DIGITAL MAPPING TECHNIQUES 2019

The following was presented at DMT'19
(May 19 – 22, 2019 - Montana Technological University)

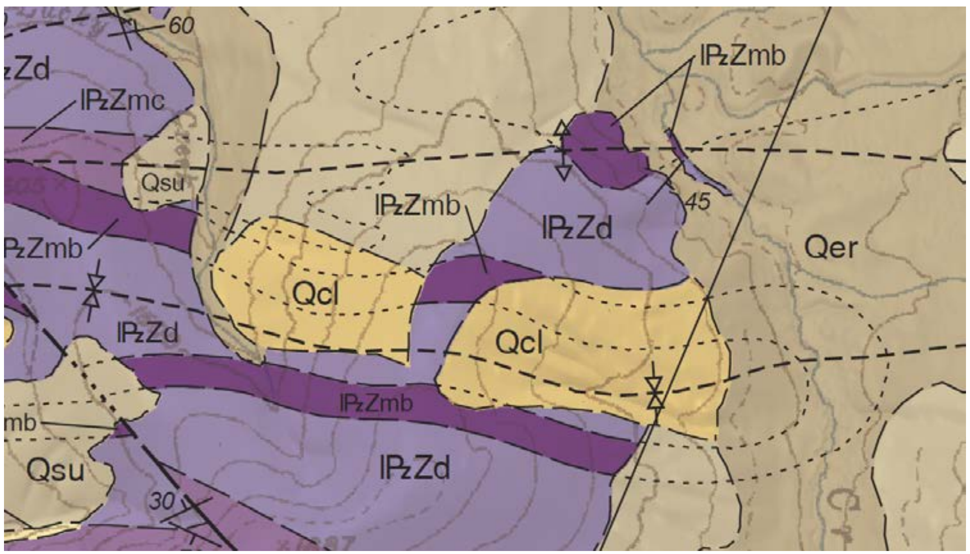
The contents of this document are provisional

See Presentations and Proceedings
from the DMT Meetings (1997-2019)

http://ngmdb.usgs.gov/info/dmt/

Supporting Multiple Planar Topologies in a GeMS Geodatabase

a baby step toward a true 3D data model?



Considerations in modeling a multi-layered geologic map

Digital Mapping Techniques Workshop
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Butte Montana

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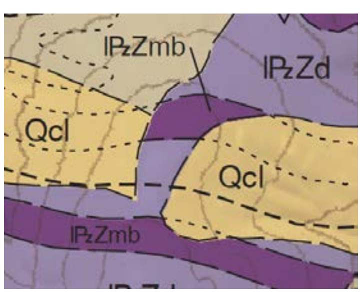
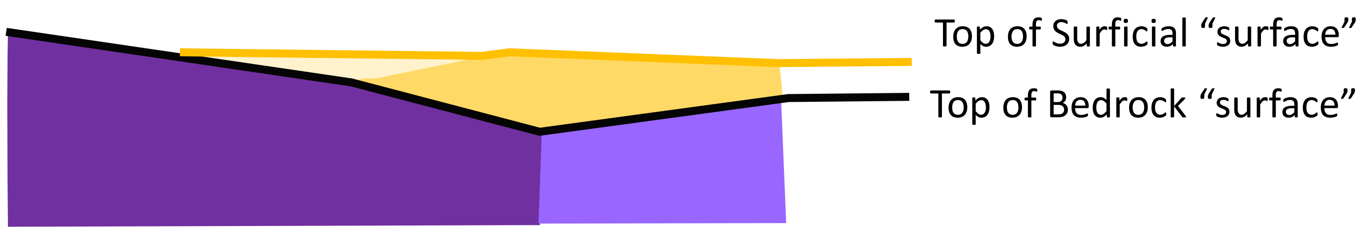
Supporting Multiple Planer Topologies in a GeMS Geodatabase

The existing GeMS schema assumes a single planar topology within the geodatabase. This single topology does not adequately model the inherent 3D nature of geologic reality, and if rigorously applied to a 2D map-centric geodatabase can introduce data gaps and confusion. One approach to this problem is to separate or identify bedrock and surficial data in such a way to allow for separate planar topologies, the extreme position is to create completely separate maps and databases. This simplistic and dualistic separation has its challenges and limitations in that: there are various ways to classify data as surficial or bedrock and there can be more than two levels, such as volcanic and modern glacial material on top of other surficial and or bedrock data. Given these complexity, this short presentation intends the explore the fundamental spatial and topologic relationships between various geologic material that is modeled on a flat map with the hopes that this can built upon to develop a geodatabase that better supports the inherent 3D nature of geologic reality.

Some Issues with a single layer conceptual model

- GeMs specifies that as part of the **Map Graphic** the requirement for *“map-unit polygons (that cover the mapped area without gaps or overlaps…”*
- This assumes a <u>single</u> conceptual planar surface, and as a result a single “Planar Topology” (*Note the importance of Planar*)
- Cartographically this can make sense, but breaks down when attempting to model robust geologic data that includes multiple layers, for example Bedrock and Surficial
- The Topologic Rule *Must not have overlaps* dictates that ‘known’ bedrock polygons under surficial polygons must be **deleted** to ensure a valid topology
- A human geologic map reader understands that the dashed hidden contacts indicates that the bedrock continues under the surficial unit (with some level of certainty). Database queries, however, will return nothing under the surficial data



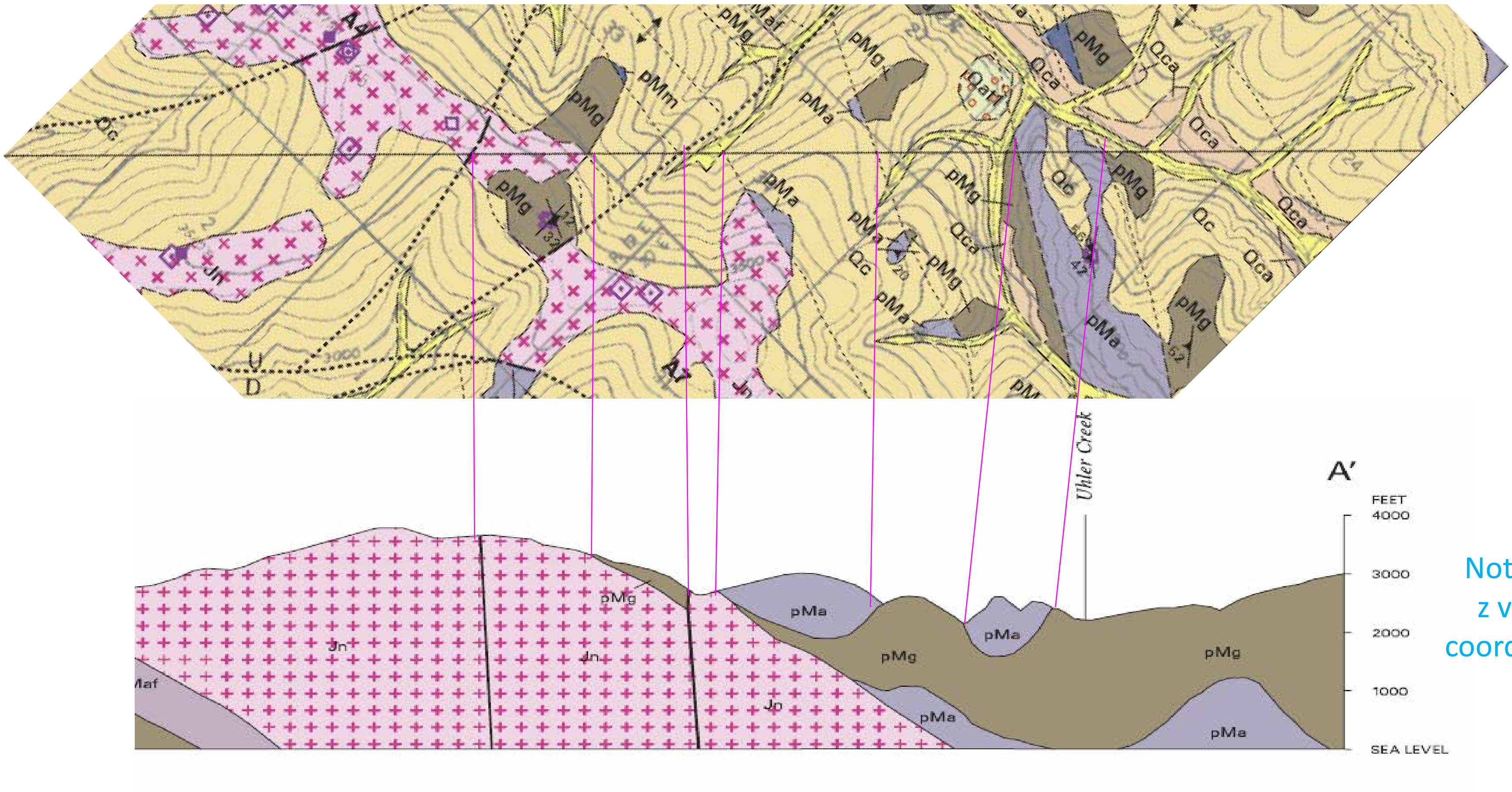


Interesting Observation from a combined map

The 2D Map Unit Bedrock polygons are removed when overlain by surficial units to ensure the Topologic Rule *Must not have overlaps* is not violated

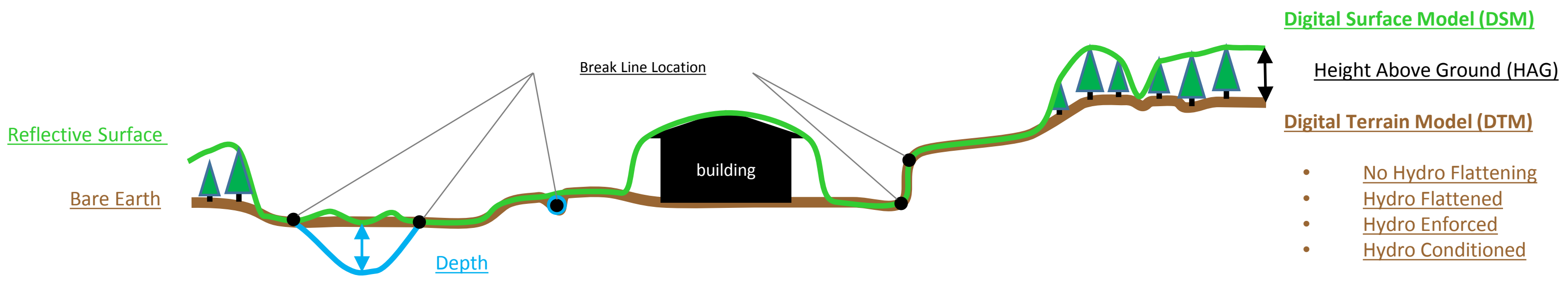
However, on the same map's cross section these units exist since surficial units are not shown

Geologic map of the Eagle A-2 Quadrangle, Alaska
http://dggs.alaska.gov/pubs/id/2669

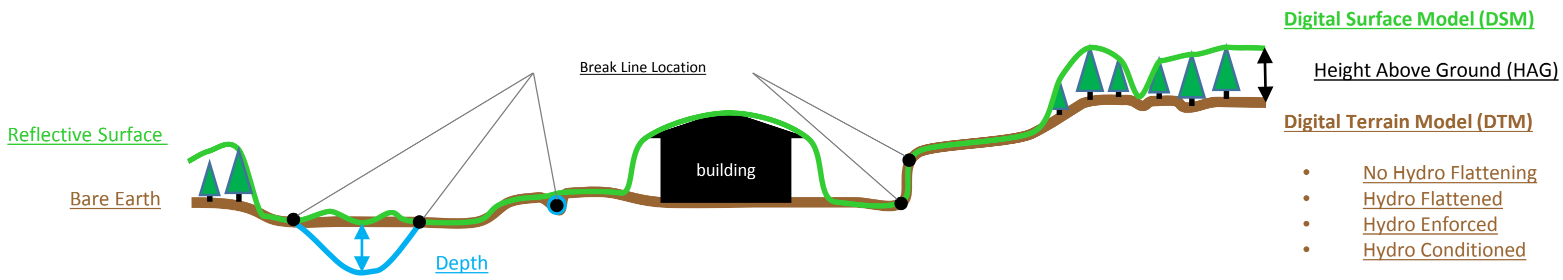


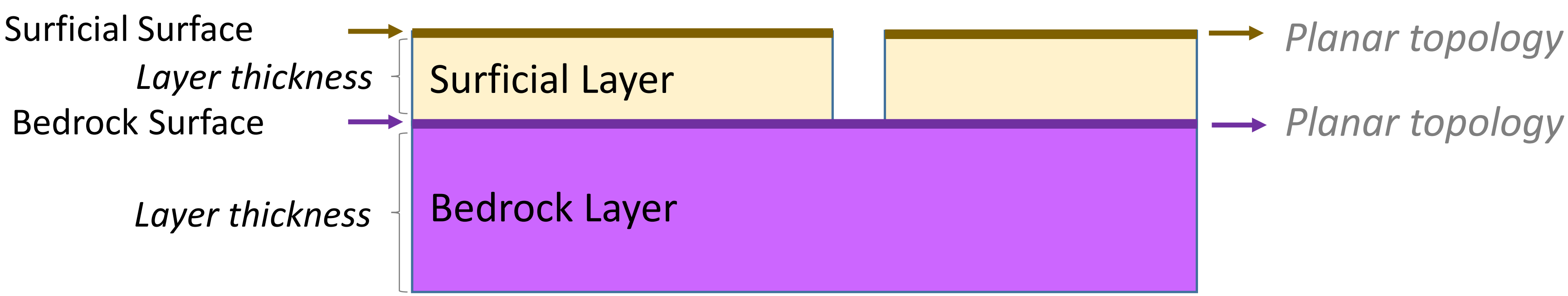
Note the z value coordinates

Elevation data as an example of modeling multiple surfaces



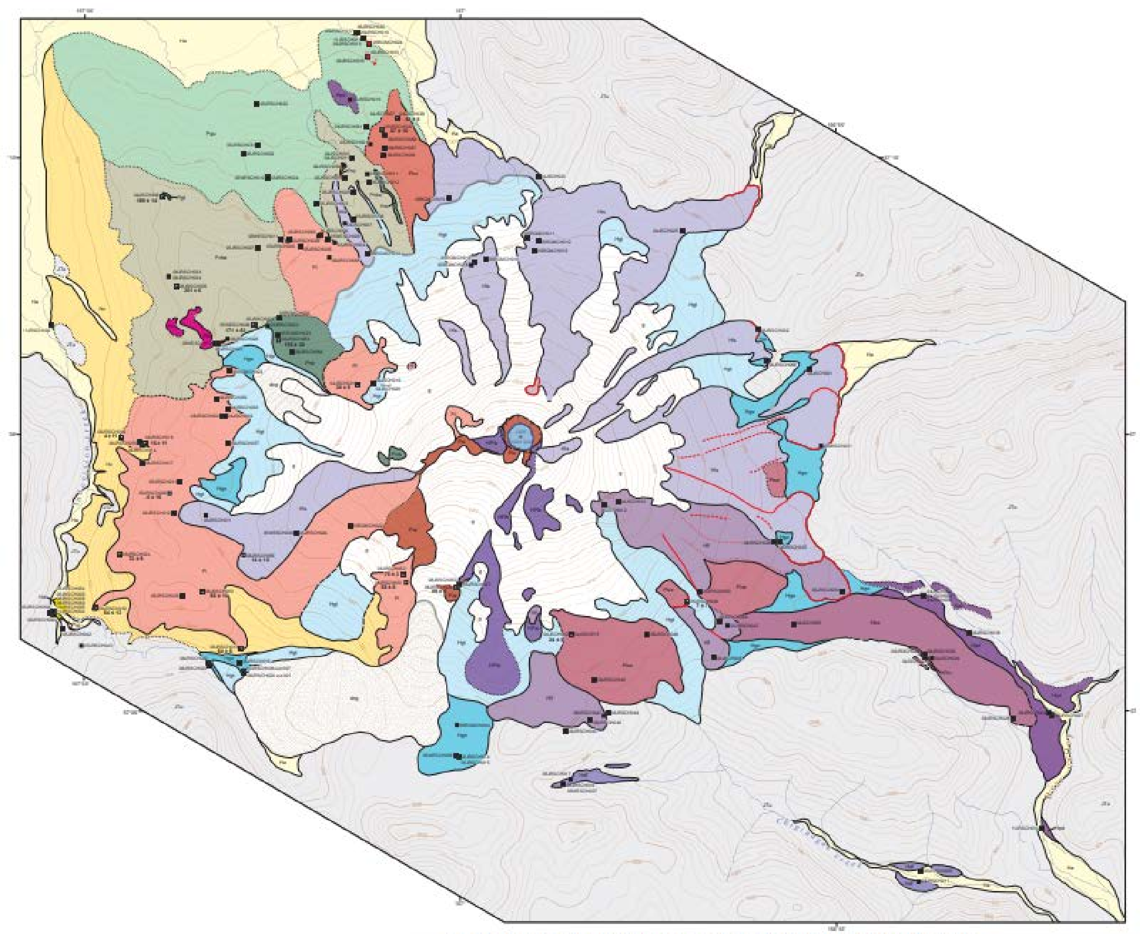
Simple binary [surficial/bedrock] layer generalization





Simple binary surficial/bedrock layer generalization is overly simplistic

For Example: Geologic map of Mount Chiginagak volcano, AK
http://dggs.alaska.gov/pubs/id/29769



GEOLOGIC MAP OF MOUNT CHIGINAGAK VOLCANO, ALASKA

DESCRIPTION OF MAP UNITS

ALLUVIAL, COLLUVIAL, AND GLACIAL DEPOSITS

Surficial deposits of non-volcanic origin are differentiated on the basis of origin and age. The entire Chiginagak region was covered by an extensive mountain ice sheet during the last glacial maximum about 20 ka (Manley and Kaufman, 2002). Glaciers extended 40 to 60 km northwest of Chiginagak, close to the present shoreline of Bristol Bay, and roughly 150 km to the southeast onto the emergent Pacific continental shelf. Diverse glacial sediments including till, outwash, and glaciolacustrine sediments were deposited over broad areas. As glaciers waned, stream and slope processes reworked glacial deposits and underlying bedrock into colluvial and alluvial deposits. As they do today, glaciers probably remained on the upper slopes of the volcano, advancing and retreating as climate fluctuated. Fresh, steep-sided moraines extending as far as 1 km beyond snouts of present glaciers mark the maximum advance of the Neoglacial period of the past few centuries.

- g — GLACIERS AND PERENNIAL SNOW FIELDS
- dcg — DEBRIS-COVERED GLACIER
- Ha — ALLUVIUM OF ACTIVE CHANNELS AND FLOODPLAINS (Holocene)
- Hgt — GLACIAL TILL OF LATE NEOGLACIAL AGE (late Holocene)
- Hgo — GLACIAL OUTWASH OF LATE NEOGLACIAL AGE (late Holocene)
- Hc — COLLUVIUM AND ALLUVIUM (Holocene and latest Pleistocene)
- Pgt — GLACIAL TILL (late Pleistocene)
- Pgu — GLACIAL DEPOSITS, UNDIFFERENTIATED (late Pleistocene)

PRODUCTS OF MOUNT CHIGINAGAK VOLCANO

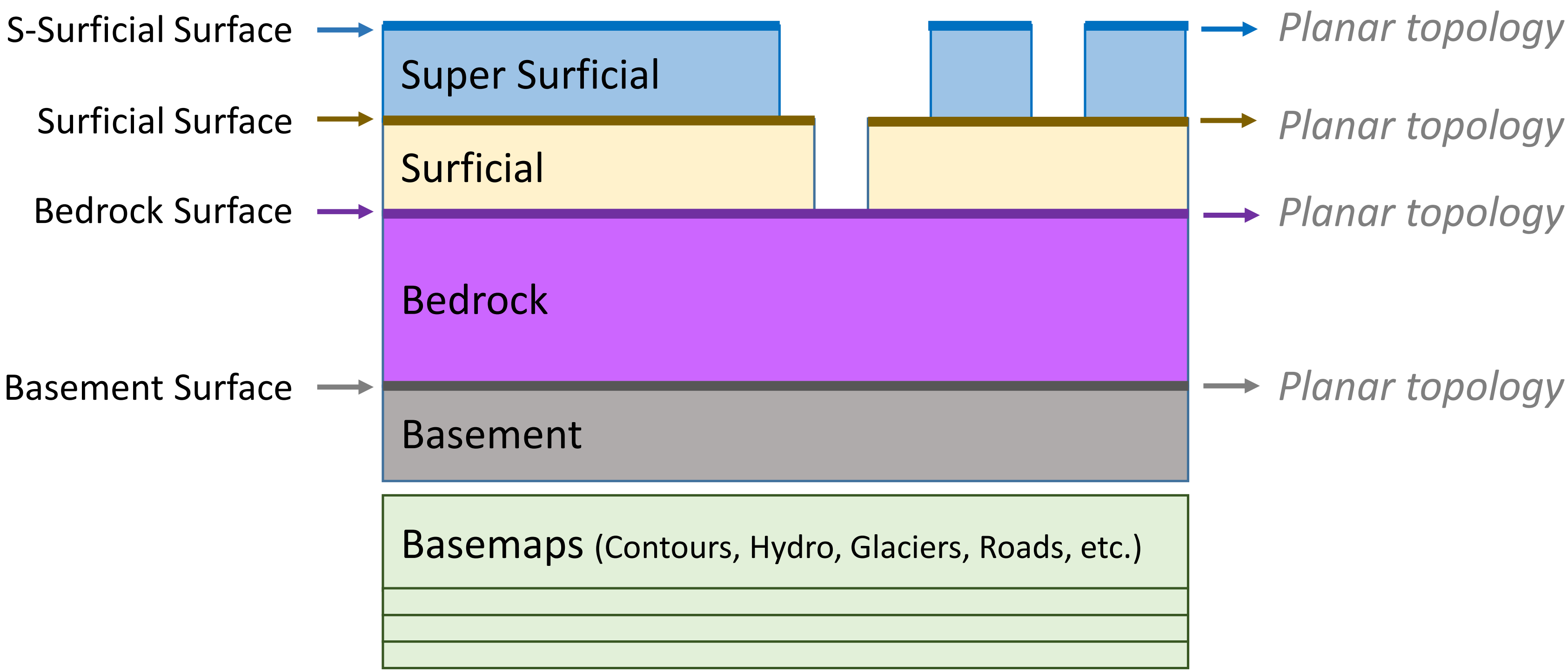
Eruptive products of Chiginagak volcano are subdivided into cone-forming andesitic and minor dacitic lava flows and associated breccias, deposits of block-and-ash pyroclastic flows derived from collapse of active lava domes or lava flows, and locally exposed pumiceous pyroclastic fall and flow deposits that may record the most explosive eruption in the volcano's history. The lava flows are divided further on the basis of age, geochemical differences, and source vent. Because the area was covered by extensive glaciers during the last major glaciation, we distinguish units that (1) predate or are synchronous with the last glaciation (that is, of Pleistocene age) and (2) those that postdate the recession of last-ice-age glaciers. Although not dated locally, regional studies show that the last glaciation peaked about 20 ka; glaciers had receded greatly by about 10 to 15 ka. The age boundary between the Pleistocene and Holocene Epochs is 11.7 ka (Cohen and others, 2013), so without local age control it is not possible to determine whether postglacial deposits are of latest Pleistocene or Holocene age. For simplicity we refer to postglacial units as Holocene, realizing that some may be slightly older. Holocene lava-flow units include small areas of overlying till and outwash of late Neoglacial age too small to show at map scale.

- Hdi — DEBRIS-FLOW DEPOSITS OF UPPER INDECISION CREEK (Holocene)
- Hdf — PYROCLASTIC-FLOW AND LAHAR DEPOSITS ALONG CHIGINAGAK CREEK (Holocene)
- Hls — LAVA FLOWS FROM SUMMIT VENT (Holocene)
- Hlf — LAVA FLOWS FROM VENT 5567 ON SOUTHEAST FLANK (Holocene)
- Hpd — DEPOSITS OF PYROCLASTIC FLOWS AND LAHARS (Holocene)
- Hba — DEPOSITS OF BLOCK-AND-ASH FLOWS AND LAHARS OF BEAR VALLEY (Holocene)
- HPbv — ANDESITE LAVA FLOW OF BEAR VALLEY (late Pleistocene or Holocene)
- HPlb — HYDROTHERMALLY ALTERED LAVA FLOWS AND BRECCIAS (late Pleistocene to Holocene)
- Plse — ANDESITE LAVA FLOWS OF SOUTHEAST FLANK (late Pleistocene)
- Pl — ANDESITE LAVA FLOWS OF SOUTH, WEST, AND NORTHWEST FLANKS (late Pleistocene)
- Plvc — ANDESITE LAVA FLOWS OF UPPER VOLCANO CREEK (late Pleistocene)
- Pla — HYDROTHERMALLY ALTERED LAVA FLOWS (late Pleistocene)
- Pnb — BANDED LAVAS OF NORTHWEST FLANK (middle to late Pleistocene)
- Pnba — BLOCK-AND-ASH-FLOW AND LAHAR DEPOSITS OF NORTH FLANK (middle to late Pleistocene)
- Pnp — PUMICE-RICH FALL AND FLOW DEPOSITS OF NORTH FLANK (middle Pleistocene)
- Plb — BASALTIC ANDESITE LAVA FLOWS OF NORTH FLANK (middle Pleistocene)

PRE-QUATERNARY BEDROCK

- JTu — BEDROCK, UNDIFFERENTIATED

Proposed 4 Layer Generalization
with addition Basemap Layers



Some Options to Model Multiple Conceptual Surfaces, aka Layers
(Bedrock, Surficial, etc.)

- Don’t worry about it. The data represents the flat map as printed, leave out the underlying layer(s)

- Separate Geodatabases (GDB) for each layer

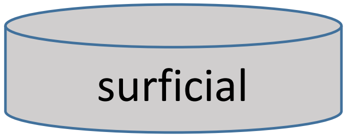
- Single GDB – Separate Feature Class for each layer
- Single GDB – Separate Feature Dataset for each layer

- Single GDB – Single Feature Class with layer attribute field
- Single GDB – Single Feature Class with layer attribute field set as subtype

Separate Geodatabases (GDB) for Surficial and Bedrock

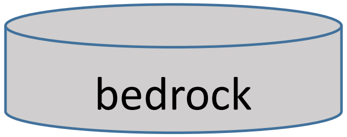
- Makes sense for separate surficial and mapping teams
- “Artificial” separation of similar concepts?
- Harder to correlate/deconflict
- Can only edit one GDB at a time

We have a some historic mapped areas with separate maps and GDBs



Map_unit_poly
Map_unit_lines
Map_unit_points
Contacts_and_faults
Geologic_polys
Geologic_lines
Geologic_points

Topology

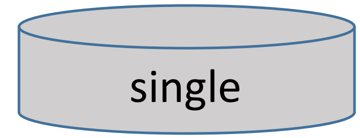


Map_unit_poly
Map_unit_lines
Map_unit_points
Contacts_and_faults
Geologic_polys
Geologic_lines
Geologic_points

Topology

Single GDB – Separate Surficial/Bedrock Feature Classes

- Table names all different than standard GeMS
- A lot of tables & feature classes



Map_unit_poly_bedrock
Map_unit_lines_bedrock
Map_unit_points_bedrock
Contacts_and_faults_bedrock
Geologic_polys_bedrock
Geologic_lines_bedrock
Geologic_points_bedrock

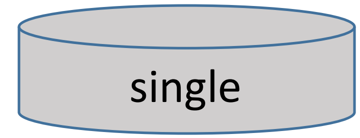
Map_unit_poly_surficial
Map_unit_lines_surficial
Map_unit_points_surficial
Contacts_and_faults_surficial
Geologic_polys_surficial
Geologic_lines_surficial
Geologic_points_surficial

Topology
Must not Overlap – Surficial
Must not Overlap – Bedrock
Must not have Gaps – Bedrock
Must not have Gaps – Surficial
etc.

We are actively testing this concept with one of our maps in production

Single GDB – Separate Feature Datasets

- Individual Feature Datasets (FDS) are GeMs Compliant
- FDS is an ESRI construct, not as open
- Unfortunately feature class names cannot be the same even if in different FDS
- Table names all different than standard GeMS



Surficial Feature Dataset (FDS)
- Map_unit_poly_surficial
- Map_unit_lines_surficial
- Map_unit_points_surficial
- Contacts_and_faults_surficial
- Geologic_polys_surficial
- Geologic_lines_surficial
- Geologic_points_surficial

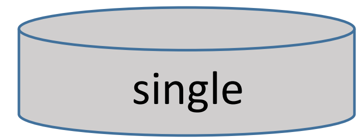
Topology - surficial

Bedrock Feature Dataset (FDS)
- Map_unit_poly_bedrock
- Map_unit_lines_bedrock
- Map_unit_points_bedrock
- Contacts_and_faults_bedrock
- Geologic_polys_bedrock
- Geologic_lines_bedrock
- Geologic_points_bedrock

Topology - bedrock

Single GDB – Single Feature Class with layer attribute field

- Individual GDB is GeMs Compliant
- Does not allow for multiple planar topologies

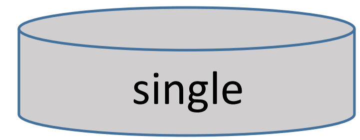


Map_unit_poly
Map_unit_lines
Map_unit_points
Contacts_and_faults
Geologic_polys
Geologic_lines
Geologic_points

Topology
 Must not Overlap
 Must not have Gaps
 etc

Single GDB – Use Subtypes for Surficial/Bedrock Distinction

- Requirement to add subtype field (must be integer)
- Subtypes are an ESRI construct, not as open
- Subtypes allows for multiple layer topologies
- A table/feature class can have only 1 subtype field
- Individual GDB is GeMs Compliant (but may cause confusion with subtypes)



Map_unit_poly
Map_unit_lines
Map_unit_points
Contacts_and_faults
Geologic_polys
Geologic_lines
Geologic_points

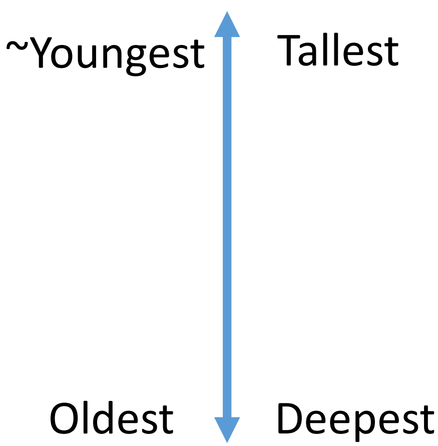
Topology
Must not Overlap – Surficial
Must not Overlap – Bedrock
Must not have Gaps – Bedrock
Must not have Gaps – Surficial
etc.

Proposed Fields to Support Ordinal Layering (stacked geologic features)

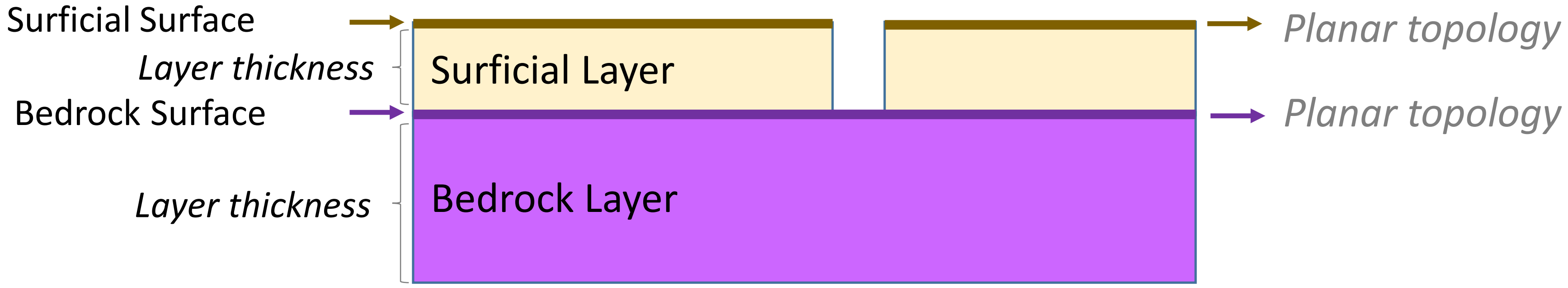
- **z_category:** Features can be queried or displayed according to these primary layers.
- **z_order:** Optional values that gives another level of layer detail.

  For example, you could have a surficial feature with the default z_value of 30, and another surficial feature layer deposited on top and given a z_value of 31

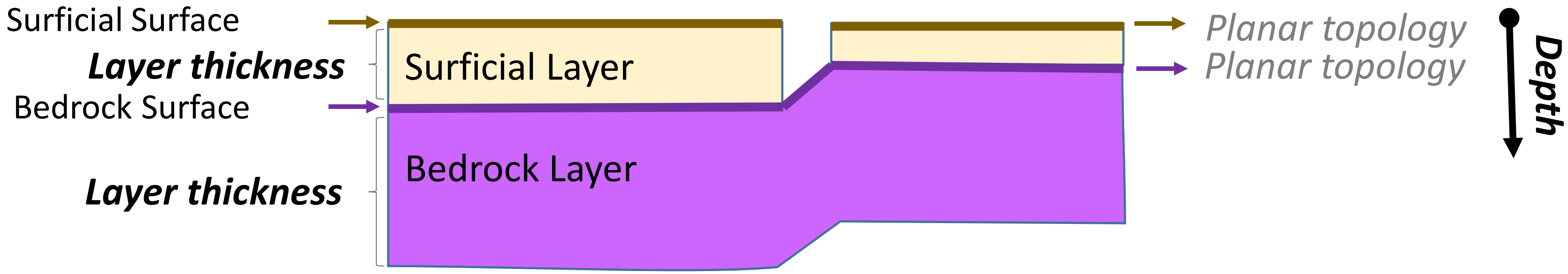
Proposed Fields	
z_category (integer)	**z_order (Integer)**
4 (Super Surficial)	40
3 (Surficial)	30
2 (Bedrock)	20
1 (Basement)	10
Subtype field	*Default values*



Interval Layering with Feature Level Depth Values



Interval Layering with Feature Level Thickness & Depth Values



Required Attribute Fields

- Thickness: Each feature (row) has a uniform thickness.
- Depth (of surface): Can be derived from overhead layer thicknesses?

Is this the eventual goal? --- Full 3D vertices