Geologic Map Databases for the Surficial Geologic Map of the Dillingham Quadrangle, southwestern Alaska

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Introduction

This map and accompanying digital files are the result of the interpretation of aerial photographs from the 1950s as well as more modern imagery. Long considered a part of Alaska that was largely not glaciated (see Karlstrom, 1964; Coulter and others, 1965; or Péwé, 1975), the Dillingham region actually has a long history reflecting local and more distant glaciations. An unpublished photogeologic map of the Dillingham quadrangle from the 1950s by J.N. Platt, Jr. was useful in the construction of this map. Limited new field mapping in the area was conducted as part of a mapping project in 2001 (Wilson and others, 2003); however, extensive aerial photograph interpretation represents the bulk of the mapping effort for this project.

The 1:250,000-scale geologic map depicts the surficial geology of the Dillingham quadrangle in southwestern Alaska. The map data is derived from a database structured similarly to the bedrock geologic map, published as part of Wilson and others (2006, 2015) and the included digital files are a subset of the data for the quadrangle released as part of Wilson and others (2015).

The map area in southwestern Alaska, is a region largely of heavily vegetated rolling hills, which show evidence from photograph interpretation that suggests the past presence of local alpine glaciers and extensive glacial advances from the Alaska Range to the east and the Ahklun Mountains to the west of late Wisconsin, earlier Wisconsin, and probably of pre-Wisconsin age. In the western part of the quadrangle, the mountains and beautiful finger lakes show strong effects from Pleistocene and Holocene glaciation (Briner and Kaufman, 2000). In particular, the finger lakes of Wood-Tikchik State Park are well-developed landlocked fjords. Extensive glacial deposits provide abundant evidence for glaciers that advanced into the quadrangle from the east and west, and probably coalesced in the northern part of the quadrangle during the early Pleistocene.

The digital datasets that form the basis for this product were compiled and created using existing published and unpublished data. The spatial and text databases here are linked through use of two parallel key fields. These fields link to the associated attribute databases in slightly different ways. The spatial data files show the source for each line and geologic unit shown on the map.

The primary link for this map between the spatial database and the attribute database is a field called *qclass*; whereas on a statewide basis a field called *nsaclass* is used in the statewide database, of which this map represents one part. This *nsaclass* field provides a linkage through the databases to the age and lithology of the map units contained on each map. *Nsaclass* is used to cover the entire geologic time scale, whereas *qclass* is restricted to and provides finer detail for Quaternary map units. *Nsaclass* and the similar *qclass* field have been added to the polygon feature class of the spatial database and can also be found in the text databases of supplemental attribute data. These

fields represent the link that correlates individual map units between sources. *Nsaclass* is used to make regional unit assignments and generally reflects a known or an inferred correlation of map units. For example, all "Surficial deposits, undivided" are assigned an *nsaclass* code of 100. The schema for *nsaclass* and *qclass* was developed as regional maps throughout Alaska were compiled and therefore reflects an iterative process. As new or additional information becomes available, the *nsaclass* or *qclass* codes for a particular map unit may be changed, either to reflect lumping or, more generally, a finer separation of map units.

Fields called *source* and *nsamod* have also been added to the polygon feature class. *Source* is a coded reference citation, indicating the manuscript or other source for the map information. The format for *source* is XX###, where XX is the two letter 1:250k quadrangle code (CAPITAL letters) and ### is a three digit number (using leading zeros) to indicate a specific reference. (Only references appropriate for the Dillingham quadrangle are included in the references files here). *Nsamod* provides information with respect to hydrothermal alteration or contact metamorphism of a map unit, either for the entire unit or for an individual polygon; it is also used to indicate map polygons having a queried unit assignment. In this way, the *nsaclass* field needs only to store the primary map unit information. Fields also in the polygon feature class are *class*, and *label* which are more fully described below.

The arc or line feature class is used to store attributes indicating the type of line features in the geodatabase and shape-file (spatial database). Inherent in the coding is information defining the type of line shown, such as a stratigraphic or fault contact, and location (certain, approximate, inferred, or concealed). In addition, each arc within a spatial database has a *source* attribute.

The standardized supplemental attribute tables were generated by extracting information from the legends of source maps and from unpublished data of the author of this map. Thus, the age and lithologic information in the attribute tables in some cases, varies from the information on the legends of the original source maps. This reflects new information or interpretation for mapping compiled decades ago. The standardized supplemental attribute tables record an abstracted map unit description, lithologic and age information, and references.

The topologic map on which this compilation was published using the Universal Transverse Mercator projection (UTM; Zone 4), North American Datum 1927 (NAD-27). The spatial databases, both geodatabases and shape files are provided in the native UTM projection of the sources as well as geographic coordinates. The UTM projection parameters are described in the metadata.

Supplemental Stand-Alone Database Tables

In order to manage the textural and coding information related to the map, we have created a series of related and interlinked databases. These databases are a subset of the databases being created and maintained statewide. As provided here, in addition to the native database format files (.fmp12), as well as ".dbf" and ".csv" (comma separated values) files, we also include a runtime version of the primary databases, which are maintained using the commercial Filemaker Pro (versions 12 through 15) database software. Within their native FileMaker Pro software and in the runtime application (included as part of this data release), each of the databases have multiple views or layouts providing selective views of the contained information. In the descriptions below of the various databases included in this release, the term "portal" will be mentioned. In this context, a portal is a feature of the database software that allows viewing of data in other databases or tables from within the selected database. Portals not only allow viewing of information, but also

can be used in searches or to update related databases. Different layouts may contain different portals. These databases are not directly connected to the Spatial database; however, the data can be linked through the .csv or .dbf files that accompany this report. Additionally, the native Filemaker Pro files can be linked in ArcGIS through ODBC. In a standalone mode, these databases can be used to guide searches of the data. By way of background, the polygon feature class has five fields that correspond to fields in the Filemaker Pro databases. These fields are *class*, *nsaclass*, *qclass*, *label,* and *source*.
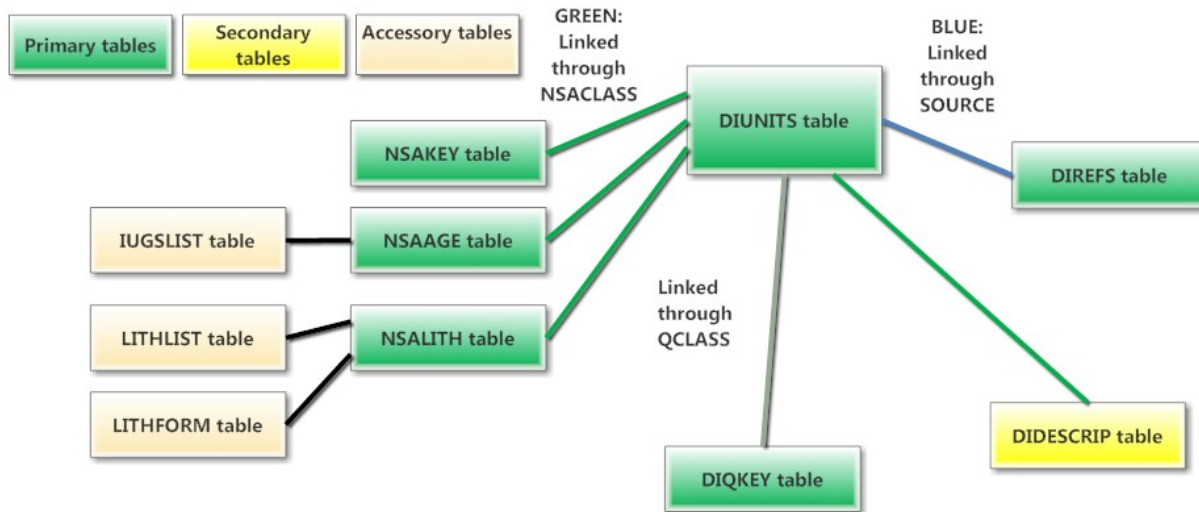

Figure 1. Illustration of Filemaker Pro database structure and linkages.

Ten database tables are included as part of this report. Additionally a menu shell is provided to facilitate file access in the runtime version of the databases. The form for the database tables is described here and 2 of the database tables are provided in appendices. They are:

DIUNITS (Table 1): A subset of the statewide database containing abstracted all geologic unit descriptions for the Dillingham quadrangle, including bedrock units and other map units not displayed. Five polygon feature class fields, *class*, *nsaclass*, *qclass*, and *source*, mentioned above, are duplicated in this database.

DIQKEY (Table 2): Database used to subdivide the Quaternary surficial deposits by assigning color symbols and labels to the Quaternary units. Linked to DIUNITS through q*class*. The color symbol code for map is included in the Spatial database and uses the WPGCMYK style sheet included with the spatial datasets.

DIDESCRIP (Table 3): This database ties *nsaclass* numbers to the more complete unit descriptions used on the Cook Inlet region geologic map. Linked to the DIUNITS database through the *nsaclass* field. Note, because of 8.3 naming limitation of the .dbf format, the .dbf and .csv versions of this file are named DIDESCRP

DIREFS (Table 4): A database containing the references for the source maps of the geologic map. Linked to the DIUNITS database through the *source* field.

DIKEY (Table 5): The statewide database that shows the color symbol and label that can be used for each *nsaclass* in the state. Note that these are **not** the colors and labels used on the Dillingham quadrangle map. We have provided the color symbols and labels appropriate for the present map in the DIDESCRIP and DIQKEY databases. DIKEY is linked to the DIUNITS

database through the *nsaclass* field. The required ARCMAP stylesheet are included with this report.

NSALITH (Table 6): The statewide database that provides information to assign to geologic units specific rock types, lithologic form or mode of occurrence, and relative proportion of the unit that rock type represents. Linked to the DIUNITS database through the *nsaclass* field.

NSAAGE (Table 7): The statewide database that provides information to assign specific ages to geologic units. Linked to the DIUNITS database through the *nsaclass* field.

IUGSLIST (Table 8): Provided as a database containing the minimum and maximum ages for every Eon, Era, Period, Epoch, and Age. Linked to the NSAAGE database through *Eon, Era, Period*, and *Epoch*. The age assignments are based on the 2008 IUGS time scale (see Cohen and others 2013).

LITHLIST (Appendix 1): Database containing all the lithologic terms (rock types) used in the lithologic coding – duplicated here in Appendix 1 of this document. Note, the metamorphic rock schema in this list is somewhat modified from previous releases of these databases. Linked to the NSALITH database.

LITHFORM (Appendix 2): Database containing the lithologic-form terms used for lithologic coding of geologic units – duplicated here in Appendix 1 of this document. Linked to the NSALITH database.

Runtime Application

Included with this data release is a runtime application of the Filemaker Pro database tables. This application, which functions under the Windows operating system is provided as a zipped directory which contains the database tables and the necessary files to provide much of the functionality of the Filemaker Pro software. To use this application, unzip the supplied zip file, which will create a folder (directory) containing needed files. Within that folder will be a file named **DI_Surficial.exe**. Double click on this file to start the runtime application. The menu shell will open. Using the "buttons" in this shell you can access any of the linked database tables. The database tables can be scrolled by clicking on the "rolodex"-like icon in the upper left corner. Searches can be made by selecting the "Find mode", found under the "View" tab and typing the desired search item in the appropriate field on the Find screen. A complete explanation of the software is not appropriate here, but experimentation will reveal many capabilities.

Database Structures

DIUNITS Database

The main database for the project is called DIUNITS. Entered into this database (table 1) are brief abstracts of the unit descriptions from each source map, which are then classified into regional or statewide units. This database is the root for correlations of units, although not necessarily the final word (more on this below). For example, late Wisconsin drift from various maps might get the same *nsaclass* and therefore be assigned to a single map unit, yet when drawn to produce a particular map, it might be given the same symbol and color as all Pleistocene glacial deposits (only for that map). Conversely, the *qclass* value allows subdivision of Quaternary *nsaclass* units; on this map *qclass* is the primary unit identifier. The standard view (called "Q-code") of the database in Filemaker Pro software has portals to five other related databases, DIQKEY, DIKEY, DIREFS, NSAAGE, and NSALITH, which show the related values in these databases. These

databases are linked through either the *nsaclass* or *source* fields in the DIUNITS database. The first seven fields in the database come directly from the source map, each of the other fields is assigned either at the time of entry into the database or later. Other views of the database tables are accessed through a tab in the upper left of the table display.

Table 1. DIUNITS field definitions.

	Field name	Information type	Field type	Links
1	*Quadrangle*	1:250,000–scale quadrangle, with the name fully spelled out. If a map covers multiple quadrangles, each quadrangle will have a set of entries for the appropriate units from that map in the database.	Text	
2	*Map unit*	Label given on the source map for a geologic unit. Some maps do not use labels; hence a color or pattern description would be entered here. In other cases, a unit subdivided using an overprint pattern (such as limestone lenses in a clastic unit) will have an entry for each variation.	Text	
3	*Unit name*	Map unit name from the source map. If a map is divided in regions, terranes, or allocthons, etc., or the unit name explicitly mentions stratigraphic divisions, then this information is included in the unit name (for example, "Lisburne Group, Kuna Formation", or "Greenstone of Venetie Subterrane of Arctic Alaska Terrane"). However, in general terrane terminology is not used in this database.	Text	
4	*Age*	Geologic age of the unit as given in the source. (Note, this is age and not stratigraphic position; Upper to Late and Lower to Early are converted, respectively.) In some cases, the age assignment has been subsequently revised; nevertheless, the age from the source map is entered here.	Text	

Table 1. DIUNITS field definitions (cont.)

	Field name	Information type	Field type	Links
5	*Description*	An abstracted version of the unit description from the source map. Focuses on lithology and important relationships as described on the source map. Also includes any special notes regarding this unit from the source. This field, though of unlimited length, is kept short.	Text	
6	*Fossil*	Brief notes on any fossil control mentioned on the source map.	Text	
7	*Radiometric age*	Brief notes on radiometric ages.	Text	
8	*Source*	Unique code assigned to each source; uses the 2-letter quadrangle code and a three digit number. By default, 001 is reserved for the topographic map for each quadrangle. Numbers above 100 indicate sources that may be significant, but not captured digitally.	Text and number combined	DIREFS, Spatial database
9	*Rock class*	General classification of unit: Igneous, Sedimentary, Metamorphic, Unconsolidated, or Melange. For mixed units, the dominant category.	Text, defined values	
10	*Nsamod*	An item to indicate if unit is altered, contact metamorphosed, or has a queried unit assignment. Some maps show contact metamorphosed areas as separate units; these units are assigned the *nsaclass* for the appropriate protolith and have "HFS" selected as *nsamod* value. If only a few polygons of a unit are altered or contact metamorphosed, then the *nsamod* value will be set for those polygons only in the Spatial database. Queried units, Tk? versus Tk for example, have the same *nsaclass* codes, but Tk? will have "Q" selected as *nsamod* value.	Text, defined values	Spatial database
11	*Class*	Unique numeric code assigned to each source unit. (Unique only within a given quadrangle and specific to each source.)	Number	Spatial database
12	*Nsaclass*	Regional numeric code assigned to like units – the main key field in the database.	Number	Spatial database, DIKEY, NSALITH

Table 1. DIUNITS field definitions (cont.)

	Field name	Information type	Field type	Links
13	*Maplabel*	Label used on the Dillingham surficial map. This information is linked from DIDESCRIP where the data is stored.	Text	DIDESCRP
14	*Qclass*	Similar to *nsaclass*; allows finer subdivision of Quaternary geologic units.	Number	Spatial database
15	*Nsasub*	The same regional numeric code assigned to like units as *Nsaclass*; used for bedrock maps to show bedrock unit under surficial deposits when and <u>if</u> known.	Number	DIKEY, Spatial database
16	*Mod_date*	Date of last modification of information in the record	Date	
17	*Source_class*	Concatenation of *Source* and *Class* fields; provides a unique link between polygons and DIUNTIS records	Text	Spatial database

Using the DIUNITS database, the disposition of any geologic unit from any source map for the map area can be determined. As such, it includes unit descriptions from maps used for different purposes or at different stages of the project that may not be explicitly reflected for this map. Each source map used in the compilation will have all of its geologic units entered in this database.

DIQKEY Database

The second most used database for this map is called DIQKEY (table 2); it is used to subdivide the Quaternary surficial deposits by assigning color symbols and labels to the Quaternary units. The primary field in this database is *qclass*, linking it to the DIUNITS database and to the Spatial database for the quadrangle. It is here that each unit gets assigned a symbol (color), and tentative label to be used on geologic map products. Note, the label provided in this database table are **not** the same as those used on the Dillingham map, but rather reflect a statewide focus (*Label* from the DIDESCRIP is used on the published map). This database allows control of the symbols and labels assigned to units and helps to eliminate undesired duplication. The database also includes a *description* field, which summarizes the regional unit in a sentence or less and commonly lists the *source* maps that contain the unit. Portals in the DIQKEY database provide a view into DIUNITS. The DIQKEY database is also used to assign duplicate colors and labels to units that are lumped in some map products, but otherwise need to be maintained as separate units in the database. Note, in the runtime version of the text databases, this table is accessed from the menu through the "Quaternary map unit key" button.

Table 2. DIQKEY field definitions

	Field name	Information type	Field type	Links
1	*Symbol*	Color number used, derived from an ArcGIS style.	Number	
2	*Overprint*	Pattern number used, also derived from an ArcGIS style.	Number	
3	*Unit Label*	Map label printed on map products.	Text	
4	*Nsaclass*	Regional numeric code assigned to like units – the main key field in the database.	Number	
5	*Qclass*	Numeric code used to subdivide surficial deposits.	Number	DIUNITS, Spatial database
6	*Geologic Unit*	Brief (5-10 words) summary of unit on a regional basis.	Text	
7	*Date_added*	Date record added (field only implemented in July 2012).	Date	

DIDESCRIP Database

This database (table 3) ties *nsaclass* numbers to the more complete unit descriptions associated with the geologic map. This table is linked to the DIUNITS database through the *nsaclass* field and has portals into DIREFS, DIUNITS, and DIQKEY databases. Note, in the runtime version of the text databases, this table is accessed from the menu through the "Map unit descriptions" button.

Table 3. DIDESCRIP field definitions

	Field name	Information type	Field type	Links
1	*Label*	Map unit label as used on the map.	Text	
2	*Name*	Map unit name as used on the map.	Text	
3	*Age*	Assigned age (range).	Text	
4	*Qclass*	Numeric code assigned to like units – the main key field in the database.	Number	Spatial database, DIUNITS, DIQKEY
5	*Description*	Full text of unit description used on the map.	Text	

DIREFS Database

The DIREFS database (table 4) contains the reference citation for source data used. Included in the reference database will be maps that have been digitized, as well as other publications that result in changes to the map (for example, a paper reassigning some deposits from one unit to another or providing new age determinations). It will also list as "written commun." the source of unpublished information responsible for changes to particular aspects of the map. This database has a portal into DIUNITS, showing the map units from that source that have been entered in the DIUNITS database. Note, in the runtime version of the text databases, this table is accessed from the menu through the "Map references" button.

Table 4. DIREFS field definitions

	Field name	Information type	Field type	Links
1	*Source*	Unique code assigned to each source that uses the two letter quadrangle id and a three digit number. This field is forced to have only unique entries by the database software.	Text and number, must be unique	DIUNITS, Spatial database
2	*Refnum*	A unique tracking number assigned by the database to each reference.	Number, auto entry	
3	*Reference*	USGS style reference citation. Also lists written communications where appropriate for modifications to maps.	Text	

DIKEY Database

Similar to DIQKEY is DIKEY (table 5). The primary field in this database is *nsaclass*, linking it to the DIUNITS databases and to the bedrock and generalized surficial units in the Spatial database for the quadrangle. This database assigns a symbol (color) and label reflecting a statewide focus. The database also includes a *description* field, which summarizes the regional unit in a sentence or less and commonly lists the *source* maps that contain the unit. Portals in the DIKEY database provide a view into DIUNITS. The DIKEY database can be used to assign duplicate colors and labels to units that are lumped in some map products, but otherwise need to be maintained as separate units in the database. Note, in the runtime version of the text databases, this table is accessed from the menu through the "Map unit key" button.

Table 5. DIKEY field definitions

	Field name	Information type	Field type	Links
1	*Symbol*	Color number used, derived from an ARC-GIS style.	Number	
2	*Overprnt*	Pattern number used, also derived from an ARC-GIS stylesheet. Generally not used.	Number	
3	*Label*	Map label printed on map products.	Text	
4	*Nsaclass*	Regional numeric code assigned to like units – the main key field in the database.	Number	DIUNITS, DIKEY, Spatial database
5	*Description*	Brief (5-10 words) summary of unit on a regional basis.	Text	

NSALITH Database

The NSALITH database (table 6) contains lithologic coding for each *nsaclass* in the database. It uses a lithologic dictionary that is contained in special linked database tables called LITHLIST and LITHFORM (listed in Appendices 1 and 2, herein). It allows for the entry of as many lithologies for a unit as needed and therefore has a many-to-one relationship through the *nsaclass* field. This

database has a portal into the DIUNITS database, showing which source maps contain that *nsaclass*.

A special field in this database combines the values of 5 other fields in the database. This field allows searching of the database at any level of the lithologic hierarchy without the need to be concerned about the level of a given term. Possible searches, for example, are for any unit containing carbonate rocks or for any unit where limestone is a major lithology. The *rank* field has four defined values allowed; Major, meaning greater than or equal to 33 percent; Minor, between 10 and 33 percent; Incidental, less than 10 percent; and Indeterminate (major). Major is added to the indeterminate category to insure "fail safe" or inclusive searches for major rock types, as rock types listed in the indeterminate category could well be major components of a map unit. These can be eliminated from search results by explicitly omitting "Indeterminate" from the result. In the runtime version of the text databases, this table is accessed through the "Map unit lithologies" button and the LITHLIST table is accessed through the "Lithologic data dictionary" button.

Table 6. NSALITH field definitions

	Field name	Information type	Field type	Links
1	*Nsaclass*	Regional numeric code assigned to like units – the main key field in the database.	Number	DIUNITS
2	*Lith1*	Highest level lithologic classification.	Text, value list	
3	*Lith2*	Next level lithologic classification, values are based on the value of *lith1* field.	Text, value list	
4	*Lith3*	As above, based on the value of *lith2* field.	Text, value list	
5	*Lith4*	As above, based on the value of *lith3* field.	Text, value list	
6	*Lith5*	As above, based on the value of *lith4* field.	Text, value list	
7	*Form*	Description of form of units, uses a value list based on the value of *lith1* field.	Text, value list	
8	*Rank*	Values allowed are: Major, Minor, Incidental, and Indeterminate (major).	Text, value list	
9	*Percent*	Optional field containing an estimate of percent of unit that given lithology represents. This information is rarely available in Alaska.	Number	
10	*Comment*	Free form comment field – optional.	Text	
11	*Record_no*	Unique tracking number assigned by the database to each record.	Number, auto entry	
12	*Totallith*	Text string that combines the information in all of the *lith* fields, allowing searches based on any aspect of the lithologic hierarchy.	Text, auto entry	

NSAAGE Database

The NSAAGE database table (table 7) is used like the NSALITH table, but is used to assign a uniform age to each *nsaclass* unit. The fields in it are assigned using a data dictionary (using the IUGSLIST database table) derived from a slightly modified version of the 2008 IUGS time scale (Gradstein and others, 2005) to assign maximum and minimum ages to geologic units. The database software then creates a field that has the full definition of the minimum or maximum age of the unit, allowing searches based on any part of the time scale, similar to the *totalith* field described above. For example, searches could be for units that are Paleozoic but no older than Devonian. Because minimum and maximum numeric ages are also populated in the databases, any unit can be searched based on a numeric maximum and minimum age as well.

Note that the ages assigned in this database are for *nsaclass* units and may not necessarily match the assignments made on any given source map or for the Dillingham surficial map. The assignment of a geologic unit to an *nsaclass* controls the lithology and the age referenced to that unit by the database. Note, in the runtime version of the text databases, this table is accessed from the menu through the "Map unit ages" button and the IUGSLIST table is accessed through the "Age data dictionary" button.

Table 7. NSAAGE field definitions

	Field name	Information type	Field type	Links
1	*Nsaclass*	Regional unit code as used above.	Number	DIUNITS, Spatial database
2	*Unit_link*	Field only used in the conterminous US (included for compatibility with Conterminous US databases; not exported to .dbf and .csv files).	Text	(Conterminous US databases)
3	*Min_eon*	The minimum or youngest age assignment for the eon of the unit, based on geologic interpretation.	Text, value list	
4	*Min_era*	As above, for era.	Text, value list	
5	*Min_period*	As above, for period.	Text, value list	
6	*Min_epoch*	As above, for epoch.	Text, value list	
7	*Min_age*	As above, for age.	Text, value list	
8	*Full_min*	Complete, concatenated minimum age assignment.	Text, auto entry	
9	*Max_eon*	The maximum or oldest age assignment for the eon of the unit, based on geologic knowledge.	Text, value list	
10	*Max_era*	As above, for era.	Text, value list	

Table 7. NSAAGE field definitions (cont.)

	Field name	Information type	Field type	Links
11	*Max_period*	As above, for period.	Text, value list	
12	*Max_epoch*	As above, for epoch.	Text, value list	
13	*Max_age*	As above, for age.	Text, value list	
14	*Full_max*	Complete, concatenated maximum age assignment.	Text, auto entry	
15	*Type*	Unit age assigned relatively (stratigraphic position or fossils) or absolutely (radiometric age).	Text, value list	
16	*Cmin_age*	The most precise minimum age coded, derived from the *full_min* field.	Text, auto entry	
17	*Cmax_age*	The most precise maximum age coded, derived from the *full_max* field.	Text, auto entry	
18	*Min_Ma*	Numeric, either from the DNAG table or radiometric determinations.	Number, auto entry	
19	*Max_Ma*	Numeric, either from the DNAG table or radiometric determinations.	Number, auto entry	
20	*Age_comments*	Free form comment field – optional.	Text	

IUGSLIST database

This database table (table 8) provides the minimum and maximum ages for every Eon, Era, Period, Epoch, and Age. Linked to the NSAAGE database through *Eon, Era, Period*, and *Epoch*. The age assignments are based on the 2008 IUGS time scale (see Cohen and others, 2013).

Table 8. IUGSLIST field definitions

	Field name	Information type	Field type	Links
1	*Eon*	Eon	Text	
2	*Era*	Era	Text	
3	*Period*	Period	Text	
4	*Epoch*	Epoch	Text	
5	*Age*	Age	Text	
6	*Minimum_Ma*	Minimum age for the stratigraphic interval of the record in millions of years.	Number	
7	*Maixmum_Ma*	Maximum age for the stratigraphic interval of the record in millions of years.	Number	
8	*Rec_no*	Record number in database for sorting use.	Number	
9	*Concat*	Concatenated field including *Eon, Era, Period, Epoch*, and *Age* where defined in record.	Text	
10	*Far_right*	Right most term from *Concat* field	Text	

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APPENDIX 1. LITHOLOGIC DATA DICTIONARY

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		

Lith1	Lith2	Lith3	Lith4	Lith5
Sedimentary				
		Evaporite		
			Anhydrite	
			Gypsum	
			Salt	
		Novaculite		
		Phosphorite		
	Coal			
		Anthracite		
		Bituminous		
		Lignite		
		Sub-bituminous		
Igneous				
	Plutonic			
		Granitic		
			Alkalli-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	

Lith1	Lith2	Lith3	Lith4	Lith5
Igneous				
	Plutonic			
		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		

APPENDIX 1. LITHOLOGIC DATA DICTIONARY (CONT.)

Igneous				
	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			
	Eclogite			
	Gneiss			
		Biotite-gneiss		
		Calc-silicate-gneiss		
		Hornblende-gneiss		
		Muscovite-gneiss		
	Granoblastic			
		Granofels		
		Hornfels		
	Granulite			
	Hydrothermally-altered			
		Greisen		
		Keratophyre		
		Skarn		
		Spilite		
	Metaigneous			
		Greenstone		
		Metaintrusive		
			Metaanorthosite	
			Metadiabase	
			Metadiorite	
			Metagabbro	
			Metagranite	
			Metaultramafic	
				Metadunite
				Metaperidotite
				Metapyroxenite

Metamorphic	Metaigneous			
		Metavolcanic		
			Metarhyolite	
			Metadacite	
			Metaandesite	
			Metabasalt	
		Orthogniess		
		Serpentinite		
	Metasedimentary			
		Calc-silicate-rock		
		Metacarbonate		
			Marble	
		Metaclastic		
			Argillite	
			Metaconglomerate	
			Metasandstone	
				Metagraywacke
			Metasiltstone	
			Pelitic-schist	
			Phyllite	
			Quartzite	
			Slate	
		Paragneiss		
	Migmatite			
	Schist			
		Amphibole-schist		
		Calc-silicate-schist		
		Mica-schist		
			Biotite-schist	
			Muscovite-schist	
		Quartz-feldspar-schist		
Tectonite				
	Cataclastite			
	Mylonite			
		Phyllonite		
	Melange			
Water				
Ice				
Indeterminate				

APPENDIX 2. LITHFORM DATA DICTIONARY

Lith1	Lithologic form		Lith1	Lithologic form
Unconsolidated			Igneous	
	Alluvial			Batholith
	Beach			Diabase
	Bed			Dike or sill
	Colluvial			Dome
	Eolian			Flow
	Eolian, loess			Flow, pillows
	Estuarine			Laccolith
	Flow, mass movement			Melange
	Fluvial			Pluton
	Glacial			Pyroclastic
	Glacial, drumlin			Pyroclastic, air fall
	Glacial, esker			Pyroclastic, ash-flow
	Glacial, outwash			Pyroclastic, cinder cone
	Glacial, rock glacier			Pyroclastic, tuff
	Glacial, till			Stock or pipe
	Lacustrine			Volcaniclastic
	Landslide			Volcaniclastic, lahar
	Mass wasting			Volcaniclastic, volcanic breccia
	Solifluction		Metamorphic	
	Swamp			Amphibolite
	Tailings			Amphibolite, epidote-amphibolite
	Terrace			Eclogite
	Terrace, marine			Blueschist
	Terrace, stream			Granulite
Sedimentary				Greenschist
	Bed			Hornfels
	Calcareous			Hornfels, biotite
	Carbonaceous			Hornfels, hornblende
	Coquina			Hornfels, pyroxene
	Deltaic			Hornfels, sanidine
	Dome			Zeolitic (prehnite-pumpellyite)
	Glauconitic		Tectonite	
	Lens			Melange, blocks
	Melange			Melange, matrix
	Olistrostrome		Water	
	Reef			Lake, stream, or ocean
	Tuffaceous		Ice	
				Mass