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Digital Mapping Techniques 2010
NPS Geologic Resources Inventory

The NPS GRI: Data Model Concepts and Implementation, and a Programmatic Approach to Digital Map Production

by

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Outline of Our Talk

Part I: Data Model Concepts and Implementation

- The Geologic Resources Inventory (GRI) Program
- GRI Data Model Design Requirements, Factors and Challenges
- GRI Data Model Implementation

Part II: A Programmatic Approach to Digital Map Production

- GRI Digital Map Production Workflow
- Our Mode of Programming
- Show GRI Production Tools
The Geologic Resources Inventory (GRI) Program

- The GRI is tasked with producing geologic information for 270 National Park Service (NPS) parks with natural resources.

- The GRI relies heavily upon cooperative relationships with other agencies and institutions such as the U.S. Geological Survey, state geologic surveys, and academia to produce our products.

- Colorado State University (CSU) is an integral partner in designing and producing GRI products.
GRI Products

- A **Scoping Meeting** to discuss park geologic features, processes and issues, as well as to identify the best source geologic map(s) for the park. The meeting is summarized in a scoping report.

- A **Geologic Report**, written for resource managers, that explains the geology of a park, and how geology is relevant to park resource management.

- A **Digital Geologic-GIS Map** that conveys useful information about the park’s geologic features, yet is also user-friendly and true to the source map(s).
Data Model Design: Requirements and Challenges

The GRI Data Model had several design requirements, including addressing our intended users and their needs to ensure that we are providing useful geologic-GIS data to them.

Our Base Requirements:

- The GRI data model needed to be implementable in standard GIS software. The GIS software widely employed by the NPS is ESRI ArcGIS.

- The intended end users of our data are park resource managers, most of whom are scientists, but not geologists!

- To preserve and effectively communicate all geologic information present on a source map as GIS data (as features and tables) or as ancillary documents (as report text, metadata or graphics).
Geology Across the NPS is Varied and Diverse:

- Each geologic terrain often has its own set of geologic features and observations, and such geologic diversity requires a data model that is flexible and can accommodate new features.

- Igneous and/or metamorphic geology (Yosemite NP and Shenandoah NP)

- Sedimentary and stratified geology (Grand Canyon NP and Canyonlands NP)

- Volcanic terrains (Yellowstone NP, Craters of the Moon NMON & NPRES, and Hawaii Volcanoes NP)
Data Model Design: Requirements and Challenges

Geology Across the NPS is Varied and Diverse:

- Glacial terrains (Glacier NP, and Glacier Bay NP & NPRES)
- Coastal geomorphic and barrier island terrains (Cape Hatteras NS and Cape Cod NS)
- Historic mining districts (Death Valley NP and Klondike Gold Rush NHP)

** Surficial geology and special derivative maps (e.g., hazard probability, erosion susceptibility).

Glacier Bay NP & NPRES
(photo by Ron Karpilo)
Data Model Design: Requirements and Challenges

Map Scale and Map Compilation Considerations:

- On large-scale maps, features are frequently more abundant and diverse, particularly point features (preferred GRI source map scale is 1:24,000 for most parks).

- Features often vary in their spatial representation (i.e., polygon, line or point) depending on map scale and their extent.

- Many GRI park maps are a compilation of multiple source maps.
  - Frequently involves the integration of many geologic features.
  - Line and point features are not omitted in compilations.
As there is varied and diverse geology across the NPS, our anticipated data users are not geologists, their uses of our data vary, we often use large-scale source maps, and we frequently produce map compilations:

Our data model needed to be flexible, not too technical, yet preserve all source map information, and present geologic features in data layers and attribution that can easily be understood and used in a GIS by our users.
Data Model Implementation: GIS Format and Design

GIS Data Format and Architecture:

- Geologic-GIS data is implemented in an ESRI 9.X personal geodatabase as polygon, line and point feature classes.
  - We continue to evaluate a move to an ESRI 9.X file-based geodatabase format.

- Feature class attribute tables are comprised of just those attribute fields necessary to fully capture all applicable attribution.

- Geologic features are often grouped into data layers (feature classes) based upon the geologic processes that created them (e.g., deformation/structural, volcanic, glacial) for ease of presentation for our intended users.
Many data model feature classes can be repeated if warranted (e.g., for different structure contour lines or for different area hazards).

To implement many feature classes our data model employs the use of shared schema. Feature classes share the same schema when they have the same:

- spatial geometry (i.e., polygon, line or point).
- attribute fields (the minimum required to fully attribute).
- table-to-table relationships.
- topological rules.

Shared data model schema are referred to as a “Template Feature Class Definition” in our data model. 7 template feature class definitions are employed to represent 44 of the 56 possible feature classes.
Data Model Implementation: Feature Classes

Data Model Template Feature Class List:

**Polygon**
- Geologic Units
- Other Area Units*
- Other Area Types*

**Line**
- Geologic Contacts
- Other Area Contacts and Boundaries*
- Geologic Line Units*
- Faults
- Folds
- Structure Contour, Other Value and Related Subsurface Lines*
- Geologic Cross Section Lines
- Linear Geologic Features and Extent Lines*

**Point**
- Geologic Point Units
- Geologic Attitude Observation Localities
- Geologic Observation Localities
- Geologic and Other Point Features*
- Geologic Sample Localities
- Geologic (Non–Attitude) Measurement Localities
- Seismic Localities
- Map Symbology

* Indicates a template feature class definition

Cape Hatteras NS (photo by US ACE FRF)
Data Model Implementation: Feature Classes

Example: The “Other Area Types” template feature class definition is used to implement 8 data model feature classes.

Feature Class Definition List

- Alteration and Metamorphic Areas (AMA)
- Aquifers (AQU)
- Deformation Areas (DEF)
- Glacial Area Features (GAF)
- Hazard Area Features (HZA)
- Mine Area Features (MAF)
- Outcrops (OCR)
- Weathered Area Features (WTH)

** Data model feature class abbreviations are in parentheses.

Feature Class Definition Attribute Table Parameters

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Field Alias</th>
<th>Data Type</th>
<th>Allow Nulls</th>
<th>Implemented</th>
<th>Domain</th>
<th>Precision</th>
<th>Scale</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
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<td>NA</td>
<td>Object ID</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>SHAPE*</td>
<td>NA</td>
<td>Geometry</td>
<td>Yes</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>FUID</td>
<td>Unique Feature ID</td>
<td>Long Integer</td>
<td>No</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>FTYPE</td>
<td>Feature Type</td>
<td>Long Integer</td>
<td>No</td>
<td>Variable (Coded)</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>NOTES</td>
<td>Notes</td>
<td>Text</td>
<td>No</td>
<td>-</td>
<td>-</td>
<td>234</td>
<td>-</td>
<td>-</td>
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<td>Text</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>SHAPE_Length</td>
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<td>-</td>
<td>0</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>SHAPE_Area</td>
<td>NA</td>
<td>Double</td>
<td>Yes</td>
<td>-</td>
<td>-</td>
<td>0</td>
<td>0</td>
<td>-</td>
</tr>
</tbody>
</table>

* Standard ESRI 9.x personal geodatabase feature class attribute field (see ESRI ArcGIS software).
(1) Relationship class foreign key field to MAP table (see Relationship Classes below).

Deformation Areas (DEF) Feature Type (DEF_FTYPE) Domain List

<table>
<thead>
<tr>
<th>Coded Domain Value</th>
<th>Domain Value</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>fault zone</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>shear zone</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>mylonite zone</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>ductile deformation</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>ground crack zone</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td>structural zone</td>
</tr>
<tr>
<td>7</td>
<td>7</td>
<td>high strain zone</td>
</tr>
<tr>
<td>8</td>
<td>8</td>
<td>breccia zone</td>
</tr>
</tbody>
</table>
John Muir NHS (JOMU) Map

Source Map: Haydon, Wayne D., 1995, Landslide Hazards in the Martinez-Orinda-Walnut Creek area, Contra Costa County, California, Landslide Hazard Identification Map No.32. OFR 95-12, Division of Mines and Geology, California Department of Conservation, 4 plates, 1:24,000 scale
Data Model Implementation: GIS Building Blocks

Attribute Fields:

- Only 25 data model attribute fields are employed for data model feature classes. Custom attribute fields can also easily be added.

Feature Class Attribute Field and Field Parameters Table

Geologic Units (GLG) Feature Class Attribute Table Parameters

* Standard ESRI geodatabase feature class attribute field.
(1) Relationship class foreign key field.
(2) Denotes a subtype field.
Data Model Implementation: GIS Building Blocks

Attribute Domains:

- Both coded and ranged attribute domains are implemented.

Strike/Trend (STRIKE_ROTATION) Ranged Domain List

<table>
<thead>
<tr>
<th>Domain Value</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>minimum value</td>
</tr>
<tr>
<td>359</td>
<td>maximum value</td>
</tr>
<tr>
<td>999</td>
<td>not applicable (NULL) value</td>
</tr>
</tbody>
</table>

Bryce Canyon NP (BRCA) Fault Layer (Feature Class) Attribute Table**

**partial attribute table, many attribute fields are not shown.
Data Model Implementation: GIS Building Blocks

Geodatabase Topology:

- Implemented to ensure no gaps, no overlaps, and no dangles, and to ensure feature coincidence between features where appropriate.

Dike intruded along a fault

Feature coincidence is maintained between the Linear Dikes (DKE) and Faults (FLT) feature classes via topology rules.

**If either line is spatially edited using topology edit tools then both features are edited.

Data Model Implementation: GIS Tables

Ancillary Tables and Table Relationships:

- Two standard ancillary tables: the Geologic Unit Information (UNIT) and Source Map Information (MAP).
- Feature classes are linked to ancillary tables via relationship classes using a common key field.
- Additional GIS tables, if present in the source data, are easily accommodated.

Shenandoah NP (SHEN) Geologic Unit Information (UNIT) Table
Data Model Implementation: Summary

- The GRI geology-GIS data model is implemented in an ESRI 9.X personal geodatabase and makes use of much of the functionality (i.e., attribute domains, topology, relationship classes) this format provides.

- Many data model feature classes are implemented using shared schema.

- Our data model preserves all source map geologic information, and presents this information in data layers and attribution that can easily be understood and used by our users.

- As a result of our design and implementation methodology, our data model is highly flexible and can easily accommodate the addition of new features as well as new data layers as these are recognized.
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GRI Digital Map Production Workflow

**Project set up**
- Create geodatabase
- Add topology

**Capture/Conversion**
- Parse features
- Custom field mapping
- and data loading
- Compile
- Clip

**Quality Checking**
- Append features to new geodatabase
- Batch frequency report
- Quality control tool

**Data Finalization**
- Repath layer files
- Create metadata
- Create relationship classes
- Finalize MXD
- Calculate unique identifiers
- Export shapefiles
- Zip GRI product
Our Mode of Programming

- Tasked with creating data products, not tool sets
  - Planning is key
  - Recycle/Reuse?

- Employ an iterative approach
  - Keep it simple to start
  - Forces us to think modular
Our Mode of Programming

What we don’t want...

“The Homer”
Summary and Conclusion

• Designed and implemented a data model that is:
  ➢ Very flexible – accommodates varying terrains and map scales
  ➢ Communicates effectively to intended users

• Continue to utilize custom tool development to aid in map production:
  ➢ Streamlined digital map production process
  ➢ Ensured quality and consistent geologic map datasets

Denali NP & NPRES (photo by Ron Karpilo)
GRI Product Information and Status

GRI Digital Map Product:
- GIS Readme file
- 9.x GIS data (personal geodatabase and shapefiles)
- 9.x ArcMap document and layer files complete with symbology
- FGDC-compliant metadata file
- GRI Map Help PDF document containing geologic unit descriptions, as well as ancillary information from all source maps

GRI Completed Map Data (as of May, 2010):
- Parks: 173 (plus 10 non-resource parks)
- Maps: 614
- Source maps used: 672

URLs:
NPS Geology-GIS Data Model documents: http://science.nature.nps.gov/im/inventory/geology/GeologyGISDataModel.cfm
Digital Geologic-GIS data available at the NPS Data Store: http://science.nature.nps.gov/nrdata/
Geologic Resources Inventory products: http://www.nature.nps.gov/geology/inventory/publications