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Database Design for Map of Surficial Materials in the Conterminous United States

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The Earth's bedrock is overlain in many places by a loosely compacted and mostly unconsolidated blanket of sediments, or by weathered, residual soil material. For the conterminous United States, these materials were shown on a map by Soller and Reheis (2004). That map was published as a PDF file, from an Adobe Illustrator-formatted version of the provisional unpublished GIS database. The provisional GIS files were further edited and processed without significantly modifying the content of the published map and were published in Soller and others (2009). This paper describes the design of the published database (fig. 1).

The Transition from Compiled Map to Database

The map is a generalized (1:5,000,000-scale) depiction of the sediments and the weathered rock material at land surface, and the approximate thickness of the entire succession of sediments that overlie bedrock. The geologic materials are classified into 14 genetically based groups that are subdivided into 55 map units by factors such as texture, source material, and sediment thickness (see Soller and Reheis, 2004). The length of the Description of Map Units is typical to relatively verbose and includes descriptive text in subheadings. Because this is a regional map, the text is relatively generic as compared to more detailed maps (fig. 2).

The map was compiled from two GIS files: (1) for the conterminous U.S. east of 102 degrees west longitude, a 1:2,500,000-scale compilation served as the principal source, and (2) to the west, GIS files of state-scale and more detailed maps were compiled together. The eastern and western GIS map files then were combined into a single PostScript file and, using Adobe Illustrator, the map was prepared and published in PDF format without an accompanying GIS database. The decision to not simultaneously publish the database was not made lightly, but was necessitated by budget and time constraints.

While preparing the map in Adobe Illustrator, certain map units were revised in order to address peer review comments that were received after the export from ArcInfo. To prepare the GIS database for publication, these edits needed to be incorporated. The two ArcInfo files (east and west parts of the map) were written to Export format, and ESRI shapefiles were generated in ArcMap. Harumi Warner (USGS, Denver) incorporated the edits and submitted to the senior author the two shapefiles (east and west parts of the map) for verification.

East and west polygon shapefiles then were merged and converted to a file geodatabase. Geodatabase topology was created and topological error logs were generated. Logs listed numerous areas where problems in topological relationships existed. Common topological problems included polygons that overlapped or had gaps between them, overlying line layers (contacts, faults, and so on) that were not coincident with polygon boundaries, and line features that self overlapped. Topology rules were set in ArcMap to remove errors and create a topologically clean layer. For attribution purposes, subtypes were assigned to the geologic contacts layer. The use of subtypes ensured data consistency during the editing stages of the project. Feature class symbolization was created to closely resemble the printed version of surficial materials map and was exported to ESRI layer files.

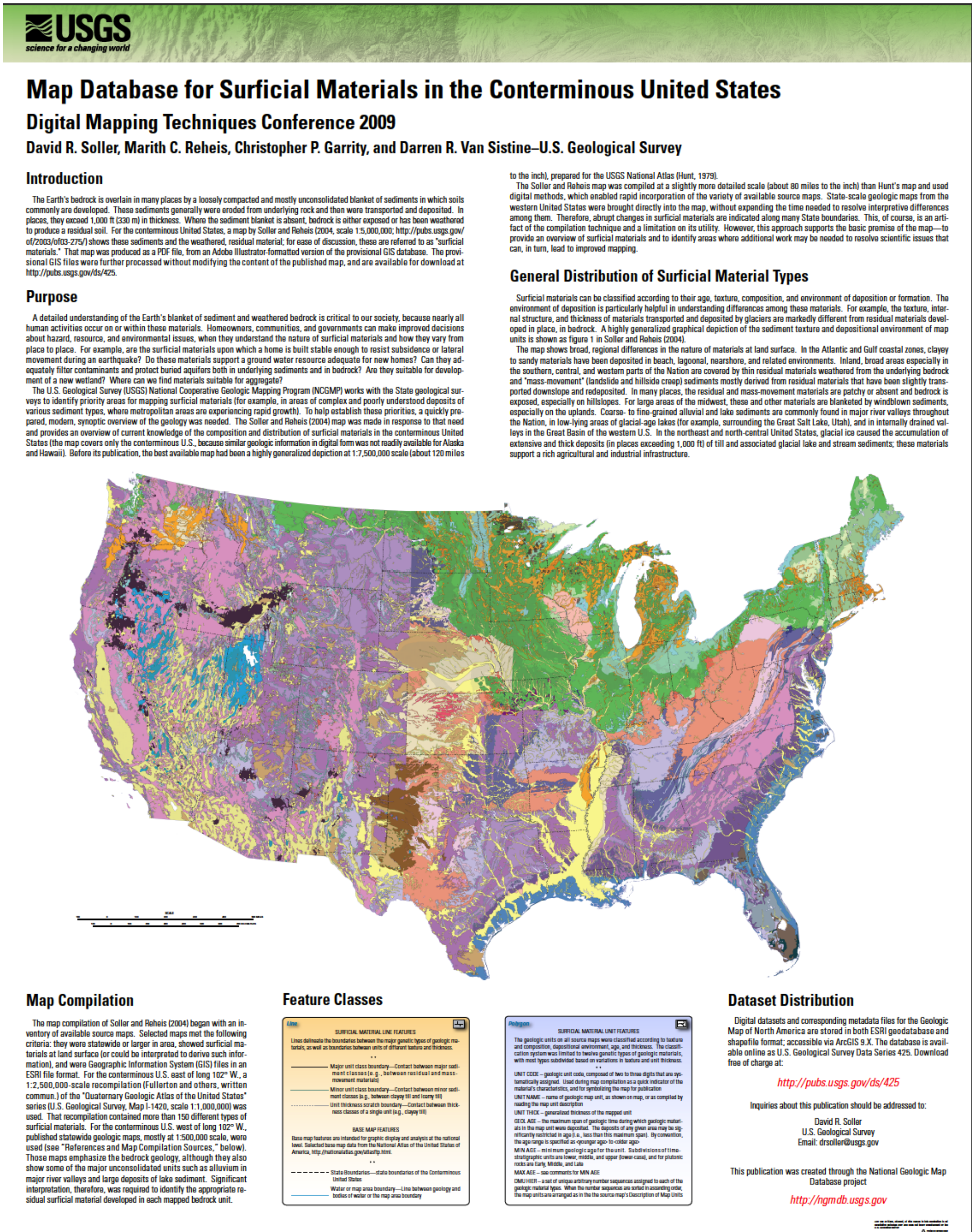
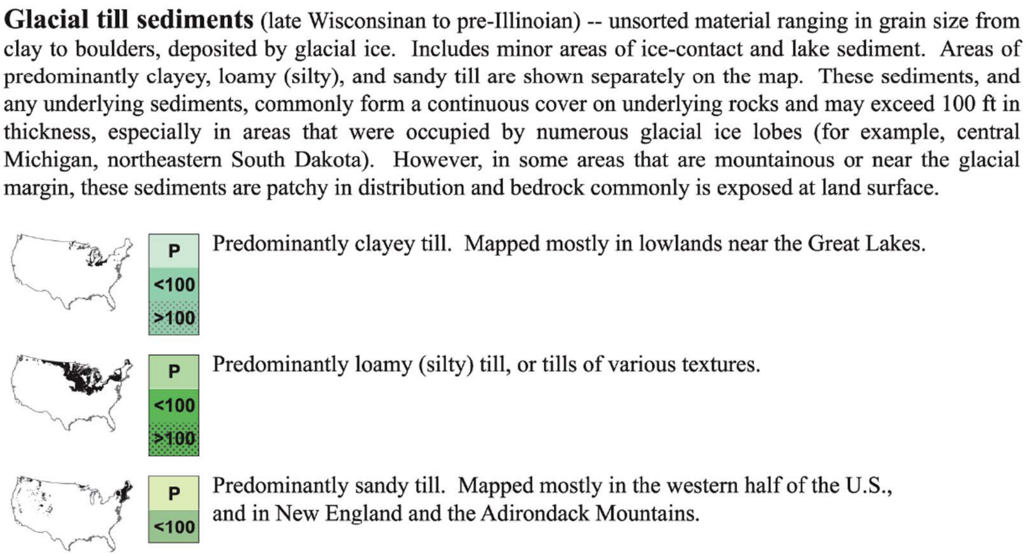


Figure 1. DMT'09 poster "Database design for map of surficial materials in the conterminous United States" (a full-resolution copy is available at *http://ngmdb.usgs.gov/Info/dmt/docs/DMT09_Soller2.pdf*).



Glacial till sediments (late Wisconsinan to pre-Illinoian) -- unsorted material ranging in grain size from clay to boulders, deposited by glacial ice. Includes minor areas of ice-contact and lake sediment. Areas of predominantly clayey, loamy (silty), and sandy till are shown separately on the map. These sediments, and any underlying sediments, commonly form a continuous cover on underlying rocks and may exceed 100 ft in thickness, especially in areas that were occupied by numerous glacial ice lobes (for example, central Michigan, northeastern South Dakota). However, in some areas that are mountainous or near the glacial margin, these sediments are patchy in distribution and bedrock commonly is exposed at land surface.

Predominantly clayey till. Mapped mostly in lowlands near the Great Lakes.

Predominantly loamy (silty) till, or tills of various textures.

Predominantly sandy till. Mapped mostly in the western half of the U.S., and in New England and the Adirondack Mountains.

Figure 2. Excerpt from the Description of Map Units.

Objectives

The map was compiled with the intention of providing information about the surficial geologic framework that could be applied, mostly by nongeologists, to a wide spectrum of issues. For example, the database was incorporated as an essential part of the new national Terrestrial Ecosystems classification system (Sayre and others, 2009; Cress and others, 2010). Provisional copies also have been 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 lakebeds), and earthquake shear wave velocities in the United States.

It was therefore deemed imperative that the database include descriptive content sufficient to inform the nongeologist. Most GIS files do not directly provide rich description content or attributes but instead rely on the user to consult other documents (for example, text, spreadsheets) in order to find this information. Numerous projects have attempted to remedy this situation by specifying database designs more comprehensive that what is commonly published (for example, see the NCGMP09 design, in this volume). At the time this map was being prepared for publication, the NCGMP09 design was under development, so the database described below adapted to this somewhat unusual map some concepts from preliminary versions of that design. Although it may not be transferable for use with other maps, the reader might gain some insight from our attempt.

Database Design

Rich information content is most efficiently stored in related tables, and so the ESRI Geodatabase format is far more appropriate than the (essentially flat-file) Shapefile format. However, because many users rely on various software's ability to import Shapefiles, we felt it important to release this database in both formats.

Regarding the Geodatabase design, geologic unit polygons and lines each are stored in one feature class ("Surficial Materials" and "Contacts"). The Contacts feature class included one attribute, LINE_CODE; it uses numeric subtype codes for the various map unit boundary types, and displays the text description. In the Shapefile version, an additional field ("CONTACT") was added in order to provide a text description for each LINE_CODE. From the Description of Map Units, information was parsed into these fields in both the Surficial Materials feature class and Shapefile (see the product metadata for details):

- UNIT_CODE – Geologic unit code, composed of two to three digits that are systematically assigned. Used during map compilation as a quick indicator of the material's characteristics, and for symbolizing the map for publication.
- UNIT_NAME – Name of geologic map unit, as shown on map, or as compiled by reading the map unit description (and parent map unit description, if any).

- UNIT_THICK – Generalized thickness of the mapped unit.
- GEOL_AGE – The maximum span of geologic time during which geologic materials in the map unit were deposited. The deposits of any given area may be significantly restricted in age (that is, less than this maximum span). By convention, the age range is specified as <younger age> to <older age>.
- MIN_AGE – Minimum (youngest) geologic age during which materials in the map unit were deposited. This is the minimum age for all sediments in the map unit; the deposits at a specific location may be significantly older.
- MAX_AGE – Maximum (oldest) geologic age during which materials in the map unit were deposited. This is the maximum age for all sediments in the map unit; the deposits at a specific location may be significantly younger.
- DMU_HIER – A set of unique arbitrary number sequences assigned to each of the geologic material types (Table 1). The number sequence is essentially an outline format. When the number sequences are sorted in ascending order, the map units are arranged as in the hierarchical, ordered format shown on the source map's Description of Map Units.

Remarks

Our intention was to provide a map database containing information useful to the general public and the geologist alike. However, the descriptive text for each map unit can be lengthy, and it is common practice to not include this in a Shapefile because of the redundancy. Regarding whether to include text descriptions in a separate table that can be linked to the polygon feature class, there are differing opinions because a table Relate must be established and maintained. In version 1.0 of this database, a table or spreadsheet of the text descriptions was not included, whether by design or accident. It now has been added – either underscoring the evolutionary nature of database design, or the old adage "There's many a slip twixt cup and lip."

Table 1. Geologic unit names and an encoding of their hierarchical arrangement in the Description of Map Units (DMU). See the NCGMP09 design (this volume) for a more thorough example drawn from a more typically complex DMU.

DMU_HIER	UNIT_NAME
001	Alluvial sediments
001-001	Alluvial sediments, thin
001-002	Alluvial sediments, thick
002	Coastal zone sediments
002-001	Coastal zone sediments, mostly fine-grained
002-002	Coastal zone sediments, mostly medium-grained
003	Calcareous biological sediments
004	Organic-rich sediments
004-001	Organic-rich muck and peat, thin
004-002	Organic-rich muck and peat, thick
005	Glacial till sediments
005-001-001	Glacial till sediments, mostly clayey, discontinuous
005-001-002	Glacial till sediments, mostly clayey, thin
005-001-003	Glacial till sediments, mostly clayey, thick
005-002-001	Glacial till sediments, mostly silty, discontinuous
005-002-002	Glacial till sediments, mostly silty, thin
005-002-003	Glacial till sediments, mostly silty, thick
005-003-001	Glacial till sediments, mostly sandy, discontinuous
005-003-002	Glacial till sediments, mostly sandy, thin
006	Glaciofluvial ice-contact sediments
006-001	Glaciofluvial ice-contact sediments, mostly sand and gravel, discontinuous
006-002	Glaciofluvial ice-contact sediments, mostly sand and gravel, thin
006-003	Glaciofluvial ice-contact sediments, mostly sand and gravel, thick
007	Proglacial sediments
007-001-001	Proglacial sediments, mostly fine grained, discontinuous
007-001-002	Proglacial sediments, mostly fine grained, thin
007-001-003	Proglacial sediments, mostly fine grained, thick
007-002-001	Proglacial sediments, mostly coarse-grained, discontinuous
007-002-002	Proglacial sediments, mostly coarse-grained, thin
007-002-003	Proglacial sediments, mostly coarse-grained, thick
008	Lacustrine and playa sediments
008-001	Lacustrine sediments
008-002	Playa sediments
009	Eolian sediments
009-001-001	Eolian sediments, mostly loess, thin
009-001-002	Eolian sediments, mostly loess, thick
009-002-001	Eolian sediments, mostly dune sand, thin
009-002-002	Eolian sediments, mostly dune sand, thick
009-003	Eolian sediments on southern High Plains
010	Mass-movement sediments
010-001-001	Colluvial sediments, discontinuous
010-001-002	Colluvial sediments, thin
010-002	Colluvial and alluvial sediments
010-003	Colluvial sediments and loess
010-004	Colluvial sediments and residual material
011	Residual materials
011-001	Residual materials developed in igneous and metamorphic rocks
011-002-001	Residual materials developed in sedimentary rocks, discontinuous
011-002-002	Residual materials developed in sedimentary rocks, thin
011-003	Residual materials developed in fine-grained sedimentary rocks
011-004-001	Residual materials developed in carbonate rocks, discontinuous
011-004-002	Residual materials developed in carbonate rocks, thin
011-005	Residual materials developed in alluvial sediments
011-006-001	Residual materials developed in bedrock, with alluvial sediments, discontinuous
011-006-002	Residual materials developed in bedrock, with alluvial sediments, thin
011-007-001	Residual materials developed in bedrock, discontinuous
011-007-002	Residual materials developed in bedrock, thin
012-001	Basaltic and andesitic volcanic rocks
012-002	Rhyolitic volcanic rocks
013	Water

References

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