Preliminary Integrated Geologic Map Databases for the United States:

Ohio, Kentucky, Tennessee, and West Virginia

Background Information and Documentation

Version 1.0

This report has not been reviewed for geologic or stratigraphic nomenclature.

CONTENTS

APPENDICES: DATA DICTIONARIES

INTRODUCTION

The exponential growth in the use of Geographic Information Systems (GIS) has highlighted the need for regional and national digital geologic maps that have standardized information about age and lithology. Such maps can be conveniently used to generate derivative maps for manifold special purposes such as mineral-resource assessment, metallogenic studies, tectonic studies, and environmental research. Although two digital geologic maps (Schruben and others, 1994; Reed and Bush, 2004) of the United States currently exist, their scales (1:2,500,000 and 1:5,000,000) are too general for many regional applications. Most states have digital geologic maps at scales of about 1:500,000, but the databases are not comparably structured and, thus, it is difficult to use the digital database for more than one state at a time. This report describes an effort by the U.S. Geological Survey to produce a series of integrated and standardized state geologic map databases that cover the entire United States.

In 1997, the United States Geological Survey's Mineral Resources Program initiated the National Surveys and Analysis (NSA) Project to develop national digital databases. One primary activity of this project was to compile a national digital geologic map database, utilizing state geologic maps, to support studies in the range of 1:250,000- to 1:1,000,000-scale. In order to accomplish this, state databases were prepared using a common standard for the database structure, fields, attribution, and data dictionaries. For Alaska and Hawaii new state maps are being prepared and the preliminary work for Alaska is being released as a series of 1:250,000 scale quadrangle reports.

This document provides the basic background and documentation for the state digital geologic map databases of this report. This report is one of a series of such reports releasing preliminary standardized geologic map databases for the United States. The data products of the project consist of two main parts, the spatial databases and a set of supplemental tables relating to geologic map units. Collectively the datasets do not represent a single map, but rather serve as a data resource to generate a variety of stratigraphic, age, and lithologic maps.

This documentation is divided into four main sections: (1) description of the set of data files provided in this report, (2) specifications of the spatial databases, (3) specifications of the supplemental tables, and (4) an appendix containing the data dictionaries used to populate some fields of the spatial database and supplemental tables.

GENERAL PROCEDURES

The first stage in developing state databases for the conterminous United States (CONUS, i.e. the contiguous 48 states) was to acquire digital versions of all existing state geologic maps. Although a significant number of digital state maps already existed, a number of states lacked them. Of the four states in this report, West Virginia has a digital state map and for the other three states, digital compilations were prepared by digitizing existing printed maps either in cooperation with the respective state geologic survey (e.g. Ohio) or by the USGS (e.g. Kentucky and Tennessee).

The second stage was to assign values to database fields for each state digital map database, using common data dictionaries and a standard data structure. The spatial databases are accompanied by supplemental map unit-, lithologic-, and age-attribute tables to provide for the generation of derivative maps. When the spatial databases are merged, these tables allow development of regional derivative maps based on stratigraphy, lithology and age. No attempt was made to reconcile differences in mapped geology between contiguous states.

All state databases were fit to a state boundary ARC/INFO coverage derived from the USGS 100k scale Digital Line Graphics (DLG) boundary layer quadrangles (B.R. Johnson and Beth Leveritch, written commun., 1998). This coverage has a polygon for each of the conterminous 48 states. The purpose of fitting is so that adjoining state databases can be merged to form regional digital maps without slivers or overlaps at the state boundaries. Existing state databases were fitted to the U.S. state boundary coverage by examining arcs along the boundary and extending or clipping them to boundary depending on whether the arcs under or overshoot the boundary arc. No “rubber sheeting” was used. Data dictionaries that were used to populate some fields of the attribute tables (Appendices 1-7) list permitted terms that can occur in the specified fields. General conventions used through this document are to show table names in capitals (e.g. STUNITS), and field names of tables in italics (e.g. *unit_name*).

The term “coverage” is used in this document because the data presented in this series are in Environmental System Research Institute (ESRI) coverage (as export files) and shapefile formats. A coverage is a proprietary ESRI format and is defined as “a digital version of a map forming the basic unit of vector data storage in ARC/INFO” (ESRI, 1997). It is a “set of thematically associated data considered as a unit. A coverage usually represents a single theme” (here such as geologic units, dikes, or faults). A coverage stores map features as primary features (such as arcs, nodes, polygons, and label points) and secondary features (such as tics, map extent, links, and annotation). Associated feature attribute tables describe and store attributes of the map features. The attribute tables are referred to as the PAT (polygon or point attribute table) and AAT (arc attribute table).

The shapefile format is an open format used by the ESRI ArcView and ArcGIS programs as well as other GIS programs and consists of a main file (.shp), an index file (.shx), and a table of attribute data (.dbf) (ESRI, 1998). Shapefiles can be viewed with the free viewer, ArcExplorer, which can be downloaded from http://www.esri.com/software/arcexplorer. The spatial data files are delivered both as coverages in ESRI’s export format (.e00) and as polygon and arc shapefiles, as is needed to recreate the geologic spatial data.

NATURE AND LIMITATIONS OF SOURCE DATA

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, the chief of which are:

1. *Differences in scale.* State geologic maps range in scale from 1:100,000 to 1:1,000,000. Thus, when data from contiguous states at different scales are merged, these scale differences may result in one state having significantly more detail at the boundary than the other and, thus, contacts and other linear features generally do not match.
2. *Differences in combined map units.* Because state geologic maps are typically published at a scale of 1:250,000 or smaller (1:500,000, 1:1,000,000 etc.), they represent considerable simplification of more detailed source maps from which they were originally compiled. It is typical for state maps to have map units composed of multiple formations, but if adjoining states have combined formations or geologic units differently, then contacts will not match along state boundaries. 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.

3. *Differences in exposure.* There is a distinct difference in state map type between eastern and western states. In the east, because of limited bedrock exposure 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 bedrock exposure is 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.

For these and other reasons, many of the contacts at state boundaries do not match contacts in adjoining states. Unfortunately to resolve most of these differences and eliminate "State boundary faults" would require that the source maps be recompiled to a common standard which is far beyond the resources of this effort. Thus, we have made no attempt rectify or resolve boundary mismatches. In general, other than basic error correction, 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 is described in the metadata accompanying each state database.

Standard File Set

The files supplied with each database consist of: (1) one or more spatial databases, and (2) a set of related supplemental tables (Table 1, Figure 1). Each state dataset has the same database structure and attribution fields using standardized data dictionaries. At a minimum, the standard file set consists of a geology (polygon) database, metadata, and three supplemental attribute tables; however, additional spatial databases for other line or point features present on the source map may also be included (e.g. faults, dikes, fold axes, volcanic vents, etc.).

Specifications and details for the standard database set are explained below in the "Database Data Structure" section. The spatial databases are provided in ESRI ARC export (.e00) and shapefile (.shp)formats. All spatial databases are provided both in geographic coordinates and a Lambert Conformal Conic projection (Table 2). The spatial database metadata is provided in three formats, ASCII text (.txt), Microsoft Word (.doc), and HTML (.htm).

The supplemental data consist of three related attribute tables; units (STUNITS), age (STAGE), and lithology (STLITH), and two additional tables (STREF and STREF-LINK) by which mapped items are linked to bibliographic references (fig. 1). The tables provide standardized attribution for the geologic map units for each map. These tables are described in detail in the "Supplemental Attribute Tables" section of this report. These tables are available in comma-separated value (csv.), ASCII (.csv), dBASE (.dbf), and FileMaker Pro (.fp5) formats.

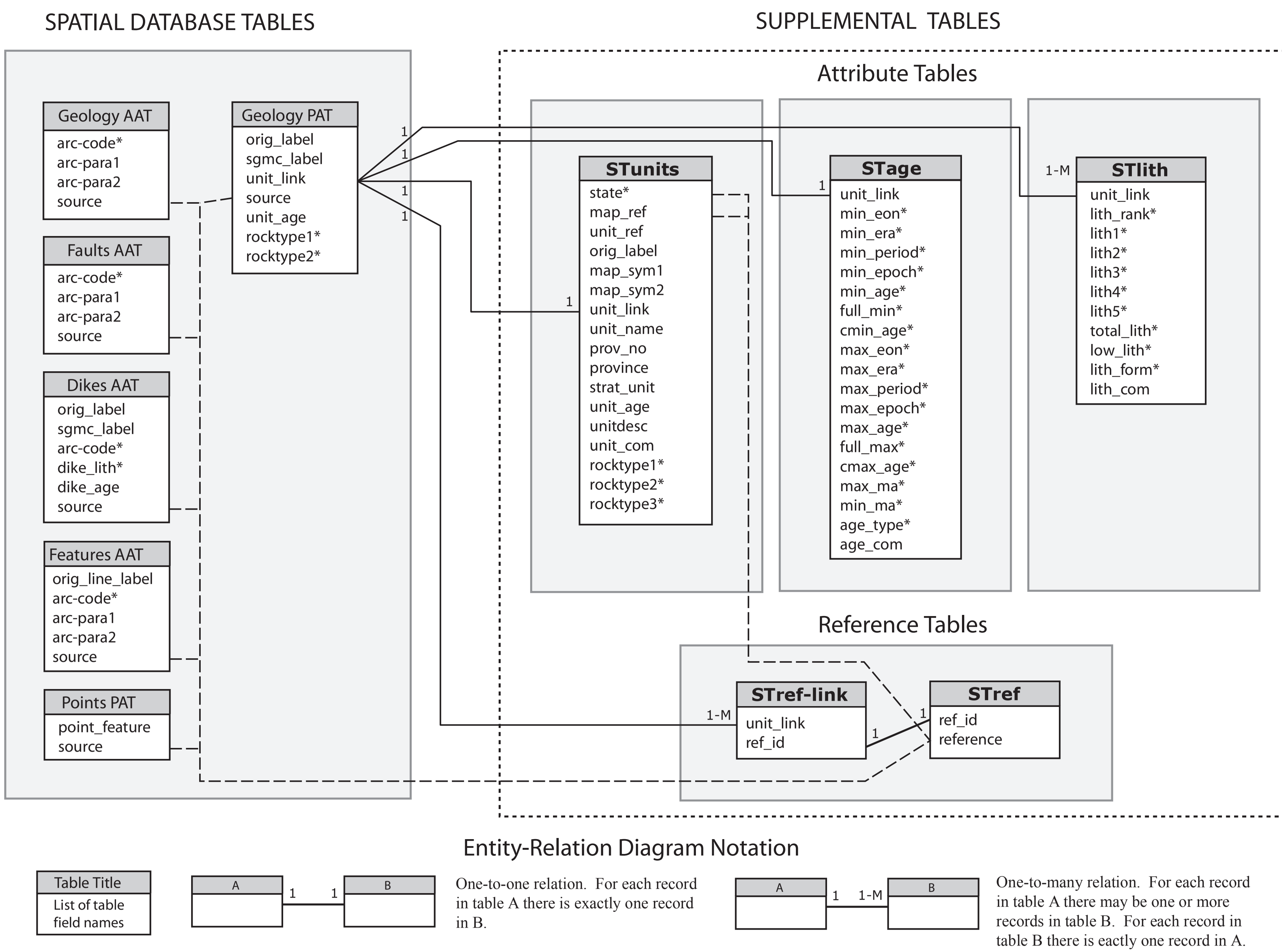

Figure 1. Data model for conterminous U.S. databases. Dashed lines indicate fields that have a one to one relationship to the *reference* field of the STref table (except the *unit_ref* field of the STunits table, see field definition in table X). Fields marked with an asterisk are populated from a data dictionary.

Table 1. Standard file set for conterminous U.S. states databases. "ST" in a file name is a placeholder for the appropriate state abbreviation (e.g. NV – Nevada, Appendix 1). This convention is used throughout this report.

File Name	Description
Database documentation	
CONUSdocumentation.pdf (the document you are reading now)	
Spatial databases and related files	
STgeol_lcc.e00 STgeol_dd.e00 STgeol_lcc.zip STgeol_dd.zip	Geology polygon database (as ERSI export .e00 files and as compressed .zip ESRI shapefiles .shp) in both Lambert Conformal Conic projection (lcc) and geographic coordinates (dd, decimal degrees).
STfaults_xxx.xxx	Fault arc database (using same naming conventions and file formats as above)
STdikes_xxx.xxx	Dikes arc database (using same naming conventions and file formats as above)
STfeature_xxx.xxx	Line and point feature spatial databases. Features represented vary depending on state (e.g. fold axes, continental glacial advance lines, cinder cones, diatremes, etc.). Inclusion of these files is dependent on available data.
STpoints_xxx.xxx	Point feature spatial databases. Features represented vary depending on state (e.g. cinder cones, diatremes, etc.). Inclusion of the files is dependent on available data.
STmetadata.txt STmetadata.doc STmetadata.htm	Metadata file in standard ASCII text (.txt) format, Microsoft Word (Microsoft Office 2003) the format (.doc), and Hypertext Markup Language (.htm).
Supplemental Tables	
STunits.xxx STage.xxx STlith.xxx STref.xxx STref-link.xxx	Units, age, lithology references, reference-link, attribute tables in three formats: comma-separated value text (.csv), dBASE (.dbf), and FileMaker Pro (.fp5).

Table 2. Projection parameters for CONUS data sets

Lambert Conformal Conic Projection	
Parameter	Value
1st Standard parallel	33º 00’ 00” N
2nd Standard parallel	45º 00’ 00” N
Central meridian	-100º 00’ 00” (W)
Latitude of projection origin	0º 00’ 00”
False easting (meters)	0
False northing (meters)	0
Units	Meters
Datum	NAD ‘27
Spheroid	Clarke, 1866

DATABASE ATTRIBUTE TABLES

This section describes the attribute tables of the spatial databases. In order to integrate the state spatial databases the original attribute tables have been replaced by our standard attribute tables documented below (Figure 1). Line features that define contact topology (e.g. all stratigraphic, plutonic, and fault contacts as well as selected water and ice boundaries) are included in the geology coverage, whereas features that do not define contact topology in this context were not (e.g. fold axes or glacial limit line). Faults in the original datasets were either embedded in the geology polygon coverage or provided as a separate coverage. For the latter situation, we have not attempted to merge the separate fault line coverages with the corresponding geology polygon coverages. For coverages where faults were embedded, we have replicated the embedded faults as separate fault line coverages in order to provide a uniform set of fault coverages for each state. Features that are not included in the geology polygon coverage such as fold axes, lineaments, metamorphic isograds, and other features typically considered “overprints” on most geologic maps are included in separate feature coverages as described below. For states that had point data overlays, such as fossil locations and structural measurements, these are included as separate point feature coverages.

GEOLOGY POLYGON ATTRIBUTION TABLE (PAT)

We developed a standardized polygon attribute table (PAT) format for the geologic polygon coverages. In addition to the standard fields created for the database by the ARC/INFO system (*stgeol#*, *stgeol-id*, *area*, *perimeter*), we have added several fields from the STUNITS table including the *unit_link* field for joins and relates to the supplemental attribute tables as well as map symbol, age, and lithology fields to facilitate quick plots of the database (Table 3).

Table 3. Geology polygon attribute table (PAT). In the format field, the numbers indicate input or stored width, and the output width of the field. "ST" in file name is placeholder for the appropriate state abbreviation in upper case (e.g. NV – Nevada, see Appendix 1).

Field Name	Format	Definition and Notes	Data dictionary
orig_label	12, 12, Character	Map unit symbol from the original source database: Examples: Ch or Krc.	
sgmc_label	16, 16, Character	Same as map_sym2 of STUNITS Table. (*orig_label* + ;n where n = province number (n = 0 if no province number) (e.g. original map unit Jtg occurs in two map provinces and is subdivided into two units with *sgmc_label*s of Jtg;1 and Jtg;2)).	
unit_link	18, 18, Character	ST + *sgmc_label*. This creates a unique identifier for every unit in the set of state databases. Examples: NJCAh;6 or ALKrc;1	
source	6, 8, Character	*ref_id* number from the references table (STREF). Documents editing changes (i.e. changes to source spatial database).	
unit_age	60, 60, Character	Free form field stating age of the unit (e.g. "Permian to Cretaceous"). Same as unit_age field of STUNITS table.	
rocktype1	40, 40, Character	Dominant lithology of the unit.	Appendix 6
rocktype2	40, 40, Character	Second most abundant lithology.	Appendix 6

Arc Attribute Tables (AAT)

The arc attribute table (AAT) stores attributes indicating the type of line features in the coverages and shape files, e.g. a normal fault and its location (certain, approximate, inferred, or concealed). In addition, each arc within a spatial database has a source attribute. This allows the user to refer to original sources to determine the reason for an attribute assignment. The line-type data dictionary is presented in Appendix 7. Arc attribute tables are uniform for all 50 states. Table 4 presents the fields used for the geology and fault AAT tables; the coding of dikes is described in a separate section below (see Table 5).

The linework or "arc" coding scheme was developed originally for use in the production of geologic maps on the Alaska Peninsula (Wilson, 1989; Wilson and others, 1995; Wilson and others, in press). Since that time, the coding scheme has been modified to allow for capture of additional information and to cover the wide range of line types found on geologic maps. The key field of this coding scheme is the attribute *arc-code*. This attribute carries the majority of the information associated with a line. A secondary attribute, *arc-para1*, provides additional information for selected line types. *Arc-para2* is an optional field and is currently not populated in file. Together these attributes provide the geologic information about a line. As used in the polygon attribute table, a *source* field is also included in the arc attribute table. For the spatial databases this field is a link to the reference table.

Directional Line Attribution

An important feature of the databases is line or arc direction. This attribute is an inherent part of the topology for an arc or network coverage, but not for a shapefile. Arcs are coded in ARC/INFO using a right hand rule; that is, when traveling along an arc from the "from-node" to the "to-node", the right side, depending on the defined line type, carries special meaning. Examples are: for thrust or high-angle reverse faults, the upper plate is always on the right, or, for caldera rims, the interior of the rim is on the right side of the arc. Conversion from ARC/INFO export (.e00) files to other formats (e.g. ESRI shapefiles or MapInfo) may not preserve the right-hand rule for arcs. Thus, it is possible that line decoration may be illustrated incorrectly in the new file. Users should double-check an original source (e.g. paper map) to ensure the correct orientation of line decorations after the import of an .e00 file to any GIS format other than an ESRI coverage. Databases that lacked line orientation topology in the source were not upgraded to include it.

Geology and Fault Attribute Tables

Geology and fault line attribution use the same fields as shown in Table 4.

Table 4. Geology and fault arc attribute tables (AAT). In the format field, the numbers indicate input or stored width, and the output width of the field.

Field Name	Format	Definition and Notes
arc-code	3, 3, Integer	Unique identifier for the type of feature (see appendix 7, Arc data dictionary)
arc-para1	3, 3, Integer	*arc-para1* is used for "decorated" lines where additional information is needed. Example: Normal fault, location certain, digitized with upthrown side on the right (code of 1 added to ARC-PARA1 where U/D is designated in source)
arc-para2	3, 3, Integer	*arc-para2* is an optional field used during processing of coverages. Field is currently not populated in file.
source	6, 8, Character	*ref_id* number from the references table (STREF). Documents editing changes (i.e. changes to source spatial database).

Dike Attribute Table

If a state source map included dikes, a separate dike database was prepared. The attribute fields of a dike database are presented in Table 5.

Table 5. Dike database arc attribute table (AAT). In the format field, I indicates a numeric code stored as integers in the PAT, C is stored as characters, the numbers indicate input or stored width, and the output width.

Field Name	Format	Definition and Notes
orig_label	12, 12, Character	Original map symbol/label (e.g. Td)
sgmc_label	18,18, Character	st + *orig_label* (e.g. NVTd), including use of special age symbols as necessary (Appendix 2).
arc_code	3,3, Integer	Numeric code from AAT data dictionary (Appendix 7)
dike_lith	20, 20, Character	General lithologic classification as specified below: unspecified mafic felsic mafic and felsic lamprophyre
dike_age	60, 60, Character	Free form field, usage same as *unit_age* field from unit coding specifications (e.g. “Tertiary”, “Cretaceous-Tertiary”, “unknown, probably Precambrian”).
source	6, 8, Character	*ref_id* number from the references table (STREF). Documents editing changes (i.e. changes to source spatial database).

Other Arc Features Attribute Table

This database is created if the source map or spatial database included line features other than faults or dikes (e.g. fold axes, glacial limit line, etc.). There is no standardized database structure for these additional tables and documentation is restricted to the metadata file for the coverage. Table 6 presents the attribute fields for a line (arc) feature coverage.

Table 6. Features coverage arc attribute table (AAT).

Field Name	Format	Definition and Notes
orig_line_label	25, 25, Character	Arc code taken from original spatial database.
arc-code	3, 3, Integer	Unique identifier for the feature (see appendix 7, AAT data dictionary)
arc-para1	3, 3, Integer	*arc-para1* is used for "decorated" lines where additional information is needed.
arc-para2	3, 3, Integer	*arc-para2* is an optional field for scratch entries used during processing of coverages. Field is currently not populated in file.
source	6, 8, Character	*ref_id* number from the references table (STREF). Documents editing changes (i.e. changes to source spatial database).

POINT FEATURE ATTRIBUTE TABLE

Point features coverages are for source maps or spatial databases that include one or more point features (e.g. volcanic vents, fossil localities, radiometric sample locations). Because only a few state maps have such features, we have not compiled a data dictionary for point features and these features are only documented in the database attribute table. Table 7 presents the attribute fields for a points feature database.

Table 7. Points coverage attribute table (PAT).

Field Name	Format	Definition and Notes
point_feature	40, 40, Character	Text descriptor of point feature from original map or spatial database (see metadata).
source	6, 8, Character	*ref_id* number from the references table (STREF). Documents editing changes (i.e. changes to source spatial database).

SUPPLEMENTAL TABLES

The supplemental attribute tables that accompany the spatial databases were developed using the Filemaker Pro (version 5.0, 5.5, or 6) database program. Data entry utilized custom FileMaker forms for each table. The completed tables are provided in Filemaker Pro format (.fp5 file extension), in comma-separated value format (.csv), and dBASE (.dbf) format. The dBase format does not permit fields to contain more than 255 characters and a few fields were truncated in creating the dbf files.

The CONUS set of supplemental tables consists of five tables: unit descriptions (STUNITS), unit ages (STAGE), unit lithology (STLITH), unit references (STREFS), and a key table linking references (STREF_LINK), where ST stands for the two-letter abbreviation for a given state. The relationship between these tables and their content fields are shown in Figure 1. The units, age, lithology and ref-link tables are related by a key field, *unit_link*, that is described below in the units table section. The STREFS and STREF-LINK tables are related by *ref_id*.

Units Table (STUNITS)

The STUNITS table (Table 8) consists of general information about each geologic map unit such as symbolization, unit name and description, stratigraphic information, and summary of age (Figure 1).

The STUNITS table stores map unit symbols and, through scripting (in FileMaker Pro), uses these fields to populate an auto-generated field named *unit_link*, which is the linking field (foreign key) to other tables in the databases. *Unit_link* is a unique identifier for every map unit in the CONUS database set thus permitting it to be used for multi-state compilations. It consists of the original map unit symbol (*map_sym1*) having the state two letter code added as a prefix (*state*) and the province number (*prov_no*) as the suffix (see Table 8 for further explanation).

The STUNITS table includes information about the unit name and description taken from the source map. Determining the map unit name can be more difficult than it appears. For example if the source map contains "*Fraser Formation: basalt, with minor andesite and greywacke*"; then clearly the unit name is "Fraser Formation" and what follows is the unit description. However if the source map presents a unit as "*Interlayered rhyolite, mafic tuff and flows, slate*", is this a unit name or description? Basically it is both and the same text will appear in both the *unit_name* and *unitdesc* fields of the STUNITS table.

On some maps, information about a map unit such as its name, description, and relationship to other stratigraphic units can be difficult to determine depending on how the map legend is organized (i.e. information about the unit may be distributed in several places within the legend and text of the source map). We have compiled such information in either the *unit_name* or unit description (*unitdesc*) fields.

For some state maps, the legend might indicate that a map unit belongs to a specific stratigraphic group, but not specify which formations comprise the group. Therefore, included in the STUNITS table is a *strat_unit* field for adding stratigraphic unit information not present on the map.

The STUNITS table also includes a comments field (*unit_com*) intended for additional information about the unit that could not be included in the standard coding fields. Three fields, *rocktype1*, *rocktype2*, and *rocktype3*, are present in the STUNITS table to facilitate the preparation of a generalized dominant lithology map for the United States. These fields are coded using the Lithclass 6.1 data dictionary (Johnson and Leveritch, written commun. 1998; Appendix

6 herein). *Rocktype1* is the lithology inferred to be the most abundant lithology in the unit; *rocktype2* is the second-most abundant lithology, and all other lithologies are listed in *rocktype3*. Neither the *rocktype1* nor the *rocktype2* fields imply anything in regards to abundance other than being the most and second most abundant of the rock types present in the unit. The fields for *rocktype1 and rocktype2* were placed in the units table because they have a one-to-one relationship to the geology PAT table as does the units table whereas the lithology table has a one-to-many relationship.

Map Symbols

Some maps use special symbols (e.g. Triassic Ŧ) to display map unit ages. To display such special symbols on a computer screen requires the use of a specialized font. Since it is unlikely that most users will have a particular special font for geologic symbols installed, we have avoided this problem by the use of an age symbol data dictionary not dependent on fonts (Appendix 2). Using this data dictionary, Triassic is coded as "TR" and therefore the unit label for a Triassic granite, Ŧgr, would be entered in the units table *map_sym1* field as TRgr.

Table 8. STUNITS table field definitions. The field column also indicates the requirement upon the compiler in regards to populating the field: mandatory (must be filled in), mandatory if (must be filled in if information available), optional (not required), and auto generated (automatically filled in script in the FileMaker database form used to compile the information). This scheme was also applied to the other supplemental tables.

Field	Explanation	Field Type	Data Dictionary
state (mandatory)	Two letter state code (e.g. NM - New Mexico).	Text, restricted value list	Appendix 1
map_ref (mandatory)	Reference id (*ref_id*) code for the state map being coded (e.g. NM001) from the STREF table.	Text	
unit_ref (mandatory if)	List of reference id codes (*ref_id*) from the references table (STREF) for sources used to compile a particular unit other than the map_ref above (*ref_id*s separated by carriage returns if more than one)	Text	
orig_label (mandatory)	Map unit label from the original digital source.	Text	
map_sym1 (mandatory)	Original map unit label as given in the source, having age part of map symbol assigned from the "Standard Age Symbol" data dictionary.	Text	Appendix 2
map_sym2 (auto generated)	Automatically generated, derived by combining *map_sym1*, a semicolon, and the *prov_no* (e.g. TRrb;0). This generates a	Text	

	unique map symbol for each province. (Same field as *sgmc_label* in PAT).		
unit_link (auto generated)	Automatically generated, combining the *state* code and *map_sym2* (e.g. NMTRrb;0). This creates a unique code for every unit in the CONUS databases. Linking field (primary key) between supplemental tables and PAT.	Text	
unit_name (mandatory)	The name of the map unit as given on the source map.	Text	
prov_no (mandatory if)	Some state geologic maps are subdivided into regions or provinces (e.g. Carolina Slate Belt, Northwestern Plateau, etc.). Provincial coding was used only in a few eastern states where units had the same map symbol within multiple provinces but a different unit description for each province. Province numbers (e.g. 1, 2, 3…) were arbitrarily assigned by the unit compiler. If provincial coding is not done, a zero is entered for the province number.	Number	
province (mandatory if)	Name of the province as given on the map (e.g. Carolina Slate Belt).	Text	
strat_unit (mandatory if)	Additional stratigraphic unit information about the map unit.	Text	
unit_age (mandatory if)	Free form field for unit age description (e.g. "Cretaceous", or "Permian to Cretaceous"; or "Permian-Cretaceous, and Miocene"). Generally from the source map or as inferred from the map correlation chart, or other referenced sources. Stated oldest to youngest.	Text	
unitdesc (mandatory if)	The unit description as given on the source map.	Text	
unit_com (optional)	Free form field for additional information about the unit or to document an action taken by a compiler.	Text	
rocktype1 (mandatory)	Single most abundant (dominant) lithology of the unit as best inferred by the complier. Does not imply any minimum percentage of abundance.	Text, restricted value list	Appendix 6
rocktype2 (mandatory_if)	Second most abundant lithology of the unit.	Text, restricted value list	
rocktype3 (mandatory_if)	All other lithologies of the unit, comma separated.	Text, restricted	

		value list	

Age Table (STAGE)

The STAGE table (Table 9) record text and numerical minimum and maximum ages (in millions of years; Ma) for each map unit. This table has a one-to-one relationship with the units table. The names used to populate fields in these tables are assigned using the Age data dictionary (Appendix 3), derived from Palmer (1983) to assign maximum and minimum ages to geologic units. The table has the full hierarchy of the maximum and minimum ages of the unit, allowing searches based on any part of the time scale. For example, searches could be for units that are at least Paleozoic but no older than Devonian. Because maximum and minimum numeric ages were automatically populated (from Palmer, 1983), the table can also be searched based on numeric maximum and minimum ages.

A field, named *age_type*, shows whether the age of the unit is based on stratigraphic or fossil control or based on radiometric dating. Only two values are allowed in this field. *Relative* is used if the unit is simply assigned an age or range based on stratigraphic position (e.g. late Triassic or late Triassic to early Cretaceous). If a map unit's age is within with a single time unit, e.g. late Triassic, then that is used for both maximum and minimum. Relative coding was used for most map units. *Absolute* is used where age determination information is available. Absolute age information, if available, was manually entered into the tables, overriding the automatically populated field entry. If a user chooses to use a different time scale, in converting from our time scale, the user would be able use this field to determine whether to shift the text age term or the numeric age term (Ma) for each unit.

The comments field (*age_com*) is used to document methodology, referencing, etc. (e.g. "U/Pb zircon isochron age, reference NV012"). If more than one determination is referred to, the overall interpreted age was used.

Table 9. STAGE table field definitions

	Field name	Information type	Field type	Data dictionary
1	*unit_link* (mandatory)	Same definition as units table	Text	UNITS
2	*min_eon* *min_era* *min_period* *min_epoch* *min_age* (mandatory if)	The minimum or youngest age assignment for the map unit.	Text, restricted value list	Appendix 3
3	*full_min* (auto generated)	Automatically generated field that concatenates all of the input from the minimum fields into a single field.	Text, auto entry	
4	*max_eon* *max_era* *max_period* *max_epoch* *max_age* (mandatory if)	The maximum or oldest age assignment for the map unit.	Text, restricted value list	Appendix 3
5	*full_max*	Automatically generated field that	Text,	

	(auto generated)	concatenates all of the input from the maximum fields into a single field.	auto entry	
6	*age_type* (mandatory if)	Only two choices: "Relative" and "Absolute" (see text for explanation).	Text, restricted value list	See explanation at left
7	*cmin_age* *cmax_age* *(auto generated)*	The lowest level geochronologic unit entered from maximum and minimum fields above.	Text, auto entry	
8	*min_Ma* *max_Ma* (auto generated)	Numerical age for the top of the youngest geochronologic unit age and bottom of the oldest. Values automatically entered from the geochronologic data dictionary, unless compiler manually entered values.	Number, auto entry	Appendix 3
9	*age_com* (optional)	Field for any additional comments about age information.	Text	

Lithology Table (STLITH)

The lithologic information contained in the legend of state geologic maps is highly variable and for some maps this information is lacking. Where lithologic information was inadequate, lithologic information was obtained by literature research. The compilers of this information only conducted such research adequate to generalize the lithology of a map unit. The lithologic compilation tells the user nothing about the distribution of lithologies within the mapped unit or which lithologies are present at any particular point within a unit.

The STLITH table (Table 10) contains a record for each rock type that was identified as being present within a map unit, therefore there will be one or more lithologies compiled for each map unit. Five hierarchical fields are used to compile each lithology (*lith1 …. lith5*). The *lith1* field contains the general class of the lithology with increasing specificity for that class down through the lithology class levels as specified by the lithology data dictionary (appendix 4). Another field, *total_lith*, concatenates the lithology fields to assist in searching for units having particular lithologies, without the user having to know where that term appears in the hierarchy.

The *lith_form* field is used to assign an additional modifier to the lithology terms. The lithologic level fields (*lith1-lith5*) describe each lithology in terms of its composition (e.g. rhyolite), whereas, *lith_form* describes various aspects, such as form (e.g. tuff), of the lithology using the Lithform Data Dictionary (Appendix 5).

The relative volumetric importance of the lithology is assigned in the *lith_rank* field. Four rank categories were used: "Major" (greater than or equal to 33 percent), "Minor" (between 10 and 33 percent), "Incidental" (between 0 and 10 percent) and "Indeterminate." As our sources rarely provide abundance information about a lithology, the compiler of the record estimated from the unit information available which category to assign each lithology, including, if necessary, the indeterminate category. The term major is added to this field to ensure that searches for units having a particular major lithology will not be overlooked because the particular lithology was coded as indeterminate.

Table 10. STLITH table field definitions

Field	Explanation	Field type	Data Dictionary
unit_link (mandatory)	As defined in UNITS table.	Text	
lith1 *lith2* *lith3* *lith4* *lith5* (mandatory)	A hierarchical classification of the lithology. The contents of each field depends on the next higher field contents (e.g. if "Sedimentary" is selected at *lith1* only sedimentary lithologic terms can be selected for *lith2*. Coding completed to the lowest level required to code a specific lithology.	Text, restricted value list	Appendix 4
total_lith (auto generated)	A text string that combines all of the coding from *lith1* to *lith5*. This string allows searches based on any aspect of the lithologic hierarchy.	Text, auto-generated	
lith_form (mandatory if)	Derived from a list of terms that modify the lithologic name. Values available dependent on choice for *lith1* field.	Text, restricted value list	Appendix 5
lith_rank (mandatory)	Relative volumetric importance of the lithology ranked by one of four categories as estimated by complier: *Major* - ≥33 1/3 % *Minor* - 10 – 33 1/3% *Incidental* - <10% *Indeterminate* – information doesn't allow compiler to estimate rank of the lithology	Text, restricted value list	See explanation at left
low_lith (auto generated)	Auto generated field showing the hierarchically lowest level lithology coded.		
lith_com (optional)	Free form comment field.		

Reference Tables (STREF and STREF-LINK)

The STREF table (Table 11) serves dual purposes: (1) it contains the citations for reference sources used in compiling the supplemental tables, and (2) contains citations for the *source* field of the spatial databases attribute tables (Figure 1).

The state databases use two reference tables to provide source references for the geologic map and the literature used to compile and code the attribute tables. The first is a linking table (STREF-LINK, Table 12) that links the primary reference table (STREF) to the supplemental attribute tables (Figure 1) and the geology PAT. This data structure was used because there is a one-to-many relationship between the *unit_link* field and the references because more than one reference may have been used to code a single unit. The STUNITS table contains two reference fields, *map_ref* and *unit_ref*, which contain the reference code for the source map and the codes for the references used to code the unit, respectively. Each reference in the table has a unique identifier (*ref_id*). The second reference table, STREF-LINK links the *reference* from the STREF table through the *ref_id* to the UNITS table through the *unit_link* field. This relate table is used because of the potential one-to-many relationship between a record in the UNITS table and references.

The reference for the primary source map will generally be the first reference in the table (i.e. ST001 where ST represents the state abbreviation). If it is possible to completely compile the supplemental attribute tables from the legend of a state source map, then there will only be one reference for that state. However, in many cases, there will be additional references used to code the individual map units.

Table 11. STREF table field definitions

Field name	Information type	Field Type
ref_id (mandatory)	The unique code assigned to each reference in the table. Format: 2 letter state abbreviation and a 3 digit number (e.g. NV001).	Text and number; unique values
Reference (mandatory)	The reference citation in standard USGS format	Text

Table 12. STREF-LINK table field definitions.

Field	Explanation	Field Type
unit_link (mandatory)	Same as STUNITS table.	Text
ref_id (mandatory)	Identifying code for each reference	Text

References Cited

Bond, J.G., Kauffman, J.D., Miller, D.A., and Venktakakrishnon, Ramesh, 1978, Geologic Map of Idaho: Idaho Bureau of Mines and Geology, Geologic Map GM-1, 1:500,000 scale.

Environmental Systems Research Institute, Inc, 1997, Understanding GIS: The ARC/INFO Method: John Wiley and Sons, New York

Environmental Systems Research Institute, Inc, 1998, ESRI Shapefile Technical Description: An ESRI White Paper - July 1998, http://www.esri.com/library/whitepapers/pdfs/shapefile.pdf

Hansen, W.R., ed., 1991, Suggestions to Authors of the Reports of the United States Geological Survey - Seventh Edition: Washington, D.C., Government Printing Office, 289 p.

International Commission on Stratigraphy, 2003, International Stratigraphic Chart: www.stratigraphy.org

Johnson, B.R., 2002, Geologic Map Unit Classification, ver. 6.1: A proposed hierarchical classification of units for digital geologic maps: North American Geologic Map Data Model (NADM), http://www.nadm-geo.org//dmdt/pdf/lithclass61.pdf.

North American Geologic-map Data Model Science Language Technical Team, 2004, Sedimentary materials: science language for their classification, description, and interpretation in digital geologic-map databases, Version 1.0 (12/18/2004): Draft report posted on the North American Data Model website (http://nadm-geo.org/sltt/products/sedimentary/sltt_sed_text_12_18_04_intro.pdf), 595 p.

Osberg, P.H., Hussey A.M. II,, Boone, G.M., and Loiselle, M.C., (editors), 1984, Bedrock Geologic Map of Maine: Maine Geological Survey Open-File Report, Volume 84-1. scale 1:500,000.

Palmer, A.R., 1983, The Decade of North American Geology 1983 Geologic Time scale: Geology, v. 11, no. 9, p. 503-504.

Reed, J.C., Jr., Bickford, M.E., Houston, R.S., Link, P.K., Rankin, D.W., Sims, P.K., and Van Schmus, W.R., eds., 1993, Precambrian: Conterminous U.S., Decade of North American Geology (DNAG), The Geology of North America, Volume C-2, Boulder, CO, Geological Society of America, 657 p., 7 plates.

Reed, J.C. and Bush, C.A., 2004, Generalized Geologic Map of the Conterminous United States, U.S. Geological Survey, scale 1:7,500,000. (URL http://pubs.usgs.gov/atlas/geologic/)

Schruben, P.G., Arndt, R.E., and Bawiec, W.J., 1994, Geology of the Conterminous United States at 1:2,500,000 Scale — A Digital Representation of the 1974 P.B. King and H.M. Beikman Map, U.S. Geological Survey Digital Data Series 11, release 2. (URL http://pubs.usgs.gov/dds/dds11/)

Wilson, A.B., 2001, Compilation of various geologic time scales, version 1.0: U.S. Geological Survey Open-File Report 01-0052 (URL: http://pubs.usgs.gov/of/2001/ofr-01-0052).

Wilson, F.H., 1989, Creation of a full color geologic map by computer: A case history from the Port Moller project resource assessment, Alaska Peninsula, *in* Dover, J.H., and Galloway, J.P., eds., Geologic studies in Alaska by the U.S. Geological Survey, 1988: U.S. Geological Survey Bulletin 1903, p. 96-103.

Wilson, F.H., Detterman, R.L., Miller, J.W., and Case, J.E., 1995, Geologic map of the Port Moller, Stepovak Bay, and Simeonof Island quadrangles, Alaska: U.S. Geological Survey Miscellaneous Investigations Map Series I-2272, scale 1:250,000, 2 sheets.

Wilson, F.H., Detterman, R.L., and DuBois, G.D., in press, Geologic framework of the Alaska Peninsula, southwest Alaska, and the Alaska Peninsula terrane: U.S. Geological Survey Bulletin 1969-B, approx. 80 ms pages, 1 oversize figure, 1 plate, scale 1:500,000.

APPENDICES: DATA DICTIONARIES

Construction of databases typically necessitates the development of a “language” for storing information in succinct terms. As used here a “data dictionary” is a table of values that define the allowable content of a database field (for example, a table of permitted lithologic terms). We have developed data dictionaries for age, lithology, and line coding (appendices 3 to 7). These data dictionaries are not intended to be comprehensive classification schemes, and only contain the terminology needed to compile the information from the state geologic maps.

APPENDIX 1. STATE ABBREVIATIONS

State	Code		State	Code
Alabama	AL		Montana	MT
Alaska	AK		Nebraska	NE
Arizona	AZ		Nevada	NV
Arkansas	AR		New Hampshire	NH
California	CA		New Jersey	NJ
Colorado	CO		New Mexico	NM
Connecticut	CT		New York	NY
Delaware	DE		North Carolina	NC
Florida	FL		North Dakota	ND
Georgia	GA		Ohio	OH
Hawaii	HI		Oklahoma	OK
Idaho	ID		Oregon	OR
Illinois	IL		Pennsylvania	PA
Indiana	IN		Rhode Island	RI
Iowa	IA		South Carolina	SC
Kansas	KS		South Dakota	SD
Kentucky	KY		Tennessee	TN
Louisiana	LA		Texas	TX
Maine	ME		Utah	UT
Maryland	MD		Vermont	VT
Massachusetts	MA		Virginia	VA
Michigan	MI		Washington	WA
Minnesota	MN		West Virginia	WV
Mississippi	MS		Wisconsin	WI
Missouri	MO		Wyoming	WY

APPENDIX 2. STANDARD AGE SYMBOLS

The following codes are used for source map unit age symbols in the *map_sym1* field of the UNITS table, e.g. a Triassic granite unit which has special symbol on the source map for Triassic + gr, would coded in the *map_sym1* field as TRgr. These symbols use standard letter characters in order to avoid using special fonts that display the symbol properly but may not be available to a user and to avoid the use of special fonts or characters in the geology PAT. As much as possible, our scheme follows the symbolization from USGS Suggestions to Authors 7th Edition (Hansen, 1991, p. 59).

Standard symbol	Footnote	Time Unit
PH	a	Phanerozoic
CZ	b	Cenozoic
Q	b	Quaternary
H	a	Holocene/recent
PS	a	Pleistocene
T	b	Tertiary
N	b	Neogene
PE	b	Paleogene
PO	a	Pliocene
MI	a	Miocene
OG	a	Oligocene
EO	a	Eocene
PN	a	Paleocene
MZ	b	Mesozoic
K	b	Cretaceous
J	b	Jurassic
TR	a	Triassic
PZ	b	Paleozoic
P	b	Permian
C	b	Carboniferous
PA	a	Pennsylvanian
M	b	Mississippian
D	b	Devonian
S	b	Silurian

O	b	Ordovician
CA	a	Cambrian
pCA	c	Precambrian
PR	a	Proterozoic
Z	b	Late Proterozoic (570-900 Ma)
Y	b	Middle Proterozoic (900-1600 Ma)
Y3	d	Late Middle Proterozoic (900-1200 Ma)
Y2	d	Middle Middle Proterozoic (1200-1400 Ma)
Y1	d	Early Middle Proterozoic (1400-1600 Ma)
X	b	Early Proterozoic (1600-2500 Ma)
X3	d	Late Early Proterozoic (1600-1800 Ma)
X2	d	Middle Early Proterozoic (1800-2100 Ma)
X1	d	Early Early Proterozoic (2100-2500 Ma)
A	b	Archean (2500-3800 Ma)
W	b	Late Archean (2500-3000 Ma)
V	b	Middle Archean (3000-3400 Ma)
U	b	Early Archean (3400-3800 Ma)

Footnotes:

a. Defined here, no symbol for this in Suggestion to Authors 7th. Ed.

b. Follows USGS Suggestions to Authors 7th Edition (Hansen, 1991, p. 59)

c. Lower case “p” can be used for pre- (e.g. Pre-Jurassic unit = pJ)

d. Subdivisions of the Middle and Early Proterozoic that have been accepted by the USGS, but are not shown in USGS Suggestions to Authors 7th Edition. These subdivisions are also shown in the Precambrian time scale figure caption on p. 7 of Reed and others (1993). Note that in Reed and others these subdivisions are superscripted, e.g. Y^3.

APPENDIX 3. GEOCHRONOLOGIC TIME SCALE DATA DICTIONARY (AGELIST)

The age data dictionary used is presented in the table below. There is no universally accepted standard geologic time scale, and many proposed time scales exist. Wilson (2001) compiled data for a number of available time scales. We chose the Geological Society of America DNAG time scale (Palmer, 1983) which we modified by adding additional sub-divisions in the Proterozoic as accepted by the USGS Geologic Names Committee. Most of the geologic maps included in this national database were created over the last four decades and reflect the particular time scale selected by the authors at that time. In addition, the time scale used by the authors is typically not recorded on the source map. During the past 10 years, considerable refinement of the time scale has resulted from the study of critical boundaries using new techniques and high-precision dating methods (International Commission on Stratigraphy, 2003); however, the source maps in this database were most likely compiled using a time scale akin to Palmer (1983).

The age unit scheme used here is not completely hierarchical because geochronologic nomenclature has not been used in a consistent manner over time; thus some adjustments were made to account for this. For example, the Tertiary, Neogene, and Paleogene are all treated as periods even though the latter two are subdivisions of the Tertiary; the same situation exists for the Carboniferous, with respect to Pennsylvanian and Mississippian. Both forms appear in the period fields of the database (i.e. Tertiary, Tertiary-Neogene, and Tertiary-Paleogene; Carboniferous, Carboniferous-Pennsylvanian, and Carboniferous-Mississippian). Also note that the term “preCambrian” is not a formal part of any scheme, but because it’s so commonly used, we have inserted it in the scheme at the eon level.

Numerical values (Ma) for the boundaries between the geochronologic age units are also included in the age data dictionary and are derived from Palmer (1983). This numeric coding was provided to allow for queries (e.g. “show all stratigraphic units with ages between 570 to 64.4 Ma”), without having to enter all of the age unit names. Although the numeric values used here may no longer reflect currently accepted values, their primary intended use is for queries that span multiple age units (e.g. the above example query would yield all map stratigraphic units between the start of the Cambrian and the end of the Cretaceous). As these numeric boundaries vary between different geologic time scales, a user may wish to supplement the scheme by adding their own values. To assist in this, a field has been added to indicate if a map unit’s age assignment is relative, (e.g., based on stratigraphic position), or is absolute (i.e. based on radiometric age determination).

Eon	Era	Period	Epoch	Age	Minimum Ma	Maximum Ma
Phanerozoic					0	570
Phanerozoic	Cenozoic				0	66.4
Phanerozoic	Cenozoic	Quaternary			0	1.6
Phanerozoic	Cenozoic	Quaternary	Holocene		0	.01
Phanerozoic	Cenozoic	Quaternary	Pleistocene		.01	1.6
Phanerozoic	Cenozoic	Quaternary	Pleistocene	Calabrian	.01	1.6
Phanerozoic	Cenozoic	Tertiary			1.6	66.4
Phanerozoic	Cenozoic	Tertiary-Neogene			1.6	23.7
Phanerozoic	Cenozoic	Tertiary	Pliocene		1.6	5.3
Phanerozoic	Cenozoic	Tertiary-Neogene	Pliocene		1.6	5.3
Phanerozoic	Cenozoic	Tertiary	Late-Pliocene		1.6	3.4
Phanerozoic	Cenozoic	Tertiary-Neogene	Late-Pliocene		1.6	3.4
Phanerozoic	Cenozoic	Tertiary	Pliocene	Piacenzian	1.6	3.4

Phanerozoic	Cenozoic	Tertiary-Neogene	Late-Pliocene	Piacenzian	1.6	3.4
Phanerozoic	Cenozoic	Tertiary	Late-Pliocene	Piacenzian	1.6	3.4
Phanerozoic	Cenozoic	Tertiary	Early-Pliocene		3.4	5.3
Phanerozoic	Cenozoic	Tertiary-Neogene	Early-Pliocene		3.4	5.3
Phanerozoic	Cenozoic	Tertiary	Pliocene	Zanclean	3.4	5.3
Phanerozoic	Cenozoic	Tertiary-Neogene	Early-Pliocene	Zanclean	3.4	5.3
Phanerozoic	Cenozoic	Tertiary	Early-Pliocene	Zanclean	3.4	5.3
Phanerozoic	Cenozoic	Tertiary	Miocene		5.3	23.7
Phanerozoic	Cenozoic	Tertiary-Neogene	Miocene		5.3	23.7
Phanerozoic	Cenozoic	Tertiary	Late-Miocene		5.3	11.2
Phanerozoic	Cenozoic	Tertiary-Neogene	Late-Miocene		5.3	11.2
Phanerozoic	Cenozoic	Tertiary	Miocene	Messinian	5.3	6.5
Phanerozoic	Cenozoic	Tertiary-Neogene	Late-Miocene	Messinian	5.3	6.5
Phanerozoic	Cenozoic	Tertiary	Late-Miocene	Messinian	5.3	6.5
Phanerozoic	Cenozoic	Tertiary	Miocene	Tortonian	6.5	11.2
Phanerozoic	Cenozoic	Tertiary-Neogene	Late-Miocene	Tortonian	6.5	11.2
Phanerozoic	Cenozoic	Tertiary	Late-Miocene	Tortonian	6.5	11.2
Phanerozoic	Cenozoic	Tertiary	Middle-Miocene		11.2	16.5
Phanerozoic	Cenozoic	Tertiary-Neogene	Middle-Miocene		11.2	16.5
Phanerozoic	Cenozoic	Tertiary	Miocene	Serravallian	11.2	15.1
Phanerozoic	Cenozoic	Tertiary-Neogene	Middle-Miocene	Serravallian	11.2	15.1
Phanerozoic	Cenozoic	Tertiary	Middle-Miocene	Serravallian	11.2	15.1
Phanerozoic	Cenozoic	Tertiary	Miocene	Langhian	15.1	16.5
Phanerozoic	Cenozoic	Tertiary-Neogene	Middle-Miocene	Langhian	15.1	16.5
Phanerozoic	Cenozoic	Tertiary	Middle-Miocene	Langhian	15.1	16.5
Phanerozoic	Cenozoic	Tertiary	Early-Miocene		16.5	23.7
Phanerozoic	Cenozoic	Tertiary-Neogene	Early-Miocene		16.5	23.7
Phanerozoic	Cenozoic	Tertiary	Miocene	Burdigalian	16.5	21.8
Phanerozoic	Cenozoic	Tertiary-Neogene	Early-Miocene	Burdigalian	16.5	21.8
Phanerozoic	Cenozoic	Tertiary	Early-Miocene	Burdigalian	16.5	21.8
Phanerozoic	Cenozoic	Tertiary	Miocene	Aquitanian	21.8	23.7
Phanerozoic	Cenozoic	Tertiary-Neogene	Early-Miocene	Aquitanian	21.8	23.7
Phanerozoic	Cenozoic	Tertiary	Early-Miocene	Aquitanian	21.8	23.7
Phanerozoic	Cenozoic	Tertiary-Paleogene			23.7	66.4
Phanerozoic	Cenozoic	Tertiary	Oligocene		23.7	36.6
Phanerozoic	Cenozoic	Tertiary-Paleogene	Oligocene		23.7	36.6
Phanerozoic	Cenozoic	Tertiary	Late-Oligocene		23.7	30.0
Phanerozoic	Cenozoic	Tertiary-Paleogene	Late-Oligocene		23.7	30.0
Phanerozoic	Cenozoic	Tertiary	Oligocene	Chattian	23.7	30.0
Phanerozoic	Cenozoic	Tertiary	Late-Oligocene	Chattian	23.7	30.0
Phanerozoic	Cenozoic	Tertiary-Paleogene	Late-Oligocene	Chattian	23.7	30.0
Phanerozoic	Cenozoic	Tertiary	Early-Oligocene		30.0	36.6
Phanerozoic	Cenozoic	Tertiary-Paleogene	Early-Oligocene		30.0	36.6
Phanerozoic	Cenozoic	Tertiary	Oligocene	Rupelian	30.0	36.6
Phanerozoic	Cenozoic	Tertiary	Early-Oligocene	Rupelian	30.0	36.6
Phanerozoic	Cenozoic	Tertiary-Paleogene	Early-Oligocene	Rupelian	30.0	36.6
Phanerozoic	Cenozoic	Tertiary	Eocene		36.6	57.8
Phanerozoic	Cenozoic	Tertiary-Paleogene	Eocene		36.6	57.8
Phanerozoic	Cenozoic	Tertiary	Late-Eocene		36.6	40.0
Phanerozoic	Cenozoic	Tertiary-Paleogene	Late-Eocene		36.6	40.0
Phanerozoic	Cenozoic	Tertiary	Eocene	Priabonian	36.6	40.0
Phanerozoic	Cenozoic	Tertiary	Late-Eocene	Priabonian	36.6	40.0
Phanerozoic	Cenozoic	Tertiary-Paleogene	Late-Eocene	Priabonian	36.6	40.0

Phanerozoic	Cenozoic	Tertiary	Middle-Eocene		40.0	52.0
Phanerozoic	Cenozoic	Tertiary-Paleogene	Middle-Eocene		40.0	52.0
Phanerozoic	Cenozoic	Tertiary	Eocene	Bartonian	40.0	43.6
Phanerozoic	Cenozoic	Tertiary	Middle-Eocene	Bartonian	40.0	43.6
Phanerozoic	Cenozoic	Tertiary-Paleogene	Middle-Eocene	Bartonian	40.0	43.6
Phanerozoic	Cenozoic	Tertiary	Eocene	Lutetian	43.6	52.0
Phanerozoic	Cenozoic	Tertiary	Middle-Eocene	Lutetian	43.6	52.0
Phanerozoic	Cenozoic	Tertiary-Paleogene	Middle-Eocene	Lutetian	43.6	52.0
Phanerozoic	Cenozoic	Tertiary	Early-Eocene		52.0	57.8
Phanerozoic	Cenozoic	Tertiary-Paleogene	Early-Eocene		52.0	57.8
Phanerozoic	Cenozoic	Tertiary	Eocene	Ypresian	52.0	57.8
Phanerozoic	Cenozoic	Tertiary	Early-Eocene	Ypresian	52.0	57.8
Phanerozoic	Cenozoic	Tertiary-Paleogene	Early-Eocene	Ypresian	52.0	57.8
Phanerozoic	Cenozoic	Tertiary	Paleocene		57.8	66.4
Phanerozoic	Cenozoic	Tertiary-Paleogene	Paleocene		57.8	66.4
Phanerozoic	Cenozoic	Tertiary	Late-Paleocene		57.8	63.6
Phanerozoic	Cenozoic	Tertiary-Paleogene	Late-Paleocene		57.8	63.6
Phanerozoic	Cenozoic	Tertiary	Paleocene	Selandian	57.8	63.6
Phanerozoic	Cenozoic	Tertiary	Late-Paleocene	Selandian	57.8	63.6
Phanerozoic	Cenozoic	Tertiary-Paleogene	Late-Paleocene	Selandian	57.8	63.6
Phanerozoic	Cenozoic	Tertiary	Paleocene	Thanetian	57.8	60.6
Phanerozoic	Cenozoic	Tertiary	Late-Paleocene	Thanetian	57.8	60.6
Phanerozoic	Cenozoic	Tertiary-Paleogene	Late-Paleocene	Thanetian	57.8	60.6
Phanerozoic	Cenozoic	Tertiary	Paleocene	Selandian-Thanetian	57.8	60.6
Phanerozoic	Cenozoic	Tertiary	Late-Paleocene	Selandian-Thanetian	57.8	60.6
Phanerozoic	Cenozoic	Tertiary-Paleogene	Late-Paleocene	Selandian-Thanetian	57.8	60.6
Phanerozoic	Cenozoic	Tertiary	Paleocene	Unnamed	60.6	63.6
Phanerozoic	Cenozoic	Tertiary	Late-Paleocene	Unnamed	60.6	63.6
Phanerozoic	Cenozoic	Tertiary-Paleogene	Late-Paleocene	Unnamed	60.6	63.6
Phanerozoic	Cenozoic	Tertiary	Paleocene	Selandian-unnamed	60.6	63.6
Phanerozoic	Cenozoic	Tertiary	Late-Paleocene	Selandian-unnamed	60.6	63.6
Phanerozoic	Cenozoic	Tertiary-Paleogene	Late-Paleocene	Selandian-unnamed	60.6	63.6
Phanerozoic	Cenozoic	Tertiary	Early-Paleocene		63.6	66.4
Phanerozoic	Cenozoic	Tertiary-Paleogene	Early-Paleocene		63.6	66.4
Phanerozoic	Cenozoic	Tertiary	Paleocene	Danian	63.6	66.4
Phanerozoic	Cenozoic	Tertiary	Early-Paleocene	Danian	63.6	66.4
Phanerozoic	Cenozoic	Tertiary-Paleogene	Early-Paleocene	Danian	63.6	66.4
Phanerozoic	Mesozoic				66.4	245
Phanerozoic	Mesozoic	Cretaceous			66.4	144
Phanerozoic	Mesozoic	Cretaceous	Late-Cretaceous		66.4	97.5
Phanerozoic	Mesozoic	Cretaceous	Late-Cretaceous	Maastrichtian	66.4	74.5
Phanerozoic	Mesozoic	Cretaceous	Late-Cretaceous	Campanian	74.5	84.0
Phanerozoic	Mesozoic	Cretaceous	Late-Cretaceous	Santonian	84.0	87.5
Phanerozoic	Mesozoic	Cretaceous	Late-Cretaceous	Coniacian	87.5	88.5
Phanerozoic	Mesozoic	Cretaceous	Late-Cretaceous	Turonian	88.5	91.0
Phanerozoic	Mesozoic	Cretaceous	Late-Cretaceous	Cenomanian	91.0	97.5
Phanerozoic	Mesozoic	Cretaceous	Early-Cretaceous		97.5	144
Phanerozoic	Mesozoic	Cretaceous	Early-Cretaceous	Albian	97.5	113

Phanerozoic	Mesozoic	Cretaceous	Early-Cretaceous	Aptian	113	119
Phanerozoic	Mesozoic	Cretaceous	Neocomian		119	144
Phanerozoic	Mesozoic	Cretaceous	Early-Cretaceous-Neocomian		119	144
Phanerozoic	Mesozoic	Cretaceous	Early-Cretaceous	Barremian	119	124
Phanerozoic	Mesozoic	Cretaceous	Early-Cretaceous-Neocomian	Barremian	119	124
Phanerozoic	Mesozoic	Cretaceous	Neocomian	Barremian	119	124
Phanerozoic	Mesozoic	Cretaceous	Early-Cretaceous	Hauterivian	124	131
Phanerozoic	Mesozoic	Cretaceous	Early-Cretaceous-Neocomian	Hauterivian	124	131
Phanerozoic	Mesozoic	Cretaceous	Neocomian	Hauterivian	124	131
Phanerozoic	Mesozoic	Cretaceous	Early-Cretaceous	Valanginian	131	134
Phanerozoic	Mesozoic	Cretaceous	Early-Cretaceous-Neocomian	Valanginian	131	134
Phanerozoic	Mesozoic	Cretaceous	Neocomian	Valanginian	131	134
Phanerozoic	Mesozoic	Cretaceous	Early-Cretaceous	Berriasian	134	144
Phanerozoic	Mesozoic	Cretaceous	Early-Cretaceous-Neocomian	Berriasian	134	144
Phanerozoic	Mesozoic	Cretaceous	Neocomian	Berriasian	134	144
Phanerozoic	Mesozoic	Jurassic			144	208
Phanerozoic	Mesozoic	Jurassic	Late-Jurassic		144	163
Phanerozoic	Mesozoic	Jurassic	Late-Jurassic	Tithonian	144	152
Phanerozoic	Mesozoic	Jurassic	Late-Jurassic	Kimmeridgian	152	156
Phanerozoic	Mesozoic	Jurassic	Late-Jurassic	Oxfordian	156	163
Phanerozoic	Mesozoic	Jurassic	Middle-Jurassic		163	187
Phanerozoic	Mesozoic	Jurassic	Middle-Jurassic	Callovian	163	169
Phanerozoic	Mesozoic	Jurassic	Middle-Jurassic	Bathonian	169	176
Phanerozoic	Mesozoic	Jurassic	Middle-Jurassic	Bajocian	176	183
Phanerozoic	Mesozoic	Jurassic	Middle-Jurassic	Aalenian	183	187
Phanerozoic	Mesozoic	Jurassic	Early-Jurassic		187	208
Phanerozoic	Mesozoic	Jurassic	Early-Jurassic	Toarcian	187	193
Phanerozoic	Mesozoic	Jurassic	Early-Jurassic	Pliensbachian	193	196
Phanerozoic	Mesozoic	Jurassic	Early-Jurassic	Sinemurian	196	204
Phanerozoic	Mesozoic	Jurassic	Early-Jurassic	Hettangian	204	208
Phanerozoic	Mesozoic	Triassic			208	245
Phanerozoic	Mesozoic	Triassic	Late-Triassic		208	230
Phanerozoic	Mesozoic	Triassic	Late-Triassic	Norian	208	225
Phanerozoic	Mesozoic	Triassic	Late-Triassic	Carnian	225	230
Phanerozoic	Mesozoic	Triassic	Middle-Triassic		230	240
Phanerozoic	Mesozoic	Triassic	Middle-Triassic	Ladinian	230	235
Phanerozoic	Mesozoic	Triassic	Middle-Triassic	Anisian	235	240
Phanerozoic	Mesozoic	Triassic	Early-Triassic		240	245
Phanerozoic	Mesozoic	Triassic	Early-Triassic	Scythian	240	245
Phanerozoic	Paleozoic				245	570
Phanerozoic	Paleozoic	Permian			245	286
Phanerozoic	Paleozoic	Permian	Late-Permian		245	258
Phanerozoic	Paleozoic	Permian	Late-Permian	Tatarian	245	253
Phanerozoic	Paleozoic	Permian	Late-Permian	Kazanian	253	258

Phanerozoic	Paleozoic	Permian	Late-Permian	Kazanian-Ufimian	253	258
Phanerozoic	Paleozoic	Permian	Late-Permian	Ufimian	253	258
Phanerozoic	Paleozoic	Permian	Early-Permian		258	286
Phanerozoic	Paleozoic	Permian	Early-Permian	Kungurian	258	263
Phanerozoic	Paleozoic	Permian	Early-Permian	Artinskian	263	268
Phanerozoic	Paleozoic	Permian	Early-Permian	Sakmarina	268	286
Phanerozoic	Paleozoic	Permian	Early-Permian	Sakmarina-Asselian	268	286
Phanerozoic	Paleozoic	Permian	Early-Permian	Asselian	268	286
Phanerozoic	Paleozoic	Carboniferous			286	360
Phanerozoic	Paleozoic	Carboniferous	Late-Carboniferous		286	320
Phanerozoic	Paleozoic	Carboniferous-Pennsylvanian	Late-Carboniferous		286	320
Phanerozoic	Paleozoic	Carboniferous-Pennsylvanian			286	320
Phanerozoic	Paleozoic	Carboniferous	Late-Carboniferous	Gzelian	286	296
Phanerozoic	Paleozoic	Carboniferous	Late-Carboniferous	Kasimovian	286	296
Phanerozoic	Paleozoic	Carboniferous	Late-Carboniferous	Gzelian-Kasimovian	286	296
Phanerozoic	Paleozoic	Carboniferous-Pennsylvanian	Late-Carboniferous	Gzelian	286	296
Phanerozoic	Paleozoic	Carboniferous-Pennsylvanian	Late-Carboniferous	Kasimovian	286	296
Phanerozoic	Paleozoic	Carboniferous-Pennsylvanian	Late-Carboniferous	Gzelian-Kasimovian	286	296
Phanerozoic	Paleozoic	Carboniferous	Late-Carboniferous	Moscovian	296	311.3
Phanerozoic	Paleozoic	Carboniferous-Pennsylvanian	Late-Carboniferous	Moscovian	296	311.3
Phanerozoic	Paleozoic	Carboniferous	Late-Carboniferous	Bashkirian	311.3	320
Phanerozoic	Paleozoic	Carboniferous-Pennsylvanian	Late-Carboniferous	Bashkirian	311.3	320
Phanerozoic	Paleozoic	Carboniferous	Early-Carboniferous		320	360
Phanerozoic	Paleozoic	Carboniferous-Mississippian			320	360
Phanerozoic	Paleozoic	Carboniferous-Mississippian	Early-Carboniferous		320	360
Phanerozoic	Paleozoic	Carboniferous	Early-Carboniferous	Serpukhovian	320	333
Phanerozoic	Paleozoic	Carboniferous-Mississippian	Early-Carboniferous	Serpukhovian	320	333
Phanerozoic	Paleozoic	Carboniferous	Early-Carboniferous	Visean	333	352
Phanerozoic	Paleozoic	Carboniferous-Mississippian	Early-Carboniferous	Visean	333	352
Phanerozoic	Paleozoic	Carboniferous	Early-Carboniferous	Tournaisian	352	360
Phanerozoic	Paleozoic	Carboniferous-	Early-	Tournaisian	352	360

		Mississippian	Carboniferous			
Phanerozoic	Paleozoic	Devonian			360	408
Phanerozoic	Paleozoic	Devonian	Late-Devonian		360	374
Phanerozoic	Paleozoic	Devonian	Late-Devonian	Famennian	360	367
Phanerozoic	Paleozoic	Devonian	Late-Devonian	Frasnian	367	374
Phanerozoic	Paleozoic	Devonian	Middle-Devonian		374	387
Phanerozoic	Paleozoic	Devonian	Middle-Devonian	Givetian	374	380
Phanerozoic	Paleozoic	Devonian	Middle-Devonian	Eifelian	380	387
Phanerozoic	Paleozoic	Devonian	Early-Devonian		387	408
Phanerozoic	Paleozoic	Devonian	Early-Devonian	Emsian	387	394
Phanerozoic	Paleozoic	Devonian	Early-Devonian	Siegenian	394	401
Phanerozoic	Paleozoic	Devonian	Early-Devonian	Gedinnian	401	408
Phanerozoic	Paleozoic	Silurian			408	438
Phanerozoic	Paleozoic	Silurian	Late-Silurian		408	421
Phanerozoic	Paleozoic	Silurian	Late-Silurian	Pridolian	408	414
Phanerozoic	Paleozoic	Silurian	Late-Silurian	Ludlovian	414	421
Phanerozoic	Paleozoic	Silurian	Early-Silurian		421	438
Phanerozoic	Paleozoic	Silurian	Early-Silurian	Wenlockian	421	428
Phanerozoic	Paleozoic	Silurian	Early-Silurian	Llandoverian	428	438
Phanerozoic	Paleozoic	Ordovician			438	505
Phanerozoic	Paleozoic	Ordovician	Late-Ordovician		438	458
Phanerozoic	Paleozoic	Ordovician	Late-Ordovician	Ashgillian	438	448
Phanerozoic	Paleozoic	Ordovician	Late-Ordovician	Caradocian	448	458
Phanerozoic	Paleozoic	Ordovician	Middle-Ordovician		458	478
Phanerozoic	Paleozoic	Ordovician	Middle-Ordovician	Llandeilan	458	468
Phanerozoic	Paleozoic	Ordovician	Middle-Ordovician	Llanvirinian	468	478
Phanerozoic	Paleozoic	Ordovician	Early-Ordovician		478	505
Phanerozoic	Paleozoic	Ordovician	Early-Ordovician	Arenigian	478	488
Phanerozoic	Paleozoic	Ordovician	Early-Ordovician	Tremadocian	488	505
Phanerozoic	Paleozoic	Cambrian			505	570
Phanerozoic	Paleozoic	Cambrian	Late-Cambrian		505	523
Phanerozoic	Paleozoic	Cambrian	Late-Cambrian	Trempealeauan	505	523
Phanerozoic	Paleozoic	Cambrian	Late-Cambrian	Franconian	505	523
Phanerozoic	Paleozoic	Cambrian	Late-Cambrian	Dresbachian	505	523
Phanerozoic	Paleozoic	Cambrian	Late-Cambrian	Trempealeauan-Franconian	505	523
Phanerozoic	Paleozoic	Cambrian	Late-Cambrian	Trempealeauan-Dresbachian	505	523
Phanerozoic	Paleozoic	Cambrian	Late-Cambrian	Trempealeauan-Franconian-Dresbachian	505	523
Phanerozoic	Paleozoic	Cambrian	Late-Cambrian	Franconian-Dresbachian	505	523
Phanerozoic	Paleozoic	Cambrian	Middle-Cambrian		523	540
Phanerozoic	Paleozoic	Cambrian	Early-Cambrian		540	570
preCambrian					570	4500
Proterozoic					570	2500

preCambrian-Proterozoic					570	2500
Proterozoic	Late-Proterozoic				570	900
Proterozoic	Middle-Proterozoic				900	1600
Proterozoic	Middle-Proterozoic	Late-Middle-Proterozoic			900	1200
Proterozoic	Middle-Proterozoic	Middle-Middle-Proterozoic			1200	1400
Proterozoic	Middle-Proterozoic	Early-Middle-Proterozoic			1400	1600
Proterozoic	Early-Proterozoic				1600	2500
Proterozoic	Early-Proterozoic	Late-Early-Proterozoic			1600	1800
Proterozoic	Early-Proterozoic	Middle-Early-Proterozoic			1800	2100
Proterozoic	Early-Proterozoic	Early-Early-Proterozoic			2100	2500
Archean					2500	3800
preCambrian-Archean					2500	3800
Archean	Late-Archean				2500	3000
Archean	Middle-Archean				3000	3400
Archean	Early-Archean				3400	3800

Appendix 4. Lithologic Data Dictionary (LITHLIST)

This data dictionary was used to populate the lithology fields of the STLITH supplemental attribute table. The LITHLIST data dictionary is a hierarchical list of common rock and unconsolidated deposit names derived from common usage. It is not a comprehensive classification but rather was created by starting with a short list of common lithology terms and adding additional terms to the data dictionary as required to support the compilation. Lithologic classification of map units is a difficult issue and the reader is directed to the work of the North American Geologic-map Data Model Science Language Technical Team, (2004, Introduction, Section 3.2.1, p.15-16).

Lith1	Lith2	Lith3	Lith4	Lith5
Unconsolidated				
	Coarse-detrital			
		Boulders		
		Gravel		
		Sand		
	Fine-detrital			
		Clay		
		Silt		
	Coral			
	Marl			
	Peat			
Sedimentary				
	Clastic			
		Mixed-clastic		
			Conglomerate-mudstone	
			Conglomerate-sandstone	
			Sandstone-mudstone	
			Siltstone-mudstone	
		Conglomerate		
		Sandstone		
			Arenite	
				Calcarenite
			Arkose	
			Graywacke	
		Siltstone		
		Mudstone		
			Claystone	
				Bentonite
			Shale	
				Black-shale
				Oil-shale
				Phosphatic-shale
		Sedimentary-breccia		
	Carbonate			
		Dolostone		
		Limestone		
			Chalk	

			Coquina	
		Marlstone		
	Chemical			
		Banded-iron-formation		
		Barite		
		Chert		
		Diatomite		
		Evaporite		
			Anhydrite	
			Gypsum	
			Salt	
		Novaculite		
		Phosphorite		
	Coal			
		Anthracite		
		Bituminous		
		Lignite		
		Sub-bituminous		
Igneous				
	Plutonic			
		Granitic		
			Alkali-feldspar-granite	
				Alkali-granite
			Granite	
				Monzogranite
				Syenogranite
			Granodiorite	
			Leucocratic-granitic	
				Alaskite
				Aplite
				Pegmatite
				Quartz-rich-granitoid
			Tonalite	
				Trondhjemite
		Charnockite		
		Syenitic		
			Alkali-feldspar-syenite	
			Monzonite	
			Quartz-alkali-feldspar-syenite	
			Quartz-monzonite	
			Quartz-syenite	
			Syenite	
		Dioritic		
			Diorite	
			Monzodiorite	
			Quartz-monzodiorite	
			Quartz-diorite	
		Gabbroic		
			Gabbro	

				Gabbronorite
				Norite
				Troctolite
			Monzogabbro	
			Quartz-gabbro	
			Quartz-monzogabbro	
		Anorthosite		
		Ultramafic		
			Hornblendite	
			Peridotite	
				Dunite
				Kimberlite
			Pyroxenite	
		Foidal-syenitic		
			Foid-syenite	
			Cancrinite-syenite	
			Nepheline-syenite	
			Sodalite-syenite	
		Foidal-dioritic		
		Foidal-gabbroic		
		Foidolite		
		Melilitic		
		Intrusive-carbonatite		
	Hypabyssal			
		Felsic-hypabyssal		
			Hypabyssal-dacite	
			Hypabyssal-felsic-alkaline	
			Hypabyssal-latite	
			Hypabyssal-quartz-latite	
			Hypabyssal-quartz-trachyte	
			Hypabyssal-rhyolite	
			Hypabyssal-trachyte	
		Mafic-hypabyssal		
			Hypabyssal-andesite	
			Hypabyssal-basalt	
			Hypabyssal-basaltic-andesite	
			Hypabyssal-mafic-alkaline	
		Lamprophyre		
	Volcanic			
		Alkalic-volcanic		
			Basanite	
			Foidite	
			Phonolite	
		Felsic-volcanic		
			Dacite	
			Latite	
			Quartz-latite	

			Quartz-trachyte	
			Rhyolite	
			Trachyte	
		Mafic-volcanic		
			Andesite	
			Basalt	
			Basaltic-andesite	
		Ultramafic		
			Komatiite	
			Picrite	
Metamorphic				
	Amphibolite			
	Argillite			
	Eclogite			
	Gneiss			
		Orthogneiss		
		Paragneiss		
	Granofels			
	Granulite			
	Greenstone			
	Hornfels			
	Marble			
	Metasedimentary			
	Metavolcanic			
	Migmatite			
	Phyllite			
	Quartzite			
	Schist			
	Serpentinite			
	Skarn			
	Slate			
Tectonite				
	Cataclastite			
	Mylonite			
		Phyllonite		
	Melange			
Water				
Ice				
Indeterminate				

Appendix 5. Lithform Data Dictionary

The LITHFORM dictionary is not restricted to terms describing form but is a way to convey additional information (modifiers) about the lithologies in a map unit. It includes terms like bed, pluton, and dike, but also terms like pyroclastic (for application to volcanic rocks), greenschist (facies information for application to metamorphic rocks), and deltaic (depositional environment information for application to sedimentary rocks). Thus rhyolite lava flows and rhyolite ash-flow tuffs are two different lithologies, as are greenschist-facies schist and amphibolite-facies schist. Like our lithology data dictionary (Appendix 4) it is not comprehensive, and was created by defining a short list of terms and adding additional terms as needed.

Lith1	Lith-form
Unconsolidated	
	Alluvial
	Beach
	Bed
	Colluvial
	Eolian
	Eolian, loess
	Estuarine
	Flow, mass movement
	Fluvial
	Glacial
	Glacial, drumlin
	Glacial, esker
	Glacial, outwash
	Glacial, rock glacier
	Glacial, till
	Lacustrine
	Landslide
	Mass wasting
	Solifluction
	Swamp
	Tailings
	Terrace
	Terrace, marine
	Terrace, stream
Sedimentary	
	Arkosic
	Bed
	Calcareous
	Carbonaceous
	Deltaic
	Dome
	Glauconitic
	Lens
	Melange
	Olistrostrome
	Pelitic
	Reef
	Tuffaceous
Igneous	

	Batholith
	Diabase
	Dike or sill
	Dome
	Flow
	Flow, pillows
	Laccolith
	Melange
	Pluton
	Pyroclastic
	Pyroclastic, air fall
	Pyroclastic, ash-flow
	Pyroclastic, cinder cone
	Pyroclastic, tuff
	Stock or pipe
	Volcaniclastic
	Volcaniclastic, lahar
	Volcaniclastic, volcanic breccia
Metamorphic	
	Amphibolite
	Amphibolite, epidote-amphibolite
	Eclogite
	Glaucophane-schist
	Granulite
	Greenschist
	Hornfels
	Hornfels, biotite
	Hornfels, hornblende
	Hornfels, pyroxene
	Hornfels, sanidine
	Pelitic
	Zeolitic (prehnite-pumpellyite)
Tectonite	
	Melange, blocks
	Melange, matrix
Water	
	Lake, stream, or ocean
Ice	
	Mass

Appendix 6. Lithclass 6.1 Lithologic Data Dictionary

This data dictionary was used to compile the contents of the *rocktype1*, *rocktype2*, and *rocktype3* fields of the STUNITS supplemental attribute table. The data dictionary used is the Geologic Map Unit Classification, version 6.1 that was developed as a lithologic data dictionary for a prototype national geologic map data model (Johnson, 2002). This lithologic coding will be used for the creation of a conterminous United States dominant lithology map.

This hierarchical dictionary uses a single term to describe lithology and contains compositional and other terms that allow the representation of lithologic information with a single variable. We have added three new terms (water, ice, and indeterminate) at the end of the dictionary that were required to ensure that we could code all geology polygons. The dictionary contains hierarchical numbering which is not used in our compilation but was retained to make the hierarchical level easy to determine.

The dictionary has not been formally published, but is available online at the web link below and the reader is referred there for details.

http://www.nadm-geo.org/dmdt/pdf/lithclass61.pdf

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1. unconsolidated deposit

- 1.1 alluvium
    - 1.1.1. flood plain
    - 1.1.2. levee
    - 1.1.3. delta
    - 1.1.4. alluvial fan
    - 1.1.5. alluvial terrace
- 1.2. lake or marine deposit (non-glacial)
    - 1.2.1. playa
    - 1.2.2. mud flat
    - 1.2.3. beach sand
    - 1.2.4. terrace
- 1.3. eolian
    - 1.3.1. dune sand
    - 1.3.2. sand sheet
    - 1.3.3. loess
- 1.4. volcanic ash
- 1.5. mass wasting
    - 1.5.1. colluvium
    - 1.5.2. mudflow
        - 1.5.2.1. lahar

- 1.5.3. debris flow
- 1.5.4. landslide
- 1.5.5. talus
- 1.6. glacial drift
  - 1.6.1. till
    - 1.6.1.1. moraine
  - 1.6.2. stratified glacial sediment
    - 1.6.2.1. outwash
    - 1.6.2.2. sub- and supra-glacial sediment
    - 1.6.2.3. glaciolacustrine
    - 1.6.2.4. glacial-marine
- 1.7. biogenic sediment
  - 1.7.1. peat
  - 1.7.2. coral
- 1.8. residuum
- 1.9. clay or mud
- 1.10. silt
- 1.11. sand
- 1.12. gravel

2. sedimentary rock

- 2.1. clastic
  - 2.1.1. mudstone
    - 2.1.1.1. claystone
      - 2.1.1.1.1. bentonite
    - 2.1.1.2. shale
      - 2.1.1.2.1. black shale
      - 2.1.1.2.2. oil shale
    - 2.1.1.3. argillite
    - 2.1.1.4. siltstone
  - 2.1.2. fine-grained mixed clastic
  - 2.1.3. sandstone
    - 2.1.3.1. arenite
      - 2.1.3.1.1. orthoquartzite
      - 2.1.3.1.2. calcarenite
    - 2.1.3.2. arkose
    - 2.1.3.3. wacke
      - 2.1.3.3.1. greywacke

        - 2.1.4. medium-grained mixed clastic
        - 2.1.5. conglomerate
        - 2.1.6. sedimentary breccia
        - 2.1.7. coarse-grained mixed clastic
        - 2.1.8. olistostrome
            - 2.1.8.1. mélange
    - 2.2. carbonate
        - 2.2.1. limestone
        - 2.2.2. dolostone (dolomite)
    - 2.3. mixed clastic/carbonate
    - 2.4. mixed clastic/volcanic
    - 2.5. phosphorite
    - 2.6. chemical
        - 2.6.1. evaporite
        - 2.6.2. chert
        - 2.6.3. novaculite
        - 2.6.4. iron formation
        - 2.6.5. exhalite
    - 2.7. coal
    - 2.8. mixed clastic/coal

3. volcanic rock (aphanitic)

- 3.1. glassy volcanic rock
    - 3.1.1. obsidian
    - 3.1.2. vitrophyre
    - 3.1.3. pumice
- 3.2. pyroclastic
    - 3.2.1. tuff
        - 3.2.1.1. welded tuff
        - 3.2.1.2. ash-flow tuff
    - 3.2.2. ignimbrite
    - 3.2.3. volcanic breccia (agglomerate)
- 3.3. lava flow
    - 3.3.1. bimodal suite
- 3.4. felsic volcanic rock
    - 3.4.1. alkali rhyolite
    - 3.4.2. rhyolite
    - 3.4.3. rhyodacite

- 3.4.4. dacite
- 3.4.5. alkali trachyte
- 3.4.6. trachyte
- 3.4.7. quartz latite
- 3.4.8. latite
- 3.5. intermediate volcanic rock
  - 3.5.1. trachyandesite
  - 3.5.2. andesite
- 3.6. mafic volcanic rock
  - 3.6.1. trachybasalt
  - 3.6.2. basalt
    - 3.6.2.1. tholeiite
    - 3.6.2.2. hawaiite
    - 3.6.2.3. alkaline basalt
- 3.7. alkalic volcanic rock
  - 3.7.1. phonolite
  - 3.7.2. tephrite (basanite)
- 3.8. ultramafitite (komatiite)
- 3.9. volcanic carbonatite

4. plutonic rock (phaneritic)

- 4.1. aplite
- 4.2. porphyry
  - 4.2.1. lamprophyre
- 4.3. pegmatite
- 4.4. granitoid
  - 4.4.1. alkali-granite (alaskite)
  - 4.4.2. granite
    - 4.4.2.1. peraluminous granite
    - 4.4.2.2. metaluminous granite
    - 4.4.2.3. subaluminous granite
    - 4.4.2.4. peralkaline granite
  - 4.4.3. granodiorite
  - 4.4.4. tonalite
    - 4.4.4.1. trondhjemite
  - 4.4.5. alkali syenite
  - 4.4.6. quartz syenite
  - 4.4.7. syenite

4.4.8. quartz monzonite

4.4.9. monzonite

4.4.10. quartz monzodiorite

4.4.11. monzodiorite

4.4.12. quartz diorite

4.4.13. diorite

4.4.13.1. diabase

4.5. gabbroid

4.5.1. quartz monzogabbro

4.5.2. monzogabbro

4.5.3. quartz gabbro

4.5.4. gabbro

4.5.4.1. norite

4.5.4.2. troctolite

4.5.5. anorthosite

4.6. alkalic intrusive rock

4.6.1. nepheline syenite

4.7. ultramafic intrusive rock

4.7.1. peridotite

4.7.1.1. dunite

4.7.1.2. kimberlite

4.7.2. pyroxenite

4.7.3. hornblendite

4.8. intrusive carbonatite

5. metamorphic rock

5.1. hornfels

5.2. metasedimentary rock

5.2.1. meta-argillite

5.2.2. slate

5.2.3. quartzite

5.2.4. meta-conglomerate

5.2.5. marble

5.3. metavolcanic rock

5.3.1. felsic metavolcanic rock

5.3.1.1. meta-rhyolite

5.3.1.2. keratophyre

5.3.2. intermediate metavolcanic rock

5.3.3. mafic metavolcanic rock

5.3.3.1. meta-basalt

5.3.3.2. spilite

5.3.3.3. greenstone

5.4. phyllite

5.5. schist

5.5.1. greenschist

5.5.2. blueschist

5.5.3. mica schist

5.5.4. pelitic schist

5.5.5. quartz-feldspar schist

5.5.6. calc-silicate schist

5.5.7. amphibole schist

5.6. granofels

5.7. gneiss

5.7.1. felsic gneiss

5.7.1.1. granitic gneiss

5.7.1.1.1. biotite gneiss

5.7.2. mafic gneiss

5.7.3. orthogneiss

5.7.4. paragneiss

5.7.5. migmatite

5.8. amphibolite

5.9. granulite

5.10. eclogite

5.11. greisen

5.12. skarn (tactite)

5.13. calc-silicate rock

5.14. serpentinite

6. tectonite

6.1.1. tectonic mélange

6.1.2. tectonic breccia

6.1.3. cataclasite

6.1.4. phyllonite

6.1.5. mylonite

6.1.6. flaser gneiss

6.1.7. augen gneiss

7. water

8. ice

9. indeterminate

APPENDIX 7. ARC (LINE) CODING DATA DICTIONARY

The table below is the data dictionary used for arcs (lines) in the geologic map and other associated line and network coverages. ARC-CODE designates the line or arc type in the coverages.

ARC-CODE	DESCRIPTION
CONTACTS	
1	Contact, location certain
2	Contact, location approximate
3	Contact, location inferred, queried
51	Contact, concealed
18	Internal contact
19	Internal contact having tics on right from origin
8	Internal contact or phase change; no symbol (not drawn)
9	Boundary of altered zone or hornfels; no symbol (not drawn)
130	Pinch out; where unit is too narrow to map as a polygon on the source map and has been represented as a line
FAULTS - GENERAL	
30	Fault, sense of displacement unknown or undefined, location certain
31	Fault, sense of displacement unknown or undefined, location approximate
32	Fault, sense of displacement unknown or undefined, location inferred or queried
100	Fault, sense of displacement unknown or undefined, concealed
NORMAL FAULTS	
4	Normal fault, location certain, digitized with upthrown side on the right (code of 1 added to *arc-para1* where U/D is designated in source)
5	Normal fault, location approximate, digitized with upthrown side on the right (code of 1 added to *arc-para1* where U/D is designated in source)
6	Normal fault, location inferred, queried, digitized with upthrown side on the right (code of 1 added to *arc-para1* where U/D is designated in source)
71	Normal fault, location certain, having right lateral oblique slip
72	Normal fault, location approximate, having right lateral oblique slip
73	Normal fault, location certain, having left lateral oblique slip
74	Normal fault, location approximate, having left lateral oblique slip
75	Normal fault, location inferred, queried, having left lateral oblique slip
76	Normal fault, location inferred, queried, having right lateral oblique slip
52	Normal fault, concealed
55	Normal fault, having right lateral oblique slip, concealed
56	Normal fault, having left lateral oblique slip, concealed
THRUST FAULTS	
10	Thrust fault, location certain, teeth on right from origin (angle of thrusting added to *arc-para1* where designated in source)
11	Thrust fault, location approximate, teeth on right from origin (angle of thrusting added to *arc-para1* where designated in source)
12	Thrust fault, location inferred, queried, teeth on right from origin (angle of

	thrusting added to *arc-para1* where designated in source)
16	Thrust fault, having left lateral oblique slip (angle of thrusting added to *arc-para1* where designated in source)
17	Thrust fault, having right lateral oblique slip (angle of thrusting added to *arc-para1* where designated in source)
53	Thrust fault, concealed
101	Thrust fault, direction of motion undefined (i.e. teeth not shown), location certain
102	Thrust fault, direction of motion undefined (i.e. teeth not shown), location approximate
103	Thrust fault, direction of motion undefined (i.e. teeth not shown), location inferred
104	Thrust fault, direction of motion undefined (i.e. teeth no shown), location concealed
105	Thrust fault, reactivated with normal motion, location certain
106	Thrust fault, reactivated with normal motion, location approximate
107	Thrust fault, reactivated with normal motion, location inferred
108	Thrust fault, reactivated with normal motion, location concealed
DETACHMENT FAULTS	
109	Detachment fault, location certain
110	Detachment fault, location approximate
111	Detachment fault, location inferred
112	Detachment fault, location concealed
HIGH-ANGLE FAULTS	
35	High-angle reverse fault, location certain, teeth on right from origin (angle of thrusting added to *arc-para1* where designated in source)
36	High-angle reverse fault, location approximate, teeth on right from origin (angle of thrusting added to *arc-para1* where designated in source)
37	High-angle reverse fault, location inferred, teeth on right from origin (angle of thrusting added to *arc-para1* where designated in source)
54	High-angle reverse fault, concealed
RIGHT-LEFT LATERAL FAULTS	
113	Strike slip fault, motion unknown, location certain
114	Strike slip fault, motion unknown, location approximate
115	Strike slip fault, motion unknown, location inferred
116	Strike slip fault, motion unknown, location concealed
87	Right lateral fault, location certain
88	Right lateral fault, location approximate
89	Right lateral fault, location inferred, queried
57	Right lateral fault, concealed
90	Left lateral fault, location certain
91	Left lateral fault, location approximate
92	Left lateral fault, location inferred, queried
58	Left lateral fault, concealed
SHEAR ZONES & FISSURES	
94	Shear zone, certain
95	Shear zone, approximate
96	Shear zone, inferred
59	Shear zone, concealed
69	Fissures
140	Mylonite zone, certain
145	Microbreccia zone, certain
SYNCLINES	
61	Syncline, no plunge, certain

62	Syncline, no plunge, location approximate
63	Syncline, no plunge, inferred, queried
21	Syncline, location certain, digitized in direction of plunge (*arc-para1* equals angle of plunge, 0 is no plunge, 1 is plunge of unknown dip)
22	Syncline, location approx., digitized in direction of plunge (*arc-para1* equals angle of plunge, 0 is no plunge, 1 is plunge of unknown dip)
23	Syncline, location inferred, queried, digitized in direction of plunge (*arc-para1* equals angle of plunge, 0 is no plunge, 1 is plunge of unknown dip)
41	Syncline, overturned, location certain, digitized in direction of plunge (*arc-para1* equals angle of plunge, 0 is no plunge, 1 is plunge of unknown dip)
42	Syncline, overturned, location approximate, digitized in direction of plunge (*arc-para1* equals angle of plunge, 0 is no plunge, 1 is plunge of unknown dip)
43	Syncline, overturned, location inferred, queried, digitized in direction of plunge (*arc-para1* equals angle of plunge, 0 is no plunge, 1 is plunge of unknown dip)
81	Syncline, inverted, location certain (*arc-para1* equals angle of plunge, 0 is no plunge, 1 is plunge of unknown dip)
82	Syncline, inverted, location approximate (*arc-para1* equals angle of plunge, 0 is no plunge, 1 is plunge of unknown dip)
83	Syncline, inverted, location inferred, queried (*arc-para1* equals angle of plunge, 0 is no plunge, 1 is plunge of unknown dip)
126	Syncline, concealed
ANTICLINES	
24	Anticline, location certain, digitized in direction of plunge (*arc-para1* equals angle of plunge, 0 is no plunge, 1 is plunge of unknown dip)
25	Anticline, location approx., digitized in direction of plunge (*arc-para1* equals angle of plunge, 0 is no plunge, 1 is plunge of unknown dip)
26	Anticline, location inferred, queried, digitized in direction of plunge (*arc-para1* equals angle of plunge, 0 is no plunge, 1 is plunge of unknown dip)
84	Anticline, inverted, location certain (*arc-para1* equals angle of plunge, 0 is no plunge, 1 is plunge of unknown dip)
85	Anticline, inverted, location approximate (*arc-para1* equals angle of plunge, 0 is no plunge, 1 is plunge of unknown dip)
86	Anticline, inverted, location inferred, queried (*arc-para1* equals angle of plunge, 0 is no plunge, 1 is plunge of unknown dip)
44	Anticline, overturned, location certain, digitized in direction of plunge (*arc-para1* equals angle of plunge, 0 is no plunge, 1 is plunge of unknown dip)
45	Anticline, overturned, location approximate, digitized in direction of plunge (*arc-para1* equals angle of plunge, 0 is no plunge, 1 is plunge of unknown dip)
46	Anticline, overturned, location inferred, queried, digitized in direction of plunge (*arc-para1* equals angle of plunge, 0 is no plunge, 1 is plunge of unknown dip)
64	Anticline, certain, no plunge
65	Anticline, approximate, no plunge
66	Anticline, inferred, queried, no plunge
127	Anticline, concealed
MONOCLINES	
117	Monocline, location certain
118	Monocline, location approximate
119	Monocline, location inferred
120	Monocline, location concealed
DIKES & SILLS	

50	Dike or sill, unspecified, drawn in heavy red line
121	Dike or sill , mafic
122	Dike or sill, felsic
123	Dike or sill, lamprophyre
ISOGRADS	
160	Subchlorite to chlorite
161	Chlorite to biotite
162	Biotite to garnet
163	Garnet to staurolite
164	Staurolite to sillimanite
165	Sillimanite to sillimanite + orthoclase
OTHER LINE TYPES	
93	Lineament
7	Shoreline or riverbank
14	Caldera or crater rim
28	Caldera or crater rim, inferred, concealed
15	Ice contact (glacier limit)
13	Moraine or till margin (scour) on bedrock
0	Hidden lines
99	Bounding line (neatline) of coverage
124	State Boundary
125	International Boundary