DIGITAL MAPPING TECHNIQUES 2025

The following was presented at DMT'25
May 18 - 21, 2025

The contents of this document are provisional

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

A GeMS-compliant framework for layering geologic map data in the Fall Zone of Virginia

By Jennie Latane (Virginia Department of Energy)

This talk describes a method for handling GeMS compliance in a 1:24,000-scale GeMS conversion where the original map contains several layers of markedly different geologic materials. The talk uses the Chesterfield quadrangle in central Virginia (Carter and others, 2010) as a case study to consider one approach to representing a three-dimensional relationship within a GeMS geodatabase.

Chesterfield quadrangle straddles the Fall Zone and depicts crystalline Piedmont bedrock, Coastal Plain sediments, and modern surficial deposits. This area of the state represents the feathered edge of the Coastal Plain, where it is possible to see both contacts between Coastal Plain units, as well as contacts between underlying hard rock. Different approaches to surficial mapping also meet here, where geologists must differentiate between localized, process-based surficial deposits and laterally extensive, but still unconsolidated Coastal Plain sediments. The original mappers traced concealed crystalline bedrock contacts underneath of Coastal Plain terraces and traced Coastal Plain contacts underneath of recent surficial deposits. The resulting deliverable in 2010 was a layered PDF with the capability to turn on and off three surfaces representing surficial, Coastal Plain, and crystalline bedrock surfaces.

These slides examine the adjustments to GeMS made to accommodate that structure and honor the original mapping. In this approach, ContactsAndFaults and MapUnitPolys are both duplicated and given a suffix to differentiate them: “_Bedrock” and “_CoastalPlain”. Each package of ContactsAndFaults and MapUnitPolys creates one topological surface. A final standard MapUnitOverlayPolys feature class creates the third, surficial layer. To comply with topological rules, MapUnitPolys_CoastalPlain must contain a “dummy” polygon representing the crystalline bedrock underneath. This dummy unit, “Bedrock” must be added to the DescriptionOfMapUnits table. Although this approach successfully passes GeMS validation and “bakes in” the original PDF deliverable structure to the database, the process may be more appropriate on a map-by-map basis than when attempting to compile maps at a smaller scale or across a region or state.

A GEMS-COMPLIANT FRAMEWORK FOR LAYERING GEOLOGIC MAP DATA IN THE FALL ZONE OF VIRGINIA

Using a “three-tiered system” to accommodate overlapping units in a GeMS conversion

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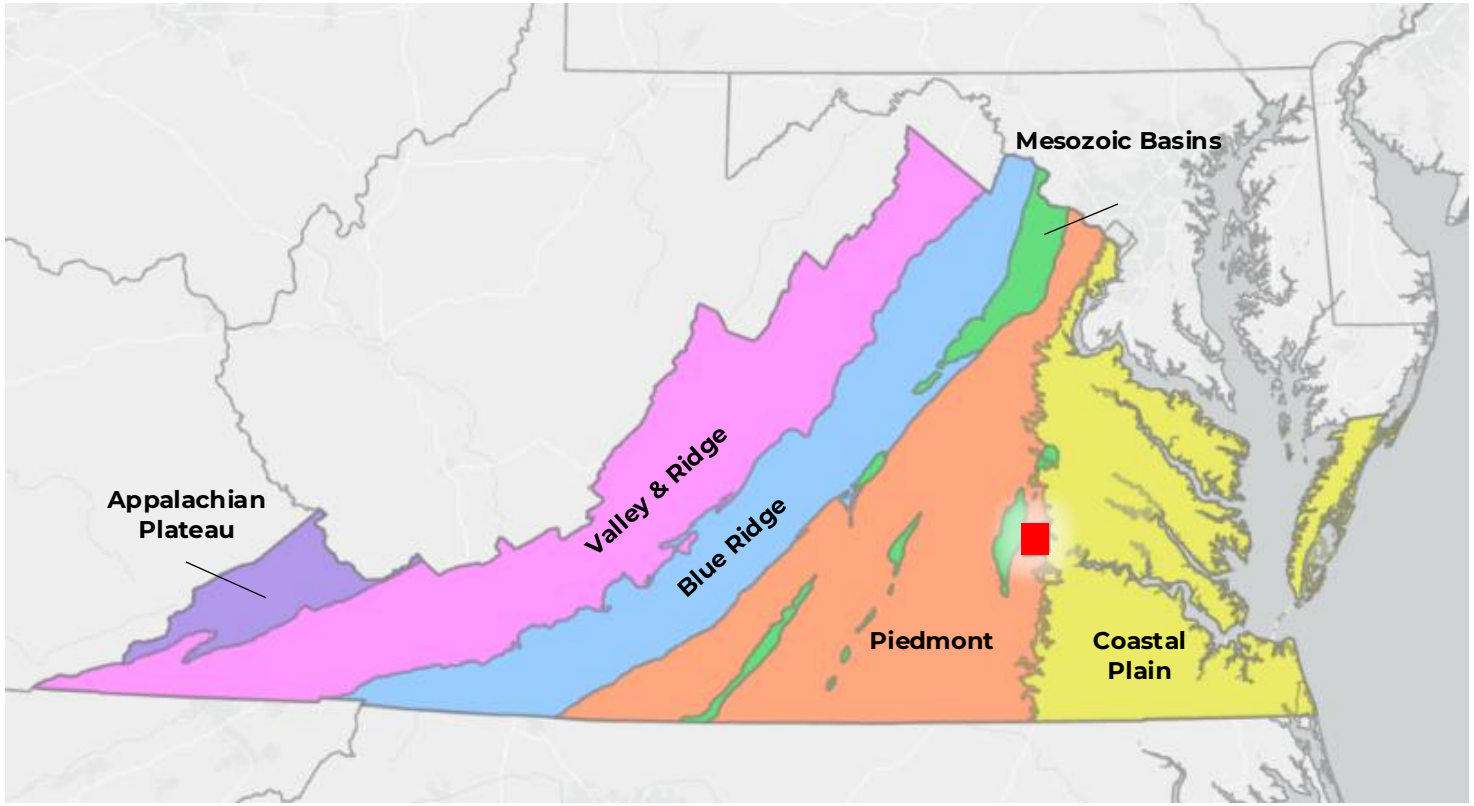
May 20, 2025

VIRGINIA Energy

CHESTERFIELD QUADRANGLE

Mapping in the Fall Zone

- Mapped in 2010*
- Fall Zone – Rivers drop down from resistant Piedmont rocks onto Coastal Plain sediments
- The “feathered edge” of the Coastal Plain – contacts are visible in drainages, borehole sampling.

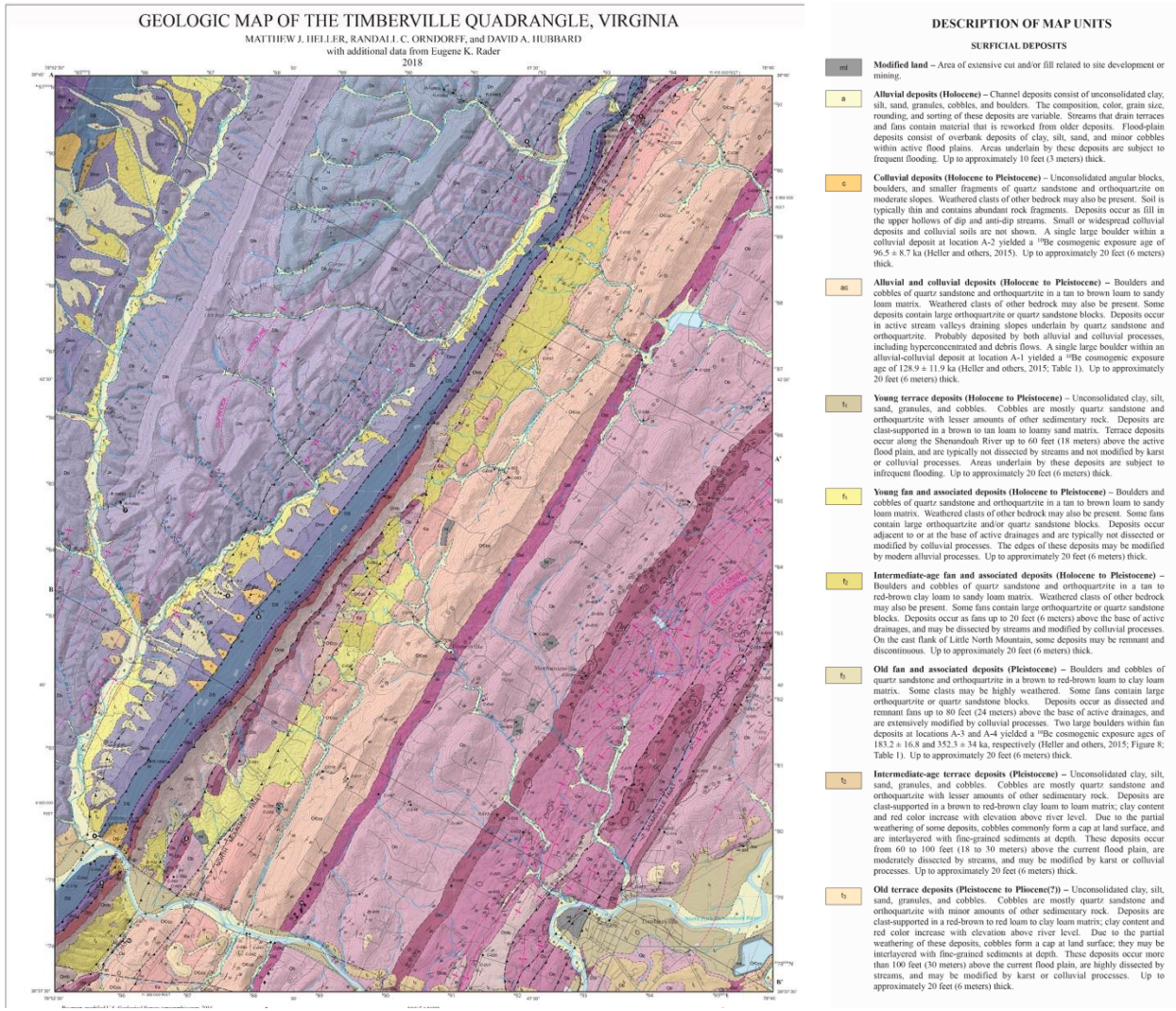


*Carter M.W., Bondurant, A.K., and Berquist, C.R., 2010, Geologic map of the Chesterfield quadrangle, Virginia: Virginia Department of Mines, Minerals and Energy, Division of Geology and Mineral Resources Open File Report 10-06, Map Scale 1:24,000.

SURFICIAL DEPOSITS

From 1:7,500,000-scale surficial map of USA (Hunt, 1984):

- Most surficial deposits are composed of poorly consolidated clay, silt, sand, or gravel-sized particles
- Particles are produced chiefly by erosion
- Transported and deposited by water, wind, or ice, but can also be partly formed by in-situ weathering of bedrock


GEOLOGIC MAP OF THE TIMBERVILLE QUADRANGLE, VIRGINIA

MATTHEW J. HELLER, RANDALL C. ORNDORFF, and DAVID A. HUBBARD

with additional data from Eugene K. Rader

2018

DESCRIPTION OF MAP UNITS

SURFICIAL DEPOSITS

Modified land – Area of extensive cut and/or fill related to site development or mining.

Alluvial deposits (Holocene) – Channel deposits consist of unconsolidated clay, silt, sand, granules, cobbles, and boulders. The composition, color, grain size, rounding, and sorting of these deposits are variable. Streams that drain terraces and fans contain material that is reworked from older deposits. Flood-plain deposits consist of overbank deposits of clay, silt, sand, and minor cobbles within active flood plains. Areas underlain by these deposits are subject to frequent flooding. Up to approximately 10 feet (3 meters) thick.

Colluvial deposits (Holocene to Pleistocene) – Unconsolidated angular blocks, boulders, and smaller fragments of quartz sandstone and orthoquartzite on moderate slopes. Weathered clasts of other bedrock may also be present. Soil is typically thin and contains abundant rock fragments. Deposits occur as fill in the upper hollows of dip and anti-dip streams. Small or widespread colluvial deposits and colluvial soils are not shown. A single large boulder within a colluvial deposit at location A-2 yielded a ^{10}Be cosmogenic exposure age of 96.5 ± 8.7 ka (Heller and others, 2015). Up to approximately 20 feet (6 meters) thick.

Alluvial and colluvial deposits (Holocene to Pleistocene) – Boulders and cobbles of quartz sandstone and orthoquartzite in a tan to brown loam to sandy loam matrix. Weathered clasts of other bedrock may also be present. Some deposits contain large orthoquartzite or quartz sandstone blocks. Deposits occur in active stream valleys draining slopes underlain by quartz sandstone and orthoquartzite. Probably deposited by both alluvial and colluvial processes, including hyperconcentrated and debris flows. A single large boulder within an alluvial-colluvial deposit at location A-1 yielded a ^{10}Be cosmogenic exposure age of 128.9 ± 11.9 ka (Heller and others, 2015; Table 1). Up to approximately 20 feet (6 meters) thick.

Young terrace deposits (Holocene to Pleistocene) – Unconsolidated clay, silt, sand, granules, and cobbles. Cobbles are mostly quartz sandstone and orthoquartzite with lesser amounts of other sedimentary rock. Deposits are clast-supported in a brown to tan loam to loamy sand matrix. Terrace deposits occur along the Shenandoah River up to 60 feet (18 meters) above the active flood plain, and are typically not dissected by streams and not modified by karst or colluvial processes. Areas underlain by these deposits are subject to infrequent flooding. Up to approximately 20 feet (6 meters) thick.

Young fan and associated deposits (Holocene to Pleistocene) – Boulders and cobbles of quartz sandstone and orthoquartzite in a tan to brown loam to sandy loam matrix. Weathered clasts of other bedrock may also be present. Some fans contain large orthoquartzite and/or quartz sandstone blocks. Deposits occur adjacent to or at the base of active drainages and are typically not dissected or modified by colluvial processes. The edges of these deposits may be modified by modern alluvial processes. Up to approximately 20 feet (6 meters) thick.

Intermediate-age fan and associated deposits (Holocene to Pleistocene) – Boulders and cobbles of quartz sandstone and orthoquartzite in a tan to red-brown clay loam to sandy loam matrix. Weathered clasts of other bedrock may also be present. Some fans contain large orthoquartzite or quartz sandstone blocks. Deposits occur as fans up to 20 feet (6 meters) above the base of active drainages, and may be dissected by streams and modified by colluvial processes. On the east flank of Little North Mountain, some deposits may be remnant and discontinuous. Up to approximately 20 feet (6 meters) thick.

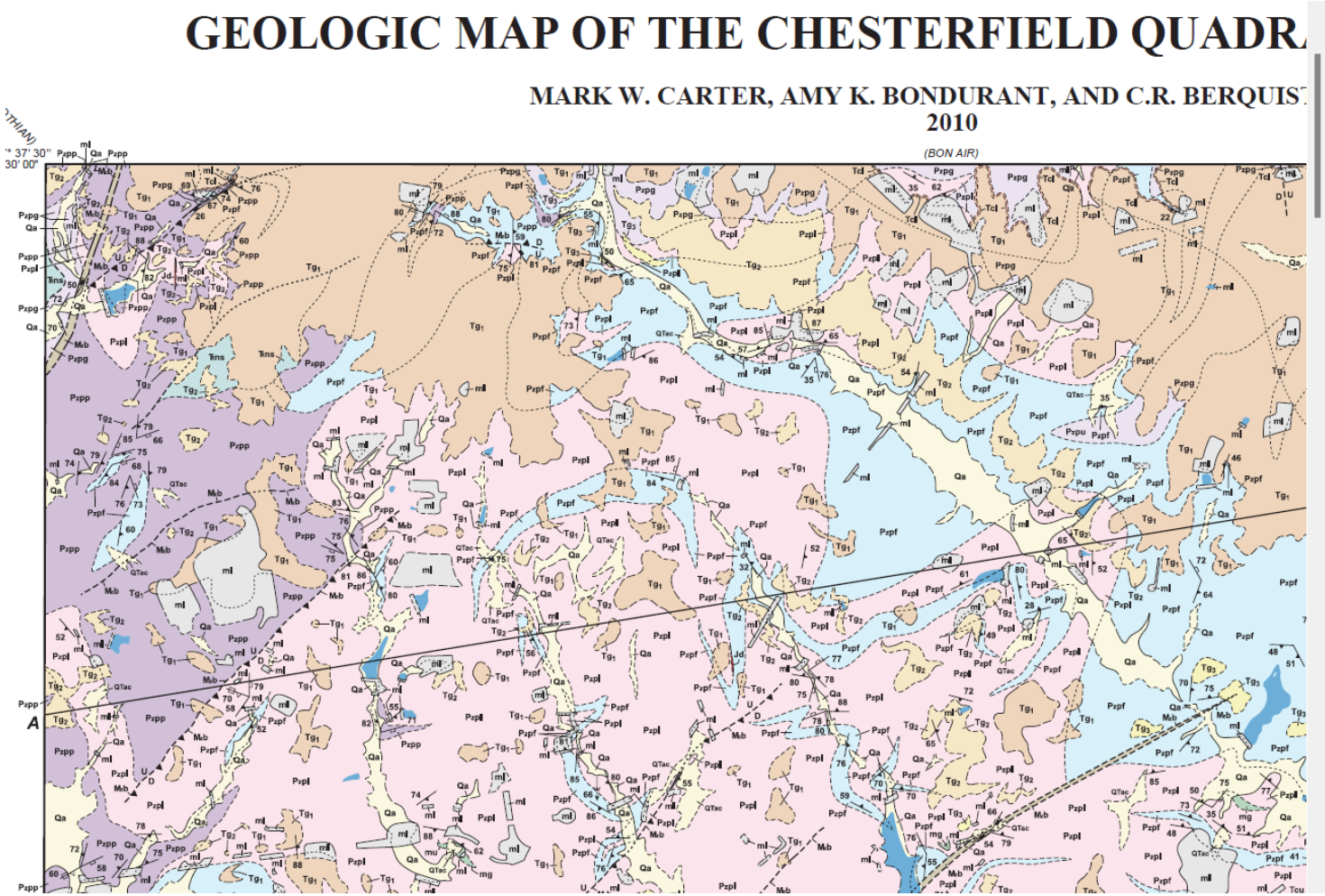
Old fan and associated deposits (Pleistocene) – Boulders and cobbles of quartz sandstone and orthoquartzite in a brown to red-brown loam to clay loam matrix. Some clasts may be highly weathered. Some fans contain large orthoquartzite or quartz sandstone blocks. Deposits occur as dissected and remnant fans up to 80 feet (24 meters) above the base of active drainages, and are extensively modified by colluvial processes. Two large boulders within fan deposits at locations A-3 and A-4 yielded a ^{10}Be cosmogenic exposure ages of 183.2 ± 16.8 and 352.3 ± 34 ka, respectively (Heller and others, 2015; Figure 8; Table 1). Up to approximately 20 feet (6 meters) thick.

Intermediate-age terrace deposits (Pleistocene) – Unconsolidated clay, silt, sand, granules, and cobbles. Cobbles are mostly quartz sandstone and orthoquartzite with lesser amounts of other sedimentary rock. Deposits are clast-supported in a brown to red-brown clay loam to loam matrix; clay content and red color increase with elevation above river level. Due to the partial weathering of some deposits, cobbles commonly form a cap at land surface, and are interlayered with fine-grained sediments at depth. These deposits occur from 60 to 100 feet (18 to 30 meters) above the current flood plain, are moderately dissected by streams, and may be modified by karst or colluvial processes. Up to approximately 20 feet (6 meters) thick.

Old terrace deposits (Pleistocene to Pliocene(?)) – Unconsolidated clay, silt, sand, granules, and cobbles. Cobbles are mostly quartz sandstone and orthoquartzite with minor amounts of other sedimentary rock. Deposits are clast-supported in a red-brown to red loam to clay loam matrix; clay content and red color increase with elevation above river level. Due to the partial weathering of these deposits, cobbles form a cap at land surface; they may be interlayered with fine-grained sediments at depth. These deposits occur more than 100 feet (30 meters) above the current flood plain, are highly dissected by streams, and may be modified by karst or colluvial processes. Up to approximately 20 feet (6 meters) thick.

Publication 186 by Heller and others, 2018

ROCK LAYERS, PDF LAYERS



Layers

- QTac Contacts - Exact
- QTac Contacts - Approximate
- QTac Contacts - Inferred
- G3 Contacts - Exact
- G3 Contacts - Approximate
- G3 Contacts - Inferred
- G2 Contacts - Exact
- G2 Contacts - Approximate
- G2 Contacts - Inferred
- Yorktown Contacts - Exact
- Yorktown Contacts - Approximate
- Yorktown Contacts - Inferred
- G1 Contacts - Exact
- G1 Contacts - Approximate
- G1 Contacts - Inferred
- Miocene Contacts - Exact
- Miocene Contacts - Inferred
- Faults - Exact
- Faults - Approximate
- Faults - Inferred

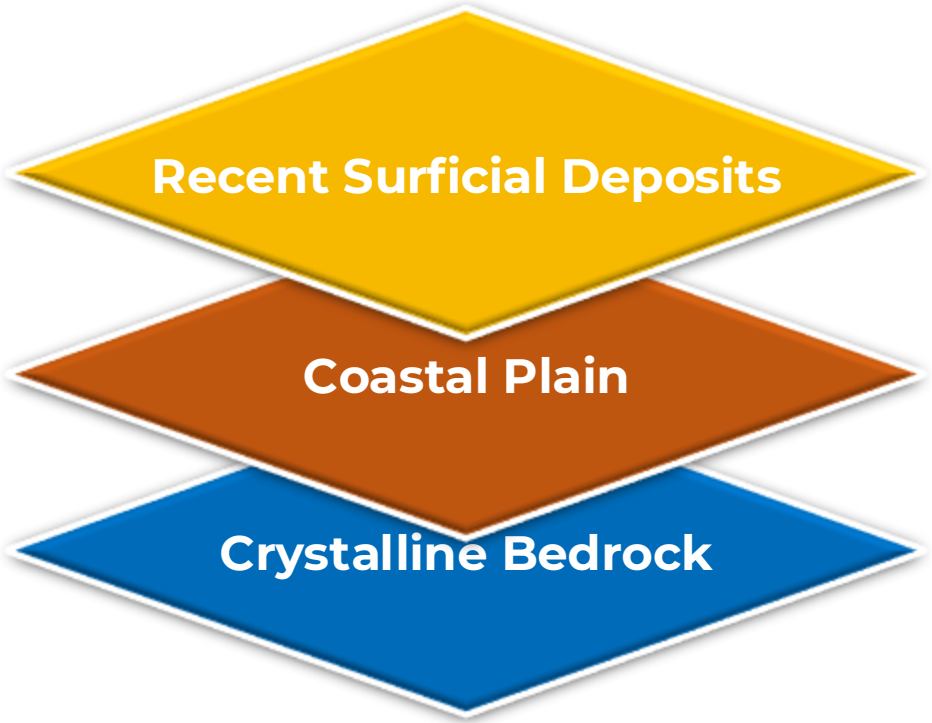
PRE-CONVERSION QUESTIONS

- Are the “Coastal Plain” units ‘map’ or ‘surficial’ units?
- How do we honor the overlapping contacts of the original map?
- Can we embed the layered PDF functionality into the database? Can we do it in a way that’s easy to understand and access?

MODIFYING GEMS

DATABASE STRUCTURE

Map Layers



Chesterfield.gdb

- CrossSectionA
- CrossSectionB
- **GeologicMap**
  - CartographicLines
  - **ContactsAndFaults_Bedrock**
  - ContactsAndFaults_BedrockAnno
  - **ContactsAndFaults_CoastalPlain**
  - GenericPoints
  - **MapUnitOverlayPolys**
  - MapUnitOverlayPolysAnno
  - **MapUnitPolys_Bedrock**
  - **MapUnitPolys_CoastalPlain**
  - MapUnitPolysAnno
  - OrientationPoints
- DataSources
- DescriptionOfMapUnits
- GeoMaterialDict
- Glossary

CHANGES WITHIN THE DATA

DescriptionOfMap Units, MapUnitPolys_CoastalPlain

MapUnit	Name	FullName	Age	HierarchyKey	Label	Symbol	GeoMaterial
	SURFICIAL UNITS			01			
ml	Modified Land	modified land	Pleistocene to Holocene	01-01	ml	322	"Made" or human-engineered land
Qa	Alluvium	alluvium	Pleistocene to Holocene	01-02	Qa	80	Alluvial sediment
cb	Carolina Bay	Carolina bay	Pleistocene to Holocene	01-03	cb	transparent	Alluvial sediment
QTac	Quaternary-Tertiary Alluvial and Colluvial Valley Fill	Quaternary-Tertiary alluvial and colluvial valley fill	Pliocene to Pleistocene	01-04	QTac	71	Debris flows, landslides, and other localized mass-movement sediment
	COASTAL PLAIN UNITS			02			
Tg3	Low-Level Tertiary Gravels	low-level Tertiary gravels	Pliocene	02-01	Tg3	40	Alluvial sediment, mostly coarse-grained
Tg2	Mid-Level Tertiary Gravels	mid-level Tertiary gravels	Pliocene	02-02	Tg2	41	Alluvial sediment, mostly coarse-grained
Tcu	Upper Chesapeake Group Sand and Gravel	Upper Chesapeake Group sand and gravel	Pliocene	02-03	Tcu	0	Alluvial sediment, mostly fine-grained
Tg1	High-Level Tertiary Gravels	high-level Tertiary gravels	Miocene to Pliocene	02-04	Tg1	143	Alluvial sediment, mostly coarse-grained
Tcl	Lower Chesapeake Group Clayey Silt	Lower Chesapeake Group clayey silt	Miocene	02-05	Tcl	43	Marine sediment, mostly fine-grained
	CATACLASTIC ROCKS			03			
Mzb	Silicified Cataclasite	silicified cataclasite	Mesozoic	03-01	}b	242	Clastic sedimentary rock
	IGNEOUS INTRUSIVE ROCKS			04			
Jd	Diabase	diabase	Jurassic	04-01	Jd	99	Coarse-grained, mafic-composition intrusive igneous rock
	NEWARK SUPERGROUP			05			
Trns	Newark Supergroup, Undivided	Newark Supergroup, undivided	Triassic	05-01	^ns	320	Sedimentary rock
	IGNEOUS INTRUSIVE ROCKS			06			
	PETERSBURG GRANITE			06-01			
Pzpg	Subidiomorphic Granite	subidiomorphic phase of the Petersburg Granite	Pennsylvanian to Mississippian	06-01-01	|pg	101	Fine-grained, felsic-composition intrusive igneous rock
Pzpp	Porphyritic Granite	porphyritic granite phase of the Petersburg Granite	Pennsylvanian to Mississippian	06-01-02	|pp	313	Coarse-grained, felsic-composition intrusive igneous rock
Pzpf	Foliated Granite	foliated granite phase of the Petersburg Granite	Pennsylvanian to Mississippian	06-01-03	|pf	200	Coarse-grained, felsic-composition intrusive igneous rock
Pzpl	Layered Granite Gneiss	layered granite gneiss phase of the Petersburg Granite	Pennsylvanian to Mississippian	06-01-04	|pl	2	Coarse-grained, felsic-composition intrusive igneous rock

MapUnit	Name	FullName	Symbol	GeoMaterial
Bedrock	Bedrock	Bedrock-derived residuum	Transparent	Rock

CHANGES WIT

DescriptionOfMap
MapUnitPolys_Coas

MapUnit	Name	FullName
	SURFICIAL UNITS	
ml	Modified Land	modified land
Qa	Alluvium	alluvium
cb	Carolina Bay	Carolina bay
QTac	Quaternary-Tertiary Alluvial and Colluvial Valley Fill	Quaternary-Tertia
	COASTAL PLAIN UNITS	
Tg3	Low-Level Tertiary Gravels	low-level Tertiary
Tg2	Mid-Level Tertiary Gravels	mid-level Tertiary
Tcu	Upper Chesapeake Group Sand and Gravel	Upper Chesapeal
Tg1	High-Level Tertiary Gravels	high-level Tertiary
Tcl	Lower Chesapeake Group Clayey Silt	Lower Chesapeal
	CATACLASTIC ROCKS	
Mzb	Silicified Cataclasite	silicified cataclasi
	IGNEOUS INTRUSIVE ROCKS	
Jd	Diabase	diabase
	NEWARK SUPERGROUP	
Tms	Newark Supergroup, Undivided	Newark Supergro
	IGNEOUS INTRUSIVE ROCKS	
	PETERSBURG GRANITE	
Pzpg	Subidiomorphic Granite	subidiomorphic pl
Pzpp	Porphyritic Granite	porphyritic granite
Pzpf	Foliated Granite	foliated granite pr
Pzpl	Layered Granite Gneiss	layered granite gr

MapUnit	Name	FullN
Bedrock	Bedrock	Bedr

LIST OF MAP UNITS

SURFICIAL UNITS

- water
- ml — Modified Land
- Qa — Alluvium
- cb — Carolina Bay
- QTac — Quaternary-Tertiary Alluvial and Colluvial Valley Fill

COASTAL PLAIN UNITS

- Tg_3 — Low-Level Tertiary Gravels
- Tg_2 — Mid-Level Tertiary Gravels
- Tcu — Upper Chesapeake Group Sand and Gravel
- Tg_1 — High-Level Tertiary Gravels
- Tcl — Lower Chesapeake Group Clayey Silt

CATACLASTIC ROCKS

- Mzb — Silicified Cataclasite

IGNEOUS INTRUSIVE ROCKS

- Jd — Diabase

NEWARK SUPERGROUP

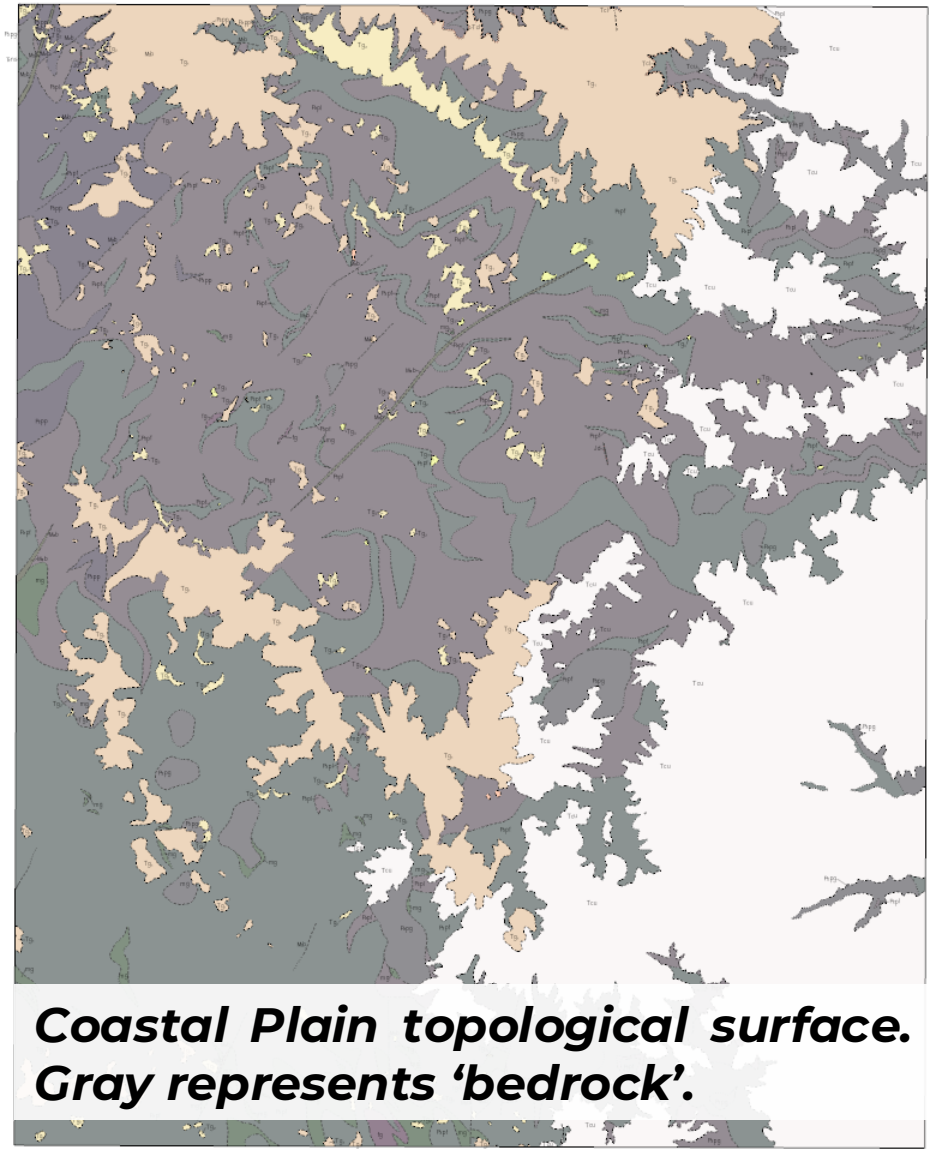
- Tkns — Newark Supergroup, Undivided

IGNEOUS INTRUSIVE ROCKS - PETERSBURG GRANITE

- Pzpg — Subidiomorphic Granite
- Pzpp — Porphyritic Granite
- Pzpf — Foliated Granite
- Pzpl — Layered Granite Gneiss

METAMORPHIC ROCKS

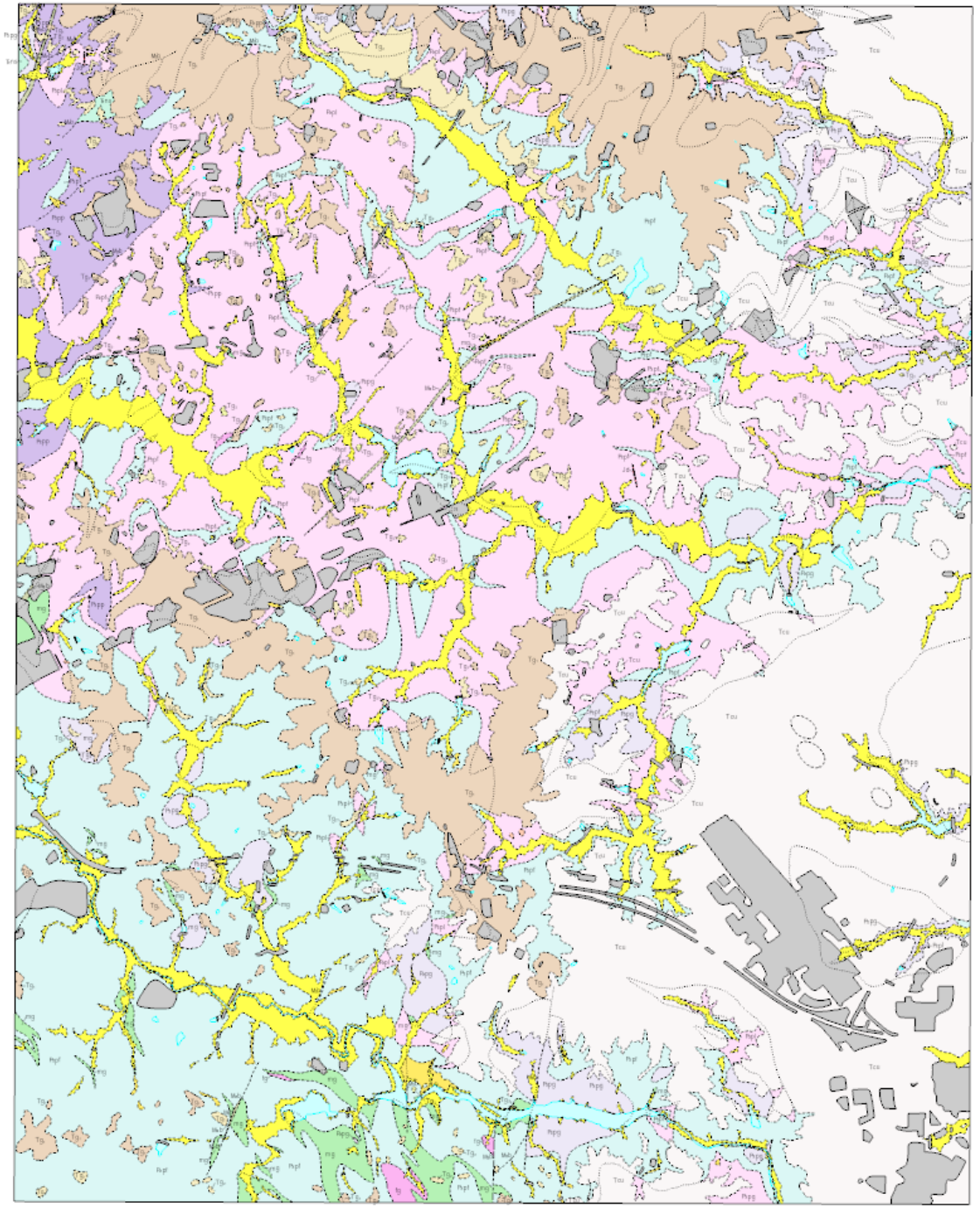
- fg — Felsic Gneiss
- mg — Mafic Gneiss



Coastal Plain topological surface. Gray represents 'bedrock'.

LESSONS LEARNED

- Database structure *does* accommodate layer-ability.
- Coastal Plain units are acknowledged as “true” map units and are treated as such by GeMS validation.
- Probably less effective for compilation.
  - Separation between “surficial” and “Coastal Plain” units will vary by author.
  - Not effective at the statewide scale.
- More labor intensive, depending on starting condition of data.



THANK YOU

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VIRGINIA Energy