From "Digital Mapping Techniques '08—Workshop Proceedings"
U.S. Geological Survey Open-File Report 2009–1298
http://pubs.usgs.gov/of/2009/1298/

The National Geologic Map Database Project – 2008 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*

Development and management of geologic map databases for support of societal decisionmaking and scientific research are critical needs. The National Geologic Mapping Act of 1992 (*http://ncgmp.usgs.gov/ncgmpabout/ngmact/ngmact1992*) and its subsequent reauthorizations mandate the 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 must 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 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 (AASG) can collaborate to build the NGMDB and also serve the 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 for building the NGMDB was defined in 1995. Based on continued public input, the NGMDB has evolved from a 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 comprehensive reference tool and data management system for spatial geoscience information in paper and digital form. It consists of the following: (1) a Map Catalog containing limited metadata for all paper and digital 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, and links to online data; (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 Congressional mandate for State-Federal collaboration has proven invaluable, facilitating progress on many technical issues that would otherwise have been much more difficult to achieve. 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). Each year in these Proceedings, and at numerous meetings and presentations, technical plans and progress are reported. 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).

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 many 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 the National Paleontology Database. ***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 will 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 Geoinformatics 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 generate 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 can be found at *http://ngmdb.usgs.gov*.

Progress in 2008

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 websites 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 2008 include:

1. Expanded Map Catalog by ~2,000 records, to a total of ~80,000 records. This includes 38,100 relevant USGS publications, 28,200 State survey publications, and 13,700 products by other publishers.

2. Engaged all States in the process of entering Map Catalog records, and processed ~1,200 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 U.S. 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. Under agreement with the USGS Publications Warehouse (PW), continued to process and serve via the Map Catalog image viewer the many thousand map images that were scanned by the PW. The agreement was undertaken to minimize duplication between the two systems, integrate them, and provide to the user the image viewer most appropriate for the publication format (MrSID format for large-format maps via NGMDB, and DjVu format for multi-page documents via PW). To increase productivity in image processing, the NGMDB purchased equipment and hired a student employee, to reside in the PW headquarters in Madison, WI.

5. Added to bibliographic records in the Map Catalog about 21,000 new links to online digital maps and reports, mostly to USGS reports served by the PW. About 40-45 percent of publications listed in the Map Catalog now have such a link; in contrast, two years ago about 13 percent of publications were linked.

6. Negotiated an arrangement to receive from the Alaska Division of Geological and Geophysical Surveys all files of USGS reports and maps of Alaska that were scanned under Federal "Data at Risk" contract funding. Files for nearly 5,000 USGS publications were received for processing and online service by NGMDB and by the PW.

7. Maintained an 8-TB computer for storage of map images and for image processing.

8. Continued to process selected NCGMP EDMAP-grant deliverables, for inclusion in the Map Catalog (e.g., *http://ngmdb.usgs.gov/Prodesc/proddesc_81551.htm*). Unpublished GIS files of these maps will be archived and password protected in the NGMDB, for later use by researchers.

9. Continued to expand and revise 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) consumed nearly all time available for this activity. As time permitted, critically important stratigraphic information (e.g., type localities) was retrieved from the authoritative published USGS lexicons (e.g., Bulletin 896) and integrated into Geolex.

10. Completed the contract scanning of all available USGS unpublished biostratigraphic reports (the Examination and Report on Referred Fossils, or "E&Rs") that in the mid-1980s had been archived on microfiche; roughly 70,000 report pages were scanned. Began to evaluate the quality of these scans, organize the reports, and record in a database the essential information from each report. To facilitate this work, a student was hired. Consolidated into a single storage facility the numerous paper copies of E&Rs, field geologists' Submittal Reports, and related files that until 1995 had been maintained by the headquarters office of the Branch of Paleontology and Stratigraphy. These paper reports and the digital information form the basis for a comprehensive NGMDB database and archive of biostratigraphic information intended for continued use by NCGMP-funded and other field mapping projects.

11. Continued to revise the Web statistics that identify the extent to which State geological survey publications are accessed via the Map Catalog. These statistics will be provided to each State geologist.

12. Customer service: Completed several hundred productive interchanges with Map Catalog and Geolex users, via the NGMDB feedback form and other mechanisms. These users vary widely in interest and background, and include school children, homeowners, local government planners, and professional geologists.

13. Gave numerous project presentations to scientists and managers at USGS, AASG, and other scientific meetings, whereby details of the project were explained and participation in building various NGMDB standards and databases was increased.

14. Worked with NCGMP to improve their data-entry procedure for Mapping in Progress database, focusing on database redesign and adding information most useful to NCGMP management.

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 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 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 (e.g., 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.

Specific accomplishments in 2008 include:

1. Coordinated work on the federally endorsed (FGDC) geologic map symbolization standard, especially preparation of the printed version of the standard, and the CD-ROM and online versions of the PostScript implementation (which will be a USGS Techniques and Methods publication). Published the online version of the PostsScript implementation. Responded to numerous inquiries and comments from users of the standard.
2. Served as Chair of the FGDC Geologic Data Subcommittee. Managed the Subcommittee's website.
3. Organized and led the twelfth annual "Digital Mapping Techniques" workshop. Developed the agenda, solicited presentations, and worked to prepare the workshop proceedings. Edited and prepared for publication the workshop Proceedings from the previous year's meeting (DMT'07, Columbia, SC). These meetings have helped the geoscience community to converge on more standardized approaches for digital mapping and GIS analysis.
4. Served as committee Secretary and as member of the U.S. Geologic Names Committee.
5. Prepared a draft version of a "core" set of standards and guidelines, eventually to be submitted to the NCGMP and AASG. Convened discussion session at DMT'08 meeting to present and refine these standards (see *Summary of DMT'08 Discussion Sessions*, this volume).
6. Continued to work with ESRI regarding: (a) collaboration on an ArcGIS Geology Data Model that will be compliant with the NGMDB data model now under development, and (b) ESRI implementation of the FGDC geologic map symbolization standard. ESRI anticipates the initial release of the FGDC implementation by early 2009.
7. Served as Coordinator of the North American Geologic Map Data Model Steering Committee (NADMSC). Managed the NADM website (*http://nadm-geo.org/*).
8. Served as U.S. representative to DIMAS, the global standards body serving the Commission for the Geological Map of the World (*http://www.geology.cz/dimas*).
9. Served as the U.S. Council Member to the IUGS Commission for the Management and Application of Geoscience Information ("CGI", *http://www.cgi-iugs.org/*).
10. Participated in the IUGS CGI-sponsored "International Data Model Collaboration Working Group" (*https://www.seegrid.csiro.au/twiki/bin/view/CGIModel/InteroperabilityWG*). Helped to develop consensus for international standards for a geologic data model. Contributed to development of the XML-format "GeoSciML" schema, which is proposed as an international data-exchange standard for geoscience information. Served as chair of Concept Definitions Working Group, and proposed initial versions of international standard science terminologies.
11. Contributed research and map data to the CGI-sponsored GeoSciML Testbed 3, which was demonstrated at the IGC2008 meeting.
12. Served 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.
13. Served as USGS technical representative to the international "OneGeology" project. Provided technical guidance and support to the project.

Phase Three

It is a commonly held vision that the National Geologic Map Database will be a repository of geologic map and related information, managed in a system distributed among the USGS and State geological surveys. The system would offer public access to complex, attributed vector and raster geoscience data, and allow users to perform queries, create derivative maps, and download source and derived map data. To realize this vision requires (1) 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. Phase Three is designed to foster an environment where the distributed database system can be prototyped while these requirements are being addressed by the partners.

The NGMDB is prototyping a system with two components: (1) a centralized database containing digital geologic map coverage for the U.S. at selected intermediate and small scales, and (2) distributed access to a more comprehensive set of map data held by the NGMDB collaborators (principally the State geological surveys). All information in the system would retain metadata that clearly indicates its source (e.g., who created the source map and, ideally, details on the origin and modifications to a particular contact, fault, or map unit attributes).

This is a long-term effort whose fully realized form is, at this time, difficult to predict. Because 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, the scope and details of Phase Three are systematically explored and developed through prototypes. Each prototype addresses aspects of the database design, implementation in GIS software (e.g., ArcGIS), standard science terminologies, and software tools designed to facilitate

data entry. Each prototype is 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 NADM 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 is being pursued in the current 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 Map Data Portal that offers public access to a simplified view of GIS data held by various cooperating agencies.

Specific accomplishments in 2008 include:

1. Evaluation of the prototype NGMDB Map Portal in late fall 2007 indicated that changes to the Web interface, science terminologies, and map-processing workflow were necessary to provide a public website that more effectively complemented rather than competed with existing GIS map servers in the State surveys and USGS. This Portal is intended to give users a quick, integrated, browse-and-query "glimpse" of map data published by many agencies, and to direct the user to the source information. This approach is used for the Phase 1 databases (e.g., Map Catalog, Geolex), and revisions to the Portal are being made to better integrate the GIS map service with the Map Catalog and Geolex. Nearly all 2008 work on this task was directed toward cleaning up and simplifying the science terminologies and the Web interface. This decision was reached with concurrence of States participating in the prototype (Washington, Oregon, Idaho, and Arizona); addition of new map data will resume when revisions to the Portal are completed and its suitability has been assessed by NGMDB cooperators. Noteworthy tasks and accomplishments include:
    a. The preliminary standard science terminologies developed in past years were simplified and reduced in scope, to be more informative to Portal users. The preliminary terminologies will remain useful to the NGMDB and others, for more detailed geologic descriptions. The new lists are synchronized with the draft international lists developed to support GeoSciML (see oral-presentation paper by Richard and Soller, this volume).
    b. The existing terminology lists describe aspects of geologic units and materials (e.g., their lithology, age, genesis) but not the geologic units themselves. Therefore a new terminology list was developed (see Soller, this volume) to more clearly show the type of units that are mapped by geologists (e.g., "alluvium" rather than "poorly sorted clastic sediment" or "sediment of fluvial origin"). This list will promote quicker understanding of geologic map information shown in the Portal.
    c. The Portal's Web interface (adopted from the Oregon Department of Geology and Mineral Resources interface) is being extensively redesigned to address issues now deemed essential (e.g., a map legend that dynamically regenerates when the user zooms or pans, to show only those units within the field of view). This redesign is based on software technology used by the Phase 1 databases.
    d. The NGMDB Data-Entry Tool was designed to provide the project and its cooperators with an interface to manage, at an enterprise level, complex, multi-versioned geologic map data from a wide variety of sources. Development of this Tool was concluded late this year; it now supports the project's needs for data entry and database management. Funding that was directed toward this software will now be redirected to (1) refinements to the Data Portal, (2) collaborative development of database design between NGMDB and the USGS Pacific Northwest Geologic Mapping project, and (3) redesign of the entire NGMDB system as described under Phase 1, above.
2. Extensive discussions with the USGS Pacific Northwest Geologic Mapping project indicated strong agreement in the approach needed to manage geologic map information for single-map publication. Work began among the technical staff of these two projects to address and, if possible, to reconcile any differences in database design and workflow. A summary of the NGMDB project's preliminary work in this regard is found in the poster-presentation paper by Richard and Soller, this volume.
3. In order to create 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 (Garrity and Soller, 2008). The GIS files and metadata for the GMNA's southern sheet were completed and peer reviewed. Minor revisions to the organization of map files then were undertaken, and the map database is being prepared for USGS approval as a Data Series publication for distribu-

tion on the Web and CD-ROM. Processing of the northern sheet is underway.

4. Developed a Web service for the Geologic Map of North America. Registered it with the international OneGeology project's portal. Because of the unusual nature of the map, new technical methods were developed in order to best represent the map in OneGeology.

5. At the request of USGS Geography's National Ecosystem mapping project, the NGMDB project contributed geologic map data for integration into their national ecosystem map. This included finalizing the GIS files from the recently published map of Surficial Materials of the U.S. (*http://pubs.usgs.gov/of/2003/of03-275/*), and extensive discussions with the Ecosystem project regarding how the map should be reclassified for ecosystem mapping.

6. NGMDB staff continued to work with ESRI and others to define an ESRI Geology Data Model that is compatible with the NGMDB and GeoSciML data structures, and that can be used as an output format from the NGMDB Map Portal. This is a long and difficult process, and the NGMDB project provided some level of coordination.

Acknowledgments

We thank the NGMDB project staff and collaborators for their enthusiastic participation and expertise, without whom the project would not be possible. In particular, we thank: Nancy Stamm (USGS, Reston; Geolex database manager and associate project chief); Alex Acosta, Dennis McMacken, Michael Gishey, Ed Pfeifer, and Jana Ruhlman (USGS, Flagstaff, Phoenix, and Tucson, AZ; Website and database management); Chuck Mayfield (USGS, Menlo Park; Map Catalog content); Robert Wardwell and Justine Takacs (USGS, Vancouver, WA, and Reston, VA; Map Catalog's Image Library); Sarah Jancuska (USGS, Reston; biostratigraphic database); Steve Richard (Arizona Geological Survey / USGS, Tucson, AZ; Phase 3 – data model and science terminology); Jon Craigue (University of Arizona / USGS, Tucson, AZ; Phase 3 – data-entry tool); and David Percy (Portland State University; Phase 3 – Data Portal). We also thank the many committee members who provided technical guidance and standards (Appendix A).

References

Garrity, C.P., and Soller, D.R., 2008, DNAG Geologic Map of North America GIS: Implementation: Overview and progress, *in* D.R. Soller, ed., Digital Mapping Techniques '07 – Workshop Proceedings: U.S. Geological Survey Open-File Report 2007-1385, p. 133-136, *http://pubs.usgs.gov/of/2008/1385/pdf/garrity.pdf*.

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., 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/*.

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)
Warren Anderson (Kentucky Geological Survey)
Sheena Beaverson (Illinois State Geological Survey)
Elizabeth Campbell (Virginia Division of Mineral Resources)
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., 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* Soller, D.R., 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* Soller, D.R., 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* Soller, D.R., 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*.