoo. Pop-ups associated with the KML data are also displayed.

Step 2: The report further provided detailed information pertaining to the slope processes that created the present Paria Amphitheatre, as well as active processes that continue to erode the amphitheatre and the park's amazing landscape. The report also made several suggestions pertaining to the inventorying and monitoring of the Paria Amphitheatre, including conducting a landslide inventory and analysis, producing a rockfall susceptibility map, and performing a trail stability study. The report also addressed the formation of the geologic hoodoos, as well identified several processes that cause and/or accelerate their erosion. As with the amphitheatre erosion, the report also listed several inventory, monitoring and research considerations on how to best study, manage and preserve the hoodoos.

Step 3: From the report I learned that amphitheatre erosion, principally landslides and rockfalls could be modeled by producing susceptibility maps. From my basic knowledge of GIS I'd think the GRI Digital geologic-GIS data could be used with digital slope data to predict where landslides and rockfall might occur. To obtain the BRCA digital geologic-GIS and KML data (displayed in figures PM5 and PM6, respectively) I went to the GRI Publications page, and from there found the NPS Data Store record for the data. To pursue this I plan to contact the NPS Geologic Resources Division and the Geologic Resources Inventory, and seek assistance in to developing such maps. As for monitoring the hoodoos I'd think my park would have a GIS dataset of prominent hoodoo locations. From here a monitoring plan of hoodoo erosion, including perhaps visitor impact, could be developed!