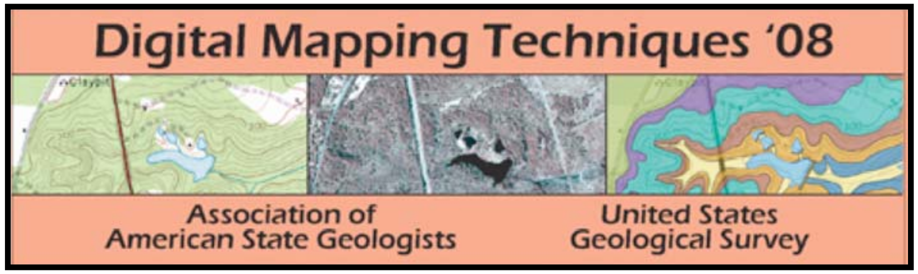

The following was presented at DMT'08 (May 18-21, 2008).

The contents are provisional and will be superseded by a paper in the DMT'08 Proceedings.

See also earlier Proceedings (1997-2007)
http://ngmdb.usgs.gov/info/dmt/

Evolution of the NPS GRE Geology-GIS Data Model (1998-2008)

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(Colorado State University)

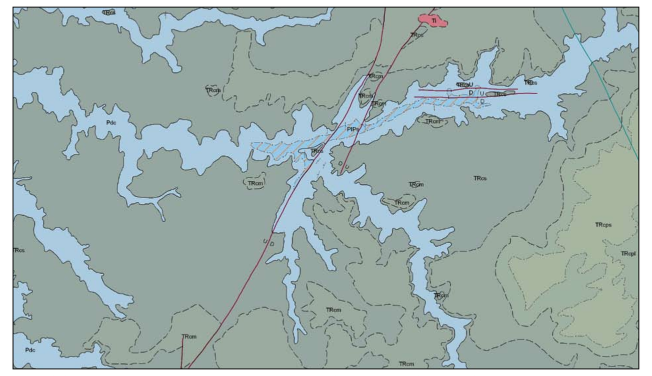
Introduction

Beginning in 1998, the National Park Service (NPS) initiated the Geologic Resource Evaluation (GRE) program to document and evaluate geologic resources related to approximately 270 NPS units (national parks, monuments, recreation areas, historic sites, seashores, etc.).

The GRE program is currently developing digital geologic-GIS maps and geologic resources summary reports for each of these 270 NPS units. Colorado State University (CSU) is a partner in the production of these products and is the primary developer of the NPS GRE geology-GIS data model adopted for the creation of GRE digital geologic-GIS data.

Over the last ten years the NPS GRE geology-GIS data model has evolved from its initial ESRI coverage-based format (Coverage Data Model), to implementation within an ESRI personal geodatabase (v. 1.x Data Model), to a recent redesign to streamline the data model and its implementation (v. 2.x Data Model). Using GRE geologic-GIS data for Mount Rainier National Park, Washington (MORA) we present the evolution of the NPS GRE geology-GIS data model to convey ***Why*** the data model format was adopted, ***What*** the basic GIS data model components are (including data layer architecture, attribute tables, domains, subtypes, topology and table relationships), and ***How*** the data model is implemented.

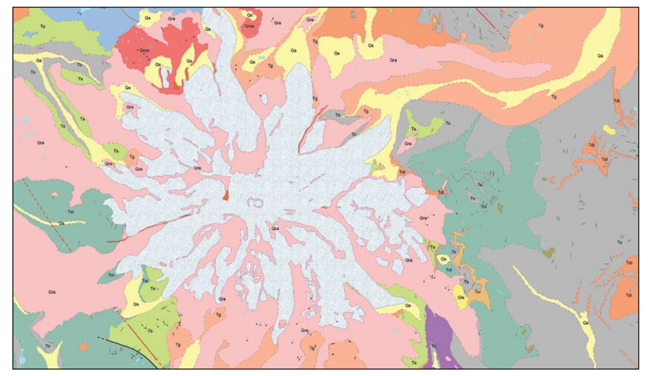

View of White House Ruins in Canyon de Chelly National Monument, Arizona.
Image: © 2005 Ron Karpilo


The NPS-GRE team is currently nearing completion of the Digital Geologic Map of Canyon de Chelly National Monument and Vicinity, Arizona. The GIS data will soon be available for free download at the NPS Data Store (http://science.nature.nps.gov/nrdata/).


View of Independence Monument in Colorado National Monument, Colorado.
Image: © 2004 Lacy Karpilo


The NPS-GRE team completed the Digital Geologic Map of Colorado National Monument and Vicinity, Colorado in 2006. The GIS data is currently available for free download at the NPS Data Store (http://science.nature.nps.gov/nrdata/).


View of the south face of Mount Rainier (14,410 ft) in Mount Rainier National Park, Washington.
Image: © 2007 Ron Karpilo


The NPS-GRE team completed the Digital Geologic Map of Mount Rainier National Park and Vicinity, Washington in 2006. The GIS data is currently available for free download at the NPS Data Store (http://science.nature.nps.gov/nrdata/).


Hikers in the Island in the Sky area of Canyonlands National Park, Utah.
Image: © 2006 Ron Karpilo

Coverage Data Model

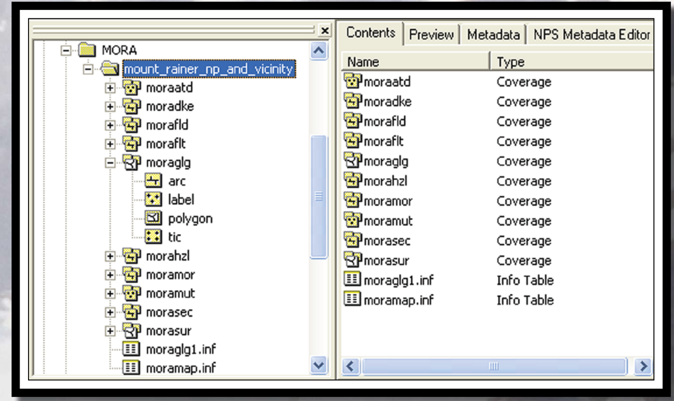
Why?

The GRE sought to create a data model that could be utilized in the production of digital geologic-GIS maps. The core requirements of this data model were: 1.) Implementable in ESRI GIS software, 2.) Flexibility to accommodate a wide variety of geologic features mapped in diverse geologic settings, and 3.) Ability to create data useful to geologists, third-party users, and most importantly, non-geologist natural resource managers working at NPS units. The data model was originally based on Washington State ArcInfo GIS Data Model (Harris 1998).

What?

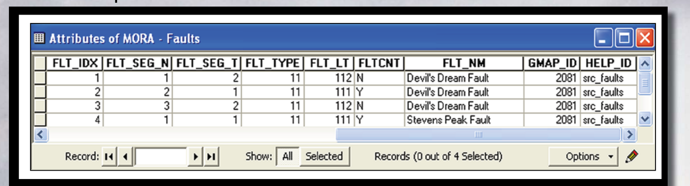
Data Layer Architecture

- Data layers in ESRI coverage format grouped based on geologic feature type (i.e., faults, attitude measurement, geologic units, etc.).
- Allows for multiple geometries (i.e., polygon, line and point) within the same data layer.



Attribute Tables

- Feature attribute tables consist of descriptive attribute fields that contain information about geologic features.
- Attribute field parameters include field name, data type, field definition, and field width parameters.



Domains

- Domains for feature type, positional accuracy/concealment, to denote feature coincidence, and to restrict azimuth, dip/plunge and rotation values.
- These domains cannot actually be implemented within the data, only linked using separate look-up tables.

Subtypes

- Although the grouping of related features that share common attribution and/or spatial coincidence (i.e., a subtype) doesn't exist within the coverage format, attribute fields were used to denote this commonality between features.

Topology

- The coverage format inherently possesses a number of topological rules that ensure features don't overlap, leave gaps, self-intersect or improperly intersect other features.
- As multiple geometries can exist within the same data layer, such as in the relationship between a polygon and its boundary in a net coverage, spatial coincidence can easily be maintained.

Table Relationships

- Although the data model defines relationships between certain tables, these are not stored in the data itself and can only be established manually or programmatically.

How?

Arc Macro Language (AML) scripts were used to create and manage data layers and tables (GENESIS AML) and to ensure some attribute validation. Spatial coincidence was ensured procedurally during the digitization process. Table "joins" in ESRI project files, such as ArcView projects and ArcGIS Map Documents, were utilized to view coded value domains and to create table relationships.

2004

v. 1.x Data Model

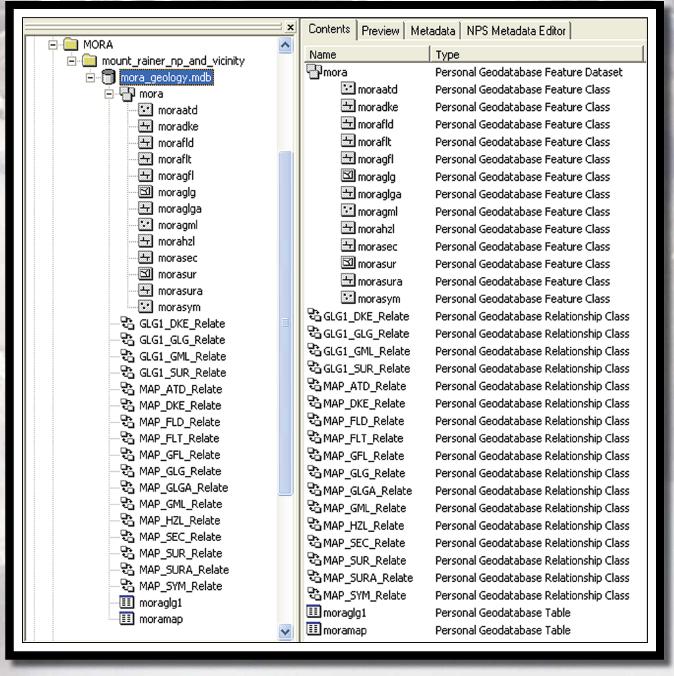
Why?

The v. 1.x data model was developed in order to leverage functionality inherent in the personal geodatabase format. A personal geodatabase can store spatial and non-spatial data in tables, feature classes, and feature datasets. In addition, the geodatabase stores attribute validation rules, domains, relationship classes, and topological rules. This added functionality, along with portability and a robust backend database, helps increase data quality and stream-line data production processes.

What?

Data Layer Architecture

- Spatial data is stored as individual feature classes within a geodatabase with feature class definitions originating from the coverage definitions in the coverage data model
- List of possible feature classes roughly parallels that of the coverage format data model.
- Coverages containing multiple geometries (net coverages) were translated into multiple feature classes in this model, one for each geometry.



Attribute Tables

- Attribute field parameters include field name, data type, whether or not to allow null values, field definition, domain association and field width (precision, scale and length).

Domains

- Coded value and range domains were implemented to define acceptable values for various feature class fields.
- In contrast to the coverage model, these domains are stored within the geodatabase and are accessible while editing in ArcMap.
- By placing limits and definitions on acceptable values, domains help to ensure quality of attribution in the data and ease difficulty of attribution during the creation of new features.

Subtypes

- Subtypes were employed to subdivide feature class data into groups sharing the same attribute or topological validation rules and/or default values.

Topology

- In addition to mimicking topology inherent within coverages, geodatabase topology, in combination with subtypes, is used to govern spatial relationships within and between different feature classes.

Table Relationships

- Implemented within the geodatabase, relationship classes are used to store information about how geodatabase objects, such as tables and feature classes, are interrelated.

How?

An iterative approach was employed that involved reviewing coverage format data layers, applying revisions and implementing with real data within a personal geodatabase. Aspects of each resulting feature class were analyzed with regards to respective attribute tables, domains, subtypes and topology; revisions were applied where necessary. This process was repeated until desired results were achieved. Data layer and table schema were stored in XML and implemented using the Geodatabase Designer tool.

2007

v. 2.x Data Model

Why?

Previous versions of the data model required the addition of a new feature class each time a new kind of geologic feature was identified. These new feature classes were modeled on an existing feature class. The new data model was designed with "feature class definitions", which were created by grouping feature classes in the v. 1.4 data model based on similarities in geometry and attribution. Feature class definitions allow for the addition of newly identified geologic features to a dataset without creating a new data model feature class, resulting in less data model maintenance and more internal consistency. The change in the data model is relatively transparent to the end user who still sees data based on geologic data layers, as in previous data models.

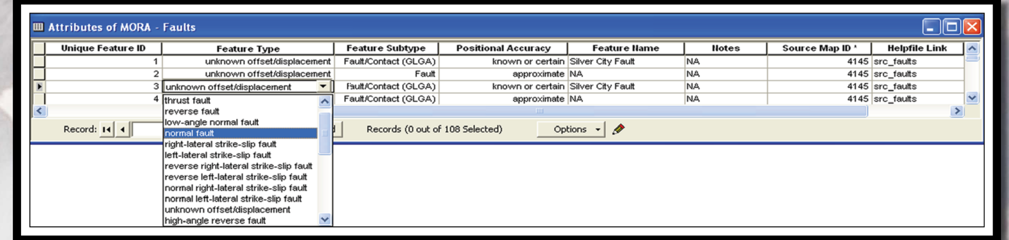
What?

Data Layer Architecture

- Geologic data layers based on geologic data appearing on source maps as in previous data models.
- Geologic data layers created from a feature class definition depending on geometry, attribution and topological rules.

Attribute Tables

- Field names have been normalized so that fields no longer contain a reference to the feature class they belong to; for example FSUBTYPE instead of FLT_SUB for the subtype field name.
- Fields have aliases, making them more understandable to the user.



Domains

- Domains are relatively unchanged in this data model, but are implemented upon the creation of a data-layer-based geodatabase, rather than being part of the data model feature class definition.

Subtypes

- Subtype aliases are normalized so that the aliases do not reflect the name of the feature class; for example, Feature/Contact instead of Surficial Contact/Contact. This is necessary in order to have a feature class definition represent several data-layer-based feature classes.

Topology

- Topological rules are unchanged from previous data model.
- Rules are implemented after creation of a data-layer-based geodatabase.

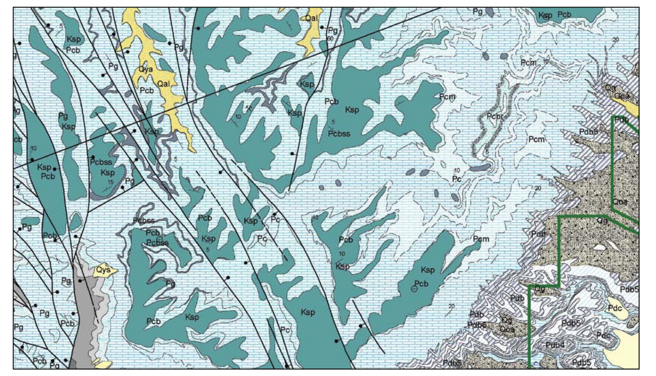
Table Relationships

- Ancillary tables still related back to individual feature classes using a relationship class.
- Geologic Unit Information table now has 'UNIT' for alias instead of 'GLG1'.

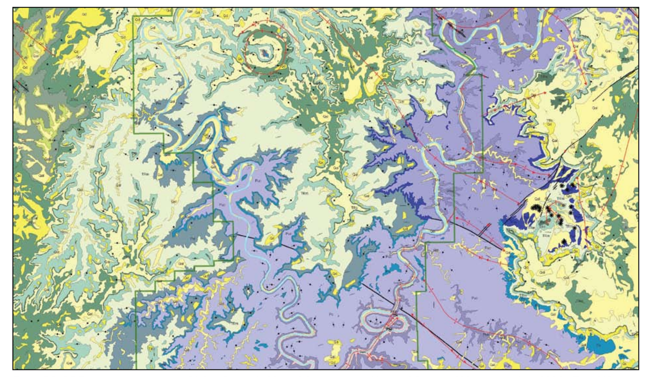
How?

The latest data model is now implemented using tools developed in Visual Basic and ArcObjects. The CreateGDB tool creates a personal geodatabase from a template, with user input for the naming of the geodatabase, the spatial reference of the data and the data model feature classes needed. Line features are still digitized into a single feature class, but are now parsed into new feature classes using the Genesis tool, which was originally developed in AML, then Python and has recently been redeveloped in Visual Basic and ArcObjects.


View of El Capitan (8,085 ft / 2,464 m) from the Permian Reef Trail in Guadalupe Mountains National Park, Texas. El Capitan is the eighth-highest peak in Texas, and is composed of Permian age limestone.
Image: © 2007 Ron Karpilo


The NPS-GRE team completed the Digital Geologic Map of Guadalupe Mountains National Park and Vicinity, Texas in 2007. The GIS data is currently available for free download at the NPS Data Store (http://science.nature.nps.gov/nrdata/).


NPS geologist in front of Mount Wilbur (10,821 ft) and Mount Orville (10,495 ft) in John Hopkins Inlet in Glacier Bay National Park and Preserve, Alaska.
Image: © 2004 Ron Karpilo


The NPS-GRE team completed the Digital Geologic Map of Canyonlands National Park and Vicinity, Utah in 2006. The GIS data is currently available for free download at the NPS Data Store (http://science.nature.nps.gov/nrdata/).


View of landslide debris on Buckskin Glacier in Denali National Park and Preserve, Alaska.
Image: © 2004 Ron Karpilo


A geologist examines basalt columns in Grand Canyon National Park, Arizona.
Image: © 2005 Ron Karpilo


View toward Kwagunt Creek from Nankoweap Butte in Grand Canyon National Park, Arizona.
Image: © 2005 Ron Karpilo

Conclusion

The NPS GRE geologic-GIS data model has evolved to take advantage of changes to GIS data formats that increase data functionality, ensure data quality and promote data integrity. This has allowed the GRE to produce digital geologic-GIS maps that are more user-friendly to the resource managers that use these products to better manage national parks. In addition, the method of production for GRE digital maps, as well as overall data quality, has been improved by using functionality inherent in ArcGIS and tools developed by the GRE program which would not have been possible without the adoption of these newer and improved GIS data formats.

The GRE program plans to continue pursuing improvements in GIS software functionality and data formats to enhance the usefulness of its products. Recent changes to the enterprise-type geodatabase format, changes to how GIS data is accessed, managed and distributed, as well as the availability of the ESRI file-based geodatabase structure seem appealing and worth continued investigation by the GRE program.

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For questions regarding the NPS GRE Data Models, please contact: Stephanie O'Meara (Stephanie.OMeara@colostate.edu), Heather Stanton (Heather_Stanton@partner.nps.gov) or James Chappell (jrchapp@lamar.colostate.edu)

Source Map References

Cooley, M.E., Harshbarger, J.W., Akers, J.P., Hardt, W.F., and Hicks, O.N., 1969, Geologic map of the Navajo and Hopi Indian reservations, Arizona, New Mexico, and Utah (sheet 5 of plate 1), in Regional hydrogeology of the Navajo and Hopi Indian Reservations, Arizona, New Mexico, and Utah: U.S. Geological Survey Professional Paper 521-A, 5 plates, 1:125,000 scale

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Poster Layout and Photography

Ron and Lacy Karpilo, Karpilo Photography, http://www.karpilo.com/

Software References

ArcGIS 8.X and 9.X - Environmental Systems Research Institute (ESRI) Inc., 380 New York St., Redlands, CA92373, http://www.esri.com

Geodatabase Designer v2 – Developed by Richie Carmichael, Environmental Systems Research Institute (ESRI) Inc., 380 New York St., Redlands, CA 92373, http://arcscripts.esri.com

NPS Data Store Reference

NPS Data Store, National Park Service, http://science.nature.nps.gov/nrdata/

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Additional information is available at the GRE website: http://www.nature.nps.gov/geology/inventory/
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