DATA-BASE MODEL SPECIFICATIONS FOR DIGITAL GEOLOGIC-MAP DATA BASES PRODUCED BY THE SOUTHERN CALIFORNIA AREAL MAPPING PROJECT (SCAMP)

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Data-base model specifications for digital geologic-map data bases produced by the southern California Areal Mapping Project (SCAMP)

Version 2.0a

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This document provides technical specifications for a data-base model supporting digital geologic-map files produced by the Southern California Areal Mapping Project (SCAMP)—a geologic-mapping project sponsored jointly by the U.S. Geological Survey and the California Division of Mines and Geology. The specifications describe data tables and relations necessary for implementation of the model in a relational Data-Base Management System (RDBMS) such as Oracle, Access, etc.

The data-base structure outlined in this document revises the version 1.0 structure described in three U.S. Geological Survey Open-file reports (97-859, 97-860, 97-861) released previously by SCAMP (Matti and others, 1997a, b, c). The current model represents an extension and evolution of the 1.0 structure, especially the move away from the multi-value data-base fields of v. 1.0 to the single-value fields of v. 2.0a. The multi-value fields required one or more parsing procedures in order to perform the inter-field relates necessary to associate attribute codes with their definitions. The v. 2.0a data-base structure represents a more standardized relational implementation of the SCAMP model in which relates can be executed more efficiently.

SCAMP's data-base structure and digital attributes anticipate nationwide spatial-data standards currently being developed under auspices of the U.S. Geological Survey's National Cooperative Geologic Mapping Program. These national standards will form the foundation of the National Geologic-Map Data Base (NGMDB), currently being developed by the U.S. Geological Survey and the State geological surveys (Soller and Berg, 1997). Information about the NGMDB project can be found at http://ncgmp.usgs.gov/ngmdbproject. The NGMDB in turn will be supported by a standardized geologic-map data model being developed by a consortium of interests, including the USGS, Geological Survey of Canada, and the State geological surveys (Johnson, B.R., Brodaric, Boyan, and Raines, G.L., 1998, http://ncgmp.usgs.gov/ngmdbproject/standards/datamodel/model42.pdf (v. 4.2). Included in this model will be nationwide spatial-data standards for polygons, lines, and points.

The SCAMP data model is intended to be fully compatible with the national model via translator utilities. Our preliminary review and evaluation of the national model (v. 4.2) found no major barriers to such a translation. Although SCAMP geologic-map data bases will support more detailed geologic information than the National Geologic-Map Data Base, these data can be generalized into the national catalogue as necessary.

We have implemented the SCAMP data model on a limited basis for trial geologic-map files. Although we have tested and evaluated the model using Computer-Aided Software Engineering (CASE) tools with data-base examples having limited attributes, SCAMP has not yet developed user-friendly software tools that create the rich geologic-map data files the model will yield. The data tables and structures described herein are intended to form the foundation for such tools. Ideally, there should be two basic tool types: a tool for creating the data sets and a tool for querying them. SCAMP would export the query tool with any data set, thus allowing users having limited computer resources and lacking a GIS to query and retrieve the information stored in the data set.

Intended purpose

This document is intended for GIS specialists having a background in Management Information Systems (MIS) and data-base implementation in the GIS environment. Table 1 contains a glossary of MIS terminology used in this report. The document provides enough information to build the data-base structure and to manage the object-attribute information. However, we do not comprehensively address all technical issues necessary to implement the model robustly. Although the data-base diagrams (figs. 1, 2) show many tables and relational interactions, a user likely would relate only those elements (tables) germane to the user's interest and task at hand. For instance, in the data-retrieval, data-analysis, or data-capture phase (which the relates in figs. 1 and 2 most closely portray), a user would likely choose to relate only those tables of primary interest via a structure most conducive to the task. Tools obviously would be the most efficient means of doing this.

An Arc/Info implementation of the model will have to use a number of techniques to handle the one-to-many relates, which can be difficult to work with in Arc/Info. Because SCAMP's implementation of the model views Arc/Info as primarily an analysis tool, rather than a production tool, this poses no problem. GIS users interested in testing and evaluating the SCAMP model should contact the authors to discuss issues related to its implementation.

DATA-BASE TERMINOLOGY	DEFINITION AS USED IN THIS REPORT
Attribute	A data field in the data base
Attribute Value	The information that is stored in attribute
Data type	A pre-defined set of characteristics for a data attribute that specifies field length, acceptable characters, and optional and required parameters. For example, char(24) specifies that an attribute can store up to 24 alpha-numeric characters
Entity	A table in the data base
Feature	An attribute value of a geologic object in the data-base file
Foreign Key	A data base attribute that has migrated through a relationship from a parent attribute to a child attribute
Geologic-map unit	A stratigraphic-rank unit that has been mapped within the data base
Inheritance	Occurs when a Primary Key migrates to another table, thereby creating a foreign key
Instance	An occurrence of data (a record) within a table. A *temporal instance* is a point along a temporal line, and is used by the data model to represent processes involved in lithologic evolution of a map object
Key	Any field or set of fields that uniquely identify an instance in a data table (see *Foreign* Key; *Primary* Key)
Lithology	A geologic material (e.g., sandstone, granite, sand and gravel)
Object	A particular geologic item in the data-base file (i.e., a geologic polygon or a linear or point geologic item)
Primary Key	A key among one or more keys that plays a major role in the relational data model. The SCAMP Primary Key "Compound" is deemed "primary" because, more than any other key, it uniquely diagnoses the smallest to the largest collection of spatially mappable data-base items
Standardized attribute list	SCAMP's cumulative master list of geologic attributes for lines, points, and polygons (version 1.0 is archived in Matti and others, 1997a,b,c; version 2.0 will be released soon and posted on the SCAMP web site http://geology.wr.usgs.gov/wgmt/scamp/scamp.html
Sub-lithology	One or more specific lithologies that occur in a given geologic-map unit

Table 1

Acknowledgments

We thank Julie A.H. Rees (U.S. Geological Survey) for her helpful review of the manuscript. Todd Fitzgibbon (U.S. Geological Survey) provided useful feedback on Version 1.0 of the SCAMP data model, and particularly pointed out potential user difficulties with the inter-field relates required for the multi-value data fields of that version. The SCAMP data model was developed in cooperation with several governmental entities that shared funding for its production: (1) Mojave Water Agency; (2) U.S. Forest Service (San Bernardino National Forest); (3) San Bernardino Valley Municipal Water District; (4) USGS National Cooperative Mapping Program (5) California Division of Mines and Geology.

SCAMP data model: Issues and Constructs

This data model supports two functions: (1) it stores information in a format that allows the data base to be easily queried and analyzed for a broad range of geologic topics, and (2) it stores information required to display and plot images of the geologic map and accompanying explanatory material (map-margin information). For graphics plots in Arc/Info, this version of the data model uses the line and marker sets (geoscamp2.lin and geoscamp2.mrk) described in Matti and others, 1997a,b,c. We also designed True-type fonts (SCAMPfont) for unique geologic-age symbols required for map plots. For SCAMP geologic-map products, the data model and its graphical elements provides a standardized basis for storing, exchanging, plotting, and querying digital geologic-map data within the project and within its southern California user community.

In the following section we discuss certain aspects of the data model and describe the use, function, and structure of selected data tables (NOTE: all the data tables described below and in figures 1 and 2 are not necessarily used for a given geologic-map data set).

Feature Attribution

As with v. 1.0 of the data model, the data-base fields are populated with standardized attribute values built using a root-suffix abbreviation method described in Matti and others, 1997a,b,c. Each attribute value is an alpha-numeric abbreviation for a geologic feature or family of features. For example, **.SDRFDM.** is the root-suffix abbreviation for "mylonitic fault rock". The abbreviation is built from the root ".SDR" (strain-dominated rock) and three suffixes: "F" (fault rock), "D" (ductile), and "M" (mylonitic). The single root-suffix abbreviation **.SDRFDM.** thus allows attribution or selection of a host of different geologic attributes, including:

- the family of strain-dominated rocks (.SDR root) without distinction among the several varieties that include fault rocks (.SDRF.), high-strain-rocks (.SDRH.), and crushed or sheared rock (.SDRC.);
- all fault rocks (.SDRF root) including both ductile (.SDRFD.) and brittle (.SDRFB.) fault rock, but not other varieties of strain-dominated rock such as crushed or sheared rock (.SDRC.) or high-strain rock (.SDRH.);
- all ductile fault rocks (.SDRFD root) without distinction among protomylonite (.SDRFDP.), mylonite (.SDRFDM.), and ultramylonite (.SDRFDU.);
- mylonitic fault rock (.SDRFDM.) but not protomylonite (.SDRFDP.) or ultramylonite (.SDRFDU.).

General data-base structure

The data model is organized into two main **Subject Areas** and several **Subareas.** Each of these contains various data tables and data fields as illustrated in Table 2 and in Figures 1 and 2:

PRIMARY GEOLOGIC INFORMATION SUBJECT AREA (fig. 1)	METADATA, DISPLAY, AND CATALOGUING SUBJECT AREA (fig. 2)
System Subarea—Provides system-level information needed in the implementation of the model Embedded Tracking Feature_topology (Generic_Table Name)_Age	**System Subarea**—Provides system-level information needed in the implementation of the model Embedded_Questions Embedded_Keywords Embedded_Citation Embedded_Contact Citation_Contact Keywords_Topics Citation_Keywords Questions_Topics Citation_Questions Topics_Citation (Generic_Table Name)_Name
Core Subarea—Stores information essential to minimal implementation of the data model Lithology Structure Stacking_Stratigraphy Stratigraphic_relations Petrography Paleontology Age Genetic_Process Lines Station Orientation Feature_Confidence	**Core Subarea**—Stores information essential to minimal implementation of the data model Name Embedded_Name Cartography FGDC_Metadata Citation Topics Questions Keywords
Secondary Subarea—Stores information helpful to but not essential to minimal implementation of the data model Geophysics Engineering_Properties Mineralogy Paleontology_Detail	**Contact Subarea**—Stores information specific to implementation of the FGDC-required contact information for spatial data bases. Because Contact plays an active role in the data model, we have broken the information out into an independent set of tables rather than implementing it only in the FGDC_Metadata table Contact Address Contact_address Contact-E-mail. Contace_voice_phone Contacy_fax_tty_tdd_phone

Table 2

Tables in **Primary Geologic Information (fig. 1)** store information describing geologic-map objects and used for the production of object-specific data. Tables in **Metadata, Display, and Cataloging (fig. 2)** contain information that tracks, documents, and elaborates many parts of the data model, including the geologic-mapping and data-capture process as a whole, categorizing and documenting geologic-map objects, and data display and plotting.

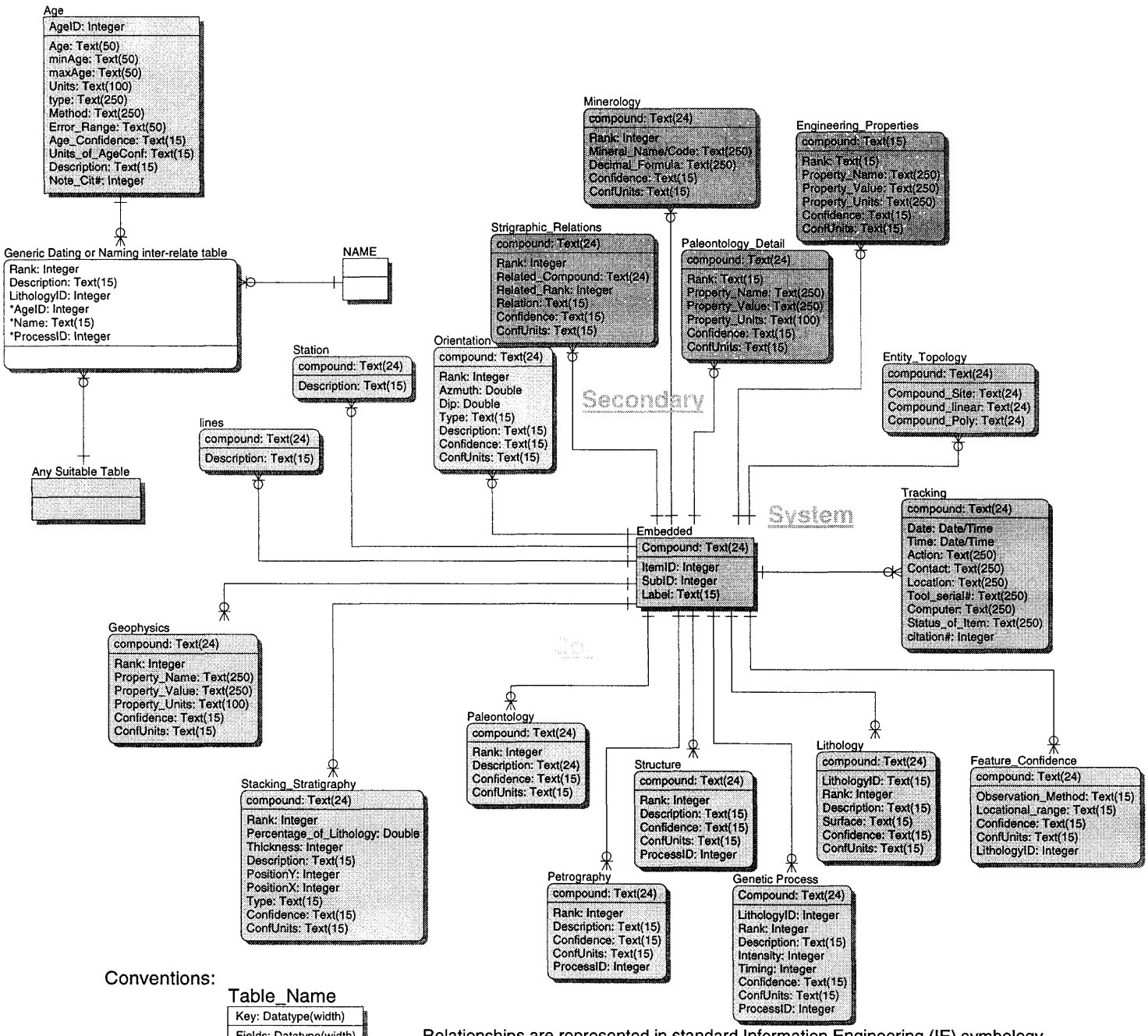
Discussion of selected data-base tables

Embedded, *Label, SubID, ItemID,* ***and*** ***Compound**

At the heart of the SCAMP data model is the System Table **Embedded**. **Embedded** is inherently linked to the graphical elements of the GIS: it corresponds to the PAT and AAT files in Arc/Info, and to what usually is mapname.dbf in shape files. **Embedded** contains three data fields (*Label*, *SubID*, and *ItemID*) and stores ***Compound,** the Primary Key for the data model (fig. 1). The following discussion emphasizes the use of **Embedded** and its data fields in the storage and retrieval of polygon attributes; however, *Label*, *SubID*, *ItemID*, and ***Compound** also are used to describe geologic lines and geologic points.

For polygons, the data field *Label* contains an alpha-numeric acronym that proxies for the formal or informal name of a map unit; the actual formal or informal name is spelled out completely and stored elsewhere in the data model. *Label* identifies stratigraphic-rank units—i.e., all polygons that, because of their lithologic commonality, are mapped together as distinct from other polygons. Thus, *Label* is the data-base category that links polygons at the smallest rock-stratigraphic-unit level. For graphics plots, *Label* is the penultimate source for acronyms used to symbolize polygons of a given map unit and for acronyms occurring in map-marginal unit descriptions (although the ultimate source for graphics plots is the table **Cartography** as related to *Label* through the use of ***Compound**).

SubID is an ID number that assigns attributes to subsets of a *Label* (Regions in Arc/Info). For example, for the map unit named Tertiary Mill Creek Formation, all polygons of *Label* Tm will share certain default attributes that are applicable to each and every polygon of Tm. However, some polygon clusters of *Label* Tm might have attributes unique to each cluster, in addition to having the default attributes for *Label* Tm. *SubID* identifies these polygon clusters. A geologic example of this would be a facies change from fine to course grain size among polygons of a single sedimentary map unit (*Label*). Another example might be a single sedimentary map unit (*Label*) having two regions of polygons each containing clasts derived from differing sources. A third example might be



Errata: (1) The table Geophysics should be in the Secondary Subarea, not in the Core Subarea.

(2) The Table Strigraphic_Relations should be Stratigraphic_ Relations.

Figure 1.--Data-base table relationships for Primary Geologic Information. The diagram displays only generalized relational structure and not all possible relates.

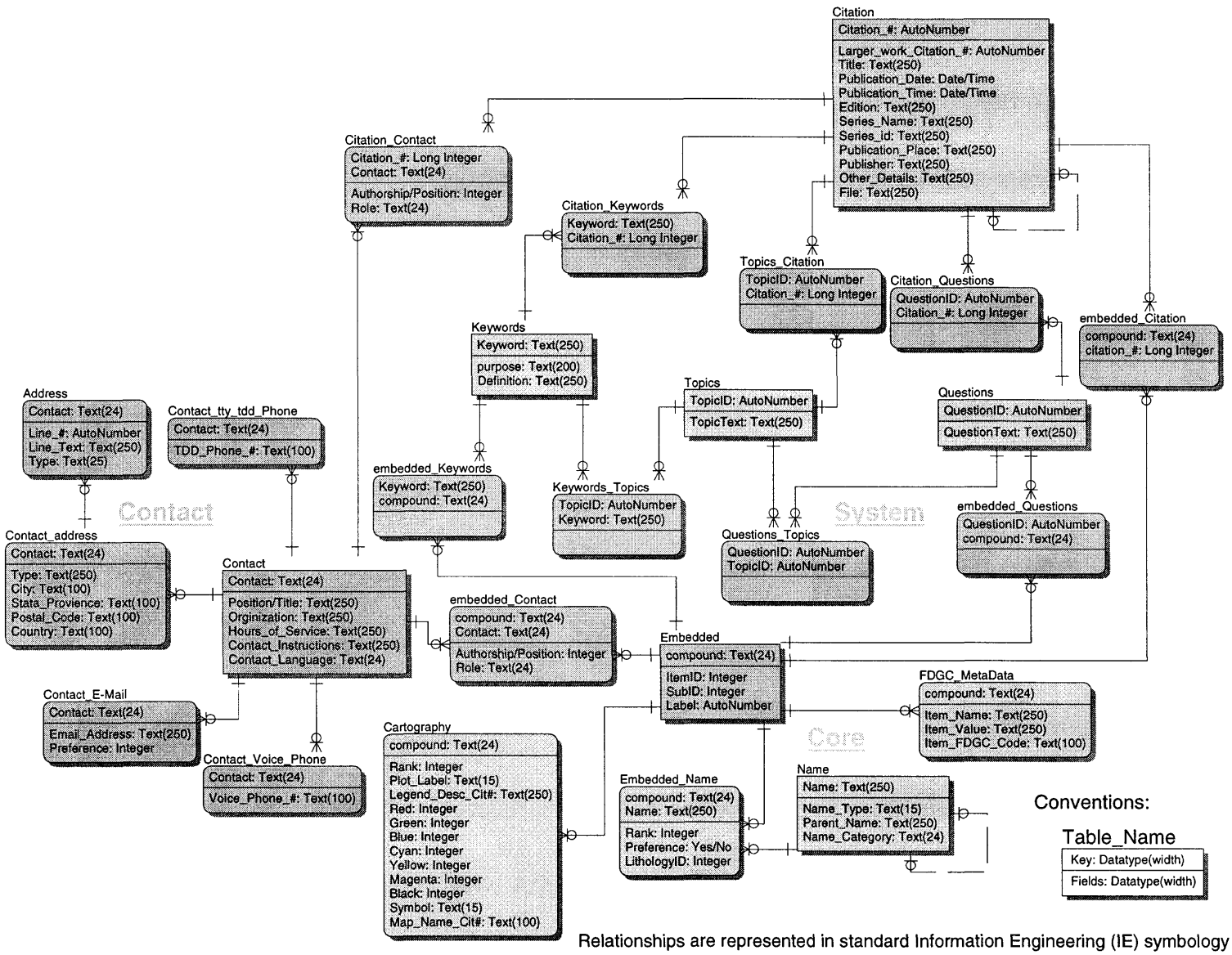


Figure 2.--Data-base table relationships for Metadata, Display, and Cataloguing. The diagram displays only generalized relational structrure and not all possible relates.

a single igneous map unit (*Label*) having unmapped equigranular and porphyritic phases. The SCAMP data model adopts the following rules for *SubID*:

- A *SubID* of zero will be the ID under which the default attributes for a given *Label* will be stored;
- a *SubID* of value = 1 will contain both the default attributes and attributes specific to subset 1
- a *SubID* of value = 2 will contain both the default attributes and attributes specific to subset 2, and so on in a series that is infinitely long.

We describe the process of preserving default attributes within polygons while simultaneously adding details unique to finer object classes as "blowing" data down through the data-base structure for any data-base entity.

ItemID is the actual identifying number of each graphical object as assigned in its PAT/AAT/shape.dbf file.

Primary Key (*Compound).—*Compound has a compound structure because it represents map objects (geologic lines, points, and [especially] polygons) that inherently contain three classes of information that need to be stored and retrieved efficiently:

- information of a default nature that applies to all lines or points of a specific type and to all polygons of a specific map unit;
- information that uniquely applies to clusters of line segments or points of a specific type and to clusters of polygons of a specific map unit;
- information that uniquely applies to a specific line segment or point type and to a specific polygon of a particular map unit;

In order to attribute and retrieve these three classes of geologic information efficiently without using multiple relational keys, the SCAMP data model uses a Primary Key having a compound structure—the field named ***Compound**. In essence, ***Compound** is unique because its calculation yields one unique value. This not only allows it to serve as a singular Primary Key but also to facilitate a range of data-base activities.

***Compound** is constructed from the entities *Label*, *SubID*, and *ItemID* separated by parsing dots (i.e., *.Label.SubID.ItemID.*). The following examples illustrate use of ***Compound**:

- ***Compound** (.Qof3.0.0.) for polygons of *Label* Qof3 will establish relates that involve queries for general default characteristics of that map unit but not for *SubID*-specific or *ItemID*-specific attributes;

- ***Compound** (.Qof3.1.0) for polygons of *Label* Qof3 will establish relates that involve queries for specific attributes associated with *SubID* 1 as well as for default *Label*-wide Qof3 attributes, but not for *ItemID*-specific attributes;
- ***Compound** (.Qof3.0.345.) will establish relates that involve queries for specific attributes associated with *ItemID* 345 and for the default *Label*-wide Qof3 attributes, but not for *SubID*-specific attributes.

In the construction of most ***Compound** values, *ItemID* is defined to be zero (.*Label.SubID*.0.); this is because individual polygons, line segments, or points in SCAMP data bases typically are not assigned unique geologic attributes. However, where a single geologic object does contain unique information, ***Compound** is calculated such that *ItemID* takes on the object's unique identifying number (e.g., .Qof3.0.*ItemID*.). The default attributes that are stored in ***Compound** = .*Label.SubID*.0. are blown down into any new ***Compound** for *ItemID*-class objects.

It is possible to store only the default attributes in *SubID*=zero and *ItemID*=zero and not blow them down into the finer ***Compound** objects of subset > zero or *ItemID* > zero. The benefit of this is a more normalized implementation of the model and an extremely small and fast data base. However, this causes a disassociation between geologic-map objects and their attribute data. In such a case, one must then be exceedingly careful when selecting graphical objects from the map, and an additional selection must be done for the ***Compound** (.*Label.SubID*=0.*ItemID*=0.). SCAMP does not implement this discrete and disassociative feature at this time because it requires the user to pay diligent attention to the data-model rules and to have *apriori* knowledge of the data-base structure.

Rank—a measure of relative lithologic abundance

Most geologic-map units (*Label*) contain more than one lithologic type (material type); we refer to these as sub-lithologies. Sub-lithologies have relative abundances that either remain constant throughout the geographic distribution of the map unit (*Label*), or that vary systematically or randomly as the map unit (*Label*) is traced throughout the map area. The data model uses the field *Rank* to express the relative abundances of lithologic types within a given *Label*. A numerical value for *Rank* is assigned for specific values of ***Compound**, using the following conventions:

- a *Rank* of 0 represents the labeled unit as a whole;
- a *Rank* of 1 represents the primary lithology;
- a *Rank* of 2 represents the secondary lithology;
- a *Rank* of 3 represents the tertiary lithology; and so on in a series that is infinitely long.

It is important to note that *Rank* is ***Compound**-specific: that is, *Rank* applies to the map object defined in ***Compound** (be it *Label*, *SubID*, or *ItemID*) and is not itself a mapped feature.

For geologic polygons, *Rank* can vary from subset to subset (*SubID*) of a given *Label*. For example, the primary lithology (*Rank* 1) for the southern distribution of a map unit may be 'sandstone' with a secondary lithology (*Rank* 2) of 'mudstone.' In the north, these relative abundances may be completely reversed, with 'sandstone' = *Rank* 2 and 'mudstone' = *Rank* 1. Geologically, it is important to monitor and store geographic *Rank* variations because spatial analyses of such factors as regional grain-size variation, regional facies patterns, paleo-environmental trends, and modal trends in igneous bodies require that the spatial distributions of specific lithologies be identifiable and retrievable.

In part, the SCAMP data model achieves this capability using the table **Name** (Metadata, Display, and Cataloging, CORE Subarea; see Table 2 and fig. 2). **Name** assigns a unique place-holding name to each *Label* and *Rank* and *ItemID* or to groups of *Labels* and *Ranks* and *ItemIDs* that are related to each other. For each of these related items, the place held is a slot in the regional time-space matrix of depositional-igneous-metamorphic-structural-erosional events that defines the geologic framework and history of southern California.

Tables used for stratigraphic relationships and map-marginal diagrams

Geologic-map units have geologic relationships with each other that include such features as stacking order (sequence of sub-lithologies within a map unit), boundaries between map units, and lateral relations among equivalent but different lithologies within a map unit (caused by lateral changes in lithology sequencing). Commonly, such stratigraphic variations will lead to differences in internal geologic organization among otherwise related map-unit objects (*Label's*, *SubID's*, and *ItemID's*). Ideally, these stratigraphic relations should be stored and tracked within the data base, enabling such manipulations as:

- Retrieve all map-units where coarse sandstone occurs beneath basalt flows of a particular age;
- Retrieve all map units wherein gravel occurs (in any amount) in the upper half of a formation;
- Retrieve all polygons of map units where limestone marble has an intrusive relationship with granite;
- Retrieve all polygons of map units that display a coarse-grained sandstone facies prograding over mudstone in the sedimentary sequence of the late tertiary;
- Retrieve all geologic-map units that are known to overlie a particular angular unconformity;

- Construct a graphic master columnar section showing the vertical succession of geologic map-units within the data base;
- Construct a map-marginal graphic showing vertical and horizontal relations among superposed map units and among map units that are entirely or partly lateral equivalents of each other (that is, a correlation of map units, CMU);

To achieve this capability, the SCAMP data model uses the following entities:

(1) The data table **Stacking_Stratigraphy** (Primary Geologic Information, CORE Subarea; see Table 2 and fig. 1) is used to describe the stacking order of geologic-map units (*Labels*) and of sub-lithologies (*Ranks*) within *Labels.* By stacking order we mean the primary succession of geologic-map units (*Labels*), irrespective of geologic events (such as faulting or folding) that may have re-arranged the primary stratigraphic succession.

(2) The data table **Stratigraphic_Relations** (Primary Geologic Information, CORE Subarea; see Table 2 and fig. 1) is used to describe relations among geologic-map units (*Labels*) and among non-mapped sub-lithologies (*Ranks*) within *Labels* (for example, *Label* X faulted against *Label* Y; *Label* X depositionally overlaps *Label* Y; *Label* X intrudes *Label* Y; *Rank* 3 (basalt) of *Label* Z overlaps *Rank* 1 (sandstone) of *Label* Z, except in polygons of *.LabelZ.SubID002.* where *Rank* 3 (basalt) overlaps *Rank* 2 (limestone).

(3) The data table **Name** (Metadata, Display, and Cataloguing, CORE Subarea; see Table 2 and fig. 2) is used to name every specific lithology type that occurs in *Label*, *SubID*, and *ItemID*. The names can be formal (such as Mill Creek Formation) or informal (the sandstone and mudstone member of the Mill Creek Formation) or common (sandstone001 or the Dominguez turbidite-sandstone wedge). **Name** has two primary purposes:

- to store map-unit-rank names in a manner that satisfies conventional naming criteria for stratigraphic-rank units (U.S. Geological Survey Lexicon of Geologic Names and The North American Commission on Stratigraphic Nomenclature, 1983)
- to store object names (not necessarily mappable) in order to establish equal-identity linkage between lithologies that have a common stratigraphic connection (for example, all coarse-grained rocks of a mid-Miocene prograding clastic wedge; all pre-Laramide granitoids; all bimodal Basin-and-Range volcanic rocks of Oligocene age);

Although our discussion of the table **Name** emphasizes its applicability to polygons of geologic-map units, **Name** also is used to store names of geologic lines (e.g., San Andreas fault; normal fault 002; thrust fault 010) and geologic points (e.g., foliation attitudes formed during Pelona Schist deformation; foliation

attitudes formed during Miocene attenuation deformation; bedding attitudes formed during Quaternary contractional deformation in the Los Angeles Basin).

When used in combination with the table **Age**, the tables **Stacking_Stratigraphy**, **Stratigraphic_Relations**, and **Name** provide a powerful means of analyzing and retrieving information about the geometry, history, and deformation of geologic-map units and their bounding geologic structures and contained geologic points. These tables also facilitate the construction of map-margin graphics such as CMU's, columnar sections, and geologic cross sections.

Geologic Object, Genetic Process, and Age

A geologic-map object (polygon, line, or point) is the result of one or more genetic processes that have operated through time to yield the current lithology, linear feature, or point feature described in the data base. A given lithology—folded and faulted limestone marble, for example—might have undergone a series of genetic events that include (from most recent to oldest):

- long-term weathering, erosion, and pedogenesis accompanied by faulting within a right-lateral strike-slip strain field;
- faulting within an extensional strain field;
- tectonic uplift and retrograde metamorphism;
- two generations of folding;
- prograde metamorphism to upper amphibolite grade;
- induration and post-induration dissolution that formed karst features and regoliths;
- deposition of skeletal sand bodies in a continental-margin shoal-water organic buildup;

The current lithology (limestone marble) records all of these events, which must be tracked through the data base. Each event will have an assigned geologic age that also must be tracked through the data base. Each event or a collection of events can be given a name—for example, Laramide orogeny would represent a number of events and processes that acted upon a given map unit or set of units, lines, or points.

The SCAMP data model handles the linkage between geologic-map object (map units, lines, points) and mode of formation (genesis) through the use of six data tables:

- **Lithology**, which stores lithologic attributes for polygons;
- **Lines**, which stores attributes for linear geologic features;
- **Station**, which stores attributes for point geologic features;

- **Genetic_Process**, which stores information about genetic processes and genetic environments;
- **Name,** which stores the names of geologic processes and events;
- **Age**, which stores information about the geologic age of each geologic process, groups of processes, and the geologic material formed by that process.

Geologic-Feature Confidence and Attribute Confidence

The SCAMP data model provides the capability for the geologic-map maker to indicate a confidence level for both (1) the locational accuracy of a geologic feature and (2) the scientific veracity of geologic features identified in the data base along with descriptive and interpretive attributes assigned to each feature.

The notions of locational confidence and attribute confidence are problematical in the geologic-mapping arena:

Locational confidence asks the question: "How confident is the map maker that line, point, and polygon features stored in the data base are located accurately in X,Y space according to some positional-accuracy standard?"

Attribute confidence asks two questions: (1) How confident is the map maker that a geologic feature (line, point, polygon) recorded in the data base has been identified correctly according to widely agreed upon usage and meaning?" and (2) "How confident is the map maker that descriptive and interpretive attributes (such as thick-bedded or yellowish gray or sandstone or monzogranite or mylonitic or thrust fault or depositional contact or regolith or landslide or mudslide or turbidite or estuarine or mid-crustal or forearc basin or dextral minor-fold-axis lineation or cataclastic foliation) have been applied accurately and correctly to lines, points, and polygons in the data base?"

Questions about locational accuracy and scientific veracity trigger controversy for several reasons:

- Geological mapping is not an exact science comparable to well-controlled laboratory experiments guided by technical methods and standards that are quantified and easily reproduced. The subjective and interpretive nature of the geologic-mapping process is appreciated by most geologists, who usually understand and accept the limitations inherent to this process and who use the information contained in geologic maps accordingly. However, some map users (for example, land-use managers, community planners, and legal counsel) may not have an appreciation for the limitations inherent to routine map production;
- Typically, a large area of geologic terrain must be covered in a short amount of time in order to produce the geologic map, and decisions about

the nature and location of geologic point, line, and polygon features necessarily must be quick judgements based on the technical skill, intuition, and experience of the geologist. Differences in these abilities among geologists make it difficult to compare and evaluate geologic maps produced by different authors;

- Before the advent of satellite-based Global Positioning Systems (GPS), the determination of locational position for line, point, and polygon features was (and largely still is) based on the use of aerial photographs in conjunction with cartographic base maps showing hypsographic and planimetric features. To the best of his or her ability, the geologist uses these features to locate the position of geologic objects—within the time frame available and with or without stating the error bars associated with each determination;
- Depending on where they received their academic training and how they acquired their career experience, geologists may use broadly differing techniques, terminology, and paradigms to describe and interpret geologic objects and to map their distribution across the landscape. These differences can make it difficult to compare and evaluate geologic maps produced by different authors;

Because of these realities, it is difficult to quantify or even address confidence levels associated with geologic-map objects. Typically, questions about confidence levels for locational accuracy and scientific veracity evoke such responses as "if I didn't think the feature was located where I show it I would have placed it in a different position", or "if I didn't think it was a thrust fault I would have shown it as some other kind of fault" or "geologic mapping is a scientific art form that is not amenable to quantitative confidence statements". Unfortunately, the constraints of digital data-base design and usability require that notions of locational confidence and scientific veracity be confronted within any geologic-map data model.

The SCAMP data model provides several mechanisms for dealing with confidence levels:

For Locational Accuracy, line and point features and some polygon features have one of the following attributes:

- location meets the map-accuracy standard;
- location may not meet the map-accuracy standard;
- information about locational accuracy is not indicated by the SCAMP data collector;
- for compiled map objects, no information about locational accuracy is provided by primary source materials, but map compiler has estimated the locational accuracy of the specified map object.

The map-accuracy standard for each SCAMP map product is indicated in the metadata information. For those geologic features whose X,Y position is known with determinable accuracy and precision, the table **Feature_Confidence** (Primary Geologic Information, CORE Subarea, Table 2, fig. 1) has a field (*Locational_Range*) where an object's divergence from it's probable X,Y position can be indicated at the geologist's discretion.

For Scientific Confidence, the SCAMP data model deals with two concepts: (1) the scientific veracity associated with the identity of each geologic object (line, point, polygon), and (2) the scientific veracity associated with the use of descriptive and interpretive attributes linked to each identified geologic-map object. The following conventions are adopted for *each and every* geologic-map object in the data base:

- The Table **Feature_Confidence** (Primary Geologic Information, CORE Subarea; Table 2, fig. 1) stores confidence information about the identity of each geologic object (line, point, and polygon) using the field *Confidence*. Confidence estimates are recorded in two ways:
    - Default statement: For all map objects, identity confidence is represented by a default sttement indicating that each object "has been identified using conventional observational techniques, and is deemed to be identified correctly".
    - Qualified statement: At the discretion of the map maker, a qualified identity confidence statement (e.g., identity confirmed; identity likely but not confirmed; identity questionable) that overrides the default identity statement can be assigned to specified map objects.
- The data-base field *Confidence* in each Primary Geologic Information data table stores confidence information about the descriptive and interpretive attributes associated with each geologic object (line, point, and attribute). This may be a default statement (similar to above) or a specific confidence statement that would over-ride the default attribute.

Metadata

The SCAMP data model supports a full implementation of the Federal Geographic Data Committee (FGDC) metadata standard (Content Standard for Digital Geospatial Metadata, v. 2.0). We also implement optional metadata elements specific to geologic mapping. Metadata elements are implemented in two ways:

- Static metadata.—The bulk of metadata information for a GIS product is static—that is, it does not play an active role in the generation of the data base (for example, map extent, specifications set by the data model-set specifications, etc.). This static information is largely collected at the beginning or end of product production. In the SCAMP data model, static

metadata information is stored in the table **FGDC_Metadata** (Metadata, Display, and Cataloging, CORE Subarea; Table 2, fig. 2). Storage of this information in the actual geologic-map data base allows for real-time access to the metadata, but with the caveat that a level of sorting and selection is required to access discrete metadata elements. The **FGDC_Metadata** table serves the additional function of allowing the data-base model to accommodate any future changes or additions to the FGDC standard with virtually no effect on the functioning of the data model. FGDC-compatible files for inclusion in the National Spatial Data Archive will be generated directly out of this table.

- Dynamic metadata.—Some metadata elements tend to be more active in the data-base activities--for example, tracking of geologic changes in the data base, contact information, and citation information. These metadata elements represent functional parts of the model that are used throughout the data-capture, data-revision, and data-retrieval process. Active metadata elements like these are directly modeled in the SCAMP data-base architecture through such tables as **Tracking** (Primary Geologic Information Area, System Subarea; Table 2 and fig. 1), **Contact,** and **Citation_Contact** (Metadata, Display, and Cataloguing Area, Contact Subarea; Table 2, fig. 2).

APPENDIX I

DATA-TABLE DESCRIPTIONS

The following section contains information about all of the data tables required to implement the SCAMP data model. The table and entity definitions contain information that allow the data base to be constructed.

Primary Geologic Information

Core Tables

Entity-Table Name: Lithology
Entity-Table Comment: Lithology contains information about the physical properties of geologic-map objects (geologic polygons typically, but also applies to geologic lines and points). Lithology answers the question 'What is the feature currently?' by storing such attributes as rock color, grain size, consolidation, induration, bedding characteristics, composition, surface geomorphology, etc.

Entity-Table Attribute Name	Entity-Table Attribute Data-type	Entity-Table Attribute Comment
***Compound**	Text(24)	***Compound** is a Primary Key for the data base
LithologyID	Integer	A numerical identifier representing the Lithology to which the record refers. An ID of 0 represents the current Lithology; an ID of 1 the progenitor to the current Lithology; an ID of 2 represents the progenitor of ID = 1, etc. (also see LithologyID in the table **Genetic_Process**)
Rank	Integer	A numerical identifier indicating the abundance ranking of a sub-lithology relative to other sub-lithologies
Description	Text(15)	Contains attributes from the standardized SCAMP attribute list
Surface	Text(15)	Contains information about surficial characteristics of a particular map unit, lithology, or sub-lithology (e.g. weathering habit, pedogenic-soil development, erosional dissection)
Confidence	Text(15)	Contains information about the level of confidence the map maker attaches to the use of a geologic attribute. Expressed either as an attribute from the SCAMP attribute list or as a numerical value from 0 to 100 representing a percentage of confidence in the interpretation
ConfUnits	Text(15)	Contains a unit indicator stating whether the *Confidence* value is a standardized SCAMP attribute or percentage-based value

Entity-Table Name: Age
Entity-Table Comment: Age contains information about the time when events happened in a geologic feature's life cycle. Examples include age of progenitor, age of deformation, age of metamorphism, age of alteration, age of weathering, and age of mineralization.

Entity-Table Attribute Name	Entity-Table Attribute Data-type	Entity-Table Attribute Comment
AgeID	Integer	A unique Numerical Identifier for the Age information recorded. ***AgeID*** also is a Primary Key for the Age table
Age	Text(50)	Contains a single age for the object defined in ***Compound**. In the case of quantitative methods, this would be the numerical age rendered by the method; in the case of relative chronologies, this would be the formal Geologic Age
MinAge	Text(50)	Holds the minimum age for the object defined in ***Compound** (i.e. youngest delimiting age)
MaxAge	Text(50)	Holds the maximum age for the object defined in ***Compound** (i.e. oldest delimiting age)
Units	Text(100)	Identifies the units of each age determination, such as "Relative age names" or "geochronologic units (Ka, Ma, Ga)", or "Text". This entity allows certain age types to be easily removed from an analytical operation or to be converted to usable form if necessary
Type	Text(250)	Describes the type of ages that are entered (e.g., relative, quantitative, etc.)
Method	Text(250)	Describes the method used for the age determination (e.g., fossils, Ar40/39, magnetostratigraphy, regional correlation, stratigraphic relations, intrusive relations, etc.)
Error_Range	Text(50)	A single value representing a span in the same units as the Units field, describing the 'error bars' around the age dates entered or as ± value for radiometric age determinations
Age_Confidence	Text(15)	Contains a confidence statement for the age of the object defined in ***Compound**. May be expressed as a confidence attribute from the standardized SCAMP attribute list or as a numerical value from 0 to 100 representing a percentage measure of confidence in the interpretation
Units_of_AgeConf	Text(15)	Contains a unit indicator stating whether the Age_Confidence value is a fuzzy, percentage-based value or a SCAMP standardized attribute

Description	Text(15)	Contains attributes from the standardized SCAMP list indicating what kind of geologic event the age describes (e.g. depositional age, intrusive age, metamorphic age, faulting age, mineralization age, etc.)
Citation#	Integer	Contains the relate item for the Citation table record for this item.

Entity-Table Name: Structure
Entity-Table Comment: Table contains information about structural features associated with an object—typically a polygon or cluster of polygons.

Entity-Table Attribute Name	Entity-Table Attribute Data-type	Entity-Table Attribute Comment
***Compound**	Text(24)	***Compound** is a Primary Key for the data base
Rank	Integer	A numerical identifier indicating the abundance ranking of a sub-lithology relative to other sub-lithologies
Description	Text(15)	Contains structural attributes from the SCAMP standardized attribute list
Confidence	Text(15)	Contains information about the level of confidence the map maker attaches to the use of a geologic attribute. Expressed either as an attribute from the SCAMP attribute list or as a numerical value from 0 to 100 representing a percentage of confidence in the interpretation
ConfUnits	Text(15)	Contains a unit indicator stating whether the Confidence value is a standardized attribute or percentage-based value
ProcessID	Integer	A numerical ID that identifies one specific geologic process among the one or more processes that formed the object identified in ***Compound** and attributed in *Description*

Entity-Table Name: Stratigraphic_Relations
Entity-Table Comment: Stratigraphic_Relations contains information about mutual stratigraphic relations among map objects (map units [*Labels*], *SubIDs*, and specific lithologies), e.g., how they are in contact with each other (depositional, intrusive, faulted) or otherwise associated with each other. Initial implementations of the data model probably will only relate objects to their given category--i.e., *Labels* to *Labels*, *SubIDs* to *SubIDs*, and individual sub-lithologies (*Ranks*) to other sub-lithologies (*Ranks*) within the same unit.

Entity-Table Attribute Name	Entity-Table Attribute Data-type	Entity-Table Attribute Comment
***Compound**	Text(24)	***Compound** is a Primary Key for the data base
Rank	Integer	A numerical identifier indicating the abundance ranking of a sub-lithology relative to other sub-lithologies
Related_Compound	Text(24)	Specifies which map object, as identified by its ***Compound**, is being related to the object specified here in ***Compound** and *Rank*
Related_Rank	Integer	Specifies which map object, as identified by its *Rank*, is being related to the object specified here in ***Compound** and *Rank*.
Relation	Text(15)	Contains attributes from the standardized SCAMP attribute list defining the relation between ***Compound**/*Rank* and *Related_*Compound--Related_Rank* pairs. The attributes refer directly to ***Compound**/*Rank* and only by inference to the related *Rank* and ***Compound**
Confidence	Text(15)	Contains information about the level of confidence the map maker attaches to the use of a geologic attribute. Expressed either as an attribute from the SCAMP attribute list or as a numerical value from 0 to 100 representing a percentage of confidence in the interpretation
ConfUnits	Text(15)	Contains a unit indicator stating whether the *Confidence* value is a standardized SCAMP attribute or percentage-based value

Entity-Table Name: Stacking_Stratigraphy
Entity-Table Comment: Stacking_Stratigraphy contains information about how geologic objects (particularly map units, i.e., *Labels*) are sequenced and (or) correlated with other geologic objects. The table also contains values for bulk-percentage estimates for a map unit and its sub-lithologies at specific localities. Information in this table is used to construct stratigraphic columns showing vertical and lateral relations among map units, but also is used to track changes in stratigraphic position and stratigraphic thickness of sub-lithologies from place to place throughout the map area.

Entity-Table Attribute Name	Entity-Table Attribute Data-type	Entity-Table Attribute Comment
***Compound**	Text(24)	***Compound** is a Primary Key for the data base
Rank	Integer	A numerical identifier indicating the abundance ranking of a sub-lithology relative to other sub-lithologies
Lithology_Percentage	Double	Contains the average bulk volumetric percentage that a given lithology or sub-lithology accounts for in the map unit as a whole
Thickness	Integer	Thickness information typically will be for ***Compound**=*ItemID*, because thickness usually varies from polygon to polygon or from region to region in the data base. *Rank*=0 would contain the average thickness for the map unit, as determined from more than one *ItemID* estimate. For any polygon or cluster of polygons, the thickness values for *Rank*s=1+n should sum to approximately the same value as for *Rank* = 0
Description	Text(15)	Contains stratigraphy-related attributes from the SCAMP master attribute list
PositionY	Integer	Vertical stratigraphic position in the stacking order of the object that ***Compound** identifies—that is, the object's vertical position relative to other objects in the same class (e.g., *Label*-level items with respect to other *Label*-level items, *Rank*-level items with other *Rank*-level items). Can be extended such that *Labels* can be matched with *Ranks*
PositionX	Integer	Horizontal stratigraphic position in the stacking order of the object that ***Compound** identifies—that is, the object's position relative to other objects in the same class (e.g., *Label*-level items with respect to other *Label*-level items, *Rank*-level items with other *Rank*-level items). Can be extended such that *Labels* can be matched with *Ranks*

Type	Text(15)	Defines the theme that the positional attributes (*PositionY*, *PositionX*) describe, e.g., master-stacking column for all *Labels*; local stratigraphic column of *Labels*, *SubIDs*, or *Ranks* within a *Label*, etc. Generally, *Label*-level stacking is an average or aggregate summation of the positional behavior of each unit throughout the data base. However, this does not preclude the data model's recognition of variation in unit stacking where the stacking sequence locally deviates from that typically defined in *Type*)
Confidence	Text(15)	Contains information about the level of confidence the map maker attaches to the use of a geologic attribute. Expressed either as an attribute from the SCAMP attribute list or as a numerical value from 0 to 100 representing a percentage of confidence in the interpretation
ConfUnits	Text(15)	Contains a unit indicator stating whether the *Confidence* value is a standardized SCAMP attribute or percentage-based value

Entity-Table Name: Petrography
Entity-Table Comment: Table contains information about the petrography of a feature (typically a polygon). Like many of the other tables in the model, Petrography forms the site/hook to which additional fields and tables can be built as required by increased detail.

Entity-Table Attribute Name	Entity-Table Attribute Data-type	Entity-Table Attribute Comment
***Compound**	Text(24)	***Compound** is a Primary Key for the data base
Rank	Integer	A numerical identifier indicating the abundance ranking of a sub-lithology relative to other sub-lithologies
Description	Text(15)	Contains petrographic attributes from the SCAMP standardized attribute list
Confidence	Text(15)	Contains information about the level of confidence the map maker attaches to the use of a geologic attribute. Expressed either as an attribute from the SCAMP attribute list or as a numerical value from 0 to 100 representing a percentage of confidence in the interpretation
ConfUnits	Text(15)	Contains a unit indicator stating whether the *Confidence* value is a standardized SCAMP attribute or percentage-based value
ProcessID	Integer	A unique identifieer that allows a genetic process to be associated with the attribute value in *Description*

Entity-Table Name: Paleontology
Entity-Table Comment: Paleontology contains information about individual fossils or about paleontologic observations for an object. This table is the basis for future expansion of paleontologic aspects of the data model. Like many other tables in the model, it forms the site/hook to which additional fields and tables can be built as required.

Entity-Table Attribute Name	Entity-Table Attribute Data-type	Entity-Table Attribute Comment
***Compound**	Text(24)	***Compound** is a Primary Key for the data base
Rank	Integer	A numerical identifier indicating the abundance ranking of a sub-lithology relative to other sub-lithologies
Description	Text(24)	Contains paleontologic attributes from the SCAMP standardized attribute list
Confidence	Text(15)	Contains information about the level of confidence the map maker attaches to the use of a geologic attribute. Expressed either as an attribute from the SCAMP attribute list or as a numerical value from 0 to 100 representing a percentage of confidence in the interpretation
ConfUnits	Text(15)	Contains a unit indicator stating whether the *Confidence* value is a standardized SCAMP attribute or percentage-based value

Entity-Table Name: Genetic_Process
Entity-Table Comment: Genetic_Process stores attributes for geologic processes that resulted in a given lithology.

Entity-Table Attribute Name	Entity-Table Attribute Data-type	Entity-Table Attribute Comment
***Compound**	Text(24)	***Compound** is a Primary Key for the data base
LithologyID	Integer	A numerical identifier that describes a specific genetic/lithologic temporal instance. *LithologyID* denotes a specific geologic condition in the cumulative temporal succession of conditions that led to the object identified by ***Compound** and described in **Lithology** (for example the 2nd of 4 successive geologic conditions that the map maker infers to have developed during the cumulative evolution of a lithology or geologic structure observed today on a hillside)
Rank	Integer	A numerical identifier indicating the abundance ranking of a sub-lithology relative to other sub-lithologies
Description	Text(24)	Contains geologic-process attributes from the SCAMP standardized attribute list
Intensity	Integer	A numerical value ranging from 0 to 10 that rates the overall intensity of the process described in *Description*, as it relates to the lithology defined by ***Compound**, *Rank*, and *LithologyID*. In the 0-10 scale, 0 = no affect and 10 = defining affect
Timing	Integer	A numerical value specifying the order in which an indicated process occurred relative to other processes identified for the lithology as defined by ***Compound**, *Rank*, and *LithologyID*.
Confidence	Text(15)	Contains information about the level of confidence the map maker attaches to each descriptive or interpretive geologic attribute. Either an attribute from the SCAMP standard-ized list or a numerical value from 0 to 100 representing a percentage of confidence in the interpretation
ConfUnits	Text(15)	Contains a unit indicator stating whether the *Confidence* value is a standardized SCAMP attribute or a percentage-based value
ProcessID	Integer	A numerical ID that identifies one specific geologic process among the one or more processes that formed the object identified in ***Compound**, *LithologyID*, and *Rank*

Entity-Table Name: Lines
Entity-Table Comment: Table contains attributes specific to a given linear feature. This essentially is the line-segment equivalent of the polygon **Lithology** table.

Entity-Table Attribute Name	Entity-Table Attribute Data-type	Entity-Table Attribute Comment
***Compound**	Text(24)	***Compound** is a Primary Key for the data base
Description	Text(24)	Description contains attributes from the SCAMP standardized attribute list for lines

Entity-Table Name: Station
Entity-Table Comment: Table contains attributes specific to a given site, whether it be an annotation station or a geologic-measurement station. This table essentially is the geologic-point equivalent of the polygon **Lithology** table.

Entity-Table Attribute Name	Entity-Table Attribute Data-type	Entity-Table Attribute Comment
***Compound**	Text(24)	***Compound** is a Primary Key for the data base
Description	Text(15)	Description contains attributes from the SCAMP standardized attribute list for points

Entity-Table Name: Orientation
Entity-Table Comment: Orientation contains information about the azimuth/strike and (or) dip/plunge of a geologic-point feature (e.g., geologic structures such as inclined sedimentary bedding, metamorphic foliation, fold-axis lineations, fault-plane dips, paleocurrent vectors, glacial striations, etc.).

Entity-Table Attribute Name	Entity-Table Attribute Data-type	Entity-Table Attribute Comment
***Compound**	Text(24)	***Compound** is a Primary Key for the data base
Rank	Text(250)	Contains the rank of the geologic-point feature being measured (e.g., a population of related point types)
Azimuth	Double	Contains the azimuth or strike of an object/feature
Inclination	Double	Contains the dip/plunge of an object/feature
Type	Text(15)	Describes the type of orientation measured (e.g., metamorphic foliation, minor-fold-axis lineation, bedding inclination, etc.). Attributes from the standardized SCAMP attribute list
Confidence	Text(15)	Contains information about the level of confidence the map maker attaches to the use of a geologic attribute. Expressed either as an attribute from the SCAMP attribute list or as a numerical value from 0 to 100 representing a percentage of confidence in the interpretation
ConfUnits	Text(15)	Contains a unit indicator stating whether the *Confidence* value is a standardized SCAMP attribute or percentage-based value

Entity-Table Name: Feature_Confidence
Entity-Table Comment: Feature_Confidence contains information about the locatability, method of observation, and interpretive confidence for a geologic feature. This table allows the map maker to assign different levels of confidence to the identity of individual features or groups of features. Each field maintains the default confidence value unless attributed otherwise.

Entity-Table Attribute Name	Entity-Table Attribute Data-type	Entity-Table Attribute Comment
***Compound**	Text(24)	***Compound** is a Primary Key for the data base
Observation_Method	Text(15)	Contains information about how the object or feature defined by ***Compound** was determined (for example, air photos, direct observation, etc.). Contains attributes from the SCAMP attribute list
Locational_Range	Text(15)	A buffer that describes the uncertainty surrounding the locatability of an object defined by ***Compound**. By default, this is the map-accuracy value inidcated in the metadata table. At the discretion of the map maker, the value for a specific object as defined in ***Compound** can be attributed to reflect a range that differs from the default as defined in the metadata accuracy statement for the dataset
Confidence	Text(15)	Contains information about the level of confidence attached to the identification of the geologic feature indicated in ***Compound**. Expressed either as an attribute from the SCAMP attribute list or as a numerical value from 0 to 100 representing a percentage of confidence in the interpretation
ConfUnits	Text(15)	Contains a unit indicator stating whether the *Confidence* value is a standardized SCAMP attribute or a percentage-based value
LithologyID	Integer	A numerical identifier that describes a genetic lithologic instance for which the record contains data

Secondary Tables

Entity-Table Name: Geophysics
Entity-Table Comment: Table contains information derived from geophysical measurements and observations. Like the metadata table, this table is currently a Property, Value, and Units type table. Any given entry in the table may store information for a very different kind of measurement/observation. The reason for this is that very little geophysical information in the form of linear, point, or polygon attributes currently is available to the SCAMP project. This table will form the basis for additional fields and tables required in the future, and will hold large volumes of geophysical data.

Entity-Table Attribute Name	Entity-Table Attribute Data-type	Entity-Table Attribute Comment
***Compound**	Text(24)	***Compound** is a Primary Key for the data base
Rank	Integer	A numerical identifier indicating the abundance ranking of a sub-lithology relative to other sub-lithologies
Property_Name	Text(250)	Contains the formal name/definition of the information recorded in *Property_Value*
Property_Value	Text(250)	Contains the measured value of the information described in *Property_Name*
Property_Units	Text(100)	*Property_Units* indicates units for the information stored in *Property_Value* (i.e., centimeters, millimeters, text, formal description, standard attribute code, etc.)
Confidence	Text(15)	Contains information about the level of confidence the map maker attaches to the use of a geologic attribute. Expressed either as an attribute from the SCAMP attribute list or as a numerical value from 0 to 100 representing a percentage of confidence in the interpretation
ConfUnits	Text(15)	Contains a unit indicator stating whether the *Confidence* value is a standardized SCAMP attribute or a percentage-based value

Entity-Table Name: Engineering_Properties
Entity-Table Comment: Table contains information derived from engineering measurements and observations. Like the metadata table, this table is currently a Property, Value, and Units type table. Any given entry in the table may store information for a very different kind of measurement/observation. The reason for this is that very little engineering information in the form of linear, point, or polygon attributes currently is available to the SCAMP project. This table will form the basis for additional fields and tables required in the future, and will hold large volumes of engineering data.

Entity-Table Attribute Name	Entity-Table Attribute Data-type	Entity-Table Attribute Comment
***Compound**	Text(24)	***Compound** is a Primary Key for the data base
Rank	Integer	A numerical identifier indicating the abundance ranking of a sub-lithology relative to other sub-lithologies
Property_Name	Text(250)	Contains the formal name/definition of the information recorded in *Property_Value*
Property_Value	Text(250)	Contains the measured value of the information described in *Property_Name*
Property_Units	Text(100)	*Property_Units* indicates units for the information stored in *Property_Value* (i.e., centimeters, millimeters, text, formal description, standard attribute code, etc.)
Confidence	Text(15)	Contains information about the level of confidence the map maker attaches to the use of a geologic attribute. Expressed either as an attribute from the SCAMP attribute list or as a numerical value from 0 to 100 representing a percentage of confidence in the interpretation
ConfUnits	Text(15)	Contains a unit indicator stating whether the *Confidence* value is a standardized SCAMP attribute or a percentage-based value

Entity-Table Name: Mineralogy
Entity-Table Comment: Mineralogy contains individual mineralogic occurrences including any formulae derived by inference, or directly for a given point, polygon, or linear feature. This table will make the basis for future expansion of the mineralogic aspects of the data model. It currently provides a foundation on which to add additional fields as needed.

Entity-Table Attribute Name	Entity-Table Attribute Data-type	Entity-Table Attribute Comment
***Compound**	Text(24)	***Compound** is a Primary Key for the data base
Rank	Integer	A numerical identifier indicating the abundance ranking of a sub-lithology relative to other sub-lithologies
Mineral_Name/Code	Text(250)	This field contains the mineral name or attribute from the SCAMP standardized list of attributes for the mineral that exists in conjunction or that is defined by ***Compound**
Decimal_Formula	Text(250)	Contains the decimal formula of the mineral. By using decimal formulas, great latitude exists for describing solid solutions and composition.
Confidence	Text(15)	Contains information about the level of confidence the map maker attaches to the use of a geologic attribute. Expressed either as an attribute from the SCAMP attribute list or as a numerical value from 0 to 100 representing a percentage of confidence in the interpretation
ConfUnits	Text(15)	Contains a unit indicator stating whether the *Confidence* value is a standardized SCAMP attribute or a percentage-based value

Entity-Table Name: Paleontology_detail
Entity-Table Comment: Paleontology_detail is a Property, Value, and Units table like Metadata and Geophysics. Any kind of observation can be stored. Examples for this table might include information on individual fossils, paleontologic-assemblage occurrences, or paleoecologic information. This table will make the basis for further expansion of the paleontologic aspects of the data model in the future. When an appropriate quantity of similarly coded items exists, this table should be broken out into additional tables.

Entity-Table Attribute Name	Entity-Table Attribute Data-type	Entity-Table Attribute Comment
***Compound**	Text(24)	***Compound** is a Primary Key for the data base
Rank	Integer	A numerical identifier indicating the abundance ranking of a sub-lithology relative to other sub-lithologies
Property_Name	Text(250)	Contains the name/definition of the information to be recorded in Property_Value
Property_Value	Text(250)	Contains the Value of the information recorded as described in Property_Name
Property_Units	Text(100)	Contains the units information for the information stored in Property_Value (i.e., centimeters, millimeters, text, formal description, etc.)
Confidence	Text(15)	Contains information about the level of confidence the map maker attaches to the use of a geologic attribute. Expressed either as an attribute from the SCAMP attribute list or as a numerical value from 0 to 100 representing a percentage of confidence in the interpretation
ConfUnits	Text(15)	Contains a unit indicator stating whether the *Confidence* value is a standardized SCAMP attribute or a percentage-based value

System Tables

Entity-Table Name: Embedded
Entity-Table Comment: Embedded is the AAT/PAT/DBF table that is directly related to the shape file. The fields listed here are the fields that are added to the file as part of the data model.

Entity-Table Attribute Name	Entity-Table Attribute Data-type	Entity-Table Attribute Comment
***Compound**	Text(24)	***Compound** is a Primary Key for the data base
ItemID	Integer	*ItemID* is a copy of the unique item number associated with individual map objects. This represents a redundant field for most GIS packages. However, it is essential to implementation of the SCAMP data model
SubID	Integer	*SubID* is the ID number for a *Label* subset. For polygons, this is a cluster of polygons within a *Label* (Regions in ARC/INFO coverages)
Label	Text(15)	*Label* contains the alphanumeric acronym for a geologic-map unit. It consists of standard English characters; specialized geologic symbols used in plotting or displaying unique characters in some *Labels* are stored in the table named **Cartography** (Metadata, Display, and Cataloguing, Subarea CORE)

Entity-Table Name: Tracking
Entity-Table Comment: Tracking contains information about specific steps in the production of the data set. The information stored in this table answers the questions: "Who did what? When? Where? And why?" The Table can be implemented with or without software and tools/AML's to help track production.

Entity-Table Attribute Name	Entity-Table Attribute Data-type	Entity-Table Attribute Comment
***Compound**	Text(24)	***Compound** is a Primary Key for the data base
Date	Date/Time	Contains the date that the tracked event was executed
Time	Date/Time	Contains the exact time that the tracked event was executed
Action	Text(250)	Contains text describing the action recorded
Contact	Text(250)	Contains the contact name for the individual who triggered the action. *Contact* acts as a relate item to the table **Contact**
Location	Text(250)	Contains where the action was executed
Tool_serial#	Text(250)	Contains the site/serial number of the software package or hardware (if any) that was used to execute the action
Computer	Text(250)	Identifies the computer (if any) that was used to perform the action. Generally this is the Serial ID number(s) of the computer's Central Processing Unit(s) (CPU)
Status_of_Item	Text(250)	Describes the status of the item ***Compound** relates too (deleted moved, updated, etc.)
Citation#	Integer	Contains the relate item for the table **Citation**

Entity-Table Name: Feature_Topology
Entity-Table Comment: Feature_Topology is an optional table containing topologic information about what a specific map object is in contact with in different coverage layers. Users making extensive use of this table may wish to break it into three separate tables in the interest of speed and data-base size.

Entity-Table Attribute Name	Entity-Table Attribute Data-type	Entity-Table Attribute Comment
***Compound**	Text(24)	***Compound** is a Primary Key for the data base
Compound_Station	Text(24)	Contains the Compound ID for a point features in contact with a map object
Compound_linear	Text(24)	Contains the Compound ID for a Linear feature in contact with a map object
Compound_Poly	Text(24)	Contains the Compound ID for polygons in contact with a map object

Metadata, Display, and Cataloguing

Core Tables

Entity-Table Name: Name
Entity-Table Comment: This table stores names for various objects in the geologic-map data base. The objects can be geologic polygons, lines, or points, and the names can be formal (such as Mill Creek Formation or San Andreas fault) or informal (the sandstone and mudstone member of the Mill Creek Formation) or common (sandstone001 or the spotted sandstone lithology). Name has two primary purposes: (1) to store map-unit-rank names in a manner that satisfies conventional naming criteria (U.S. Geological Survey Lexicon of Geologic Names and The North American Commission on Stratigraphic Nomenclature, 1983), and (2) to store object names so that equal-identity linkage is established between spatial and non-spatial objects that have a common geologic connection. Note that every polygon object and line and point objects must have names of some kind to fulfil various analytical aspects of the data model.

Entity-Table Attribute Name	Entity-Table Attribute Data-type	Entity-Table Attribute Comment
Name	Text(250)	Contains the formal, informal, or common name for a geologic object. For polygons, the feature name relates to the object calculated in ***Compound** (*Label*, *SubID*, or *ItemID*) or to ***Compound** and *Rank* used in conjunction. The latter might yield (for example) the coarse sandstone facies of *Label* Qof3 or the brown mudstone facies of the lower and middle members of *Label* Mill Creek Formation.
Name_Type	Text(24)	Describes the type of nomenclature used in ***Name*** (e.g.: formal name, informal name, common name, field name, sequence name)
Parent_Name	Text(15)	Contains the superset name for the item in ***Name*** (Grand Canyon Group might be a parent for Bright Angel Shale)
Name_Category	Text(15)	Contains the subject area to which the nomenclature in ***Name*** refers. Categories include: unit label, sublithology, process, etc.

Entity-Table Name: Embedded_Name
Entity-Table Comment: Embedded_Name provides the link between map objects and names that may relate to them and their subcategories.

Entity-Table Attribute Name	Entity-Table Attribute Data-type	Entity-Table Attribute Comment
***Compound**	Text(24)	***Compound** is a Primary Key for the data base
Name	Text(250)	Contains the formal, informal, or common name for a geologic object. The feature name relates to the object calculated in ***Compound** (*Label*, *SubID*, or *ItemID*) or to ***Compound** and *Rank* used in conjunction. The latter might yield (for example) the coarse sandstone facies of *Label* Qof3 or the brown mudstone facies of the lower and middle members of *Label* Mill Creek Formation.
Rank	Integer	A numerical identifier indicating the abundance ranking of a sub-lithology relative to other sub-lithologies
Preference	Binary	A flag used to indicate whether *Name* is the preferred name for the object
LithologyID	AutoNumber	A numerical identifier that describes a specific genetic/lithologic temporal instance. *LithologyID* links to a specific geologic condition in the cumulative temporal succession of geologic conditions that led to the object identified by ***Compound** and described in **Name**

Entity-Table Name: Cartography
Entity-Table Comment: Cartography contains information that is required to generate displays and plots of the geologic-map data.

Entity-Table Attribute Name	Entity-Table Attribute Data-type	Entity-Table Attribute Comment
***Compound**	Text(24)	***Compound** is a Primary Key for the data base
Rank	Integer	A numerical identifier indicating the abundance ranking of a sub-lithology relative to other sub-lithologies
Plot_Label	Text(15)	Contains specialized geologic symbols for plotting or displaying a map
Legend_Desc_Cit#	Text(250)	Contains a citation number for the file that contains the legend description for each map object
Red	Integer	Red value for a map object in the RGB color model
Green	Integer	Green value for a map object in the RGB color model
Blue	Integer	Blue value for a map object in the RGB color model
Cyan	Integer	Cyan value for a map object in the CMYK color model
Yellow	Integer	Yellow value for a map object in the CMYK color model
Magenta	Integer	Magenta value for a map object in the CMYK color model
Black	Integer	Black value for a map object in the CMYK color model
Symbol	Text(15)	Contains the symbol number/identifier for line symbols, point symbols, and fill patterns. NOTE: Symbol_Arc may need to be created to identify symbols in the SCAMP Arc/Info symbol libraries (geoscamp2.lin and geoscamp2.mrk). Currently, *Symbol* holds this information
Map_Name_Cit#	Text(100)	Citation# for the map plot about which the record contains information

Entity-Table Name: FGDC_MetaData
Entity-Table Comment: Contains most of the FGDC Metadata information (Content Standard for Digital Geospatial Metadata, v. 2.0, with the exception of contact and citation data. The latter are stored in **Contact** and **Citation** because they are more dynamic than most of the other information contained in the metadata standard. This table is a property, value, and units table like **Geophysics** Table.

Entity-Table Attribute Name	Entity-Table Attribute Data-type	Entity-Table Attribute Comment
***Compound**	Text(24)	***Compound** is a Primary Key for the data base
Item_Name	Text(250)	Contains a field name for the data. For example, 'Map/Data-set projection' might be the field description for the record where projection information should be stored
Item_Value	Text(250)	Contains information for a given *Item_Name*
Item_FGDC_Code	Text(100)	Contains 1.3.5.1-style outline stacking codes as used by the FGDC to delineate areas of the Metadata standard. They are stored here more as a convenience for searching and reference than out of any imperative need

Entity-Table Name: Citation
Entity-Table Comment: Citation contains the full FGDC-compliant citation information for data stored in and related to the data set. This specific kind of metadata applies to geologic-map information compiled from sources other than the authors of the SCAMP geologic-map data base.

Entity-Table Attribute Name	Entity-Table Attribute Data-type	Entity-Table Attribute Comment
Citation_#	Integer	Unique referencing number for each bibliographic citation
Larger_work_Citation _#	AutoNumber	Unique referencing number for any citation that a given citation may be a subset of or derived from
Title	Text(250)	Title of cited information
Publication_Date	Date/Time	Date of Publication/Creation
Publication_Time	Date/Time	Time of Publication/Creation
Edition	Text(250)	Edition of publication
Series_Name	Text(250)	Series Name for the publication
Series_id	Text(250)	ID of the series
Publication_Place	Text(250)	Place of Publication
Publisher	Text(250)	Name of the Publisher
Other_Details	Text(250)	Other details related to the publication/cited reference/Item
File	Text(250)	File name (with relative data path) of the item being sited

Entity-Table Name: Topics
Entity-Table Comment: Topics contains a topical list for attribute values found in **Keywords** and **Questions**.

Entity-Table Attribute Name	Entity-Table Attribute Data-type	Entity-Table Attribute Comment
TopicID	AutoNumber	Unique referencing number for a topic
TopicText	Text(250)	Topical heading under which information in **Questions** and **Keywords** is categorized

Entity-Table Name: Questions
Entity-Table Comment: Table contains predefined questions referenced to various map objects. This table allows the map maker to anticipate questions that may be of interest to the end user (e.g., questions about map objects or features that demonstrate particularly significant or interesting topics in the data set).

Entity-Table Attribute Name	Entity-Table Attribute Data-type	Entity-Table Attribute Comment
QuestionID	AutoNumber	Unique referencing number for a question
QuestionText	Text(250)	Predefined question related to map objects or citations

Entity-Table Name: Keywords
Entity-Table Comment: Contains keywords associated with one or many map objects. This table allows the map maker to predefine keywords for ease of non-technical searching of the data base.

Entity-Table Attribute Name	Entity-Table Attribute Data-type	Entity-Table Attribute Comment
Keyword	Text(250)	Predefined keyword associated with map objects or citations
Definition	Text(250)	Definition of the keyword as it is proxies for an attribute (or attributes) in the context of a given data set
Purpose	Text(200)	Contains a justification statement for why a keyword was produced for information that otherwise is stored as an attribute code elsewhere in the data model. Justifications typically are data-set specific, and serve a user-oriented purpose—for e.g., the information contained under ***Keyword*** may have *no geologic significance*

System Tables

Entity-Table Name: **Embedded_Citation**
Entity-Table Comment: Embedded_Citation allows for full citation of any map object.

Entity-Table Attribute Name	Entity-Table Attribute Data-type	Entity-Table Attribute Comment
***Compound**	Text(24)	***Compound** is a Primary Key for the data base
Citation_#	Integer	Contains the unique identifier for a citation

Entity-Table Name: **Embedded_Keywords**
Entity-Table Comment: Embedded_Keywords provides keywords as proxies for attribute values recorded elsewhere in the data base. This is a linking table that solves the many-to-many relate issue between keywords and their associated map objects.

Entity-Table Attribute Name	Entity-Table Attribute Data-type	Entity-Table Attribute Comment
***Compound**	Text(24)	***Compound** is a Primary Key for the data base
Keyword	Text(250)	Pre-defined keyword linked to map objects or citations

Entity-Table Name: **Citation_Keywords**
Entity-Table Comment: Citation_Keywords allows for full citation of any keyword in the data base.

Entity-Table Attribute Name	Entity-Table Attribute Data-type	Entity-Table Attribute Comment
Keyword	Text(250)	Contains the keyword
Citation_#	Integer	Contains the unique identifier for a citation

Entity-Table Name: **Keywords_Topics**
Entity-Table Comment: Keywords_Topics allows for full association between keywards and topics.

Entity-Table Attribute Name	Entity-Table Attribute Data-type	Entity-Table Attribute Comment
TopicID	AutoNumber	Contains the unique identifier for a topic
Keyword	Text(250)	Contains the keyword

Entity-Table Name: Embedded_Questions
Entity-Table Comment: Embedded_Questions provides the link between map objects and questions that may relate to them.

Entity-Table Attribute Name	Entity-Table Attribute Data-type	Entity-Table Attribute Comment
***Compound**	Text(24)	***Compound** is a Primary Key for the data base
QuestionID	AutoNumber	Unique referencing number for a question

Entity-Table Name: Citation_Questions
Entity-Table Comment: Citation_Questions allows for full citation of any question in the data base.

Entity-Table Attribute Name	Entity-Table Attribute Data-type	Entity-Table Attribute Comment
QuestionID	AutoNumber	Contains the unique identifier for a question
Citation_#	Integer	Contains the unique identifier for a citation

Entity-Table Name: Questions_Topics
Entity-Table Comment: Questions_Topics allows for full association between questions and topics.

Entity-Table Attribute Name	Entity-Table Attribute Data-type	Entity-Table Attribute Comment
QuestionID	AutoNumber	Contains the unique identifier for a question
TopicID	AutoNumber	Contains the unique identifier for a topic

Entity-Table Name: Topics_Citation
Entity-Table Comment: Topics_Citation allows for full citation of any topic in the data base.

Entity-Table Attribute Name	Entity-Table Attribute Data-type	Entity-Table Attribute Comment
TopicID	AutoNumber	Contains the unique identifier for a topic
Citation_#	Integer	Contains the unique identifier for a citation

Entity-Table Name: **Embedded_Contact**
Entity-Table Comment: Embedded_Contact allows for full source contact of any map object.

Entity-Table Attribute Name	Entity-Table Attribute Data-type	Entity-Table Attribute Comment
***Compound**	Text(24)	***Compound** is a Primary Key for the data base
Contact	Text(24)	Name of the individual who is associated in some way with the data set or with a citation, object, or tracking event
Authorship/Position	Integer	A numerical value ranking the authorship position of the *Contact* (i.e. 1 = primary; 2= secondary etc.)
Role	Text(24)	Contains a label describing the contact's role (i.e. geologic mapper, map compiler, GIS operations, map author, map editor, etc.)

Entity-Table Name: **Citation_Contact**
Entity-Table Comment: Citation_Contact allows for full source citation of any map object.

Entity-Table Attribute Name	Entity-Table Attribute Data-type	Entity-Table Attribute Comment
Citation_#	Integer	Contains the unique identifier for a citation
Contact	Text(24)	Name of the individual who is associated in some way with the data set or with a citation, object, or tracking event
Authorship/Position	Integer	A numerical value ranking the authorship position of the *Contact* (i.e. 1 = primary; 2= secondary etc.)
Role	Text(24)	Contains a label describing the contact's role (i.e. geologic mapper, map compiler, GIS operations, map author, map editor, etc.)

Contact-Information Tables

Entity-Table Name: Contact
Entity-Table Comment: Contains the FGDC-compliant contact information on individuals and organizations associated with information in the data set.

Entity-Table Attribute Name	Entity-Table Attribute Data-type	Entity-Table Attribute Comment
Contact	Text(24)	Contains the contact name for the individual who is associated with the data set, a citation, an object, or tracking event. Rarely, this may also be the Organization (discouraged).
Position/Title	Text(250)	Name of the title or position held by the contact.
Organization	Text(250)	Name of the contact's organization
Hours_of_Service	Text(250)	Hours the organization is open for business
Contact_Instructions	Text(250)	Supplemental instructions on how or when to contact the individual or organization
Contact_Language	Text(24)	Primary language of the contact and contact organization.

Entity-Table Name: Contact_address
Entity-Table Comment: Provides addressing information for a contact organization or individual.

Entity-Table Attribute Name	Entity-Table Attribute Data-type	Entity-Table Attribute Comment
Contact	Text(24)	Contains the contact name for the individual who is associated with the data set, a citation, an object, or tracking event
Type	Text(250)	Type of Address "mailing" "physical" "mailing and physical", free text
City	Text(100)	City for the Address
State_Province	Text(100)	State or Province of the address
Postal_Code	Text(100)	Postal code of the address
Country	Text(100)	Country of the address

Entity-Table Name: Address (sub-table of Contact_address)
Entity-Table Comment: Address is a relational table that allows for unlimited address lines for an address.

Entity-Table Attribute Name	Entity-Table Attribute Data-type	Entity-Table Attribute Comment
Contact	Text(24)	Contains the contact name for the individual who is associated with the data set, a citation, an object, or tracking event
Type	Text(250)	Type of Address "mailing" "physical" "mailing and physical", free text
Line_#	AutoNumber	Address line number (for lines that appear below the contacts name but before the address city
Line_Text	Text(250)	Text of the address line

Entity-Table Name: Contact_E-Mail
Entity-Table Comment: Provides e-mail addresses for contacts.

Entity-Table Attribute Name	Entity-Table Attribute Data-type	Entity-Table Attribute Comment
Contact	Text(24)	Contains the contact name for the individual who is associated with the data set, a citation, an object, or tracking event
Email_Address	Text(250)	Email address of the contact
Preference	Integer	Value defining the contacts preference in contact email address' from primary (1), secondary (2), etc.

Entity-Table Name: Contact_Voice_Phone
Entity-Table Comment: Provides the voice telephone numbers for the contact.

Entity-Table Attribute Name	Entity-Table Attribute Data-type	Entity-Table Attribute Comment
Contact	Text(24)	Contains the contact name for the individual who is associated with the data set, a citation, an object, or tracking event
Voice_Phone_#	Text(100)	Phone number of contact

Entity-Table Name: **Contact__fax_tty_tdd_Phone**
Entity-Table Comment: Contains information for disabled persons.

Entity-Table Attribute Name	Entity-Table Attribute Data-type	Entity-Table Attribute Comment
Contact	Text(24)	Contact name for the individual who is associated with the data set, a citation, a map object, or tracking event.
TDD_Phone_#	Text(100)	FAX, TTY/TDD phone of contact
Fax_Phone_#	Text(24)	Fax Phone number of contact

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