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The National Geologic Map Database Project – 2009 Report of Progress

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Introduction

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 (*http://ncgmp.usgs.gov/ncgmpabout/ngmact/ngmact1992*) and its subsequent reauthorizations stipulate creation and maintenance of a National Geologic Map Database (NGMDB, *http://ngmdb.usgs.gov*) 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 should adhere to technical and science standards that are to be developed as needed under the guidance of the NGMDB project. Development of a national database and its attendant standards is a daunting task requiring 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 (AASG) can collaborate to build the NGMDB and also serve the needs of their own agencies.

The congressional mandate for State-Federal collaboration on the NGMDB has proven invaluable, facilitating progress on many technical issues that would otherwise have been much more difficult to achieve by separate efforts within agencies. The NGMDB's long record of accomplishment owes a significant debt to its many collaborators and to the institutions with which it interacts (appendix A). At numerous meetings during the year, technical plans and progress are reported, and discussion and comment is requested; these activities are recorded each year by a progress report in the DMT Proceedings. In order to minimize repetition in this report, we have limited the background and explanatory information, which are contained in previous reports of progress (appendix B; in particular the 2005 report); however, some repetition is considered necessary here in order to provide background for first-time readers.

Strategy and Approach

From the guidance in the National Geologic Mapping Act, and through extensive discussions and forums with the geoscience community and the public, a general strategy for building the NGMDB was defined in 1995 (see Soller and Berg, 1995 and 1997, in appendix B). Based on continued public input, the NGMDB has evolved from that concept to a set of resources that substantially help the Nation's geological surveys provide to the public, in a more efficient manner, standardized digital geoscience information.

The NGMDB is designed to be a suite of related databases, products, and services consisting of (1) a Map Catalog containing information and Web links for all paper and digital geoscience maps and related reports of the Nation, and images of many of these maps, (2) the U.S. Geologic Names Lexicon, (3) the Mapping in Progress Database, (4) nationwide geologic map coverage at intermediate and small scales, (5) an online database of geologic maps (predominantly in vector format; planned as a distributed system), (6) a set of Web interfaces to permit access to these products, and (7) 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.

The project's success depends on strong endorsement by agency management, and collaboration with technical consultants, in the USGS and AASG. This support is critical because (1) the project has responsibility for standards development, and standards cannot successfully be implemented until they are widely endorsed, (2) many of the various project tasks are at least partly conducted by collaborators rather than by funded project members, and (3) this project is national in scope and does not fit cleanly into the USGS regional organizational structure. The project therefore relies on USGS and AASG management to implement and maintain certain policies and standards that support NGMDB objectives and to help promote constructive interaction with new initiatives whose objectives may be similar (for example, the USGS National Geological and Geophysical Data Preservation Program; the NSF-funded U.S. Geoinformatics Network project).

Example "Outcomes"

In yearly proposals for project funding, the USGS requires that three examples of a project's impact and contributions be provided; the NGMDB project's are as follows.

1. On a monthly basis, the NGMDB Web site receives 50-60,000 visits from about 25,000 users (nearly all non-USGS). This high level of Web traffic spawns numerous user requests for information and assistance, as these users vary widely in interest and background, and include schoolchildren, homeowners, local government planners, and professional geologists. Mostly they use the NGMDB data-discovery databases (Map Catalog, Geolex, Mapping in Progress) to find geoscience maps and publications. With many of these users we have personal contact by email to ensure they find what they need.
2. A surficial geologic map database of the conterminous U.S. was prepared and published by the NGMDB project in 2009 (Soller and others, 2009). It has been incorporated as an essential part of the new national Terrestrial Ecosystems classification system (now published as USGS Professional Paper 1768, supported by a set of Scientific Investigations Maps). This surficial geologic map also is being used for regional-scale research and mapping of plant distribution, the effects of geologic conditions on animal habitats and distribution, air-mass trajectories (for example, where do the winds blow the salty materials from dry lake beds), and earthquake shear wave velocities in the United States.
3. For 13 years, the NGMDB project has organized annual workshops on "Digital Mapping Techniques." The workshops support the needs of State and Federal agencies, for information exchange and for development of more efficient methods for digital mapping, cartography, GIS analysis, and information management. These workshops have been very successful and have significantly helped the geoscience community converge on more standardized approaches for digital mapping and GIS analysis. The workshop Proceedings are widely read and consulted for technological advances and trends. As a response to information shared at these workshops, agencies have adopted new, more efficient techniques for digital map preparation, analysis, and production. Examples are numerous; here is one from the first DMT meeting: "After attending the Digital Mapping Techniques '97 (DMT '97) conference in Lawrence, KS, we decided to model our digital cartographic production program after that of the Nevada Bureau of Mines and Geology ...[which] expedited our overall cartographic production. Months of trial-and-error digitizing and interaction between geologists and technicians were replaced by a single scanned image that could be quickly drafted. In about two weeks, the 1:24,000 Alameda geologic quadrangle went from an inked mylar to a multicolor plotted map sheet, complete with cross sections."

Project Organization

The project consists of 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 project's objectives. ***Phase One*** of this project principally involves the building of a comprehensive Geoscience Map Catalog of bibliographic records and online images of all available paper and digital maps, and books, guidebooks, and journal articles that either include maps or describe the geology of an area; although the project's name refers only to maps, the Catalog contains information related to the numerous earth-science themes specified in the National Geologic Mapping Act of 1992. Critical to this first phase is the design and development of the U.S. Geologic Names Lexicon (Geolex), the Mapping in Progress Database, and a database and archive of USGS Paleontology and Stratigraphy reports. ***Phase Two*** addresses the development of standards and guidelines for geologic map and database content and format. ***Phase Three*** is a long-term effort to develop a distributed database containing nationwide geologic map coverage at multiple map scales, populated according to a set of content and format specifications that are standardized through general agreement among all partners in the NGMDB (principally the AASG and USGS); this database would be integrated with the databases developed in Phase One. The NGMDB project's technology and standards

development efforts also are coordinated with various entities, including the Federal Geographic Data Committee, ESRI, the North American Geologic Map Data Model Steering Committee, the NSF-funded U.S. Geoinformatics Network project, the IUGS Commission on the Management and Application of Geoscience Information (IUGS CGI), the IUGS Commission on Stratigraphy, the OneGeology initiative, and the IUGS-affiliated Commission for the Geological Map of the World.

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 build Web interfaces and search engines and to continually improve them, and to develop the data management and administrative protocols necessary to ensure that the NGMDB will function efficiently in the future. The NGMDB's databases and project information are found at *http://ngmdb.usgs.gov*.

Progress in 2009

Phase One

A wealth of geoscience information is available in various paper and digital formats. With the emergence of the Web, the public has come to expect rapid, easy, and unfettered access to government data holdings. Geoscience data must therefore become widely available via the Web, and the concepts presented in its products must be understandable to the public. If our information is more readily available to the public, and if tools are offered to help integrate and provide access to that information, its utility may be greatly increased.

However, providing effective public Web access to our products presents a real challenge for each geoscience agency, because of new and rapidly evolving technology, restricted funding, new requirements from the user community, and the somewhat confusing array of Web sites at which various types and quality of information can be found. To help address these challenges, Phase One focuses on providing simple, straightforward access to a broad spectrum of geoscience information, and forms the stable platform upon which the other NGMDB tasks and capabilities are based.

Specific accomplishments in 2009 include:

1. Expanded the Map Catalog by ~2,800 records, to a total of ~82,800 records. It now includes 38,700 USGS publications, 30,400 State survey publications, and 13,700 products by other publishers.
2. Engaged all States in the process of entering Map Catalog records. Processed ~2,200 new records for State geological survey publications.
3. In response to NCGMP and AASG requests, and in part to address NCGMP performance metrics required by the Office of Management and Budget, provided (a) index maps showing areas in the United States that have been geologically mapped at various scales and time periods and (b) computations including the number of square miles geologically mapped at intermediate and more detailed scales (see Soller, 2005).
4. In cooperation with USGS Publications Warehouse (PW), continued to process and serve via Map Catalog the many thousand map images scanned by the PW. Collaboration with PW was undertaken to minimize duplication of effort and to better integrate the two systems. From various university libraries (especially from The Ohio State University), acquired hundreds of old publications not yet obtained by PW for scanning; these include rare atlas sheets from USGS Monographs, informally released USGS Strategic Minerals Maps and Reports, and Bulletins from the late 1800s. Publications were cataloged and stored in our offices, to be shipped to a PW contractor for scanning.
5. Continued to add to bibliographic records in the Map Catalog the Web links to online digital maps and reports, mostly to USGS reports served by the PW. About 45 percent of publications listed in the Map Catalog now have at least one such link. Many of these publications have multiple links, to individual map sheets. Worked with PW to begin inserting into their citations the links to images managed by the NGMDB.
6. Continued to process 5,000 files of USGS publications scanned by Alaska DGGS. When completed, files will be loaded to the NGMDB or PW, and citation errors will be corrected in NGMDB, PW, and Alaska databases.
7. Scanned, processed, and loaded into the Map Catalog about 2,000 map images for 1,400 publications.
8. Upgraded and maintained a 12-TB computer for storage of map images and for image processing.
9. Continued to process selected EDMAP deliverables, for inclusion in the Map Catalog.
10. Continued to revise existing records in Geolex. Given the many and disparate origins of this lexicon, revision of existing electronic records inherited from the last-published USGS listing of names (in USGS DDS-6) remains the focus of work. As time permits, critically important stratigraphic information (for example, type localities) is retrieved from the authoritative published USGS lexicons (for example, Bull. 896) and integrated into Geolex.
11. As the first step in the NGMDB database and Web site redesign, Map Catalog and Geolex citations

are being merged into one database to better serve both databases and to provide integrated search and reporting of publications, geologic names, and study area footprints. Included in this time-consuming work is error-checking against the Publications Warehouse citation; any errors found there are reported to their database manager. This work is nearly complete, and the merged database is being prepared to serve the redesign's next step -- enhanced database search and reporting capabilities.

12. Continued to revise the Web statistics that identify the extent to which State geological survey publications are accessed via the Map Catalog. These statistics are now provided to each State geologist, via a password-protected site.
13. Customer service: completed several hundred productive interchanges with Map Catalog and Geolex users, via the NGMDB feedback form and other mechanisms.

Phase Two

Geoscience information increasingly is available in digital format. Within an agency, program, or a project, there are standard practices for the preparation and distribution of this information. However, widely accepted standards and (or) guidelines for the format, content, and symbolization of this information do not yet exist. Such standards are critical to the broader acceptance, comprehension, and use of geoscience information by the nonprofessional and professional alike. Under the mandate of the National Geologic Mapping Act, the NGMDB project serves as one mechanism for coordinating and developing the standards and guidelines that are deemed necessary by the U.S. and international geoscience community.

The NGMDB project leads or assists in development of standards and guidelines for digital database and map preparation, publication, and management. This activity is a challenging one that entails a lengthy period of conceptual design, documentation, and test-implementation. For example: (1) a conceptual data model must be shown to be implementable in a commonly available GIS such as ESRI's ArcGIS; (2) a data-interchange standard must be demonstrated to be an effective mechanism for integrating (for example, through the NGMDB portal) the many and varied data systems maintained by the State geological surveys, USGS, and others; and (3) a map symbolization standard must be implemented in, for example, PostScript or ArcGIS before it can be used to create a map product. Then, of course, each proposed standard must become widely adopted; otherwise, it isn't really a standard. Internationally, the NGMDB participates in venues that help to develop and refine the U.S. standards. These venues also bring our work to the international community, thereby promoting greater standardization with other countries.

The accomplishments listed below address a fundamental NGMDB goal -- to propose a "core" set of standards and guidelines for endorsement by the Nation's geological surveys. Throughout the past decade and more, geological surveys have collaborated on geologic map database design, science terminology, and data interchange standards. Progress has been significant, and was in part facilitated by long-term technical and funding support by the NGMDB project and by the 13 annual DMT meetings.

Specific accomplishments in 2009 include:

1. Organized and led the thirteenth annual "Digital Mapping Techniques" workshop. Developed the agenda, solicited presentations, and worked to prepare the workshop proceedings. Edited the workshop Proceedings from the previous year's meeting (DMT '08, Moscow, ID).
2. Collaborated with the USGS Pacific Northwest project to define a database format for publication of geologic maps. Extensive technical sessions among project geologists served to reconcile minor differences in database design and workflow. The resulting design ("NCGMP09"; see related paper in these Proceedings) is a carefully planned balance between the map-preparation and publication-workflow needs of a mapping project and the long-term, national need to archive standardized geologic map data from many projects. NCGMP09 is an ArcGeodatabase design supported by example map databases, standard vocabularies, documentation, and prototype tools such as error-checking scripts. At DMT'09 it was released for public comment and testing. Design revisions and tool development to facilitate data entry and management are planned.
3. Continued to collaborate with ESRI on an ArcGIS Geology Data Model compatible with NCGMP09.
4. Coordinated work on the FGDC geologic map symbolization standard. Prepared and published online the PostScript version (USGS T&M 11-A2) and the printed version of the standard; for the latter, served as sole means of distribution to all requestors. Responded to numerous inquiries and comments from users.
5. Continued to work with ESRI on implementation of the FGDC standard. Provided technical guidance on science and technical aspects, and on workflows and Arc template design for creating well-symbolized products from legacy maps and new map databases. ESRI publicly released their first version of the implementation at the DMT'09 meeting, and it was well received.
6. Project members served as committee Secretary and as member of the U.S. Geologic Names Committee.
7. Project member served as Chair of FGDC Geologic Data Subcommittee, and managed the

Subcommittee's Web site.

8. Project member served as (a) U.S. Council Member to IUGS Commission for the Management and Application of Geoscience Information (CGI), (b) U.S. representative to DIMAS, the standards body for the Commission for the Geological Map of the World, and (c) USGS technical representative to the OneGeology project.
9. Project member participated in CGI's International Data Model Collaboration Working Group. Contributed to development of the XML-format GeoSciML schema, which is becoming an international data-exchange standard for geoscience information. Served as chair of Concept Definitions Working Group, and continued to advance development of international standard science terminologies.

Phase Three

From the NGMDB project's origin in 1995 it has been the generally held vision, by users and colleagues alike, that the National Geologic Map Database would, principally, be a repository of GIS data for geologic maps and related information, managed in a complex system distributed among the USGS and State geological surveys. The system would offer public access to attributed vector and raster geoscience data, and allow users to perform queries online, create derivative maps, and download source and derived map data. Further, all information in the database would retain metadata that clearly indicates its source (that is, who created a particular contact, fault, or delineation of a map unit contained in the database, and how the feature or attributes were later modified by further study).

To realize this vision would require (1) full commitment and close collaboration among the partners, (2) a flexible and evolving set of standards, guidelines, and data management protocols, (3) a clear understanding of the technical challenges to building such a system, and (4) an adequate source of funding. This task is designed to foster an environment where the distributed database system can be prototyped while these requirements are being considered by the partners.

This is a long-term effort whose fully realized form is, at this time, difficult to predict. It is a complex task that depends on data availability, technological evolution, skilled personnel (in high demand and, therefore, in short supply), and the ability for all participants to reach consensus on the approach. Bearing this in mind, the scope and details of Phase Three have been systematically explored and developed through prototypes. Each prototype addressed aspects of the database design, implementation in GIS software (for example, ArcGIS), standard science terminologies, and software tools designed to facilitate data entry. Each prototype was presented to the participants and the public for comment and guidance. The focus of new prototypes is guided by the comments received.

For example, in FY01 the NGMDB completed a major prototype in cooperation with the Kentucky Geological Survey, the Geological Survey of Canada, the University of California at Santa Barbara, and the private sector (Soller and others, 2002). The principal goal was to implement the North American Data Model (NADM; *http://nadm-geo.org/*) draft standard logical data model in a physical system, and to demonstrate certain very basic, essential characteristics of the envisioned system. That prototype was demonstrated and discussed at numerous scientific meetings, and its data model contributed to development of the North American conceptual data model. The project then considered plans to improve that system by adding more complex geologic data and software functionality. However, it would have required significant new funding at a time when technology and geoscience community ideas on database design were rapidly evolving. Therefore, a more limited approach was pursued in the most recent prototype, in which draft NGMDB science terminologies, a NADM-based database design, and data-entry tools were devised in order for the project to develop a Data Portal that offers public access to a simplified view of GIS data held by various cooperating agencies.

The NGMDB Data Portal was, in late 2008, released for comment to the four participating State geological surveys (Washington, Oregon, Idaho, and Arizona). A revised version was publicly released in June 2009 (*http://maps.ngmdb.us/dataviewer/*). As with previous Phase Three prototypes, further development of this Portal through more collaboration with these States, or others, depends on public response.

Specific accomplishments on this task in 2009 include:

1. Development of standard science terminology. The terminology lists created by NGMDB, IUGS-CGI GeoSciML working group, and others describe aspects of geologic units and materials (for example, their lithology, age, genesis), but not overall nature of the geologic units themselves. Therefore a new terminology was developed to more clearly show, within the constraints of a Web interface, the type of units that are mapped by geologists (for example, "alluvium" rather than "poorly sorted clastic sediment"). This terminology promotes quicker comprehension by integrating the geology across all source maps and by providing simple terms and definitions. Prototyped in FY08, this terminology was revised, documented in a DMT'08 paper (Soller, 2009), and applied to maps used in the Data Portal.
2. This map-unit-based terminology is displayed in the Portal via a Dynamic Legend; as the user zooms and pans across the maps, the Legend automatically updates to show only those map units within the field of view. This feature addresses a common and critical problem with Web-mapping systems

-- effective presentation of complex spatial and textual information within the strict limitations of a Web browser. The software coding, and selection of informative map unit colors and patterns, was a significant challenge.

3. Using the NGMDB Data-Entry Tool (developed in 2007-08), map datasets were revised and retagged as needed, with updated science terminologies. These updates occurred because terminology lists continue to evolve via discussion within the GeoSciML Concept Definitions Working Group and NGMDB.
4. All aspects of the Data Portal's back-end database and interface design were completed in 2009. These include (i) the Dynamic Legend, (ii) tear-off information tabs or boxes, (iii) converting the back-end database from flat-file (ESRI Shapefile) to a relational database design (in PostGIS) that will be compatible with NCGMP09, and (iv) establishing all links to State geological survey Web-mapping sites and the NGMDB's Map Catalog and Geolex databases.

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References

Soller, D.R., 2005, Assessing the Status of Geologic Map Coverage of the United States—A New Application of the National Geologic Map Database, in D.R. Soller, ed., Digital Mapping Techniques '05 – Workshop Proceedings: U.S. Geological Survey Open-File Report 2005-1428, p. 41-47, *http://pubs.usgs.gov/of/2005/1428/soller2/*.

Soller, D.R., 2009, A Classification of Geologic Materials for Web Display of National and Regional-Scale Mapping, in D.R. Soller, ed., Digital Mapping Techniques '08 – Workshop Proceedings: U.S. Geological Survey Open-File Report 2009-1298, p. 105-121, *http://pubs.usgs.gov/of/2009/1298/pdf/usgs_of2009-1298_soller4.pdf*.

Soller, D.R., Brodaric, Boyan, Hastings, J.T., Wahl, Ron, and Weisenfluh, G.A., 2002, The central Kentucky prototype: An object-oriented geologic map data model for the National Geologic Map Database: U.S. Geological Survey Open-File Report 02-202, 38 p., *http://pubs.usgs.gov/of/2002/of02-202/*.

Soller, D.R., Reheis, M.C., Garrity, C.P., and Van Sistine, D.R., 2009, Map database for surficial materials in the conterminous United States: U.S. Geological Survey Data Series 425, scale 1:5,000,000, *http://pubs.usgs.gov/ds/425/*.

Appendix A. Principal Committees and People Collaborating with the National Geologic Map Database Project

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)
Courtney Cloyd (U.S. Forest Service, Minerals and Geology Management)
Mark Crowell (Department of Homeland Security, Federal Emergency Management Agency)
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)
Sheena Beaverson (Illinois State Geological Survey)
Scott McColloch (West Virginia Geological and Economic Survey)
George Saucedo (California Geological Survey)
Loudon Stanford (Idaho Geological Survey)
Tom Whitfield (Pennsylvania Geological Survey)

DMT Listserve:
Maintained by Doug Behm, University of Alabama

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 Interoperability Working Group of the IUGS Commission for the Management and Application of Geoscience Information):
Steve Richard (Arizona Geological Survey / U.S. 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 and GEOLEX. 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)

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 McColloch (West Virginia Geological and Economic Survey)
Steve Richard (Arizona Geological Survey)
Loudon Stanford (Idaho Geological Survey)
Jerry Weisenfluh (Kentucky 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., ed., 2009, Digital Mapping Techniques ‘08—Workshop Proceedings: U.S. Geological Survey Open-File Report 2009-1298, 216 p., *http://pubs.usgs.gov/of/2009/1298/*.

Soller, D.R., ed., 2008, Digital Mapping Techniques ‘07—Workshop Proceedings: U.S. Geological Survey Open-File Report 2008-1385, 140 p., *http://pubs.usgs.gov/of/2008/1385/*.

Soller, D.R., ed., 2007, Digital Mapping Techniques ‘06—Workshop Proceedings: U.S. Geological Survey Open-File Report 2007-1285, 217 p., *http://pubs.usgs.gov/of/2007/1285/*.

Soller, D.R., ed., 2005, Digital Mapping Techniques ‘05—Workshop Proceedings: U.S. Geological Survey Open-File Report 2005-1428, 268 p., *http://pubs.usgs.gov/of/2005/1428/*.

Soller, D.R., ed., 2004, Digital Mapping Techniques ‘04—Workshop Proceedings: U.S. Geological Survey Open-File Report 2004-1451, 220 p., *http://pubs.usgs.gov/of/2004/1451/*.

Soller, D.R., ed., 2003, Digital Mapping Techniques ‘03—Workshop Proceedings: U.S. Geological Survey Open-File Report 03-471, 262 p., *http://pubs.usgs.gov/of/2003/of03-471/*.

Soller, D.R., ed., 2002, Digital Mapping Techniques ‘02—Workshop Proceedings: U.S. Geological Survey Open-File Report 02-370, 214 p., *http://pubs.usgs.gov/of/2002/of02-370/*.

Soller, D.R., ed., 2001, Digital Mapping Techniques ‘01—Workshop Proceedings: U.S. Geological Survey Open-File Report 01-223, 248 p., *http://pubs.usgs.gov/of/2001/of01-223/*.

Soller, D.R., ed., 2000, Digital Mapping Techniques ‘00—Workshop proceedings: U.S. Geological Survey Open-File Report 00-325, 209 p., *http://pubs.usgs.gov/of/2000/of00-325/*.

Soller, D.R., ed., 1999, Digital Mapping Techniques ‘99—Workshop proceedings: U.S. Geological Survey Open-File Report 99-386, 216 p., *http://pubs.usgs.gov/of/1999/of99-386/*.

Soller, D.R., ed., 1998, Digital Mapping Techniques ‘98—Workshop Proceedings: U.S. Geological Survey Open-File Report 98-487, 134 p., *http://pubs.usgs.gov/of/1998/of98-487/*.

Soller, D.R., ed., 1997, Proceedings of a workshop on digital mapping techniques: Methods for geologic map data capture, management, and publication: U.S. Geological Survey Open-File Report 97-269, 120 p., *http://pubs.usgs.gov/of/1997/of97-269/*.

Soller, D.R., 2008, The National Geologic Map Database Project – 2007 Report of Progress, in D.R. Soller, ed., Digital Mapping Techniques ’07 – Workshop Proceedings: U.S. Geological Survey Open-File Report 2008-1385, p. 11-20, *http://pubs.usgs.gov/of/2008/1385/pdf/soller.pdf*.

Soller, D.R., 2007, The National Geologic Map Database Project: Overview and Progress, in D.R. Soller, ed., Digital Mapping Techniques ’06 – Workshop Proceedings: U.S. Geological Survey Open-File Report 2007-1285, p. 7-13, *http://pubs.usgs.gov/of/2007/1285/pdf/Soller.pdf*.

Soller, D.R., Berg, T.M., and Stamm, N.R., 2005, The National Geologic Map Database Project: Overview and Progress, in D.R. Soller, ed., Digital Mapping Techniques ’05 – Workshop Proceedings: U.S. Geological Survey Open-File Report 2005-1428, p. 23-40, *http://pubs.usgs.gov/of/2005/1428/soller1/*.

Soller, D.R., Berg, T.M., and Stamm, N.R., 2004, The National Geologic Map Database project: Overview and progress, in Soller, D.R., ed., Digital Mapping Techniques ‘04—Workshop Proceedings: U.S. Geological Survey Open-File Report 2005-1451, p.15-31, *http://pubs.usgs.gov/of/2004/1451/soller/*.

Soller, D.R., and Berg, T.M., 2003, The National Geologic Map Database project: Overview and progress, in Soller, D.R., ed., Digital Mapping Techniques ‘03—Workshop Proceedings: U.S. Geological Survey Open-File Report 03-471, p. 57-77, *http://pubs.usgs.gov/of/2003/of03-471/soller1/*.

Soller, D.R., and Berg, T.M., 2002, The National Geologic Map Database: A progress report, in Soller, D.R., ed., Digital Mapping Techniques ‘02—Workshop Proceedings: U.S. Geological Survey Open-File Report 02-370, p. 75-83, *http://pubs.usgs.gov/of/2002/of02-370/soller2.html*.

Soller, D.R., and Berg, T.M., 2001, The National Geologic Map Database--A progress report, in Soller, D.R., ed., Digital Mapping Techniques ‘01—Workshop Proceedings: U.S. Geological Survey Open-File Report 01-223, p. 51-57, *http://pubs.usgs.gov/of/2001/of01-223/soller1.html*.

Soller, D.R., and Berg, T.M., 2000, The National Geologic Map Database--A progress report, in Soller, D.R., ed., Digital Mapping Techniques ‘00—Workshop Proceedings: U.S. Geological Survey Open-File Report 00-325, p. 27-30, *http://pubs.usgs.gov/of/of00-325/soller2.html*.

Soller, D.R., and Berg, T.M., 1999a, Building the National Geologic Map Database: Progress and challenges, in Derksen, C.R.M, and Manson, C.J., eds., Accreting the continent’s collections: Geoscience Information Society Proceedings, v. 29, p. 47-55, *http://ngmdb.usgs.gov/info/reports/gisproc98.html*.

Soller, D.R., and Berg, T.M., 1999b, The National Geologic Map Database—A progress report, in Soller, D.R., ed., Digital Mapping Techniques ‘99—Workshop Proceedings: U.S. Geological Survey Open-File Report 99-386, p. 31-34, *http://pubs.usgs.gov/of/of99-386/soller1.html*.

Soller, D.R., and Berg, T.M., 1998, Progress Toward Development of the National Geologic Map Database, in Soller, D.R., ed., Digital Mapping Techniques ‘98—Workshop Proceedings: U.S. Geological Survey Open-File Report 98-487, p. 37-39, *http://pubs.usgs.gov/of/of98-487/soller2.html*.

Soller, D.R., and Berg. T.M., 1997, The National Geologic Map Database—A progress report: Geotimes, v. 42, no. 12, p. 29-31, *http://ngmdb.usgs.gov/info/reports/geotimes97.html*.

Soller, D.R., and Berg, T.M., 1995, Developing the National Geologic Map Database: Geotimes, v. 40, no. 6, p. 16-18, *http://ngmdb.usgs.gov/info/reports/geotimes95.html*.