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The contents are provisional and will be
superseded by a paper in the
DMT'09 Proceedings.

See also earlier Proceedings (1997-2008)

<http://ngmdb.usgs.gov/info/dmt/>



Geologic Resources Inventory of Our National Parks

Case Study: Timpanogos Cave National Monument

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Introduction

The Geologic Resources Inventory (GRI) is one of 12 inventories funded under the National Park Service (NPS) Natural Resource Challenge designed to enhance baseline information available to park managers. The Geologic Resources Division of the Natural Resource Program Center administers this program. The GRI team relies heavily on partnerships with Colorado State University (CSU), the U.S. Geological Survey, individual state surveys, and other organizations in developing GRI products. 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.

CSU plays an integral role in creating and developing geologic products for use in managing park natural resources. CSU research associates work side-by-side with GRD staff attending scoping meetings at parks to identify mapping needs, park-specific geologic issues, features, and processes. Research associates then produce a record of those meetings in a scoping summary, write geologic reports about the park's geology, and create digital geologic-GIS data for use by park staff. CSU research associates have taken the lead in creating the NPS GRI Geology-GIS Geodatabase Data Model to detail a series of guidelines for the capture and presentation of the geologic-GIS data, as well as designing the map unit properties table which provides a link between the properties of the geologic units on the digital map with the rest of the geologic information in the report to interest to park natural resource managers.

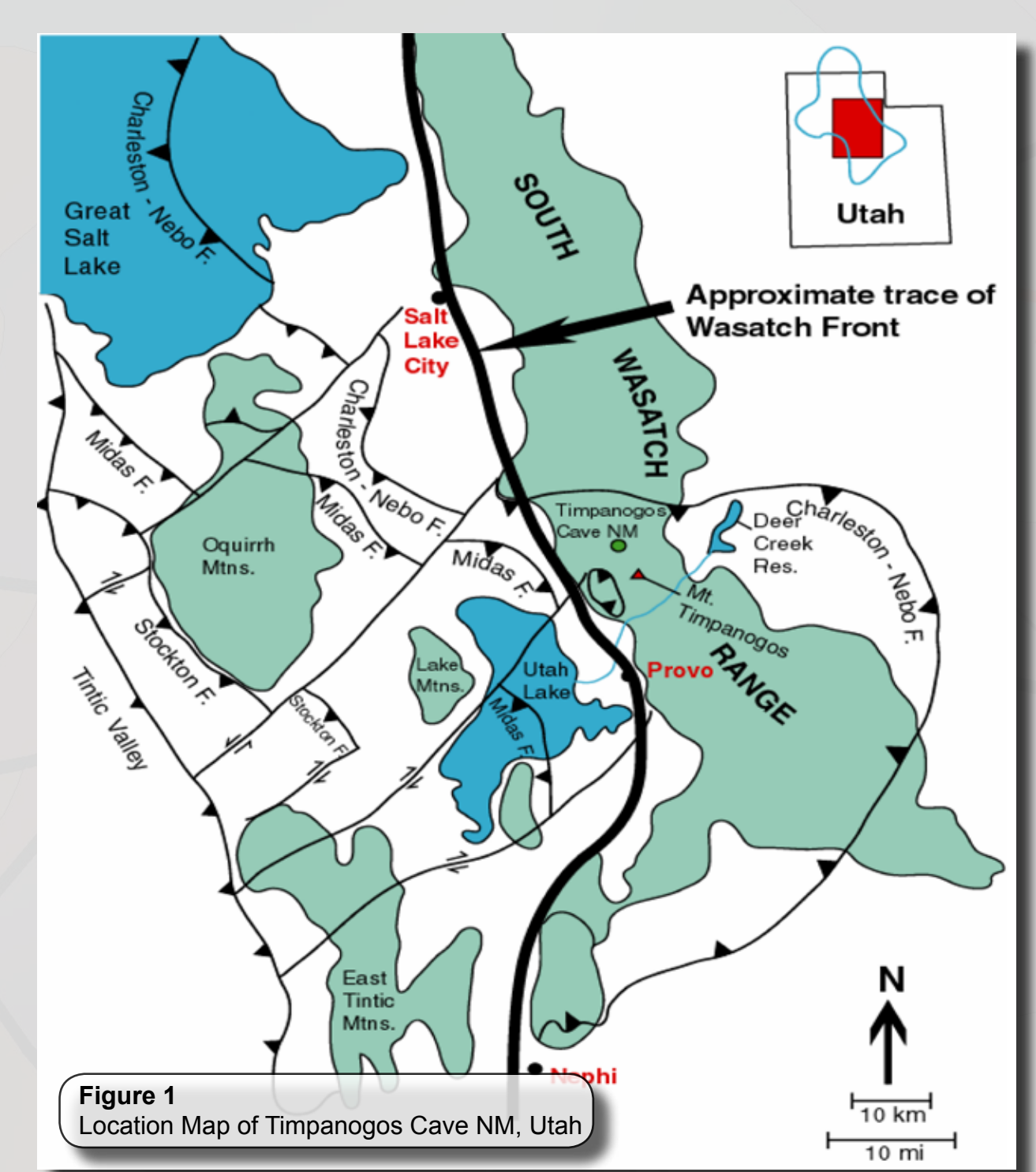
This poster presents the GRI map and report products created for Timpanogos Cave National Monument, focusing on the Mississippian Desert Limestone and its implications for park resource management.

Scoping

CSU Research Associates participated in a GRI scoping meeting at Timpanogos Cave National Monument, which involved a site visit and roundtable discussion. The purpose of this meeting was to 1) introduce the GRI program and products, 2) investigate and evaluate existing geologic map coverage and potential mapping needs, 3) discuss geologic resource management issues and potential research and monitoring needs, and 4) identify distinctive geologic features and processes at the monument. The scoping meeting included geologists and local experts from the NPS, Utah Geological Survey, University of Arizona, Brigham Young University, and Timpanogos Cave National Monument.

- A scoping summary generated from discussions at the meeting included:
 - Brief description of the GRI
 - Overview of the monument's geologic setting and geologic resources
 - Status of mapping coverage and plan for producing the digital geologic map
 - Prioritized list of geologic resource management issues
 - Description of geologic features and processes of interest
 - Lists of research and monitoring recommendations and action items
 - Participants list and contact information

This summary served as an interim geologic report for the monument until the GRI produced the digital geologic map and accompanying final geologic report.



Map and Report Production Process

Map Production Process
At the scoping meeting for Timpanogos Cave National Monument, participants decided that no new mapping was needed to meet the resource management needs of the park and that the digital geologic map for the monument should include the entire Timpanogos Cave Quadrangle from the following paper map:

Baker, A.A., M.D. Crittenden, Jr. 1961. Geology of the Timpanogos Cave Quadrangle, Utah. U.S. Geological Survey, Report: GQ-0132.

After available maps have been identified, they are either scanned at high-resolution and digitized or converted to the NPS GRI Geology-GIS Geodatabase Data Model, which lays out standards for attribution and spatial relationships that incorporate topological rules, subunits, domains, and relationship classes. The goal is to maintain all aspects of the original paper map or data while enhancing usability by providing all aspects of the map in a compact digital format that is usable in ArcGIS and other software.

For Timpanogos Cave, cross sections were provided as separate images to be linked from ArcMap and additional information found on the source paper map, such as its report, legend and references, were added to a map information document in Acrobat PDF format. GIS data layers digitized from the map include attitude measurements, faults, folds, geologic units and contacts, mine features, cross sections and map symbology. In addition, two tables containing information about the geologic units and source map references were created. In addition to the GIS data and map information document, the final digital geologic map product for Timpanogos Cave National Monument includes layer files storing symbology for each geologic data layer and FGDC-compliant metadata.

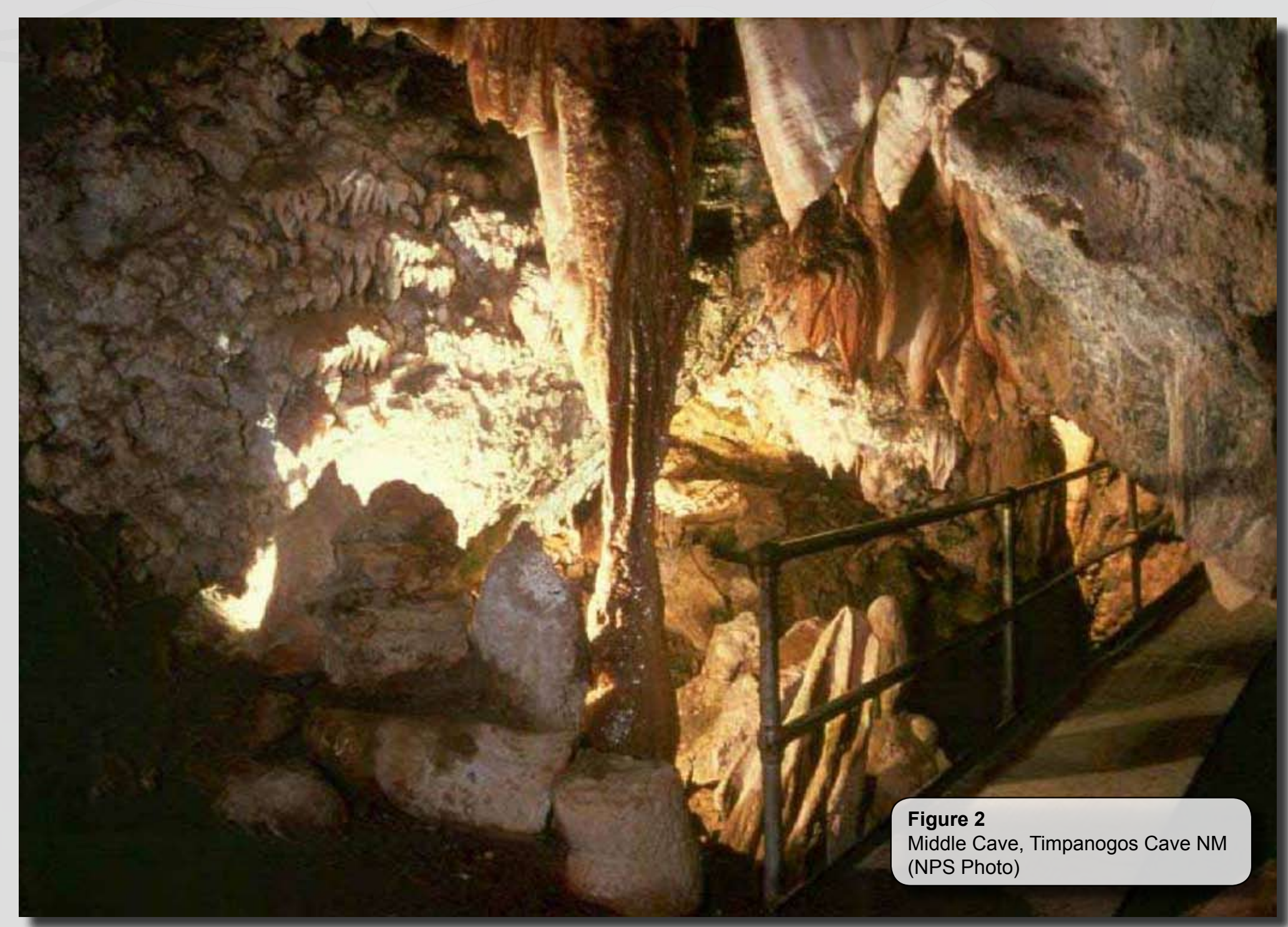
Report Production Process

Once the GRI completed and distributed the digital geologic map for Timpanogos Cave National Monument, CSU research associates began production of the final geologic report. The GRI intended the geologic report for Timpanogos Cave National Monument to be concise and accessible to non-geoscientists.

Information from the digital geologic map (including unit descriptions) and the scoping summary served as the foundation for the report. Additional research incorporated resources such as park planning documents, geologic journals, professional communication with local experts, park-specific publications, and the Timpanogos Cave National Monument Web site.

The final report included a map unit properties table, which describes each unit that appears on the digital geologic map delineating properties of interest to monument resource managers. This table serves as a direct connection between the report and digital geologic map.

Once written, the final geologic report underwent an extensive review process with input from park staff and GRD technical experts, and final copyediting. Once finalized, the NPS-GRD distributed a hardcopy of the GRI report for Timpanogos Cave National Monument accompanied by a CD containing a transmittal letter, PDF image of the digital geologic map, guide for using GIS data, the digital geologic map data, an ArcGIS geologic map document (.mxd), the GRI Geology-GIS Geodatabase Data Model, and a PDF of the geologic report.



Map Products

GIS Data

- Delivered in both ESRI Personal Geodatabase and shapefile formats with attribute tables for both formats conveying information about the characteristics and properties of mapped geologic features.
- Accompanied by layer files (.lyr) that display geologic map symbology for individual data layers and an ArcGIS map document (.mxd) that presents all GIS components of the GRI digital geologic map for Timpanogos Cave in a user-friendly format for viewing and data analysis.

Metadata and Readme files

- FGDC-compliant metadata (.txt) that conveys layer and map specific information such as data origin, data scale, how the data was created and its intended use, whom to contact with regards to the data, etc.
- The GIS Data Explanation readme file (.pdf) describes the contents of the GRI GIS product and recommends entry points for viewing and using the GIS data.

Ancillary Tables

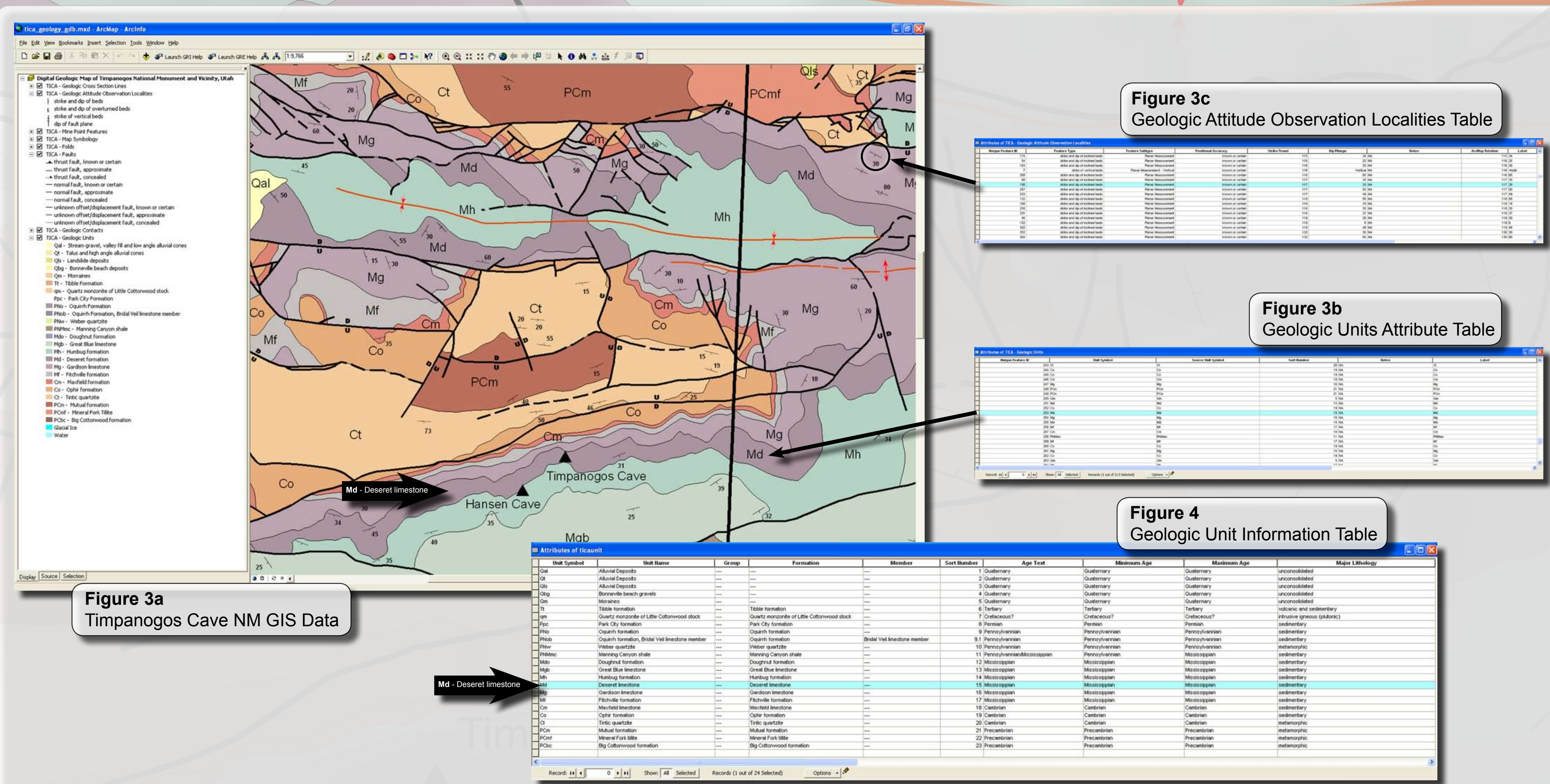
- The Geologic Unit Information Table displays detailed name and age information about geologic units contained within the Timpanogos Cave GIS data.
- The Source Map Information Table contains citation information for all mapping data used in the creation of the GIS data.
- Both tables are linked through a relationship class to be viewable along with the GIS data in ArcMap.

GRI Map Help Document

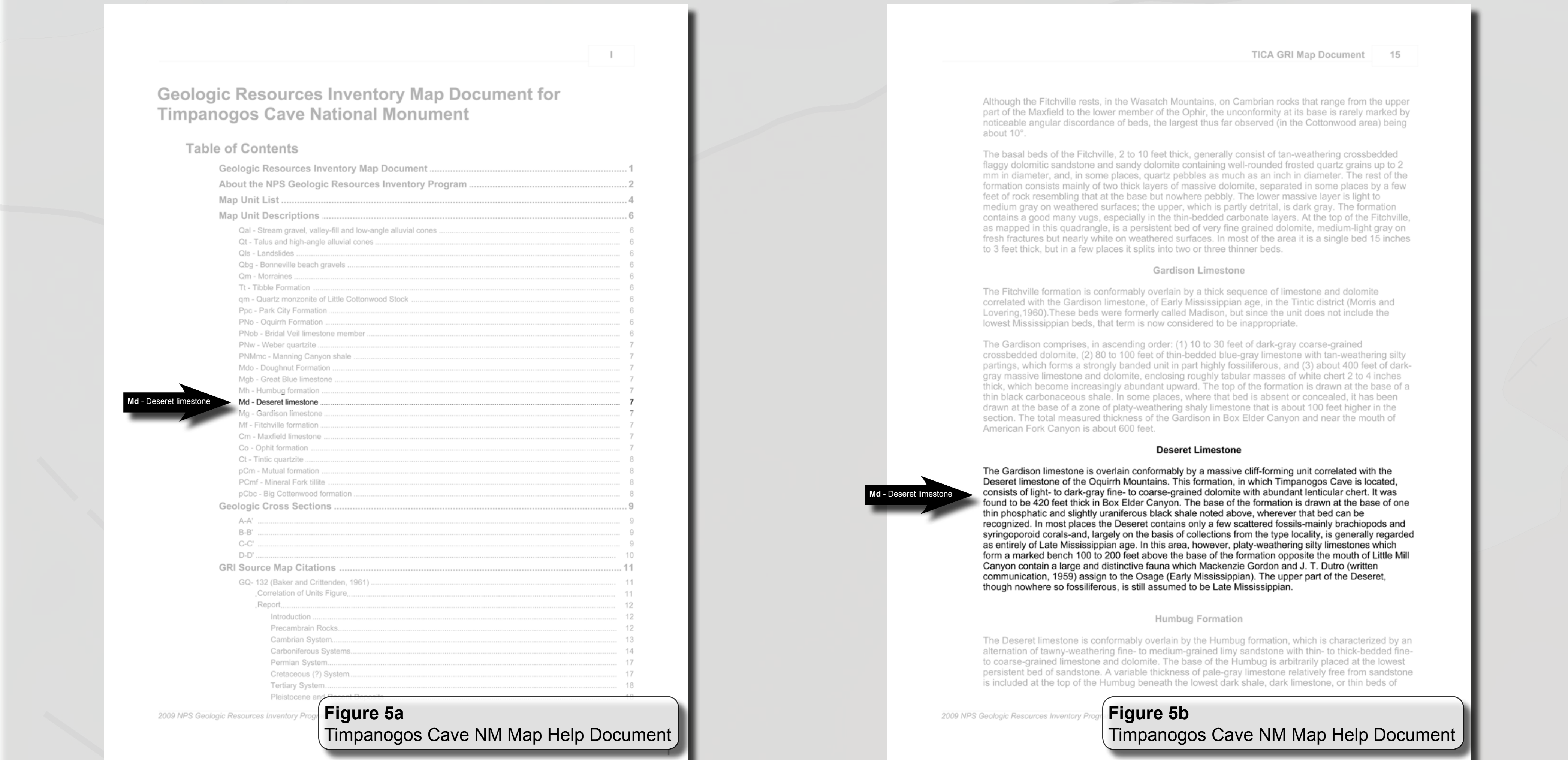
- Provided in Portable Document Format (.pdf) and intended to supplement the GIS data by providing lithologic descriptions, legends, figures, tables, as well as citation information from source maps used for this park.
- Contains information about the GRI program and about the methods and formats employed in the creation of the GIS data.
- Uses hotlinks to enable easy and logical navigation within the document.

Map Layout and Geologic Cross-sections

- The map layout (.pdf) displays a cartographic representation of the GIS data and the park boundary – contains standard geologic map elements such as legends, correlation of units, scale, etc.
- Separate images of geologic cross-sections are annotated with citation information and "hot-linked" to the geologic cross sections in the GIS data.



The Timpanogos cave complex is composed of three caves called Hansen, Middle and Timpanogos Caves. The caves formed in the Mississippian Desert Limestone (Md) through persistent work of acidic water along ground-water paths of concentrated flow. The Desert Limestone is represented in the GIS data with color-filled polygons (figure 3a), and an attribute table describing basic information about it and other units (figures 3b). An attribute table presenting some of the highly inclined bedding near the caves is also presented (figure 3c). Additional information about the unit, including its age, name and grouping, are shown in the geologic unit information table (figure 4). Finally, a unit description for the Desert Limestone (Md) and other units, as well as geologic cross sections and other additional source map information are presented in the GRI Map Help PDF document (figures 5a and 5b).



Report Products

The GRI report for Timpanogos Cave National Monument includes the following sections:

Executive summary and Introduction

- A summary of the key points in the report.
- Describes the GRI program, geologic setting and history of Timpanogos Cave National Monument, and cave formation at Timpanogos.

Geologic Issues

- Describes resource management issues such as seismicity associated with the Wasatch Front, mine features, slope processes, cave restoration and preservation, wind erosion, sediment loading, and streamflow with issue-specific recommendations for inventory, monitoring, and research.

Geologic Features and Processes

- Describes the Charleston Fault Zone, formation of the cave and karst landscapes, and speleothems at Timpanogos Cave National Monument.

Map Unit Properties Table

- Presents physical characteristics, potential resources, cultural information, and scientific significance of each unit on the digital geologic map.

Geologic History

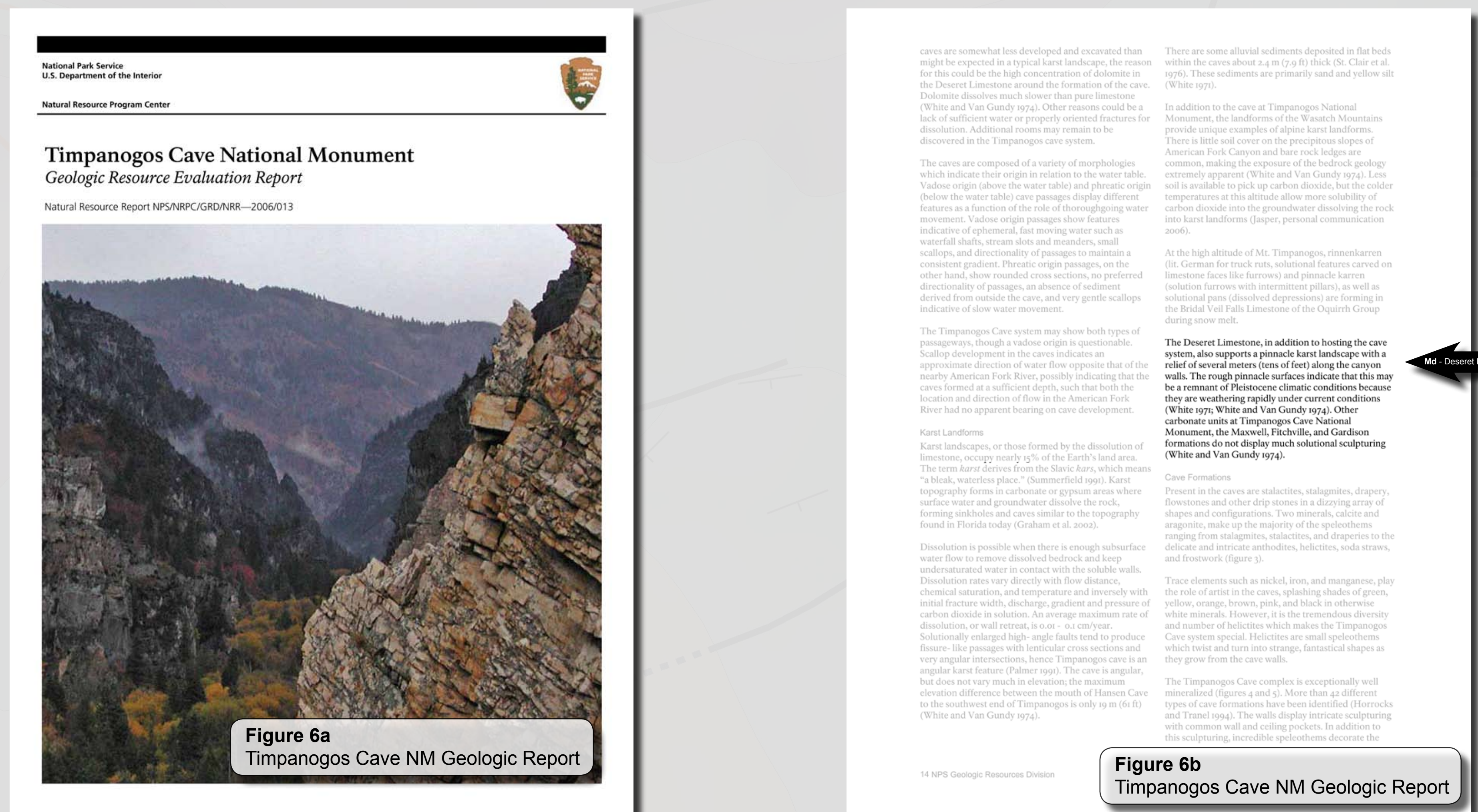
- Describes the rocks and unconsolidated deposits that appear on the digital geologic map of Timpanogos Cave National Monument, the environment in which those units were deposited, and the timing of geologic events that created the present landscape.

Glossary and References

- Defines technical geologic terms used throughout the report.
- Lists references cited in the report and a general bibliography for resource manager use.

Appendix A and B:

- Geologic map graphic - A snapshot of the geologic map for Timpanogos Cave National Monument.
- Scoping summary - Excerpts from the GRI scoping summary.



The GRI report makes the information presented in the GIS data more relevant and accessible to park resource managers by providing resource-specific information about each geologic unit (figure 6b), and the geologic setting. The Map Unit Properties Table (figure 7) shows this information more graphically, and ties back to the map product by replicating the color of the unit as it appears on the GIS map (figures 3a).

Resource Management Implications

CSU research associates and GRD staff provided Timpanogos Cave National Monument staff with a complete GRI product, including a summary of the scoping meeting, digital geologic-GIS data, and the geologic report summarizing the park's geologic features and processes. The Desert Limestone is of particular significance because it is the geologic unit that hosts the majority of the cave complex at the national monument (figures 9 and 10). The GIS data can be used to understand the spatial distribution of the Desert Limestone, thereby also identifying other potential locations of cave formation. The geologic report provides more detailed information about the unit and its particular properties. Combining information from the GIS data and the report, park resource managers have a powerful tool for determining which locations are suitable for development, which areas need resource protection, and where potential hazards may exist.

At Timpanogos Cave National Monument, the Desert Limestone is relatively resistant to weathering and erosion, forming steep slopes. The limestone is unsuitable for development in areas where dissolution is high as pervasively dissolved areas do not provide the structural integrity for heavy development, nor the adsorption capabilities necessary for wastewater treatment. The unit is also fossiliferous, posing the potential need to develop a resource management plan to protect exposures of the Desert Limestone from park visitors in search of fossil samples. In addition, the information contained in the report and GIS data can be used to help identify habitats for various plants and animals. For instance, the caves within the Desert Limestone may provide habitat for mountain lions as well as cave flora and fauna. The mineralized caves at Timpanogos (figure 8) are famous for myriad speleothems including rare examples of helictites. Trace elements derived from units such as the Desert Limestone are responsible for the variety of colored dripstones and flowstones. Geochemical sampling of Desert Limestone and associated speleothems may yield paleoclimate information and data regarding the timing of cave formation. The GRI product is an informative component available to park interpretive staff for creating programs designed to educate monument visitors about the geology of the area. Linking the geologic history of the Desert Limestone to that of the entire region broadens the scope of a program whereas discussing the processes of cave formation within the limestone narrows the focus.

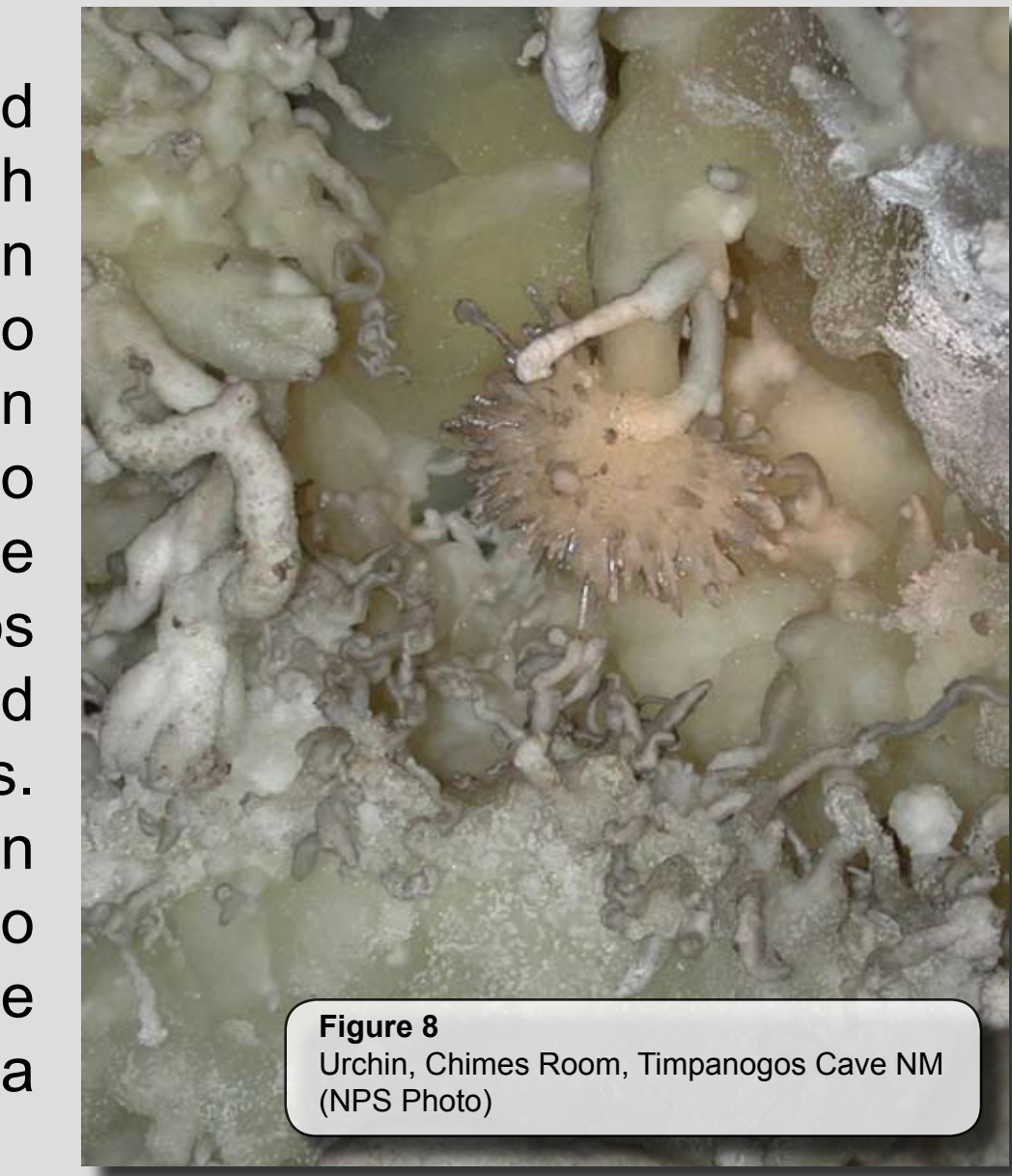


Figure 9: View of the GRI geologic GIS data in American Fork Canyon surrounding Timpanogos Cave NM

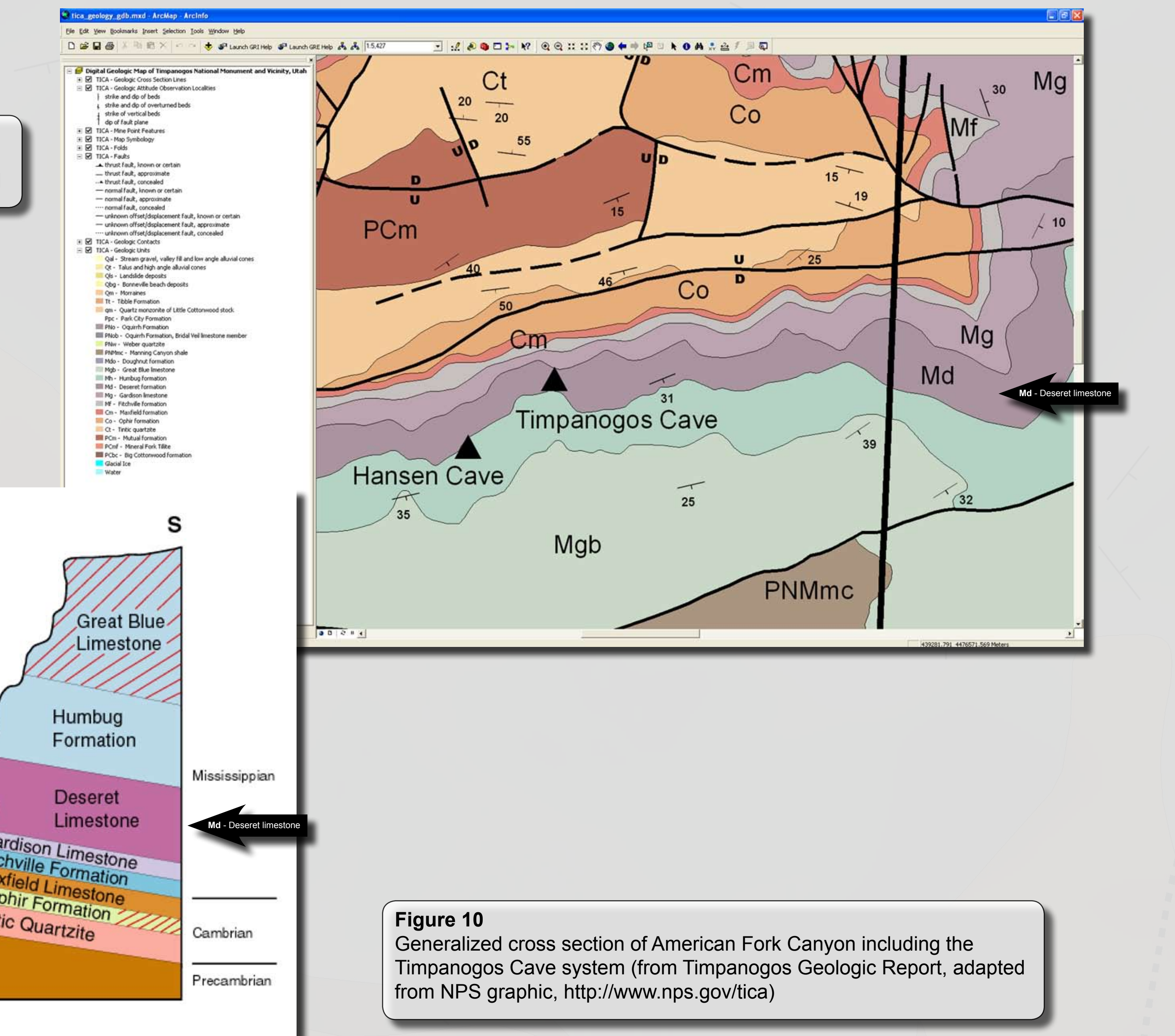


Figure 10: Generalized cross section of American Fork Canyon including the Timpanogos Cave system (from Timpanogos Geologic Report, adapted from NPS graphic. <http://www.nps.gov/ica>)

NPS GRI Team

Colorado State University (CSU)

- Stephanie O'Meara (Map Team Coordinator)
- Heather Stanton (Map Project Manager)
- James Chappell (Map Project Manager)
- Ronald Karpilo Jr. (Map Project Manager)
- Trista Thornberry-Ehrlich (Report Writer)
- John Graham (Report Writer)
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- Michael Cox (Database Developer)

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- Carol McCoy (Program Manager)
- Bruce Hesse (Program Coordinator)
- Tim Connors (Mapping Coordinator)
- Gregory Mack (Map Project Manager)
- Georgia Hybels (Map Project Manager)
- Andrea Croskey (Map Project Manager)
- Jason Kenworthy (Report Coordinator)

Additional information is available at the GRI website: <http://www.nature.nps.gov/geology/inventory/>
For questions about the NPS GRI Program, please contact: Bruce Hesse (Bruce_Hesse@nps.gov) or Tim Connors (Tim_Connors@nps.gov)

References

- Data Model References**
O'Meara, Stephanie A., Stanton, Heather L., and Chappell, James R., with contributions from Greg Mack, Georgia Hybels, Ron Karpilo, and Andrea Croskey, 2008. National Park Service Geologic Resources Inventory Geology-GIS Geodatabase Data Model (v. 2.1). <http://science.nature.nps.gov/inventory/geology/GeologyGISDataModel.htm>
For questions regarding the NPS GRI Data Model, please contact: Stephanie O'Meara (Stephanie.O'Meara@colorado.edu), Heather Stanton (Heather_Stanton@nps.gov) or James Chappell (rchapp@nps.gov)
- Source Map References**
Baker, A.A., M.D. Crittenden, Jr. 1961. Geology of the Timpanogos Cave Quadrangle, Utah. U.S. Geological Survey, Report: GQ-0132.
- Software References**
ARC/INFO v. 3.1 - Environmental Systems Research Institute (ESRI) Inc., 380 New York St., Redlands, CA 92373. <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/ds/>
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