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The National Geologic Map Database Project – 2010 Report of Progress

By David R. Soller and Nancy R. Stamm

U.S. Geological Survey
926-A National Center
Reston, VA 20192
Telephone: (703) 648-6907
Fax: (703) 648-6977
email: *drsoller@usgs.gov*, *nstamm@usgs.gov*

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 United States, at the State and Federal levels. The Act, therefore, creates the environment within which the U.S. Geological Survey (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, 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 the strong endorsement and collaboration of management and 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. They are included here.

1. On a monthly basis, the NGMDB Web site receives 90,000-100,000 visits from about 25,000 users (nearly all non-USGS). This high level of Web traffic spawns numerous user requests for information and assistance—these users vary widely in interest and background and include schoolchildren, homeowners, local government planners, and professional geologists. Most often 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. Public interest in two national map databases published by the NGMDB project in 2010 remains high. These are databases for (1) the Geologic Map of North America (GMNA; Garrity and Soller, 2009) and (2) surficial materials of the conterminous United States (Soller and others, 2009). In response to this interest, a resources page for the GMNA was developed (*http://ngmdb.usgs.gov/gmna/*) to provide access to the numerous file formats (for example, shapefiles, Google Earth) requested by users after formal publication in ESRI Geodatabase format. The resources page also addresses the emerging uses for the GMNA in various Web Mapping Services. Similar requests for the surficial materials database are being handled informally, but a resources page also may be developed.

3. For 14 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 learned 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, Kansas, 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

This project has been designed as a set of related tasks that will develop, over time, an 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. Since the project's inception, the plan for its design has been described in three phases. This approach has served to communicate the general plan, but as the project evolved in response to changing technology and to changing perceptions regarding its proper role in support of the U.S. geoscience community, the three-phase design became somewhat misleading. These three phases are now more accurately referred to simply as tasks, and are executed concurrently.

Task One (formerly Phase One) 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 and related information, that adhere to the earth-science themes specified in the National Geologic Mapping Act of 1992. Development and maintenance of the U.S. Geologic Names Lexicon (Geolex) is an essential component of Task One, serving as a foundation for the Nation's geologic mapping science. This task also includes related activities such as design and maintenance of the Mapping in Progress Database. Task Two (formerly Phase Two) addresses development of standards and guidelines for geologic map and database content and format. Task Three (formerly Phase Three) is a long-term effort

to develop a database (principally vector, GIS-compatible information) that contains national, regional, and detailed geologic map coverage managed 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 Task One.

The NGMDB project's technology and standards development efforts also are coordinated with various related entities including: the Federal Geographic Data Committee, ESRI Inc., the USGS Geological and Geophysical Data Preservation Program, the NSF-funded Geoinformatics project (GIN), the North American Geologic Map Data Model Steering Committee, the International Union of Geological Sciences (IUGS) Commission on the Management and Application of Geoscience Information (CGI), the IUGS Commission on Stratigraphy, and the IUGS-affiliated Commission for the Geological Map of the World.

A full realization of the project's Task Three 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 the NGMDB, extensive work will be conducted to develop 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 2010

Task One

A wealth of geoscience information is available in various paper and digital formats. With the emergence of the Internet and 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 readily understood by 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, and new types of demands from the user community. To help address these challenges, this task provides 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 2010 include:

1. Began the first major redesign of all NGMDB databases and Web pages since the project began 15 years ago. This work was undertaken in order to reduce system maintenance and to provide users with greatly enhanced search and display options. As the first step in redesigning the NGMDB database and Web site, Map Catalog and Geolex citations were merged into a single Oracle database, to provide integrated search and reporting of publications, geologic names, and study area footprints. Citations were error-checked against USGS Publications Warehouse (PW) citations, and errors in both NGMDB and PW systems were corrected. The majority of citation revisions were completed, and the merged database is being prepared to serve the redesign's next step—enhanced database search and reporting capabilities.

2. Expanded the Map Catalog by ~6,700 records, to a total of ~89,500 records. Some 1,500 records are new publications, and 5,200 were added from Geolex when their citations lists were merged. The Catalog now includes 40,000 USGS publications, 31,600 state survey publications, and 17,900 by other publishers.

3. Engaged all states in the process of entering Map Catalog records. Processed ~658 new records for State geological survey publications.

4. 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). Helped NCGMP to revise their metrics, to better measure annual and cumulative productivity in geologic mapping.

5. Collaborated with the USGS Publications Warehouse (PW) on publication-tracking, database-compatibility, and image-processing issues to minimize duplication of effort and to better integrate the two systems. Collected from various donors, organized, and shipped to the PW a pallet of USGS publications to be scanned and put online.

6. Continued to add to Map Catalog the Web links to online digital maps and reports. Forty-six percent of the publications (more than 41,000) now have at least one link. Many publications have multiple links, to individual map sheets. Contributed to the PW more than 3,000 links to online publications, to insert into their citation pages.

7. Scanned, processed, and loaded into the Map Catalog about 2,200 map images.

8. Public requests for map images in various formats prompted initial phase of development work on a complex set of methods to bulk-process thousands of images into: (a) TIFF, (b) PDF, containing metadata from the Map Catalog; (c) JPEG; and (d) MrSID.

9. Hand-assembled a high speed computer to replace the current image-processing machine, and maintained a 12-terabyte (TB) disk array for storage of map images. This computer will process all scanned maps into various formats.

10. Researched, acquired, and began configuring two servers and a 36-TB disk array. This upgrade of the computing infrastructure will permit significantly better services to be offered to the public (see image formats noted above).

11. 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 Digital Data Series 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, Bulletins 896, 1200) and integrated into Geolex. To support this work, Bulletins 896 and 1200 were scanned with Optical Character Recognition under contract.

12. Revised and reissued contract to scan the Geologic Name Committee's (GNC) master card file of geologic names (~220,000 cards, located in Reston, Va.). This collection will be a valuable supplement to Geolex, especially regarding relevant publications for geologic names. Continued to scan and process the USGS Menlo Park, Calif., collection of GNC cards, which are an invaluable complement to the Reston set.

13. With collaboration from the Wyoming Geological Survey and ESRI, developed a prototype application using ESRI's ImageServer, and demonstrated it at the DMT'10 meeting. This application provides a visualization of available geologic maps of Wyoming and links to the Map Catalog Product Description Page for each map. It provides a new means of access to the Catalog and will facilitate searching and downloading of map images in various formats. It is anticipated that this initiative will be greatly expanded in future years.

14. 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.

15. Customer service: completed several hundred productive interchanges with Map Catalog and Geolex users via the NGMDB feedback form and other mechanisms.

Task 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 non-professional 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 challenging activity 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 14 annual DMT meetings.

Specific accomplishments in 2010 include:

1. Organized and led the fourteenth 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 '09, Morgantown, W.Va.), and completed production of the DMT'08 Proceedings.

2. Continued to collaborate with the USGS Pacific Northwest project to design a database format suitable for digital publication of single, traditional geologic maps. This database design ("NCGMP09") attempts to balance 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 (NCGMP, 2010). NCGMP09 is an ArcGeodatabase design supported by example map databases, standard vocabularies, documentation, and prototype tools such as error-checking scripts. In early- to mid-2010, extensive technical sessions were held with geologists and GIS specialists in USGS geologic mapping projects, in order to evaluate the design and solicit suggested changes. In this initial phase of development, the focus was limited to the geologic-map preparation requirements of NCGMP-funded projects in the USGS, with the intention to then hold discussion with the State geological surveys in order to further refine the database design. Revisions made to NCGMP09 after its introduction at the DMT'09 meeting were discussed at the DMT'10 meeting, specifically to begin to solicit comment from the State geological surveys.

3. Evaluated the draft set of NGMDB standard terminology lists, developed in past years, for their suitability to support the NGMDB project and NCGMP09. Began evaluating the IUGS CGI-sponsored GeoSciML terminology lists. This is an ongoing process, as these term lists evolve by consensus among various scientists and interest groups.

4. Continued collaboration with ESRI on an ArcGIS Geology Data Model compatible with NCGMP09. Discussed feasibility of developing a book in their ArcGIS database design series that focuses on geologic map database design.

5. Coordinated work on the FGDC geologic map symbolization standard. Made minor revisions to the standard and addressed all user comments, requests for materials, and technical questions.

6. Continued to work with ESRI on their implementation of the FGDC standard. Provided technical guidance on science and technical aspects, and on preferred workflows for creating well-symbolized products from legacy maps and new map databases. Worked with ESRI on details of adapting their implementation to more directly support the NCGMP09 design. Funded the continuing work by USGS staff to create technical specifications and to evaluate ESRI's implementation.

7. Served as committee Secretary and as member of the U.S. Geologic Names Committee.

8. Served as Chair of FGDC Geologic Data Subcommittee. Managed the Subcommittee's Web site.

9. 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.

Task 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 will 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 addressed 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 this task 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 project 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 and GeoSciML (see Task 2).

We 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 next 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 (*http://maps.ngmdb.us/dataviewer/* and see discussion in Soller, 2009). The prototype NGMDB Data Portal was publicly released in June 2009; it offered public access to a simplified view of GIS data held by various cooperating agencies. As with previous Task 3 prototypes, further development of this Data Portal based on more collaboration with these states, or others, depends on public response.

Status of this task in 2010 was as follows:

1. After developing the NGMDB Data Portal (*http://maps.ngmdb.us/dataviewer/*) sufficiently to make it available at a public Web site, we entered an evaluation phase. Further development of the Data Portal's interface, and additions to content, were temporarily halted in order to assess public reaction to the site and to solicit expressions of interest or concern from our partners in AASG. Public comment indicated that the Data Portal has some value as an entry point to the Map Catalog and that the science portrayed in the Portal is well expressed with the Data Portal's Dynamic Legend. Comments from the AASG were insufficient to indicate whether, if we proceed with further development, there could be a productive effort to integrate this Data Portal with similar GIS-based Web-mapping sites in the State geological surveys. Comment and guidance will continue to be solicited, in order to determine if, or how, this work will proceed. The two most probable actions are these: (a) the Data Portal will be significantly expanded, with new datasets and interface features; and (or) (b) concepts, software components, and (or) datasets will be used in other NGMDB applications (for example, to improve the Map Catalog's "Geographic Search" function). Given the nature of prototyping a system such as this, under conditions of rapidly changing technologies, it is entirely possible that only action "b" will be taken, and the Data Portal's technology would be absorbed into other parts of the project. This evaluation also will consider the appropriate role for NGMDB in providing GIS-based map information to the public. The evaluation will principally be based on guidance from the USGS and AASG.
2. ESRI's "Geology base map" (similar in purpose to the NGMDB Data Portal) also was publicly released this year and became a static entity that remains under evaluation. Scientific guidance and discussions continued with ESRI regarding possible collaboration and integration of their portal and NGMDB's.
3. Continued discussions with USGS Central Energy Resources Science Center (CERSC), regarding establishing collaborative computing and Web services in order to conserve funds and bring more map content to their system and the NGMDB. The initial focus, to set up an OGC-compliant Web service for the newly published database of the Geologic Map of North America (Garrity and Soller, 2009) was successful in linking this map database to the CERSC's global GIS interface for energy-related maps and information ("EnergyVision", *http://certmapper.cr.usgs.gov/data/envision/index.html*).

Acknowledgments

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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 (U.S. Department of Agriculture-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 (National Oceanic and Atmospheric Administration, 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.

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