

The National Geologic Map Database Project: Overview and Progress

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In the past decade, the National Geologic Map Database (NGMDB) project has evolved from a general concept to a set of resources that have helped the Nation's geological surveys provide to the public, in a more efficient manner, standardized digital geologic map information. Throughout this period, I have had the honor of serving as the NGMDB project chief. In this capacity, I worked closely with the Association of American State Geologists (AASG; see Appendix A) and, in particular, with my AASG chief liaison, Thomas M. Berg (State Geologist and Chief, Ohio Geological Survey). Tom retired soon after the DMT'06 meeting, and I wish to thank him profusely for his many years of guidance, support, and friendship.

After 10 years of managing the NGMDB project and organizing the Digital Mapping Techniques workshops, I found that a slight reduction in certain activities has been necessary in order to bring new priorities and direction to the project. For example, by comparison to the progress reports of previous years (see Appendix B), this report is quite limited in scope. Below, I briefly document the project's progress during this year; for detailed descriptions of this project's goals and accomplishments, please refer to the DMT'05 report (Soller and others, 2005).

BACKGROUND

Development and management of science databases for support of societal decisionmaking and scientific research are critical and widely recognized needs. The National Geologic Mapping Act of 1992 and its subsequent reauthorizations stipulate creation and maintenance of a National Geologic Map Database (NGMDB), as a national archive of spatially referenced geoscience data, including geology, paleontology, and geochronology. The Act further stipulates that all new information contributed to the NGMDB adhere to standards, which are to be developed as needed under the guidance of the NGMDB project. Development of a national database and its at-

endant standards is a daunting task that requires close collaboration among all geoscience agencies in the U.S., at the State and Federal levels. The Act, therefore, creates the environment within which the USGS and the Association of American State Geologists can collaborate to build the NGMDB and serve as well the specific needs of their own agencies.

From the guidelines in the National Geologic Mapping Act, and through extensive discussions and forums with the geoscience community and with the public, a general strategy was designed by which to build the National Geologic Map Database (NGMDB). This strategy was publicly stated in 1995 and, based on public input, has gradually evolved. The NGMDB is designed to be a comprehensive reference tool and data management system for spatial geoscience information in paper and digital form. More specifically, the NGMDB will consist of the following: 1) limited metadata in its Map Catalog for all paper geoscience maps and book publications that contain maps (including maps of any part of the Nation, published by any agency), online viewable images of paper and digital maps, metadata for published digital map data, and links to online data; 2) ancillary databases that provide further information about geoscience in the USGS and the state geological surveys (e.g., the Geologic Names Lexicon, the Mapping in Progress Database, and the National Paleontology Database); 3) nationwide geologic map coverage at intermediate and small scales; 4) an online database of geologic maps (predominantly in vector format; planned as a distributed system); 5) a set of Web interfaces to permit access to these products; and 6) a set of standards and guidelines to promote more efficient use and management of spatial geoscience information. The NGMDB system is a hybrid – some aspects are centralized and some are distributed, with the map information held by various cooperators (for example, the State geological surveys). Through a primary entry point on the Web, users can browse and query the NGMDB, and obtain access to the information wherever it resides.

Project Organization

The project has been designed as a set of related tasks that will develop, over time, a NGMDB with increasing complexity and utility. This is being accomplished through a network of geoscientists, computer scientists, librarians, and others committed to supporting the objectives of the NGMDB. **Phase One** of this project principally involves the building of a comprehensive Map Catalog of bibliographic records and online images of all available paper and digital maps, and book publications containing maps, that adhere to the earth-science themes specified in the National Geologic Mapping Act of 1992. The first phase also includes the design and development of the Geologic Names Lexicon, the Mapping in Progress Database, and the National Paleontology Database. **Phase Two** is the development of standards and guidelines for geologic map and database content and format. **Phase Three** is a long-term effort to develop a database that contains nationwide geologic map coverage at a variety of map scales, according to a complex set of content and format specifications that are standardized through general agreement among all partners in the NGMDB (principally the AASG); this database will be integrated with the databases developed in Phase One. The NGMDB project's technology and standards development efforts also are coordinated with various international bodies, including the Federal Geographic Data Committee, the North American Geologic Map Data Model Steering Committee, ESRI, the U.S. National Science Foundation's Geoinformatics project "GEON," the IUGS Commission on the Management and Application of Geoscience Information ("IUGS CGI"), the IUGS Commission on Stratigraphy, the IUGS-affiliated Commission for the Geological Map of the World, and the International Association of Mathematical Geology (IAMG).

A full realization of the project's third phase is not assured and will require a strong commitment among the cooperators as well as adequate technology, map data, and funding. The project will continue to assess various options for development of this database, based on realistic funding projections and other factors. During the development of these phases of the NGMDB, extensive work will be conducted to generate Web interfaces and search engines, and continually improve them. Development of the data management and administrative protocols will be a priority as well, to ensure that the NGMDB will function efficiently in the future. The NGMDB's databases and project information can be found at <http://ngmdb.usgs.gov>.

PROGRESS

Phase One

As noted above, the objective of Phase One is to provide quick access to existing geoscience resources. As evidence of success in this activity, the NGMDB "Phase One" databases (Map Catalog, Geolex, Mapping in Progress) receive about 135,000 visits a month from about 35,000 users (nearly all of whom are non-USGS). This usage has increased dramatically since mid-2005 – most likely this was achieved through: 1) increased content; 2) persistent (and more effective?) outreach to users at scientific meetings and through email and publications; 3) a successful appeal to USGS to identify NGMDB as the link from "Geologic Information" on the USGS home page; and 4) increased market prices for earth resource commodities, which thereby increases the demand for geoscience information. With this increased Web traffic has come an increase in user requests for information and assistance – these users vary widely in interest and background, and include school children, homeowners, local government planners, and professional geologists. With many of these users we have personal contact by email to ensure they find what they need.

Specific accomplishments this year include:

1. Expansion of the NGMDB Map Catalog by about 4000 records, to a total of about 75,000 records. This includes 36,000 USGS maps in map, book, and open-file series, essentially all relevant USGS publications. It also includes 26,000 State survey publications and 13,000 products by other publishers.
2. Engagement of 45 states in the process of entering Map Catalog records and processing of about 2000 new records for State geological survey publications.
3. Doubling of the number of links to online publications, including map images; the total is now 10,000.
4. Continued the expansion and revision of Geolex (the geologic names lexicon), with a major update completed in mid-year.
5. Completion of the incorporation of the prototype Image Library into the Map Catalog. The Image Library utilized a subset of Catalog records and provided a Web interface that did not easily scale upward to accommodate new images. This incorporation was a significant effort that will provide

users with a more productive search process; the project is now focused on providing a geographic-search capability within the Map Catalog to give users a search option we attempted to provide via the Image Library.

6. Writing of a prototype application that generates a file to display Map Catalog search results in Google Earth. This application was made available for public comment.
7. Completion of several hundred productive interchanges with Map Catalog, Geolex, and Image Library users via the NGMDB feedback form and other mechanisms.
8. Numerous project presentations to scientists and managers at USGS, AASG, and other scientific meetings, whereby details of the project were explained and participation of professionals in building various NGMDB standards and databases was increased (e.g., Map Catalog, Geolex, online map database).
9. Participation with USGS National Cooperative Geologic Mapping Program (NCGMP) in an effort to begin to revise significantly the Mapping in Progress database, focusing on database redesign and adding information that will be useful to NCGMP management.
10. The providing of index maps, in response to requests by USGS and AASG management, that show areas in the U.S. that have been geologically mapped at various scales and time periods (see Soller, 2005). These maps and statistics (e.g., square miles mapped at 1:24,000-scale from year 2000 to 2005) were presented at various venues and were used by NCGMP to prepare responses to the Office of Management and Budget during their annual performance appraisal.

Phase Two

Phase Two addresses a Congressional mandate to develop standards and guidelines for geologic map and database content and format. Specific accomplishments this year by members of the NGMDB project staff include:

1. Coordination of work on the Federal Geographic Data Committee's draft standard for geologic map symbolization; revisions to the standard, based on FGDC Standards Working Group review; gaining final approval from the FGDC Coordination Committee for release as the Federal standard. This

standard includes: a new terminology for representing the scientific and locational confidence associated with geologic map features (e.g., contacts, faults, sample locations), a Postscript implementation of the standard (the ArcGIS implementation is under development), and a comprehensive response to all comments received in the FGDC-sanctioned Public Review.

2. Serving as Chair of the FGDC Geologic Data Subcommittee.
3. Organization and leadership of the tenth annual "Digital Mapping Techniques" workshop, and publication of the workshop Proceedings from the previous year's meeting (DMT '05, Baton Rouge, LA). These meetings have proven to be a principal means by which to help the geoscience community converge on more standardized approaches for digital mapping and GIS analysis.
4. Serving as committee Secretary and as member of the newly-formed U.S. Geologic Names Committee, and assistance in proposal of geologic time scale and color scheme for adoption by USGS.
5. Serving as Coordinator of the North American Geologic Map Data Model Steering Committee (NADMSC) and managing the NADM website.
6. Continuing to provide strong intellectual input on design and implementation of the NADMSC conceptual data model ("NADM C1.0"). This data model was published in late 2004 and is based in part on results of the NGMDB-Kentucky database prototype that was developed in 2002-03.
7. Serving as U.S. representative to DIMAS, the global standards body that serves the Commission for the Geological Map of the World. Provision of technical information and guidance on data model and science language standards under development in North America, and participation in DIMAS initiatives to develop global standards.
8. Serving as the U.S. Council Member to the IUGS Commission for the Management and Application of Geoscience Information ("CGI").
9. Participation in the IUGS CGI-sponsored "International Data Model Collaboration Working Group." Assistance in developing consensus for international standards for a geologic data model. Contributing to development of the XML-format "GeoSciML" schema, which will be proposed as an international data-exchange standard.
10. Serving as IUGS CGI liaison to the "Multi-Lingual Thesaurus Working Group." This group is

enabling global exchange of geoscience information by developing a common science vocabulary that is translated into many languages.

11. Continued interaction with ESRI, regarding collaboration on an ArcGIS Geology Data Model.
12. Serving as member of IAMG Strategic Planning Committee and providing guidance regarding GIS and IT issues.

Phase Three

As noted above, Phase Three is a long-term effort to develop a database that contains nationwide geologic map coverage at a variety of map scales, according to a complex set of content and format specifications that are standardized through general agreement among all partners in the NGMDB. Project activities this year included:

1. Continued development of the prototype database, focusing on compilation of a standard science terminology, implementation of the NADM conceptual data model in ESRI's ArcGIS, and creation of a data-entry tool to assist geologists and GIS specialists in creating standardized map databases. The prototype data model was posted to the ESRI Geology Data Model website for evaluation by the international community.
2. Participation in the Database Interoperability Testbed #2, sponsored by the IUGS CGI's Working Group on Data Model Collaboration. This testbed required disparate map data to be managed in a prototype online map database system that could demonstrate various query and symbolization functionality as well as the ability to output selected map data to the GeoSciML data interchange format. A critical part of this task was identifying and contracting for highly skilled geologists with strong backgrounds in programming, GIS, spatial database design, and Web delivery of information. This is a vitally important testbed involving at least 8 agencies worldwide. NGMDB participation involved the Arizona Geological Survey, Portland State University, DOGAMI (Oregon GS), and the University of Arizona.
3. In order to have modern, small-scale, consistent geologic map coverage for the U.S., the NGMDB project is converting the recently published Geologic Map of North America (GMNA) to digital format. This is a daunting task, and so an area was selected in which a prototype map database would

be developed (it included part of the U.S., Canada, and the Pacific Ocean). The prototype map was created and subjected to peer review at the DMT'06 meeting (see Garrity and Soller, this volume). This prototype demonstrated the feasibility of converting the enormously complex map files from Adobe Illustrator to ArcGIS. Participating agencies (Geological Society of America, Geological Survey of Canada, Woods Hole Oceanographic Institute, and USGS) have since been contacted with regard to finalizing the NGMDB proposal so as to create and manage the GMNA map database.

ACKNOWLEDGEMENTS

I principally thank my long-time colleague on this project, Thomas M. Berg (State Geologist and Chief, Ohio Geological Survey), for his friendship and innumerable contributions to the success of this project. I also thank the NGMDB project staff and collaborators for their enthusiastic and expert support, without whom the project would not be possible. In particular, I thank: Nancy Stamm (USGS, Reston; Geolex database manager and associate project chief); Ed Pfeifer, Alex Acosta, Dennis McMacken, Jana Ruhlman, and Michael Gishey (USGS, Flagstaff and Tucson, AZ; Website and database management), Chuck Mayfield (USGS; Map Catalog content), Robert Wardwell and Ben Carter (USGS, Vancouver, WA, and Reston, VA; Image Library), Steve Richard (Arizona Geological Survey, Tucson, AZ; data model and science terminology), Jon Crague (University of Arizona/USGS, Tucson, AZ; data-entry tool), and David Percy (Portland State University; Google Earth application for the Map Catalog). I also thank the many committee members who provided technical guidance and standards (Appendix A).

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APPENDIX A

Principal committees and people collaborating with the National Geologic Map Database project.

Digital Geologic Mapping Committee of the Association of American State Geologists:

Tom Berg (Ohio Geological Survey and Committee Chair)
 Rick Allis (Utah Geological Survey)
 Larry Becker (Vermont Geological Survey)
 Rick Berquist (Virginia Division of Mineral Resources)
 Jim Cobb (Kentucky Geological Survey)
 Ian Duncan (Texas Bureau of Economic Geology)
 Rich Lively (Minnesota Geological Survey)
 Jay Parrish (Pennsylvania Geological Survey)
 Bill Shilts (Illinois State Geological Survey)
 Nick Tew (Alabama Geological Survey)
 Harvey Thorleifson (Minnesota Geological Survey)

Geologic Data Subcommittee of the Federal Geographic Data Committee:

Dave Soller (U.S. Geological Survey and Subcommittee Chair)
 Jerry Bernard (USDA-Natural Resources Conservation Service)
 Mark Crowell (Dept. of Homeland Security, Federal Emergency Mgmt. Agency)
 Jim Gauthier-Warinner (U.S. Forest Service, Minerals and Geology Management)
 Laurel T. Gorman (U.S. Army Engineer Research and Development Center)
 John L. LaBrecque (National Aeronautics and Space Administration)
 Lindsay McClelland (National Park Service)
 Jay Parrish (State Geologist, Pennsylvania Geological Survey)
 George F. Sharman (NOAA National Geophysical Data Center)
 Dave Zinzer (Minerals Management Service)

Map Symbol Standards Committee:

Dave Soller (U.S. Geological Survey and Committee Coordinator)
 Tom Berg (State Geologist, Ohio Geological Survey)
 Bob Hatcher (University of Tennessee, Knoxville)
 Mark Jirsa (Minnesota Geological Survey)
 Taryn Lindquist (U.S. Geological Survey)
 Jon Matti (U.S. Geological Survey)
 Jay Parrish (State Geologist, Pennsylvania Geological Survey)
 Jack Reed (U.S. Geological Survey)
 Steve Reynolds (Arizona State University)
 Byron Stone (U.S. Geological Survey)

AASG/USGS Data Capture Working Group:

Dave Soller (U.S. Geological Survey and Working Group Chair)
 Warren Anderson (Kentucky Geological Survey)
 Rick Berquist (Virginia Geological Survey)
 Elizabeth Campbell (Virginia Division of Mineral Resources)
 Rob Krumm (Illinois State Geological Survey)
 Scott McCulloch (West Virginia Geological and Economic Survey)
 Gina Ross (Kansas Geological Survey)
 George Saucedo (California Geological Survey)
 Barb Stiff (Illinois State Geological Survey)
 Tom Whitfield (Pennsylvania Geological Survey)

DMT Listserve:

Maintained by Doug Behm, University of Alabama

North American Data Model Steering Committee:

Dave Soller (U.S. Geological Survey and Committee Coordinator)
 Tom Berg (Ohio Geological Survey)
 Boyan Brodaric (Geological Survey of Canada and Chair of the Data Model Design Technical Team)
 Peter Davenport (Geological Survey of Canada)
 Bruce Johnson (U.S. Geological Survey and Chair of the Data Interchange Technical Team)
 Rob Krumm (Illinois State Geological Survey)
 Scott McCulloch (West Virginia Geological and Economic Survey)
 Steve Richard (Arizona Geological Survey)
 Loudon Stanford (Idaho Geological Survey)
 Jerry Weisenfluh (Kentucky Geological Survey)

IUGS Commission for the Management and Application of Geoscience Information:

Dave Soller (U.S. Geological Survey, Council Member)

Conceptual Model/Interchange Task Group (of the Data Model Collaboration Working Group of the IUGS Commission for the Management and Application of Geoscience Information):

Steve Richard (Arizona Geological Survey, Task Group Member)

DIMAS (Digital Map Standards Working Group of the Commission for the Geological Map of the World):

Dave Soller (U.S. Geological Survey, Working Group Member)

NGMDB contact-persons in each State geological survey:

These people help the NGMDB with the Geoscience Map Catalog, GEOLEX, the Geologic Map Image Library, and the Mapping in Progress Database. Please see <http://ngmdb.usgs.gov/info/statecontacts.html> for this list.

These groups have fulfilled their mission and are no longer active:**NGMDB Technical Advisory Committee:**

Boyan Brodaric (Geological Survey of Canada)
 David Collins (Kansas Geological Survey)
 Larry Freeman (Alaska Division of Geological & Geophysical Surveys)
 Jordan Hastings (University of California, Santa Barbara)
 Dan Nelson (Illinois State Geological Survey)
 Stephen Richard (Arizona Geological Survey)
 Jerry Weisenfluh (Kentucky Geological Survey)

AASG/USGS Metadata Working Group:

Peter Schweitzer (U.S. Geological Survey and Working Group Chair)
 Dan Nelson (Illinois State Geological Survey)
 Greg Hermann (New Jersey Geological Survey)

Kate Barrett (Wisconsin Geological and Natural History Survey)
 Ron Wahl (U.S. Geological Survey)

AASG/USGS Data Information Exchange Working Group:

Dave Soller (U.S. Geological Survey and Working Group Chair)
 Ron Hess (Nevada Bureau of Mines and Geology)
 Ian Duncan (Virginia Division of Mineral Resources)
 Gene Ellis (U.S. Geological Survey)
 Jim Giglierano (Iowa Geological Survey)

AASG/USGS Data Model Working Group:

Gary Raines (U.S. Geological Survey and Working Group Chair)
 Boyan Brodaric (Geological Survey of Canada)
 Jim Cobb (Kentucky Geological Survey)
 Ralph Haugerud (U.S. Geological Survey)
 Greg Hermann (New Jersey Geological Survey)
 Bruce Johnson (U.S. Geological Survey)
 Jon Matti (U.S. Geological Survey)
 Jim McDonald (Ohio Geological Survey)
 Don McKay (Illinois State Geological Survey)
 Steve Schilling (U.S. Geological Survey)
 Randy Schumann (U.S. Geological Survey)
 Bill Shilts (Illinois State Geological Survey)
 Ron Wahl (U.S. Geological Survey)

APPENDIX B

List of progress reports on the National Geologic Map Database,
and Proceedings of the Digital Mapping Techniques workshops.

- Soller, D.R., editor, 2005, Digital Mapping Techniques '05—Workshop Proceedings: U.S. Geological Survey Open-File Report 2005-1428, 268 p., accessed at <http://pubs.usgs.gov/of/2005/1428/>.
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