DIGITAL MAPPING TECHNIQUES 2023

The following was presented at DMT'23
May 21 - 24, 2023

The contents of this document are provisional

See Presentations and Proceedings
from the DMT Meetings (1997-2023)

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

MBMG GeMS Workflows

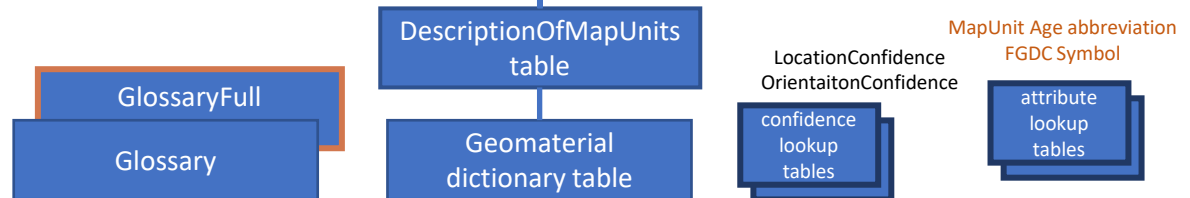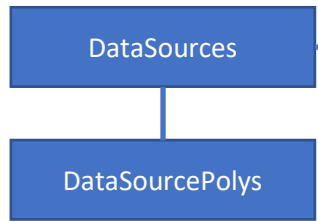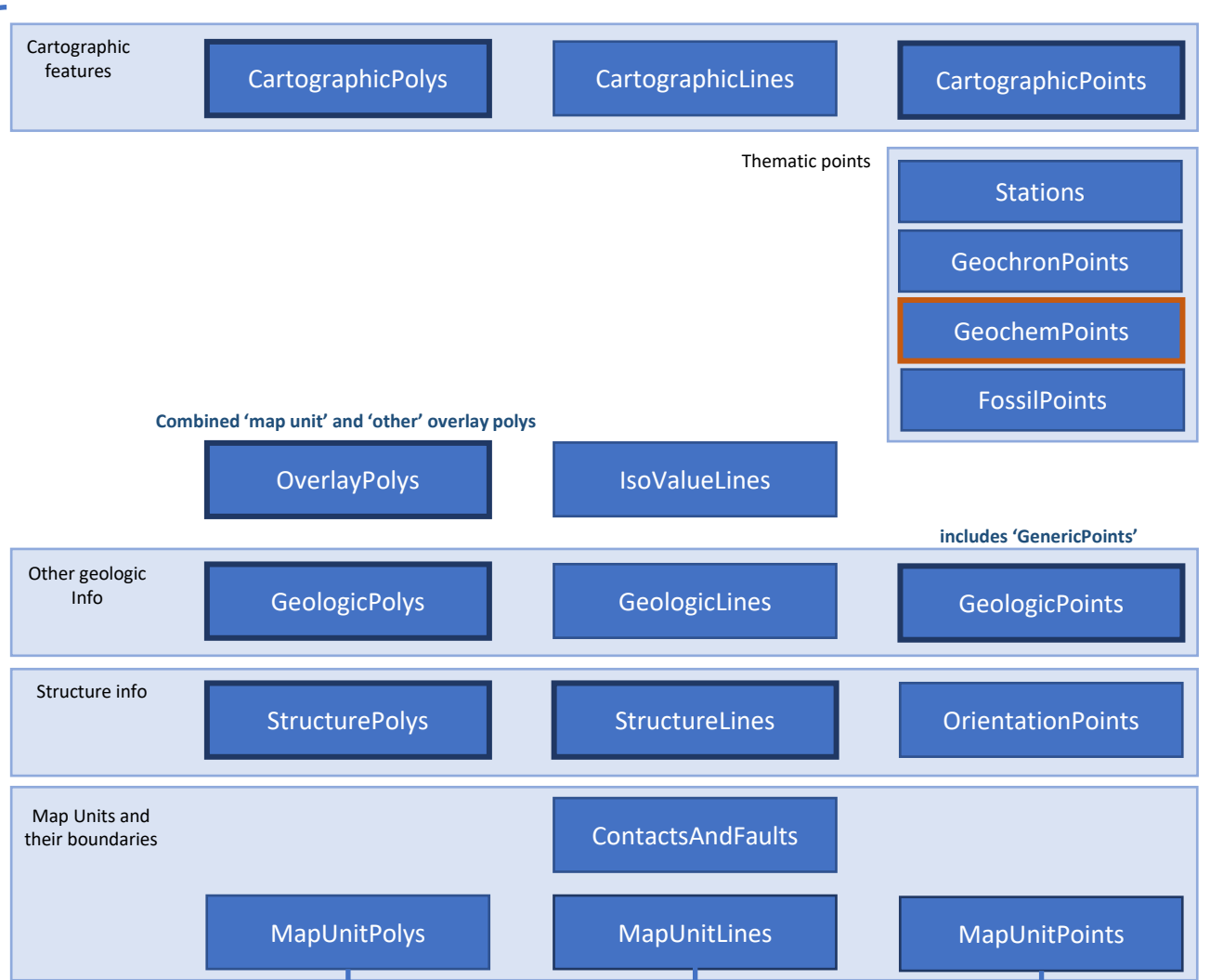

Patricia Gallagher Ekberg
Yiwen Li
John Sanford

Digital Mapping Techniques
May 21st – 24th 2023
Anchorage, Alaska

MT GeMS extension*

Single-Map MT GeMS
Geodatabase Schema

Cartographic features

CartographicPolys · CartographicLines · CartographicPoints

Thematic points

Stations
GeochronPoints
GeochemPoints
FossilPoints

Combined 'map unit' and 'other' overlay polys

OverlayPolys · IsoValueLines

includes 'GenericPoints'

Other geologic Info

GeologicPolys · GeologicLines · GeologicPoints

Structure info

StructurePolys · StructureLines · OrientationPoints

Map Units and their boundaries

ContactsAndFaults

MapUnitPolys · MapUnitLines · MapUnitPoints

DataSources

DataSourcePolys

DescriptionOfMapUnits table

GlossaryFull

Glossary

Geomaterial dictionary table

LocationConfidence
OrientaitonConfidence

confidence lookup tables

MapUnit Age abbreviation
FGDC Symbol

attribute lookup tables

= AK GeMS additions

= MT GeMS addition

*As adapted from AK GeMS (Hendricks and others, 2021)
https://dggs.alaska.gov/pubs/id/30669

MT GeMS extension

MT GeMS

GeMS ⟷ AK GeMS

Is more similar to GeMS …

- MT GeMS uses PascalCase for field and fc names
- Uses GeMS required field names
    - age_label to Age, map_unit_assoc to MapUnit, etc
    - Replaced LocationSourceID and AnalysisSourceID for point fcs
    - Replaced PlotAtScale field
    - Removed Alaska specific fcs and fields (product_info table, product_id field , etc)
    - Added ExistenceConfidence back into MapUnitPoints and MapUnit lines fc
- These changes allow use of GeMS Validation and Editing tools

… but keeps the goodness of AK GeMS …

- Thematic structure and additional fcs (OverlayPolys, StructureLines, CartographicPoints, lookup tables, etc)
- Extended fields (Category, LocationConfidence, LocationConfidenceMethod, DataSourceMethod, SourceBibRef, etc)
- Domain values and Glossary definitions (cites to AGI Glossary)
- Data Dictionary excel table for "one-stop" explanations and examples
- AK GeMS style file system (with additional symbols and symbol documentation)

MT GeMS extension

...with a few Montana specific additions

- Lookup table for "standard" map unit abbreviations based on age

FGDCRefernceNumber	StratigraphicAge	MapUnitAgeAbbreviation	FGDCGeoAgeLabel	KeyboardPosition	SubdivisionType
32.01	Cenozoic	CZ	{	left curly bracket = shift–left square bracket	Era
32.02	Quaternary	Q	Q	No keyboard substitution needed	Period
32.03	Tertiary	T	T	No keyboard substitution needed	Period
32.04	Neogene	N	N	No keyboard substitution needed	Subperiod
32.05	Paleogene	PE	:	colon = shift–semi-colon	Subperiod
32.06	Mesozoic	MZ	}	right curly bracket = shift–right square bracket	Era
32.07	Cretaceous	K	K	No keyboard substitution needed	Period
32.08	Jurassic	J	J	No keyboard substitution needed	Era
32.09	Triassic	TR	^	caret = shift-6	Period
32.01	Paleozoic	PZ	|	vertical line = shift-backslash	Era
32.11	Permian	P	P	No keyboard substitution needed	Period
32.12	Carboniferous	C	C	No keyboard substitution needed	Period
32.13	Pennsylvanian	IP	*	asterisk = shift-8	Period
32.14	Mississippian	M	M	No keyboard substitution needed	Period
32.15	Devonian	D	D	No keyboard substitution needed	Period
32.16	Silurian	S	S	No keyboard substitution needed	Period
32.17	Ordovician	O	O	No keyboard substitution needed	Period
32.18	Cambrian	CB	_	underscore = shift-hyphen	Period
32.19	Precambrian	pCB	=	equal sign	Era
32.20	Proterozoic	PR	<	"less than" sign = shift-comma	Eon
32.21	Late Proterozoic	Z	Z	No keyboard substitution needed	Era

MT GeMS extension

...with a few Montana specific additions

- Lookup table for map unit abbreviations based on age

- Lookup table for FGDC Symbol codes and Glossary Definitions*

Symbol * ▲	Category	Type	ExistenceConfidence	IdentityConfidence	LocationConfidence	Default24kLocationCo...	Default50kLocationCo...	Default100kLoc
01.01.01	contact	contact, generic	certain	certain	accurate	25	50	100
01.01.02	contact	contact, generic	questionable	questionable	accurate	25	50	100
01.01.03	contact	contact, generic	certain	certain	approximate	50	100	200
01.01.04	contact	contact, generic	questionable	questionable	approximate	50	100	200
01.01.05	contact	contact, generic	certain	certain	inferred	120	250	500
01.01.06	contact	contact, generic	questionable	questionable	inferred	120	250	500

Value	GlossaryDefinition	DataSource
absolute	Age assignment is based on radiometric dating.	AK GeMS Data Dictionary
accurate	Indicates that the author is reasonably confident in the location of the feature, and the feature is accura...	AK GeMS Data Dictionary
approximate	Indicates that the author is somewhat confident in the location of the feature, and the feature is approx...	AK GeMS Data Dictionary
basemap data	Basemap data such as topographic maps, imagery, or elevation data.	AK GeMS Data Dictionary
basin	As defined in the AGI Glossary of Geology, see term "basin".	AGI Glossary of Geology
basin, generic	As defined in the AGI Glossary of Geology, see term "basin".	AGI Glossary of Geology
bedding	As defined in the AGI Glossary of Geology, see term "bed [stratig]".	AGI Glossary of Geology
bedding, contorted	As defined in the AGI Glossary of Geology, see term "convolute lamination".	AGI Glossary of Geology
bedding, crenulated	As defined in the AGI Glossary of Geology, see term "bed [stratig]" and modified by term "crenulation".	AGI Glossary of Geology
bedding, crossbedded	As defined in the AGI Glossary of Geology, see term "cross-bedding".	AGI Glossary of Geology

* MBMG uses custom script to pull necessary glossary values for final database delivery, including values in non-GeMS fields (Category, DataSourceMethod, etc.). MBMG databases have two glossary tables – Glossary (just GeMS field definitions) and GlossaryFull (all values used in database).

MT GeMS extension

...with a few Montana specific additions

- Lookup table for map unit abbreviations based on age
- Lookup table for FGDC Symbol codes and Glossary Definitions*
- GeochemPoints feature class

Category	Type	Symbol	Label	ObservedMapUnit	FieldSampleID	MBMGID	MBMGURL	TASDesignation	LocationConfidence
geochem	geochem, whole-rock	mt.102.01	KCS-16-17	Keml	KCS-16-17	MBMG-KCS-16-BNM-03	https://data.mbmg.mtech.edu/collections/Vie	basaltic trachyandesite	accurate
geochem	geochem, whole-rock	mt.102.01	KCS-16-34	Keml	KCS-16-34	MBMG-KCS-16-BNM-17	https://data.mbmg.mtech.edu/collections/Vie	basaltic trachyandesite	accurate
geochem	geochem, whole-rock	mt.102.01	KCS-16-45	Keml	KCS-16-45	MBMG-KCS-16-BNM-28	https://data.mbmg.mtech.edu/collections/Vie	basaltic andesite	accurate
geochem	geochem, whole-rock	mt.102.01	KCS-16-33	Keml	KCS-16-33	MBMG-KCS-16-BNM-16	https://data.mbmg.mtech.edu/collections/Vie	trachyandesite	accurate
geochem	geochem, whole-rock	mt.102.01	KCS-16-46	Kei	KCS-16-46	MBMG-KCS-16-BNM-29	https://data.mbmg.mtech.edu/collections/Vie	<Null>	accurate
geochem	geochem, whole-rock	mt.102.01	KCS-16-12	Kat	KCS-16-12	MBMG-KCS-16-BNM-02	https://data.mbmg.mtech.edu/collections/Vie	basaltic trachyandesite	accurate

MBMG *Montana Bureau of Mines and Geology*

ABOUT MBMG   MONTANA GEOLOGY   WATER & ENVIRONMENT   MAPS, DATA, & PUBLICATIONS   MINERAL MUSEUM

MONTANA TECHNOLOGICAL UNIVERSITY

Sample Information   General Age & Geochronology Report   Geochemistry Report

MBMG-KCS-16-BNM-03 KCS-16-17

Geochemistry Report	
TAS_designation	Basaltic Trachyandesite
SiO2	51.43
TiO2	0.86
Al2O3	14.46
FeO_Total	7.89
MnO	0.13
MgO	4.87

MT GeMS extension

...with a few Montana specific additions

- Lookup table for map unit abbreviations based on age

- Lookup table for FGDC Symbol codes and Glossary Definitions*

- GeochemPoints feature class

- Added more options to location confidence lookup table
    - Used to populate LocationConfidenceMeters field when LocationConfidenceMethod = "generalized" and author inputs or calculates text value into LocationConfidence field (accurate, approximate, inferred)

ScaleDenom	AccurateMin	AccurateDefault	AccurateMax	ApproximateMin	ApproximateDefault	ApproximateMax	InferredMin	InferredDefault	InferredMax
24000	0	25	25	26	50	50	51	120	<Null>
50000	0	50	50	51	100	100	101	250	<Null>
100000	0	100	100	101	200	200	201	500	<Null>
500000	0	254	254	255	508	508	509	<Null>	<Null>

Table 1. Example picklist of values for the LocationConfidenceMeters field.

[Abbreviations: DEMs, digital elevation models; GPS, global positioning system; m, meter(s); NAIP, National Agriculture Imagery Program]

Example value (m)	Comments
5	Appropriate for well-defined features located in the field by clear-sky GPS, by inspection of high-resolution topography (for example, 1- or 2-m-resolution lidar DEMs), or by inspection of large-scale, well-rectified digital orthophotographs (for example, NAIP images)
25	Reasonable for locations established by inspection of 1:24,000-scale maps, or for "accurately located" features digitized from 1:24,000-scale paper source maps
50	May be appropriate for some "approximately located" lines on 1:24,000-scale maps; other "approximately located" lines on the same map may have values of 100 m or more
100	Appropriate for "accurately located" features digitized from 1:100,000-scale paper source maps
250	Appropriate for "accurately located" features digitized from 1:250,000-scale paper source maps, or when a geologist, working at 1:24,000 scale, says, *"My confidence in locating this feature is exceptionally low"*

MT GeMS extension

...with a few Montana specific additions

- Lookup table for map unit abbreviations based on age
- Lookup table for FGDC Symbol codes and Glossary Definitions*
- GeochemPoints feature class
- Added more options to location confidence lookup table
- Added domain values and glossary definitions, documented in MT GeMS data dictionary

Domains Coded Values tab in MT GeMS data dictionary

geol_pts_type_dom	Geologic points type coded domain.	
Code	**Description**	**Glossary Definition**
700	natural resources, generic	Natural assets (raw materials such as minerals, oil, forests, water, air, wind, and fertile land) occurring in nature that can be used for economic production or consumption.
701	natural resources, prospect	As defined in the AGI Glossary of Geology, see term "prospect hole".
702	natural resources, pit	As defined in the AGI Glossary of Geology, see term "pit [geol]".
703	natural resources, adit	As defined in the AGI Glossary of Geology, see term "adit".

Glossary tab in MT GeMS data dictionary

Value	GlossaryDefinition	DataSource	Lineage (where did term originally appear)
field analysis	Measurement taken in the field using handheld instruments.	MT GeMS Data Dictionary	Custom wording included in MT GeMS Data
field analysis, magnetic susceptibility	The degree to which a material can be magnetized in an external magnetic field. The measurement is taken in the field using a handheld Kappameter KM-7.	MT GeMS Data Dictionary	Custom wording included in MT GeMS Data Dictionary
field mapping	Field Mapping data, sketches, report, and notes.	AK GeMS Data Dictionary	Custom wording included in DGGS MP170 (Hendricks and others, 2021)

MT GeMS extension

...with a few Montana specific additions

Compound FGDC tab in MT GeMS symbology documentation

Symbol Type	First Symbol Code (fault, fold, etc.)	Second Symbol Code (decoration, etc.)	Symbol Code (firstcode.secondcode)	Picture	Feature Class	Category	Type	Feature Description
MT GeMS Custom	02.08.07	02.02.07	02.08.07/02.02.07		ContactsAndFaults	fault	fault, thrust	Thrust fault reactivated as normal fault—Identi certain, location concealed. Symbols on hangin
AK GeMS Custom	02.08.08	02.13.14	02.08.08/02.13.04		ContactsAndFaults	fault	fault, thrust	Thrust fault—Identity or existence questionable concealed. Displacement during Quaternary tin (undifferentiated).
MT GeMS Custom	05.01.01	05.10.05	05.01.01/05.10.05		StructureLines	fold	fold, anticline	Plunging anticline—Identity and existence certa accurate. Large arrowhead shows direction of
MT GeMS Custom	05.01.01	05.10.06	05.01.01/05.10.06		StructureLines	fold	fold, anticline	Doubly plunging anticline—Identity and existen location accurate. Large arrowheads show dire

- Added symbols and descriptions to MT GeMS style file and symbol documentation

Custom Symbols NO FGDC Section tab in MT GeMS symbology documentation

Symbol Type	Section	Subsection	Symbol Code	Picture	Feature Class	Category	Type	Feature Description
MT GeMS Custom	mt	mt.101 — geochron	mt.101.01		GeochronPoints	geochron	geochron, U-Pb	Sample analyzed by U-Pb geochronology method.
MT GeMS Custom	mt	mt.101 — geochron	mt.101.02		GeochronPoints	geochron	geochron, K-Ar	Sample analyzed by K-Ar geochronology method.
MT GeMS Custom	mt	mt.101 — geochron	mt.101.03		GeochronPoints	geochron	geochron, 40Ar/39Ar	Sample analyzed by 40Ar/39Ar geochronology method.
MT GeMS Custom	mt	mt.101 — geochron	mt.101.04		GeochronPoints	geochron	geochron, fission-track	Sample analyzed by fission-track geochronology method.
MT GeMS Custom	mt	mt.102 — geochem	mt.102.01		GeochemPoints	geochem	geochem, whole-rock	Sample analyzed by geochemical whole-rock method.
MT GeMS Custom	mt	mt.103 — field analysis	mt.103.01		GeologicPoints	field analysis	field analysis, magnetic susceptibility	The degree to which a material can be magnetized in an external magnetic field. The measurement is taken in the field using a handheld Kappameter KM-7.

MBMG Single Geologic Map Production Process

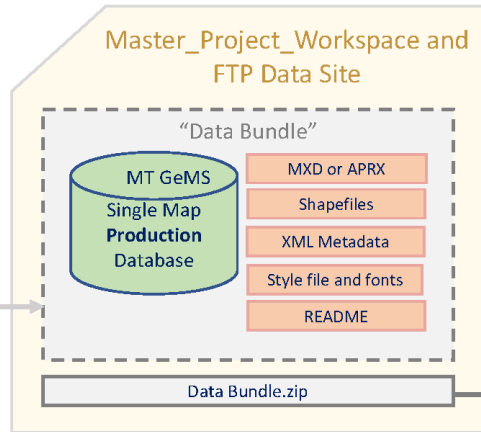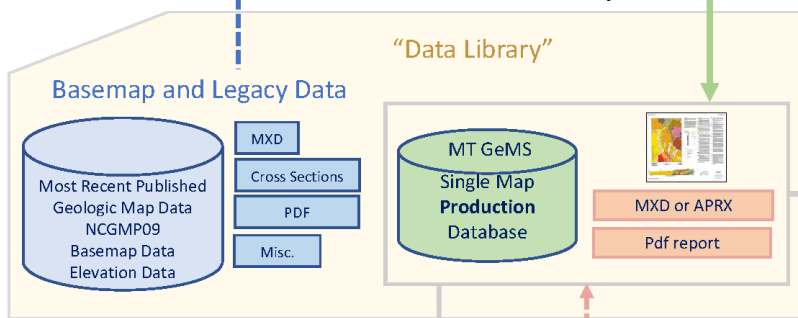**1** Fieldwork

Data Production

2 "Working Folders"

- APRX
- Temp fcs

MT GeMS
Single Map **Production** Database

- Author Review/Editing
- Validate QA/QC

View or Import

3 Review

Draft maps and geologic review

GIS files ready to publish

4 QA/QC

Cartography

5

Publication Team Cartography Workflow

- Pdf report
- Supplemental Spreadsheets

To NGMDB Map Catalog

Publication

6

Publication Web Page
(public distribution)

Basemap and Legacy Data

Most Recent Published Geologic Map Data NCGMP09 Basemap Data Elevation Data

- MXD
- Cross Sections
- PDF
- Misc.

"Data Library"

MT GeMS
Single Map **Production** Database

- MXD or APRX
- Pdf report

Package

Master_Project_Workspace and FTP Data Site

"Data Bundle"

MT GeMS
Single Map **Production** Database

- MXD or APRX
- Shapefiles
- XML Metadata
- Style file and fonts
- README

Data Bundle.zip

Package
(STATEMAP Projects only)

STATEMAP Deliverables folder

Federal GeMS Submission Package

MT GeMS
Single Map **Production** Database

- Pdf report
- MXD or APRX

- Checklist
- XML Metadata
- Shapefiles
- Transmission letter
- Validation Reports
- Style file and fonts

Federal GeMS Submission Package.zip

NGMDB Connect portal
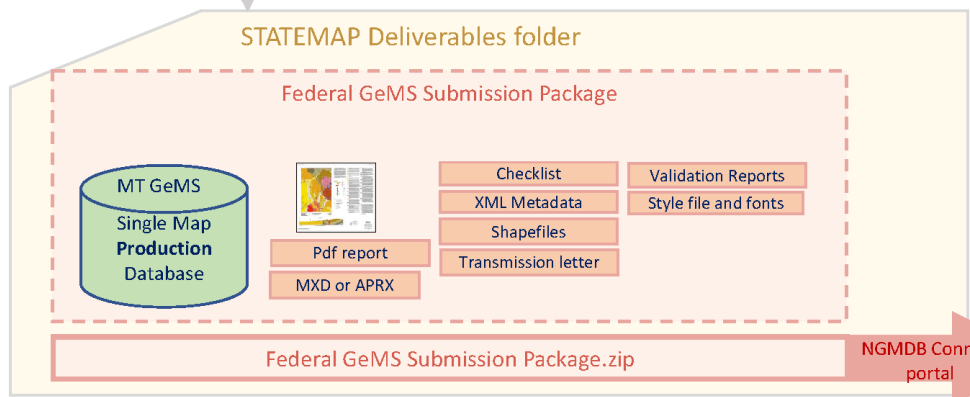
Corrections from GeMS QC team

To USGS

Field Data Collection

In the field

- Field Notebooks

- Paper and Mylar

- iPhone and FieldMove Clino

FieldMove Clino 4+
Petroleum Experts Limited
Designed for iPhone
★★★★☆ 4.2 • 13 Ratings
Free

  - Collect orientation points, photos and photo points, and note points
  - Clino allows for upload of georeferenced maps and topos from other programs
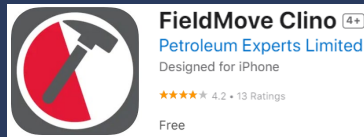
On return from field

- Export points as multiple excel files and folder of photos

- Note points and orientation points added directly into Pro

- Photos are added individually as attachments

  Is there a better way to do this?
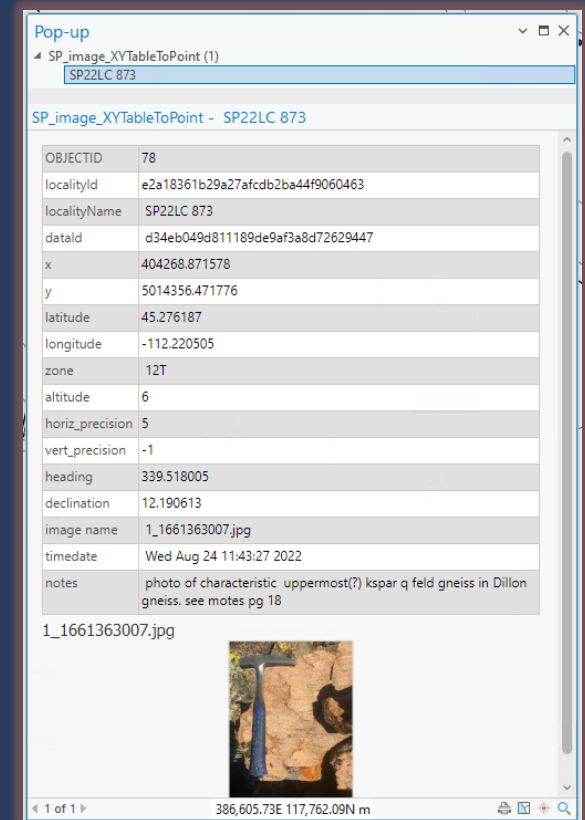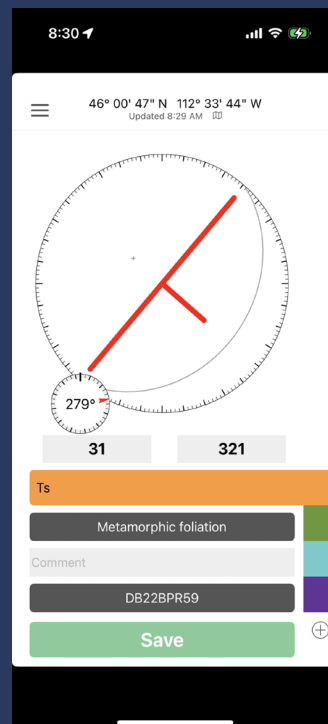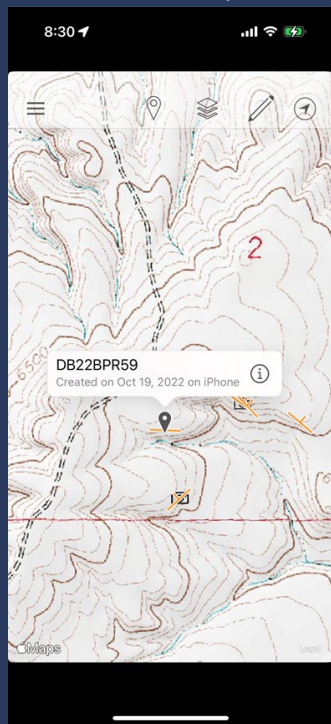
Data Production

Feature Creation

- Point tables from FieldMove Clino merged with GeMS fc to make "temp" fc

- Lines and points digitized from mylars or created directly by geologists

- Symbol code defaults allow for default values using template or can be populated later

- Create and Edit ContactsAndFaults and MapUnitPoints, generate temp MapUnitPolys
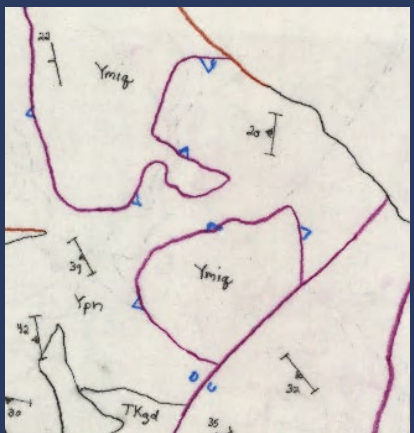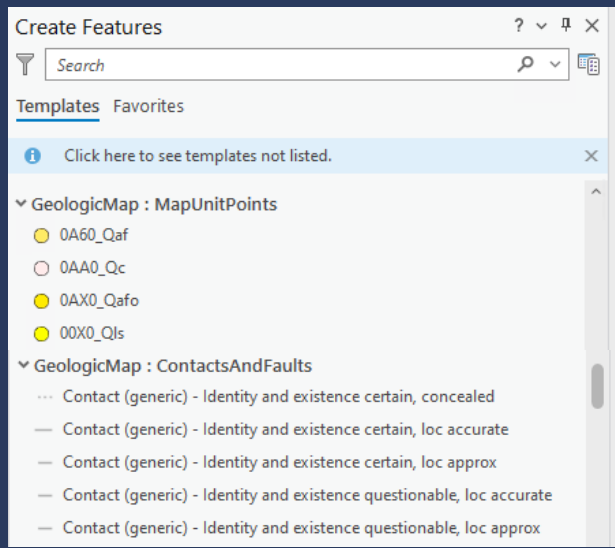
Symbology

- Symbol codes refer to MT GeMS Symbology style file

- CMYK color codes useful but difficult for statewide mapping
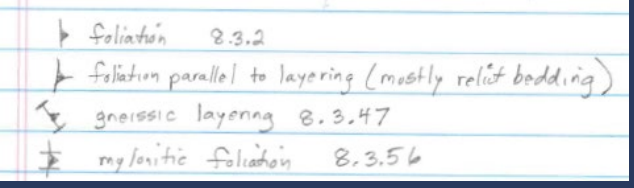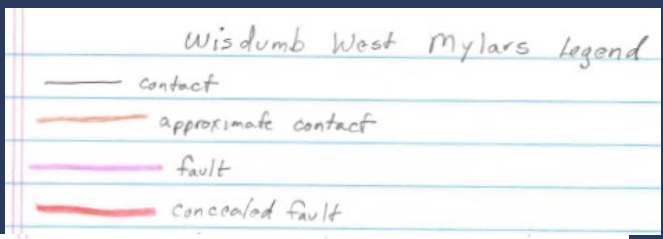
Geologic Review

- Paper map is reviewed and approved prior to or coincident with QC steps

Data Quality and Validation

- Topology check – valid errors noted for GeMS submission letter

- Unsplit and Planarize ContactsAndFaults (AK GeMS tool)
    - Careful with unsplit
    - Planarize can sometimes create very short lines

- Rebuild MapUnitPolys

- Check attribute values, build Author Review Checklist

- Archive working database, remove empty fcs and temp fcs

- Validate Database (GeMS tool)

- Geologic Names Check (GeMS tool)

- Author final edits

- Final clean up of attributes

- Build and populate two Glossary tables

- Edit project specific metadata

- Validate Database (GeMS tool)

Before unsplit
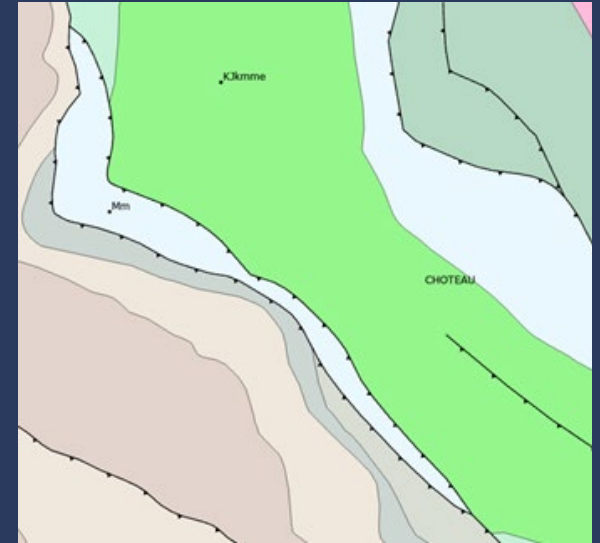
After unsplit
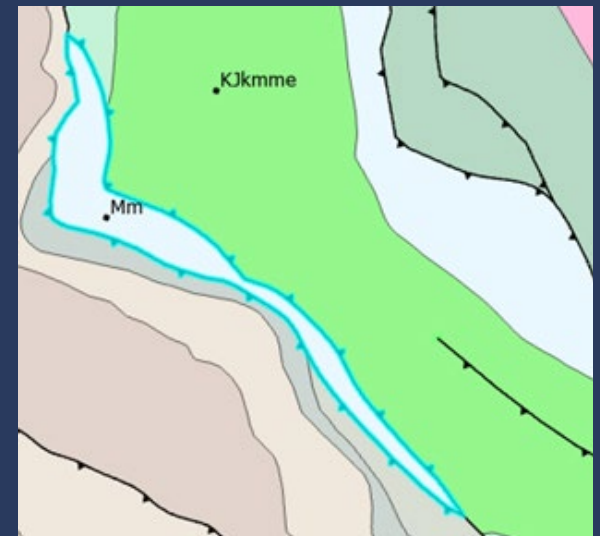
Cartography

- Symbolize and Label features

- Export to AIX (character markers as polygons)

- Symbol clean-up and Layout done in Adobe Illustrator by Cartographer

- Drafts approved by author and sent to review, approved by Director

- Final map created from final GIS data

- Publication team creates publication number
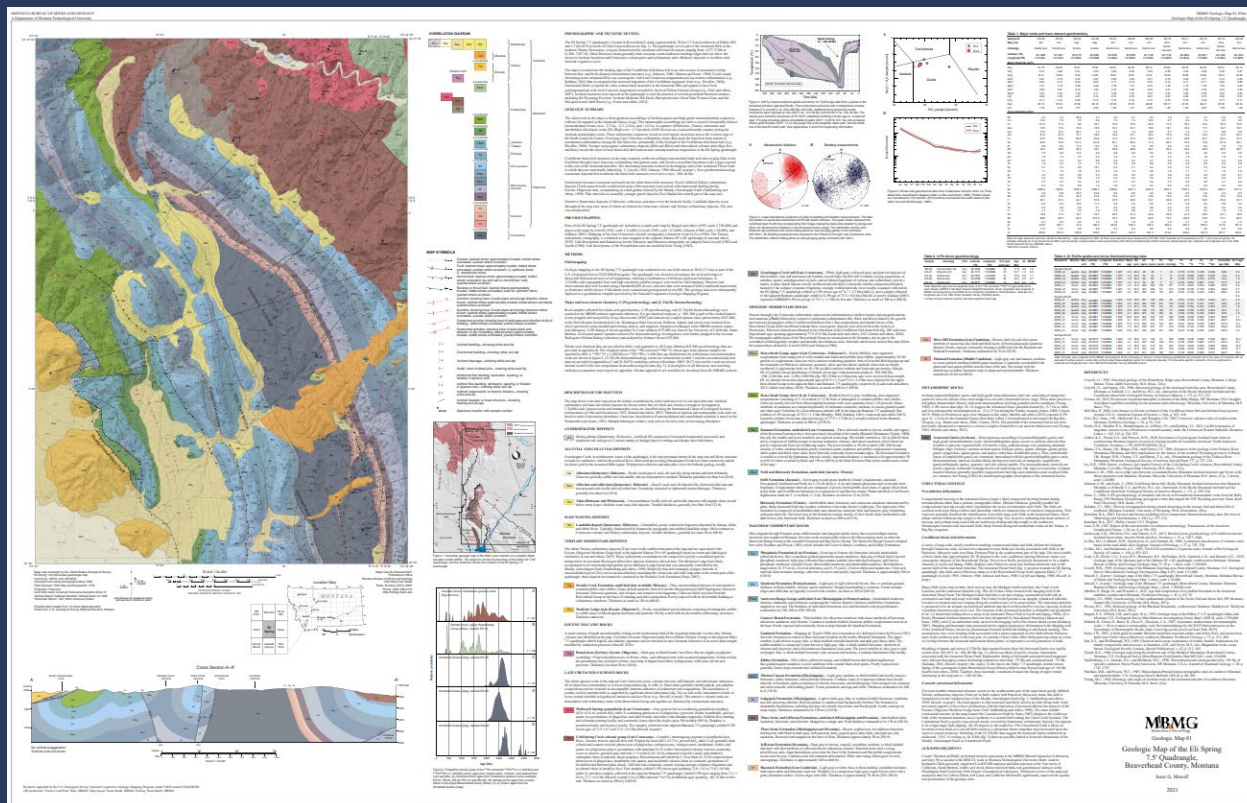
Publication

Cartographic products

- Publication team uploads pdf map, pdf report and appendices to MBMG website

- Publication team uploads pdf map to NGMDB catalog with link to MBMG website

GIS products

- Package MBMG Data Bundle
  - to MBMG website through FTP site

- Package for USGS delivery
  - deliver via Connect Portal

MasterProjectWorkspace and FTP Data Site

"Data Bundle"

- MT GeMS Single Map **Production** Database
- MXD or APRX
- Shapefiles
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Federal GeMS Submission Package.zip

NGMDB Connect portal → To USGS

Ongoing Efforts for Statewide Mapping

Updated 500k Seamless Geology of Montana

- Updated ContactsAndFaults and MapUnitPolys

- Updated stratigraphic chart and unit descriptions

Upcoming 100k Surficial Deposits Compilation

- Add glacial, gravel and landslide deposits to 100k seamless geologic mapping

- Pilot project of four 100k quads as proof of concept
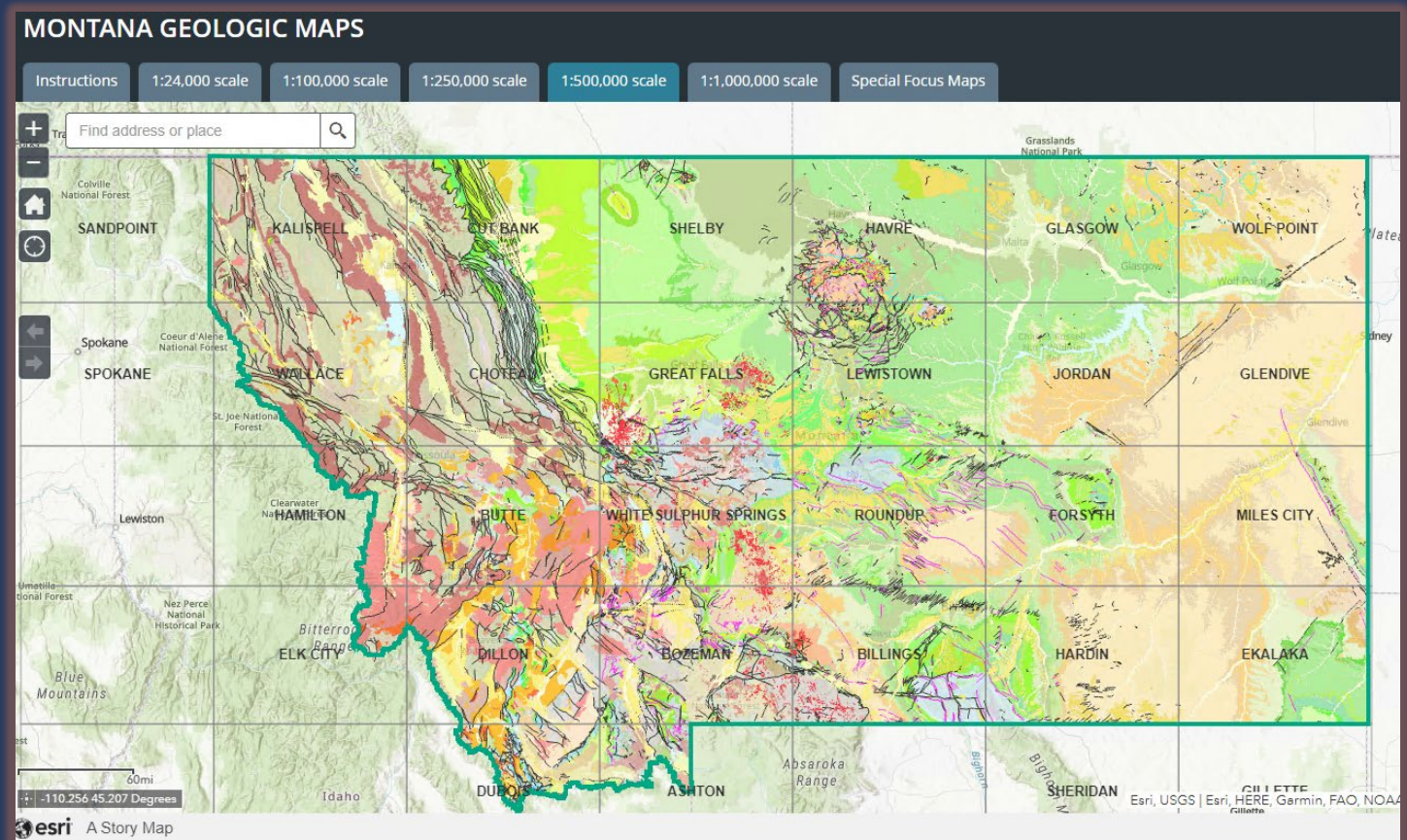
GIS Tips and Tricks

GIS education and training