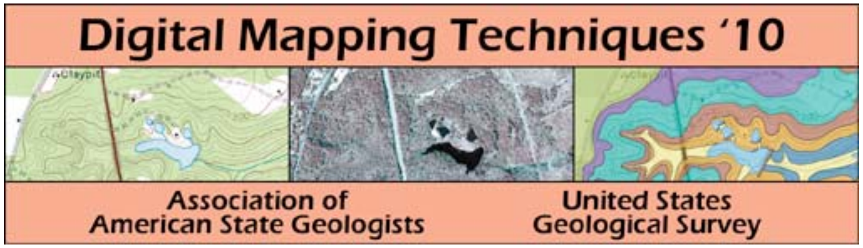

The following was presented at DMT'10
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The contents are provisional and will be superseded by a paper in the DMT'10 Proceedings.

See also earlier Proceedings (1997-2009)
http://ngmdb.usgs.gov/info/dmt/

The New Mexico Bureau of Geology & Mineral Resources geologic data model, a comparison with other existing models

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see: http://geoinfo.nmt.edu/statemap/datamodel

What is a geology data model and why would I want to use one?

Like most other mapping agencies, the New Mexico Bureau of Geology and Mineral Resources (NMBGMR) has produced geologic maps for many years using a Geographic Information System (GIS). A GIS is essentially a geospatial database that stores information about the shape and position of mapped features as well as associated data. In order for a particular GIS-based map to be interoperable with other maps, their geo-spatial databases must be organized with a consistent structure. A data model is a standardized database structure (also called a database schema) that defines what features (or entities) are recorded, what their attributes are (often with a pre-defined set of possible values), and how they relate to one another.

Hasn't a good geology data model already been created?

Yes and no—several comprehensive data models have been proposed, but none are in common use throughout the country or the world. Geologic maps are extremely complicated documents that attempt to record both geological observations and interpretations in four dimensions—through space and time. There are many reasonable approaches to encoding geological data and a lot of institutional inertia to keep doing what has been working, if imperfectly, because it is painful to migrate existing data to a new schema. Like most change, adoption of new ways of doing things only occurs when old methods are too painful to continue using and new methods have obvious benefits.

When we decided we needed a better data model, we looked at existing geologic data models and at the time we found that they were either too complex to be practical or otherwise don't fit our needs. So, we chose to create our own model from scratch, borrowing useful ideas from other models. Since both field-mapping and digitization of maps are already fairly labor-intensive, we didn't want to add needless complexity to the process of producing maps. However, we did want have the ability to create a fully attributed geologic map in a GIS.

Model Comparison

Our model developed in tandem with both the NCGMP09 and ESRI models and shares several design features with them -- but also has some important differences:

Feature Classes

We have far more granular feature classes in our model than the NCGMP09 model does and a different structure than the ESRI Geologic Mapping Template. The benefit of separate feature classes is that it is easier to create maps that display just the features of interest. For instance, if a structure map is needed, you can just display the faults, folds, and perhaps structure contour layers. To do this in the NCGMP09 model would require querying the data and perhaps exporting features to new feature classes to construct these derivative maps. Another benefit of feature classes dedicated to a particular type of feature is that attributes can be more specific for that feature type. Of course, the drawback of our approach is that having more feature classes can make geodatabases more complicated.

Confidence, Locational Accuracy, and Exposure

Traditionally, lines (generally contacts and faults) on printed geologic maps are either solid, dashed, dotted or queried. Solid lines were used to represent linear features that were confidently identified, well located, and exposed. Dotted lines were used for concealed features that a geologist felt reasonably confident in projecting beneath another unit. Queries along lines reflected decreased confidence about both existence and location. Dashed lines were more mysterious. Dashed lines could represent decreased confidence because a contact was mapped with binoculars or air photos, was poorly exposed, wasn't well located in areas of low relief, or was interpolated. The main problem with the standard line types used on paper geologic maps is that there are multiple inter-related attributes than can be effectively symbolized with such a simple system of line types.

We chose to attribute linear features using a combination of two attributes, **1) Exposure** (exposed, obscured or intermittent, concealed) and **2) Scientific Confidence** combining confidence regarding the existence and/or identification of a feature (certain, probable, uncertain). Note that for simplicity, positional accuracy is not recorded for lines and does not affect our symbology (positional accuracy can be recorded for points along the line however). Another reason for not attributing locational accuracy is that it quickly becomes very difficult to create a workable field symbology for use on paper field maps.

Topology

We have defined a number of important topology rules that should be valid for any geologic map. Most of these rules are obvious: no gaps between polygons, contacts must overlie polygon boundaries, contacts can't dangle etc. These rules help identify and fix inevitable digitization errors. Other rules require that fold and fault measurements should line on their respective line types or be marked as exceptions. These exceptions will additionally have an attribute "MappedFeature" set to FALSE so that they can easily be symbolized as minor structures.

A more fundamental topologic relationship exists for point data that can have measurements for both planar and linear data, like faults with slickenlines, fold axial planes and fold axes, foliations with extension lineations, or bedding with paleocurrent vectors. For all these types of features, planar and linear data resides in the same record. Of course, there are many ways to store such a relationship in a database, but this method is by far the simplest to use and understand when editing or viewing the database. Many other geologic data models store one point for a fault plane and another for the slickenline in that plane. It then becomes very difficult to extract this key data from what is really a single data point.

Our line features are structured somewhat differently than other data models. Lithologic contacts are separated into two feature classes: *Lith_Contacts* and *Concealed_Contacts*. Additionally, faults are stored and fully attributed in *Fault_line* rather than being combined with contacts as in the NCGMP09 model. After faults are attributed, non-concealed faults (that participate in polygon topology) are copied to the *Lith_Contacts* layer where they will retain their LineClass attribute of 'fault'. Before building polygons, the *Map_Boundary* polyline is also copied to the *Lith_Contacts* layer and the topology is validated. Faults that dangle are deleted from the *Lith_Contacts* layer and any other topology problems are fixed. When there are no topology errors -- and no exceptions -- polygons can be built from the *Lith_Contacts* layer (and attributed using Lith_poly_label points if present).

Lithologic Classification

We chose to proceed from very general lithologic attributes to more specific attributes:

LithClass: (LithType)

- **Sedimentary:** (siliciclastic, mixed, nonsiliciclastic)
- **Volcanic:** (lava flow, dome, ash, volcaniclastic)
- **Intrusive:** (plutonic, hypabyssal, dike, sill)
- **Metamorphic:** (metasedimentary, metavolcanic, metaplutonic, unknown protolith)
- **Anthropogenic:** (disturbed land, artificial fill, tailings, dump)

The most specific lithologic attributes are divided into *PrimaryLithology* and *SecondaryLithology* which could either use uncontrolled terms or use the NGMDB vocabularies.

In addition to a long Text field for *UnitDescription*, we also include a *ShortDescription* field suitable for the map legend.

Geologic Events

A geologic events table as specified in the NCGMP09 model is not currently part of our model. However, features like faults have attributes for *Ancestry* and *LastActive*. Our *Lithology* table has attributes for min/max/preferred age, *GeneticEnvironment* and *DepositionalSystem*. Having all geologic features linked to attributes about their geologic history sounds like it could be very useful, but that may be extremely difficult to implement.

Attributes

Almost all attributes in our model are human-readable text. This is less space efficient than using numeric codes and precludes the use of ArcGIS subtypes, but it makes the database much easier to comprehend, especially if it has been exported to a shapefile. Many of these have coded value domains that provide pick lists for acceptable attributes. Aliases show the text used as the code within brackets to facilitate editing when more than one feature is attributed with the ArcMap field calculator. For instance, "obscured" is a code that has the alias: "[obscured]: Intermittantly exposed / obscured by colluvium".

Some feature classes like *DataPoint* are just containers for the location of point data that can be attributed in separate tables as needed. In general, however, most feature classes have a fairly comprehensive set of attributes. These could be expanded as the need arises. Another approach is to use extended attributes as used by the NCGMP09 and ESRI Geologic Mapping Template. This allows for uncommonly used attributes to be stored in a separate related table. In these models, one table is used for extended attributes for all feature classes by relying on user-maintained keys specifying the parent feature and the parent feature class. This approach seems difficult to manage if a large number of extended attributes are used. Perhaps future classes could have rarely used and extended attributes in a dedicated table and use one-to-one relationship classes to maintain the link between features and attributes. For instance, Fabric_point could store rarely used attributes and extended attributes in a table called Fabric_pt_attr. This wouldn't rely on user-maintained database keys and would allow for automatic deletion of attribute data when the parent feature is deleted. The downside of this approach would be more tables in the geodatabase.

Correlation of Map Units (CMU)

We don't currently encode the correlation of map units diagram within our geodatabases. The flexibility of producing custom diagrams in a graphics program is somewhat offset by the utility of standardization as advocated by the NCGMP09. The encoding scheme in the NCGMP09 seems rather complicated for practical use however.

Relationship Feature Classes

We have set up geodatabase relationship classes between features and stand-alone tables. For instance *Lith_poly* units are in a relationship class with the *Lithology* table. Relationship classes have the advantage over standard database joins or relates in that the relationship is stored in the geodatabase itself and not in the ArcMap MXD file.

Subcrop

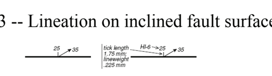
We include feature classes for creating an bedrock map beneath alluvium/colluvium or other cover. These derivative maps are very useful for hydrologic modeling, basin analysis, and other geotechnical projects.

Symbology

When we began constructing our model, cartographic representations were not available in ArcMap and symbology was (and still is) limited to combinations of three attributes at a time. Our feature classes were designed with this in mind. Many feature classes had somewhat generic attributes based on a *Class*, *Type*, *SubType* attribute hierarchy. This has evolved somewhat over time, but we have tried wherever possible to limit the number of attributes that must be considered to define symbology to three.

Cartographic representations are another approach to symbology but require that all symbology be abstracted from a code. They also require orientation of symbols to be attributed opposite to azimuth conventions on geologic maps. One problem with the FDGC standard and ESRI approach to using cartographic representations of it is that a number of the symbol codes refer to multiple features that should be symbolized separately. For instance:

2.11.13 -- Lineation on inclined fault surface—Tick shows fault dip value and direction; arrow shows bearing and plunge of lineation



While the fault plane and lineation (slickenline) are both fundamentally part of one data point measurement (see above), They need to be symbolized with two instances of the data. Of course, there are individual FDGC codes for each of these elements, but it might be useful to eliminate the FGDC codes that aren't granular enough to apply to individual features and data types. Another problem with the code approach is that it would be very easy for the code to not be synchronized with the actual attributes of the feature which would become very confusing to end-users. One way to get around this problem would be to have separate joined tables that allow determination of symbol codes based on attributes. This has the added benefit of separating style from content the same way that standards-compliant HTML encodes content while CSS applies styles for Web pages.

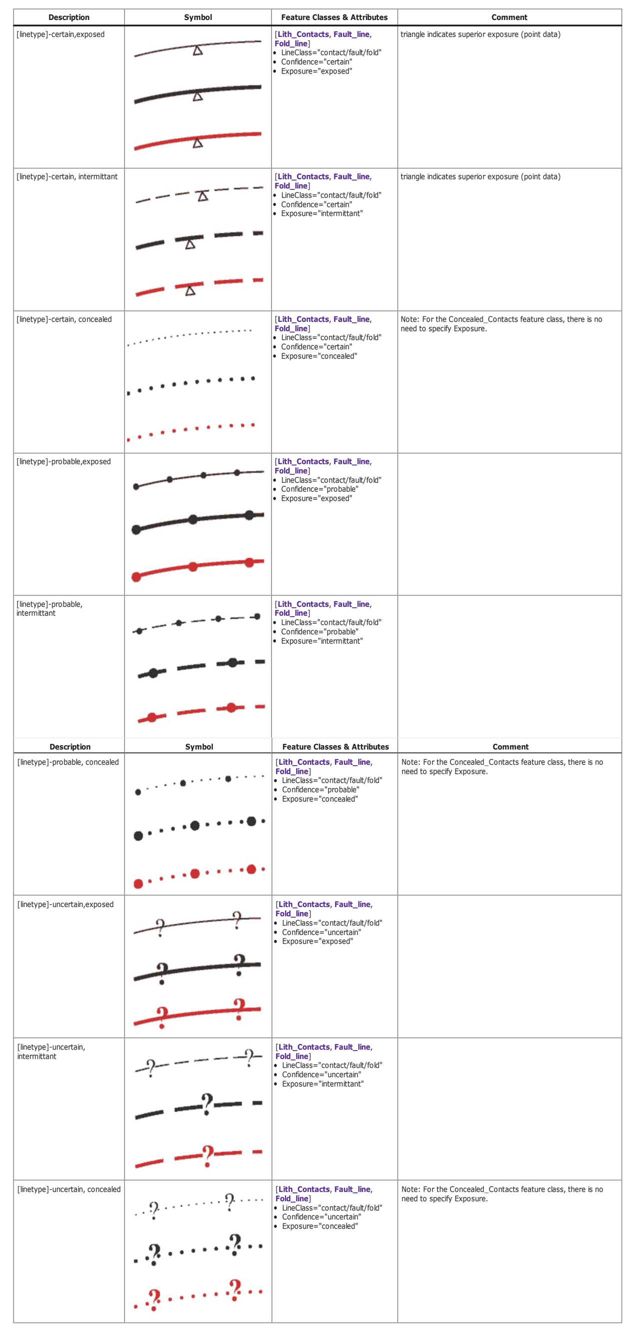
Where do we go from here?

Eventually, some consensus will probably be reached and a single geology data model will be widely adopted and be interoperable with GeoSciML. This will make it much easier for anybody who tries to produce compilations, create derivative maps, or to perform spatial analyses of existing geologic map data. While our model has been working reasonably well for us, we don't presume that it will be the model adopted. Nonetheless, we do hope that some of the ideas presented by this model will be borrowed by other models -- just as we have done.

Feature Data Sets/Feature Classes	
Geology	**Geometry**
Alter_line	Polyline
Alter_poly	Polygon
Attribution_poly	Polygon
Concealed_Contacts	Polyline
Contour_line	Polyline
Data_point	Point
Fabric_point	Point
Fault_line	Polyline
Fault_point	Point
Fault_Symbol	Point
Feature_line	Polyline
Feature_point	Point
Fold_line	Polyline
Fold_point	Point
Fold_Symbol	Point
Isograd_line	Polyline
Landform_poly	Polygon
Lith_Contacts	Polyline
Lith_poly	Polygon
Lith_poly_label	Point
Map_Boundary	Polyline
MapExtent_poly	Polygon
Metamorphic_poly	Polygon
Mine_line	Polyline
Mine_point	Point
Mine_poly	Polygon
Mineral_line	Polyline
Mineral_poly	Polygon
Overlay_line	Polyline
Overlay_poly	Polygon
Sect_line	Polyline
Subcrop_poly	Polygon
Surface_Contacts	Polyline
Surface_poly	Polygon
Tics	Point
Well_point	Point
Xsect_AA	**Geometry**
Xsect_poly	Polygon
XsectBound	Polyline
XsectLines	Polyline
XsectSymbl	Point
XsectTics	Polyline
TABLES	
Geochronology	
Images	
Lithology	
Samples	
Sources	
Surfaces	

General line types

(Applies to Lith_Contacts, Fault_line, Fold_line — colors and line-weights vary)



Feature Class: Fabric_point

This feature class represents points of measured planar and/or linear geologic fabrics, such as attitudes of sedimentary bedding or foliations, but excludes fault plane / point data and fold data (which are treated separately). Foliation measurements taken within discrete shear zones with good shear criteria should be recorded in Fault_point.

Field Name	Field Alias	Length (text fields)	Field Type	Field Value	Default	Allow Nulls?	Attributes / Examples	Description / Notes
FGDC_plane	"	16	String	CVD variable FGDC_FabricPlanar	[null]	TRUE	30.3.12	FGDC geologic symbol reference number.
StationID	"	50	String	variable	[null]	TRUE	[null], to link to notes, photos, etc.	Station ID (if specified)
RockType	"	16	String	CVD fixed	sedimentary	TRUE	sedimentary, volcanic, intrusive, metamorphic, unknown	[illegible]
PlaneType	"	25	String	CVD variable FabricPlaneType	bedding	TRUE	[illegible]	Type of planar fabric
PlnSubType	PlaneSubType	25	String	CVD variable FabricPlaneSubType	[null]	TRUE	[illegible]	Sub-type of planar fabric of specified type.
Inclnation	Inclination	16	String	CVD fixed	inclined	TRUE	unspecified, inclined, vertical, horizontal, overturned	Description of inclination; used to determine symbol type.
Surface	"	50	String	variable	[null]	TRUE	[illegible]	[illegible]
PlaneAsym	[illegible]	16	String	variable	[null]	TRUE	[illegible]	Asymmetry of planar fabric
Strike	"		Short Integer	variable	[null]	TRUE	[null], 256, 123, etc. (0-360)	Azimuth of strike (right hand rule).
DipDir	DipDirection		Short Integer	variable	[null]	TRUE	[null], 166, 123, etc. (0-360)	Azimuth of dip-direction.
Dip	"		Short Integer	variable	[null]	TRUE	[null], 45, 56, etc, (0-90)	Value of dip.
Younging	"	16	String	CVD fixed	[null]	TRUE	[illegible]	Determination of younging direction
YoungCrit	YoungingCriteria	16	String	CVD variable	[null]	TRUE	unspecified, graded beds, cross beds, strat relations, etc.	Younging criteria used.
FGDC_line	"	16	String	CVD variable FGDC_FabricLinear	[null]	TRUE	30.3.12	FGDC geologic symbol reference number.
LineType	"	25	String	CVD variable FabricLineType	[null]	TRUE	[illegible]	Type of linear fabric
LnSubType	LineSubType	25	String	CVD variable FabricLineSubType	[null]	TRUE	[illegible]	Subtype of linear fabric of specified type
Trend	"		Short Integer	variable	[null]	TRUE	[null], 166 (0-360)	Azimuth of trend.
Plunge	"		Short Integer	variable	[null]	TRUE	[null], 45	Value of plunge.
Rake	"		Short Integer	variable	[null]	TRUE	[null], 45	[illegible]
Magnitude	"		Single	variable	[null]	TRUE	[illegible]	[illegible]
LineAsymm	LineAsymmetry	16	String	CVD variable	[null]	TRUE	[illegible]	Asymmetry of linear fabric
SubLnAsym	SubLineAsymmetry	16	String	CVD variable	[null]	TRUE	[illegible]	Subtype of linear fabric asymmetry
AsymmCrit	AsymmetryCriteria	50	String	CVD variable	[null]	TRUE	[illegible]	Criteria for asymmetry determination
MeasMethod	MeasurementMethod	50	String	CVD fixed	[null]	TRUE	unspecified, measured, compass sight, visual average, compiled, photo interp	Method of measurement.
LocAccType	LocAccuracyType	50	String	variable	[null]	TRUE	precision gps, handheld gps, good topo, poor topo, planimetric, survey, map and compass, triangulation, distinctive feature	Accuracy of position.
LocAccMeas	LocAccuracyMeasure	16	String	variable	[null]	TRUE	EPE(m), PDOP	Criteria for determining accuracy of position.
LocAccVal	LocAccuracyValue		Single	variable	[null]	TRUE	15	Numeric measurement of locataion accuracy
DsplyScale	DisplayScale		Long Integer	CVD fixed	24000	TRUE	0, 24000, 50000, 12000, 6000, 100000, 250000,500000, 1000000	Denominator of display scale: display feature at scales larger than number specified (=< denominator). Zero indicates data that should never be displayed.
SourceID	"	128	String	variable	[null]	TRUE	unknown; unspecified; Smith, 2006b [variable]	Feature level metadata (who mapped this); related to bibliographic detail
Comments	"	255	String	variable	[null]	TRUE	description	Comments about this particular feature.

Feature Class: Fault_point

This feature class represents points of detailed data about faults, joints, and ductile shear zones. Foliation measurements outside of discrete shear zones with or without lineations and shear criteria should be recorded as point data in Fabric_point. These features can be of any scale and may or may not be shown as mapped faults. Mapped faults are recorded as lines in Fault_line and, where measured, are topologically related to fault_point. Only the subset of point data representing mapped faults will lie on mapped fault lines and should have **MappedFeat = 'yes'**, while exceptions to the topology rule should have **MappedFeat = 'no'**. Some fault decorations, like bar-ball symbols, U & D symbols, fault teeth, etc are stored as point data in Fault_Symbol to allow better cartographic control.

Field Name	Field Alias	Length (text fields)	Field Type	Field Value	Default	Allow Nulls?	Attributes / Examples	Description / Notes
FGDC_plane	"	16	String	CVD variable FGDC_FaultPlanar	[null]	TRUE	30.3.12	FGDC geologic symbol reference number.
StationID	"	50	String	variable	[null]	TRUE	[null], to link to notes, photos, etc.	Station ID (if specified)
MappedFeat	MappedFeature		Short Integer	boolean	1 (TRUE)	FALSE	1=yes/TRUE (on Fault_line) 0=no/FALSE (minor structure not on Fault_line)	Is fault related to a mapped fault_line?: Requires definition query: for a minor fault symbology changes (strike line is removed).
StrctClass	StructClass	16	String	CVD variable StrctClass	unknown	FALSE	unknown, fault, fault-scarp, fault zone, joint, joint set, fracture, fracture zone, breccia zone, shear zone, mylonite, ultramylonite, pseudotachylite, shear band	Class of fault.
FaultType	"	16	String	CVD fixed	[null]	TRUE	[null], unknown, dip-slip, strike slip, oblique slip	Type of fault. Dip-slip includes normal, reverse, thrust; slip oblique slip where a SubSlipSense is specified.
SlipSense	"	16	String	CVD fixed	[null]	TRUE	unknown, [all except strike-slip] normal, reverse, thrust, detachment, dextral, sinistral, right-lateral, left-lateral	Dominant slip sense.
SubSlipSns	SubSlipSense	16	String	CVD fixed	[null]	TRUE	unknown, [all except strike-slip] normal, reverse, thrust, detachment, dextral, sinistral	Subordinate slip sense.
SlipBasis	"	128	String	CVD variable	[null]	TRUE	unspecified, map pattern, minor faults, observed offset, slickenlines, geomorphic evidence, kinematic indicators, piercing line/point	Basis for determination of dominant slip sense.
ShearCrit	ShearCriteria	128	String	CVD variable	[null]	TRUE	unspecified, slickenlines, riedel shears, mineral fibers, offset marker, sigma porphyroclast, imbricate clasts, s-c fabric, [joint]: mode-[1,2,3], etc.	Shear criteria.
SlipConfid	SlipConfidence	20	String	CVD fixed Confidence	[null]	TRUE	unspecified, certain, probable, uncertain	Confidence of slip determination
SlipRate	"		Single	variable	[null]	TRUE	10	Slip rate at this locality, details in comments below or linked to separate data table
SlipRateUn	SlipRateUnits	16	String	variable	[null]	TRUE	mm/yr	Units of slip rate
Inclnation	**Inclination**	16	String	CVD fixed	inclined	FALSE	unspecified, unknown, inclined, vertical, horizontal	Description of inclination; used to determine symbol type.
Strike	"		Short Integer	variable	[null]	TRUE	[null], 256, 123, etc. (0-360)	Azimuth of strike (right hand rule).
DipDir	DipDirection		Short Integer	variable	[null]	TRUE	[null], 166, 123, etc. (0-360)	Azimuth of dip-direction.
Dip	"		Short Integer	variable	[null]	TRUE	[null], 45, 56, etc, (0-90)	Value of dip.
FaultGen	FaultGeneration	50	String	variable	[null]	TRUE	[null] unspecified, unknown, early, late, Laramide, Neogene, 1, 2, 3, 4, etc.	Relative fault age based on meso/macroscopic relationships
FltSurface	FaultSurface	20	String	variable	[null]	TRUE	unspecified, unknown, gouge, slickensides, pseudotachylite, hackle marks, rib marks	Type of surface measured.
Thickness	"		Single	variable	[null]	TRUE	[thickness]	Thickness of gouge/ fault zone.
ThickUnits	"	8	String	CVD fixed LengthUnits	[null]	TRUE	meters, cm, mm, feet, inches	Units of thickness.
FGDC_line	"	16	String	CVD variable FGDC_FaultLinear	[null]	TRUE	30.3.12	FGDC geologic symbol reference number.
FltLnType	**FaultLineType**	16	String	CVD fixed	[null]	TRUE	slickenline, ext-lineation	Type of linear fault fabric element.
FltLnSub	FaultLineSubType	16	String	CVD variable	[null]	TRUE	unspecified, Slickenlines: scratch-gouge, ridge-groove, slickenfibers Extension lineations: L1, L2, L3, L4 etc.	Subtype of linear fault fabric element of specified type.
Trend	"		Short Integer	range 0-360	[null]	TRUE	[null], 345	Trend of slickenlines.
Plunge	"		Short Integer	range 0-90	[null]	TRUE	[null], 45	Plunge of slickenlines.
Rake	"		Short Integer	range 0-180	[null]	TRUE	45, 123; (0-180)	Rake of slickenlines from strike azimuth (right-hand rule).
DipSeparat	DipSeparation		Single	variable	[null]	TRUE	34.3	Stratigraphic separation down dip.
StrikeSep	StrikeSeparation		Single	variable	[null]	TRUE	24.7	Stratigraphic separation along strike.
SepUnits	SeparationUnits	16	String	CVD fixed LengthUnits	[null]	TRUE	[null] unspecified, km, meters, cm, mm, miles, feet, inches	Units of separation.
MeasMethod	MeasurementMethod	50	String	CVD fixed	[null]	TRUE	unspecified, measured, compass sight, visual average, compiled, photo interp	Method of measurement.
LocAccType	LocAccuracyType	50	String	variable	[null]	TRUE	precision gps, handheld gps, good topo, poor topo, planimetric, survey, map and compass, triangulation, distinctive feature	Accuracy of position.
LocAccMeas	LocAccuracyMeasure	16	String	variable	[null]	TRUE	EPE(m), PDOP	Criteria for deteriming accuracy of position.
LocAccVal	LocAccuracyValue		Single	variable	[null]	TRUE	15	Numeric measurement of locataion accuracy
DsplyScale	DisplayScale		Long Integer	CVD fixed	24000	TRUE	0, 24000, 50000, 12000, 6000, 100000, 250000,500000, 1000000	Denominator of display scale: display feature at scales larger than number specified (=< denominator). Zero indicates data that should never be displayed.
SourceID	"	128	String	variable	[null]		unknown; unspecified; Smith, 2006b [variable]	Feature level metadata (who mapped this); related to bibliographic detail
Comments	"	255	String	variable	[null]	TRUE	description	Comments about this particular feature.

Fault_line

This feature class represents mapped faults, joints, and shear zones (measured fault orientations are in fault_point). Fault data such as measurements of fault planes and slickenlines are recorded as point data in fault_point which, for mapped faults, lie along these lines. Fault annotation can be handled by fault_point. Particularly good and/or important exposures of faults could be recorded as point data in Feature_point and assigned a special symbol along the fault. Node order for faults should be set such that the right side of the fault is down for every fault type (except purely strike-slip faults).

Field Name	Field Alias	Length (text fields)	Field Type	Field Value	Default	Allow Nulls?	Attributes / Examples	Description / Notes
FGDC_code	"	16	String	CVD variable	[null]	TRUE	30.3.12	FGDC geologic symbol reference number.
LineClass	"	50	String	CVD variable	fault	FALSE	[illegible]	Class of linear fault element.
IDmethod	"	50	String	CVD variable	field evidence	TRUE	unspecified, field, photo, vegetation, subsurface, aeromag, gravity, seismic, analytical, lidar, remote sensing, etc.	The basis for identification of this feature.
Confidence	"	16	String	CVD fixed	certain	TRUE	unspecified, certain, probable, uncertain	Confidence regarding the existence/identification and position of this feature.
Exposure	"	16	String	CVD fixed	[null]	TRUE	unspecified, exposed, obscured, concealed	Exposure of the feature at the surface.
FaultType	"	16	String	CVD fixed	[null]	TRUE	[illegible]	[illegible]
SlipSense	"	16	String	CVD fixed	[null]	TRUE	[illegible]	[illegible]
SubSlipSns	SubSlipSense	16	String	CVD fixed	[null]	TRUE	[illegible]	Subordinate slip sense (see above)
SlipBasis	"	128	String	CVD variable	[null]	TRUE	[illegible]	Basis for determination of dominant slip sense.
SlipRate	"		Single	variable	[null]	TRUE	10	[illegible]
SlipUnits	"	16	String	variable	[null]	TRUE	mm/yr	Units of slip rate
Width	"		Single	variable	[null]	TRUE	[illegible]	[illegible]
WidthUnits	"	16	String	CVD fixed	[null]	TRUE	[illegible]	[illegible]
StrikeSep	StrikeSeparation		Single	variable	[null]	TRUE	24.7	[illegible]
DipSeparat	DipSeparation		Single	variable	[null]	TRUE	34.3	[illegible]
SepUnits	SeparationUnits	16	String	CVD fixed LengthUnits	[null]	TRUE	[illegible]	Units of separation.
FltDipDir	FaultDip		Short Integer	variable	[null]	TRUE	[illegible]	General Dip direction of fault segment.
DipDirEst	[illegible]		Short Integer	variable	[null]	TRUE	[illegible]	[illegible]
Ancestry	"	128	String	variable	[null]	TRUE	[illegible]	Ancestry of reactivated fault.
LastActive	"	128	String	variable	[null]	TRUE	Pleistocene	most recent movement
DsplyScale	DisplayScale		Long Integer	CVD fixed	24000	TRUE	0, 24000, 50000, 12000, 6000, 100000, 250000,500000, 1000000	Denominator of display scale: display feature at scales larger than number specified (=< denominator). Zero indicates data that should never be displayed.
SourceID	"	128	String	variable	[null]	TRUE	"Smith, 1999a"	Feature level metadata (who mapped this)
Comments	"	255	String	variable	[null]	TRUE	[illegible]	Comments about this particular feature.

Feature Class: Lith_poly

This feature class represents geologic units, water, or anthropogenic deposits (built from contacts and faults) that occupy mappable areas. These polygons are built from contacts. Detailed information about each unit is provided via a link based on the GeoID field to a lithology table.

Field Name	Field Alias	Length (text fields)	Field Type	Field Value	Default	Allow Nulls?	Attributes / Examples	Description / Notes
FGDC_code	"	16	String	CVD variable	[null]	TRUE	30.3.12	FGDC geologic symbol reference number.
GeoID	"	16	String	variable	undefined	FALSE	Tb, QTa	[illegible]
Modified	"	24	String	CVD variable	[null]	TRUE	[illegible]	[illegible]
Lean	"	16	String	variable	[null]	TRUE	Tb, QTa?	Includes queries
Confidence	"	16	String	CVD fixed	certain	TRUE	unspecified, certain, probable, uncertain	confidence regarding feature level ID
LithIDbasis	LithIDbasis	128	String	CVD variable	exposed	TRUE	[illegible]	Basis for identification of lithologic unit.
General_ID	Generalized_ID	16	String	variable	[null]	TRUE	QaT	How to Generalize this polygon.
SourceID	"	128	String	variable	[null]	TRUE	unknown; unspecified; Smith, 2006b [variable]	Feature level metadata (who mapped this); related to bibliographic detail
Description	"	255	String	variable	[null]	TRUE	Description of unit in area of polygon (feature level)	[illegible]

Lith_Contacts

This feature class represents contacts between geologic units which may be either lithostratigraphic (stratiform) and lithodemic (do not conform to law of superposition). LithContacts are used to build polygons (Geo_poly) and are topologically related to these polygons. Concealed, surficial, and overlay contacts are handled elsewhere. Fault contacts that affect topology are copied here (from Fault_line) since they bound geologic units. Faults that do not completely cut polygons (dangles) are not copied to eliminate topology errors. Also, no attributes besides LineClass, Exposure, and Confidence are copied with these faults. Polygons should only be constructed from the Lith_Contacts feature class when all topology errors have been fixed. Particularly good and/or important exposures of contact relations should be recorded as point data in Feature_point and assigned a special symbol along the contact.

Field Name	Field Alias	Length (text fields)	Field Type	Field Value	Default	Allow Nulls?	Attributes / Examples	Description / Notes
FGDC_code	"	16	String	CVD variable	[null]	TRUE	30.3.12	FGDC geologic symbol reference number.
LineClass	**LineClass**	50	String	CVD fixed ContactClass	contact	FALSE	contact, fault, intrusive, gradational, mass wasting, map-boundary, shoreline, intra-unit	Basic class of contact.
IDmethod	"	50	String	CVD variable	field evidence	TRUE	unspecified, field, photo, vegetation, subsurface, aeromag, gravity, seismic, analytical, lidar, remote sensing, etc.	The basis for identification of this feature.
Confidence	"	16	String	CVD fixed	certain	TRUE	unspecified, certain, probable, uncertain	Confidence regarding the existence/identification and position of this feature.
Exposure	"	16	String	CVD fixed	[null]	TRUE	unspecified, exposed, obscured	Exposure of this feature at the surface.
CtType	ContactType	50	String	CVD variable	[null]	TRUE	contact: unspecified, conformity, paraconformity, disconformity, nonconformity, angular unconformity,; fault: [null]; intrusive: [null], dike; gradational: conformity, extent; mass wasting: landslide, slump, debris flow; intra-unit: flow boundary, distinctive bed, etc.	Type of basic contact (fault contacts are null because they are described in detail elsewhere).
CtGeometry	ContactGeometry	50	String	CVD variable	[null]	TRUE	unspecified, inclined, horizontal, vertical, curvilinear, intertonguing, buttress, wavy, irregular	Geometry of contact.
CtNature	ContactNature	50	String	CVD variable	[null]	TRUE	unspecified, sharp, gradational-gradual, gradational-intercalated, soil, stylolites, drapes paleotopography, chilled margin, intermingled, indistinct, etc.	Nature of contact..
Name	"	50	String	variable	[null]	TRUE	great unconformity, K-T boundary, etc	Feature name (will generally be NULL)
DsplyScale	DisplayScale		Long Integer	CVD fixed	24000	TRUE	0, 24000, 50000, 12000, 6000, 100000, 250000,500000, 1000000	Denominator of display scale: display feature at scales larger than number specified (=< denominator). Zero indicates data that should never be displayed.
SourceID	"	128	String	variable	[null]	TRUE	"Smith, 1999a"	Feature level metadata (who mapped this)
Comments	"	255	String	variable	[null]	TRUE	Free text e.g. identified from detailed stereo photos	Comments about this particular feature.

Concealed_Contacts

This feature class records contacts concealed for some distance by alluvium or other cover. These lines bound subcrop polygons (Subcrop_poly) and might be combined later with other lines and with Subcrop_poly to make a derivative bedrock map.

Field Name	Field Alias	Length (text fields)	Field Type	Field Value	Default	Allow Nulls?	Attributes / Examples	Description / Notes
FGDC_code	"	16	String	CVD variable	[null]	TRUE	30.3.12	FGDC geologic symbol reference number.
LineClass	**LineClass**	24	String	CVD fixed	contact	FALSE	contact, fault intrusive, gradational, mass [illegible]	Basic class of contact.
IDmethod	"	50	String	CVD variable	field evidence	TRUE	[illegible]	The basis for identification of this feature.
Confidence	"	16	String	CVD fixed	certain	TRUE	unspecified, certain, probable, uncertain	Confidence regarding the existence/identification and position of this feature.
CtType	ContactType	50	String	CVD variable	[null]	TRUE	[illegible]	Type of basic contact (fault contacts are null because they are described in detail elsewhere).
CtGeometry	ContactGeometry	50	String	CVD variable	[null]	TRUE	[illegible]	Geometry of contact.
CtNature	ContactNature	50	String	CVD variable	[null]	TRUE	[illegible]	Nature of contact..
Name	"	50	String	variable	[null]	TRUE	great unconformity, K-T boundary, etc	Feature name (will generally be NULL)
DsplyScale	DisplayScale		Long Integer	CVD fixed	24000	TRUE	0, 24000, 50000, 12000, 6000, 100000, 250000,500000, 1000000	Denominator of display scale: display feature at scales larger than number specified (=< denominator). Zero indicates data that should never be displayed.
SourceID	"	128	String	variable	[null]	TRUE	"Smith, 1999a"	Feature level metadata (who mapped this)
Comments	"	255	String	variable	[null]	TRUE	Free text	Comments about this particular feature.

Feature Class: Feature_point

This feature class represents point locations of distinct physical or geologic features of interest that are neither linear or planar such as fumaroles, fossil localities, volcanic vents, springs and the like or locations of key outcrops/good exposures. Extensive datasets collected regarding these features should be linked to this table via Feature_ID.

Field Name	Field Alias	Length (text fields)	Field Type	Field Value	Default	Allow Nulls?	Attributes / Examples	Description / Notes
FGDC_code	"	16	String	CVD variable	[null]	TRUE	30.3.12	FGDC geologic symbol reference number.
Feature_ID	"	50	String	variable	[null]	TRUE	[illegible]	[illegible]
Name	"	50	String	variable	[null]	TRUE	[illegible]	[illegible]
LargeFeatr	LargeFeature	50	String	variable	[null]	TRUE	[illegible]	[illegible]
FeatrClass	FeatureClass	50	String	CVD variable FeaturePointClass	unspecified	FALSE	[illegible]	Class of feature
FeatrType	FeatureType	50	String	CVD variable	[null]	TRUE	[illegible]	Type of feature of specified class.
FeatrSubTyp	FeatureSubType	50	String	CVD variable	[null]	TRUE	[illegible]	Subtype of feature of specified type.
LocAccType	LocAccuracyType	50	String	variable	[null]	TRUE	[illegible]	Accuracy of position.
LocAccMeas	LocAccuracyMeasure	16	String	variable	[null]	TRUE	EPE(m), PDOP	Criteria for determining accuracy of position.
LocAccVal	LocAccuracyValue		Single	variable	[null]	TRUE	15	Numeric measurement of location accuracy
RotAngle	RotationAngle		Short Integer	variable	[null]	TRUE	45, 278	Symbol rotation
DsplyScale	DisplayScale		Long Integer	CVD fixed	24000	TRUE	0, 24000, 50000, 12000, 6000, 100000, 250000,500000, 1000000	Denominator of display scale: display feature at scales larger than number specified (=< denominator). Zero indicates data that should never be displayed.
SourceID	"	128	String	variable	[null]	TRUE	"Smith, 1999a"	Feature level metadata (who mapped this)
Comments	"	255	String	variable	[null]	TRUE	description	Comments about this particular feature.

Feature_line

This feature class represents linear features like dikes, marker beds, or dikes that do not have sufficient area to be mapped as polygons. Features that are not linear and don't occupy enough area to be mapped as polygons can be recorded as Feature_points.

Field Name	Field Alias	Length (text fields)	Field Type	Field Value	Default	Allow Nulls?	Attributes / Examples	Description / Notes
FGDC_code	"	16	String	CVD variable	[null]	TRUE	30.3.12	FGDC geologic symbol reference number.
LineClass	"	50	String	CVD variable	unspecified	FALSE	[illegible]	Class of mappable linear feature.
GeoID	"	16	String	variable	undefined	FALSE	[illegible]	[illegible]
Lean	"	16	String	variable	[null]	TRUE	Tb, Tf?, etc.	Includes queries
IDmethod	"	50	String	CVD variable	field evidence	TRUE	[illegible]	The basis for identification of this feature.
Confidence	"	16	String	CVD fixed	certain	TRUE	unspecified, certain, probable, uncertain	Confidence regarding the existence/identification and position of this feature.
Exposure	"	16	String	CVD fixed	[null]	TRUE	[illegible]	Exposure of the feature at the surface.
LineType	"	50	String	CVD variable	[null]	TRUE	[illegible]	Type of linear feature of specified class.
LineSubType	"	50	String	CVD variable	[null]	TRUE	[illegible]	Subtype of linear feature of specified type.
Trend	"		Short Integer	variable	[null]	TRUE	[illegible]	[illegible]
Younging	"	16	String	CVD fixed	[null]	TRUE	[illegible]	Determination of younging "vector".
YoungCrit	YoungingCriteria	16	String	CVD fixed	[null]	TRUE	[illegible]	Younging criteria used.
Thickness	"		Single	variable	[null]	TRUE	[illegible]	Thickness or width of feature where important.
ThickUnits	"	8	String	CVD fixed LengthUnits	[null]	TRUE	[illegible]	Units of thickness.
DsplyScale	DisplayScale		Long Integer	CVD fixed	24000	TRUE	[illegible]	[illegible]
SourceID	"	128	String	variable	[null]	TRUE	"Smith, 1999a"	Feature level metadata (who mapped this)
Comments	"	255	String	variable	[null]	TRUE	[illegible]	Comments about this particular feature.

Feature Class: Fold_point

This feature class represents fold data measured at a point. Folds can be map-scale (macroscopic folds) or might range from small parasitic folds or outcrop-scale folds. Only the subset of point data representing mapped folds will lie on mapped fold_lines and should have **MappedFeat = 'yes'**, while exceptions to topology rule should have **MappedFeat ='no'**. Axial traces and other linear map elements describing folds are recorded in Fold_lines to allow better cartographic control.

Field Name	Field Alias	Length (text fields)	Field Type	Field Value	Default	Allow Nulls?	Attributes / Examples	Description / Notes
FGDC_plane	"	16	String	CVD variable FGDC_FoldPlanar	[null]	TRUE	30.3.12	FGDC geologic symbol reference number.
StationID	"	50	String	variable	[null]	TRUE	[null], to link to notes, photos, etc.	Station ID (if specified)
MappedFeat	**MappedFeature**		Short Integer	boolean	0 (FALSE)	FALSE	1=yes/TRUE (on Fold_line) 0=no/FALSE (minor structure not on Fold_line)	Is fold related to a mapped Fold_line?: Requires defininition query: for a minor fold symbology changes (strike line is removed).
Geometry	"	24	String	CVD fixed FoldGeometry	unspecified	FALSE	unspecified, anticline, syncline, monocline, antiform, synform, synformal anticline, antiformal syncline	Fold geometry; (this mixes younging with geometry, but is simpler than having a field for shape and one for younging because having "synformal syncline" on a map legend seems like overkill).
Attitude	"	20	String	CVD fixed FoldAttitude	[null]	TRUE	unspecified, unknown, upright-horizontal, upright-plunging, inclined-horizontal, inclined-plunging, reclined, recumbent,	Fold attitude defined by plunge of the hinge and the dip of the axial surface.
DefmEnv	DeformationEnv	16	String	CVD fixed	[null]	TRUE	[null] unspecified, unknown, upper-crustal, ductile, rheomorphic, soft-sed, migmatitic	Deformation environment for fold genesis.
FoldGen	FoldGeneration	16	String	CVD fixed	[null]	TRUE	[null] unspecified, unknown, F1, F2, F3, F4	Fold generation based on fold/fabric relationships (ductile)
FoldStyle	"	24	String	CVD fixed	[null]	TRUE	unspecified, 1A, 1B (parallel), 1C, 2 (similar), 3; chevron, fault-bend, kink, acute, gentle, open, close, tight, isoclinal, obtuse, disharmonic, cylindrical, non-cylindrical, conical	Fold style based on various fold classification schemes.
MapAsymm	MapAsymmetry	16	String	CVD fixed FoldMapAsymmetry	[null]	TRUE	hinge, sinistral, dextral, M-fold, Z-fold, S-fold	Map view asymmetry of fold
APstrike	AxialPlaneStrike		Short Integer	variable	[null]	TRUE	[null], 256 (right hand rule azimuth of strike of axial plane)	Axial Plane Strike
APdipDir	APdipDirection		Short Integer	variable	[null]	TRUE	[null], 166	Axial Plane dip direction
APdip	AxialPlaneDip		Short Integer	variable	[null]	TRUE	[null], 45	Axial Plane dip
Facing	"	16	String	CVD fixed FoldFacing	[null]	TRUE	unspecified, unknown, upward, downward, see-vergence	Facing where known (direction towards stratigraphically younger rocks from fold hinge). See-vergence for inclined folds.
YoungCrit	YoungingCriteria	16	String	CVD fixed	[null]	TRUE	unspecified, graded beds, cross beds, strat relations, etc.	Younging criteria used.
Vergence	"	16	String	CVD fixed OctantDirections	[null]	TRUE	N,NE,E,SE,S,SW,W,NW	Vergence of fold (the orientation of the younging "vector" when it is not vertical).
FGDC_line	"	16	String	CVD variable FGDC_FoldLinear	[null]	TRUE	30.3.12	FGDC geologic symbol reference number.
FldAxisTrd	FoldAxisTrend		Short Integer	variable	[null]	TRUE	[null], 166	Fold axis trend.
FldAxisPlg	FoldAxisPlunge		Short Integer	variable	[null]	TRUE	[null], 45	Fold axis plunge.
MeasMethod	MeasurementMethod	50	String	CVD fixed	[null]	TRUE	unspecified, measured, compass sight, visual average, compiled, photo interp	Method of measurement.
LocAccType	LocAccuracyType	50	String	variable	[null]	TRUE	precision gps, handheld gps, good topo, poor topo, planimetric, survey, map and compass, triangulation, distinctive feature	Accuracy of position.
LocAccMeas	LocAccuracyMeasure	16	String	variable	[null]	TRUE	EPE(m), PDOP	Criteria for deterimining accuracy of position.
LocAccVal	LocAccuracyValue		Single	variable	[null]	TRUE	15	Numeric measurement of locataion accuracy
DsplyScale	DisplayScale		Long Integer	CVD fixed	24000	TRUE	0, 24000, 50000, 12000, 6000, 100000, 250000,500000, 1000000	Denominator of display scale: display feature at scales larger than number specified (=< denominator). Zero indicates data that should never be displayed.
SourceID	"	128	String	variable	[null]		unknown; unspecified; Smith, 2006b [variable]	Feature level metadata (who mapped this); related to bibliographic detail
Comments	"	255	String	variable	[null]	TRUE	description	Comments about this particular feature.

Fold_line

This feature class represents mapped folds. Measured fold data is recorded as point data in fold_point which lie along these lines. Definition queries will be required to split out the FoldClass attributes since ArcGIS can only symbolize on permutations of 3 attributes.

Field Name	Field Alias	Length (text fields)	Field Type	Field Value	Default	Allow Nulls?	Attributes / Examples	Description / Notes
FGDC_code	"	16	String	CVD variable	[null]	TRUE	30.3.12	FGDC geologic symbol reference number.
Geometry	"	24	String	CVD fixed FoldGeometry	unspecified	FALSE	[illegible]	[illegible]
Confidence	"	16	String	CVD fixed	certain	TRUE	unspecified, certain, probable, uncertain	Confidence regarding the existence/identification and position of this feature.
Exposure	"	16	String	CVD fixed	[null]	TRUE	unspecified, exposed, obscured, concealed	Exposure of the feature at the surface.
FoldLnType	FoldLineType	16	String	CVD fixed	[null]	TRUE	[illegible]	Fold line.
Attitude	"	20	String	CVD fixed	[null]	TRUE	[illegible]	Fold attitude defined by plunge of the hinge and the dip of the axial surface.
ShowPlunge	"		Short Integer	CVD fixed	[null]	TRUE	[null], 1 (single), 2 (double)	Specifies if plunge arrows should be drawn, for 1 (single arrow), the line may need to be flipped for correct display.
FoldGen	FoldGeneration	16	String	CVD fixed	[null]	TRUE	[null] unspecified, unknown, F1, F2, F3, F4	Would be basis for symbology for superposed folds
TypeEvidnc	TypeEvidence	20	String	CVD fixed FoldTypeEvidence	[null]	TRUE	[illegible]	Geologic evidence used to determine fold type.
MapAsymm	MapAsymmetry	16	String	CVD fixed FoldMapAsymmetry	[null]	TRUE	[illegible]	Map view asymmetry of fold
FoldStyle	"	24	String	CVD fixed	[null]	TRUE	[illegible]	Fold style based on various fold classification schemes.
Facing	"	16	String	CVD fixed FoldFacing	[null]	TRUE	[illegible]	[illegible]
YoungCrit	YoungingCriteria	16	String	CVD fixed	[null]	TRUE	[illegible]	Younging criteria used.
Vergence	"	16	String	CVD fixed OctantDirections	[null]	TRUE	N,NE,E,SE,S,SW,W,NW	Vergence of fold (the orientation of the younging "vector" when it is not vertical).
Rank	"	50	String	CVD fixed	[null]	TRUE	[illegible]	Fold name (where named).
StrucRel	StructuralRelief		Single	variable	[null]	TRUE	[illegible]	Structural relief of the amplitude of the fold.
Units	"	16	String	CVD fixed LengthUnits	[null]	TRUE	[illegible]	Units of structural relief.
DsplyScale	DisplayScale		Long Integer	CVD fixed	24000	TRUE	0, 24000, 50000, 12000, 6000, 100000, 250000,500000, 1000000	Denominator of display scale: display feature at scales larger than number specified (=< denominator). Zero indicates data that should never be displayed.
SourceID	"	128	String	variable	[null]	TRUE	"Smith, 1999a"	Feature level metadata (who mapped this)
Comments	"	255	String	variable	[null]	TRUE	[illegible]	Comments about this particular feature.

Feature Class: Data_point

This feature class records the location of samples or non-oriented point data that are not uniquely mappable (such as field collected provenance, gradation, or paleocurrent directions). Extensive data related to points should be recorded in other tables or related tables. [illegible]

Field Name	Field Alias	Length (text fields)	Field Type	Field Value	Default	Allow Nulls?	Attributes / Examples	Description / Notes
FGDC_code	"	16	String	CVD variable	[null]	TRUE	30.3.12	FGDC geologic symbol reference number.
StationID	"	50	String	variable	[null]	FALSE	606-44	Station ID to link to notes, photos, etc.
StationClass	StationClass	16	String	CVD fixed	sample location	FALSE	[sample] location, [station] location, [measurement] location	Main purpose of recording information
StationType	StationType	50	String	CVD variable	[null]	TRUE	[illegible]	Type of recorded information of specified class.
SampleID	"	50	String	variable	[null]	TRUE	[null], 606-05-99	[illegible]
PhotoID	"	50	String	variable	[null]	TRUE	[null], frame 25	linked to image table
LargerFtr	LargerFeature	50	String	variable	[null]	TRUE	[illegible]	[illegible]
LocAccType	LocAccuracyType	50	String	variable	[null]	TRUE	[illegible]	Accuracy of position.
LocAccMeas	LocAccuracyMeasure	16	String	variable	[null]	TRUE	EPE(m), PDOP	Criteria for determining accuracy of position.
LocAccVal	LocAccuracyValue		Single	variable	[null]	TRUE	15	Numeric measurement of location accuracy
DsplyScale	DisplayScale		Long Integer	CVD fixed	24000	TRUE	0, 24000, 50000, 12000, 6000, 100000, 250000,500000, 1000000	Denominator of display scale: display feature at scales larger than number specified (=< denominator). Zero indicates data that should never be displayed.
SourceID	"	128	String	variable	[null]	TRUE	unknown; unspecified; Smith, 2006b [variable]	Feature level metadata (who mapped this); related to bibliographic detail
Comments	"	255	String	variable	[null]	TRUE	description	Comments about this particular feature.

Table Name: Lithology

This table is used to link detailed information about mapped lithostratigraphic and lithodemic geologic units to Lith_poly and Subcrop_poly. The one-to-many relationship is based on the GeolID field. The attributes within this table apply to all areas within a given map extent with matching GeoIDs.

Field Name	Field Alias	Length (text fields)	Field Type	Field Value	Default	Allow Nulls?	Attributes / Examples	Description / Notes
GeoID	"	16	String	variable	undefined	FALSE	IPm	basis of relationship with Lith_poly and Subcrop_poly
Name	"	128	String	variable	[null]	TRUE	Madera Group undifferentiated	Name of lithologic unit.
LithClass	"	50	String	CVD fixed	[null]	TRUE	sedimentary, intrusive, volcanic, metamorphic, anthropogenic, water	Class of lithologic unit
LithType	"	50	String	CVD variable	[null]	TRUE	**Sedimentary:** siliciclastic, mixed, nonsiliciclastic **Volcanic:** lava flow, dome, ash, volcaniclastic **Intrusive:** plutonic, hypabyssal, dike, sill **Metamorphic:** metasedimentary, metavolcanic, metaplutonic, unknown protolith **Anthropogenic:** disturbed land, artificial fill, tailings, dump	Type of unit of specified class
IgneousCmp	IgneousComposition	50	String	CVD variable	[null]	TRUE	unknown, leucocratic, silicic, felsic, intermediate, mafic, ultramafic, [other - specify]	Igneous composition (if applicable)
MMfacies	MetamorphicFacies	50	String	CVD fixed	[null]	TRUE	unknown, zeolite, prehnite-pumpellyite, greenschist, amphibolite, granulite, blueschist, eclogite, hornfels, sanidinite	Metatmorphic facies (if applicable)
Mineralogy	"	255	String	variable	[null]	TRUE	*mineral assemblage*: e.g. Bt+Qtz+Kspar+musc; Cc; etc.	Mineralogy (if applicable)
PrimLith	PrimaryLithology	128	String	variable	[null]	TRUE	sand, gravel, limestone, rhyolite, granite, diorite, amphibolite, schist, gneiss, mudstone, shale, sandstone etc. Could use defined ontologies like NGMDB vocabularies.	Primary lithology
SecondLith	SecondaryLithology	128	String	variable	[null]	TRUE	minor- sand, gravel, limestone, rhyolite, granite, diorite, amphibolite, mudstone, shale, sandstone etc. Could use defined ontologies like NGMDB vocabularies.	Secondary lithology
ShortDesc	ShortUnitDescription	255	String	variable	[null]	TRUE	Concise unit description.	Description of the unit throughout the map area.
UnitDesc	UnitDescription	65535	TEXT	variable	[null]	TRUE	Unit description	Description of the unit throughout the map area.
Texture	"	255	String	CVD variable	[null]	TRUE	angular, subangular, subrounded, rounded, well-rounded, clastic, glassy, ahphanitic, phaneritic, porphyritic, megacrystic, brecciated, mylonitic, etc.	Provenance of unit
Color	"	255	String	variable	[null]	TRUE	Munsell(?) color	Color of unit.
GrainSize	"	255	String	variable	[null]	TRUE	grain size: coarse, medium, fine, silt, clay, [or numeric: e.g. 1m clasts]	Grainsize of unit.
Sorting	"	255	String	variable	[null]	TRUE	well, moderate, poor, bimodal	Degree of sorting of grains.
Cemntation	Cementation	255	String	variable	[null]	TRUE	unspecified, none, silica, calcite, hematite, zeolite, etc.	Cementation of unit.
Induration	"	255	String	CVD variable	[null]	TRUE	unspecified, well, moderate, poor, unconsolidated	Induration of unit.
Bedding	"	255	String	variable	[null]	TRUE	unspecified, massive, tabular, lenticular, thick, thin, cross bedded, etc.	Description of bedding
BedThkness	BedThickness		Double	variable	[null]	TRUE	e.g. 4	Typical thickness of bedding. Specify units in ThickUnits
Protolith	"	255	String	variable	[null]	TRUE	unspecified, pelite, sandstone, basalt, etc.	Induration of unit.
Provenance	"	255	String	variable	[null]	TRUE	westerly, easterly,northerly,southerly, San Juan Mts	Provenance of unit.
GenEnvrnmt	GeneticEnvironment	255	String	variable	[null]	TRUE	unspecified, alluvial, colluvial, fluvial, glacial eolian, lacustrine, deltaic, marine, mass wasting, upper crust, middle crust, mantle, etc.	Genetic Environment that produced unit.
GenLndform	GeneticLandform	255	String	variable	[null]	TRUE	unspecified, delta, point bar, dune, reef, piedmont, debris flow, alluvial slope, reef, delta, deep-marine, shallow-marine, near-shore, intertidal, etc.	Interpreted landform associated with depositional environment (if applicable).
DepoSyst	DepositionalSystem	255	String	variable	[null]	TRUE	unspecified, unknown, piedmont, axial-fluvial, transitional, lacustrine, eolian, debris flow, alluvial slope, reef, delta, deep-marine, shallow-marine, near shore, beach, etc.	Depositional system that produced unit (if applicable).
SuperGroup	"	128	String	variable	[null]	TRUE	If unit is part of a supergroup (e.g. Grand Canyon Super Group)	Supergroup rank (not used in NM yet)
GeoGroup	Group	128	String	variable	[null]	TRUE	Madera	Group rank ('Group' is a reserved DBMS word)
Formation	"	128	String	variable	[null]	TRUE	Los Moyos	Formation rank
Member	"	128	String	variable	[null]	TRUE	Wild Cow	Member rank
Lithosome	"	128	String	variable	[null]	TRUE	A	Lithosome ID
Eon	"	24	String	CVD fixed	[null]	TRUE	Phanerozoic, Proterozoic, Archean, Hadean	Geologic Eon of unit
Era	"	128	String	CVD fixed	[null]	TRUE	Cenozoic, Mesozoic, Paleozoic, Neoproterozoic, Mesoproterozoic, Paleoproterozoic, Neoarchean, Mesoarchean, Paleoarchean, Eoarchean	Geologic Era of unit
Period	"	128	String	CVD fixed	[null]	TRUE	Quaternary, Neogene, Paleogene, Tertairy, Cretaceous, Jurassic, Triassic, Permian, Carboniferous, Devonian, Silurian, Ordovician, Cambrian, etc.	Geologic Period of unit
Epoch	"	128	String	CVD fixed	[null]	TRUE	Holocen, Pleistocene, Pliocene, Miocene, Oligocene, Eocene, Paleocene, etc.	Geologic Epoch of unit
Age	"	128	String	variable	[null]	TRUE	e.g. Albian	Geolgic Age of unit
MaxAge	"	128	String	variable	[null]	TRUE	e.g. Aptian or numeric age	Maximum geolgic Age of unit
MinAge	"	128	String	variable	[null]	TRUE	e.g. Cenomanian or numeric age	Minimum geolgic Age of unit
AgeBasis	"	255	String	variable	[null]	TRUE	fossils, geochron, position, etc	Basis of age determination.
IsoDateID	"	128	String	variable	[null]	TRUE	sample info/link to best date data	Isotopic date ID (links to Date Detail)
UntThckMin	UnitThicknessMin		Double	variable	[null]	TRUE		Minimum thickness of unit
UntThckMax	UnitThicknessMax		Double	variable	[null]	TRUE		Maximum thickness of unit
UntThckTyp	UnitThicknessTypical		Double	variable	[null]	TRUE	e.g. 345	Typical thickness of unit
ThickUnits	ThicknessUnits	8	String	CVD fixed LengthUnits	[null]	TRUE	m, ft, etc.	Thickness unit of measure.
SourceID	"	128	String	variable	[null]		unknown; unspecified; Smith, 2006b [variable]. Specify when attributes like description need attribution.	Feature level metadata (who mapped this); related to bibliographic detail
Comments	"	255	String	variable	[null]	TRUE		Comments about this particular feature.

Table Name: Sources

This table records bibliographic data cited by the SourceID field in various other feature classes.

Field Name	Field Alias	Length (text fields)	Field Type	Field Value	Default	Allow Nulls?	Attributes / Examples	Description / Notes
SourceID	"	128	String	variable	[null]	TRUE	McIntosh et. al., 2005b	basis of relation from SourceID from other tables and feature classes
FirstAuthr	FirstAuthor	50	String	variable	[null]	TRUE	McIntosh W.C.	First Author
OtherAuthr	OtherAuthors	255	String	variable	[null]	TRUE	[illegible]	Other Authors (semicolon delimited)
Title	"	255	String	variable	[null]	TRUE	[illegible]	Title of work
PubDate	PublicationDate		Short Integer	variable	[null]	TRUE	[illegible]	Publication date
RevDate	RevisionDate		Date	variable	[null]	TRUE	[illegible]	Revision date
DocType	"	128	String	variable	[null]	TRUE	[illegible]	Document type
Format	"	128	String	variable	[null]	TRUE	[illegible]	Format reference was originally published
Publisher	"	128	String	variable	[null]	TRUE	NMBGMR, USGS, Elsevier, Geological Society of America, etc.	Publisher
Series	"	128	String	variable	[null]	TRUE	[illegible]	Series
Volume	"		Short Integer	variable	[null]	TRUE	[illegible]	Volume number
Subvolume	"	8	String	variable	[null]	TRUE	[illegible]	Sub volume number
Issue	"		Short Integer	variable	[null]	TRUE	[illegible]	Issue number
Scale	"		Integer	variable	[null]	TRUE	24000	Denominator of absolute scale of map reference
ISBN	"	16	String	variable	[null]	TRUE	[illegible]	ISBN number (books)
ISSN	"	16	String	variable	[null]	TRUE	[illegible]	ISSN number (journals)
DOI	"	128	String	variable	[null]	TRUE	[illegible]	DOI (Digital Object Identifier)
ResValue	ResolutionValue		Single	variable	[null]	TRUE	[illegible]	Raster resolution value
ResUnits	ResolutionUnits	16	String	variable	[null]	TRUE	[illegible]	Raster resolution units
Media	"	24	String	variable	[null]	TRUE	[illegible]	Media reference is stored on
LargerWork	"	255	String	variable	[null]	TRUE	[illegible]	Larger work the reference may be part of
Hotlink	"	128	String	variable	[null]	TRUE	[illegible]	link to source document (internet or intranet)
Conversion	"	255	String	variable	[null]	TRUE	[illegible]	Description of steps taken to digitize or convert this data.
Comments	"	255	String	variable	[null]	TRUE	[illegible]	Comments about this particular reference.

Table Name: Samples

This table is just an example of a generic sample analysis table that could be linked to Data_point. It is assumed that it will have a user defined structure and will relate to spatial entities in point feature classes via StationID.

Field Name	Field Alias	Length (text fields)	Field Type	Field Value	Default	Allow Nulls?	Attributes / Examples	Description / Notes
SampleID	"	50	String	variable	[null]	FALSE	606-99-123	Sample ID (links to Data_point)
LargerFtr	LargerFeature	50	String	variable	[null]	TRUE	[illegible]	[illegible]
ThinSect	ThinSection		Short Integer	boolean	0 (no)	FALSE	1=yes/TRUE, 0=no/FALSE	Thin section made ?
Geochem	"		Short Integer	boolean	0 (no)	FALSE	1=yes/TRUE, 0=no/FALSE	Geochem done?
Geochron	"		Short Integer	boolean	0 (no)	FALSE	1=yes/TRUE, 0=no/FALSE	Geochronology analysis done?
WholeRock	"		Short Integer	boolean	0 (no)	FALSE	1=yes/TRUE, 0=no/FALSE	Whole rock chemistry done?
Paleontology	Paleontology		Short Integer	boolean	0 (no)	FALSE	1=yes/TRUE, 0=no/FALSE	Paleontology done?
Pmag	"		Short Integer	boolean	0 (no)	FALSE	1=yes/TRUE, 0=no/FALSE	Paleomagnetic analysis done?
OtherAnlys	OtherAnalysis	16	String	variable	[null]	TRUE	[illegible]	Other analysis done
DataType	"	128	String	variable	[null]	TRUE	[illegible]	[illegible]
Data	"	10.6	Double	variable	[null]	TRUE	[illegible]	[illegible]
DataSubtyp	DataSubtype	128	String	variable	[null]	TRUE	[illegible]	[illegible]
SubData	"	12	String	variable	[null]	TRUE	[illegible]	[illegible]
DataAccur	DataAccuracy	12	String	variable	[null]	TRUE	[illegible]	accuracy of measurement
DataPrecis	DataPrecision	12	String	variable	[null]	TRUE	[illegible]	precision of measurement
DataConfid	DataConfidence	16	String	CVD fixed	[null]	TRUE	unspecified, certain, probable, uncertain	[illegible]
LocAccType	LocAccuracyType	50	String	variable	[null]	TRUE	[illegible]	Accuracy of position
LocAccMeas	LocAccuracyMeasure	16	String	variable	[null]	TRUE	EPE(m), PDOP	[illegible]
LocAccVal	LocAccuracyValue	8	Single	variable	[null]	TRUE	15	[illegible]
SourceID	"	128	String	variable	[null]	TRUE	unknown; unspecified; Smith, 2006b [variable]	Feature level metadata (who mapped this); related to bibliographic detail
Comments	"	255	String	variable	[null]	TRUE	[illegible]	Comments about this particular feature.