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The State Geologic Map Compilation (SGMC) Geodatabase of the Conterminous United States

Data Series 1052
Version 1.1, August 2017

U.S. Department of the Interior
U.S. Geological Survey

Cover. Lithology from the State Geological Map Complilation using the GENERALIZED_LITH field of the SGMC_Geology feature class. (Imagery basemap sources: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS [Centre National d'Etudes Spatiales (National Centre for Space Studies)/Airbus Defence and Space], U.S. Department of Agriculture, U.S. Geological Survey, AeroGRID, IGN [l'Institut national de l'information géographique et forestière (National Institute of Geographic and Forest Information)], and the GIS User Community.)

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RYAN K. ZINKE, Secretary

U.S. Geological Survey
William H. Werkheiser, Acting Director

U.S. Geological Survey, Reston, Virginia: 2017
First release: 2017
Revised: August 2017 (ver 1.1)

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Suggested citation:
Horton, J.D., San Juan, C.A., and Stoeser, D.B., 2017, The State Geologic Map Compilation (SGMC) geodatabase of the conterminous United States (ver. 1.1, August 2017): U.S. Geological Survey Data Series 1052, 46 p., https://doi.org/10.3133/ds1052.

ISSN 2327-638X (online)

Acknowledgments

The authors would like to thank Suzanne W. Nicholson, Connie L. Dicken, and Peter N. Schweitzer of the U.S. Geological Survey (USGS) for providing user feedback on the Preliminary Integrated Geologic Map Databases which aided in discovering and fixing issues that were incorporated into the State Geologic Map Compilation. Suzanne and Connie also provided original State data and detailed information and guidance regarding the Preliminary Integrated Geologic Map Databases. The authors acknowledge Nora B. Shew and Keith A. Labay of the USGS for their tremendous work in processing the 2007 State geologic map of Montana. Special thanks to Edmund G. Deal, Susan M. Vuke, and Paul Thale of the Montana Bureau of Mines and Geology for all their help and information while processing the 2007 State geologic map of Montana. Also, thanks to Pamela Dunlap of the USGS for her work on the project including coding the 2005 State geologic map of Illinois.

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Datum

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD83).

Abbreviations

CSV	comma-separated values
GIS	geographic information system
PIGMD	Preliminary Integrated Geologic Map Database
SGMC	State Geologic Map Compilation
URL	Uniform Resource Locator
USGS	U.S. Geological Survey

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Abstract

The State Geologic Map Compilation (SGMC) geodatabase of the conterminous United States (https://doi.org/10.5066/F7WH2N65) represents a seamless, spatial database of 48 State geologic maps that range from 1:50,000 to 1:1,000,000 scale. A national digital geologic map database is essential in interpreting other datasets that support numerous types of national-scale studies and assessments, such as those that provide geochemistry, remote sensing, or geophysical data. The SGMC is a compilation of the individual U.S. Geological Survey releases of the Preliminary Integrated Geologic Map Databases for the United States. The SGMC geodatabase also contains updated data for seven States and seven entirely new State geologic maps that have been added since the preliminary databases were published. Numerous errors have been corrected and enhancements added to the preliminary datasets using thorough quality assurance/quality control procedures. The SGMC is not a truly integrated geologic map database because geologic units have not been reconciled across State boundaries. However, the geologic data contained in each State geologic map have been standardized to allow spatial analyses of lithology, age, and stratigraphy at a national scale.

Introduction

Between 1997 and 2006, the U.S. Geological Survey (USGS) Mineral Resources Program, in partnership with State geological survey programs, compiled State geologic maps into a standardized geospatial format for the conterminous United States. The State geologic maps were developed in support of mineral resource and geoenvironmental assessments, as well as ore deposit research, at scales ranging from approximately 1:50,000 to 1:1,000,000. During the original project, State databases were processed into a USGS geographic information system (GIS) database structure with standardized fields, attribution, and vocabularies. The data were released as 48 separate GIS databases with accompanying reports entitled “Preliminary Integrated Geologic Map Databases for the United States.” The reports and data are organized to address three broad geographic areas: the Western United States (Ludington and others, 2007), Central United States (Stoeser and others, 2007), and Eastern United States (Dicken and others, 2007, 2008; Nicholson and others, 2007a, b, d). Geologic maps for the States of Alaska and Hawaii were in development during this period and thus were not included in the original collection of digital GIS databases. Although maps for those States are now available (Sherrod and others, 2007; Wilson and others, 2015), the focus of this report remains on the 48 conterminous States.

Since 2006, the USGS Mineral Resources Program has continued to improve what is now formally called the State Geologic Map Compilation (SGMC) by incorporating new versions of State geologic maps and geologic data, resolving discrepancies, and developing a single GIS database from the original 48 databases. The new SGMC data represent a considerable improvement relative to the original information and provide considerably more detailed views of national-scale geologic relations than can be gleaned from the 1:2,500,000-scale map of King and Beikman (1974) and King and others (1974) (digital version by Schruben and others, 1994) or the digital 1:5,000,000-scale Geologic Map of North America (Reed and others, 2005a, b). The purpose of this report is to describe the contents of the SGMC, how the SGMC can be used, the challenges involved in merging the State datasets, and the rationale for database enhancements.

The SGMC includes the following seven new State geologic maps that have been released since the original Preliminary Integrated Geologic Map Databases (PIGMDs) were published: Idaho—2012, Illinois—2005, Iowa—2010, Minnesota—2011, Montana—2007, Nevada—2007, and Vermont—2011. The SGMC also incorporates new supplemental data for the States of California—2010 (updated georeferencing of geology and faults, and new point features), Indiana—2011 (minor geology updates), New Jersey—2009 (updated faults), New Mexico—2003 (age updates, new volcanic mapping, new structures), and North Carolina—2007 (new geology polygons, faults, and dikes). In addition, the surface geologic maps for North Dakota and South Dakota have been replaced with 2001 and 2004 bedrock geologic maps. Appendix 1 identifies the new print and digital State geologic maps used for the SGMC, and contains URL links to the paper map version in the USGS National Geologic Map Database and the original PIGMD references for the Western, Central, and Eastern United States that were used for each State.

State Geologic Map Compilation Geodatabase Structure

File Geodatabase (USGS_StateGeologicMapCompilation.gdb)

The SGMC consists of a single Esri ArcGIS 10 file geodatabase (Esri, 2016b) containing 3 feature classes, 5 tables, and 4 relationship classes that represent data derived from the official State geologic maps of the 48 conterminous States (Horton, 2017). Esri Shapefile versions of the feature classes and comma-separated values (CSV) versions of the tables are also provided. See appendix 2 for a complete list of field definitions and figure 1 for the SGMC file geodatabase model structure.

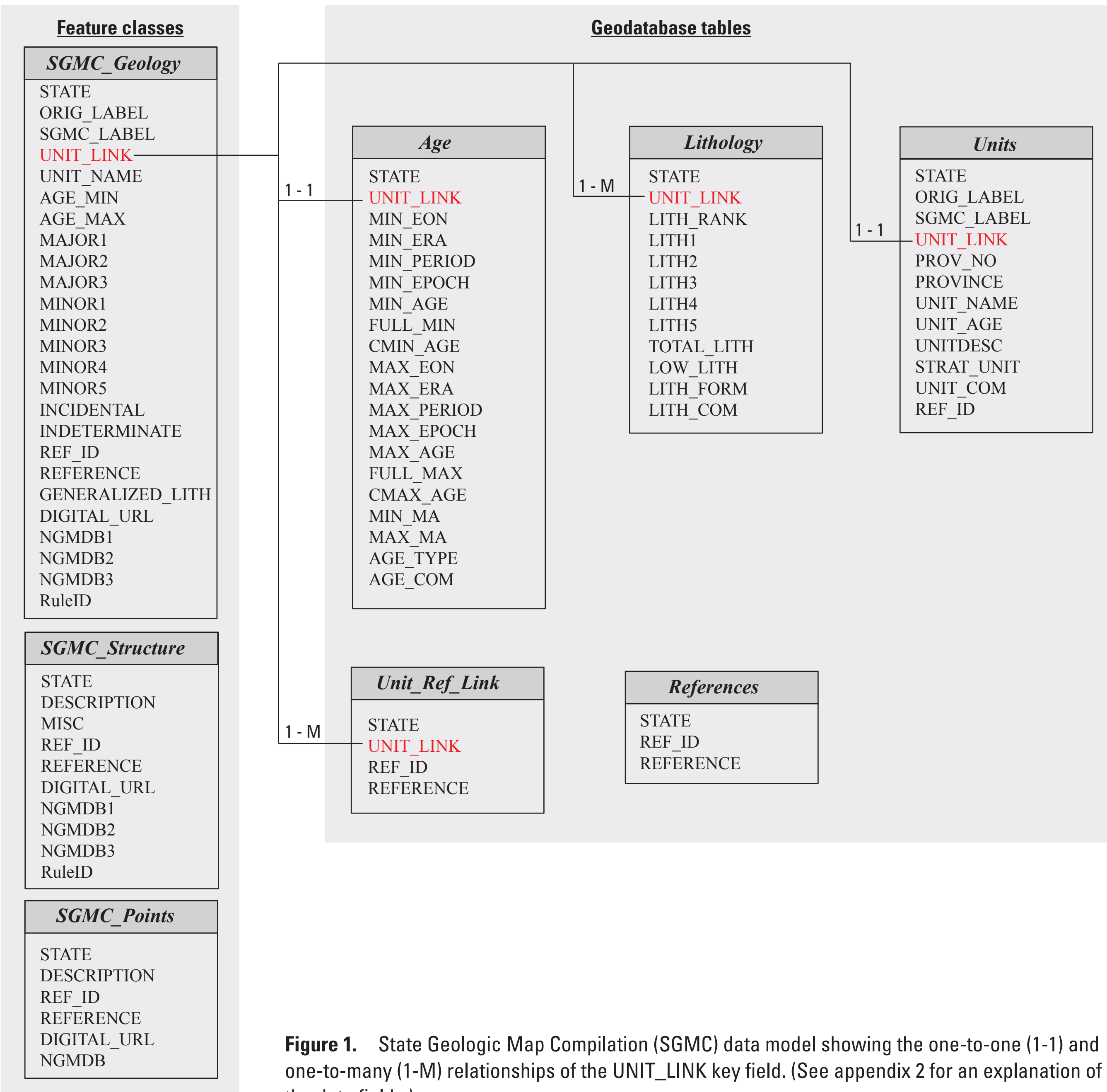


Figure 1. State Geologic Map Compilation (SGMC) data model showing the one-to-one (1-1) and one-to-many (1-M) relationships of the UNIT_LINK key field. (See appendix 2 for an explanation of the data fields.)

<u>Feature Classes</u>:

***SGMC_Geology*—**Polygons representing geologic features.

***SGMC_Structure*—**Polylines representing structural geologic features (for example, faults, folds, dikes).

SGMC_Points—Points representing miscellaneous point features (for example, volcanic vents, sample sites for geochronology). Only available for California, Colorado, Missouri, New Mexico, Nevada, Vermont, and Wyoming.

<u>Tables</u>:

***Age*—**Geologic ages of units in SGMC format (appendix 3).

***Lithology*—**Lithology of the geologic units in SGMC format (appendix 4).

***Units*—**Geologic unit descriptions/information from the printed State geologic maps.

***Unit_Ref_Link*—**Table used to link the references in the *References* table to the *SGMC_Geology* feature class using the UNIT_LINK key field (one-to-many relationship).

***References*—**The literature sources used to assemble each State map identified with unique values (REF_ID). For each State, reference(s) for the paper and (or) digital version(s) of its geologic map are provided. Different references for lithology, geologic ages, or stratigraphic names may have been used in the process of coding fields in other tables.

<u>Relationship Classes</u>:

Age_Relate (one-to-one relationship)**—**Relates the *Age* table to the *SGMC_Geology* feature class using the key field of UNIT_LINK.

Lithology_Relate (one-to-many relationship)**—**Relates the *Lithology* table to the *SGMC_Geology* feature class using the key field of UNIT_LINK.

Unit_Relate (one-to-one relationship)**—**Relates the *Units* table to the *SGMC_Geology* feature class using the key field of UNIT_LINK.

Unit_Ref_Link_Relate (one-to-many relationship)**—**Relates the *Unit_Ref_Link* table to the *SGMC_Geology* feature class using the key field of UNIT_LINK.

Using the Data

The *SGMC_Geology* feature class represents the geologic units from the State geologic maps. Numerous geologic queries can be performed on the feature class attributes or on the five related tables that contain more detailed information. For ease of use, most attributes in the *SGMC_Geology* feature class duplicates information from the related tables.

Queries of specific map units should be performed on ORIG_LABEL, which is the original symbol used on the State map, or the UNIT_NAME field of the *SGMC_Geology* feature class, but more unit names may be found by searching the UNITDESC and STRAT_UNIT fields of the *Units* table. Queries of geologic age should be performed on AGE_MIN or AGE_MAX of the *SGMC_Geology* feature class; these fields are copies of FULL_MIN and FULL_MAX from the *Age* table. The list of searchable age attributes can be found in the *Age* table data dictionary in appendix 3. The *Age* table contains hierarchical fields that separate age attributes into eon, era, period, epoch, and age. Numeric values for ages, both relative and absolute, are available for querying from the MIN_MA and MAX_MA fields. Queries of lithology should be performed on MAJOR1–3, MINOR1–5, INCIDENTAL, and INDETERMINATE fields of the *SGMC_Geology* feature class. The list of searchable lithologic attributes is provided in the *Lithology* table data dictionary in appendix 4. All the ranked fields should be searched when looking for a specific lithology because the numbered order of these fields does not imply relative abundance; that is, MAJOR1 is not more important than MAJOR2 or MAJOR3. For example, selecting all instances of “Limestone” that are ranked as Major requires searching MAJOR1, MAJOR2, MAJOR3, and the INDETERMINATE fields. These ranked lithology fields come from the *Lithology* table. In the *Lithology* table, values are represented by the increasingly hierarchical fields LITH1—LITH5; from generalized terms in LITH1 (“Unconsolidated,” “Sedimentary,” “Igneous,” “Metamorphic,” “Tectonite”) to more specific terms in LITH2–5 (“Sand,” “Limestone,” “Basalt,” “Marble,” “Phyllonite”). TOTAL_LITH concatenates the LITH1–LITH5 values into one field. LOW_LITH is the highest hierarchical LITH value and thus the best field to search for a specific lithology.

Age, Lithology, Units, and *Unit_Ref_Link* tables are related to the *SGMC_Geology* feature class by relationship classes in the geodatabase. These relationships can be used to select corresponding records using the “Related Tables” option in the attribute table toolbar. Selecting a geologic polygon from the geology feature class will also select corresponding records from related tables by using the “Related Tables” menu button (fig. 2). These relationships also allow selected records from the tables to select the corresponding geologic polygons. An example of the process for using these relationships by querying the geodatabase for a specific lithology is explained in figure 3. Maps created by querying lithologies from the SGMC are shown for geologic units classified as “Carbonate” and ranked as “Major” (fig. 4) and “Volcanic” ranked as “Major” (fig. 5). A map of Cretaceous age geology by querying the *Age* table using this technique is also provided (fig. 6).

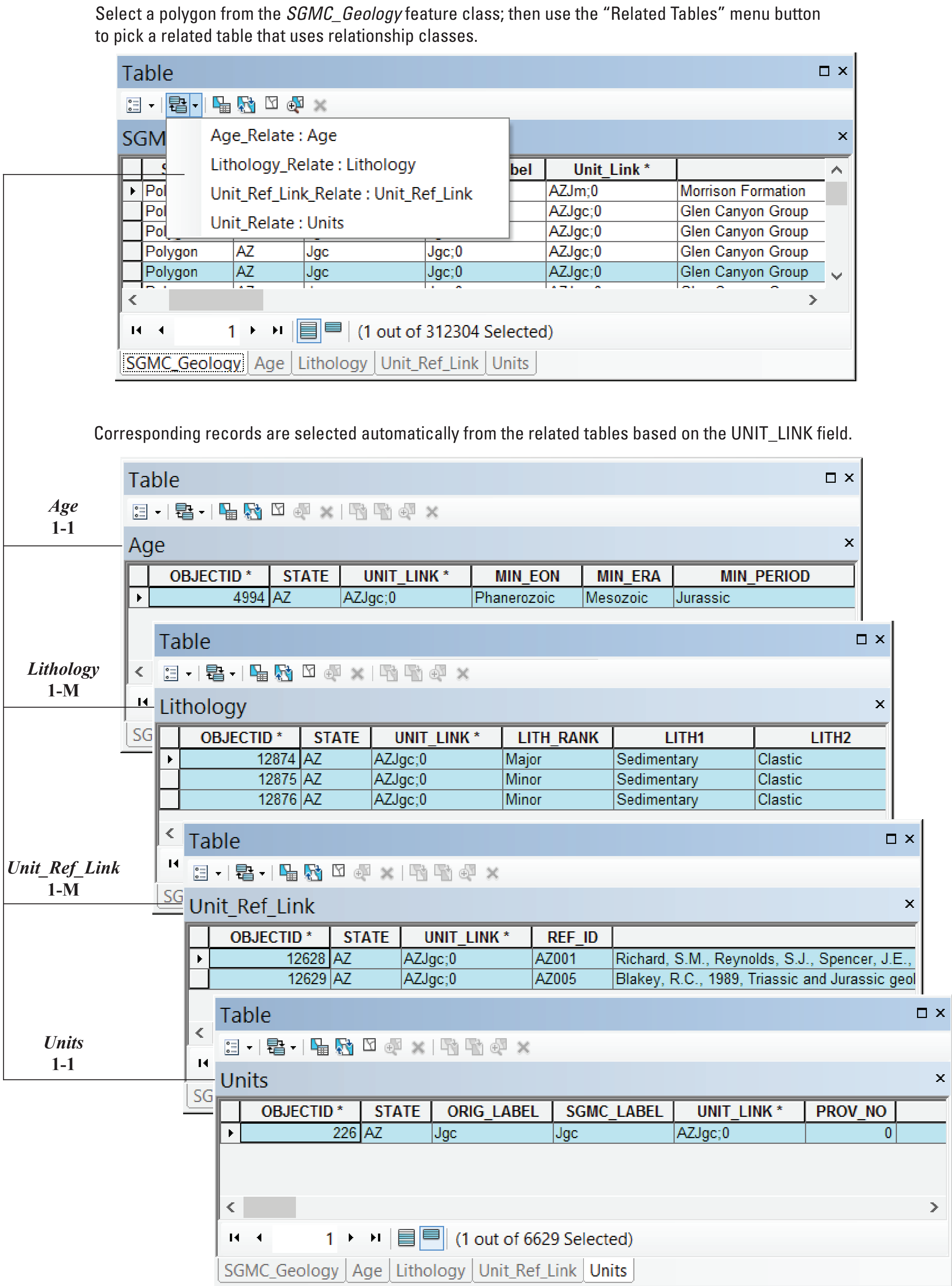
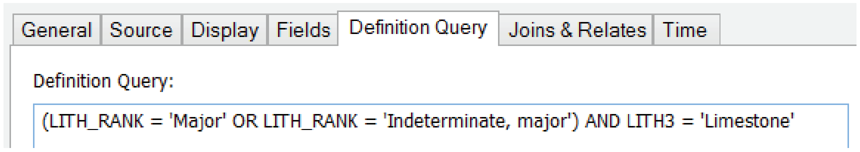
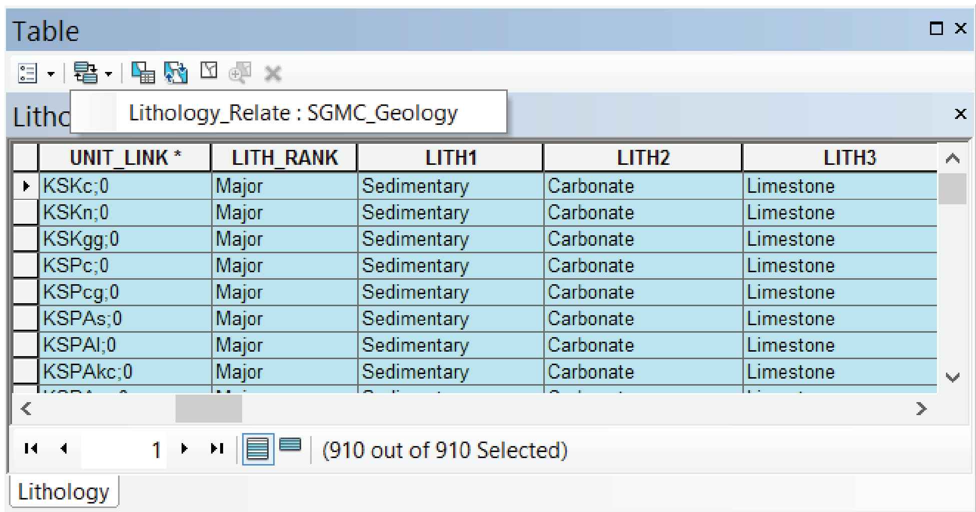


Figure 2. Using the "Related Tables" menu button to select corresponding records from related tables in ArcMap.

Build a query on the *Lithology* table to create a subset of records that are “Limestone” from LITH3 (appendix 4) and that are ranked as *Major* or *Indeterminate, major*.



Select all the records in the *Lithology* table and use the “Related Tables” menu button to select corresponding records in the *SGMC_Geology* feature class.



UNIT_LINK *	LITH_RANK	LITH1	LITH2	LITH3
KSKc;0	Major	Sedimentary	Carbonate	Limestone
KSKn;0	Major	Sedimentary	Carbonate	Limestone
KSKgg;0	Major	Sedimentary	Carbonate	Limestone
KSPc;0	Major	Sedimentary	Carbonate	Limestone
KSPcg;0	Major	Sedimentary	Carbonate	Limestone
KSPAs;0	Major	Sedimentary	Carbonate	Limestone
KSPAl;0	Major	Sedimentary	Carbonate	Limestone
KSPAkc;0	Major	Sedimentary	Carbonate	Limestone

Polygons that are “Limestone” and ranked as *Major* or *Indeterminate, major* are automatically selected (bright blue) in the related *SGMC_Geology* feature class using the UNIT_LINK key field.

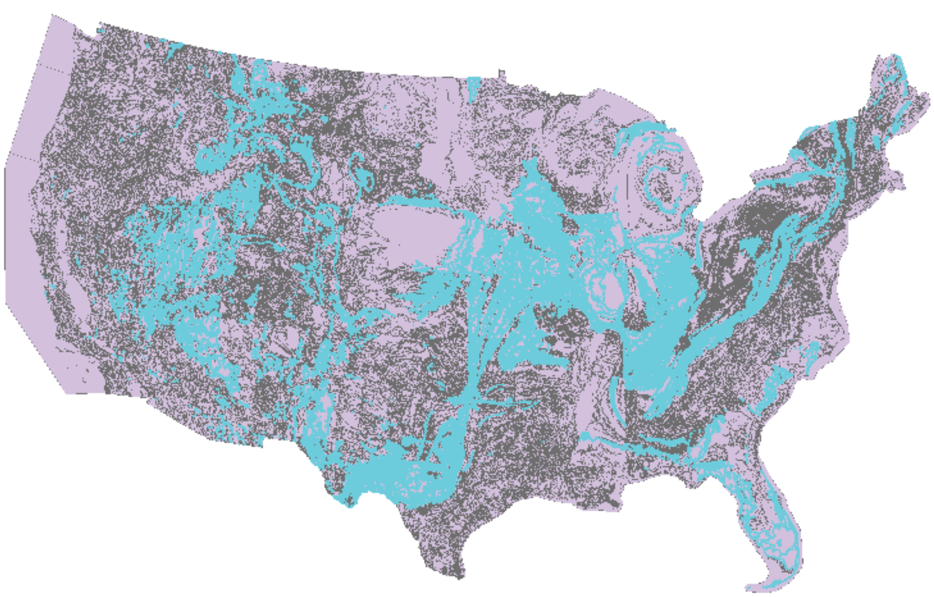
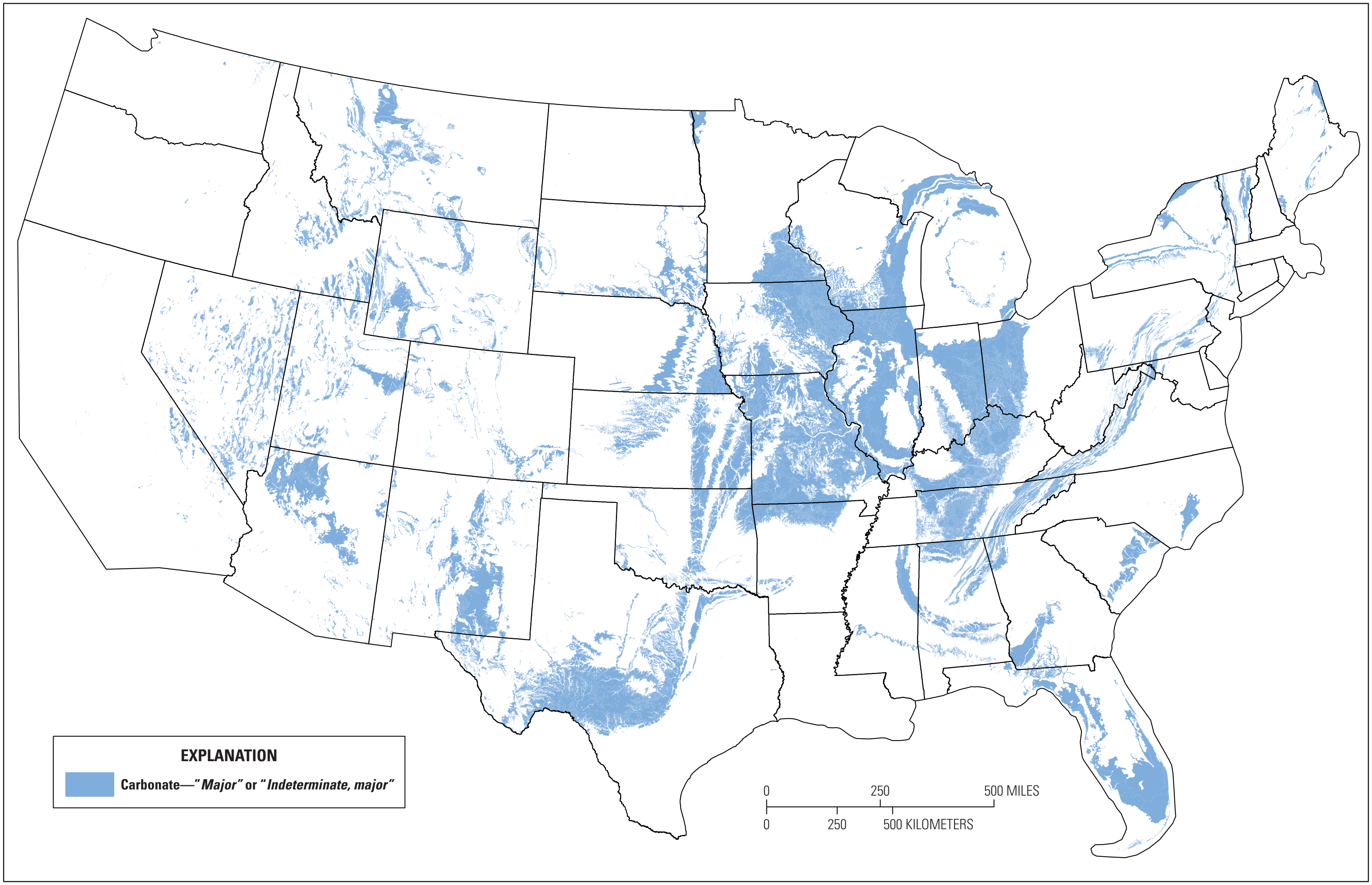
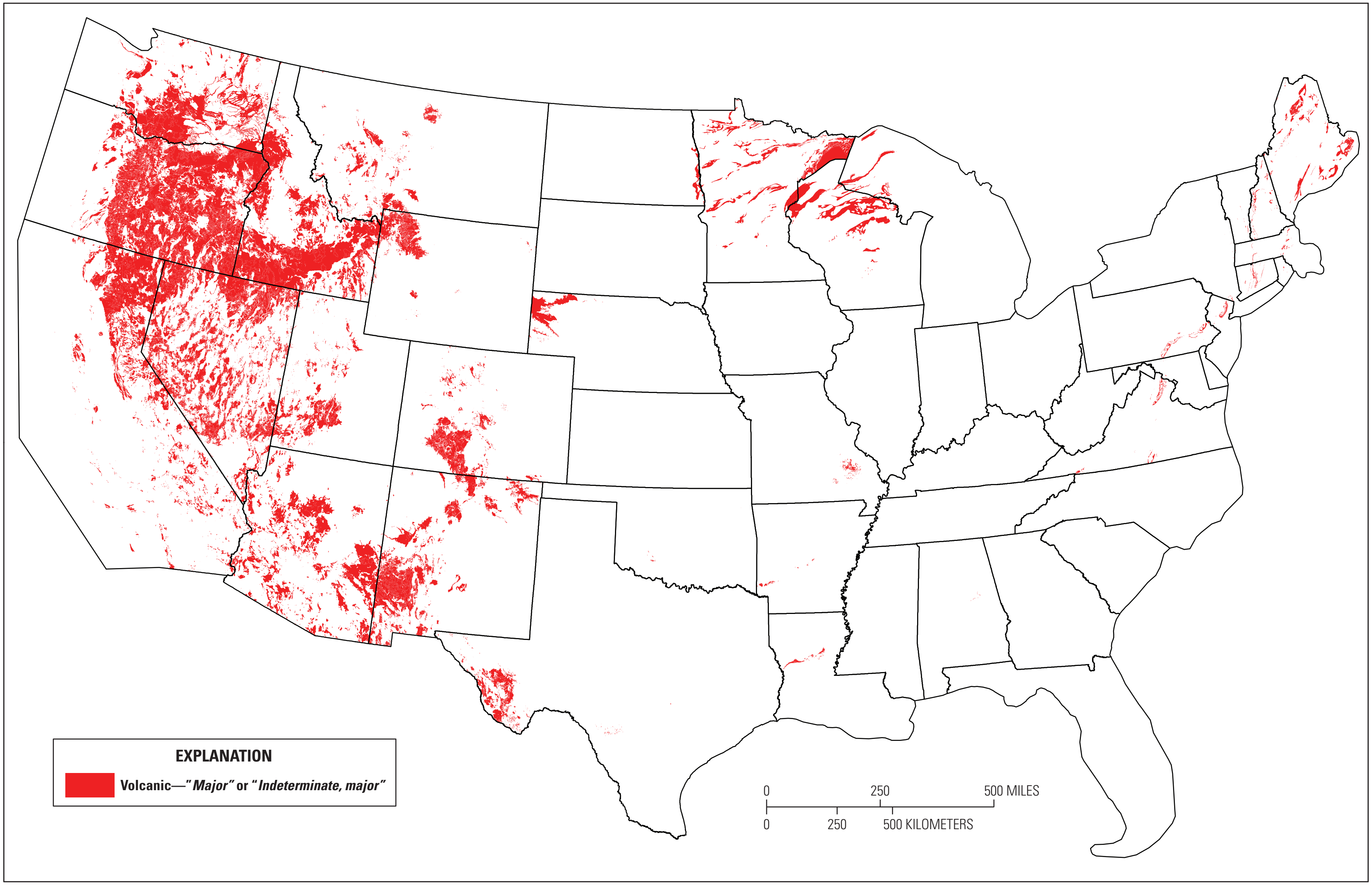


Figure 3. Querying the *Lithology* table for specific lithologies and selecting corresponding geologic polygons from the *SGMC_Geology* feature class using the “Related Tables” button on the table menu bar in ArcMap.



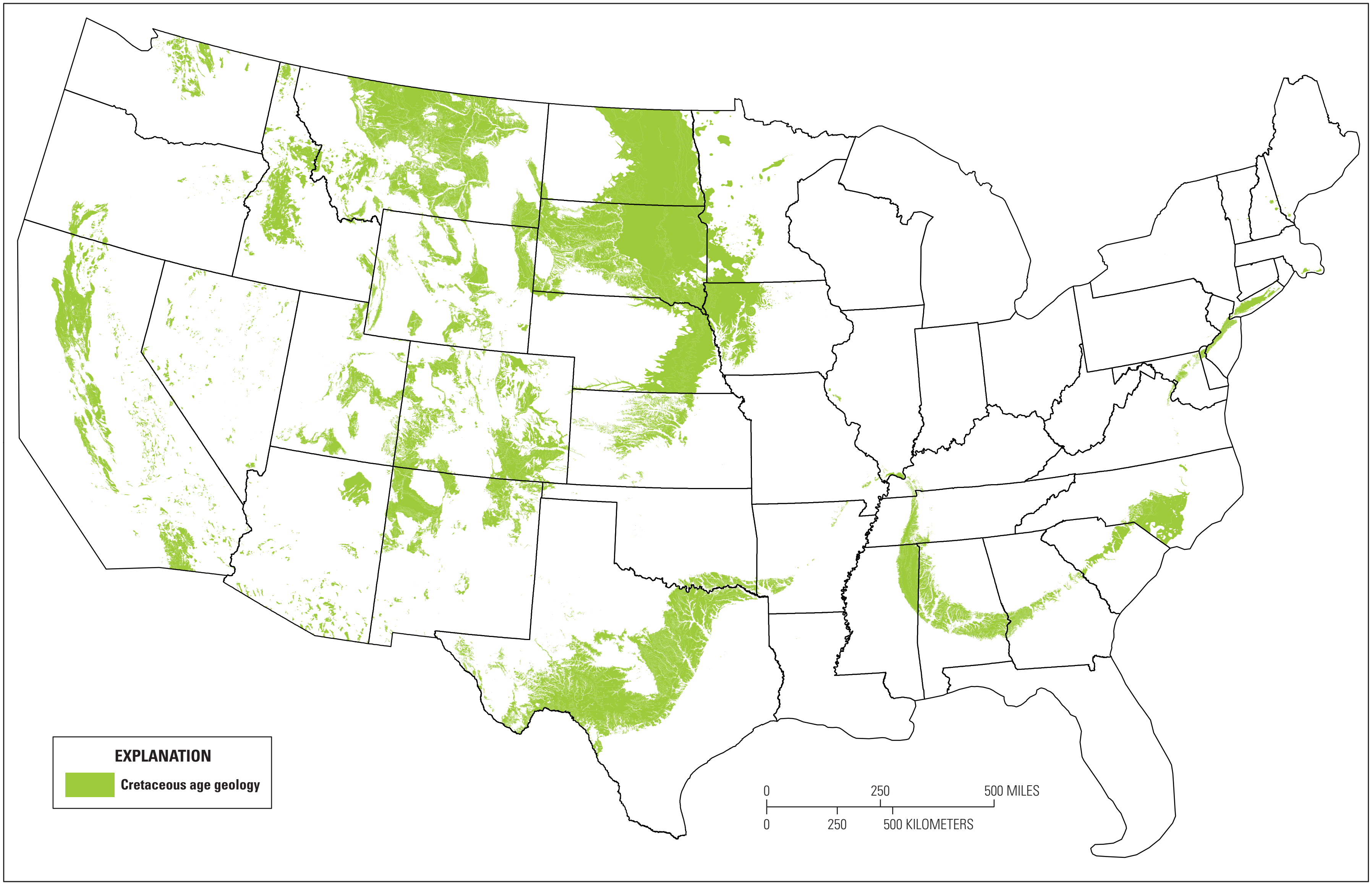
State boundaries derived from U.S. Geological Survey Digital Line Graph boundary layer quadrangles, 1:100,000, 2007
Standard parallels 29°5' N. and 45°5 N.
USA Contiguous Albers Equal Area Conic Projection.
Central meridian, 96° W., latitude of origin, 23° N.
North American Datum of 1983.

Figure 4. Major carbonate lithology from the State Geologic Map Compilation using the query "LITH2 = 'Carbonate' AND (LITH_RANK = 'Major' OR LITH_RANK = 'Indeterminate, major')" from the *Lithology* table.



State boundaries derived from U.S. Geological Survey Digital Line Graph boundary layer quadrangles, 1:100,000, 2007
Standard paralleLs 29°5' N. and 45°5' N.
USA Contiguous Albers Equal Area Conic Projection.
Central meridian, 96° W., latitude of origin, 23° N.
North American Datum of 1983.

Figure 5. Major volcanic lithology from the State Geologic Map Compilation using the query "LITH2 = 'Volcanic' AND (LITH_RANK = 'Major' OR LITH_RANK = 'Indeterminate, major')" from the *Lithology* table.



State boundaries derived from U.S. Geological Survey Digital Line Graph boundary layer quadrangles, 1:100,000, 2007
Standard parallels 29°5' N. and 45°5' N.
USA Contiguous Albers Equal Area Conic Projection.
Central meridian, 96° W., latitude of origin, 23° N.
North American Datum of 1983.

Figure 6. Cretaceous age lithology from the State Geologic Map Compilation using the query "MIN_PERIOD = 'Cretaceous' OR MAX_PERIOD = 'Cretaceous'" from the *Age* table.

The *SGMC_Structure* feature class represents geologic structures (faults, dikes, folds) that have been symbolized using Federal Geographic Data Committee standards for geologic maps with a geodatabase representation. Symbology was meticulously compared to printed State geologic maps to ensure correct orientation (teeth of thrust faults, ball/bars on normal faults, solid lines for certain faults, dashed lines for concealed/inferred faults). The DESCRIPTION field (appendix 5) can be used to query about specific types of structures, but visualization using this default geodatabase representation symbology adds value to the geologic polylines without any queries being performed.

General Procedures

The methods used to develop the PIGMDs and this SGMC version of the State geologic map data are essentially the same and involve data acquisition, standardized attribution, and fitting GIS features to a national-scale State boundary layer. During the original PIGMD project, considerable time was required to acquire digital State geologic map data for the conterminous United States. Some States lacked digital geologic map data (for example, Kentucky, Texas) so the States' geological survey programs and the USGS worked cooperatively to digitize existing paper maps. Some States (for example, Ohio, South Carolina, South Dakota) did not have State geologic maps, so the USGS merged larger scale geologic maps to develop statewide coverages. Fortunately, digital GIS data were available for the newer State geologic maps that were added to the SGMC and improved GIS technology streamlined compilation. State-scale GIS data generally include a polygon layer representing geologic units, a line layer that represents geologic structures, and sometimes, a point layer that contains miscellaneous geologic information (for example, volcanic vents, sample sites for geochronology).

Once GIS data are acquired, the resulting data must be standardized into a database that is consistent at a national scale. This phase required that the existing State attribute information be restructured and recoded using consistent field definitions and data dictionaries. The data dictionaries consist of allowable field terms, as codified in attribute tables. Data dictionaries for geologic age, lithology, structure, lithology form, geologic age symbols, and generalized lithology are presented in appendixes 3–8, respectively. These dictionaries standardize information presented on the State geologic maps of the conterminous United States only and therefore are a subset of a much broader range of possible geologic terms. A schema developed by the USGS establishes database organizational structure and defines relational links between the GIS layers and tables (fig. 1). The organizational design allows users to manipulate the tabular and spatial data and derive maps based on stratigraphy, lithology, and age. The State abbreviations used for the SGMC are listed in appendix 9.

Subsequently, State line and polygon GIS layers were adjusted to fit within a national-scale State boundary layer. The State boundaries used for the SGMC were established during the original PIGMD project and were derived from the USGS 1:100,000-scale Digital Line Graph boundary layer quadrangles. Merging State GIS layers into a national framework helped produce a seamless mosaic by eliminating areas that overlapped near State boundaries or by filling gaps where State map edges did not meet properly. This process involved manually extending or clipping lines relative to State boundaries rather than "rubber sheeting," which warps lines to achieve fit along boundaries.

National-Scale Database Integration

Integrating the 48 State digital geologic map databases into a single geodatabase represents a major enhancement of the SGMC. The integrated compilation provides a basis for considering and synthesizing data at a national scale, and importantly, it exposes the true geologic diversity that exists among State geologic maps of the conterminous United States. Whereas the previously described standardization methods produced GIS layers with consistent schemas and attribution, they did not resolve disparities among State geologic maps that result from diversity across the conterminous United States. Familiarity with the geologic diversity portrayed within the SGMC data is essential to most accurately synthesize the geologic implications of these data. The reasons for disparities between State geologic maps are summarized by Nicholson and others (2007c, p. 2-3) as follows:

> "Although the concept of combining state level digital maps to create a national digital map database appears straightforward, the disparate nature of the source maps places serious restrictions on how these data can be used and the degree to which they can be integrated. These restrictions arise for a number of different reasons, including:
>
> "1. *Differences in scale.* State geologic maps range in scale from 1:100,000 to 1:1,000,000. When data at different scales from contiguous states are merged, differences may result from one state having significantly more detail at the boundary than the other. For this reason, contacts and other linear features may not match.
>
> "2. *Differences in combined map units.* State geologic maps represent considerable simplification of more detailed source maps from which they were originally compiled. Thus, it is typical for adjoining state maps to have map units whose contacts will not match across state boundaries, due to differences in how groups of units were generalized or differences in the philosophy with which the units were mapped.

> "3. *Differences in exposure.* There is a distinct difference in state map type between eastern and western states. In the east, because of limited outcrop and extensive soil or glacial cover, interpretive bedrock maps are typically produced and may be accompanied by one or more separate surficial deposit maps. In the west, because outcrops are fairly common, state geologic maps consist of a mix of mapped exposed bedrock areas and alluvial or other surficial units mapped along stream and river valleys or as valley fill between mountain ranges.
>
> "4. *Differences in mapping philosophy.* For a variety of reasons, a few state maps are not the normal stratigraphic-unit based maps. For example, the Idaho state geologic map (Bond and others, 1978) is a compilation of lithostratigraphic units; and the state map of Maine (Osberg and others, 1984) shows the interpreted original protolith rather than the existing metamorphic lithology. Also, compilers for one state may have strived to maintain as much stratigraphic unit detail as possible, whereas in an adjoining state, units were lumped together to create broader combined units. Likewise, some mappers may choose to emphasize igneous rocks whereas others may focus on sedimentary stratigraphy. For these and many other reasons, each state map is different.
>
> "For these and other reasons, many of the map units at state boundaries do not match between adjoining states. Thus, the USGS has made no attempt to rectify or resolve boundary mismatches. In general, the standardized state digital maps in this series present polygons and arcs unmodified from their sources; however, the amount of error correction and updating of state maps varies considerably and are described in the metadata accompanying each state database."

Quality Assurance/Quality Control Procedures

In addition to the inherent disparity among SGMC data, additional variability results when complex State geologic maps are rendered digitally. Typical State digital geologic maps consist of tens of thousands of points, lines, and polygons, and accurately converting these map features to a GIS is a daunting task. Integrating 48 State digital geologic map databases into a single geodatabase revealed inconsistencies that were difficult to discern on individual State geologic maps. Detecting and correcting errors have been major emphases of SGMC updates and revisions. Errors that were revealed include (1) spatial data that were distorted or shifted relative to the original State source data, (2) attributes incorrectly transferred from State maps into the GIS data, (3) typographic errors, (4) nonstandardized data entries, (5) variable database schemas, and (6) internally inconsistent lithologic coding of geologic units. The following sections detail procedures used to address errors; however, the revised and updated SGMC data probably still include minor errors.

Comparison of Spatial Data

Shifts and distortions of geospatial data have been reported by users of the PIGMDs for some States. These issues were verified and required every State in the SGMC to be checked against the original State data to ensure spatial integrity. ArcGIS file geodatabase topology tools and techniques were used to identify and correct spatial mismatches. Spatial relationships of shared geometry datasets were evaluated using rules and specialized editing tools in a GIS environment (Esri, 2016a).

Comparison of Attribution

A small percentage of polygon attributes in the PIGMDs contained erroneous information. Some of these inaccuracies were introduced during the original digitization of the printed map. When encountered, the USGS corrected these errors and noted the correction in the attributes of the PIGMD. A small number of attribute errors were inadvertently introduced during the USGS development of the PIGMDs. As part of the SGMC effort, polygon attribution was thoroughly reviewed again to identify and correct any errors introduced when State digital files were converted to the PIGMD schema. To accomplish this, original State data were compared to the PIGMD schema using polygon centroids and spatial joins to compare features and (or) attributes based on spatial location to identify discrepancies. Printed State maps were considered to be the definitive sources unless more accurate sources were identified and cited. Detected errors were corrected, but it was not possible to check all the digital polygons in each State relative to the original printed maps.

Conversion of Tabular Data

FileMaker relational database software was used during the PIGMD project to code the original State geologic map information according to the USGS schema into tables of *Age, Lithology, References, Reference Link*, and *Units*. The PIGMDs provide these tables in three file formats for each State: FileMaker 5 (.fp5), dBASE (.dbf), and CSV. ArcGIS software does not allow direct importing of FileMaker tables, and the dBASE versions of the tables truncate any text field entries that exceed 254 characters due to format limitations. Because some of the table entries exceed 7,000 characters, the CSV versions of the PIGMD tables were used to import data into the SGMC geodatabase format to avoid losing any attribute information. Even with these precautions, some truncation errors were discovered in text fields, so the process described in the next paragraph was developed to address this issue.

The FileMaker format allows carriage returns within cell values of tables, so carriage returns were often used when entering text in some fields of the PIGMDs. These carriage returns were also present in the CSV format versions of the PIGMD tables because they were created from the FileMaker files. Because ArcGIS software does not allow carriage returns in text fields, the software either truncates cell entries or inserts special ASCII line control characters when carriage returns are encountered. Therefore, carriage returns were removed from all text fields of the original FileMaker formatted tables and new CSV formatted tables were created and used to import files into the geodatabase properly. This process ensured that all the original PIGMD tables were correctly imported into the SGMC geodatabase format without losing attribute information. To view long table entries in ArcMap, it may be necessary to change the attribute table cell height to 400 percent or more under "Table→Options→Appearance." When set, the text wraps within the field rendering the entire text entry visible. Shapefile versions of this dataset will still have field attribute entries truncated to 254 characters and field names limited to 10 characters due to the aforementioned data limitations of this file type.

Validating the UNIT_LINK Field

The UNIT_LINK field is the primary key field in the database and is used to establish links between the feature classes and the tables (fig. 1). Each geologic map unit has a unique attribute designated in this field. These unique values were created by combining the fields STATE, SGMC_LABEL, and PROV_NO from the *Units* table. The SGMC_LABEL consists of the ORIG_LABEL, the label used on the original State map, with age symbols replaced by the SGMC standardized age symbols (appendix 7). For example, an Eocene-aged geologic unit on the original Louisiana geologic map has a symbol of "Ej." The SGMC_LABEL would be "EOj" using the standardized age symbol for Eocene from appendix 7 and the PROV_NO of "0" because provinces are not used in this State. Therefore, the UNIT_LINK for this unit would be "LAEOj;0." The syntax of UNIT_LINK entries must match exactly or links with the other tables (*Age, Lithology, Units*, or *References*) will be broken and valuable information for a geologic unit will not be available. The PIGMDs had issues with the UNIT_LINK key field not linking correctly in some States. Consequently, all UNIT_LINK joins were investigated for each State. This involved joining the tables to the polygons so that every geologic polygon correctly linked to a table entry, and joining the polygons to the tables so that every table entry correctly linked to a corresponding geologic polygon. Most of the linking errors were caused by missing or incorrect province numbers (PROV_NO) or typographic errors of values in the UNIT_LINK field.

Some State maps use the concept of geologic provinces on their geologic maps to define changes in geography-dependent facies within a single unit. In these instances, a single geologic unit label might have multiple unit descriptions and lithologies as a function of its spatial location across geologic provinces within the State. The PIGMDs used sequential numbers (PROV_NO*)* and names (PROVINCE*)* to represent these different provinces in the *Units* table. The province number was used to create the UNIT_LINK value to ensure every geologic unit had a unique identifier in the database. Some province numbers were missing or not applied correctly in the PIGMDs and had to be corrected in order to fix linking issues between the tables and the *SGMC_Geology* feature class.

Additionally, some tabular entries of the PIGMDs did not link to any geologic polygons even after typographic and improper province number coding errors had been corrected. These errors reflected coded elements from the printed maps that were absent in the GIS data. These entries include units that were described in cross section only, represented as lines or points on the printed map but not included in the original GIS, or deleted by the standardized State boundary clipping process. Tabular entries without a corresponding geologic polygon were deleted from this dataset. In the SGMC database, all tabular attributes correspond to geologic polygons and vice versa.

Data Standardization

The frequency of unique text values (strings) and summary statistics were computed for each field of the SGMC attribute tables after the data were combined into a single dataset for the conterminous United States. This process revealed attribute standardization issues in numerous fields in almost every State. Standardized database dictionaries had not been used consistently and (or) coders entered nonstandard values, especially in the *Age* and *Lithology* tables. Consequently, all attribute entries were rechecked and standardized to established database schemas.

Many State geologic datasets also include polyline data that correspond to geologic structures such as faults, dikes, and folds. These polyline data were also merged and their attributes were standardized. Geodatabase representation symbology using Federal Geographic Data Committee symbols (Federal Geographic Data Committee, 2006) were created for the *SGMC_Structure* feature class (polyline data). This is the default symbology used when the *SGMC_Structure* feature class is added to an ArcMap session. Lines were manually checked relative to the printed State maps for correct polarity (that is, normal and thrust fault up/down symbols are on the correct side of the line). Polyline verification and addition of new State geologic maps required the associated coding schema for the DESCRIPTION field to be extensively revised (appendix 5).

Verification of Topology

State boundaries are an important component of the dataset because State geologic maps do not necessarily conform to standardized national-scale boundaries. Although reconciling geologic units across State boundaries has not been attempted, establishing a standardized State boundary is important to ensure the dataset is continuous and does not have any spatial gaps or overlaps near State boundaries. The PIGMD project used State boundaries derived from the USGS 1:100,000-scale Digital Line Graphs boundary layer quadrangles. Geodatabase topology was used to ensure that all the new geologic maps were fitted to this boundary and to verify the PIGMD data. The geologic data were spatially compared to the State boundary data with the rules "must not have gaps" and "must not overlap" set to a 1-meter (3.281-feet) tolerance. Original State data that extended past the State boundary were clipped to fix overlaps, and data that did not spatially reach the State boundary were extended to fix gaps. PIGMD data for some State maps were not correctly clipped to the boundary and required adjustments. Geologic structural (faults, dikes, folds) polyline data were also subjected to topological evaluation. Similarly, the topology of the geologic polygons within a State and across the entire dataset for the conterminous United States was evaluated to ensure spatial integrity.

Enhancements Made to the State Geologic Map Compilation

Lithology Ranking

Many States have very generalized unit descriptions with no specific abundance information for the lithologies mentioned. Other States have extremely long unit descriptions describing numerous lithologies within lumped units. This makes ranking of the lithologies complicated and caused variability in the coding of lithologies between States in the PIGMDs. The PIGMD guidelines for ranking lithologies included quantitative, volumetric percent guidelines. This detailed type of abundance information is not usually provided in geologic unit descriptions, especially at the small scale of the State maps, and therefore the SGMC has employed a more qualitative approach to ranking the lithologies. Lithology ranking is either determined from geologic unit descriptions on State geologic maps or by research done by the coder using other references. The relative abundance of the lithology is estimated and recorded in the LITH_RANK field of the *Lithology* table as either Major, Minor, Incidental, or Indeterminate, major (could not be determined). Approximately 98 percent of the geologic units in the PIGMD had three or less Major lithologies, so we chose to limit units in the SGMC to a maximum of three Major lithologies. The PIGMD also had approximately 425 geologic units with lithologies ranked as Indeterminate. These pertained to less than 10 percent of the units in the entire database; however, some of these units occupied spatially extensive map areas so their Indeterminate lithologic ranking was more visibly apparent. The additional LITH_FORM field used to capture the form of the lithology being ranked also contributed to inconsistent rankings that were also addressed during the compilation of the SGMC.

Lithologic ranking issues were addressed in different ways depending on the type of geologic unit. For instance, alluvium and unconsolidated deposits, which are typically described as gravel, sand, silt, and clay and usually have no specific abundance information, were often originally ranked as Indeterminate or as having more than three Majors in the PIGMD. In the SGMC, these units were reclassified to a lower level in the *Lithology* table to rank these lithologies more consistently. Depending on the unit description, either Major—Coarse-detrital or Major—Fine-detrital from the LITH2 class was employed. Entering any specifically enumerated lithology (Gravel, Sand, Silt, Clay) in the LITH_COM field eliminated most of the Indeterminate rankings and units having more than three Major lithologies.

Indeterminate lithologic rankings in the PIGMD were also frequently used for map unit descriptions that included numerous lithologies without abundance information. During the compilation of the SGMC, it was assumed that the lithologies in a map unit description are described in order of decreasing abundance. Thus, the first three lithologies listed in a unit description are ranked as Major and the rest are ranked as Minor or Incidental as best as could be determined. This process best captures implied relative abundance information from State maps when no other information is available and significantly lowers the number of Indeterminate rankings in the SGMC.

The LITH_FORM field of the *Lithology* table was intended to capture additional information about a lithology, such as a rhyolite occurring in tuff form or a schist occurring as greenschist facies. LITH_FORM coding was effective when lithologies and forms described in a unit description were limited. When a lithologic description contained multiple forms, however, ranking the various forms became problematic. In some cases in the PIGMD, a lithology that should be a major part of the unit might be ranked as Minor or Indeterminate due to the numerous forms described in the map unit description. To minimize these issues and create a more consistent lithologic database, when a unit's lithology had multiple entries of LITH_FORM in the *Lithology* table, they were concatenated to one entry separated by commas. Ultimately, in the SGMC, ranking of the basic lithology was deemed more important than ranking the various forms of a given lithology, especially given the small map scales characteristic of the State geologic maps. To avoid inaccuracies, the correction process was not automated. Multiple ranked forms of the same lithology in the PIGMD were reviewed in the context of the original State geologic unit description to ensure that the new lithologic ranking was properly established as best as could be determined.

Additional Attribution

The PIGMD geologic polygon attribute tables included very limited information pertaining to the geologic units. In order to access pertinent information about a particular geologic unit, manual tabular joins to other database tables were required. In the SGMC, some attributes from the linked tables have been added to the *SGMC_Geology* polygon feature class, which makes the information more accessible. Specifically, the field UNIT_NAME from the *Units* table, AGE_MIN and AGE_MAX from the *Age* table (FULL_MIN and FULL_MAX fields), and REFERENCE (digital State geologic map reference) from the *References* table were added. In addition, web address Uniform Resource Locator (URL) links to the original digital data and paper State geologic maps (USGS National Geologic Map Database (NGMDB)) were added in the fields: DIGITAL_URL, NGMDB1, NGMDB2, AND NGMDB3 if they were available.

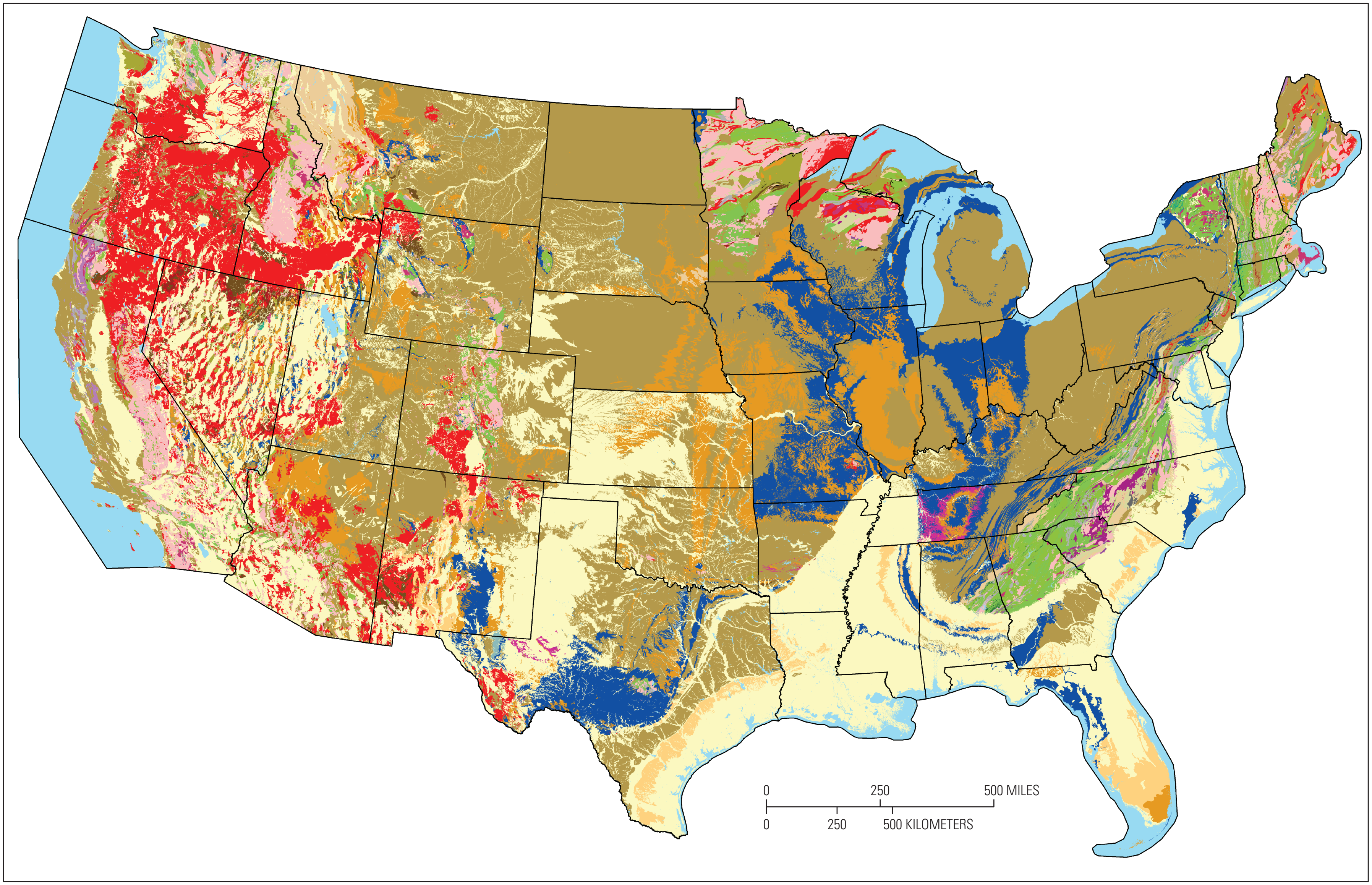
The PIGMD geologic polygon attribute table used the fields ROCKTYPE1 and ROCKTYPE2 to identify the lithology of any given geologic unit. These fields used an entirely different lithologic schema to classify the rocks than was used in the *Lithology* table. For consistency and simplicity, lithologic terms used in the *SGMC_Geology* feature class attribute table are now based only on the LITH1–LITH5 fields in the *Lithology* table data dictionary (appendix 4). The relationship between the geologic polygon attributes and the *Lithology* table is a one-to-many relationship. Indeed, any given geologic unit may include multiple lithologies. Therefore, the *Lithology* table was flattened in order to add this lithologic information to each polygon. MAJOR1, MAJOR2, MAJOR3, MINOR1, MINOR2, MINOR3, MINOR4, MINOR5, INCIDENTAL, and INDETERMINATE fields were added to the *SGMC_Geology* feature class attribute table from the *Lithology* table. For the MINOR5 field, values were concatenated if more than six minor lithologies were ranked; for the INCIDENTAL and INDETERMINATE fields, multiple values were concatenated.

The order of these numbered fields does not imply the relative importance of a given lithology. For example, the lithology listed in the MAJOR1 field does not indicate more abundance than the lithology listed in MAJOR2 or MAJOR3. Consequently, all three MAJOR fields and the INDETERMINATE field must be considered when conducting searches for specific MAJOR lithologies in the *SGMC_Geology* attribute table. Fortunately, the new fields better represent the lithology of any given geologic polygon, and queries yield more accurate maps based on the entries identical to those in the *Lithology* table.

The GENERALIZED_LITH field (appendix 8) has also been added to provide generalized rock classifications based on the MAJOR1–MAJOR3 or INDETERMINATE fields. Generalized lithologic maps can be created using data contained in this single field (fig. 7). A geodatabase representation has been created and is the default symbology used for the *SGMC_Geology* feature class when added to an ArcMap session.

Relationship Classes

Using the key field of UNIT_LINK, relationship classes were created in the geodatabase that relate the attribute information in the tables to the geology polygon feature class. These new relationship classes add additional functionality to ArcMap sessions. The “Related Tables” button, accessible through the table menu dialog toolbar, allows geologic polygon selection and viewing of corresponding records in the linked geodatabase tables. Records selected from within the geodatabase tables can be used to display the corresponding geologic polygons without having to perform manual joins of multiple tables (figs. 2 and 3).



State boundaries derived from U.S. Geological Survey Digital Line Graph boundary layer quadrangles,
1:100,000, 2007
Standard parallels 29°5' N. and 45°5' N.
USA Contiguous Albers Equal Area Conic Projection.
Central meridian, 96° W., latitude of origin, 23° N.
North American Datum of 1983.

Figure 7. Lithology from the State Geologic Map Compilation using the GENERALIZED_LITH field of the *SGMC_Geology* feature class.

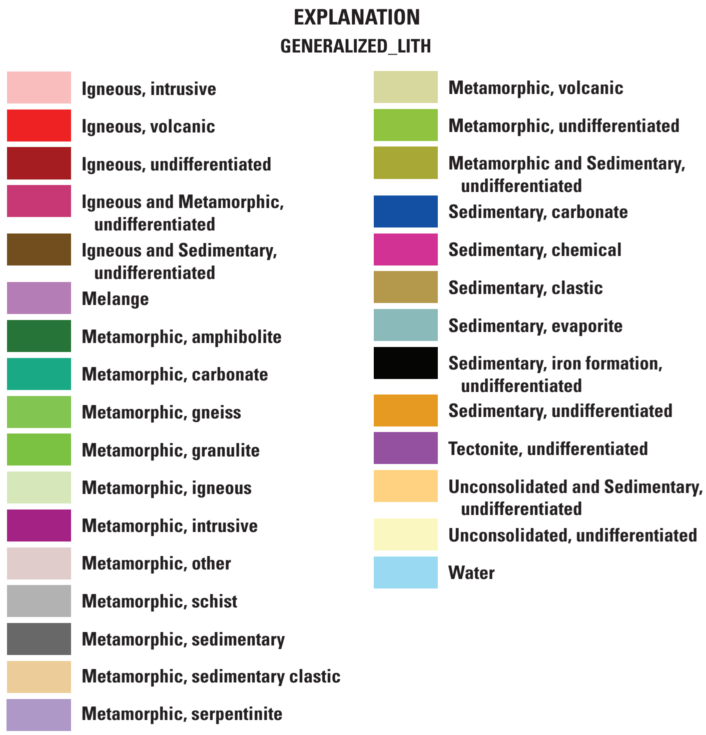


Figure 7. Lithology from the State Geologic Map Compilation using the GENERALIZED_LITH field of the *SGMC_Geology* feature class.—Continued

Summary

Changes and improvements incorporated into the State Geologic Map Compilation (SGMC) were done to create a seamless, conterminous State geologic map database. Many of the inconsistencies came about after combining the Preliminary Integrated Geologic Map Databases (PIGMDs) into a single database and considering it as a whole; rather than State by State. The main emphases during the compilation of the SGMC were correcting spatial and topological errors present in the PIGMDs and ensuring attributes adhered to data dictionaries created for the project. The SGMC changes, especially those regarding lithologic coding and rankings, make the data more consistent between the States and with the original State geologic maps. The updated SGMC geodatabase structure also makes the data easier to use. Numerous attributes from the related tables have been duplicated in the *SGMC_Geology* feature class to make more geologic information readily available. The geodatabase format of the SGMC allows symbology and relationship classes to be stored with the data and streamlines tasks that previously required combining multiple PIGMD geographic information system datasets and tables.

The possibility of creating a truly integrated geologic map for the conterminous United States was explored during the compilation of the SGMC. Integration would involve reconciling geologic units across State lines to eliminate the State boundary breaks obvious in this database. Eliminating State boundary breaks would undoubtedly require new geologic mapping and interpretations across the entire United States. Although the SGMC data would provide a starting point, integration of the map is beyond the scope of this project. In the interim, symbolizing the SGMC database using the newly added geodatabase representation of the GENERALIZED_LITH field in the *SGMC_Geology* feature class will produce a more visually seamless geologic map based on lithologic groupings (fig. 7).

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King, P.B., Beikman, H.M., and Edmonston, G.J., 1974, Geologic map of the United States (exclusive of Alaska and Hawaii): U.S. Geological Survey, scale 1: 2,500,000, accessed February 2017 at https://pubs.er.usgs.gov/publication/70136641.

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Nicholson, S.W., Dicken, C.L., Horton, J.D., Foose, M.P., Mueller, J.A.L., and Hon, R., 2007b, Preliminary integrated geologic map databases for the United States—Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, Rhode Island and Vermont (ver. 1.1, December 2007): U.S. Geological Survey Open-File Report 2006–1272, accessed September 18, 2009, at https://pubs.usgs.gov/of/2006/1272.

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Osberg, P.H., Hussey A.M., II, Boone, G.M., and Loiselle, M.C., eds., 1984, Bedrock geologic map of Maine: Maine Geological Survey Open-File Report Volume 84-1, scale 1:500,000.

Reed, J.C., Jr., Wheeler, J.O., and Tucholke, B.E., 2005a, Geologic map of North America: Boulder, Colo., Geological Society of America, Decade of North American Geology, 3 sheets, scale 1:5,000,000.

Reed, J.C., Jr., Wheeler, J.O., and Tucholke, B.E., 2005b, Geologic map of North America—Perspectives and explanation: Boulder, Colo., Geological Society of America, Decade of North American Geology, 28 p.

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Wilson, F.H., Hults, C.P., Mull, C.G, and Karl, S.M, compilers., 2015, Geologic map of Alaska: U.S. Geological Survey Scientific Investigations Map 3340, pamphlet 196 p., 2 sheets, scale 1:1,584,000, accessed February 2017 at https://doi.org/10.3133/sim3340.

Appendixes 1–9

Appendix 1. State Geologic Maps Bibliography

The citations presented here are for the paper versions of the State geologic maps with a U.S. Geological Survey (USGS) National Geologic Map Database (NGMDB) URL link provided for convenience. The sources for all data in the State Geologic Map Compilation (SGMC) are the original USGS Preliminary Integrated Geologic Map Databases (PIGMD) unless otherwise noted. Please see the PIGMD citation provided for more detailed geologic map source information.

Alabama (AL)—Scale 1:250,000

Osbourne, W.E., Szabo, M.W., Neathery, T.L., and Copeland, C.W., Jr., 1988, Geologic map of Alabama—Northeast sheet: Geological Survey of Alabama Special Map 220, scale 1:250,000.

Szabo, M.W., and Copeland, C.W., Jr., 1988, Geologic map of Alabama—Southeast sheet: Geological Survey of Alabama Special Map 220, scale 1:250,000.

Szabo, M.W., and Copeland, C.W., Jr., 1988, Geologic map of Alabama—Southwest sheet: Geological Survey of Alabama Special Map 220, scale 1:250,000.

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NGMDB—Available at https://ngmdb.usgs.gov/Prodesc/proddesc_55859.htm.

PIGMD—Available at https://pubs.usgs.gov/of/2005/1323/#AL.

Arizona (AZ)—scale 1:1,000,000

Richard, S.M., Reynolds, S.J., Spencer, J.E., and Pearthree, P.A., 2000, Geologic map of Arizona: Arizona Geological Survey Map 35, 1 sheet, scale 1:1,000,000.

NGMDB—Available at https://ngmdb.usgs.gov/Prodesc/proddesc_34746.htm.

PIGMD—Available at https://pubs.usgs.gov/of/2005/1305/#AZ.

Arkansas (AR)—scale 1:500,000

Haley, B.R., assisted by Glick, E.E., Bush, W.V., Clardy, B.F., Stone, C.G., Woodward, M.B., and Zachry, D.L., 1993, Geologic map of Arkansas, U.S. Geological Survey Special Geologic Map, scale 1:500,000.

NGMDB—Available at https://ngmdb.usgs.gov/Prodesc/proddesc_16308.htm.

PIGMD—Available at https://pubs.usgs.gov/of/2005/1351/#AR.

California (CA)—scale 1:750,000

The PIGMD spatial data (geology, structure, and points) have been replaced with the newer updated version from the California Geologic Survey; however, the SGMC table attributions have been retained from the PIGMD.

Jennings, C.W., with modifications by Gutierrez, C., Bryant, W., Saucedo, G., and Wills, C., 2010, Geologic map of California, Version 2.0 (California Geological Survey 150th Anniversary Edition), Department of Conservation, California Geological Survey: California Geologic Data Map Series, GDM No. 2, scale 1:750,000, accessed July 2017 at ftp://ftp.consrv.ca.gov/pub/dmg/rgmp/Published_GIS_Data/GDM_002_GMC_750k_v2/GDM_002_GMC_750k_v2_GIS.zip.

NGMDB—Available at https://ngmdb.usgs.gov/Prodesc/proddesc_96750.htm.

PIGMD—Available at https://pubs.usgs.gov/of/2005/1305/#CA.

Colorado (CO)—scale 1:500,000

Tweto, Ogden, 1979, Geologic map of Colorado: U.S. Geological Survey, scale 1:500,000.

NGMD—Available at https://ngmdb.usgs.gov/Prodesc/proddesc_68589.htm.

PIGMD—Available at https://pubs.usgs.gov/of/2005/1351/#CO.

Connecticut (CT)—scale 1:50,000

Rodgers, J., 1985, Bedrock geological map of Connecticut: Connecticut Geological and Natural History Survey, Connecticut Natural Resources Atlas Series, 2 sheets, scale 1:125,000.

NGMDB—Available at https://ngmdb.usgs.gov/Prodesc/proddesc_54245.htm.

PIGMD—Available at https://pubs.usgs.gov/of/2006/1272/#CT.

Delaware (DE)—scale 1:297,500

Spoljaric, N., and Jordan, R.R., 1966, Generalized geologic map of Delaware: Delaware Geological Survey Special Publication 4, scale 1:297,500.

NGMDB—Available at https://ngmdb.usgs.gov/Prodesc/proddesc_86696.htm.

PIGMD—Available at https://pubs.usgs.gov/of/2005/1325/#DE.

Florida (FL)—scale 1:750,000

Scott, T. M., Campbell, K. M., Rupert, F. R., Arthur, J. D., Missimer, T. M., Lloyd, J. M., Yon, J. W., and Duncan, J. G., 2001, Geologic map of the State of Florida: Florida Department of Environmental Protection, Florida Geological Survey Map Series 146, scale 1:750,000.

NGMDB—Available at https://ngmdb.usgs.gov/Prodesc/proddesc_54101.htm.

PIGMD—Available at https://pubs.usgs.gov/of/2005/1323/#FL.

Georgia (GA)—scale 1:500,000

Lawton, D.E., Moye, F.J., Murray, J.B., O'Connor, B.J., Penley, H.M., Sandrock, G.S., Marsalis, W.E., Friddell, M.S., Hetrick, J.H., Huddlestun, P.F., Hunter, R.E., Mann, W.R., Martin, B.F., Pickering, S.M., Schneeberger, F.J., and Wilson, J.D., 1976, Geologic map of Georgia: Georgia Geological Survey, scale 1:500,000.

NGMDB—Available at https://ngmdb.usgs.gov/Prodesc/proddesc_16532.htm.

PIGMD—Available at https://pubs.usgs.gov/of/2005/1323/#GA.

Idaho (ID)—scale 1:750,000

This is a new geologic map addition to the SGMC that replaces what was used in the PIGMD.

Lewis, R.S., Link, P.K., Stanford, L.R., and Long, S.P., Geologic map of Idaho, 2012, Idaho Geological Survey Geologic Map 9 (M-9); scale 1:750,000, accessed September 2012 at http://www.idahogeology.org/Products/reverselook.asp?switch=title&value=Geologic_Map_of_Idaho.

NGMDB—Available at https://ngmdb.usgs.gov/Prodesc/proddesc_97750.htm.

Illinois (IL)—scale 1:500,000

This is a new geologic map addition to the SGMC that replaces what was used in the PIGMD.

Kolata, D.R., comp., 2005, Bedrock geology of Illinois: Champaign, Ill., Illinois State Geological Survey Illinois Map Series 14, scale 1:500,000, accessed January 2012 at https://clearinghouse.isgs.illinois.edu/data/geology/bedrock-geology-2005.

NGMDB—Available at https://ngmdb.usgs.gov/Prodesc/proddesc_87181.htm.

Indiana (IN)—scale 1:500,000

Gray, H.H., Ault, C.H., and Keller, S.J., 1987, Bedrock geologic map of Indiana: Indiana Geological Survey Miscellaneous Map 48, scale 1:500,000.

NGMDB—Available at https://ngmdb.usgs.gov/Prodesc/proddesc_16538.htm.

PIGMD—Available at https://pubs.usgs.gov/of/2004/1355/#IN.

Iowa (IA)—scale 1:500,000

This is a new geologic map addition to the SGMC that replaces what was used in the PIGMD.

Witzke, B.J., Anderson, R.R., and Pope, J.P., 2010, Bedrock geologic map of Iowa: Iowa Geological Survey Open-File Map OFM-2010-01, Scale 1:500,000, accessed November 2011 at ftp://ftp.igsb.uiowa.edu/gis_library/IA_state/Geologic/Bedrock/Bedrock_Geologic_Map.zip.

NGMDB—Available at https://ngmdb.usgs.gov/Prodesc/proddesc_96753.htm.

Kansas (KS)—scale 1:500,000

Ross, J.A., 1991, Geology map of Kansas: Kansas Geological Survey Map M-23, scale 1:500,000.

NGMDB—Available at https://ngmdb.usgs.gov/Prodesc/proddesc_16542.htm.

PIGMD—Available at https://pubs.usgs.gov/of/2005/1351/#KS.

Kentucky (KY)—scale 1:500,000

Noger, M.C., 1988, Geologic map of Kentucky: U.S. Geological Survey in cooperation with the Kentucky Geological Survey, scale 1:500,000.

NGMDB—Available at https://ngmdb.usgs.gov/Prodesc/proddesc_16355.htm.

PIGMD—Available at https://pubs.usgs.gov/of/2005/1324/#KY.

Louisiana (LA)—scale 1:500,000

Snead, J.I., and McCulloh, R.P., 1984, Geologic map of Louisiana: Louisiana Geological Survey Geologic Map 5, scale 1:500,000.

NGMDB—Available at https://ngmdb.usgs.gov/Prodesc/proddesc_39755.htm.

PIGMD—Available at https://pubs.usgs.gov/of/2005/1351/#LA.

Maine (ME)—scale 1:500,000

Osberg, P.H., Hussey, A.M., II, and Boone, G.M., 1985, Bedrock geologic map of Maine: Maine Geological Survey Geologic Map Series BGMM, scale 1:500,000.

NGMDB—Available at https://ngmdb.usgs.gov/Prodesc/proddesc_16547.htm.

PIGMD—Available at https://pubs.usgs.gov/of/2006/1272/#ME.

Maryland (MD)—scale 1:250,000

Cleaves, E.T., Edwards, Jonathan, Jr., and Glaser, J.D., 1968, Geologic map of Maryland: Maryland Geological Survey, scale 1:250,000.

NGMDB—Available at https://ngmdb.usgs.gov/Prodesc/proddesc_16548.htm.

PIGMD—Available at https://pubs.usgs.gov/of/2005/1325/#MD.

Massachusetts (MA)—scale 1:250,000

Zen, E-An, Goldsmith, G.R., Ratcliffe, N.L., Robinson, Peter, and Stanley, R.S., 1983, Bedrock geologic map of Massachusetts: U.S. Geological Survey Monograph series, 3 sheets, scale 1:250,000.

NGMDB—Available at https://ngmdb.usgs.gov/Prodesc/proddesc_16357.htm.

PIGMD—Available at https://pubs.usgs.gov/of/2006/1272/#MA.

Michigan (MI)—scale 1:500,000

Milstein, R.L. comp., 1987, Bedrock geology of southern Michigan: Michigan Department of Natural Resources Geological Publication BG-01, scale 1:500,000.

NGMDB—Available at https://ngmdb.usgs.gov/Prodesc/proddesc_71887.htm.

Reed, R.C., and Daniels, Jennifer, comps., 1987, Bedrock geology of northern Michigan: Michigan Department of Natural Resources, Geological Survey Division, scale 1:500,000.

NGMDB—Available at https://ngmdb.usgs.gov/Prodesc/proddesc_71888.htm.

Sims, P.K., 1992, Geologic map of Precambrian rocks, southern Lake Superior region, Wisconsin and northern Michigan: U.S. Geological Survey Miscellaneous Investigations Map I-2185, scale 1:500,000.

NGMDB—Available at https://ngmdb.usgs.gov/Prodesc/proddesc_10177.htm.

PIGMD—Available at https://pubs.usgs.gov/of/2004/1355/#MI.

Minnesota (MN)—scale 1:500,000

This is a new geologic map addition to the SGMC that replaces what was used in the PIGMD.

Jirsa, M.A., Boerboom, T.J., Chandler, V.W., Mossler, J.H., Runkel, A.C., and Setterholm, D.R., 2011, S-21 geologic map of Minnesota—Bedrock geology: Minnesota Geological Survey, scale 1:500,000, accessed March 2012 at http://conservancy.umn.edu/handle/11299/101466.

NGMDB—Available at https://ngmdb.usgs.gov/Prodesc/proddesc_96821.htm.

Mississippi (MS)—scale 1:500,000

Moore, W.H., and Bicker, A.R., Jr., comps., 1969, Geologic map of Mississippi: Mississippi Geological Survey, scale 1:500,000.

NGMDB—Available at https://ngmdb.usgs.gov/Prodesc/proddesc_16555.htm.

PIGMD—Available at https://pubs.usgs.gov/of/2005/1323/#MS.

Missouri (MO)—scale 1:500,000

Middendorf, M.A., 2003, Geologic map of Missouri—Sesquicentennial Edition: Missouri Department of Natural Resources, Division of Geology and Land Survey, Missouri State Geologic Maps SGM-2003, scale 1:500,000.

NGMDB—Available at https://ngmdb.usgs.gov/Prodesc/proddesc_81881.htm.

PIGMD—Available at https://pubs.usgs.gov/of/2005/1351/#MO.

Montana (MT)—scale 1:500,000

This is a new geologic map addition to the SGMC that replaces what was used in the PIGMD.

Vuke, S.M., Porter, K.W., Lonn, J.D., and Lopez, D.A., 2007, Geologic map of Montana—Compact disc: Montana Bureau of Mines and Geology Geologic Map 62-C, 73 p., 2 sheets, scale 1:500,000, accessed Summer 2012 at http://www.mbmg.mtech.edu/mbmgcat/public/ListCitation.asp?pub_id=30080&. This map was digitized in 2012 as a result of a contract between USGS and the Montana Bureau of Mines and Geology.

NGMDB—Available at https://ngmdb.usgs.gov/Prodesc/proddesc_81651.htm.

Nebraska (NE)—scale 1:1,000,000

Burchett, R.R., 1986, Geologic bedrock map of Nebraska: Nebraska Geological Survey, Conservation and Survey Division, University of Nebraska-Lincoln, scale 1:1,000,000.

NGMDB—Available at https://ngmdb.usgs.gov/Prodesc/proddesc_39227.htm.

PIGMD—Available at https://pubs.usgs.gov/of/2005/1351/#NE.

Nevada (NV)—scale 1:250,000

This is a new geologic map addition to the SGMC that replaces what was used in the PIGMD.

Crafford, A.E.J., 2007, Geologic map of Nevada: U.S. Geological Survey Data Series 249, 1 CD-ROM, 46 p., 1 plate, scale 1:250,000, accessed November 2013 at https://pubs.usgs.gov/ds/2007/249/.

NGMDB—Available at https://ngmdb.usgs.gov/Prodesc/proddesc_81584.htm.

New Hampshire (NH)—scale 1:250,000

Lyons , J.B., Bothner, W.A., Moench, R.H., and Thompson, J.B., Jr., 1997, Bedrock geologic map of New Hampshire: U.S. Geological Survey Special Map, 2 sheets, scale 1:250,000.

NGMDB—Available at https://ngmdb.usgs.gov/Prodesc/proddesc_37338.htm.

PIGMD—Available at https://pubs.usgs.gov/of/2006/1272/#NH.

Note that the new geologic map of Vermont by Ratcliff and others (2011) overlaps with portions of New York and New Hampshire and the newer Vermont data for structure and geology are used in these areas.

New Jersey (NJ)—scale 1:100,000

Drake, A.A., Jr., Volkert, R.A., Monteverde, D.H., Herman, G.C., Houghton, H.F., Parker, R.A., and Dalton, R.F., 1996, Bedrock geologic map of northern New Jersey: U.S. Geological Survey Miscellaneous Investigations Series Map I-2540-A, 2 sheets, scale 1:100,000.

NGMDB—Available at https://ngmdb.usgs.gov/Prodesc/proddesc_13025.htm.

Owens, J.P., Sugarman, P.J., Sohl, N.F., Parker, R.A., Houghton, H.F., Volkert, R.A., Drake, A.A., Jr., and Orndorff, R.C., 1998, Bedrock geologic map of central and southern New Jersey: U.S. Geological Survey Miscellaneous Investigations Series Map I-2540-B, 4 sheets, scale 1:100,000.

NGMDB—Available at https://ngmdb.usgs.gov/Prodesc/proddesc_19458.htm.

PIGMD—Available at https://pubs.usgs.gov/of/2006/1272/#NJ.

New Mexico (NM)—scale 1:500,000

Green, G.N., and Jones, G.E., 1997, Digital geologic map of New Mexico in Arc/Info export format: U.S. Geological Survey Open-File Report OF-97-52, scale 1:500,000.

NGMDB—Available at https://ngmdb.usgs.gov/Prodesc/proddesc_22974.htm.

PIGMD—Available at https://pubs.usgs.gov/of/2005/1351/#NM.

New Mexico Bureau of Geology and Mineral Resources, 2003, Geologic map of New Mexico: New Mexico Bureau of Geology and Mineral Resources, scale 1:500,000, accessed August 2011 at https://geoinfo.nmt.edu/publications/maps/geologic/state/home.cfml.

The PIGMD data was updated with the 2003 map in the SGMC by John Horton in 2012 (heads up digitizing).

NGMDB—Available at https://ngmdb.usgs.gov/Prodesc/proddesc_59219.htm.

New York (NY)—scale 1:250,000

Fisher, D.W., Isachsen, Y.W., and Rickard, L.V., 1970, Geologic map of New York State, consisting of 5 sheets—Niagara, Finger Lakes, Hudson-Mohawk, Adirondack, and Lower Hudson: New York State Museum and Science Service Map and Chart Series 15, scale 1:250,000.

NGMDB—Available at https://ngmdb.usgs.gov/Prodesc/proddesc_98670.htm.

PIGMD—Available at https://pubs.usgs.gov/of/2005/1325/#NY.

Note that the new geologic map of Vermont by Ratcliff and others (2011) overlaps with portions of New York and New Hampshire and the newer Vermont data for structure and geology are used in these areas.

North Carolina (NC)—scale 1:250,000

Rhodes, T.S., and Conrad, S.G., 1985, Geologic map of North Carolina: North Carolina Department of Natural Resources and Community Development, Division of Land Resources, and the North Carolina Geological Survey, scale 1:500,000.

NGMDB—Available at https://ngmdb.usgs.gov/Prodesc/proddesc_55091.htm.

PIGMD—Available at https://pubs.usgs.gov/of/2005/1323/#NC.

North Dakota (ND)—scale 1:670,000

North Dakota Geological Survey, 2001, NDHUB.GeologyBedrock, Geologic bedrock map of North Dakota, digital version of Bluemle, John P., 1983, Geologic and topographic bedrock map of North Dakota: North Dakota Geological Survey Miscellaneous Map 25, scale 1:670,000, accessed September 2014 at https://gishubdata.nd.gov/dataset/bedrock-geology.

NGMDB—Available at https://ngmdb.usgs.gov/Prodesc/proddesc_16522.htm.

In the SGMC, the Bluemle (1983) bedrock map replaces the surficial map by Clayton and others (1980) that was used in the PIGMD. However, the linear structural features were retained from the PIGMD.

Structural features only—Clayton, Lee, Moran, S.R., Bluemle, J.P., and Carlson, C.G., 1980, Geology map of North Dakota: North Dakota Geological Survey, scale 1:500,000.

NGMDB—Available at https://ngmdb.usgs.gov/Prodesc/proddesc_16520.htm.

PIGMD—Available at https://pubs.usgs.gov/of/2005/1351/#ND.

Ohio (OH)—scale 1:500,000

Slucher, E.R., Swinford, E.M., Larsen, G.E., Schumacher, G.A., Shrake, D.L., Rice, C.L., Caudill, M.R., and Rea, R.G., comps., and Powers, D.M., cartographic comp., 2006, Bedrock geologic map of Ohio: Ohio Geological Survey Map BG-1, scale 1:500,000.

NGMDB—Available at https://ngmdb.usgs.gov/Prodesc/proddesc_82513.htm.

PIGMD—Available at https://pubs.usgs.gov/of/2005/1324/#OH.

Oklahoma (OK)—scale 1:250,000

Heran, W.D., Green, G.N., and Stoeser, D.B., comps., 2003, A digital geologic map database for the State of Oklahoma: U.S. Geological Survey Open-File Report 03-247, scale 1:250,000.

NGMDB—Available at https://ngmdb.usgs.gov/Prodesc/proddesc_55294.htm.

PIGMD—Available at https://pubs.usgs.gov/of/2005/1351/#OK.

Oregon (OR)—scale 1:500,000

Walker, G.W., and MacLeod, N.S., 1991, Geologic map of Oregon: U.S. Geological Survey, scale 1:500,000.

NGMDB—Available at https://ngmdb.usgs.gov/Prodesc/proddesc_16259.htm.

PIGMD—Available at https://pubs.usgs.gov/of/2005/1305/#OR.

Pennsylvania (PA)—scale 1:250,000

Berg, T.M., Edmunds, W.E., Geyer, A.R., Glover, A.D., Hoskins, D.M., MacLachlan, D.B., Root, S.I., Sevon, W.D., and Socolow, A.A., 1980, Geologic map of Pennsylvania (2d ed.): Pennsylvania Geological Survey Map 1, 3 sheets, scale 1:250,000.

NGMDB—Available at https://ngmdb.usgs.gov/Prodesc/proddesc_34341.htm.

PIGMD—Available at https://pubs.usgs.gov/of/2005/1325/#PA.

Rhode Island (RI)—scale 1:100,000

Hermes, O.D., Gromet, L.P., Murray, D.P., Hamidzada, N.A., Skehan, J.W., and Mosher, S., 1994, Bedrock geologic map of Rhode Island: Rhode Island Geological Survey Rhode Island Map Series No. 1, scale 1:100,000.

NGMDB—Available at https://ngmdb.usgs.gov/Prodesc/proddesc_19719.htm.

PIGMD—Available at https://pubs.usgs.gov/of/2006/1272/#RI.

South Carolina (SC)—scale 1:500,000

No official State geologic paper map exists other than a very generalized 1:1,000,000 geologic map; see reference below for sources used in this compilation.

PIGMD—Available at https://pubs.usgs.gov/of/2005/1323/#SC.

South Dakota (SD)—scale 1:500,000

Western half of state—Martin, J.E., Sawyer, J.F., Fahrenbach, M.D., Tomhave, D.W., and Schulz, L.D., 2004, Geologic map of South Dakota: South Dakota Geological Survey G-10, scale 1:500,000.

NGMDB—Available at https://ngmdb.usgs.gov/Prodesc/proddesc_72317.htm.

PIGMD—Available at https://pubs.usgs.gov/of/2005/1351/#SD.

Eastern half of state—Tomhave, D.W., and Schulz, L.D., 2004, Bedrock geologic map showing configuration of the bedrock surface in South Dakota east of the Missouri River: South Dakota Geological Survey G-09, scale 1:500,000, accessed May 2012 at http://www.sdgs.usd.edu/pubs/other/esdbedrock_20040630.zip.

The Tomhave and Schulz (2004) map is used in the SGMC and replaces the Martin and others (2004) map used in the PIGMD for the Eastern half of the state (east of the Missouri River).

NGMDB—Available at https://ngmdb.usgs.gov/Prodesc/proddesc_96370.htm.

Tennessee (TN)—scale 1:250,000

Hardeman, W.D., Miller, R.A., and Swingle, G.D., 1966, Geologic map of Tennessee: Tennessee Division of Geology, 4 sheets, scale 1:250,000.

NGMDB—Available at https://ngmdb.usgs.gov/Prodesc/proddesc_91768.htm.

PIGMD—Available at https://pubs.usgs.gov/of/2005/1324/#TN.

Texas (TX)—scale 1:500,000

Barnes, V.E., Hartmann, Barbara, and Scranton, D.F., 1992, Geologic map of Texas: University of Texas at Austin, Bureau of Economic Geology, scale 1:500,000.

NGMDB—Available at https://ngmdb.usgs.gov/Prodesc/proddesc_68390.htm.

PIGMD—Available at https://pubs.usgs.gov/of/2005/1351/#TX.

Utah (UT)—scale 1:500,000

Hintze, L.F., Willis, G.C., Laes, D.Y.M., Sprinkel, D.A., and Brown, K.D., 2000, Digital geologic map of Utah: Utah Geological Survey Map 179DM, scale 1:500,000.

NGMDB—Available at https://ngmdb.usgs.gov/Prodesc/proddesc_67350.htm.

PIGMD—Available at https://pubs.usgs.gov/of/2005/1305/#UT.

Vermont (VT)—scale 1:100,000

This is a new geologic map addition to the SGMC that replaces what was used in the PIGMD.

Ratcliffe, N.M., Stanley, R.S., Gale., M.H., Thompson, P.J., and Walsh, G.J., 2011, Bedrock geologic map of Vermont: U.S. Geological Survey Scientific Investigations Series Map 3184, 3 sheets, scale 1:100,000, accessed May 2012 at http://dec.vermont.gov/geological-survey/publication-gis/VTrock.

NGMDB—Available at https://ngmdb.usgs.gov/Prodesc/proddesc_96860.htm.

Virginia (VA)—scale 1:500,000

Virginia Division of Mineral Resources, 1993, Geologic map of Virginia: Virginia Division of Mineral Resources, scale 1:500,000.

NGMDB—Available at https://ngmdb.usgs.gov/Prodesc/proddesc_34878.htm.

PIGMD—Available at https://pubs.usgs.gov/of/2005/1325/#VA.

Washington (WA)—scale 1:500,000

Hunting, M.T., Bennett, W.A.G., Livingston, V.E., Jr., and Moen, W.S., 1961, Geologic map of Washington: Washington Division of Mines and Geology, scale 1:500,000.

NGMDB—Available at https://ngmdb.usgs.gov/Prodesc/proddesc_30777.htm.

PIGMD—Available at https://pubs.usgs.gov/of/2005/1305/#WA.

West Virginia (WV)—scale 1:250,000

Cardwell, D.H., Erwin, R.B., and Woodward, H.P., 1968, Geologic map of West Virginia: West Virginia Geological and Economic Survey Map 1, scale 1:250,000.

NGMDB—Available at https://ngmdb.usgs.gov/Prodesc/proddesc_13205.htm.

PIGMD—Available at https://pubs.usgs.gov/of/2005/1324/#WV.

Wisconsin (WI)—scale 1:500,000–1:1,000,000

Mudrey, M.G., Jr., Brown, B.A., and Greenberg, J.K., 1982, Bedrock geologic map of Wisconsin: Wisconsin Geological and Natural History Survey State Map 18, scale 1:1,000,000.

NGMDB—Available at https://ngmdb.usgs.gov/Prodesc/proddesc_49339.htm.

Sims, P.K., 1992, Geologic map of Precambrian rocks, southern Lake Superior region, Wisconsin and northern Michigan: U.S. Geological Survey Miscellaneous Investigations Series Map I-2185, scale: 1:500,000.

NGMDB—Available at https://ngmdb.usgs.gov/Prodesc/proddesc_10177.htm.

PIGMD—Available at https://pubs.usgs.gov/of/2004/1355/#WI.

Wyoming (WY)—scale 1:500,000

Love, J.D., and Christiansen, A.C., 1985, Geologic map of Wyoming: U.S. Geological Survey, scale 1:500,000.

NGMDB—Available at https://ngmdb.usgs.gov/Prodesc/proddesc_16366.htm.

PIGMD—Available at https://pubs.usgs.gov/of/2005/1351/#WY.

Appendix 2. State Geologic Map Compilation Attribute Field Definitions for All Feature Classes and Tables

Tables 2-1 to 2-8 provide attribute field definitions for all feature classes and tables used in the State Geologic Map Compilation organized by file name.

Table 2-1. *SGMC_Geology* feature class attributes.

[SGMC, State Geologic Map Compilation; URL, Uniform Resource Locator; USGS, U.S. Geological Survey]

Field	Explanation	Data dictionary
STATE	Two letter state abbreviation (for example, NM = New Mexico).	Appendix 9
ORIG_LABEL (Original label)	Map unit label (symbol) from the original source digital map (which typically does not use special characters in map symbols), not from paper maps (which may use special characters for ages in map symbols). Original source digital maps may include additional records such as “water,” which typically forms polygons on digital maps but are not coded as a geologic unit from the paper map. Commonly, when paper maps are digitized, one-to-one correspondences between the digital versions of the maps and source paper maps may not exist because map units may be added, deleted, or modified.	
SGMC_LABEL	The map unit symbol as identified on the source map was used whenever possible. However, the age component of map unit symbols were coded using appendix 7 (geologic age symbols) rather than special characters. This label may also diverge from ORIG_LABEL if it was determined that the original source map data was incorrect by comparison to the paper state map (errors in original source data).	
UNIT_LINK	Field entries generated by combining the STATE, SGMC_LABEL, and PROV_NO fields from the *Units* table. The purpose of this field is to create a unique value for every unit in the database. It is the linking field (key field) between all tables.	
UNIT_NAME	The name of the map unit as given on the source map (from the *Units* table).	
AGE_MIN	FULL_MIN field from the *Age* table.	Appendix 3
AGE_MAX	FULL_MAX field from the *Age* table.	Appendix 3
MAJOR1 **MAJOR2** **MAJOR3**	Copied terms from the *Lithology* table with a LITH_RANK of Major.	Appendix 4
MINOR1 **MINOR2** **MINOR3** **MINOR4** **MINOR5**	Copied terms from the *Lithology* table with a LITH_RANK of Minor. MINOR5 is concatenated when six or more Minors exist.	Appendix 4
INCIDENTAL	Copied terms from the *Lithology* table with a LITH_RANK of Incidental; concatenated.	Appendix 4
INDETERMINATE	Copied terms from the *Lithology* table with a LITH_RANK of Indeterminate, major; concatenated.	Appendix 4
REF_ID	A unique identification number of the digital source reference (from the *References* table).	
REFERENCE	The reference citation for the digital source (from the *References* table).	
GENERALIZED_LITH	The generalized lithology of the unit using the MAJOR1 through MAJOR3 fields.	Appendix 8
DIGITAL_URL	URL web address link to the state geologic map digital data (if applicable).	
NGMDB1	USGS National Geologic Map Database URL web address link to the state geologic paper map.	
NGMDB2	USGS National Geologic Map Database URL web address link to the state geologic paper map (if applicable).	
NGMDB3	USGS National Geologic Map Database URL web address link to the state geologic paper map (if applicable).	
RuleID	Domain used by ArcGIS software to store representation rules used for symbology within the geodatabase. Based on the GENERALIZED_LITH field.	Appendix 8

Table 2-2. *SGMC_Structure* feature class attributes.

[SGMC, State Geologic Map Compilation; URL, Uniform Resource Locator; USGS, U.S. Geological Survey]

Field	Explanation	Data dictionary
STATE	Two letter state abbreviation (for example, NM = New Mexico).	Appendix 9
DESCRIPTION	Standardized description used by SGMC to classify different structural line types.	Appendix 5
MISC	Free form field used for any additional miscellaneous descriptive terms from the original state source files.	
REF_ID	A unique identification number of the digital source reference (from the *References* table).	
REFERENCE	The reference citation for the digital source (from the *References* table).	
DIGITAL_URL	URL web address link to the state geologic map digital data (if applicable).	
NGMDB1	USGS National Geologic Map Database URL web address link to the state geologic paper map.	
NGMDB2	USGS National Geologic Map Database URL web address link to the state geologic paper map (if applicable).	
NGMDB3	USGS National Geologic Map Database URL web address link to the state geologic paper map (if applicable).	
RuleID	Domain used by ArcGIS software to store representation rules used for symbology within the geodatabase. Based on the DESCRIPTION field.	Appendix 5

Table 2-3. *SGMC_Points* feature class attributes. These attributes are available only for the following states: California, Colorado, Missouri, New Mexico, Nevada, Vermont, and Wyoming.

[URL, Uniform Resource Locator; USGS, U.S. Geological Survey]

Field	Explanation	Data dictionary
STATE	Two letter state abbreviation (for example, NM = New Mexico).	Appendix 9
DESCRIPTION	Free form field for the descriptions of points from the original state source digital files. No standardization applied.	
REF_ID	A unique identification number of the digital source reference (from the *References* table).	
REFERENCE	The reference citation for the digital source (from the *References* table).	
DIGITAL_URL	URL web address link to the state geologic map digital data (if applicable).	
NGMDB	USGS National Geologic Map Database URL web address link to the state geologic paper map.	

Table 2-4. *Units* table attributes. One-to-one relationship with the *SGMC_Geology* feature class. The *Units* table compiles basic information about the map unit as described on the source map along with additional available information.

Field	Explanation	Data dictionary
STATE	Two letter state abbreviation (for example, NM = New Mexico).	Appendix 9
ORIG_LABEL (Original label)	Map unit label (symbol) from the original source digital map (which typically does not use special characters in map symbols), not from paper maps (which may use special characters for ages in map symbols). Original source digital maps may include additional records such as "water" that typically forms polygons on digital maps but are not coded as a geologic unit from the paper map. Commonly, when paper maps are digitized, one-to-one correspondences between the digital versions of the maps and source paper maps may not exist because map units may be added, deleted, or modified.	
SGMC_LABEL	The map unit symbol as identified on the source map was used whenever possible. However, the age component of map unit symbols were coded using appendix 7 (geologic age symbols) rather than special characters. This label may also diverge from ORIG_LABEL if it was determined that the original source map data was incorrect by comparison to the paper state map (errors in original source data).	
UNIT_LINK	Field entries generated by combining the STATE, SGMC_LABEL, and PROV_NO fields. The purpose of this field is to create a unique value for every unit in the database. It is the linking field (key field) between all tables.	
PROV_NO (Province number)	Many state geologic maps are subdivided into regions or provinces (for example, Carolina Slate Belt, Northwestern Plateau). Typically, each of these provinces has a corresponding stratigraphic column. A province number has been assigned to each of these map regions (for example,. 1, 2, 3, and so forth). If the map does not have individual provinces, then 0 was used for the province number. Province coding is used only when the state map is subdivided into regions or provinces and individual map units, with unique unit descriptions, are included in more than one province.	
PROVINCE	Name of the province on the paper map or as identified in other sources.	
UNIT_NAME	The name of the map unit as identified on the source map. If the map legend says "Fraser Formation: basalt, with minor andesite and greywacke," then the unit name is clearly "Fraser Formation." Sometimes, however, the map may say "interlayered rhyolite, mafic tuff and flows, slate." Accordingly, unit names are coded both as a unit name and as the unit description, although an abbreviated unit name version may be composed for excessively long text entries.	
UNIT_AGE	Free form field to capture unit age (for example. "Cretaceous," or "Permian to Cretaceous," or "Permian-Cretaceous," and possibly "Paleocene," and so on). This field has not been standardized. It is meant to capture age information exactly as it appears on the paper source state map or inferred from correlation diagrams or other sources.	
UNITDESC (Unit description)	The unit description as given on the source paper map. If there is no distinct unit description (common for many state geologic maps), the UNIT_NAME is repeated here. Unusual circumstances that required modification of unit descriptions and (or) unit names are explained in the UNIT_COM (unit comment) field.	
STRAT_UNIT (Stratigraphic unit)	Field to add additional stratigraphic units beyond those listed on the source map. For example, formation names are a key element to the database but may not be listed on the map if only a group or member is given. Thus, the map unit might be the "Little Bigfoot Group." The "Little Bigfoot Group" is subdivided into formations, but if these formations are not listed on the map they are entered here using additional references.	
UNIT_COM (Unit comment)	Free form field for inclusion of any additional relevant information about the unit or actions made during data compilation.	
REF_ID	Unique identification number(s) for reference(s) used to code the geologic unit separated by commas. These codes are numbered using the state symbol (AL001, AL002, and so on.). The codes refer to REF_ID in the *References* table and are used in the UNIT_REF_LINK table to link the references using the UNIT_LINK key field.	

Table 2-5. *Age* table attributes. One-to-one relationship with the *SGMC_Geology* feature class. This table contains geochronological age attribution for each map unit (one record for each map unit). Attribution for this table uses a geochronological data dictionary (appendix 3) that is based on the 2016 International Chronostratigraphic Chart (ver. 2016/04) available at http://www.stratigraphy.org/ in a slightly modified form. [The *Age* attribute table also contains numerical (Ma, mega annum or millions of years ago) values for the maximum (MAX) and minimum (MIN) ages based on the 2016 International Stratigraphic Chart. It is intended that the values allow queries over a specific age range (for example, 250–400 Ma) without having to search on the names of each age unit. This coding only contains the names of the earliest and latest age units that bound unit chronostratigraphic age.]

[ICS, International Commission on Stratigraphy; Ma, mega annum or millions of years ago; U/Pb, uranium/lead]

Field	Explanation	Data dictionary
STATE	Two letter state abbreviation (for example, NM = New Mexico).	Appendix 9
UNIT_LINK	Field entries generated by combining the STATE, SGMC_LABEL, and PROV_NO fields from the *Units* table. The purpose of this field is to create a unique value for every unit in the database. It is the linking field (key field) between all tables.	
MIN_EON **MIN_ERA** **MIN_PERIOD** **MIN_EPOCH** **MIN_AGE**	Youngest geochronological unit age (for example, Phanerozoic, Mesozoic, Jurassic, Early-Jurassic, Toarcian). Fields are populated to the lowest appropriate level.	Appendix 3
FULL_MIN	Field that concatenates all of the input from the MIN fields into a single field. Example: Phanerozoic – Mesozoic – Jurassic – Early-Jurassic – Toarcian.	Appendix 3
CMIN_AGE	The lowest-level geochronological entry from the FULL_MIN field. Example from above: Toarcian.	Appendix 3
MAX_EON **MAX_ERA** **MAX_PERIOD** **MAX_EPOCH** **MAX_AGE**	Oldest geochronological unit age (for example, Phanerozoic, Mesozoic, Jurassic, Early-Jurassic, Toarcian). Fields are populated up to the highest appropriate level.	Appendix 3
FULL_MAX	Field that concatenates all of the input from the MAX fields into a single field (just like the FULL_MIN field).	Appendix 3
CMAX_AGE	The lowest level geochronological entry from the FULL_MAX field.	Appendix 3
MIN_MA **MAX_MA**	Numerical age corresponding to the top of the youngest geochronological unit age and bottom of the oldest. Exact value if the AGE_TYPE is "Absolute." Use appendix 3 if "Relative."	Appendix 3
AGE_TYPE	Two attributes: Relative or Absolute. Relative is used if the unit is simply assigned an age or range of ages relative to the geochronological age scheme (for example, Late-Triassic or Late-Triassic to Early-Cretaceous). Absolute is used when age determination information is available (for example, an U/Pb zircon isochronological age of 455±9 Ma). Following the example, 455±9 Ma is entered in MIN_MA and MAX_MA fields; for example, maximum of 464 Ma and minimum of 446 Ma. Using the 2016 ICS time scale, these ages correspond to a maximum relative age of Darriwillian (Middle-Ordovician) and a minimum age of Hirnantian (Late-Ordovician); those designations are entered in the MIN and MAX fields. AGE_COM field is used to document the method, and corresponding references (REF_ID code from *References* table).	
AGE_COM (Age comment)	Free-form field for any additional comments about age information (for example, absolute age method used, references).	

Table 2-6. *Lithology* table attributes. One-to-many relationship with the *SGMC_Geology* feature class. The lithologic information for map units is highly variable on state maps and ranges from no information to extensive descriptions. Some state maps have explanations that are sufficiently detailed that lithology (LITH) can be coded directly from the map; in other cases, some degree of research is required to code lithology.

Field	Explanation	Data dictionary
STATE	Two letter state abbreviation (for example, NM = New Mexico).	Appendix 9
UNIT_LINK	A field generated by combining the STATE, SGMC_LABEL, and PROV_NO fields from the *Units* table. The purpose of this field is to create a unique value for every unit in the database. It is the linking field (key field) between all the tables.	
LITH_RANK	Defines the volumetric importance of the unit as interpreted from available information. Available terms: Major, Minor, Incidental, or Indeterminate, major.	
LITH1 **LITH2** **LITH3** **LITH4** **LITH5**	Primary fields for unit lithologies. Only the top most level field must be populated. Additional fields are populated depending on how far down the lithology hierarchy it is appropriate to go in order to select the appropriate term as defined in the lithology data dictionary (appendix 4).	Appendix 4
TOTAL_LITH	Field that concatenates the LITH1–LITH5 fields. An example is Sedimentary – Clastic – Mudstone – Shale – Black-shale.	Appendix 4
LOW_LITH	The lowest level lithology coded. An example from above is Black-shale.	Appendix 4
LITH_FORM	Lithology form includes a list of terms that amplify the lithology (for example, that the rhyolite is a tuff, the sandstone occurs in bed form, or that a schist is of greenschist facies). Multiple forms of the same ranked lithology are separated by commas.	Appendix 6
LITH_COM *(*Lithology comment)	Free form field for comments related to lithologic entries.	

Table 2-7. *References* table attributes. This table is a list of all references used to compile the information used in various fields of the geodatabase.

Field	Explanation	Data dictionary
STATE	Two letter state abbreviation (for example, NM = New Mexico).	Appendix 9
REF_ID	Unique identification number for each reference used in compiling the geologic map information, which is composed of the STATE field and the assigned serial number starting with 001 (for example, MA001). The reference for the state map being coded is usually the first (001) reference. REF_ID codes from the *References* table are used in the *Units* and *Unit_Ref_Link* tables and the *SGMC_Geology*, *SGMC_Structure*, and *SGMC_Points* feature classes and various comment fields.	
REFERENCE	The reference citation.	

Table 2-8. *Unit_Ref_Link* table attributes. One-to-many relationship with the *SGMC_Geology* feature class. This is a relate table that lists all of the references used to code each map unit. If three references were used to code a particular unit, then there would be three records each with the same UNIT_LINK label but with a different REF_ID entered for each. The REFERENCE citation from the *References* table is duplicated in this table to avoid having to do multiple joins. A single relate of this table to the spatial data (using UNIT_LINK) accesses reference information for each unit.

Field	Explanation	Data dictionary
STATE	Two letter state abbreviation (for example, NM = New Mexico).	Appendix 9
UNIT_LINK	A field generated by combining the STATE, SGMC_LABEL, and PROV_NO fields from the *Units* table. The purpose of this field is to create a unique value for every unit in the database. It is the linking field (key field) between all the tables.	
REF_ID	The REF_ID number from the *References* table.	
REFERENCE	The reference citation.	

Appendix 3. *Age* Table Data Dictionary

Table 3-1 provides the terms used in the *Age* table and the AGE_MIN/MAX fields of the *SGMC_Geology* feature class. The table is based on the 2016 International Chronostratigraphic Chart (v2016/04), which is available at http://www.stratigraphy.org/ in a slightly modified form.

Table 3-1. *Age* table data dictionary.

[MIN_MA, minimum Ma (mega annum or millions of years ago); MAX_MA, maximum Ma (mega annum or millions of years ago)]

EON	ERA	PERIOD	EPOCH	AGE	MIN_MA	MAX_MA
Phanerozoic					0	542
Phanerozoic	Cenozoic				0	66
Phanerozoic	Cenozoic	Quaternary			0	2.58
Phanerozoic	Cenozoic	Quaternary	Holocene		0	0.0117
Phanerozoic	Cenozoic	Quaternary	Pleistocene		0.0117	2.58
Phanerozoic	Cenozoic	Quaternary	Pleistocene	Late-Pleistocene	0.0117	0.126
Phanerozoic	Cenozoic	Quaternary	Pleistocene	Middle-Pleistocene	0.126	0.781
Phanerozoic	Cenozoic	Quaternary	Pleistocene	Calabrian	0.781	1.8
Phanerozoic	Cenozoic	Quaternary	Pleistocene	Gelasian	1.8	2.58
Phanerozoic	Cenozoic	Tertiary			2.58	66
Phanerozoic	Cenozoic	Tertiary-Neogene			2.58	23.03
Phanerozoic	Cenozoic	Tertiary-Neogene	Pliocene		2.58	5.333
Phanerozoic	Cenozoic	Tertiary-Neogene	Late-Pliocene	Piacenzian	2.58	3.6
Phanerozoic	Cenozoic	Tertiary-Neogene	Early-Pliocene	Zanclean	3.6	5.333
Phanerozoic	Cenozoic	Tertiary-Neogene	Miocene		5.333	23.03
Phanerozoic	Cenozoic	Tertiary-Neogene	Late-Miocene		5.333	11.63
Phanerozoic	Cenozoic	Tertiary-Neogene	Late-Miocene	Messinian	5.333	7.246
Phanerozoic	Cenozoic	Tertiary-Neogene	Late-Miocene	Tortonian	7.246	11.63
Phanerozoic	Cenozoic	Tertiary-Neogene	Middle-Miocene		11.63	15.97
Phanerozoic	Cenozoic	Tertiary-Neogene	Middle-Miocene	Serravallian	11.63	13.82
Phanerozoic	Cenozoic	Tertiary-Neogene	Middle-Miocene	Langhian	13.82	15.97
Phanerozoic	Cenozoic	Tertiary-Neogene	Early-Miocene		15.97	23.03
Phanerozoic	Cenozoic	Tertiary-Neogene	Early-Miocene	Burdigalian	15.97	20.44
Phanerozoic	Cenozoic	Tertiary-Neogene	Early-Miocene	Aquitanian	20.44	23.03
Phanerozoic	Cenozoic	Tertiary-Paleogene			23.03	66
Phanerozoic	Cenozoic	Tertiary-Paleogene	Oligocene		23.03	33.9
Phanerozoic	Cenozoic	Tertiary-Paleogene	Late-Oligocene	Chattian	23.03	28.1
Phanerozoic	Cenozoic	Tertiary-Paleogene	Early-Oligocene	Rupelian	28.1	33.9
Phanerozoic	Cenozoic	Tertiary-Paleogene	Eocene		33.9	56
Phanerozoic	Cenozoic	Tertiary-Paleogene	Late-Eocene	Priabonian	33.9	37.8
Phanerozoic	Cenozoic	Tertiary-Paleogene	Middle-Eocene		37.8	47.8
Phanerozoic	Cenozoic	Tertiary-Paleogene	Middle-Eocene	Bartonian	37.8	41.2
Phanerozoic	Cenozoic	Tertiary-Paleogene	Middle-Eocene	Lutetian	41.2	47.8
Phanerozoic	Cenozoic	Tertiary-Paleogene	Early-Eocene	Ypresian	47.8	56
Phanerozoic	Cenozoic	Tertiary-Paleogene	Paleocene		56	66
Phanerozoic	Cenozoic	Tertiary-Paleogene	Late-Paleocene	Thanetian	56	59.2
Phanerozoic	Cenozoic	Tertiary-Paleogene	Middle-Paleocene	Selandian	59.2	61.6

Table 3-1. *Age* table data dictionary.—Continued

[MIN_MA, minimum Ma (mega annum or millions of years ago); MAX_MA, maximum Ma (mega annum or millions of years ago)]

EON	ERA	PERIOD	EPOCH	AGE	MIN_MA	MAX_MA
Phanerozoic	Cenozoic	Tertiary-Paleogene	Early-Paleocene	Danian	61.6	66
Phanerozoic	Mesozoic				66	252.23
Phanerozoic	Mesozoic	Cretaceous			66	145.0
Phanerozoic	Mesozoic	Cretaceous	Late-Cretaceous		66	100.5
Phanerozoic	Mesozoic	Cretaceous	Late-Cretaceous	Maastrichtian	66	72.3
Phanerozoic	Mesozoic	Cretaceous	Late-Cretaceous	Campanian	72.3	83.8
Phanerozoic	Mesozoic	Cretaceous	Late-Cretaceous	Santonian	83.8	86.8
Phanerozoic	Mesozoic	Cretaceous	Late-Cretaceous	Coniacian	86.8	90.1
Phanerozoic	Mesozoic	Cretaceous	Late-Cretaceous	Turonian	90.1	93.9
Phanerozoic	Mesozoic	Cretaceous	Late-Cretaceous	Cenomanian	93.9	100.5
Phanerozoic	Mesozoic	Cretaceous	Early-Cretaceous		100.5	145.0
Phanerozoic	Mesozoic	Cretaceous	Early-Cretaceous	Albian	100.5	113
Phanerozoic	Mesozoic	Cretaceous	Early-Cretaceous	Aptian	113	125
Phanerozoic	Mesozoic	Cretaceous	Early-Cretaceous	Barremian	125	129.4
Phanerozoic	Mesozoic	Cretaceous	Early-Cretaceous	Hauterivian	129.4	132.9
Phanerozoic	Mesozoic	Cretaceous	Early-Cretaceous	Valanginian	132.9	139.8
Phanerozoic	Mesozoic	Cretaceous	Early-Cretaceous	Berriasian	139.8	145.0
Phanerozoic	Mesozoic	Jurassic			145.0	201.5
Phanerozoic	Mesozoic	Jurassic	Late-Jurassic		145.0	164.5
Phanerozoic	Mesozoic	Jurassic	Late-Jurassic	Tithonian	145.0	153
Phanerozoic	Mesozoic	Jurassic	Late-Jurassic	Kimmeridgian	153	158.3
Phanerozoic	Mesozoic	Jurassic	Late-Jurassic	Oxfordian	158.3	164.5
Phanerozoic	Mesozoic	Jurassic	Middle-Jurassic		164.5	175.1
Phanerozoic	Mesozoic	Jurassic	Middle-Jurassic	Callovian	164.5	167.3
Phanerozoic	Mesozoic	Jurassic	Middle-Jurassic	Bathonian	167.3	169.6
Phanerozoic	Mesozoic	Jurassic	Middle-Jurassic	Bajocian	169.6	171.7
Phanerozoic	Mesozoic	Jurassic	Middle-Jurassic	Aalenian	171.7	175.1
Phanerozoic	Mesozoic	Jurassic	Early-Jurassic		175.1	201.5
Phanerozoic	Mesozoic	Jurassic	Early-Jurassic	Toarcian	175.1	183.4
Phanerozoic	Mesozoic	Jurassic	Early-Jurassic	Pliensbachian	183.4	191.8
Phanerozoic	Mesozoic	Jurassic	Early-Jurassic	Sinemurian	191.8	199.6
Phanerozoic	Mesozoic	Jurassic	Early-Jurassic	Hettangian	199.6	201.5
Phanerozoic	Mesozoic	Triassic			201.5	252.23
Phanerozoic	Mesozoic	Triassic	Late-Triassic		201.5	237
Phanerozoic	Mesozoic	Triassic	Late-Triassic	Rhaetian	201.5	208.5
Phanerozoic	Mesozoic	Triassic	Late-Triassic	Norian	208.5	227
Phanerozoic	Mesozoic	Triassic	Late-Triassic	Carnian	227	237
Phanerozoic	Mesozoic	Triassic	Middle-Triassic		237	247.2
Phanerozoic	Mesozoic	Triassic	Middle-Triassic	Ladinian	237	242
Phanerozoic	Mesozoic	Triassic	Middle-Triassic	Anisian	242	247.2
Phanerozoic	Mesozoic	Triassic	Early-Triassic		247.2	252.23
Phanerozoic	Mesozoic	Triassic	Early-Triassic	Olenikian	247.2	251.2
Phanerozoic	Mesozoic	Triassic	Early-Triassic	Induan	251.2	252.23

Table 3-1. *Age* table data dictionary.—Continued

[MIN_MA, minimum Ma (mega annum or millions of years ago); MAX_MA, maximum Ma (mega annum or millions of years ago)]

EON	ERA	PERIOD	EPOCH	AGE	MIN_MA	MAX_MA
Phanerozoic	Paleozoic				252.23	542
Phanerozoic	Paleozoic	Permian			252.23	299.05
Phanerozoic	Paleozoic	Permian	Lopingian		252.23	260.2
Phanerozoic	Paleozoic	Permian	Lopingian	Changhsingian	252.23	254.21
Phanerozoic	Paleozoic	Permian	Lopingian	Wuchiapingian	254.21	260.2
Phanerozoic	Paleozoic	Permian	Guadalupian		260.2	272.8
Phanerozoic	Paleozoic	Permian	Guadalupian	Capitanian	260.2	265.5
Phanerozoic	Paleozoic	Permian	Guadalupian	Wordian	265.5	269.3
Phanerozoic	Paleozoic	Permian	Guadalupian	Roadian	269.3	272.8
Phanerozoic	Paleozoic	Permian	Cisuralian		272.8	299.05
Phanerozoic	Paleozoic	Permian	Cisuralian	Kungurian	272.8	284.1
Phanerozoic	Paleozoic	Permian	Cisuralian	Artinskian	284.1	290.36
Phanerozoic	Paleozoic	Permian	Cisuralian	Sakmarian	290.36	295.18
Phanerozoic	Paleozoic	Permian	Cisuralian	Asselian	295.18	299.05
Phanerozoic	Paleozoic	Carboniferous			299.05	359.3
Phanerozoic	Paleozoic	Carboniferous	Pennsylvanian		299.05	323.6
Phanerozoic	Paleozoic	Carboniferous	Late-Pennsylvanian		299.05	307.1
Phanerozoic	Paleozoic	Carboniferous	Late-Pennsylvanian	Gzhelian	299.05	303.8
Phanerozoic	Paleozoic	Carboniferous	Late-Pennsylvanian	Kasimovian	303.8	307.1
Phanerozoic	Paleozoic	Carboniferous	Middle-Pennsylvanian	Moscovian	307.1	315.4
Phanerozoic	Paleozoic	Carboniferous	Early-Pennsylvanian	Bashkirian	315.4	323.6
Phanerozoic	Paleozoic	Carboniferous	Mississippian		323.6	359.3
Phanerozoic	Paleozoic	Carboniferous	Late-Mississippian	Serpukhovian	323.6	331.1
Phanerozoic	Paleozoic	Carboniferous	Middle-Mississippian	Visean	331.1	347.1
Phanerozoic	Paleozoic	Carboniferous	Early-Mississippian	Tournaisian	347.1	359.3
Phanerozoic	Paleozoic	Devonian			359.3	422.4
Phanerozoic	Paleozoic	Devonian	Late-Devonian		359.3	384.3
Phanerozoic	Paleozoic	Devonian	Late-Devonian	Famennian	359.3	373.8
Phanerozoic	Paleozoic	Devonian	Late-Devonian	Frasnian	373.8	384.3
Phanerozoic	Paleozoic	Devonian	Middle-Devonian		384.3	394.5
Phanerozoic	Paleozoic	Devonian	Middle-Devonian	Givetian	384.3	388.5
Phanerozoic	Paleozoic	Devonian	Middle-Devonian	Eifelian	388.5	394.5
Phanerozoic	Paleozoic	Devonian	Early-Devonian		394.5	422.4
Phanerozoic	Paleozoic	Devonian	Early-Devonian	Emsian	394.5	410.2
Phanerozoic	Paleozoic	Devonian	Early-Devonian	Pragian	410.2	413.6
Phanerozoic	Paleozoic	Devonian	Early-Devonian	Lockhovian	413.6	422.4
Phanerozoic	Paleozoic	Silurian			422.4	445.3
Phanerozoic	Paleozoic	Silurian	Pridoli		422.4	425.3
Phanerozoic	Paleozoic	Silurian	Ludlow		425.3	427.9
Phanerozoic	Paleozoic	Silurian	Ludlow	Ludfordian	425.3	426.5
Phanerozoic	Paleozoic	Silurian	Ludlow	Gorstian	426.5	427.9
Phanerozoic	Paleozoic	Silurian	Wenlock		427.9	434.2

Table 3-1. *Age* table data dictionary.—Continued

[MIN_MA, minimum Ma (mega annum or millions of years ago); MAX_MA, maximum Ma (mega annum or millions of years ago)]

EON	ERA	PERIOD	EPOCH	AGE	MIN_MA	MAX_MA
Phanerozoic	Paleozoic	Silurian	Wenlock	Homerian	427.9	431.2
Phanerozoic	Paleozoic	Silurian	Wenlock	Sheinwoodian	431.2	434.2
Phanerozoic	Paleozoic	Silurian	Llandovery		434.2	445.3
Phanerozoic	Paleozoic	Silurian	Llandovery	Telychian	434.2	439.6
Phanerozoic	Paleozoic	Silurian	Llandovery	Aeronian	439.6	442
Phanerozoic	Paleozoic	Silurian	Llandovery	Rhuddanian	442	445.3
Phanerozoic	Paleozoic	Ordovician			445.3	487.3
Phanerozoic	Paleozoic	Ordovician	Late-Ordovician		445.3	459.3
Phanerozoic	Paleozoic	Ordovician	Late-Ordovician	Hirnantian	445.3	446.6
Phanerozoic	Paleozoic	Ordovician	Late-Ordovician	Katian	446.6	453.7
Phanerozoic	Paleozoic	Ordovician	Late-Ordovician	Sandbian	453.7	459.3
Phanerozoic	Paleozoic	Ordovician	Middle-Ordovician		459.3	471.4
Phanerozoic	Paleozoic	Ordovician	Middle-Ordovician	Darriwillian	459.3	468.4
Phanerozoic	Paleozoic	Ordovician	Middle-Ordovician	Dapingian	468.4	471.4
Phanerozoic	Paleozoic	Ordovician	Early-Ordovician		471.4	487.3
Phanerozoic	Paleozoic	Ordovician	Early-Ordovician	Floian	471.4	479.1
Phanerozoic	Paleozoic	Ordovician	Early-Ordovician	Tremadocian	479.1	487.3
Phanerozoic	Paleozoic	Cambrian			487.3	542
Phanerozoic	Paleozoic	Cambrian	Furongian		487.3	497
Phanerozoic	Paleozoic	Cambrian	Middle-Cambrian		497	521
Phanerozoic	Paleozoic	Cambrian	Early-Cambrian		521	542
preCambrian					542	4600
preCambrian-Proterozoic					542	2500
preCambrian-Proterozoic	Neoproterozoic				542	1000
preCambrian-Proterozoic	Neoproterozoic	Ediacaran			542	635
preCambrian-Proterozoic	Neoproterozoic	Cryogenian			635	720
preCambrian-Proterozoic	Neoproterozoic	Tonian			720	1000
preCambrian-Proterozoic	Mesoproterozoic				1000	1600
preCambrian-Proterozoic	Mesoproterozoic	Stenian			1000	1200
preCambrian-Proterozoic	Mesoproterozoic	Ectasian			1200	1400
preCambrian-Proterozoic	Mesoproterozoic	Calymmian			1400	1600
preCambrian-Proterozoic	Paleoproterozoic				1600	2500
preCambrian-Proterozoic	Paleoproterozoic	Statherian			1600	1800
preCambrian-Proterozoic	Paleoproterozoic	Orosirian			1800	2050
preCambrian-Proterozoic	Paleoproterozoic	Rhyacian			2050	2300
preCambrian-Proterozoic	Paleoproterozoic	Siderian			2300	2500
preCambrian-Archean					2500	4000
preCambrian-Archean	Neoarchean				2500	2800
preCambrian-Archean	Mesoarchean				2800	3200
preCambrian-Archean	Paleoarchean				3200	3600
preCambrian-Archean	Eoarchean				3600	4000
preCambrian-Hadean					4000	4600

Appendix 4. LITH1–LITH5 (*Lithology* Table) Data Dictionary

Table 4-1 provides the terms used in the LITH1–LITH5 fields of the *Lithology* table and the MAJOR1–3, MINOR1–5, INCIDENTAL, and INDETERMINATE fields of the *SGMC_Geology* feature class. Hierarchical structure from generalized (LITH1) to more specific (LITH2–LITH5).

Table 4-1. LITH1–LITH5 (*Lithology* table) data dictionary.

LITH1	LITH2	LITH3	LITH4	LITH5
Unconsolidated				
Unconsolidated	Coarse-detrital			
Unconsolidated	Coarse-detrital	Boulders		
Unconsolidated	Coarse-detrital	Gravel		
Unconsolidated	Coarse-detrital	Sand		
Unconsolidated	Fine-detrital			
Unconsolidated	Fine-detrital	Clay		
Unconsolidated	Fine-detrital	Silt		
Unconsolidated	Coral			
Unconsolidated	Marl			
Unconsolidated	Peat			
Sedimentary				
Sedimentary	Clastic			
Sedimentary	Clastic	Mixed-clastic		
Sedimentary	Clastic	Mixed-clastic	Conglomerate-mudstone	
Sedimentary	Clastic	Mixed-clastic	Conglomerate-sandstone	
Sedimentary	Clastic	Mixed-clastic	Sandstone-mudstone	
Sedimentary	Clastic	Mixed-clastic	Siltstone-mudstone	
Sedimentary	Clastic	Conglomerate		
Sedimentary	Clastic	Sandstone		
Sedimentary	Clastic	Sandstone	Arenite	
Sedimentary	Clastic	Sandstone	Arenite	Calcarenite
Sedimentary	Clastic	Sandstone	Arkose	
Sedimentary	Clastic	Sandstone	Graywacke	
Sedimentary	Clastic	Siltstone		
Sedimentary	Clastic	Mudstone		
Sedimentary	Clastic	Mudstone	Claystone	
Sedimentary	Clastic	Mudstone	Claystone	Bentonite
Sedimentary	Clastic	Mudstone	Shale	
Sedimentary	Clastic	Mudstone	Shale	Black-shale
Sedimentary	Clastic	Mudstone	Shale	Oil-shale
Sedimentary	Clastic	Mudstone	Shale	Phosphatic-shale
Sedimentary	Clastic	Sedimentary-breccia		
Sedimentary	Carbonate			
Sedimentary	Carbonate	Dolostone		
Sedimentary	Carbonate	Limestone		
Sedimentary	Carbonate	Limestone	Chalk	

Table 4-1. LITH1–LITH5 (*Lithology* table) data dictionary.—Continued

LITH1	LITH2	LITH3	LITH4	LITH5
Sedimentary	Carbonate	Limestone	Coquina	
Sedimentary	Carbonate	Marlstone		
Sedimentary	Chemical			
Sedimentary	Chemical	Banded-iron-formation		
Sedimentary	Chemical	Chert		
Sedimentary	Chemical	Diatomite		
Sedimentary	Chemical	Evaporite		
Sedimentary	Chemical	Evaporite	Anhydrite	
Sedimentary	Chemical	Evaporite	Gypsum	
Sedimentary	Chemical	Evaporite	Salt	
Sedimentary	Chemical	Novaculite		
Sedimentary	Chemical	Phosphorite		
Sedimentary	Coal			
Sedimentary	Coal	Anthracite		
Sedimentary	Coal	Bituminous		
Sedimentary	Coal	Lignite		
Sedimentary	Coal	Sub-bituminous		
Igneous				
Igneous	Plutonic			
Igneous	Plutonic	Granitic		
Igneous	Plutonic	Granitic	Alkali-feldspar-granite	
Igneous	Plutonic	Granitic	Alkali-feldspar-granite	Alkali-granite
Igneous	Plutonic	Granitic	Granite	
Igneous	Plutonic	Granitic	Granite	Monzogranite
Igneous	Plutonic	Granitic	Granite	Syenogranite
Igneous	Plutonic	Granitic	Granodiorite	
Igneous	Plutonic	Granitic	Leucocratic-granitic	
Igneous	Plutonic	Granitic	Leucocratic-granitic	Alaskite
Igneous	Plutonic	Granitic	Leucocratic-granitic	Aplite
Igneous	Plutonic	Granitic	Leucocratic-granitic	Pegmatite
Igneous	Plutonic	Granitic	Tonalite	
Igneous	Plutonic	Granitic	Tonalite	Trondhjemite
Igneous	Plutonic	Charnockite		
Igneous	Plutonic	Syenitic		
Igneous	Plutonic	Syenitic	Alkali-feldspar-syenite	
Igneous	Plutonic	Syenitic	Monzonite	
Igneous	Plutonic	Syenitic	Quartz-alkali-feldspar-syenite	
Igneous	Plutonic	Syenitic	Quartz-monzonite	
Igneous	Plutonic	Syenitic	Quartz-syenite	
Igneous	Plutonic	Syenitic	Syenite	
Igneous	Plutonic	Dioritic		
Igneous	Plutonic	Dioritic	Diorite	

Table 4-1. LITH1–LITH5 (*Lithology* table) data dictionary.—Continued

LITH1	LITH2	LITH3	LITH4	LITH5
Igneous	Plutonic	Dioritic	Monzodiorite	
Igneous	Plutonic	Dioritic	Quartz-monzodiorite	
Igneous	Plutonic	Dioritic	Quartz-diorite	
Igneous	Plutonic	Gabbroic		
Igneous	Plutonic	Gabbroic	Gabbro	
Igneous	Plutonic	Gabbroic	Gabbro	Norite
Igneous	Plutonic	Gabbroic	Gabbro	Troctolite
Igneous	Plutonic	Gabbroic	Quartz-gabbro	
Igneous	Plutonic	Anorthosite		
Igneous	Plutonic	Ultramafic		
Igneous	Plutonic	Ultramafic	Hornblendite	
Igneous	Plutonic	Ultramafic	Peridotite	
Igneous	Plutonic	Ultramafic	Peridotite	Dunite
Igneous	Plutonic	Ultramafic	Peridotite	Kimberlite
Igneous	Plutonic	Ultramafic	Pyroxenite	
Igneous	Plutonic	Foidal-syenitic		
Igneous	Plutonic	Foidal-syenitic	Foid-syenite	
Igneous	Plutonic	Foidal-syenitic	Nepheline-syenite	
Igneous	Plutonic	Intrusive-carbonatite		
Igneous	Hypabyssal			
Igneous	Hypabyssal	Felsic-hypabyssal		
Igneous	Hypabyssal	Felsic-hypabyssal	Hypabyssal-dacite	
Igneous	Hypabyssal	Felsic-hypabyssal	Hypabyssal-felsic-alkaline	
Igneous	Hypabyssal	Felsic-hypabyssal	Hypabyssal-latite	
Igneous	Hypabyssal	Felsic-hypabyssal	Hypabyssal-quartz-latite	
Igneous	Hypabyssal	Felsic-hypabyssal	Hypabyssal-quartz-trachyte	
Igneous	Hypabyssal	Felsic-hypabyssal	Hypabyssal-rhyolite	
Igneous	Hypabyssal	Felsic-hypabyssal	Hypabyssal-trachyte	
Igneous	Hypabyssal	Mafic-hypabyssal		
Igneous	Hypabyssal	Mafic-hypabyssal	Hypabyssal-andesite	
Igneous	Hypabyssal	Mafic-hypabyssal	Hypabyssal-basalt	
Igneous	Hypabyssal	Mafic-hypabyssal	Hypabyssal-basaltic-andesite	
Igneous	Hypabyssal	Mafic-hypabyssal	Hypabyssal-mafic-alkaline	
Igneous	Hypabyssal	Lamprophyre		
Igneous	Volcanic			
Igneous	Volcanic	Alkalic-volcanic		
Igneous	Volcanic	Alkalic-volcanic	Basanite	
Igneous	Volcanic	Alkalic-volcanic	Foidite	
Igneous	Volcanic	Alkalic-volcanic	Phonolite	
Igneous	Volcanic	Felsic-volcanic		
Igneous	Volcanic	Felsic-volcanic	Dacite	
Igneous	Volcanic	Felsic-volcanic	Latite	

Table 4-1. LITH1–LITH5 (*Lithology* table) data dictionary.—Continued

LITH1	LITH2	LITH3	LITH4	LITH5
Igneous	Volcanic	Felsic-volcanic	Quartz-latite	
Igneous	Volcanic	Felsic-volcanic	Quartz-trachyte	
Igneous	Volcanic	Felsic-volcanic	Rhyolite	
Igneous	Volcanic	Felsic-volcanic	Trachyte	
Igneous	Volcanic	Mafic-volcanic		
Igneous	Volcanic	Mafic-volcanic	Andesite	
Igneous	Volcanic	Mafic-volcanic	Basalt	
Igneous	Volcanic	Mafic-volcanic	Basaltic-andesite	
Igneous	Volcanic	Ultramafic		
Igneous	Volcanic	Ultramafic	Komatiite	
Igneous	Volcanic	Ultramafic	Picrite	
Metamorphic				
Metamorphic	Amphibolite			
Metamorphic	Eclogite			
Metamorphic	Gneiss			
Metamorphic	Gneiss	Biotite-gneiss		
Metamorphic	Gneiss	Calc-silicate-gneiss		
Metamorphic	Gneiss	Hornblende-gneiss		
Metamorphic	Gneiss	Muscovite-gneiss		
Metamorphic	Granoblastic			
Metamorphic	Granoblastic	Granofels		
Metamorphic	Granoblastic	Hornfels		
Metamorphic	Granulite			
Metamorphic	Metaigneous			
Metamorphic	Metaigneous	Greenstone		
Metamorphic	Metaigneous	Metaintrusive		
Metamorphic	Metaigneous	Metaintrusive	Metaanorthosite	
Metamorphic	Metaigneous	Metaintrusive	Metadiabase	
Metamorphic	Metaigneous	Metaintrusive	Metadiorite	
Metamorphic	Metaigneous	Metaintrusive	Metagabbro	
Metamorphic	Metaigneous	Metaintrusive	Metagranite	
Metamorphic	Metaigneous	Metaintrusive	Metatonalite	
Metamorphic	Metaigneous	Metaintrusive	Metatonalite	Metatrondhjemite
Metamorphic	Metaigneous	Metaintrusive	Metaultramafic	
Metamorphic	Metaigneous	Metaintrusive	Metaultramafic	Metadunite
Metamorphic	Metaigneous	Metaintrusive	Metaultramafic	Metaperidotite
Metamorphic	Metaigneous	Metaintrusive	Metaultramafic	Metapyroxenite
Metamorphic	Metaigneous	Metavolcanic		
Metamorphic	Metaigneous	Metavolcanic	Metaandesite	
Metamorphic	Metaigneous	Metavolcanic	Metabasalt	
Metamorphic	Metaigneous	Metavolcanic	Metadacite	
Metamorphic	Metaigneous	Metavolcanic	Metarhyolite	

Table 4-1. LITH1–LITH5 (*Lithology* table) data dictionary.—Continued

LITH1	LITH2	LITH3	LITH4	LITH5
Metamorphic	Metaigneous	Orthogneiss		
Metamorphic	Metaigneous	Serpentinite		
Metamorphic	Metasedimentary			
Metamorphic	Metasedimentary	Calc-silicate-rock		
Metamorphic	Metasedimentary	Metacarbonate		
Metamorphic	Metasedimentary	Metacarbonate	Marble	
Metamorphic	Metasedimentary	Metaclastic		
Metamorphic	Metasedimentary	Metaclastic	Argillite	
Metamorphic	Metasedimentary	Metaclastic	Metaconglomerate	
Metamorphic	Metasedimentary	Metaclastic	Metasandstone	
Metamorphic	Metasedimentary	Metaclastic	Metasandstone	Metagraywacke
Metamorphic	Metasedimentary	Metaclastic	Metasiltstone	
Metamorphic	Metasedimentary	Metaclastic	Phyllite	
Metamorphic	Metasedimentary	Metaclastic	Quartzite	
Metamorphic	Metasedimentary	Metaclastic	Slate	
Metamorphic	Metasedimentary	Paragneiss		
Metamorphic	Migmatite			
Metamorphic	Schist			
Metamorphic	Schist	Amphibole-schist		
Metamorphic	Schist	Calc-silicate-schist		
Metamorphic	Schist	Pelitic-schist		
Metamorphic	Schist	Mica-schist		
Metamorphic	Schist	Mica-schist	Biotite-schist	
Metamorphic	Schist	Mica-schist	Muscovite-schist	
Metamorphic	Schist	Quartz-feldspar-schist		
Metamorphic	Hydrothermally-altered			
Metamorphic	Hydrothermally-altered	Skarn		
Metamorphic	Hydrothermally-altered	Spilite		
Tectonite				
Tectonite	Cataclasite			
Tectonite	Mylonite			
Tectonite	Mylonite	Phyllonite		
Tectonite	Melange			
Ice				

Appendix 5. DESCRIPTION (*SGMC_Structure* Feature Class) Data Dictionary

Table 5-1 provides terms used in the DESCRIPTION and RULE_ID fields of the *SGMC_Structure* feature class.

Table 5-1. DESCRIPTION (*SGMC_Structure* feature class) data dictionary.

[MISC, miscellaneous field; U/D, up/down]

RuleID	Description
1	Undefined type; generic line symbol; (see MISC column)
2	Anticline, approximate
3	Anticline, certain
4	Anticline, concealed
5	Anticline, inferred, queried
6	Anticline, inverted, certain
7	Anticline, overturned, certain
8	Contact, certain
9	Contact, concealed
10	Contact, unconformity
11	Detachment fault, approximate
12	Detachment fault, certain
13	Detachment fault, concealed
14	Dike or sill, felsic
15	Dike or sill, lamprophyre
16	Dike or sill, mafic and felsic
17	Dike or sill, mafic
18	Dike or sill, unspecified
19	Vein
20	Esker
21	Fault, sense of displacement unknown or undefined, approximate
22	Fault, sense of displacement unknown or undefined, certain
23	Fault, sense of displacement unknown or undefined, concealed
24	Fault, sense of displacement unknown or undefined, inferred or queried
25	Fold, unknown type, approximate
26	Fold, unknown type, certain
27	Fold, unknown type, concealed
28	Fold, unknown type, inferred, queried
29	High-angle reverse fault, (teeth on right from origin), certain
30	High-angle reverse fault, (teeth on right from origin), approximate
31	High-angle reverse fault, (teeth on right from origin), concealed
50	High-angle reverse fault, having left lateral oblique slip, certain
32	Ice contact (glacier limit)
33	Left lateral fault, approximate
34	Left lateral fault, certain
35	Left lateral fault, concealed
36	Left lateral fault, inferred or queried
37	Lineament

Table 5-1. DESCRIPTION (*SGMC_Structure* feature class) data dictionary.—Continued

[MISC, miscellaneous field; U/D, up/down]

RuleID	Description
38	Monocline, approximate
39	Monocline, certain
40	Monocline, concealed
41	Monocline, inferred or queried
21	Normal fault, approximate
42	Normal fault, approximate, (U/D designated in source)
22	Normal fault, certain
43	Normal fault, certain, (U/D designated in source)
23	Normal fault, concealed
44	Normal fault, concealed, (U/D designated in source)
45	Normal fault, having left lateral oblique slip, certain
46	Normal fault, having right lateral oblique slip, certain
47	Normal fault, having right lateral oblique slip, concealed
24	Normal fault, inferred or queried
48	Normal fault, inferred or queried, (U/D designated in source)
22	Normal fault, overturned, certain
49	Right lateral fault, approximate
50	Right lateral fault, certain
51	Right lateral fault, concealed
52	Right lateral fault, inferred or queried
53	Scarp
54	Shear zone
55	Shoreline or riverbank
22	Strike slip fault, motion unknown, certain
56	Syncline, approximate
57	Syncline, certain
58	Syncline, concealed
59	Syncline, inferred or queried
60	Syncline, inverted, certain
61	Syncline, overturned, certain
62	Thrust fault, approximate, (teeth on right from origin)
63	Thrust fault, certain, (teeth on right from origin)
64	Thrust fault, concealed, (teeth on right from origin)
22	Thrust fault, direction of motion undefined, certain
23	Thrust fault, direction of motion undefined, concealed
50	Thrust fault, having right lateral oblique slip, certain
65	Thrust fault, inferred or queried, (teeth on right from origin)
66	Thrust fault, overturned, certain, (teeth on right from origin)
21	Thrust fault, reactivated with normal motion, approximate
22	Thrust fault, reactivated with normal motion, certain
23	Thrust fault, reactivated with normal motion, concealed

Appendix 6. LITH_FORM (*Lithology* Table) Data Dictionary

Table 6-1 provides terms used in the LITH_FORM field of the *Lithology* table.

Table 6-1. LITH_FORM (*Lithology* table) data dictionary.

LITH1	LITH_FORM
Unconsolidated	
Unconsolidated	Alluvial
Unconsolidated	Beach
Unconsolidated	Bed
Unconsolidated	Colluvial
Unconsolidated	Eolian
Unconsolidated	Eolian-loess
Unconsolidated	Estuarine
Unconsolidated	Fluvial
Unconsolidated	Glacial
Unconsolidated	Glacial-esker
Unconsolidated	Glacial-outwash
Unconsolidated	Glacial-till
Unconsolidated	Lacustrine
Unconsolidated	Landslide
Unconsolidated	Mass wasting
Unconsolidated	Playa
Unconsolidated	Swamp
Unconsolidated	Terrace
Unconsolidated	Terrace-marine
Unconsolidated	Terrace-stream
Sedimentary	
Sedimentary	Arkosic
Sedimentary	Bed
Sedimentary	Calcareous
Sedimentary	Carbonaceous
Sedimentary	Deltaic
Sedimentary	Glauconitic
Sedimentary	Lens
Sedimentary	Melange
Sedimentary	Olistrostrome
Sedimentary	Reef
Sedimentary	Tuffaceous
Igneous	
Igneous	Batholith
Igneous	Diabase
Igneous	Dike or sill
Igneous	Dome
Igneous	Flow

Table 6-1. LITH_FORM (*Lithology* table) data dictionary.—Continued

LITH1	LITH_FORM
Igneous	Flow-pillows
Igneous	Laccolith
Igneous	Melange
Igneous	Pluton
Igneous	Pyroclastic
Igneous	Pyroclastic-air fall
Igneous	Pyroclastic-ash flow
Igneous	Pyroclastic-cinder cone
Igneous	Pyroclastic-tuff
Igneous	Stock or pipe
Igneous	Volcaniclastic
Igneous	Volcaniclastic-lahar
Igneous	Volcaniclastic-volcanic breccia
Metamorphic	
Metamorphic	Amphibolite
Metamorphic	Amphibolite epidote-amphibolite
Metamorphic	Blueschist
Metamorphic	Eclogite
Metamorphic	Glaucophane-schist
Metamorphic	Granulite
Metamorphic	Greenschist
Metamorphic	Hornfels
Metamorphic	Zeolitic (prehnite-pumpellyite)
Ice	
Ice	Mass

Appendix 7. Geologic Age Symbols (SGMC_LABEL in *Units* Table) Data Dictionary

Table 7-1 provides the geologic age symbols used in the SGMC_LABEL (*SGMC_Geology* feature class and *Units* table) and in all the UNIT_LINK fields.

Table 7-1. Geologic age symbols (SGMC_LABEL in *Units* table) data dictionary.

[Ma, million years ago]

Symbol	Age
PH	Phanerozoic
CZ	Cenozoic
Q	Quaternary
H	Holocene
PS	Pleistocene
T	Tertiary
N	Neogene
PE	Paleogene
PO	Pliocene
MI	Miocene
OG	Oligocene
EO	Eocene
PN	Paleocene
MZ	Mesozoic
K	Cretaceous
J	Jurassic
TR	Triassic
PZ	Paleozoic
P	Permian
C	Carboniferous
PA	Pennsylvanian
M	Mississippian
D	Devonian
S	Silurian
O	Ordovician
CA	Cambrian
pCA	Precambrian
PR	Proterozoic
Z	Neoproterozoic (1,000–542 Ma)
Y	Mesoproterozoic (1,600–1,000 Ma)
Y3	Late Mesoproterozoic (1,200–1,000 Ma)
Y2	Middle Mesoproterozoic (1,400–1,200 Ma)
Y1	Early Mesoproterozoic (1,600–1,400 Ma)
X	Paleoproterozoic (2,500–1,600 Ma)
X3	Late Paleoproterozoic (1,800–1,600 Ma)
X2	Middle Paleoproterozoic (2,300–1,800 Ma)
X1	Early Paleoproterozoic (2,500–2,300 Ma)
A	Archean (4,000–2,500 Ma)
W	Neoarchean (2,800–2,500 Ma)
V	Mesoarchean (3,200–2,800 Ma)
U	Paleo-Eoarchean (4,000–3,200 Ma)
pA	Pre-Archean (Hadean) (>4,000 Ma)

Appendix 8. GENERALIZED_LITH (*SGMC_Geology* Feature Class) Data Dictionary

Table 8-1 provides terms used in the GENERALIZED_LITH field of the *SGMC_Geology* feature class.

Table 8-1. GENERALIZED_LITH (*SGMC_Geology* feature class) data dictionary.

Dam
Ice
Igneous and Metamorphic, undifferentiated
Igneous and Sedimentary, undifferentiated
Igneous, intrusive
Igneous, undifferentiated
Igneous, volcanic
Melange
Metamorphic and Sedimentary, undifferentiated
Metamorphic, amphibolite
Metamorphic, carbonate
Metamorphic, gneiss
Metamorphic, granulite
Metamorphic, igneous
Metamorphic, intrusive
Metamorphic, other
Metamorphic, schist
Metamorphic, sedimentary
Metamorphic, sedimentary clastic
Metamorphic, serpentinite
Metamorphic, undifferentiated
Metamorphic, volcanic
Sedimentary, carbonate
Sedimentary, chemical
Sedimentary, clastic
Sedimentary, evaporite
Sedimentary, iron formation, undifferentiated
Sedimentary, undifferentiated
Tectonite, undifferentiated
Unconsolidated and Sedimentary, undifferentiated
Unconsolidated, undifferentiated
Unknown
Water

Appendix 9. State Abbreviations

Table 9-1 provides the State abbreviations used in the STATE fields of all feature classes and tables.

Table 9-1. State abbreviations.

State	Symbol
Alabama	AL
Arizona	AZ
Arkansas	AR
California	CA
Colorado	CO
Connecticut	CT
Delaware	DE
Florida	FL
Georgia	GA
Idaho	ID
Illinois	IL
Indiana	IN
Iowa	IA
Kansas	KS
Kentucky	KY
Louisiana	LA
Maine	ME
Maryland	MD
Massachusetts	MA
Michigan	MI
Minnesota	MN
Mississippi	MS
Missouri	MO
Montana	MT

State	Symbol
Nebraska	NE
Nevada	NV
New Hampshire	NH
New Jersey	NJ
New Mexico	NM
New York	NY
North Carolina	NC
North Dakota	ND
Ohio	OH
Oklahoma	OK
Oregon	OR
Pennsylvania	PA
Rhode Island	RI
South Carolina	SC
South Dakota	SD
Tennessee	TN
Texas	TX
Utah	UT
Vermont	VT
Virginia	VA
Washington	WA
West Virginia	WV
Wisconsin	WI
Wyoming	WY

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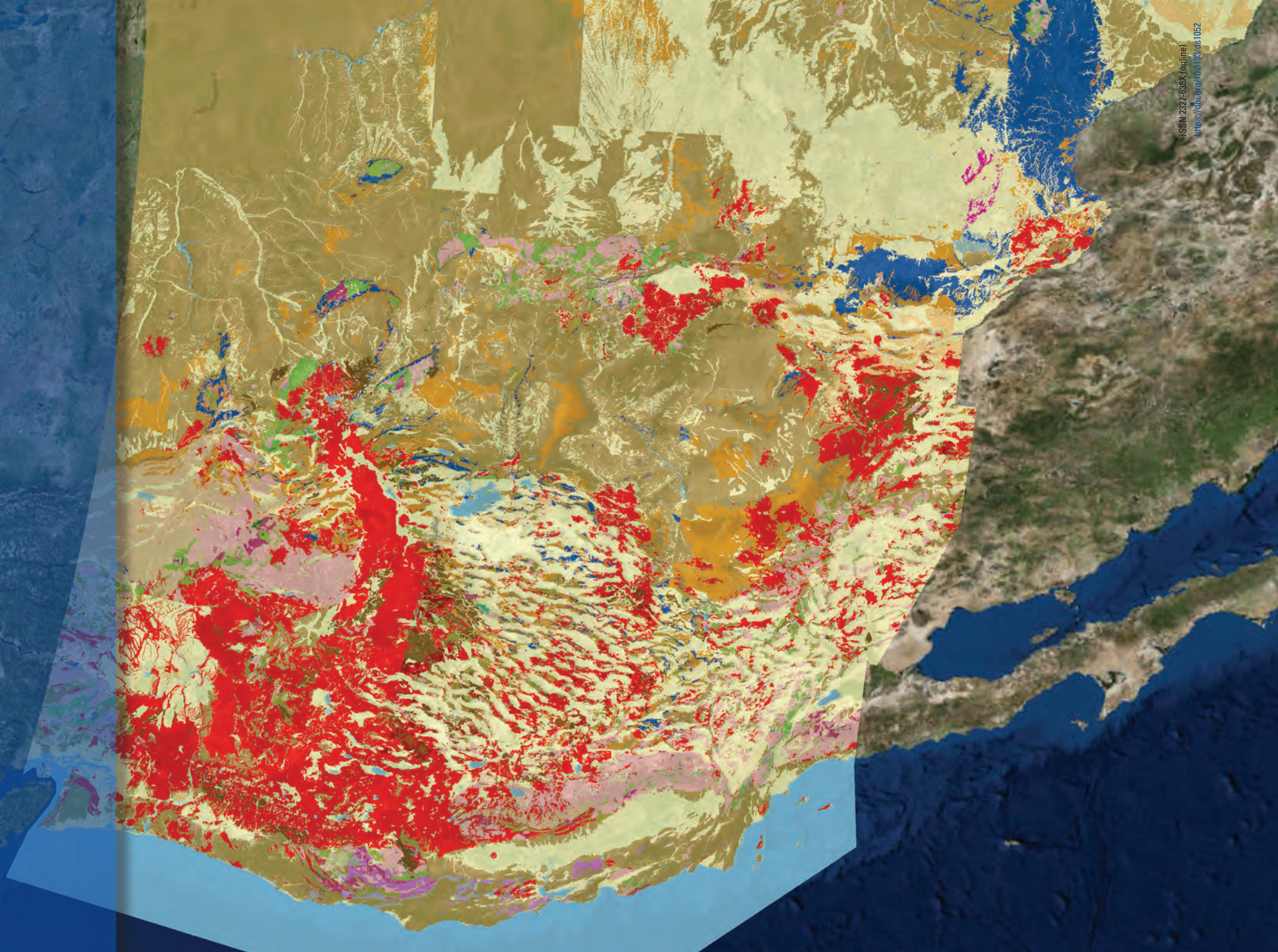

ISSN 2327-638X (online)
https://doi.org/10.3133/ds1052