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The contents are provisional and will be
superseded by a paper in the
DMT'12 Proceedings.

See also earlier Proceedings (1997-2011)
http://ngmdb.usgs.gov/info/dmt/

# Communicating a Digital Geologic Map in the Digital World

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## The Geologic Resources Inventory

The Geologic Resources Inventory (GRI) is one of 12 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 relies heavily on partnerships with Colorado State University (CSU), the U.S. Geological Survey, individual state geological surveys, and other organizations in developing its 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 map products, and writes a geologic report for use by park staff.

## Introduction

**Communicating the Full Geologic Map**

Digital data products including GIS data and on-line map services are making geologic maps more available and accessible to map users. However, what is often not included in many of these developed data products and services is the information present in the margins of a geologic map such as a correlation of units, cross sections, lithologic descriptions, references and/or related map graphics and text. Without such ancillary information a geologic map is often of limited utility and value. A complete digital geologic map should thus provide ancillary information as a part of the map, and not require a user to discover and/or access the information through means that deter or are difficult for the user. Below, in the box titled "A Source Geologic Map", is a scan of the USGS Geologic Map of the Dinosaur Quarry Quadrangle, Utah highlighting ancillary map components and to the right of that scan, those same components in the GRI Ancillary Map Information document.

**The Importance of Symbology with Geologic Maps**

Geologic maps rely heavily upon symbolization and labels to communicate information about geologic features. This often includes denoting the type of feature, as well as its accuracy and/or relative certainty using symbology. In addition, the age and major lithology (e.g., limestone, dolomite, or sandstone) of mapped geologic units is typically communicated via colors according to adopted standards (e.g., Cretaceous rocks are typically shades of green). Furthermore, geologic maps typically present information about features such as a feature's name or an observation value (e.g. a dip value associated with inclined bedding).

GRI digital map products provide symbology for all geologic map features with the goal of being true to the source map. However, in some cases, primarily due to data format and/or software limitations, symbology may be limited and/or generalized.

**A User-Friendly Digital Geologic Map**

A digital geologic map should also consider the user's needs. These needs can range from a simple visualization of the map to a focused in-depth GIS analysis of the map data. Furthermore, users will likely possess varying degrees of geologic knowledge, as well as competency with geospatial software. Ultimately, a digital geologic map should attempt to address these factors by making the map user-friendly and by utilizing software, such as Google Earth, that is designed for the average or less technical user.

**Existing and Planned GRI Digital Geologic Map Formats**

GRI digital geologic maps are presently available in Personal Geodatabase and Shapefile GIS formats, as well as in a Google Earth (.kml/.kmz) format. The GRI is currently looking into providing a digital geologic map as an on-line map service and is co-developing with the Inventory and Monitoring Division (I&MD) an on-line map viewer that would allow users to access and visualize GRI digital geologic maps through a web browser.

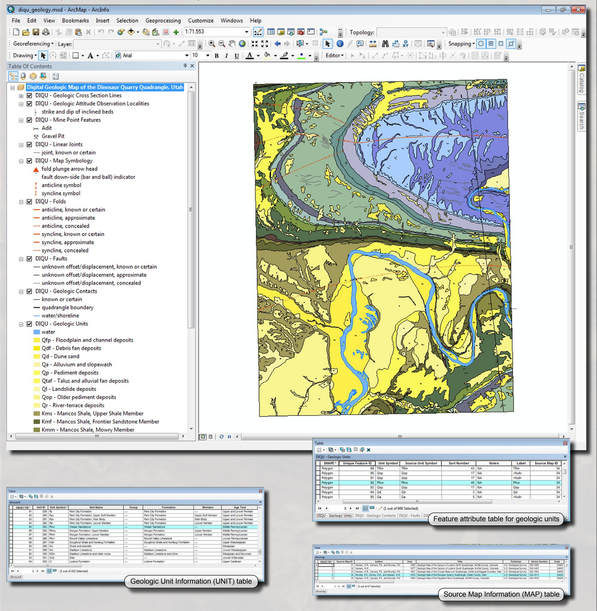
**GRI Digital Geologic Map Product Components**

In addition to the spatial data component (i.e., the mapped features) the GRI GIS and Google Earth digital map products also include additional files pertaining to the digital map. These files include a FGDC and NPS-Profile compliant metadata record and a Readme (.pdf) Document that contains basic information about the data, the GRI, and how to obtain other GRI products. Furthermore, both map products include an Ancillary Map Information (.pdf) Document that contains source map ancillary text and graphics (see the GRI Ancillary map Information section of this poster for more details). Other map components also exist depending on the product format (see GRI Digital Map Products sections for more details).

GRI map products are detailed in the boxes to the right. Each product is first briefly presented, followed by a more detailed description of the product, and finally pertinent information about each product including identifying the pros and cons of the product and utilized software.

## GRI Geology-GIS Data in ArcMap

The GRI Digital Geologic Map of the Dinosaur Quarry Quadrangle, Utah is presented in ArcMap below. The ArcMap (.mxd) document displays the map's geologic data layers complete with feature attribution (e.g., Geologic Units), as well as two ancillary GRI map tables, the Geologic Unit Information (UNIT) table and the Source Map Information (MAP) table.




**Product Details:**

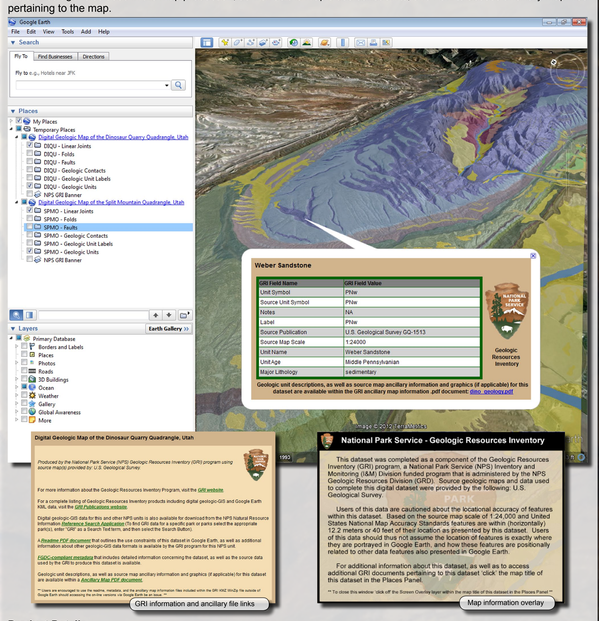
GRI digital geologic-GIS maps are available in personal geodatabase and shapefile GIS formats. In addition to the GIS data files and standard GRI map components (see Existing and Planned GRI Digital Geologic Map Products section above) each map includes an ArcMap (.mxd) document (geodatabase format only) that presents the full map complete with all layers, ancillary tables, feature symbology, and labeling. Furthermore, the product includes map layer (.lyr) files that also convey symbology and labeling so individual layer can be added to other ArcMap documents. Symbology is true to the source map for most features, and ancillary map files are included with the map.

**Product Functionality and Use:**

- Requires an ArcGIS software license, as well as a certain "comfort-level" with the software. Non-GIS users will often not wish to use the software or the free limited version viewer, ArcReader, since it's commonly perceived as difficult to learn and use.
- Software allows for robust GIS analysis of data, such as accessing ancillary table information via database relationships. Basic ArcMap doesn't present data in 3-D although other licensed ArcGIS software does. Cartographic products can also be created for plotting and/or transferred digitally.
- Ancillary GRI map documents are accessed separately. Although custom means to view them could be developed.
- Base map layers such as imagery and common map layers (e.g., roads, cities and popular localities), although abundant, must be acquired and added to the software for inclusion and viewing.

## GRI Digital Geologic Maps in Google Earth

The GRI Digital Geologic Map of the Dinosaur Quarry Quadrangle, Utah, as well as the GRI Digital Geologic Map of the Split Mountain Quadrangle, Utah presented in Google Earth. A GRI Google Earth product displays common geologic data layers with generalized symbology, and allows users access to feature attribution through formatted balloons. Information about the GRI and related map ancillary files is also accessed through a formatted balloon. A custom screen overlay lists the source agencies used in the map production, as well as the map's use constraints, and how to access ancillary map files pertaining to the map.




**Product Details**

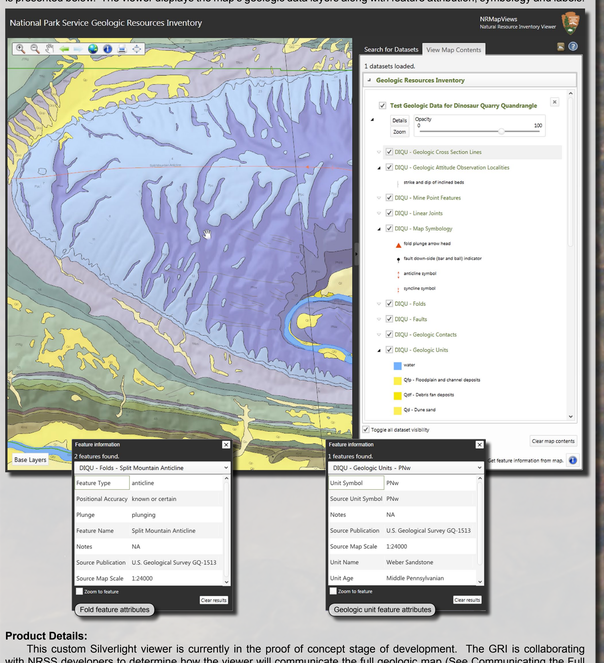
The Google Earth map includes a single Google earth (.kmz) file with the metadata presented as an easy to read FAQ .html file. Each ancillary map file can be viewed in Google Earth via web-links in balloons.

**Product Functionality and Use:**

- Google Earth software is free and easy to use.
- Portrays digital geographic data spectacularly in 3-D complete with panning, zooming, and view rotation, as well as touring capabilities. Supports use in Google Maps, is available as a browser plug-in, and as a mobile device application.
- Software has limited to no GIS functionality.
- Doesn't easily support complex symbology, and so area patterns and most line symbols are limited in their presentation.
- Ancillary GRI map documents are accessed separately, although custom means to access them could be developed.
- Base data layers such as 3-D topography and imagery, as well as common geographical themes (e.g., places, roads) are provided by Google Earth on-line, however, uncommon data layers not present in Google Earth (e.g., park boundaries) must be obtained or created from other digital data formats.
- Data can be distributed as either a (.kmz) file users download, or by accessing the data via an on-line map service (see GRI Map Service Products section of this poster).

## GRI Digital Geologic Maps in a Custom Online Viewer

The GRI Digital Geologic Map of the Dinosaur Quarry Quadrangle, Utah displayed in the IM NRSS NRMapViews viewer is presented below. The viewer displays the map's geologic data layers along with feature attribution, symbology and labels.




**Product Details:**

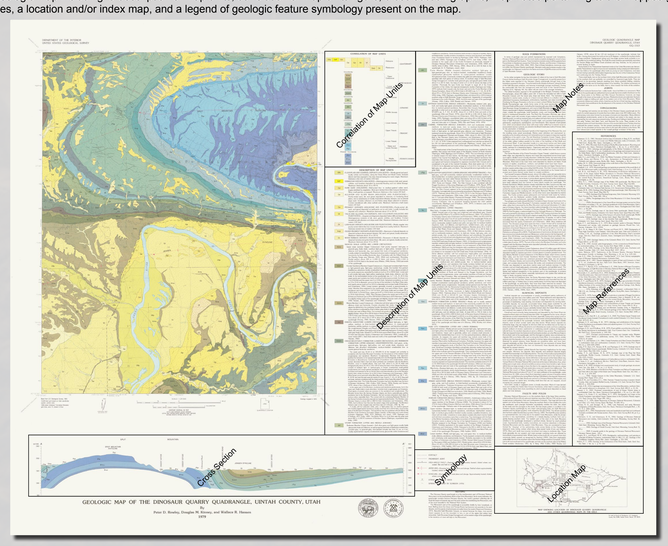
This custom Silverlight viewer is currently in the proof of concept stage of development. The GRI is collaborating with NRSS developers to determine how the viewer will communicate the full geologic map (See Communicating the Full Geologic Map section in the Introduction of this poster). Currently, this viewer displays map data with symbology and labeling, and provides access to feature attribute tables. Layer naming, organization and legends are similar in appearance to how the GRI digital map appears in ArcMap; however, ancillary documents such as metadata and the GRI Map PDF are not available to the user.

**Product Functionality/Use**

- Requires an internet browser and connection to use.
- Enables users to query features, navigate (zoom, pan), plot the map and toggle visibility of individual layers as well as adjust layer opacity.
- Provides only viewing functionality – limited to no GIS functionality.
- Derives symbology, labeling and feature attributes direct from the GRI geodatabase (.mdb) and map document (.mxd) for this map through an NRSS online map service.
- The GRI is working with NRSS developers to include access to GRI ancillary map documents from the viewer.
- A variety of base layers such as shaded relief, satellite imagery and topographic maps are available in the viewer although uncommon data layers such as park boundaries are not currently available.

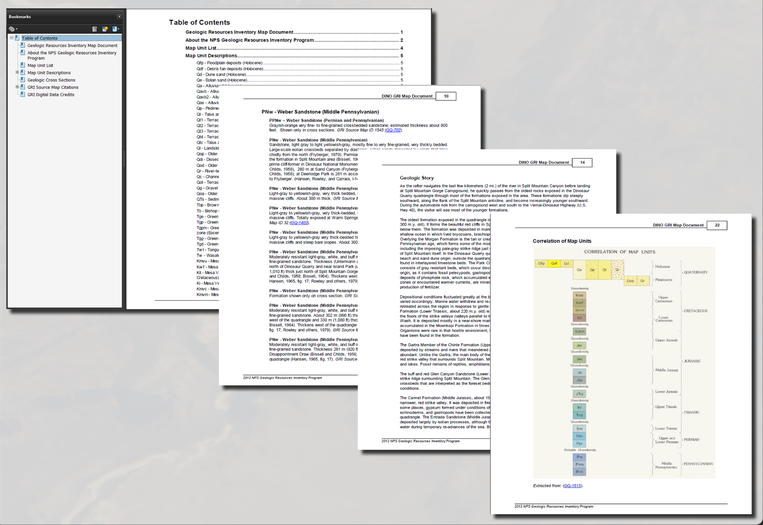
## A Source Geologic Map

The published Dinosaur Quarry Quadrangle map by Rowley, Kinney and Hansen (1979) showing common ancillary map components present on a typical geologic map including: a description of map units, correlation of map units figure, cross section graphic, map notes pertaining to the mapped geology, references, a location and/or index map, and a legend of geologic feature symbology present on the map.



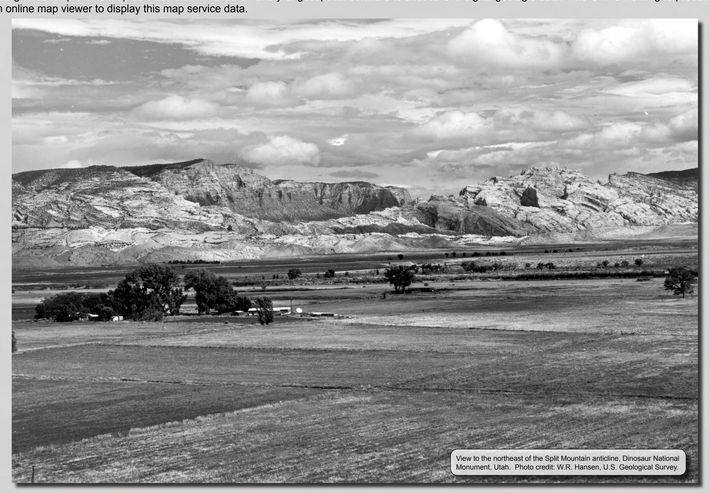

## GRI Ancillary Map Information Document

The GRI produces an Ancillary Map Information Document (in .pdf format) to present all ancillary source map information pertaining to a GRI Digital Geologic Map. The document contains a formatted table of contents and makes use of topic bookmarks, as well as hyperlinks to assist users in navigating and using the document. Source map graphics are scanned at high resolution (300 dpi) enabling users to zoom-in to view large and detailed graphics.




## Summary

An effectively communicated digital geologic map product should include and grant users easy access to ancillary map information. In addition, the map should present features utilizing source map symbology, and consider a user's needs as well as their level of geologic knowledge and software competency. The GRI strives to provide this through a suite of digital geologic map products in which ancillary information is contained within an easy to access and read document, and where possible, symbology is true to the source map. Additionally these products are provided in different map data formats that utilize software ranging from easy to use and highly visual (e.g., Google Earth) to software that is designed primarily for GIS analysis (e.g., ArcGIS). Currently, the GRI is working to develop online map services that will allow a variety of geospatial software to access GRI digital geologic data. The GRI is working to produce its own online map viewer to display this map service data.



View to the northeast of the Split Mountain anticline, Dinosaur National Monument, Utah. Photo credit: W.R. Hansen, U.S. Geological Survey

**Source U.S. Geological Survey Map Publications**

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, 1:24000 scale

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, 1:24000 scale

**Software**

ArcGIS 9.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

**Geologic Resource Inventory Geology-GIS Geodatabase Data Model**

O'Meara, S.A., Stanton, H.I., and Chappell, J.R., with contributions from Mack, G., Hybels, G., Karpilo, R.D., and Croskrey, A., 2010, National Park Service Geologic Resources Inventory Geology-GIS Geodatabase Data Model (v .2.1) Colorado State University and National Park Service, 95 p., http://science.nature.nps.gov/im/inventory/geology/GeologyGISDataModel.htm

**Geologic Resource Inventory Information and Products**

Geologic Resources Inventory Web Site: http://www.nature.nps.gov/geology/inventory

Geologic Resources Inventory Products Web Site: http://www.nature.nps.gov/geology/inventory/gre_publications.cfm

**Poster Background Image**

The background image used in this poster is a photo of Dinosaur National Monument taken by an Expedition 15 crewmember on the International Space Station on September 12, 2007. Photo credit: NASA.