Developing a standard geologic data model to incorporate 3-D information

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When preparing a geologic map, whether in analog or digital format, the author manages the basic information and interpretations within some organizational framework. This framework can be both scientific (e.g., a set of guiding principles for the regional stratigraphy) and physical (e.g., putting the information into field notebooks, spreadsheets, databases, or a GIS). Commonly, geologists are not consciously aware of this framework – they just use it. This is especially true in GIS, where users (whether geologist-authors or GIS professionals) traditionally have either used the data structure, or data model, provided by the software (e.g., ArcInfo) or have modified it slightly according to project or agency needs. As a result, there has evolved a wide variety of data models. Because digital data offers vast potential for sharing, integration, and reinterpretation of information, many geologists have concluded that some standardization would be beneficial. Development of standard science language (e.g., to describe rock lithologies) and/or a strategy for correlating among local or regional science languages has become essential.

In the United States, the Geologic Mapping Act of 1992 and its subsequent reauthorizations stipulate the development of a National Geologic Map Database (NGMDB) and the standards necessary to support it. In 1996, the Association of American State Geologists, the Geological Survey of Canada, and the U.S. Geological Survey agreed to collaborate on development of a standard data model and science language. This work was begun through a newly-formed committee, the Data Model Working Group, which developed a draft data model. Beginning in about 1998, this data model was informally evaluated by many agencies. In 1999, the North American Data Model Steering Committee (NADMSC) was formed, to supercede the Working Group and to continue the data model development.

Currently the NADMSC is redesigning the draft standard model based on test-implementations by the various agencies, and is developing standard science language. Because of the difficulties in designing a data model and a standard science language that can be uniformly implemented by many agencies, the NADMSC’s current philosophy accepts the need for (and the reality of) local-agency deviations from the standard, and is focusing on two things: 1) a high-level conceptual data model that would specify the concepts necessary to adequately describe geologic map information, and 2) a universal translator (possibly using XML) that would serve as a bridge between the various implementations. For such a translator to be feasible, each agency would standardize its data model and science language, and be capable of writing their information to the NADMSC standard via the translator. Further information is available at <http://geology.usgs.gov/dm> and <http://ncgmp.usgs.gov/ngmdbproject>.

At present, this data model addresses two-dimensional geologic data. However, the developers understand the need to incorporate into the model the detailed 3D information that decisionmakers and scientific researchers require. In the central Great Lakes area, where 3D information on surficial deposits has been widely developed, the NGMDB has approached the Central Great Lakes Geologic Mapping Coalition with an offer to collaborate on a prototype project to extend the conceptual data model so that it can manage the 3D map information gathered by the agency members of the Coalition (the geological surveys of Illinois, Indiana, Ohio, and Michigan, and the USGS). It is hoped that a prototype can be pursued in the coming years.
If the data model is extended to incorporate 3D information, in what form will that information be available? Will it be a series of “stack-unit” maps that show the topography of each significant buried surface and, by comparison of surfaces, also show the geometry (i.e., the thickness) of each geologic unit? In stack-unit mapping, physical attributes such as lithology are assigned to each unit; although it is well known that units are not homogenous, this style of mapping must inherently apply an attribute uniformly across a unit. In contrast, might geologists develop 3D maps where each location in 3D space (i.e., each volume pixel or voxel) possesses a uniquely-defined set of attributes. This, for the purposes of detailed analysis is the ideal data set, but is it a reasonable and attainable goal for the geological surveys? Through continued discussions among mappers, GIS and computer professionals, and agency managers, the geoscience community will face these questions and develop strategies to deliver high-quality, useful 3D data to decision makers and researchers.