

# An interactive, literature-integrated digital crust in support of critical minerals assessment

Daven P. Quinn<sup>1</sup>, Shanan E. Peters<sup>1</sup>, Shivaram Venkataraman<sup>2</sup>, Brian Bockelman<sup>3</sup>

1. Macrostrat, Dept. of Geoscience, University of Wisconsin–Madison
2. Dept. of Computer Science, University of Wisconsin–Madison
3. Morgridge Institute of Research, Madison, WI



# MACROSTRAT / UW-MADISON TEAM

## Department of Geoscience

*Project and system design*

- Daven Quinn, PI
- Shanan Peters, Co-PI

## Morgridge Institute of Research

*Infrastructure and software development*

- Brian Bockelman, Co-PI
- Cannon Lock
- Brian Aydemir

## Department of Computer Science

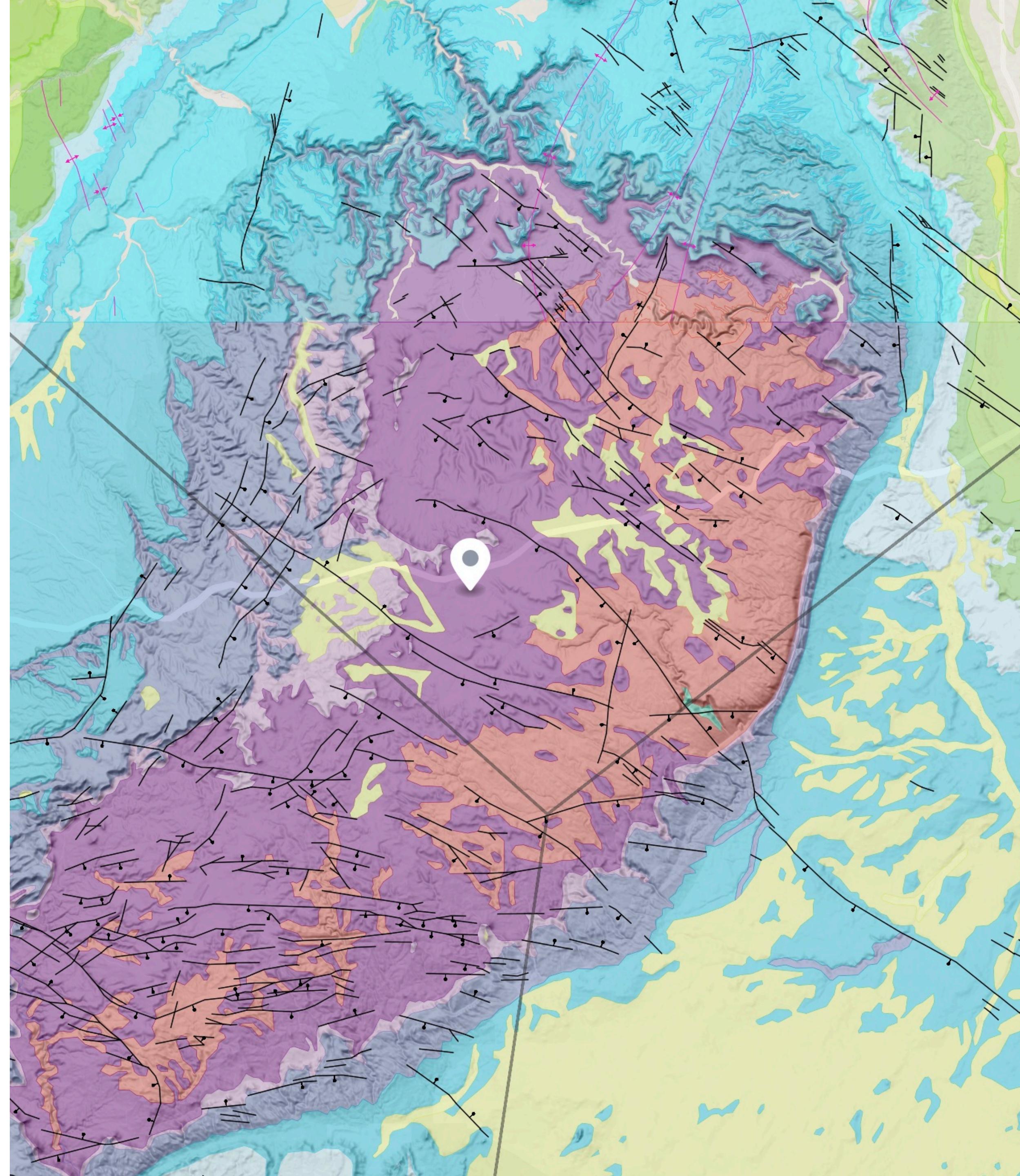
*xDD/Literature data extraction/Entity canonicalization*

- Shivaram Venkataraman, Co-PI
- Ian Ross, xDD lead



# MACROSTRAT

A quantitative,  
descriptive data  
system for  
geological  
information

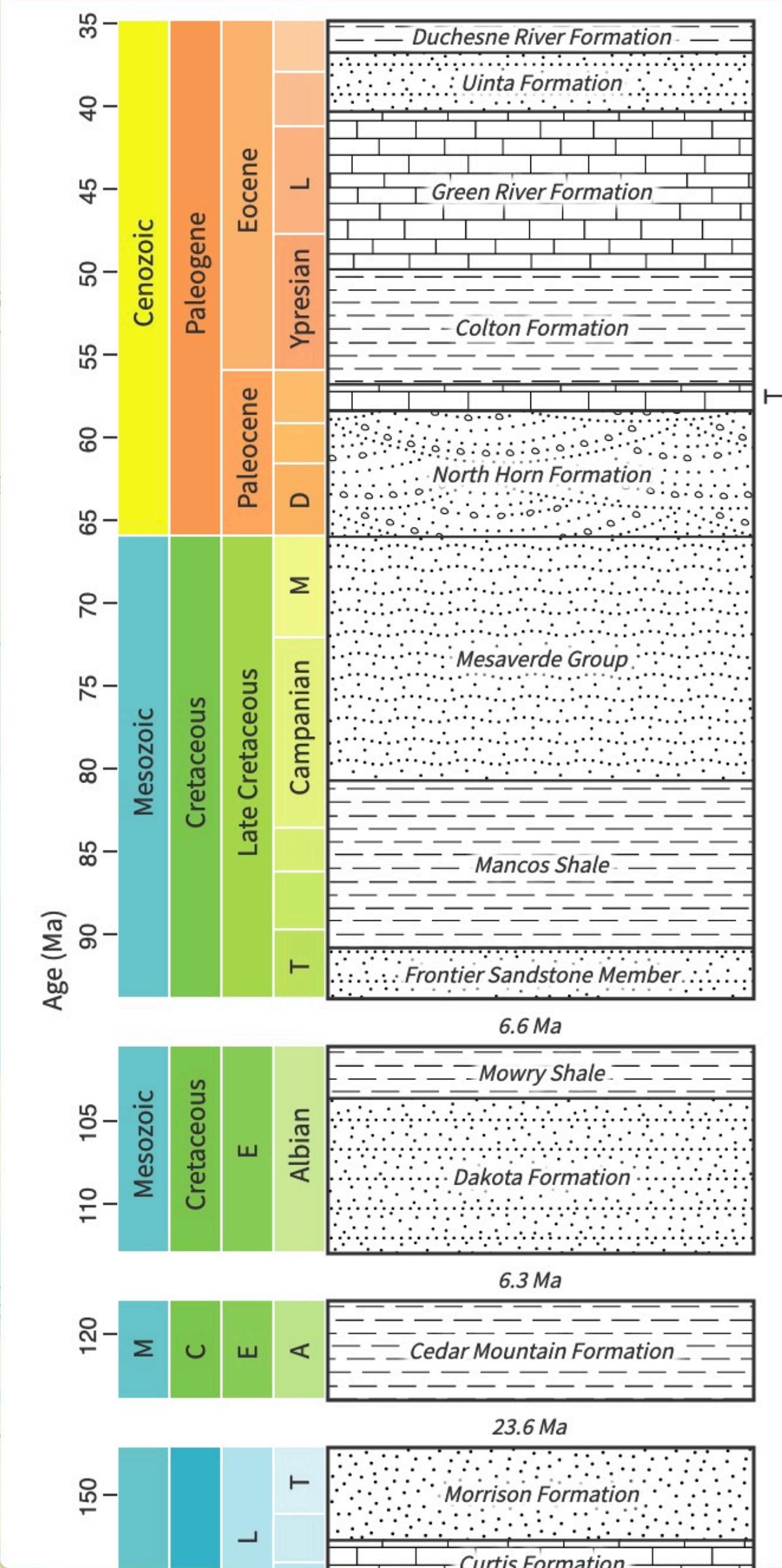


Copy link [🔗](#)

38.862° N, 110.691° W 2039 m (6690 ft) X

← Western Uinta Basin

502



10km

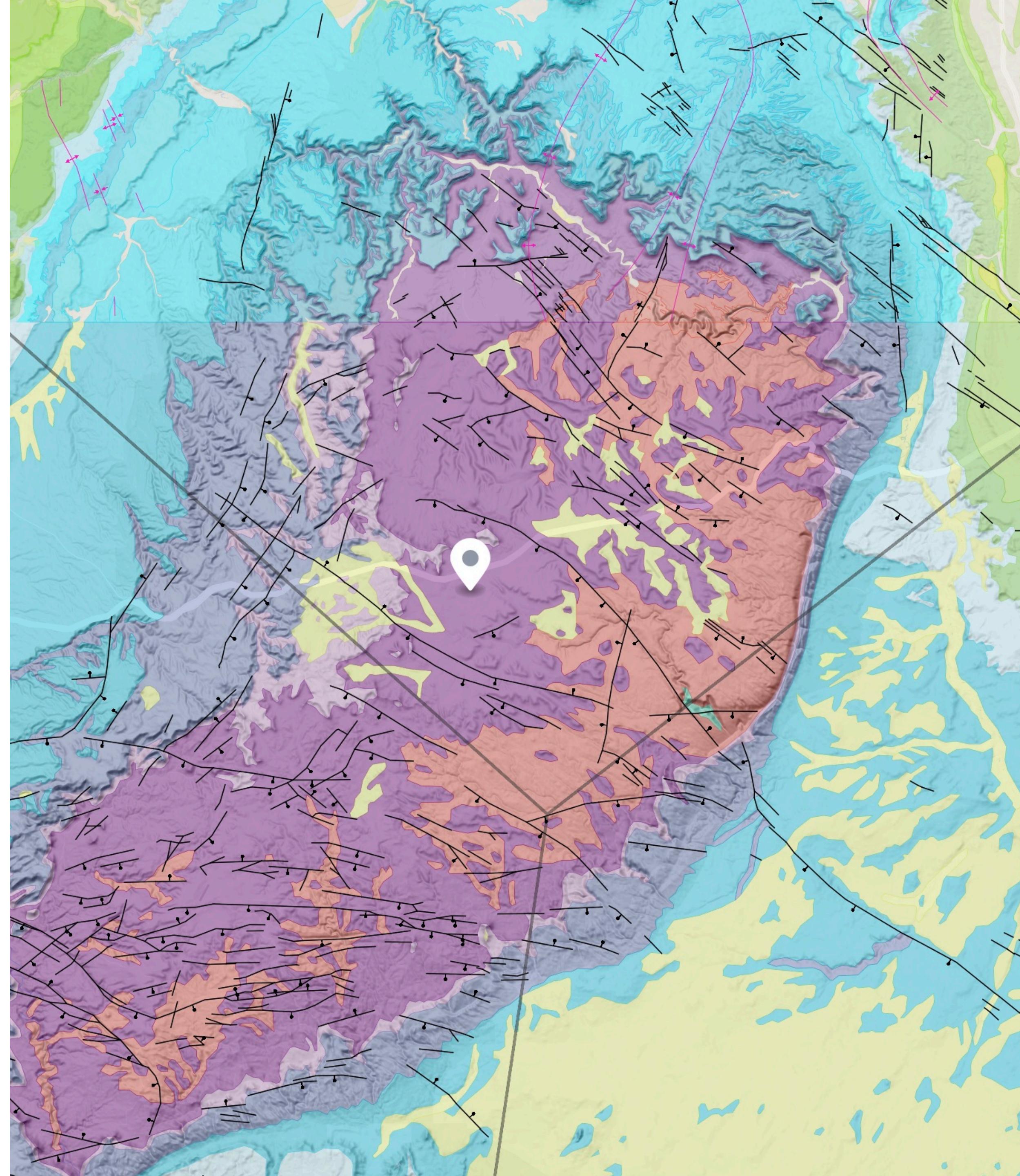
# MACROSTRAT

A quantitative,  
descriptive data  
system for  
geological  
information



# MACROMAAS

Macrostrat  
extended for  
Critical Minerals  
assessment

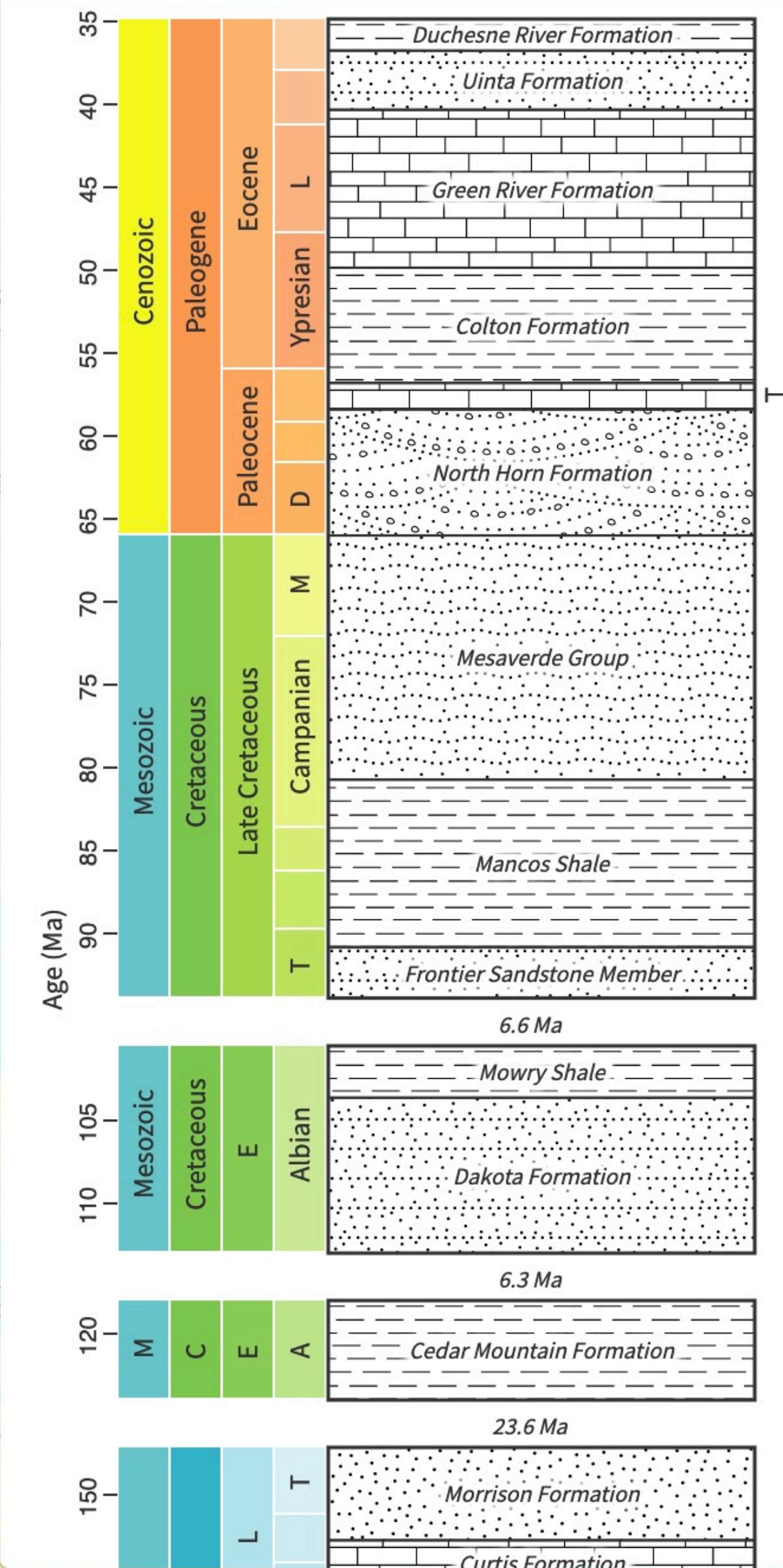


Copy link

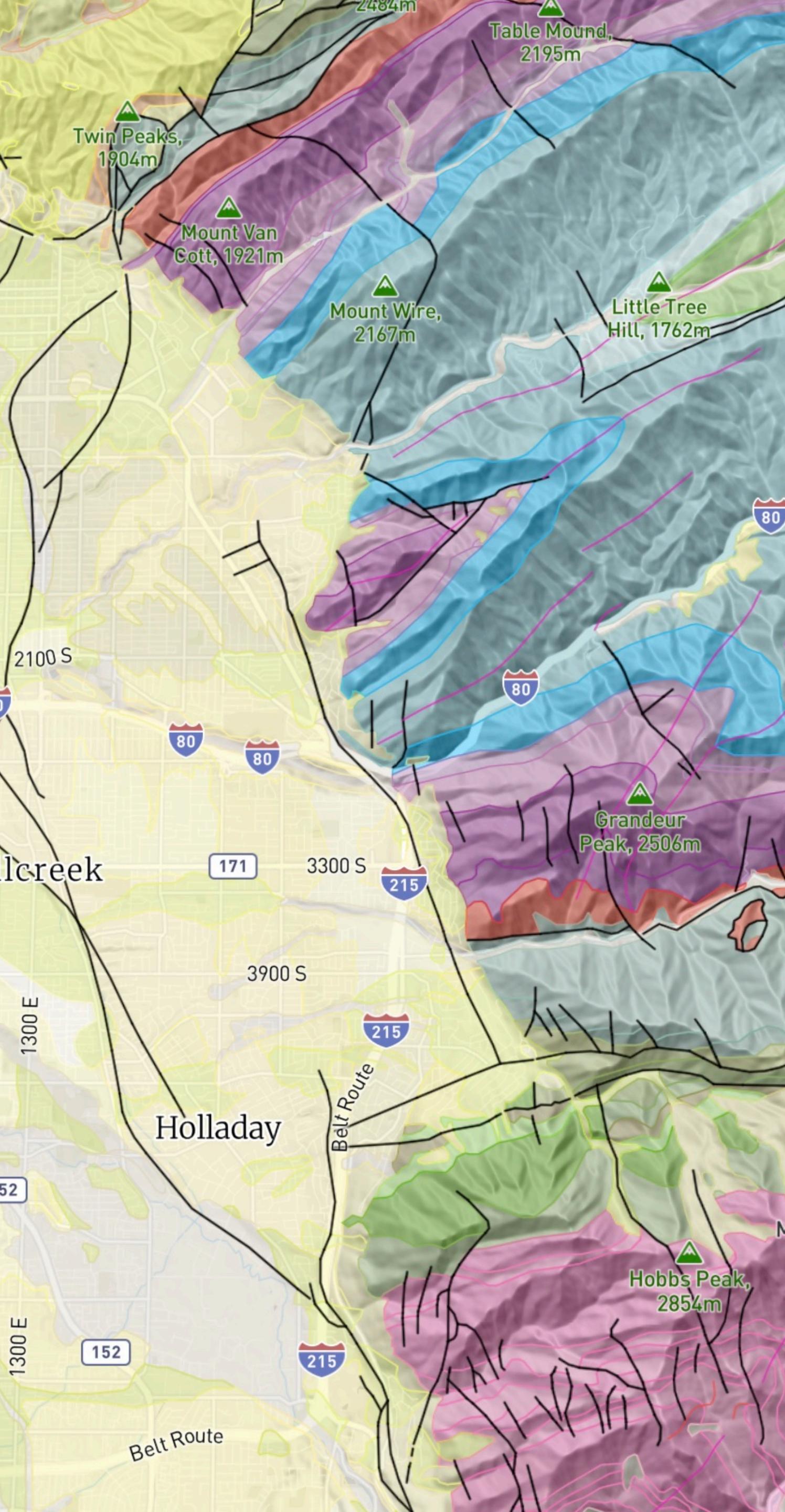
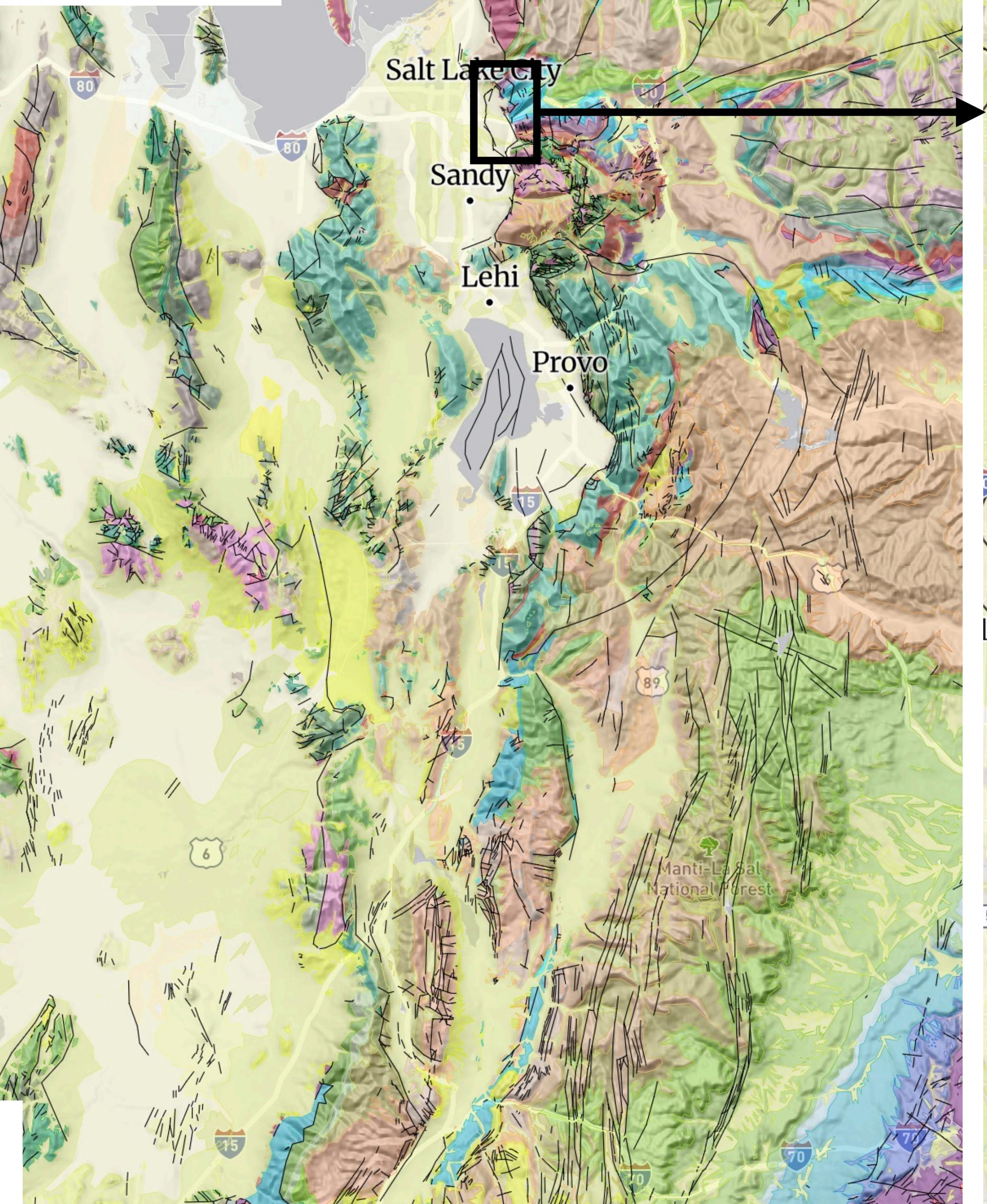
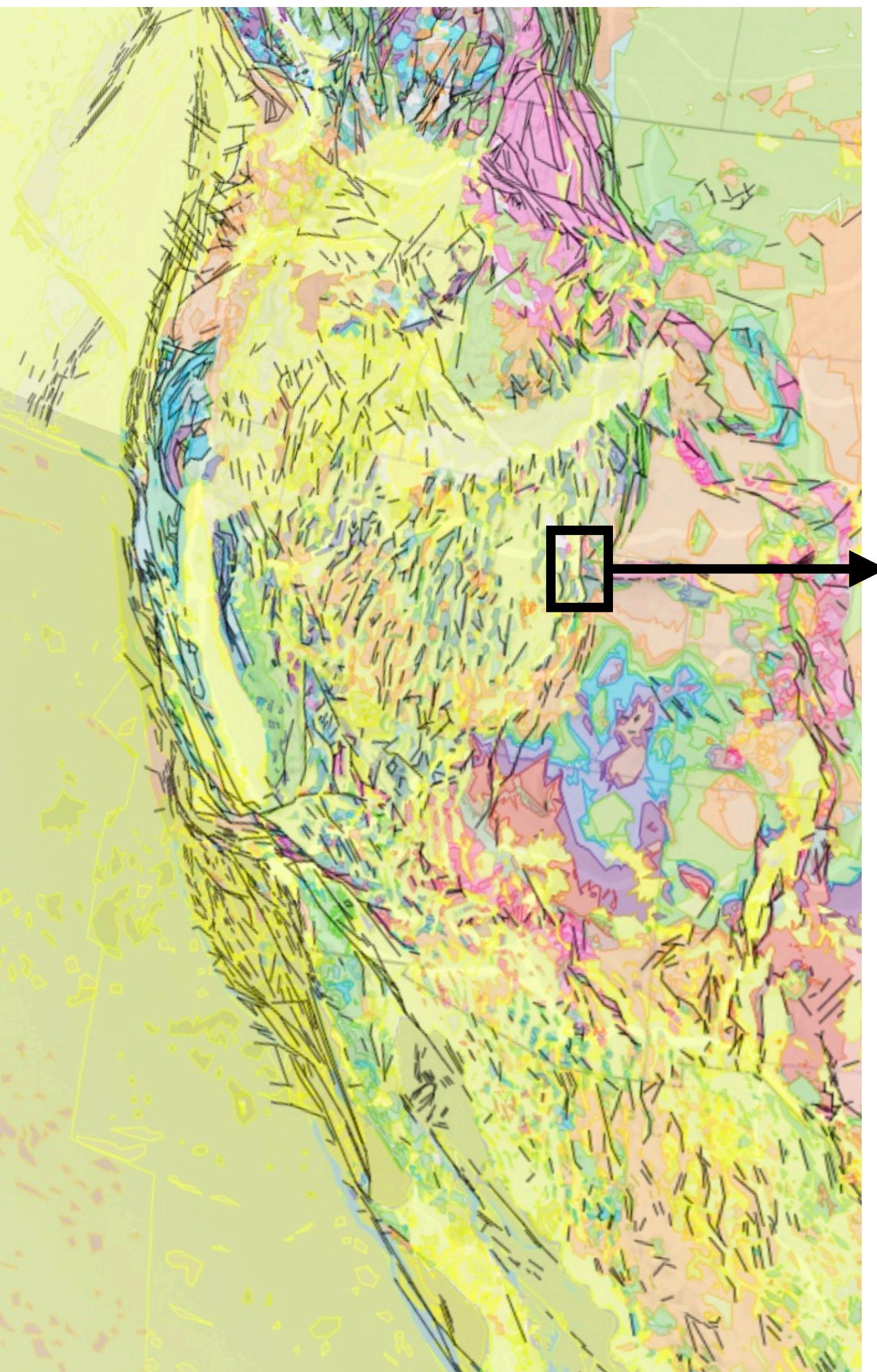
38.862° N, 110.691° W 2039 m (6690 ft) X

← Western Uinta Basin

502

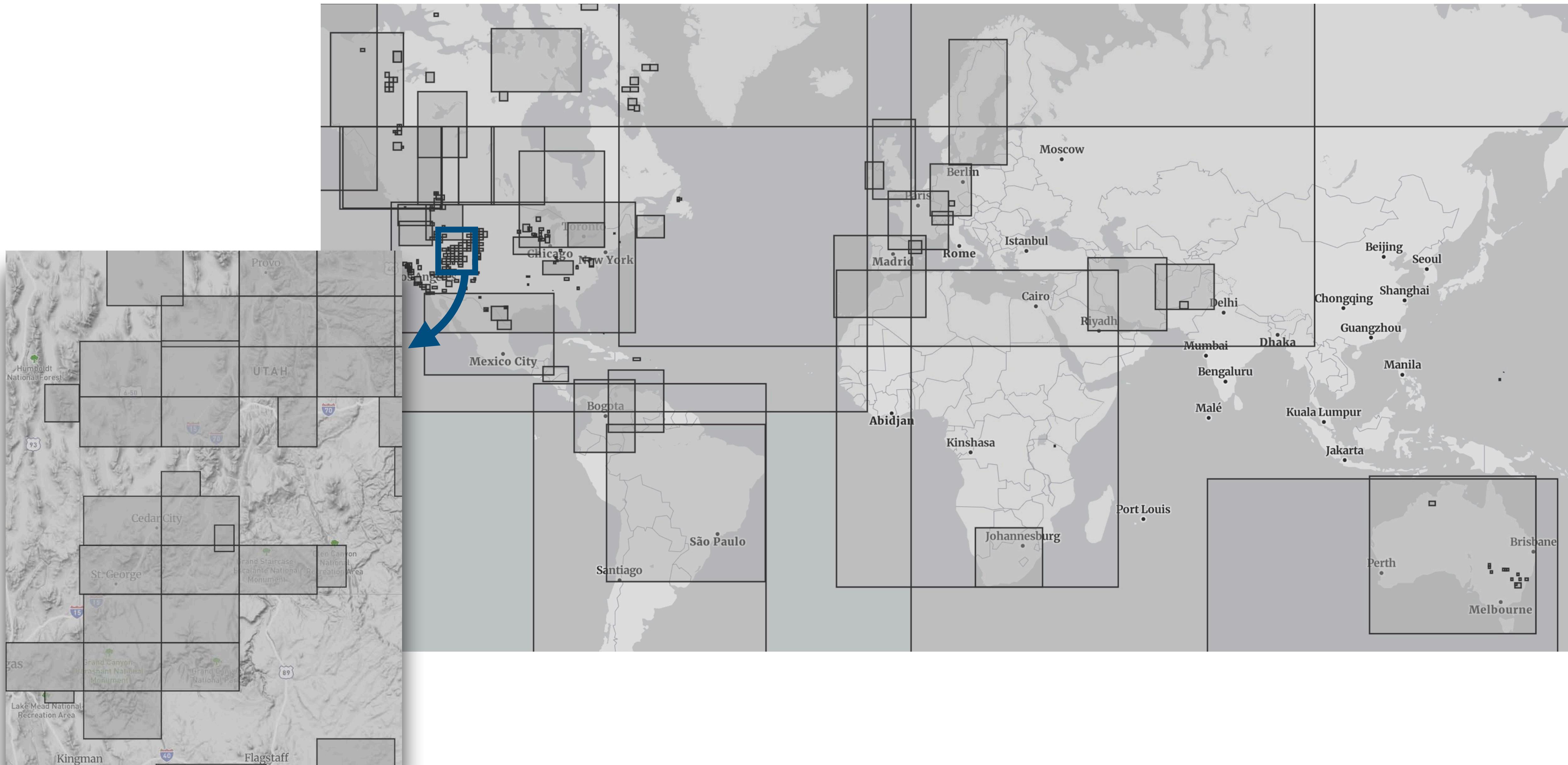


# MACROSTRAT'S GEOLOGIC MAP



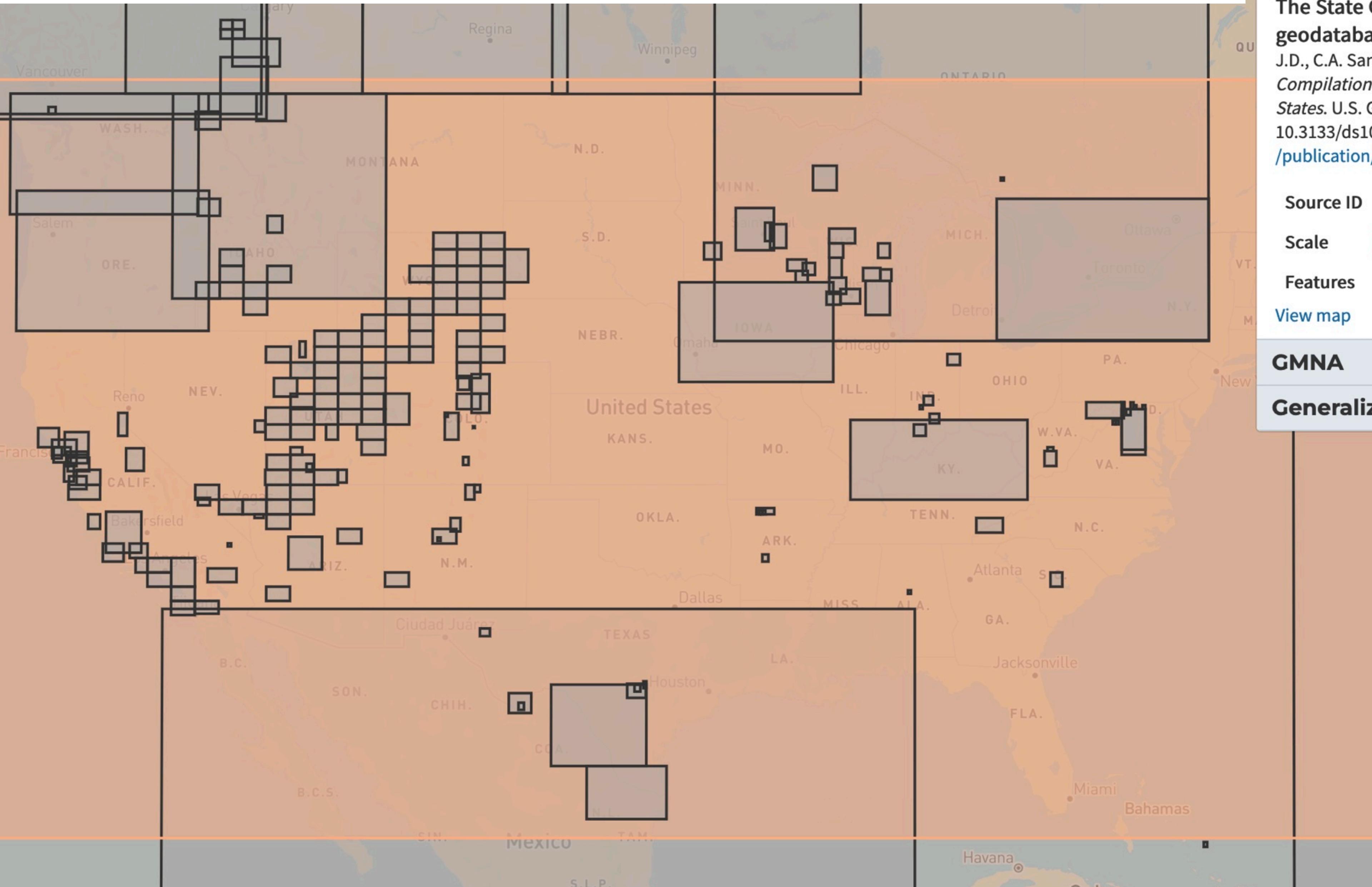
# MACROSTRAT'S GEOLOGIC MAP

MORE THAN 300 SOURCES



# Most maps are produced by USGS and state surveys

## USGS State Map Compilation: ~10% of map polygons

[Back](#)

Selected Sources

Options ^

### State Geologic Map Compilation

The State Geologic Map Compilation (SGMC) geodatabase of the conterminous United States Horton, J.D., C.A. San Juan, and D.B. Stoeser (2017). *The State Geologic Map Compilation (SGMC) geodatabase of the conterminous United States*. U.S. Geological Survey Data Series 1052. doi: 10.3133/ds1052. Retrieved from <https://pubs.er.usgs.gov/publication/ds1052>.

Source ID 133

Scale medium

Features 312304

[View map](#)

### GMNA

### Generalized Geology of the World

# Macrostrat's geologic map: Ingestion and harmonization

< Back      Selected Sources      Options ^

**South San Francisco** ^

Preliminary geologic map of the San Francisco South 7.5' quadrangle and part of the Hunters Point 7.5' quadrangle, San Francisco Bay area, California Bonilla, M.G. (1998). *Preliminary geologic map of the San Francisco South 7.5' quadrangle and part of the Hunters Point 7.5' quadrangle, San Francisco Bay area, California*. U.S. Geological Survey Open-File Report 98-354.. Retrieved from <http://pubs.usgs.gov/of/1998/of98-354/>.

Source ID 88

Scale large

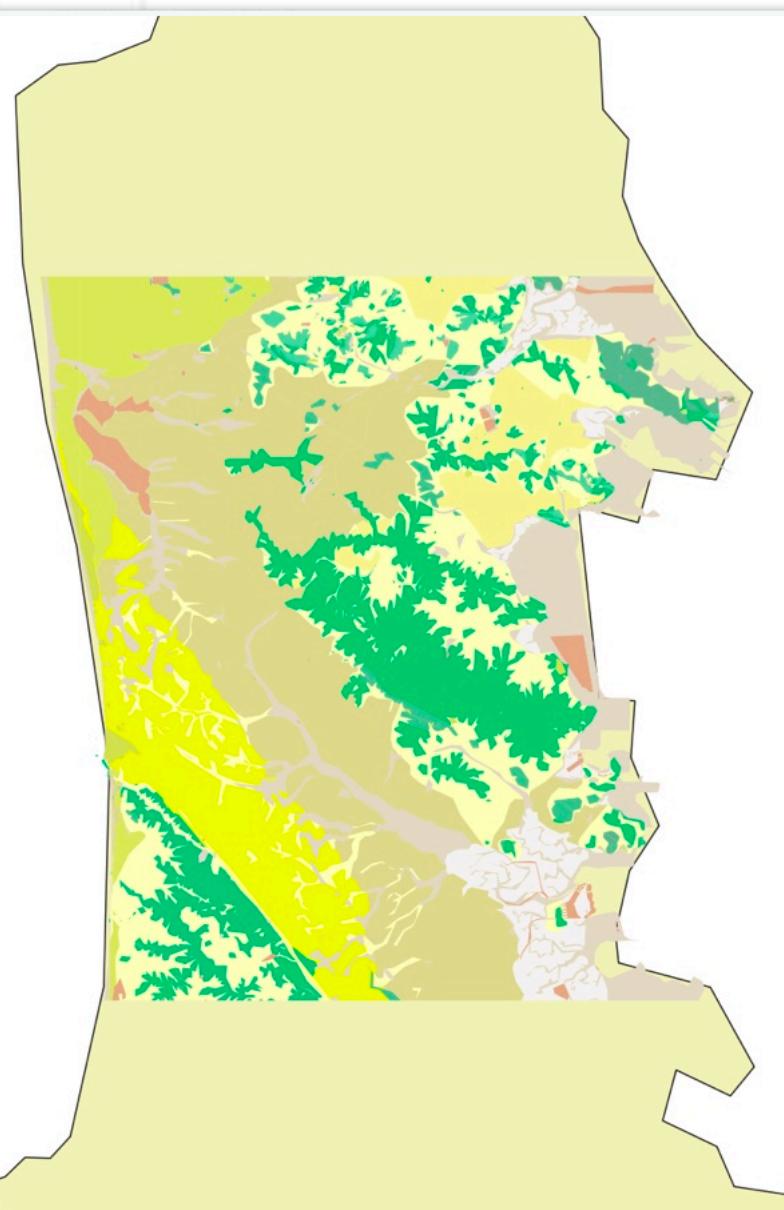
Features 1441

[View map](#)

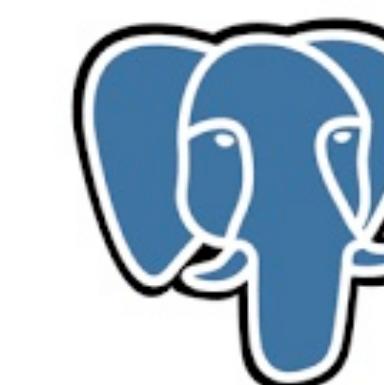
Starting point: a *vector* geologic map

# Macrostrat's geologic map: Ingestion and harmonization

d	ptype	age	early_id	late_id	name
4	Qya	Holocene and late Pleistocene	492	3	Young alluvia
5	Qoa	late to middle Pleistocene	502	492	Old alluvial fl
6	Qyc	Holocene and late Pleistocene	492	3	Young colluv
7	Qya	Holocene and late Pleistocene	492	3	Young alluvia
8	Qyf	Holocene and late Pleistocene	492	3	Young alluvia
9	Tcs	early Pliocene and late Miocene	488	489	Capistrano F
10	Tcs	early Pliocene and late Miocene	488	489	Capistrano F
11	Qls	Holocene and Pleistocene	4	3	Landslide de
		NULL	NULL	NULL	water
		Holocene and Pleistocene	4	3	Landslide de
		Holocene and late Pleistocene	492	3	Young colluv
		Holocene and Pleistocene	4	3	Landslide de
		Cretaceous	33	33	Heterogeneou
		Holocene and late Pleistocene	492	3	Young alluvia
		Holocene and Pleistocene	4	3	Landslide de
		early Pliocene and late Miocene	488	489	Capistrano F
		Holocene and Pleistocene	4	3	Landslide de
21	Qls	Holocene and Pleistocene	4	3	Landslide de



Map ingestion into open-source PostGIS geospatial database



PostgreSQL

Attributes are minimally cleaned

Unit names and age ranges are linked to common definitions

Manual ingestion assisted by Python scripts

# Geologic map sources are categorized into four scales and composited

The map shows the following geological features and sources:

- Bryce Canyon National Park**:
  - Digital Geologic Map of Bryce Canyon National Park and Vicinity, UtahNational Park Service Geologic Resources Evaluation program (2010). *Digital Geologic Map of Bryce Canyon National Park and Vicinity, Utah*. National Park Service.. Retrieved from <https://catalog.data.gov/dataset/digital-geologic-map-of-bryce-canyon-national-park-and-vicinity-utah-nps-grd-gri-brca-brca-digi>.
  - Source ID 53
  - Scale **large**
  - Features 409
- Panguitch, UT**:
  - State Geologic Map Compilation
  - The State Geologic Map Compilation (SGMC) geodatabase of the conterminous United StatesHorton, J.D., C.A. San Juan, and D.B. Stoeser (2017). *The State Geologic Map Compilation (SGMC) geodatabase of the conterminous United States*. U.S. Geological Survey Data Series 1052.doi: 10.3133/ds1052. Retrieved from <https://pubs.er.usgs.gov/publication/ds1052>.
  - Source ID 133
  - Scale **medium**
  - Features 312304
- GMNA**:
  - Generalized Geology of the World

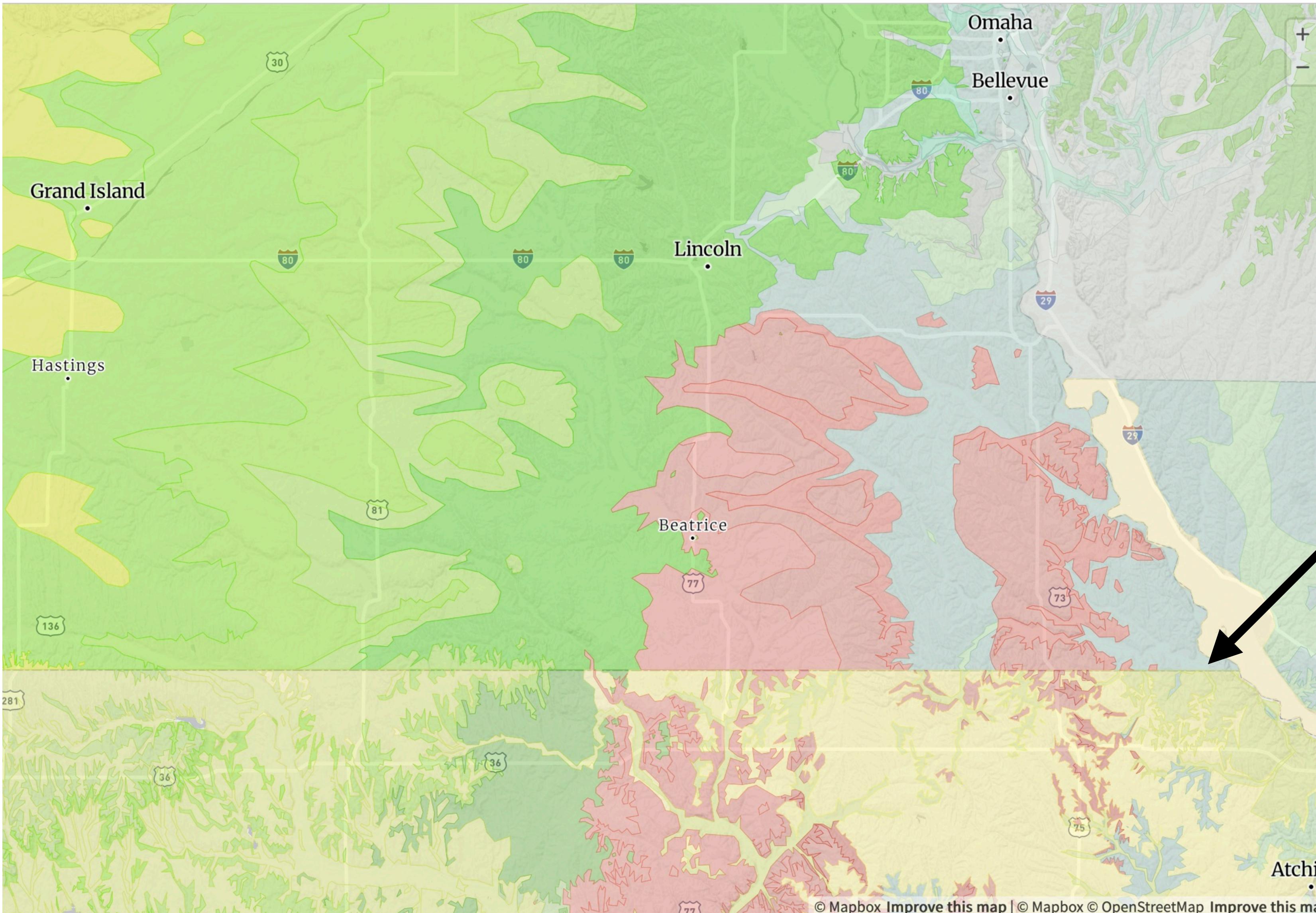
large

medium

small

tiny

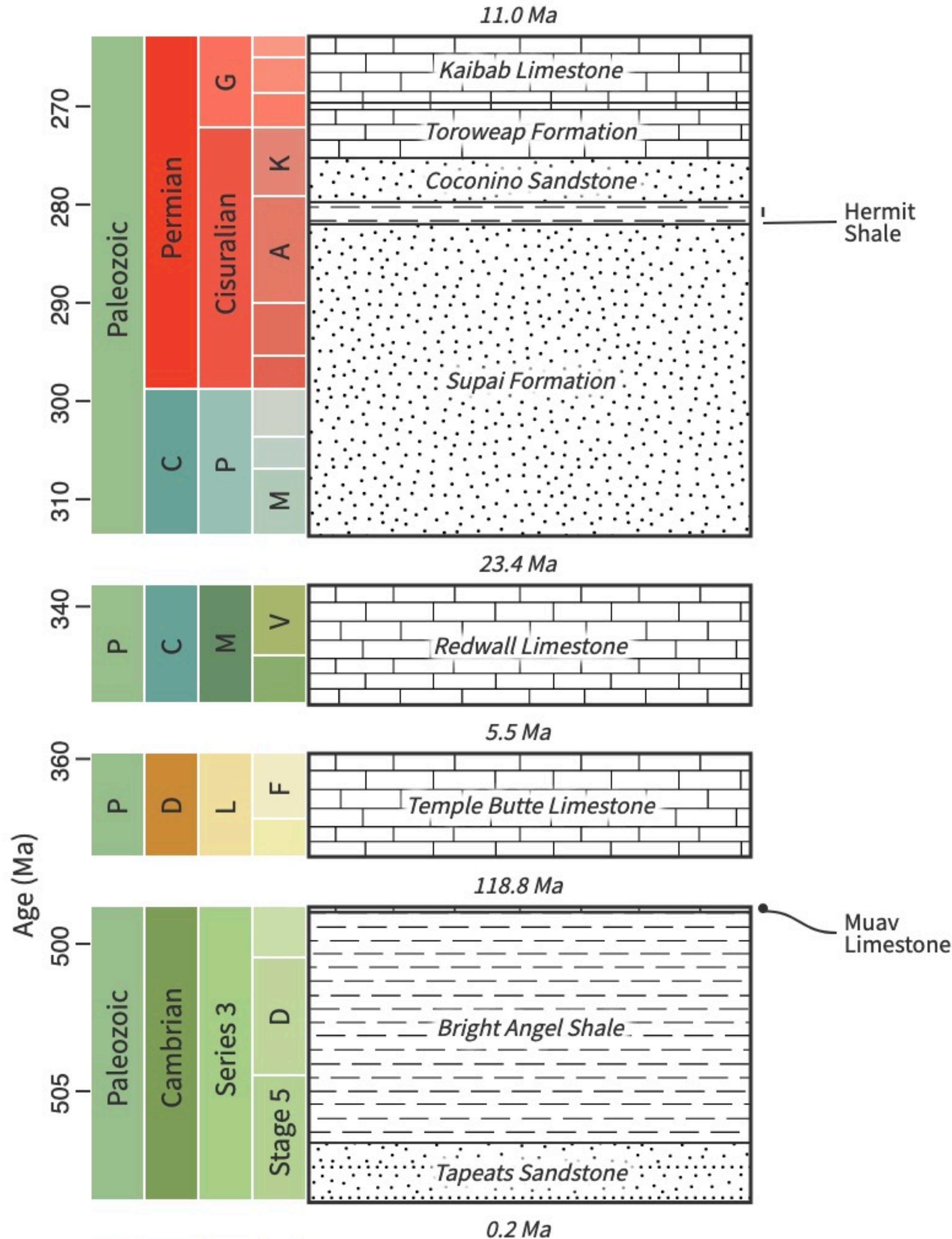
# Macrostrat's geologic map: Ingestion and harmonization



- Maps are composited into a topologically seamless product
- This is computationally intensive
- **NOT seamless map units**
- Source boundaries are often quite apparent

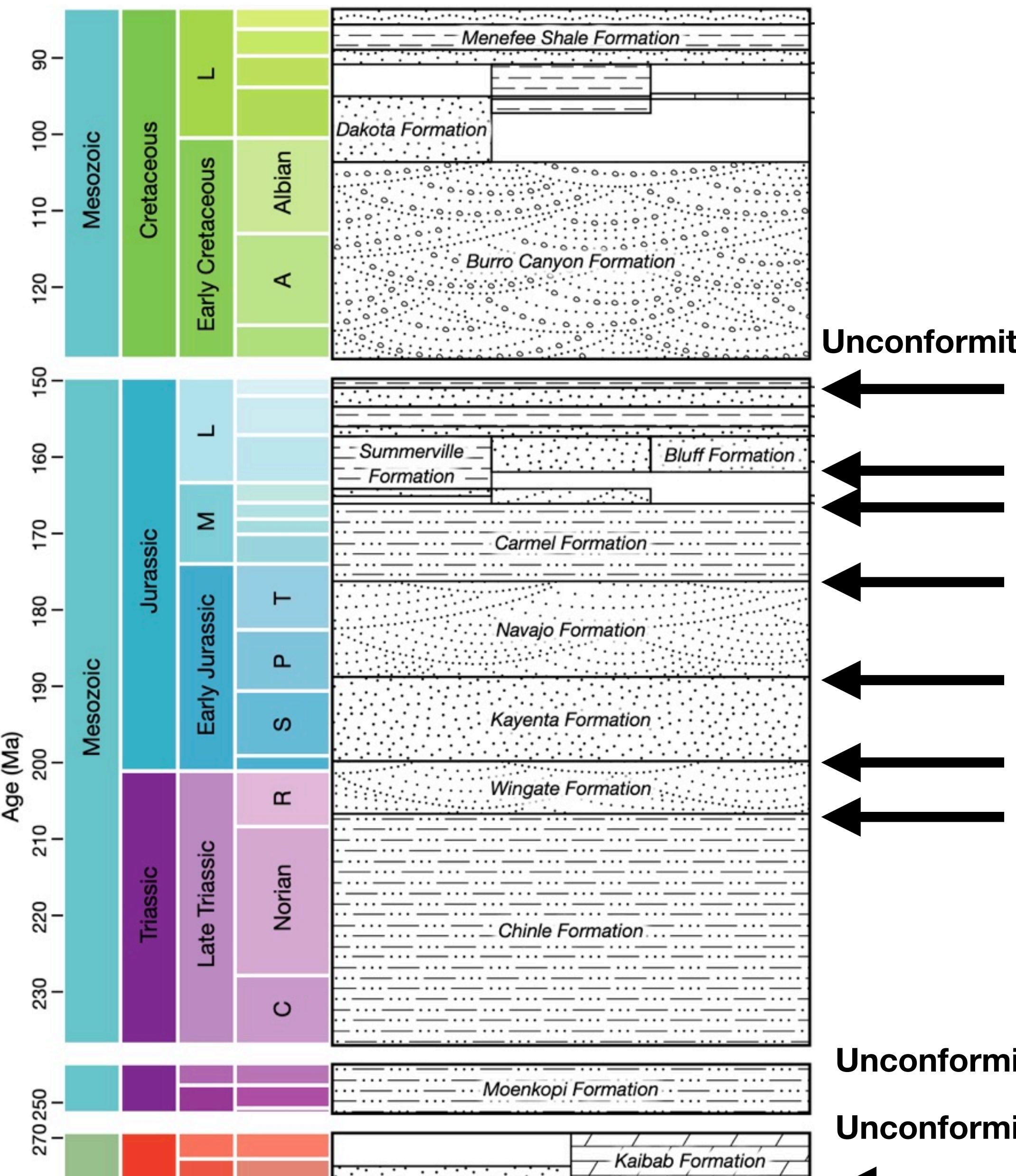
It is not a single map...it is a harmonized “view” of many maps with some standardization

# Stratigraphy: another representation of geological framework



# Macrostrat stratigraphic column database: continuous time age model

## Paradox Basin



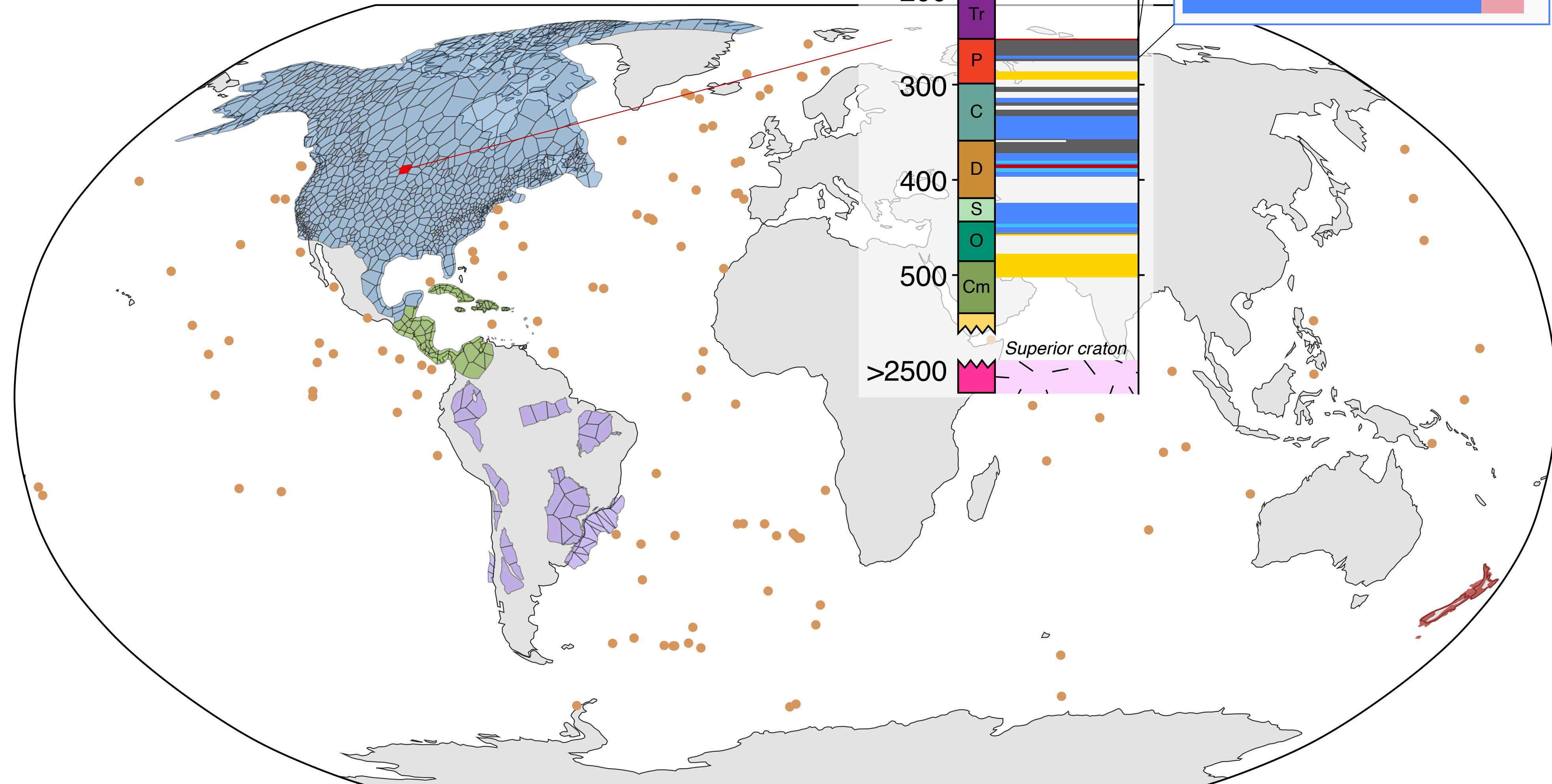
boundaries between units acquire a unique chronostratigraphic identity:

- relative ages: position in a chronostratigraphic bin expressed as a proportion (e.g., 25% through “Middle Cambrian”)
- absolute ages: position on a numerical time line (e.g., 511 Ma)
- Interpolating between boundaries produces a high-resolution, continuous record of geologic time

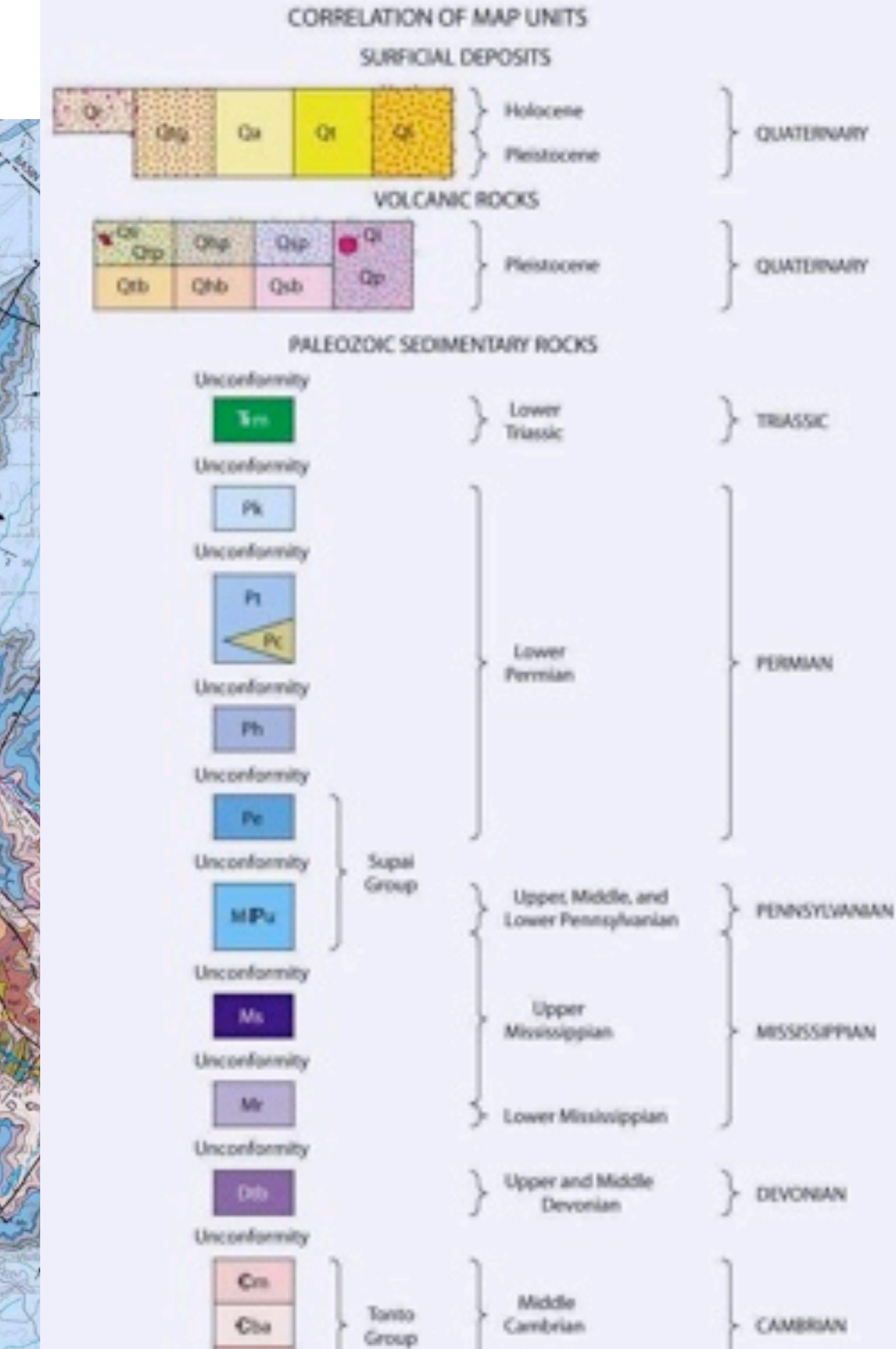
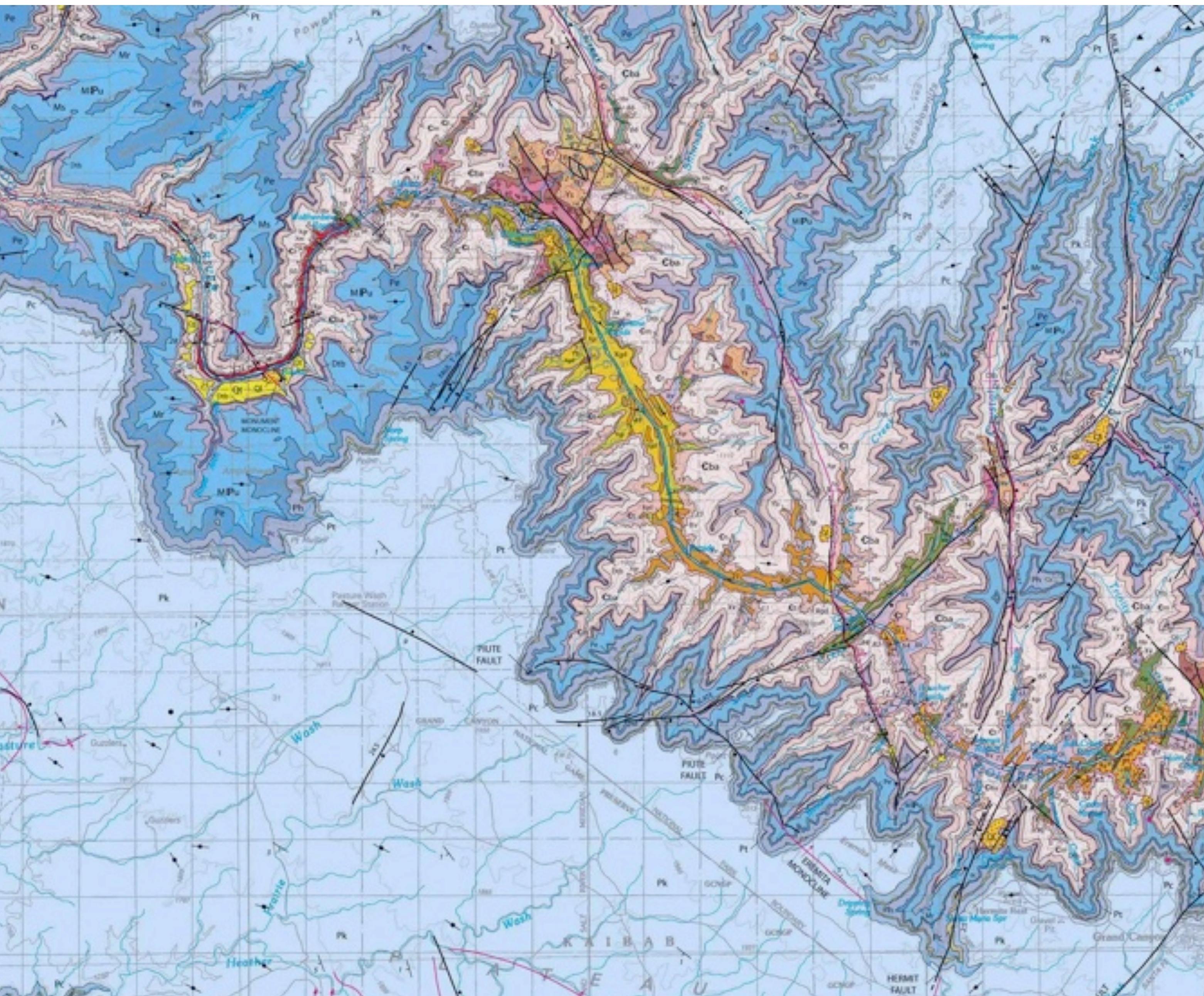
# Macrostrat column database

**Comprehensive  
and harmonized  
(at least within  
North America)**

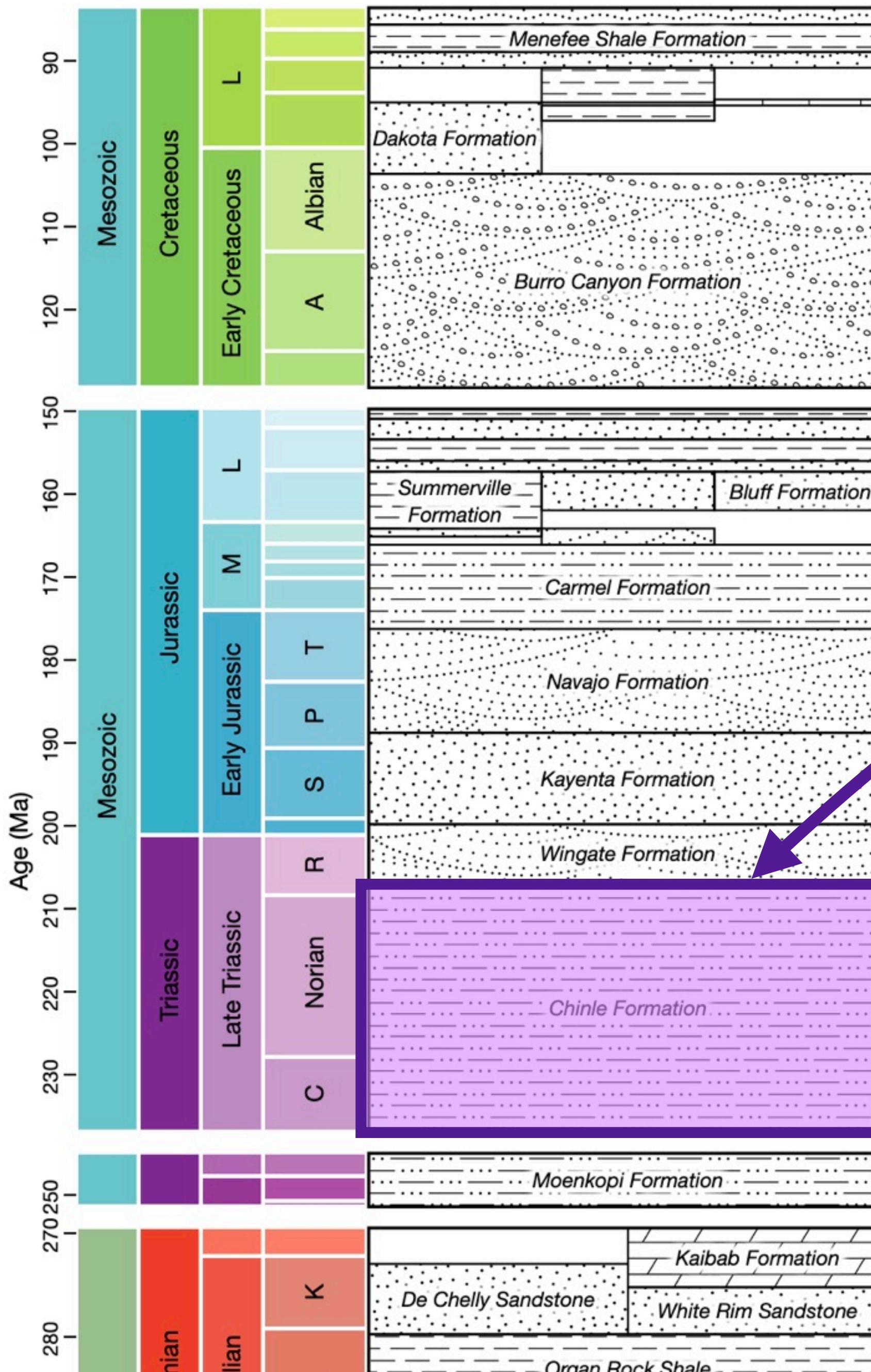
sedimentary lithologies key	
conglomerate	limestone
sandstone	dolostone
siltstone	anhydrite
shale	halite



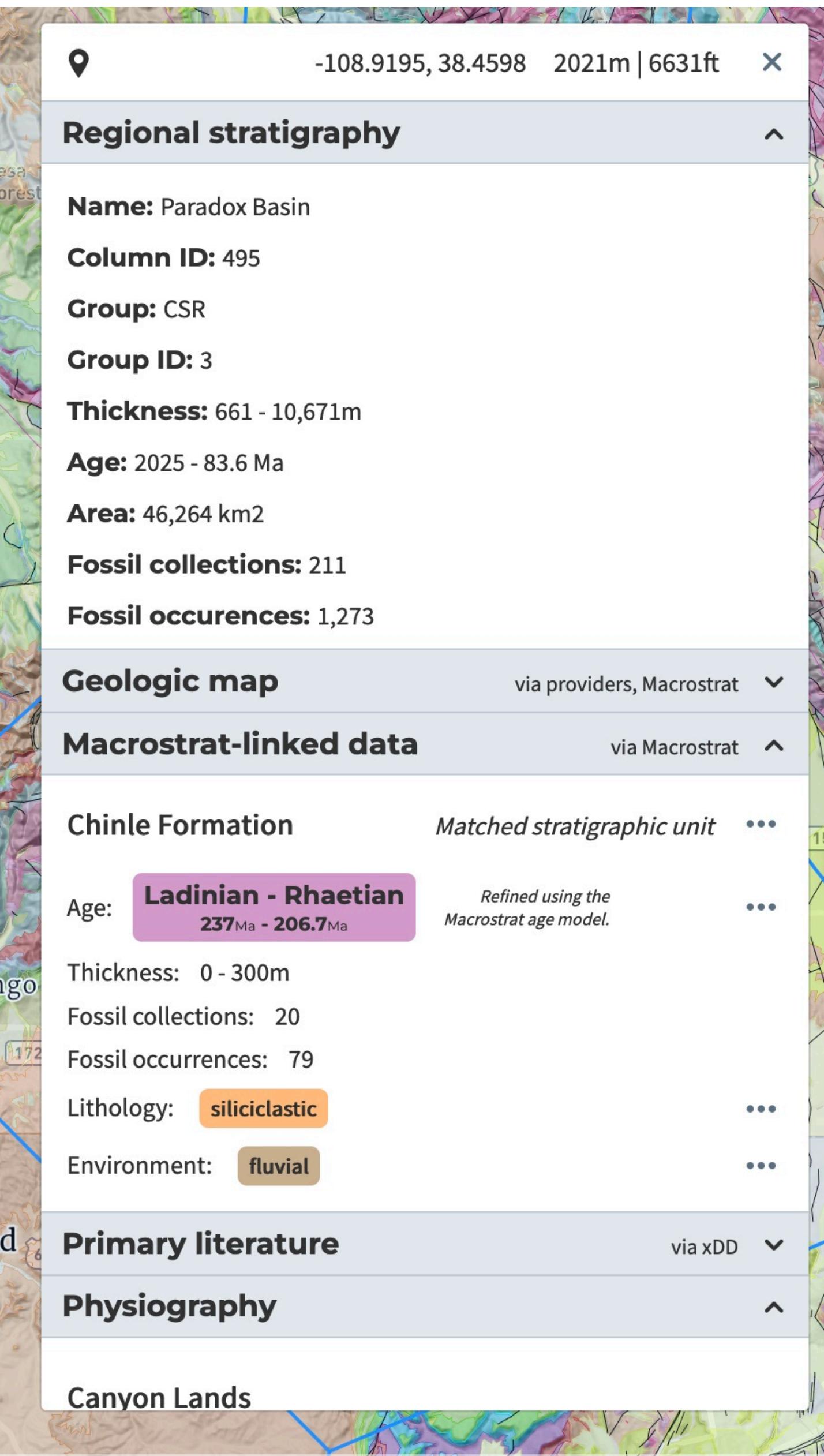
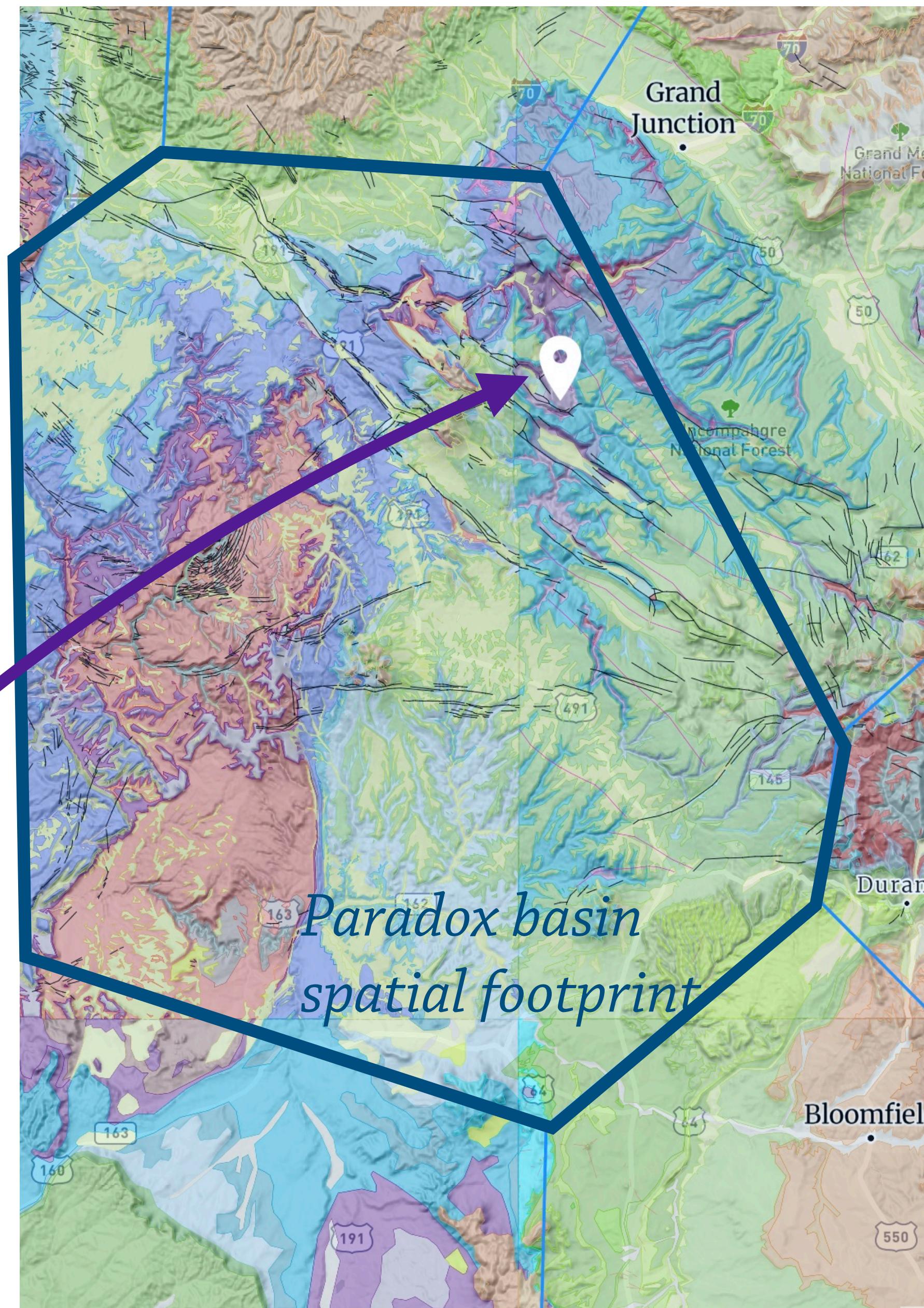
# Geologic maps have a stratigraphic representation



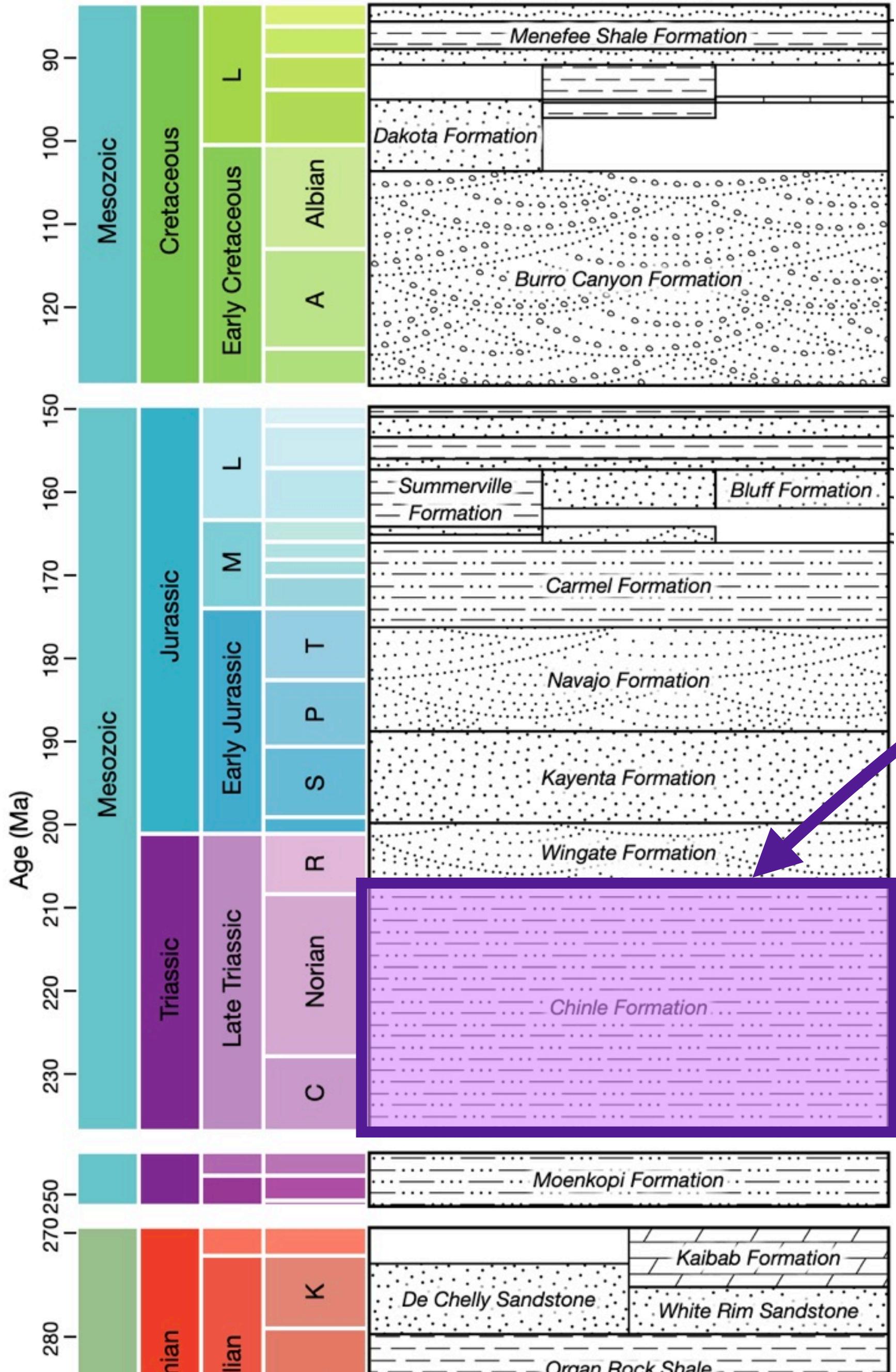
## Paradox Basin



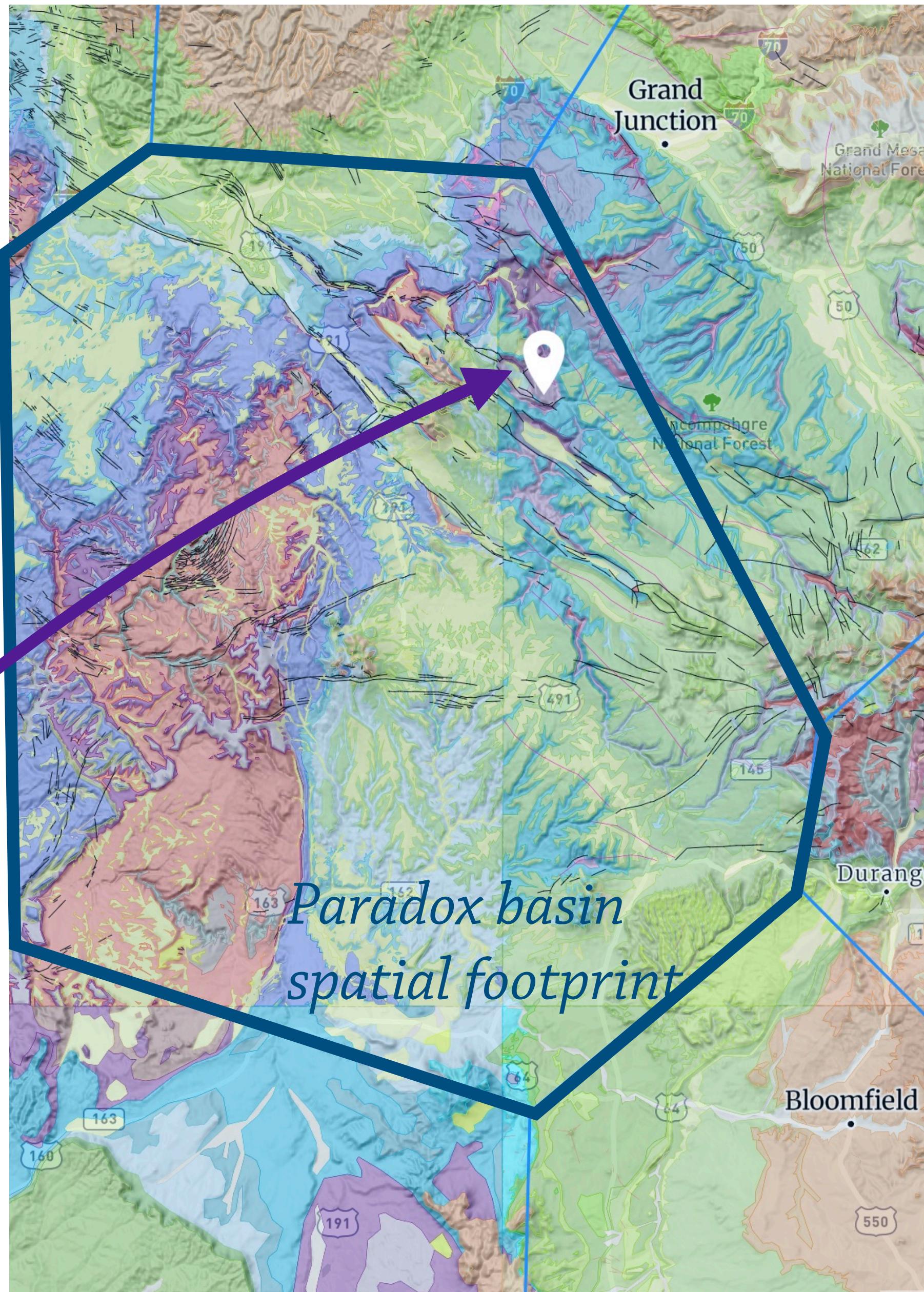
# Map harmonization: Linking columns to maps



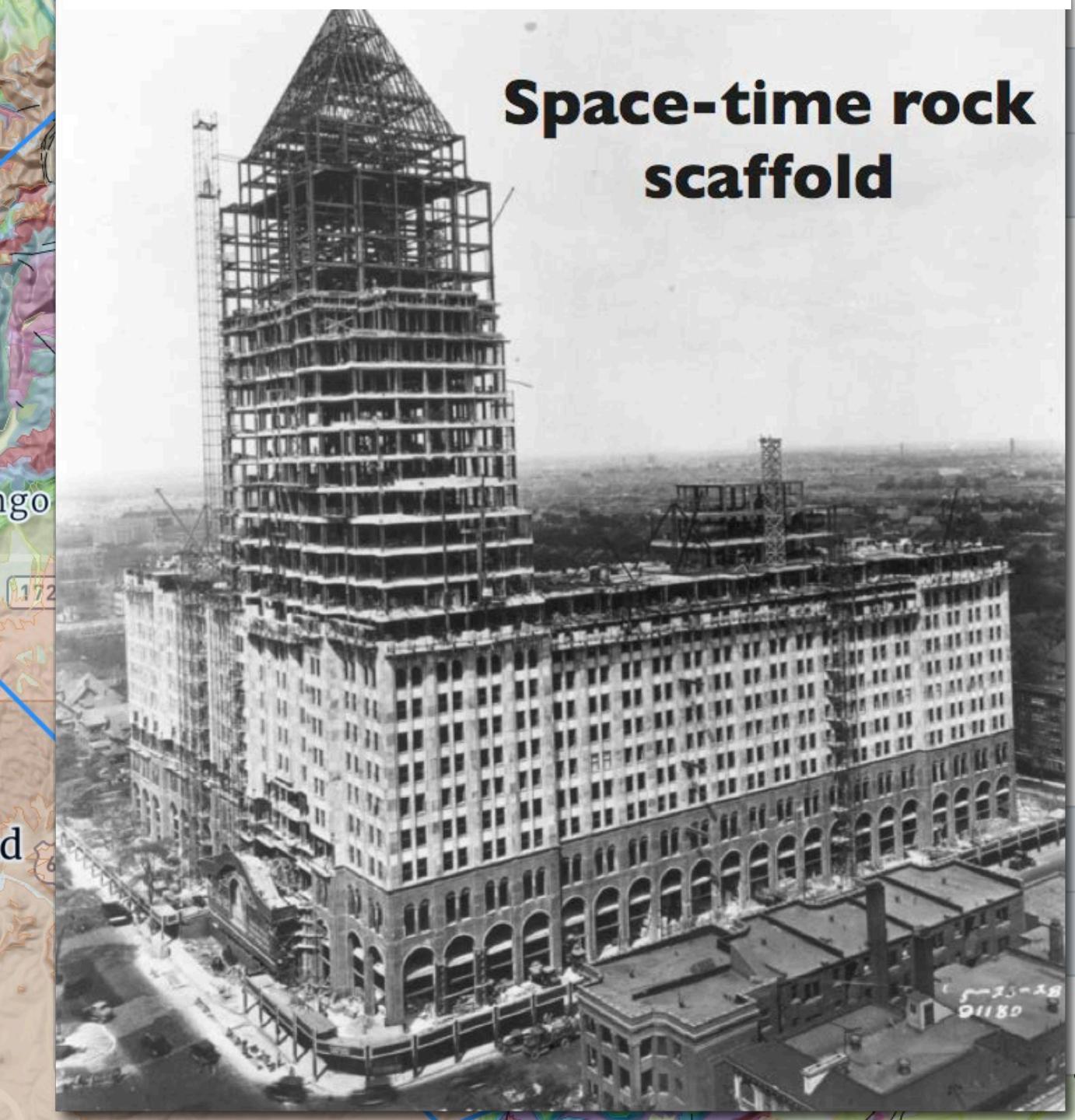
## Paradox Basin



## Map harmonization: Linking columns to maps



A space-time  
“scaffold” for the  
Earth’s crust



# COLUMNS + MAPS + GEOCHRONOLOGY

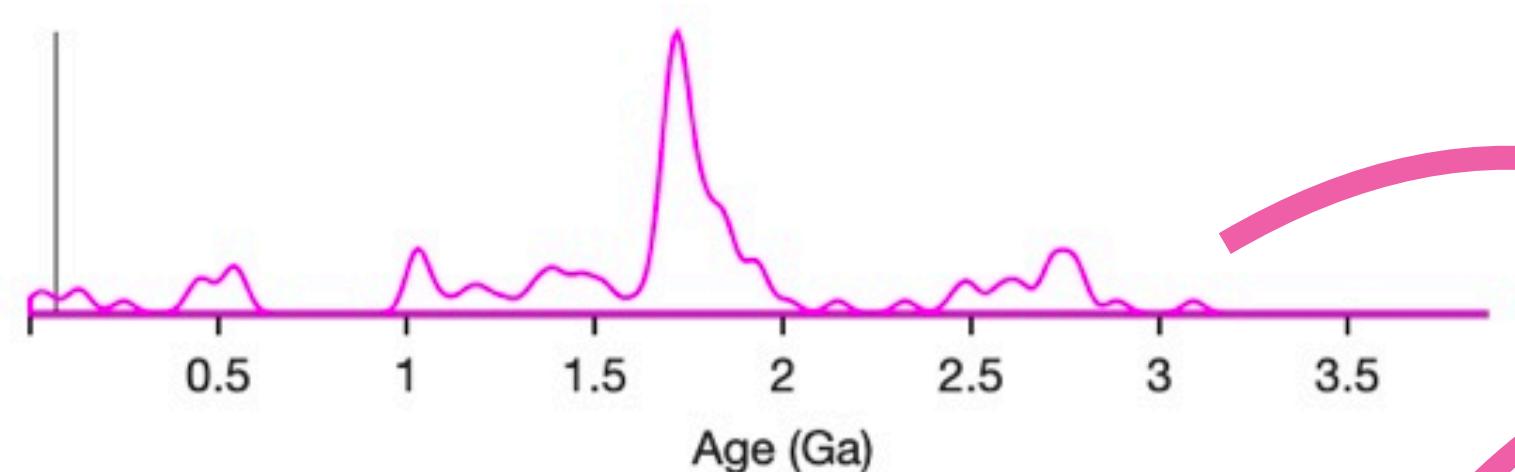
RESEARCH ARTICLE | JUNE 24, 2021

## Igneous rock area and age in continental crust ⚙

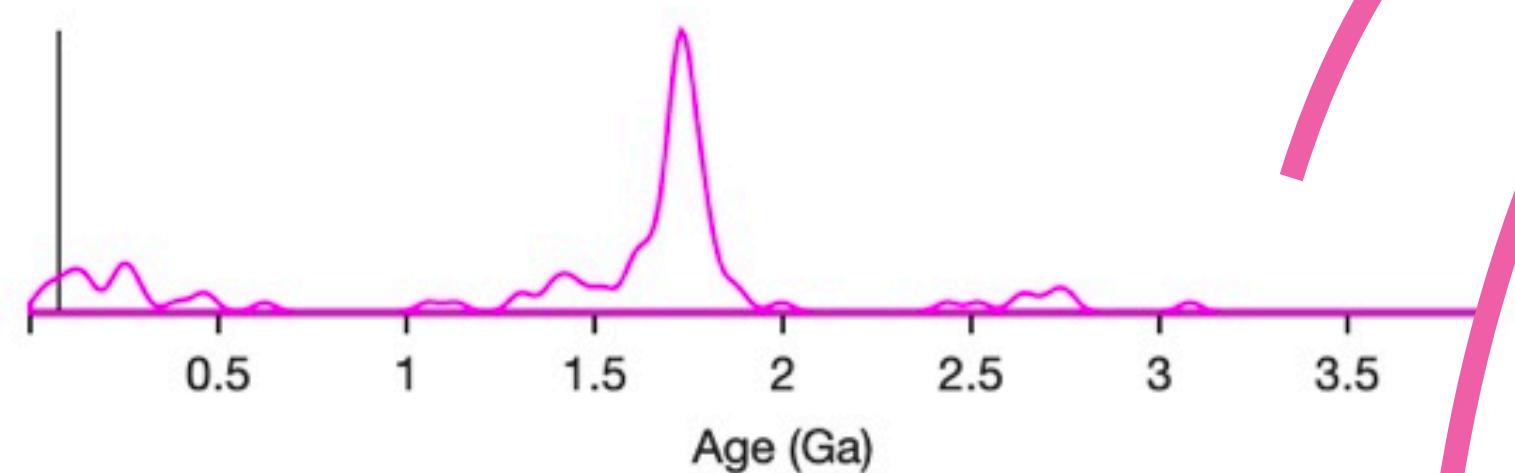
Shanan E. Peters; Craig R. Walton; Jon M. Husson; Daven P. Quinn; Oliver Shorttle; C. Brenhin Keller; Robert R. Gaines

Geology (2021) 49 (10): 1235–1239.

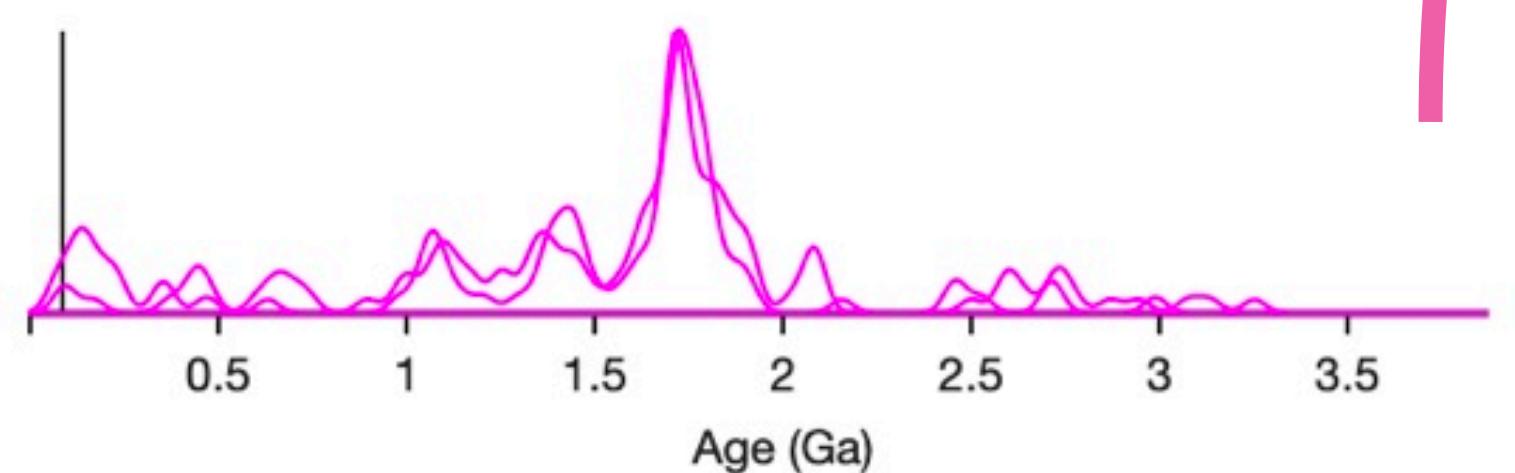
Lance Formation



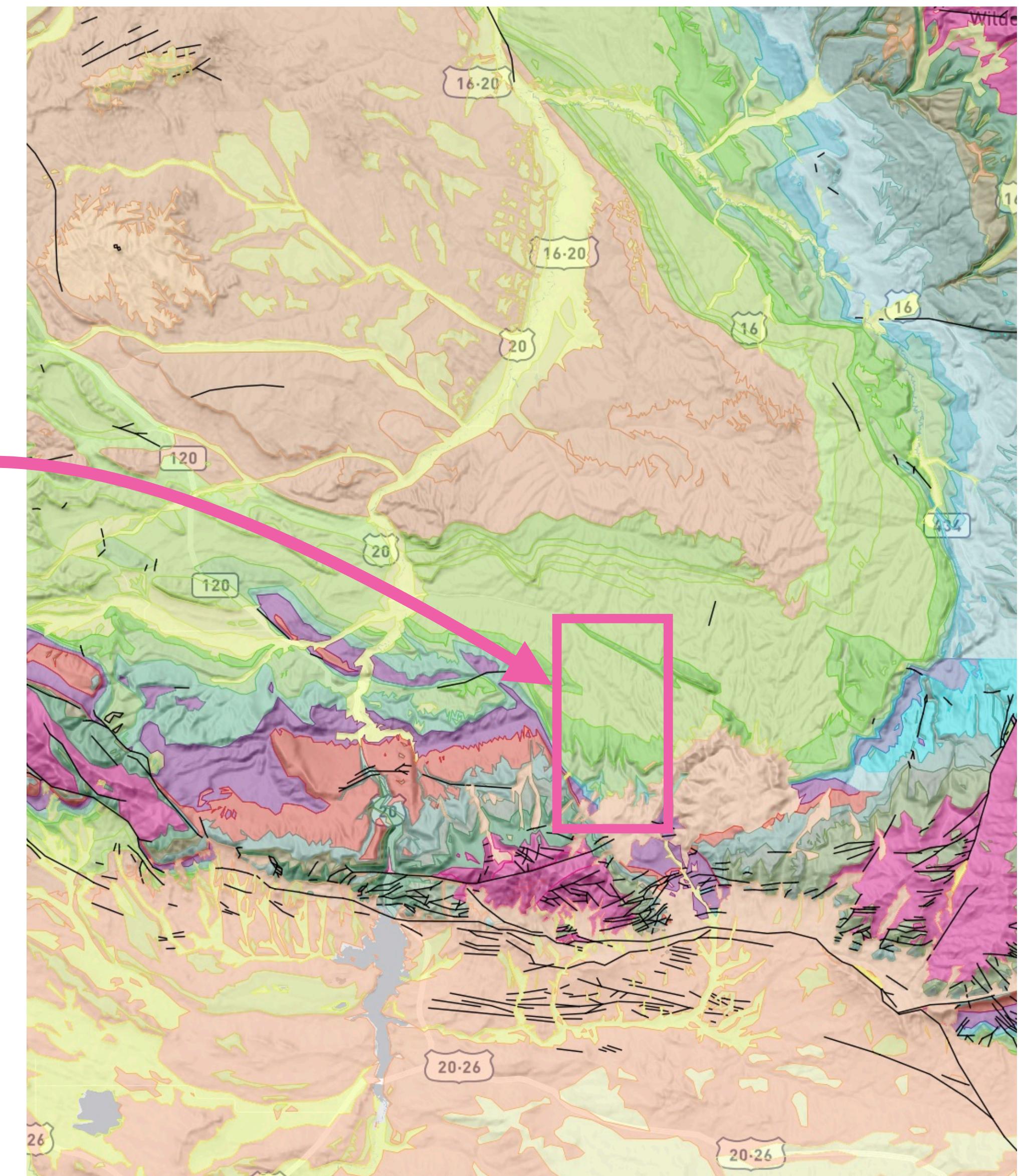
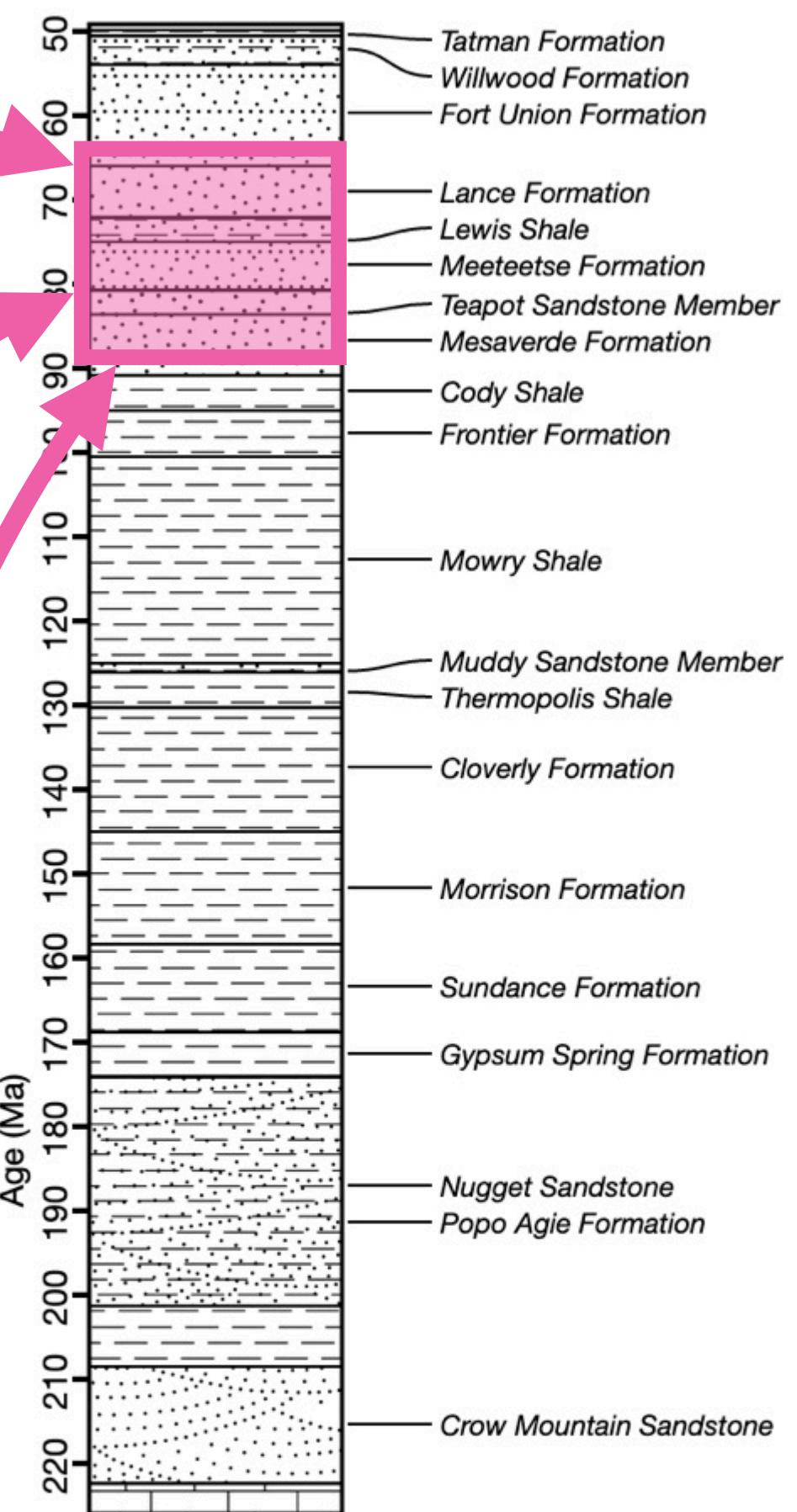
Meeteetse Formation



Mesaverde Formation



## Bighorn Basin



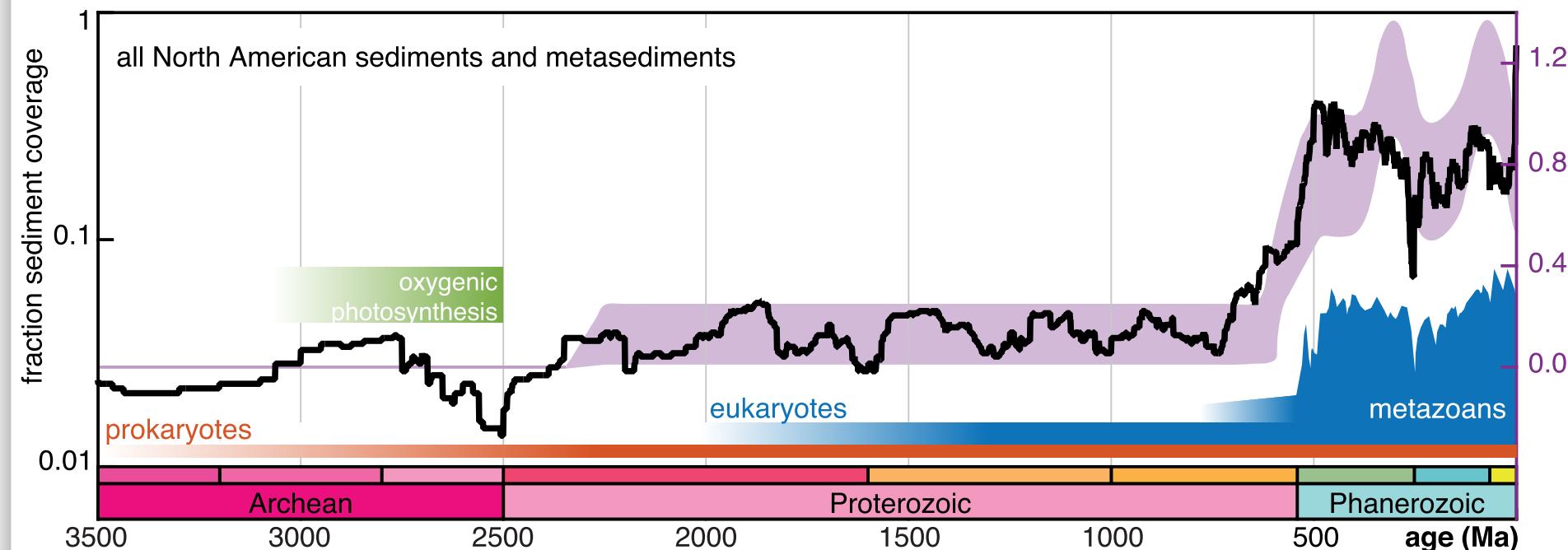
# MACROSTRAT'S ORIGINAL GOAL

ANSWER “BIG” SCIENCE QUESTIONS ABOUT THE EVOLUTION OF THE EARTH

Atmospheric oxygenation driven by unsteady growth of the continental sedimentary reservoir

Jon M. Husson\*, Shanan E. Peters

Department of Geoscience, University of Wisconsin–Madison, 1215 W. Dayton Street, Madison, WI, 53706, USA



## LETTER

doi:10.1038/nature10969

### Formation of the ‘Great Unconformity’ as a trigger for the Cambrian explosion

Shanan E. Peters<sup>1</sup> & Robert R. Gaines<sup>2</sup>

The transition between the Proterozoic and Phanerozoic eons, beginning 542 million years (Myr) ago, is distinguished by the diversification of multicellular animals and by their acquisition of mineralized skeletons during the Cambrian period<sup>1</sup>. Considerable progress has been made in documenting and more precisely correlating biotic patterns in the Neoproterozoic–Cambrian fossil record with geochemical and physical environmental perturbations<sup>2–5</sup>, but the mechanisms responsible for those perturbations remain uncertain<sup>1,2</sup>. Here we use new stratigraphic and geochemical data to show that early Palaeozoic marine sediments deposited approximately 540–480 Myr ago record both an expansion in the area of shallow epicontinental seas and anomalous patterns of chemical sedimentation that are indicative of increased oceanic alkalinity and enhanced chemical weathering of continental crust. These geochemical conditions were caused by a protracted period of widespread

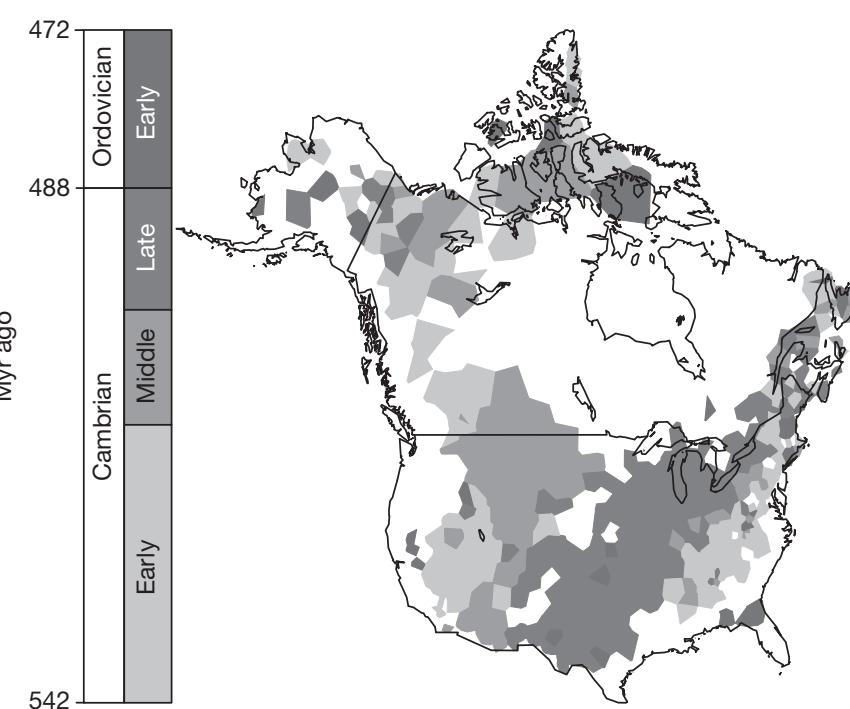


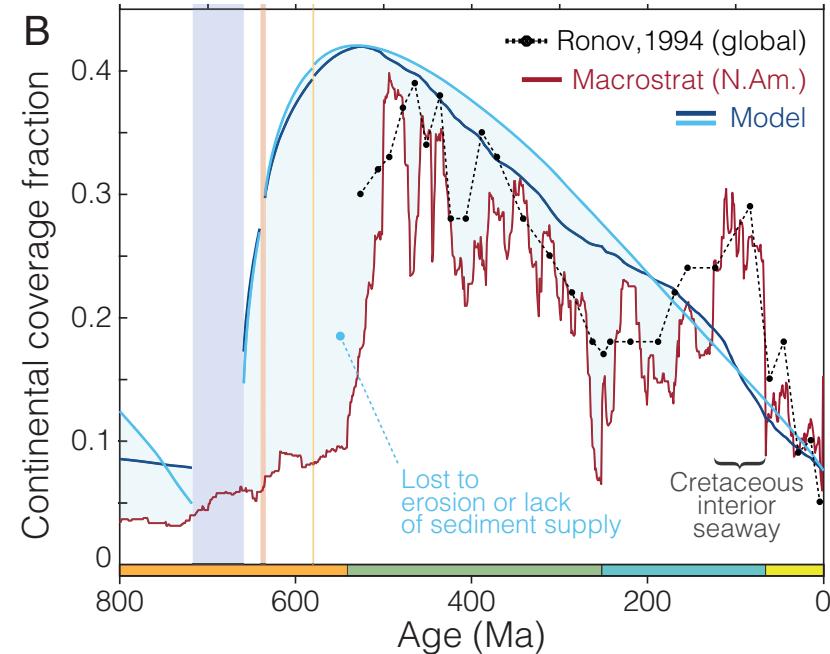
Figure 1 | Sauk Sequence in North America. Distribution and age of the oldest Phanerozoic sedimentary rocks in North America.

### Neoproterozoic glacial origin of the Great Unconformity

C. Brenhin Keller<sup>a,b,1</sup>, Jon M. Husson<sup>c</sup>, Ross N. Mitchell<sup>d</sup>, William F. Bottke<sup>e</sup>, Thomas M. Gernon<sup>f</sup>, Patrick Boehnke<sup>g,h</sup>, Elizabeth A. Bell<sup>i</sup>, Nicholas L. Swanson-Hysell<sup>b</sup>, and Shanan E. Peters<sup>j</sup>

<sup>a</sup>Berkeley Geochronology Center, Berkeley, CA 94709; <sup>b</sup>Department of Earth and Planetary Science, University of California, Berkeley, CA 94720; <sup>c</sup>School of Earth and Ocean Sciences, University of Victoria, Victoria, BC V8W 2Y2, Canada; <sup>d</sup>Department of Applied Geology, Curtin University, Perth, WA 6845, Australia; <sup>e</sup>Southwest Research Institute, Boulder, CO 80302; <sup>f</sup>Ocean and Earth Science, University of Southampton, Southampton SO17 1BJ, United Kingdom; <sup>g</sup>Department of the Geophysical Sciences, The University of Chicago, Chicago, IL 60637; <sup>h</sup>Chicago Center for Cosmochemistry, Chicago, IL 60637; <sup>i</sup>Department of Earth, Planetary, and Space Sciences, University of California, Los Angeles, Los Angeles, CA 90095; and <sup>j</sup>Department of Geoscience, University of Wisconsin–Madison, Madison, WI 53706

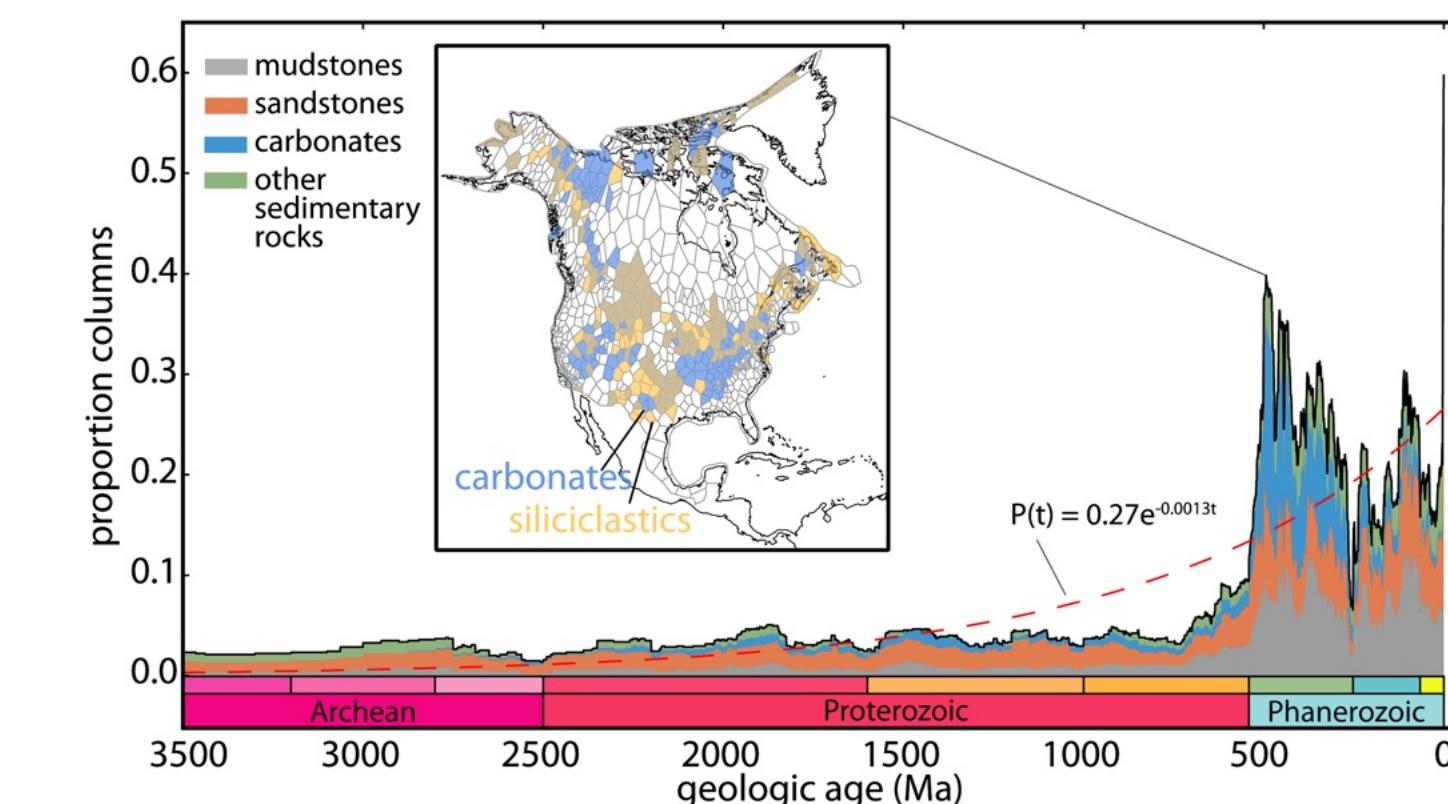
The Great Unconformity, a profound gap in Earth’s stratigraphic record often evident below the base of the Cambrian system, has remained among the most enigmatic field observations in Earth science for over a century. While long associated directly or indirectly with the occurrence of the earliest complex animal fossils, a conclusive explanation for the formation and global extent of the Great Unconformity has remained elusive. Here we show that the Great Unconformity is associated with a set of large global oxygen and hafnium isotope excursions in magmatic zircon that suggest a late Neoproterozoic crustal erosion and sediment subduction event of unprecedented scale. These excursions, the Great Unconformity, preservational irregularities in the terrestrial bolide impact record, and the first-order pattern of Phanerozoic sedimentation can together be explained by spatially heterogeneous Neoproterozoic glacial erosion totaling a global average of 3–5 vertical kilometers, along with the subsequent thermal and isostatic consequences of this erosion for global continental freeboard.



### Nature of the sedimentary rock record and its implications for Earth system evolution

Jon M. Husson<sup>1</sup> and Shanan E. Peters<sup>2</sup>

<sup>1</sup>School of Earth and Ocean Sciences, University of Victoria, Victoria, Canada; <sup>2</sup>Department of Geoscience, University of Wisconsin–Madison, Madison, WI, USA



# Macrostrat – A platform for geological exploration

Public, web-based “application  
programming interface” (API)

<https://macrostrat.org/api/v2>

1,534 columns      9,162 packages      35,478 units      1,245,645 measurements

2,540,323 geologic  
map polygons      51,212 stratigraphic  
names

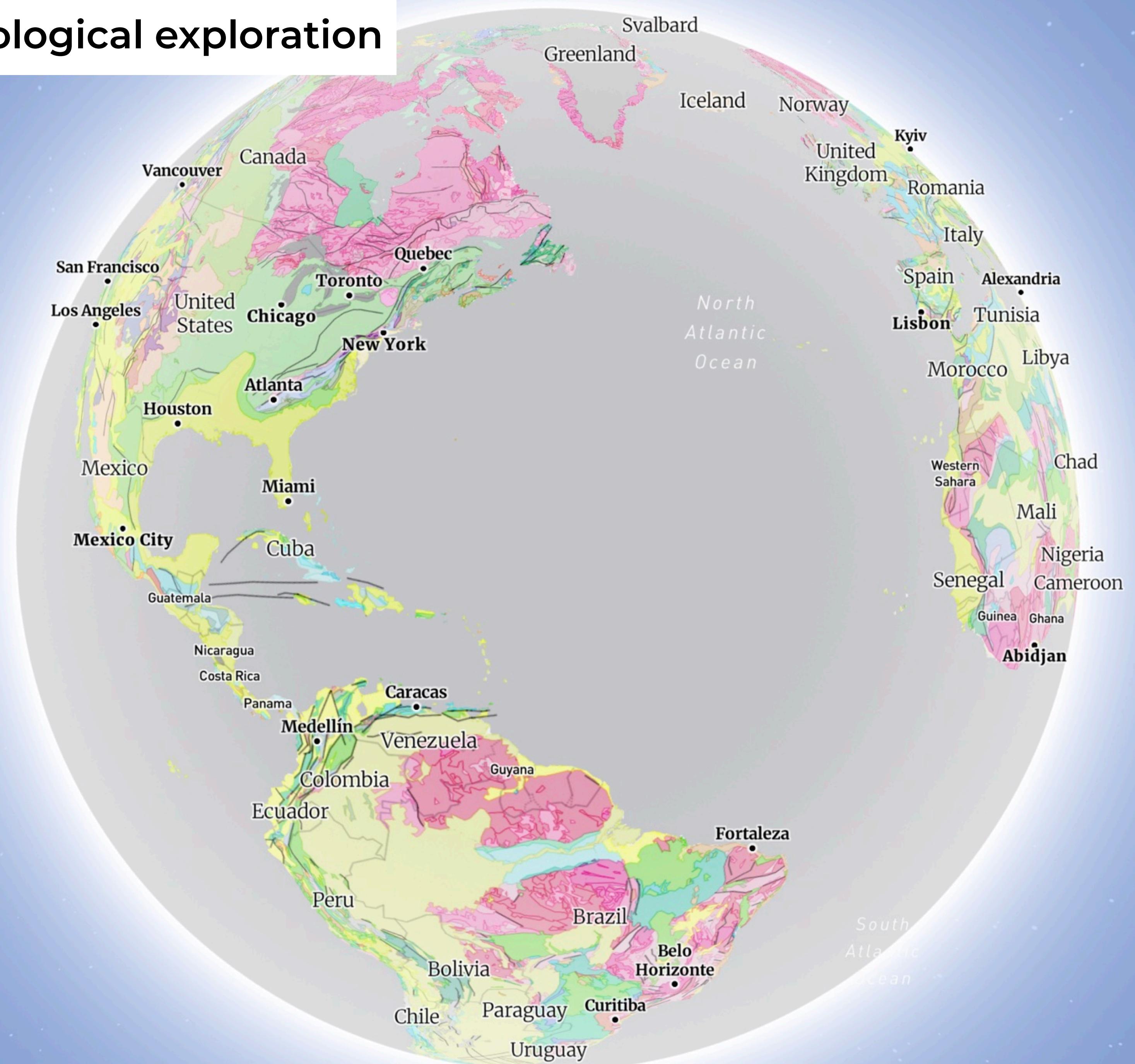
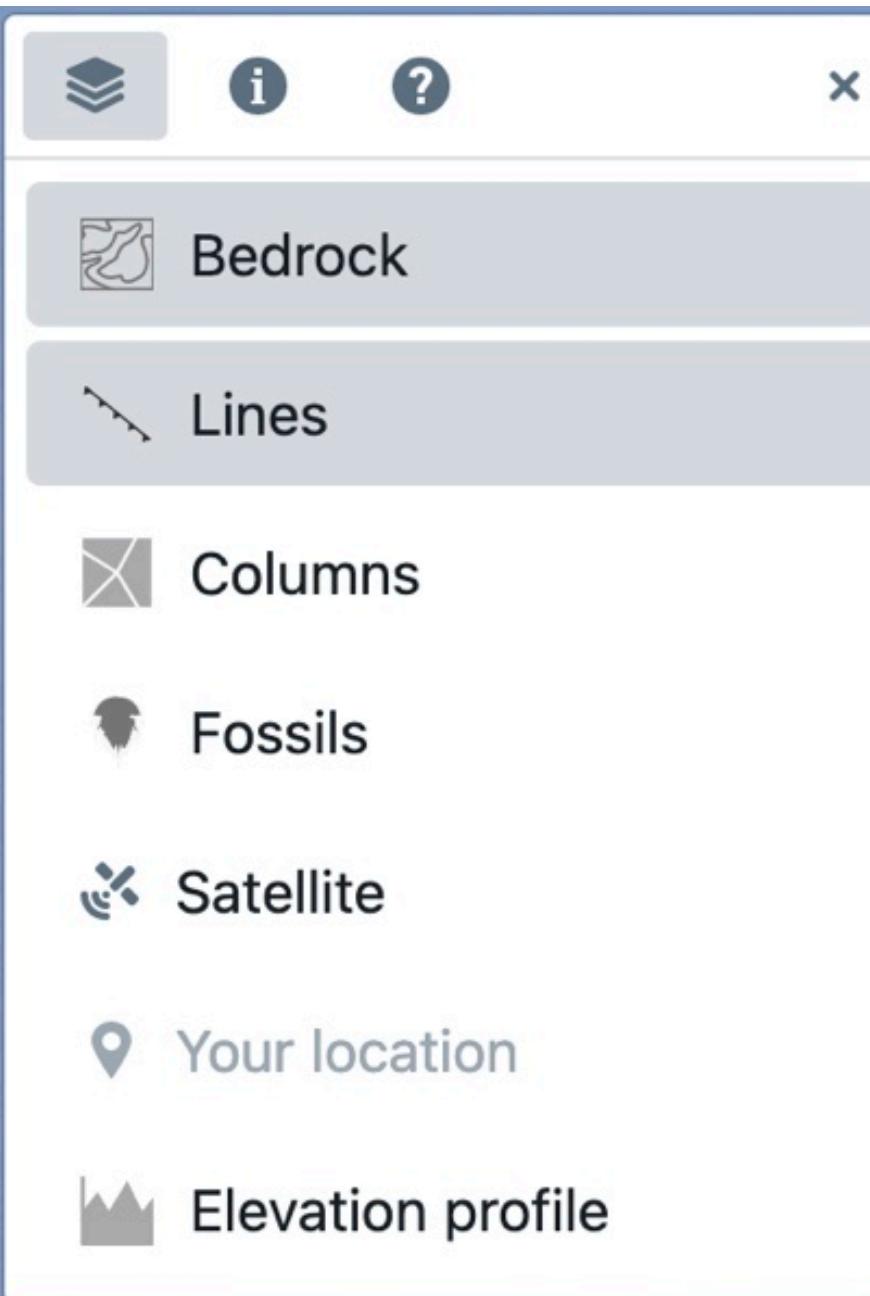
```
{  
    "unit_id": 16008,  
    "section_id": 4229,  
    "col_id": 515,  
    "project_id": 1,  
    "col_area": 26704.309,  
    "unit_name": "Mesaverde Fm",  
    "strat_name_id": 1281,  
    "Mbr": "",  
    "Fm": "Mesaverde",  
    "Gp": "",  
    "SGp": "",  
    "t_age": 80.725,  
    "b_age": 90.825,  
    "max_thick": 0,  
    "min_thick": 0,  
    "outcrop": "",  
    "pbdb_collections": 0,  
    "pbdb_occurrences": 0  
},  
{  
    "unit_id": 15988,  
    "section_id": 4229,  
    "col_id": 515,  

```

# Macrostrat – A platform for geological exploration

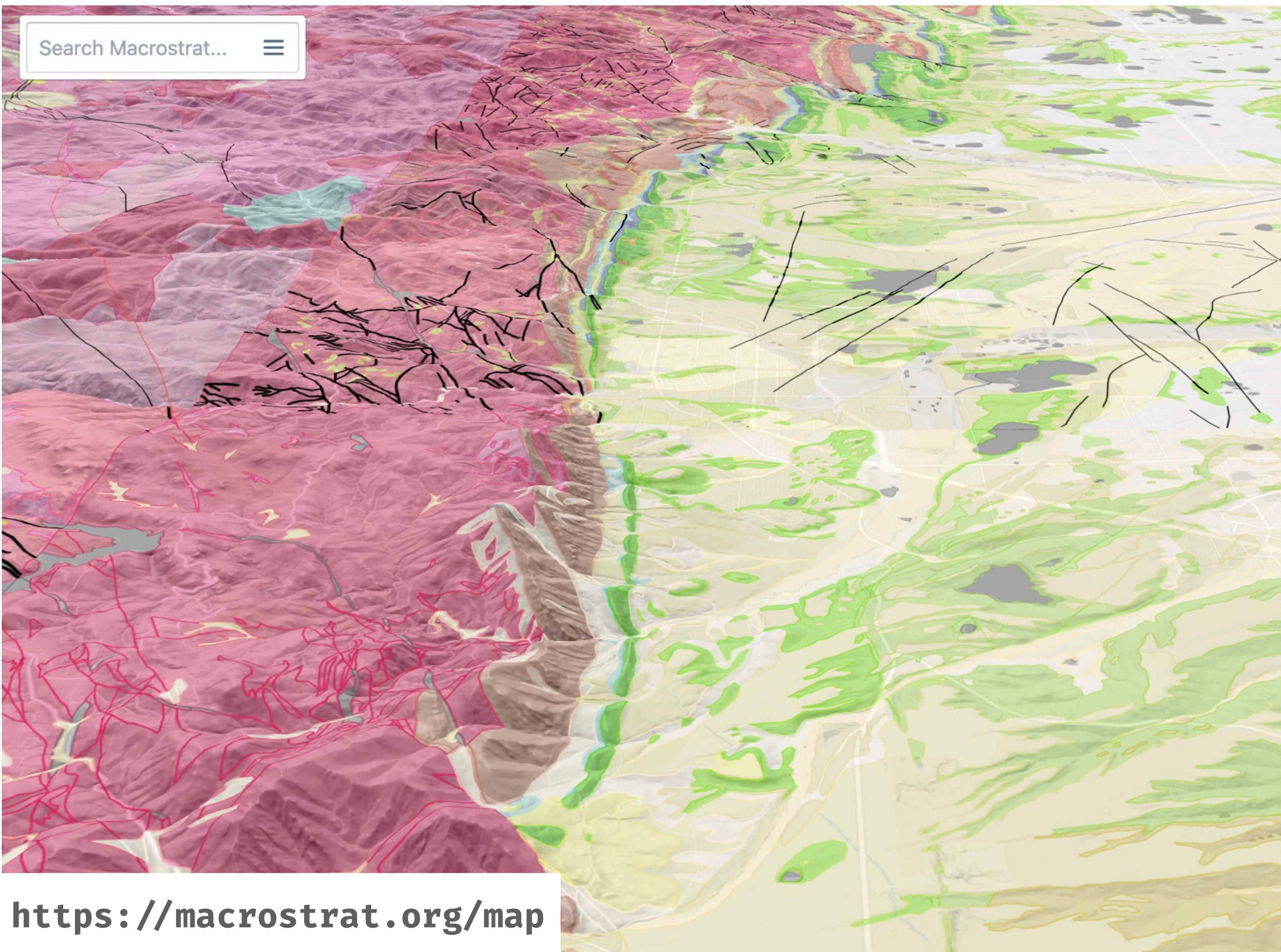
+

-



# Macrostrat – A platform for geological exploration

Web interface



Search Macrostrat... ≡

-110.6935, 48.2710 881m | 2890ft X

**Geologic map** via providers, Macrostrat ^

**Name:** Claggett Formation

**Age:** Campanian  
83.6Ma - 72.1Ma

**Stratigraphic name(s):** Claggett Formation

**Lithology:** Major:{shale}, Minor:{sandstone}

**Description:** Dark gray to gray shale that weathers brown, with thin, gray sandstone laminae and beds in upper or middle part and calcareous concretions in lower part. Marine. Thickness as much as 170 m (558 ft).

Original map source: Vuke, S.M., Porter, K.W., Lonn, J.D., and Lopez, D.A., 2007, Geologic Map of Montana - Compact Disc: Montana Bureau of Mines and Geology: Geologic Map 62-C, 73 p., 2 sheets, scale 1:500,000. This map was digitized in 2012 as a r... ▼

**Source:** Horton, J.D., C.A. San Juan, and D.B. Stoeser, 2017, [The State Geologic Map Compilation \(SGMC\) geodatabase of the conterminous United States](#): U.S. Geological Survey Data Series 1052, doi: 10.3133/ds1052.133 / 2984391

**Macrostrat-linked data** via Macrostrat ^

**Claggett Formation** Matched stratigraphic unit ...

**Age:** **Campanian**  
**80.725Ma - 74.975Ma** Refined using the Macrostrat age model. ...

**Thickness:** 27 - 408m

**Fossil collections:** 3

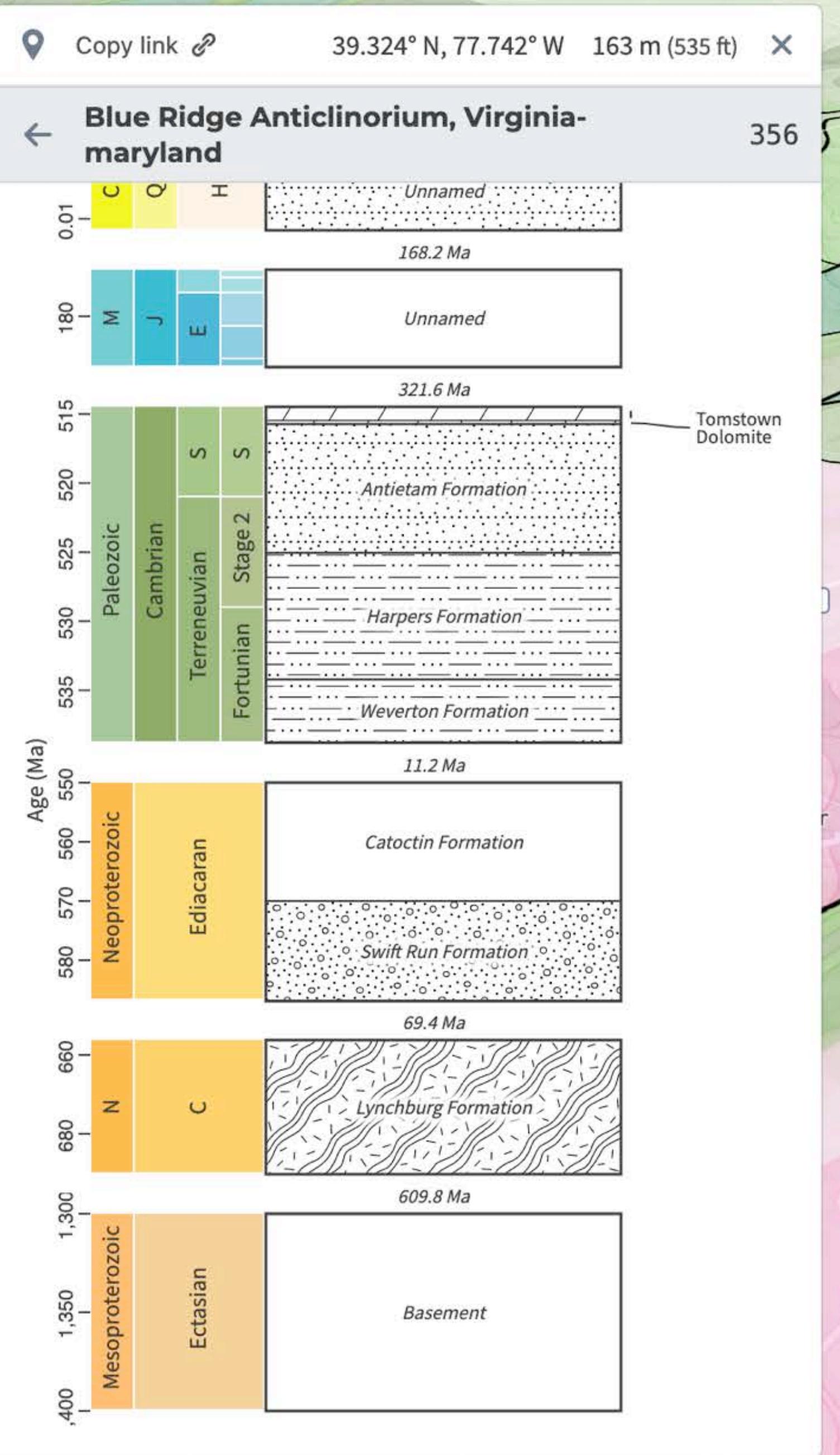
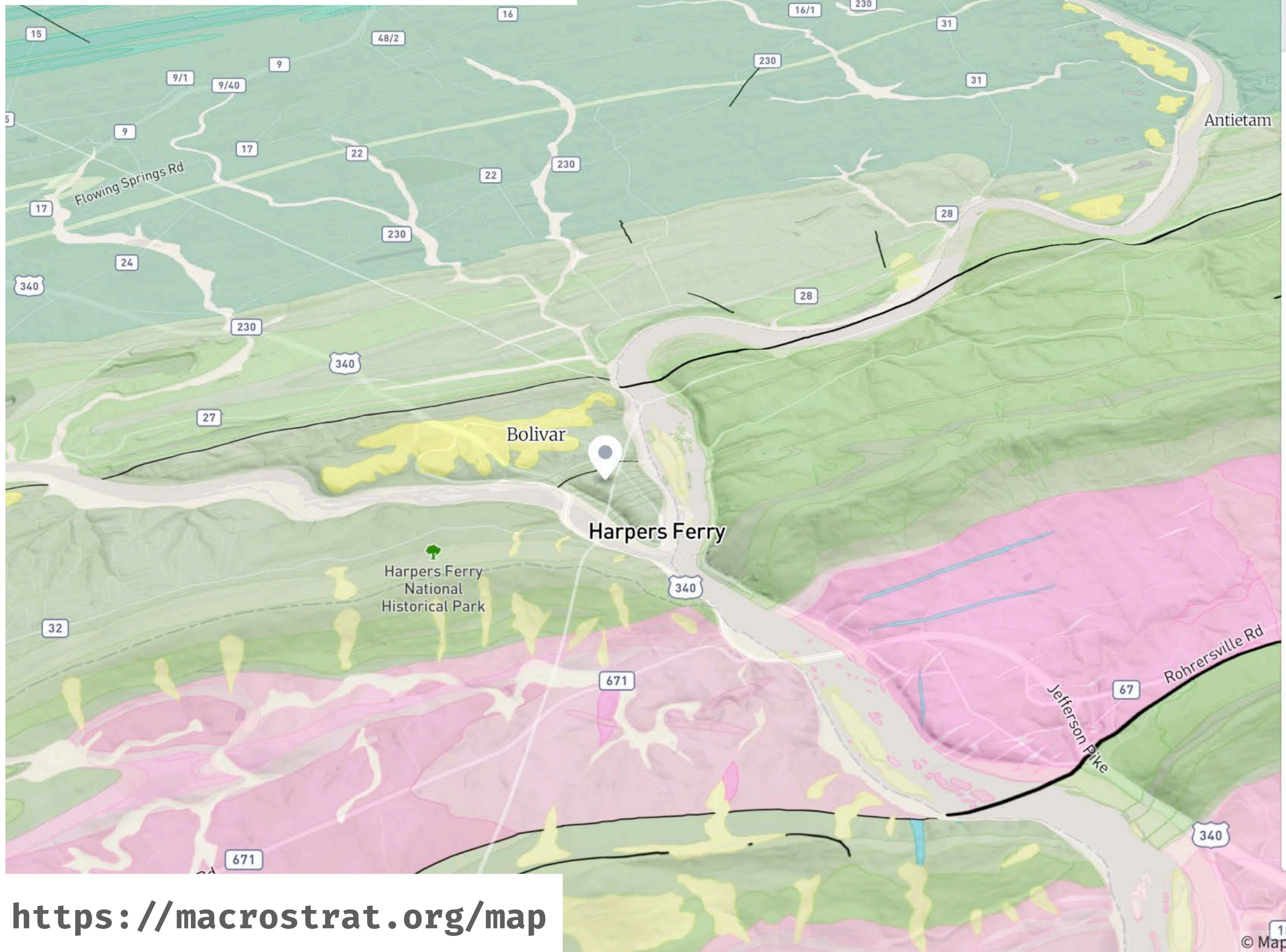
**Fossil occurrences:** 3

**Lithology:** siliciclastic

**Environment:** other ...

<https://macrostrat.org/map>

# Field trip area: Harper's Ferry



<https://macrostrat.org/map>

# Macrostrat – A platform for geological exploration

Map filtering

Search Macrostrat... ≡

Filtering by: Cretaceous remove all

-105.2761, 39.9110 2057m | 6749ft X

**Geologic map** via providers, Macrostrat ^

**Name:** Dakota Group

**Age:** Lower Cretaceous  
145Ma - 100.5Ma

**Stratigraphic name(s):** Dakota Group

Consists of an upper interbedded sandstone and shale unit (the South Platte Formation) about 61 to 91 m thick, and a lower conglomeratic sandstone formation (the Lytle Formation) about 12 to 24 m thick. Forms the most prominent hogback ridge along th...

**Source:** Trimble, D.E., M.N. Machette, 2003, [Geologic Map of the Greater Denver Area, Front Range Urban Corridor, Colorado](#): U.S. Geological Survey Geologic Investigations Series I-856-H. 64 / 2444400

**Macrostrat-linked data** via Macrostrat ^

**Huntsman Shale Member** Matched stratigraphic unit ...

All matched names: Huntsman Shale Member, Plainview Sandstone Member, Fall River Sandstone, J-Sandstone Member, Skull Creek Shale Member

**Age:** Aptian - Cenomanian  
119.3Ma - 97.233Ma Refined using the Macrostrat age model. ...

**Age refinement:**

Macrostrat age model

Map legend

Thickness: 46 - 209m

Fossil collections: 22

Fossil occurrences: 38

# Macrostrat – A platform for geological exploration

Search Macrostrat... ≡

Filtering by: Cretaceous remove all

Bedrock

Lines

Columns

Fossils

Satellite

Your location

Elevation profile

-105.1904, 39.6774 1823m | 5981ft

via PBDB

#66900

**Fossil collections**

**Alameda Parkway tracksite** #66900

**Info** Occurrences (5)

**Age:** Albian (93.5 - 93.5Ma)

**Group:** Dakota

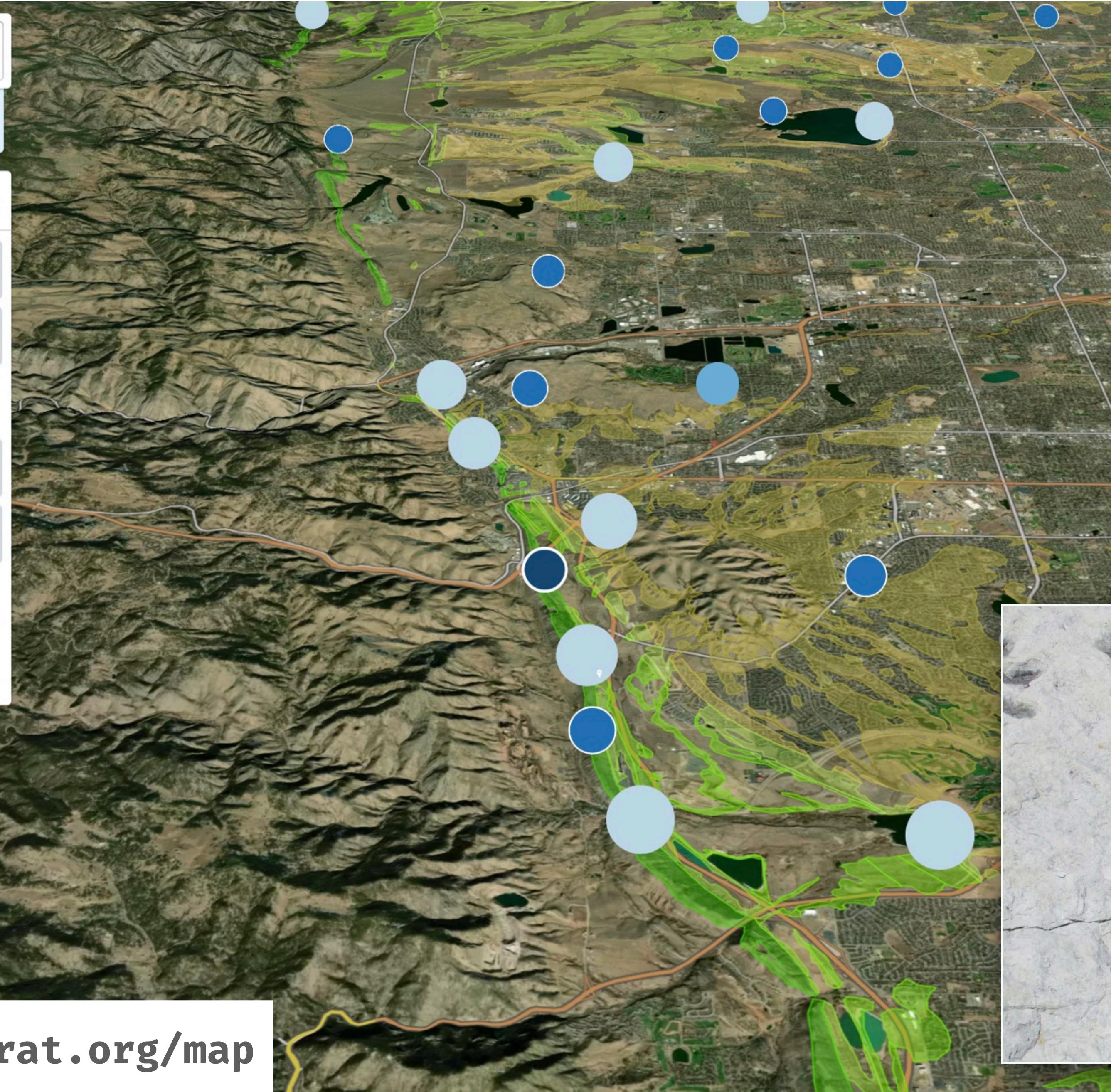
**Formation:** Muddy Sandstone

**Lithology:** sandstone , siltstone

**Environment:** estuary/bay

**Reference:** C. M. Boos, T. C. Hiestand, and D. W. Schacht. 1962. Geology of Foothills and Front Range in the Vicinity of Morrison, Colorado. Part One: Guidebook for Field Trip.. Denver: Denver Public Schools and Rocky Mountain Association of Geologists.

**Alameda Parkway North tracksite** #66901



<https://macrostrat.org/map>

**Macrostrat API** – provides mapping data to other projects

Rockd – *our own app!*

<https://rockd.org>



Mancos



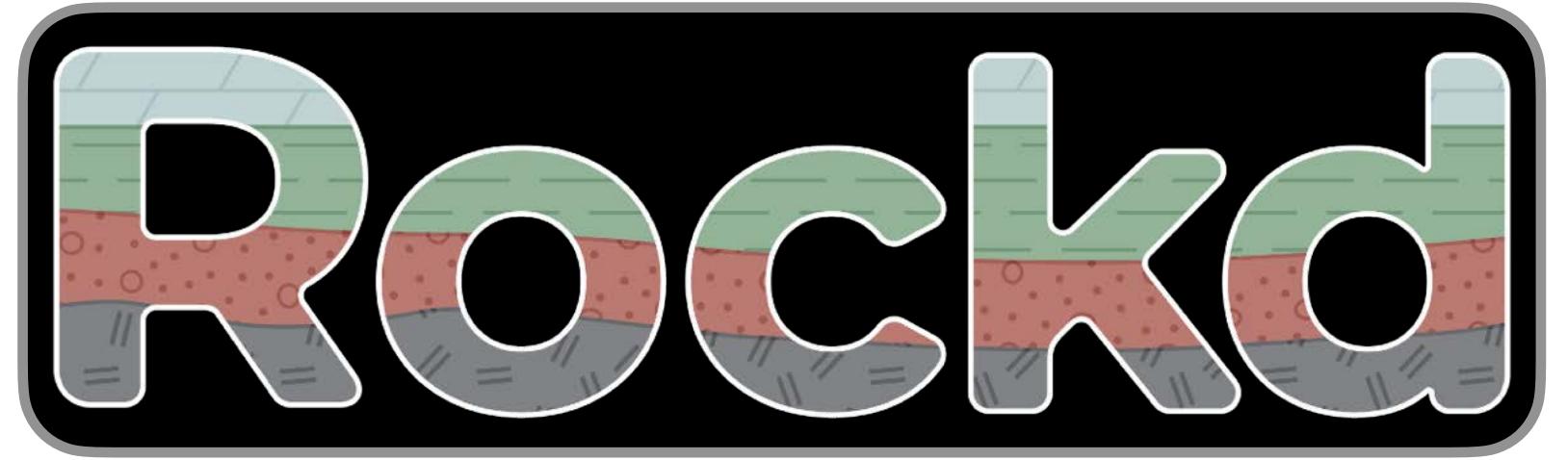
Flyover Country



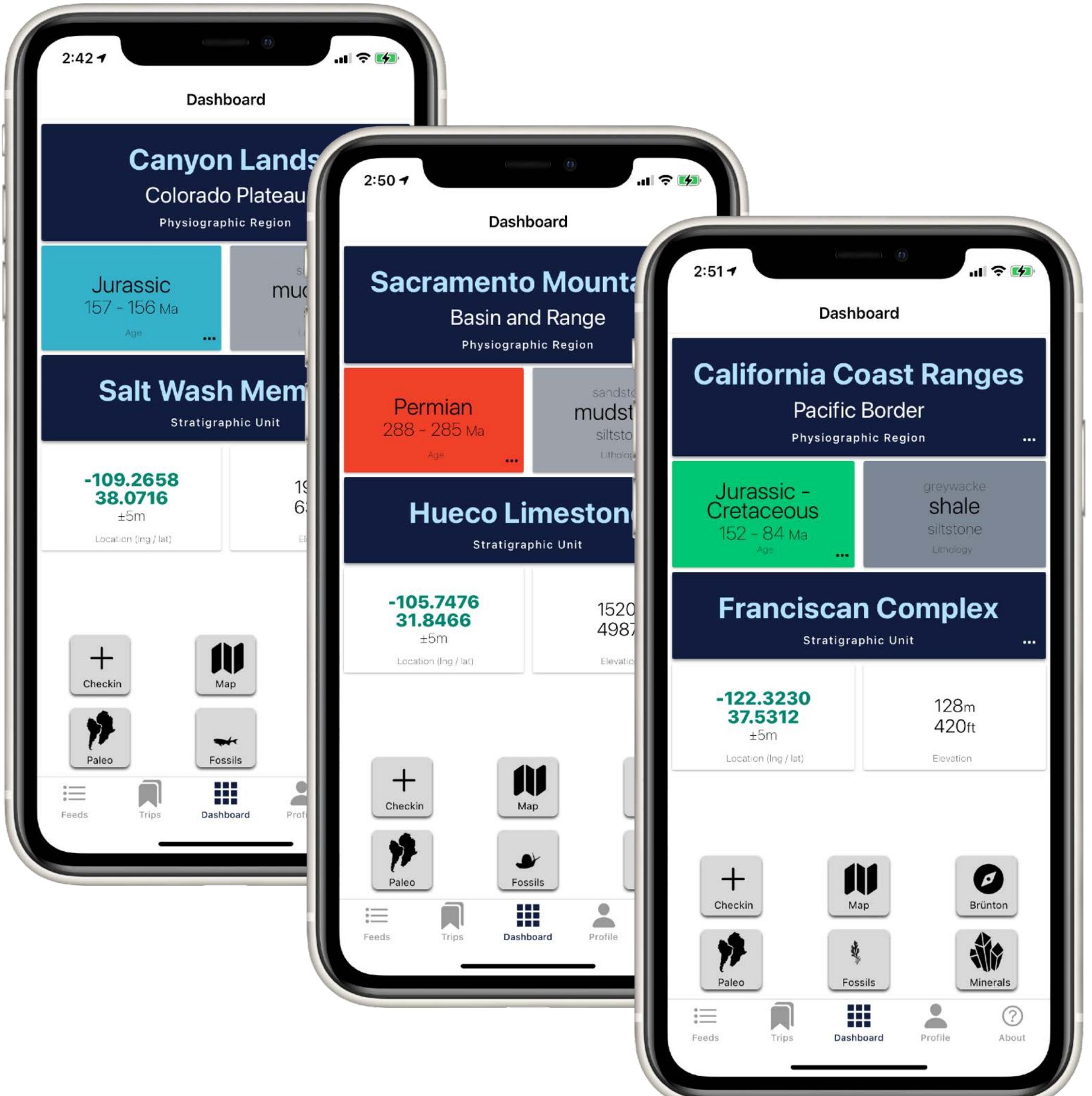
StraboSpot



...and many more!

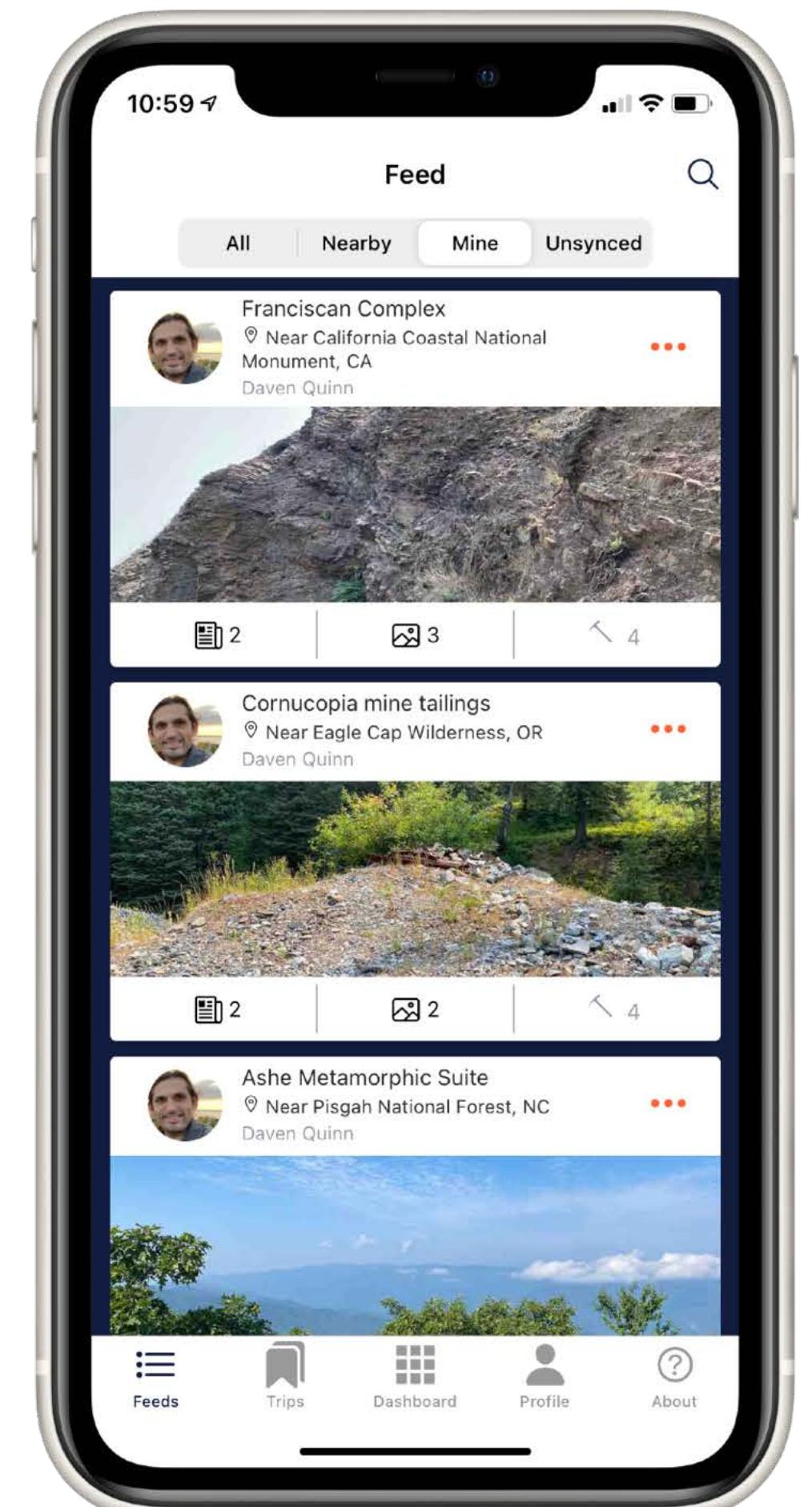


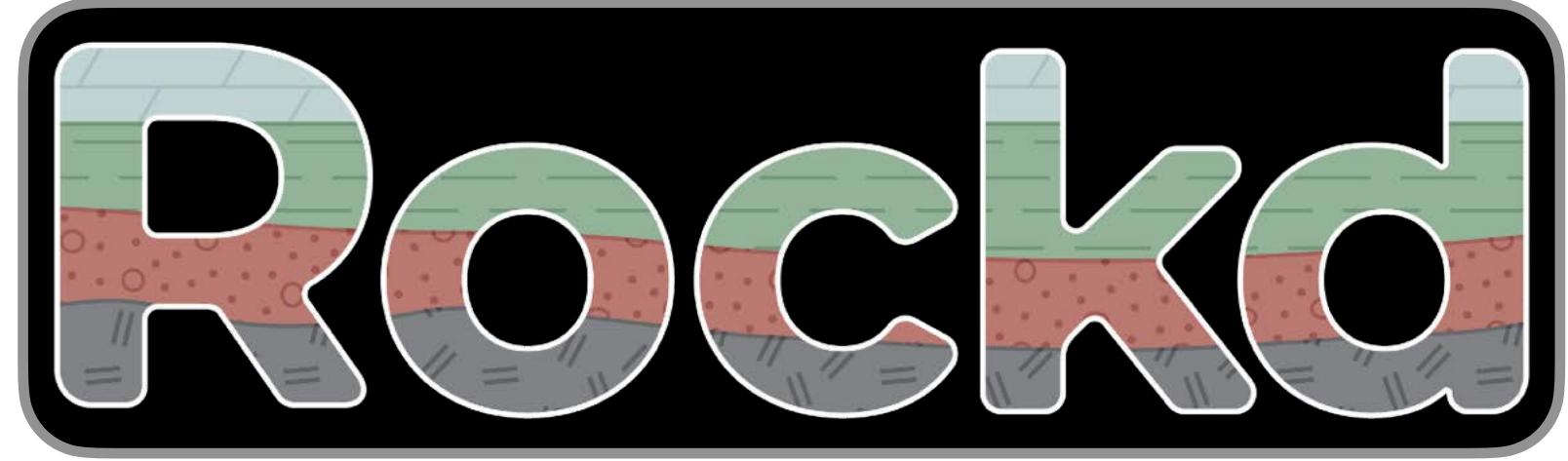
EXPLORE THE GEOLOGY AROUND YOU



<https://rockd.org>

COLLECT AND VIEW  
LOCAL OBSERVATIONS



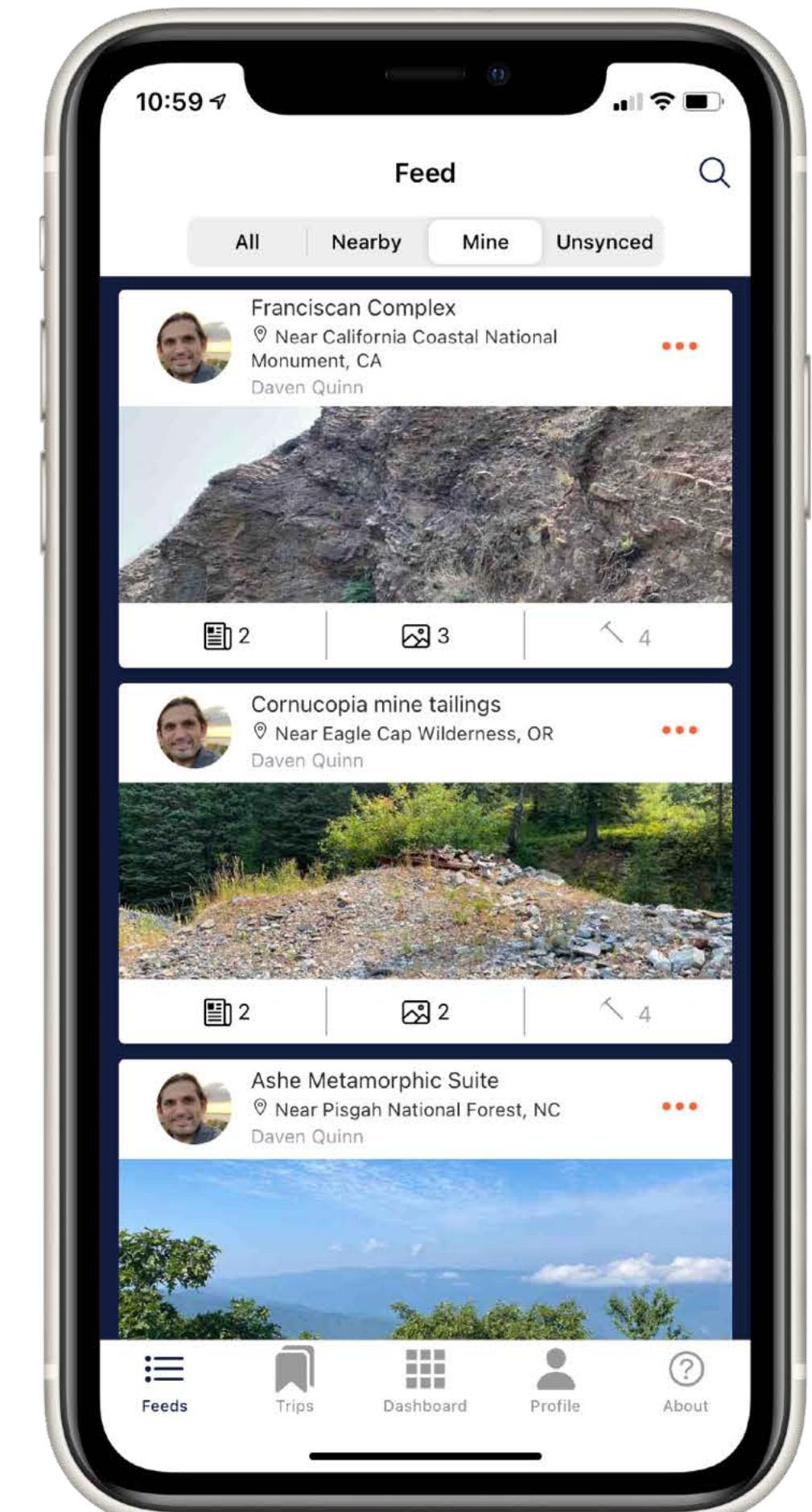


EXPLORE THE GEOLOGY AROUND YOU



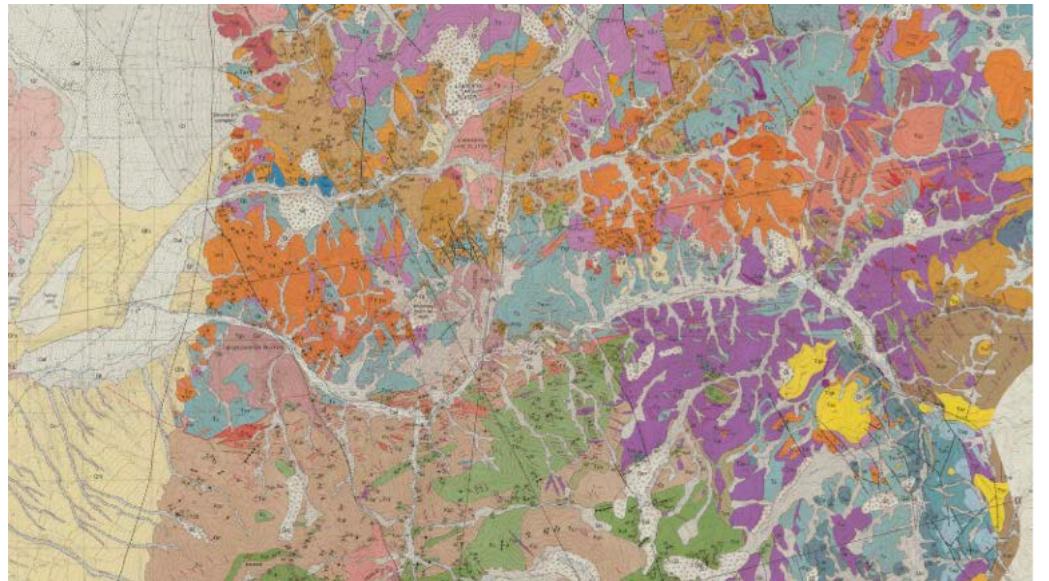
<https://rockd.org>

COLLECT AND VIEW  
LOCAL OBSERVATIONS



# Macrostrat system architecture

## Geologic maps



from  
National agencies

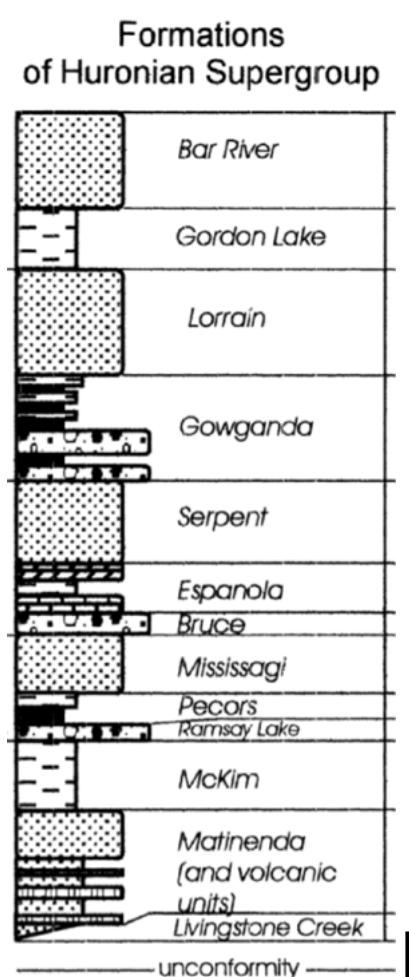


State surveys

Academic curators

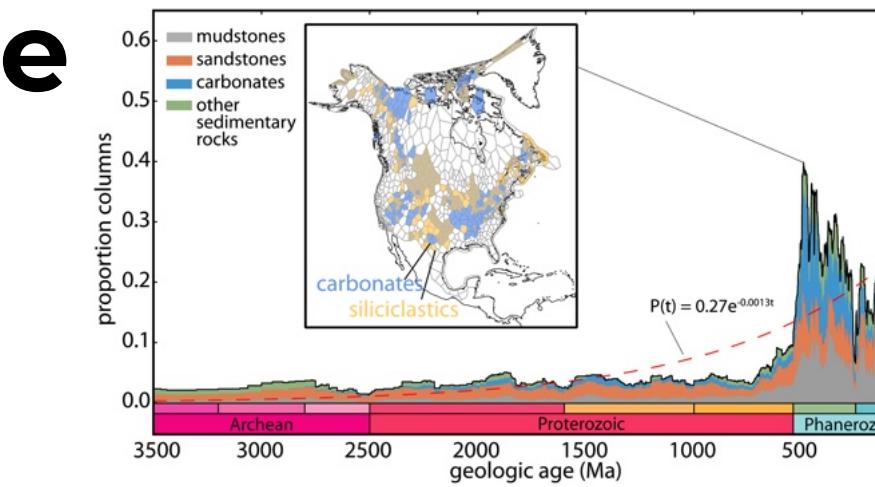


...and other sources

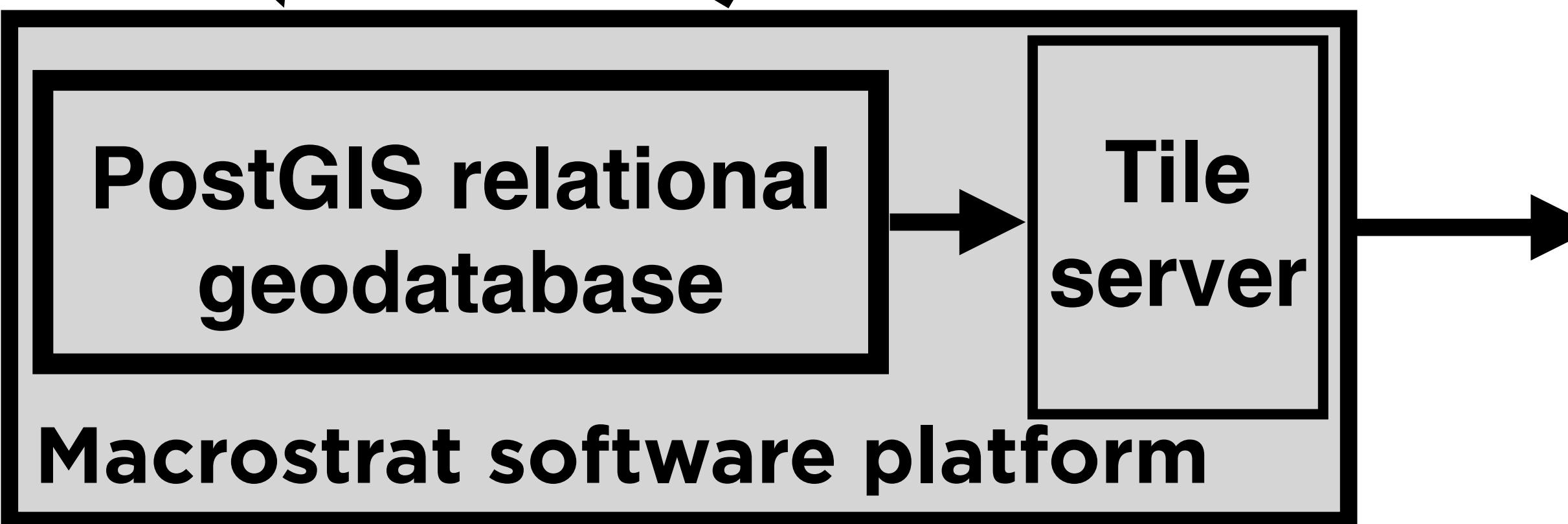
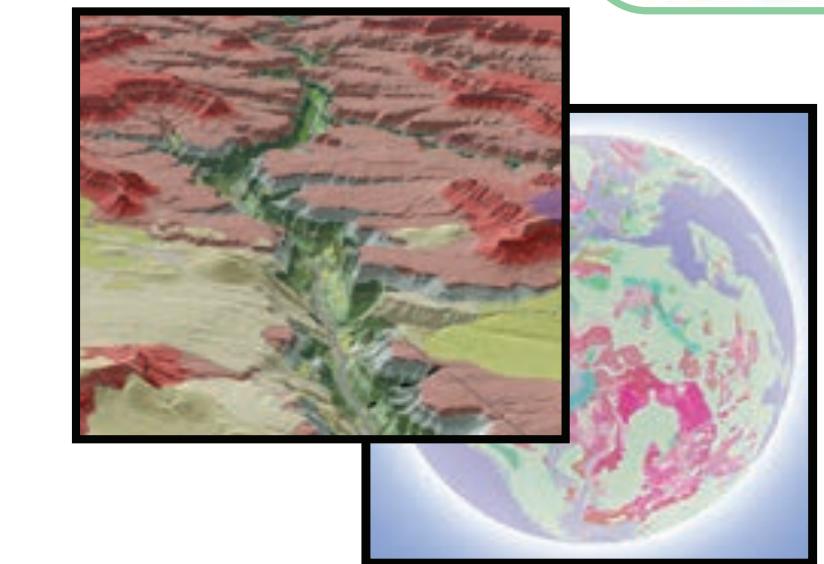


## Stratigraphic columns

## Global, integrative science



## Apps + web viewers



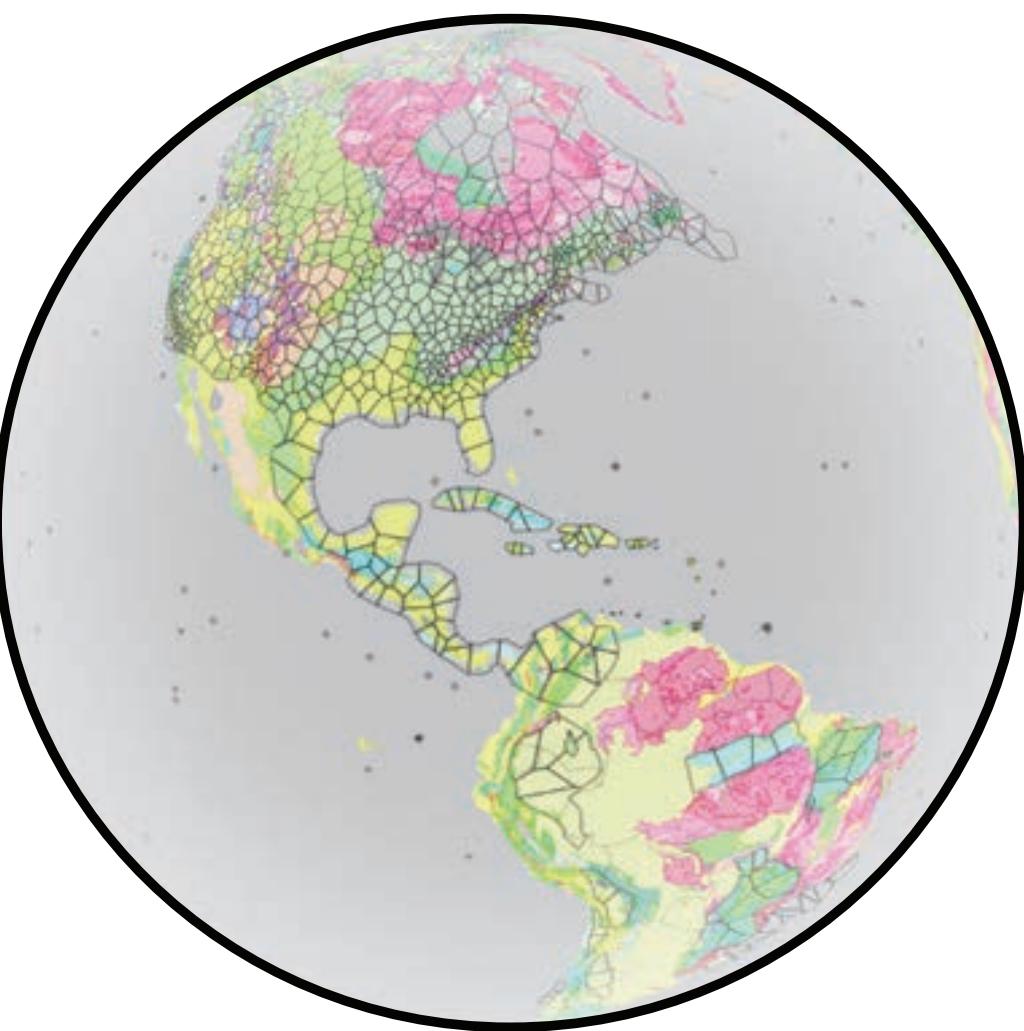
*Ingestion + harmonization*  
*Partially automated*

**Open APIs**  
*Automated*

**GIS platforms**

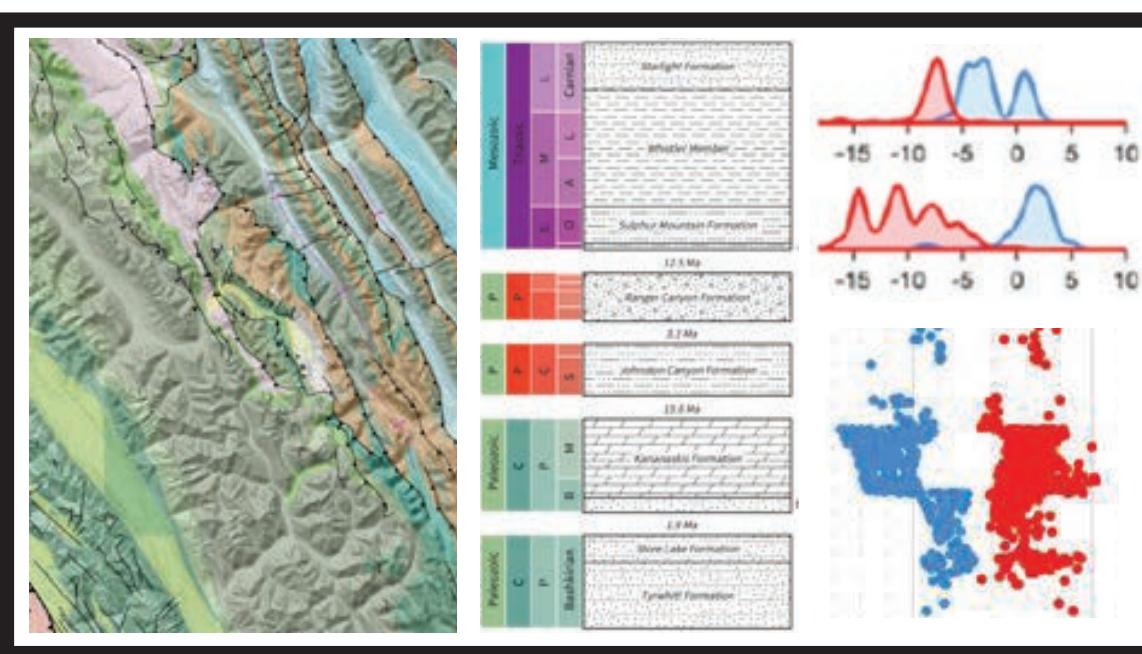
# Macrostrat

- Software infrastructure that adds context to geologic datasets
- APIs to serve harmonized geologic information to other systems
- Human-computer interfaces for geological data visualization



## MacroMAAS (Macrostrat for Mineral Assessment with AI Support)

- + Make it modular + scalable!
- + Ingest candidate geologic datasets provided by AI pipelines
- + Include contextual data sources relevant to critical minerals assessment
- + Add interfaces for feedback/correction of candidate datasets



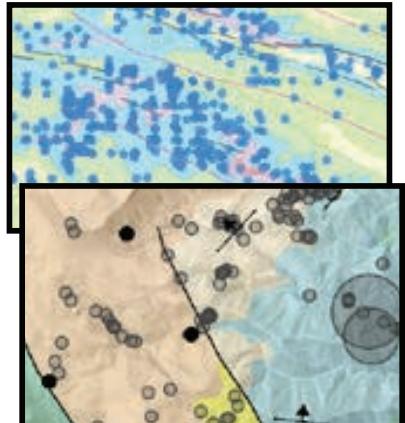
# MacroMAAS

## Proposed system architecture

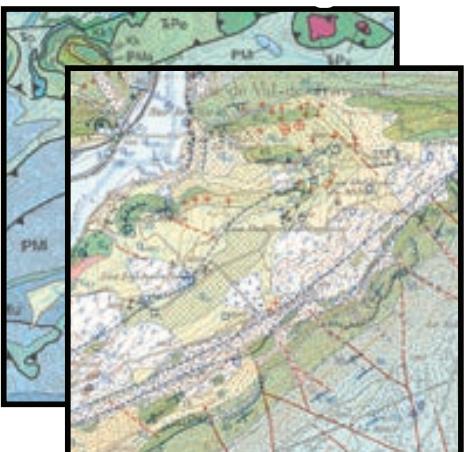
### New data sources



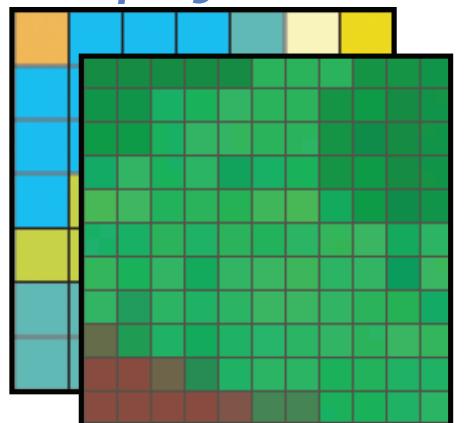
Measurements



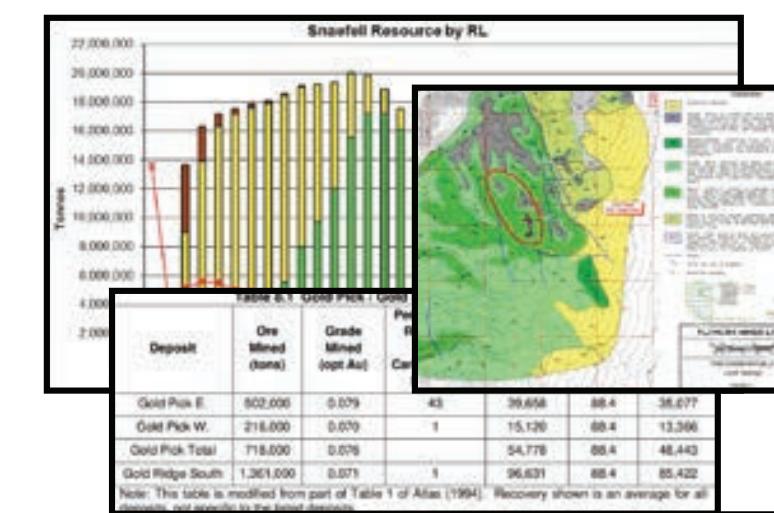
Raster maps



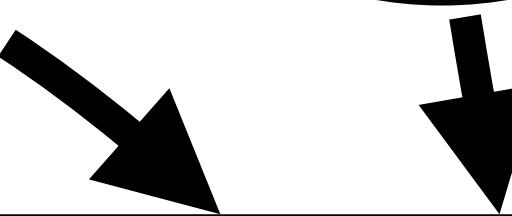
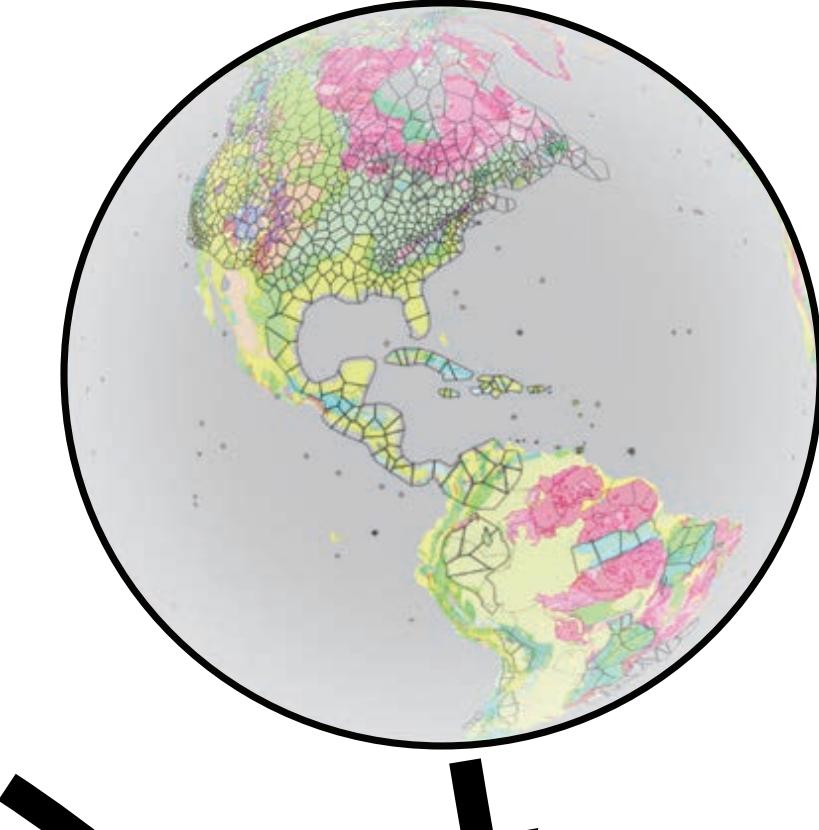
Geophysics



Literature extractions



Macrostrat



TA1-2

PostGIS relational  
geodatabase

Tile  
server

TA3

Ingestion + harmonization

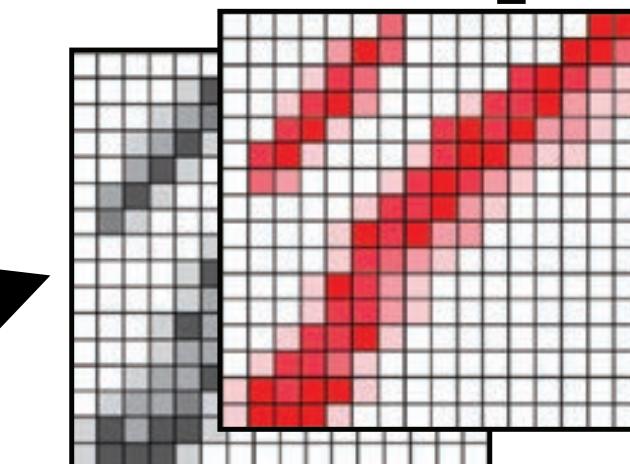
~~Partially automated~~

Fully automated

Feedback

*“Human in the loop”*

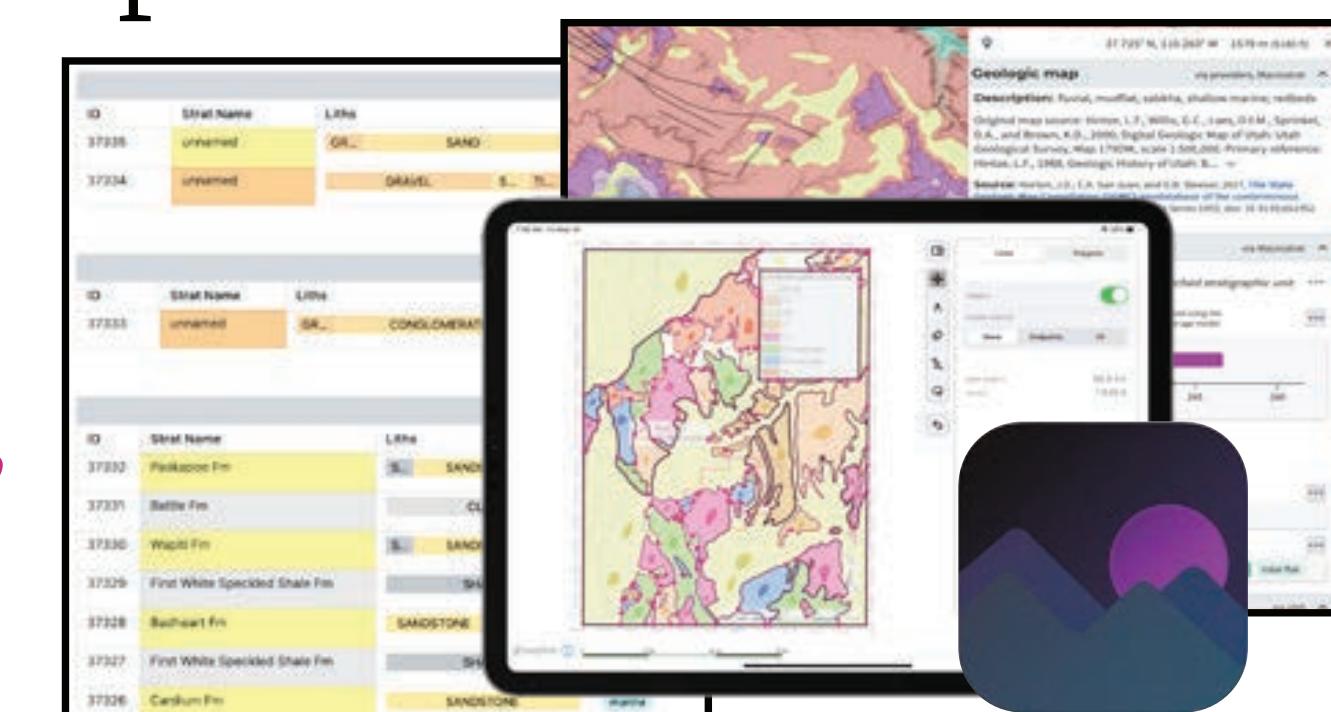
Predictive  
mineral maps



GIS platforms



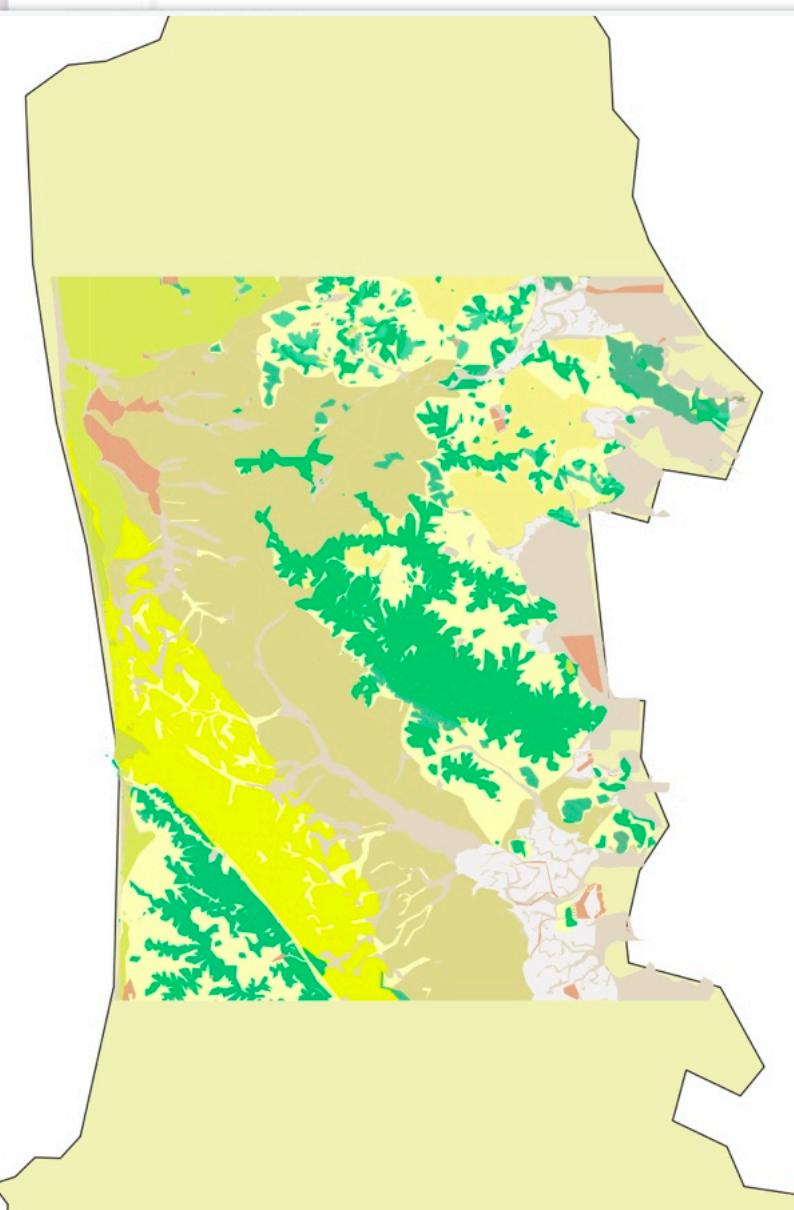
Expert feedback interfaces



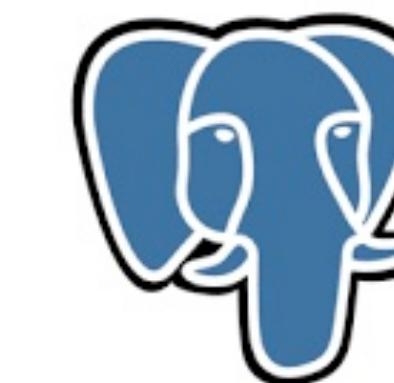
# Ingestion of AI-generated candidate map datasets (TAI output)

Planned

d	ptype	age	early_id	late_id	name
4	Qya	Holocene and late Pleistocene	492	3	Young alluvia
5	Qoa	late to middle Pleistocene	502	492	Old alluvial fl
6	Qyc	Holocene and late Pleistocene	492	3	Young colluvia
7	Qya	Holocene and late Pleistocene	492	3	Young alluvia
8	Qyf	Holocene and late Pleistocene	492	3	Young alluvia
9	Tcs	early Pliocene and late Miocene	488	489	Capistrano F
10	Tcs	early Pliocene and late Miocene	488	489	Capistrano F
11	Qls	Holocene and Pleistocene	4	3	Landslide de
		NULL	NULL	NULL	water
		Holocene and Pleistocene	4	3	Landslide de
		Holocene and late Pleistocene	492	3	Young colluvia
		Holocene and Pleistocene	4	3	Landslide de
		Cretaceous	33	33	Heterogeneous
		Holocene and late Pleistocene	492	3	Young alluvia
		Holocene and Pleistocene	4	3	Landslide de
		early Pliocene and late Miocene	488	489	Capistrano F
		Holocene and Pleistocene	4	3	Landslide de
21	Qls	Holocene and Pleistocene	4	3	Landslide de



Map ingestion into open-source PostGIS geospatial database



PostgreSQL

- Attributes are minimally cleaned
- Unit names and age ranges are linked to common definitions

~~Manual ingestion assisted by Python scripts~~

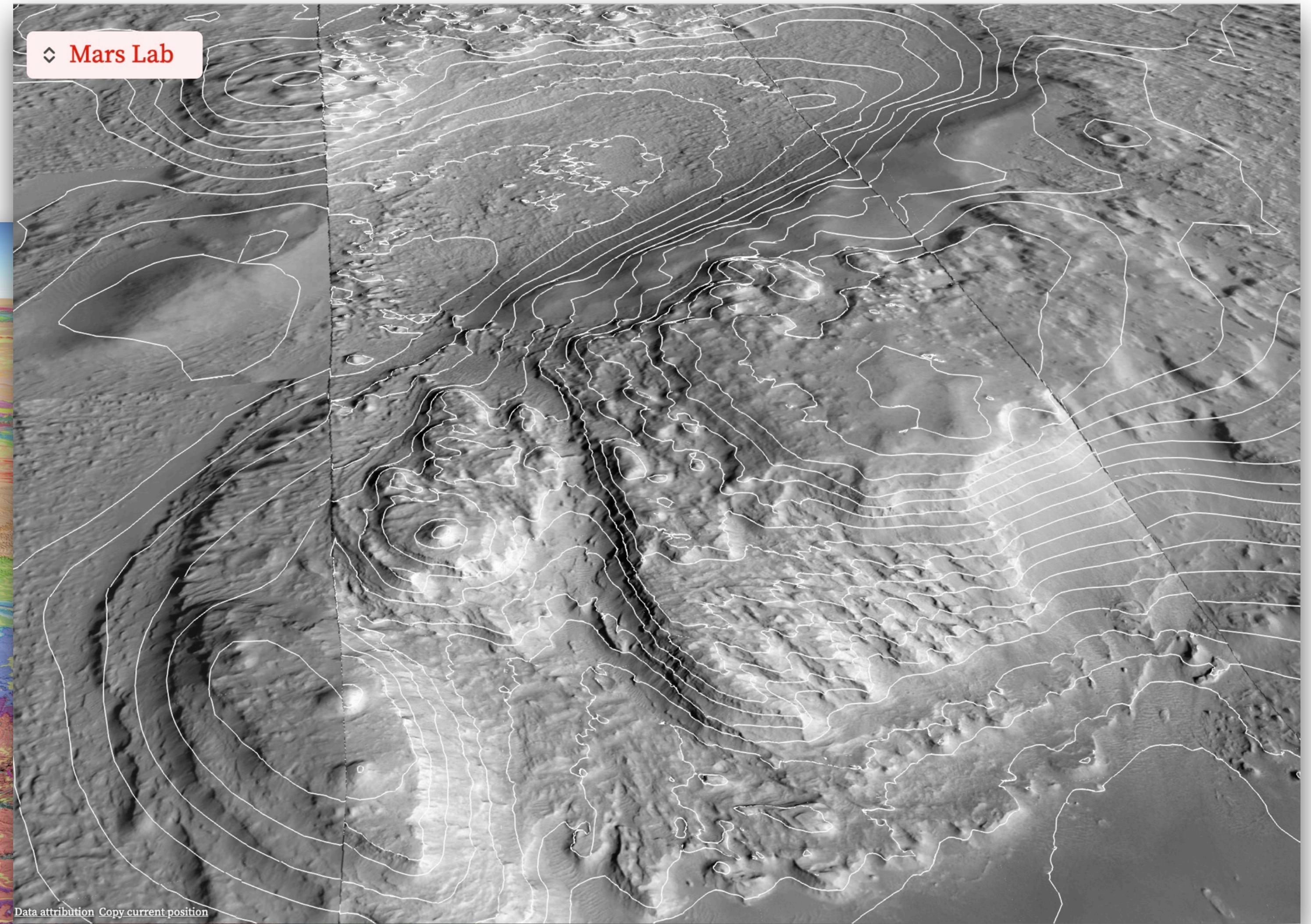
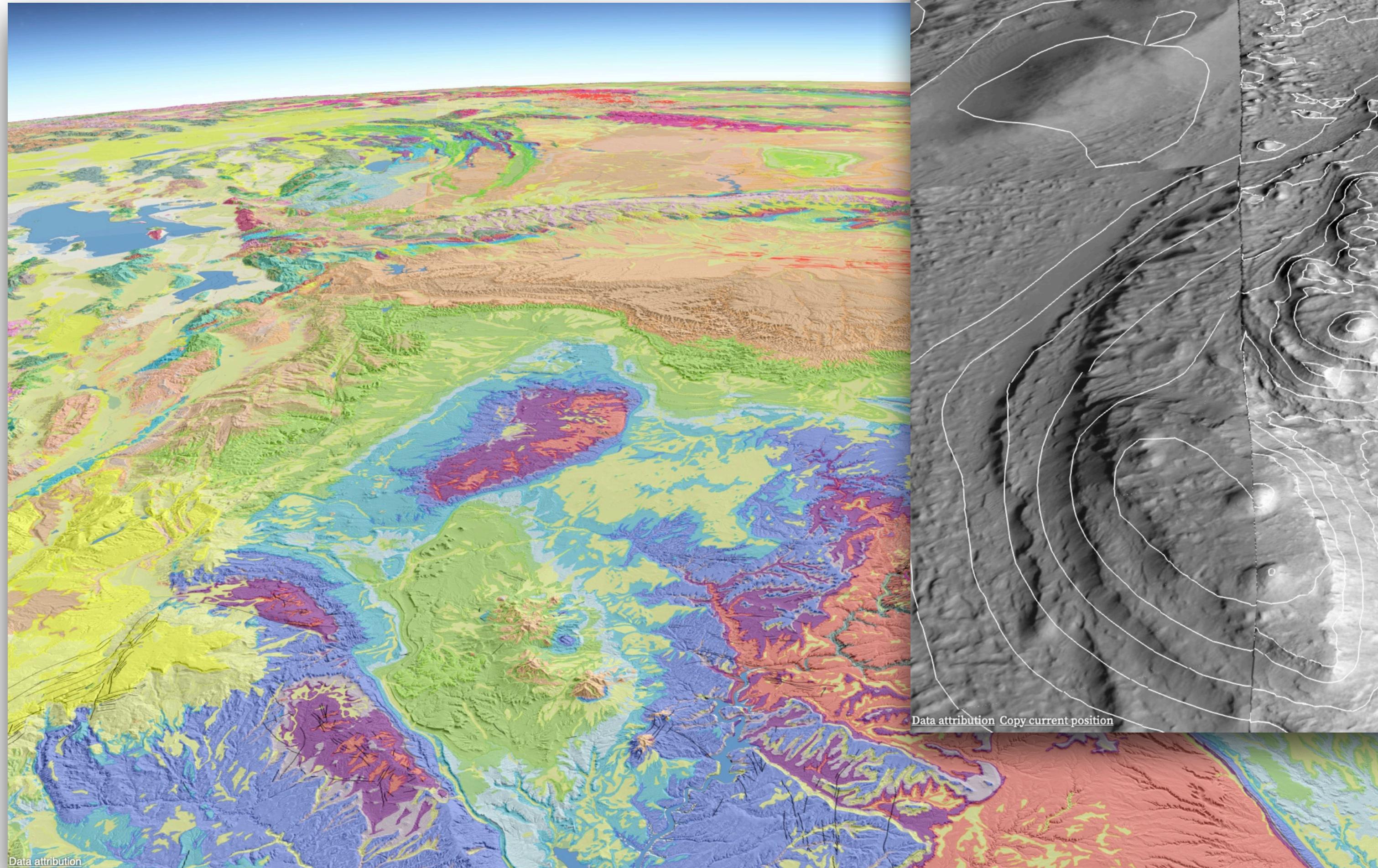
Automated “best-effort” ingestion

# Integrating new contextual data sources

## A dynamic tile server for raster datasets

*Prototype capability*

<https://argyre.geoscience.wisc.edu/app/>



In collaboration with

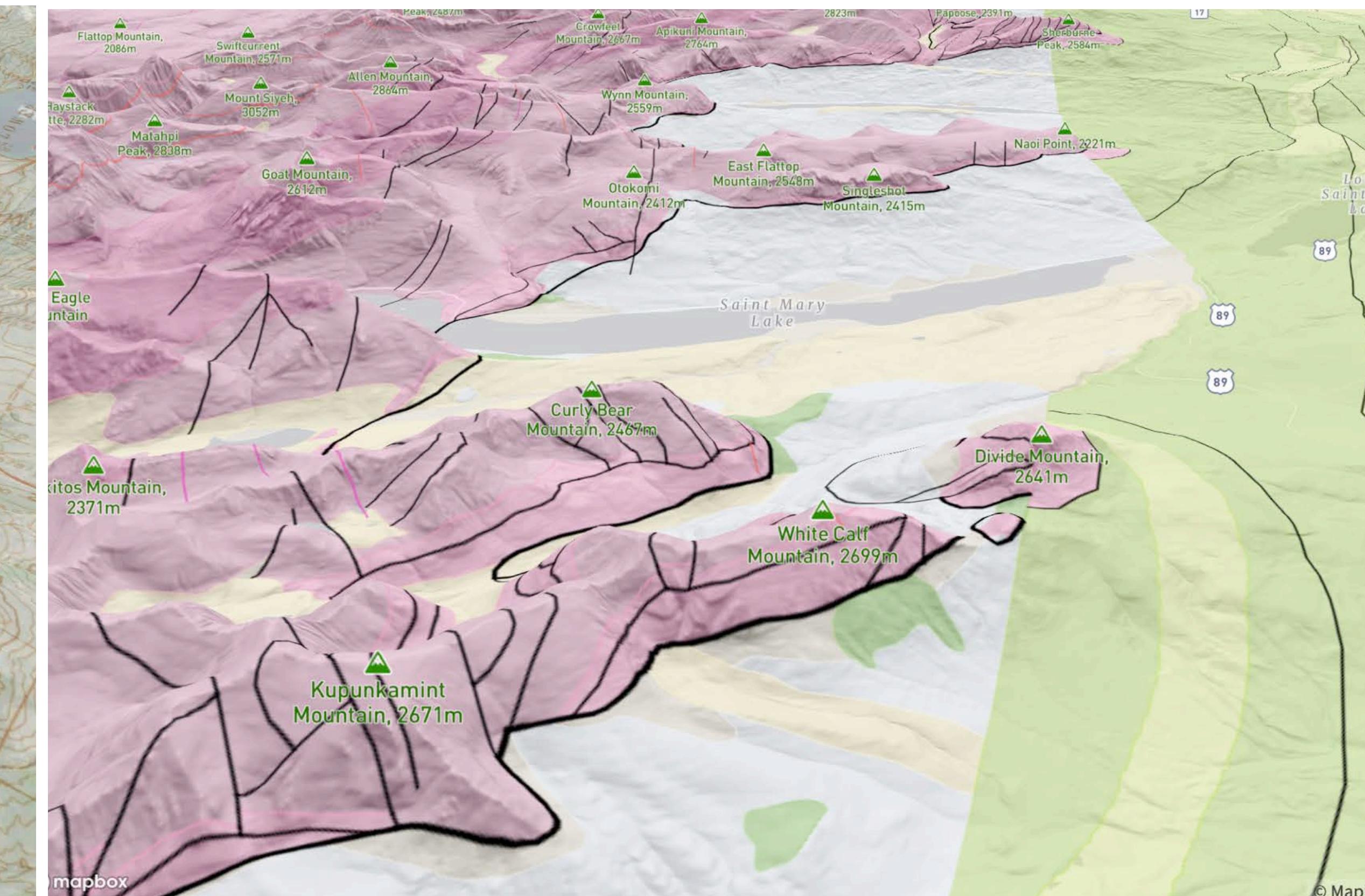
# Integrating new contextual data sources

## A dynamic tile server for raster datasets

Prototype capability



Macrostrat web interface showing raster geologic map

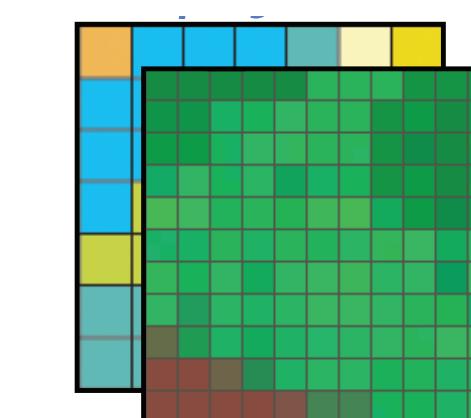


Vectorized version of same map

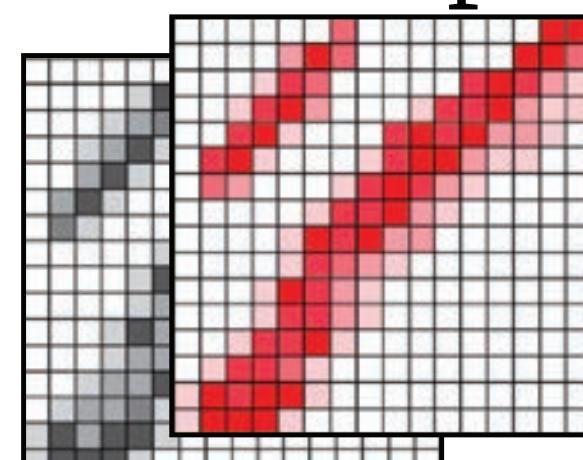
Critical for surfacing  
Geologic basemaps



Geophysical  
evidence layers



Predictive  
mineral maps

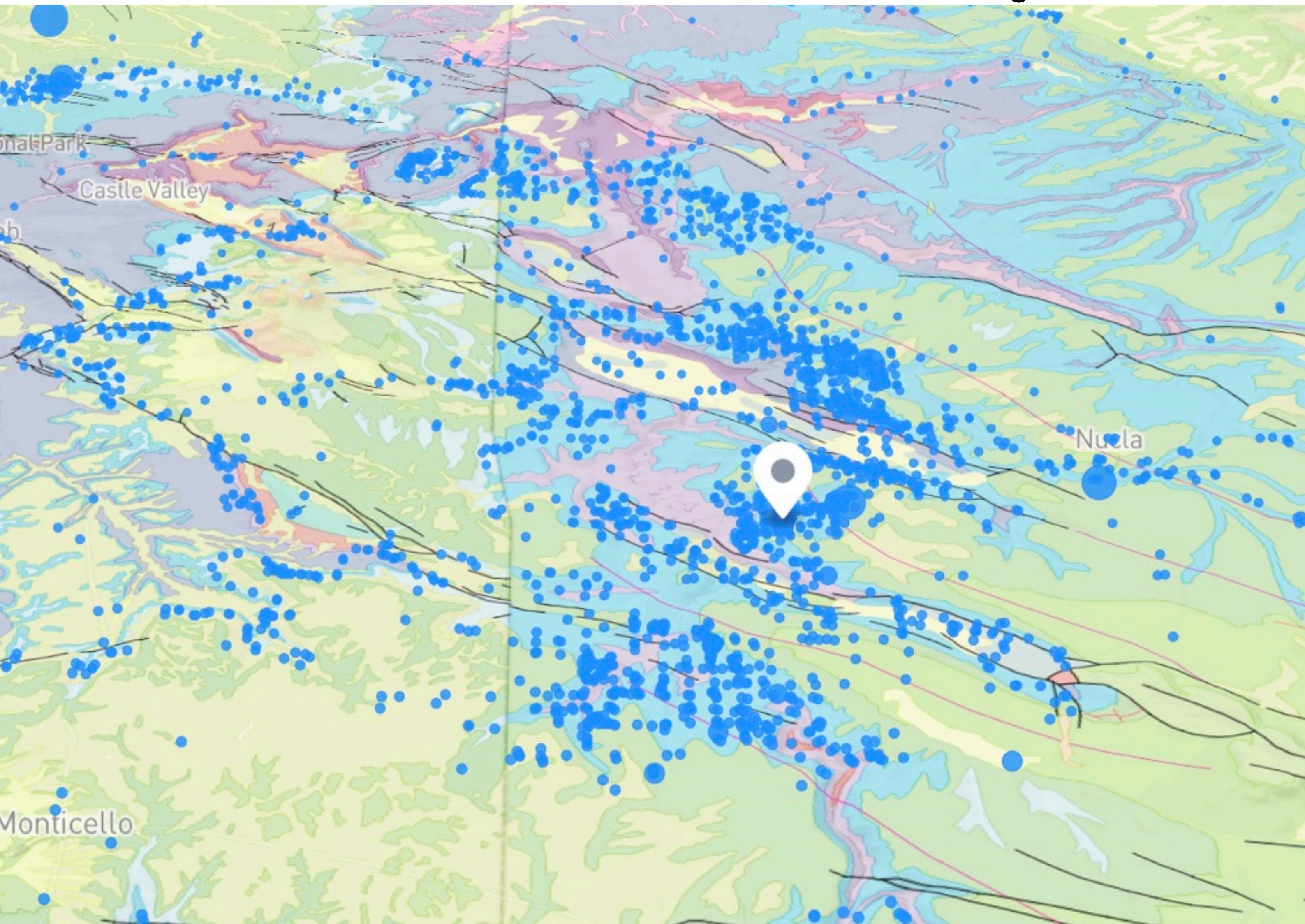


# Integrating new contextual data sources

Prototype capability

A flexible system for integrating/representing station-based data

## Site data from Mineral Resources Data System



**USGS**  
science for a changing world

Mineral Resources / Online Spatial Data / Mineral Resource Data System (MRDS)

### Club #3 Mine

Unknown in Montrose county in Colorado, United States with commodities Uranium, Vanadium

[Map](#) [XML](#) [JSON](#) [KML](#) [D](#)

#### Geologic information

##### Identification information

Deposit ID	10305115
MAS/MILS ID	0080850689
Record type	Site
Current site name	Club #3 Mine

##### Geographic coordinates

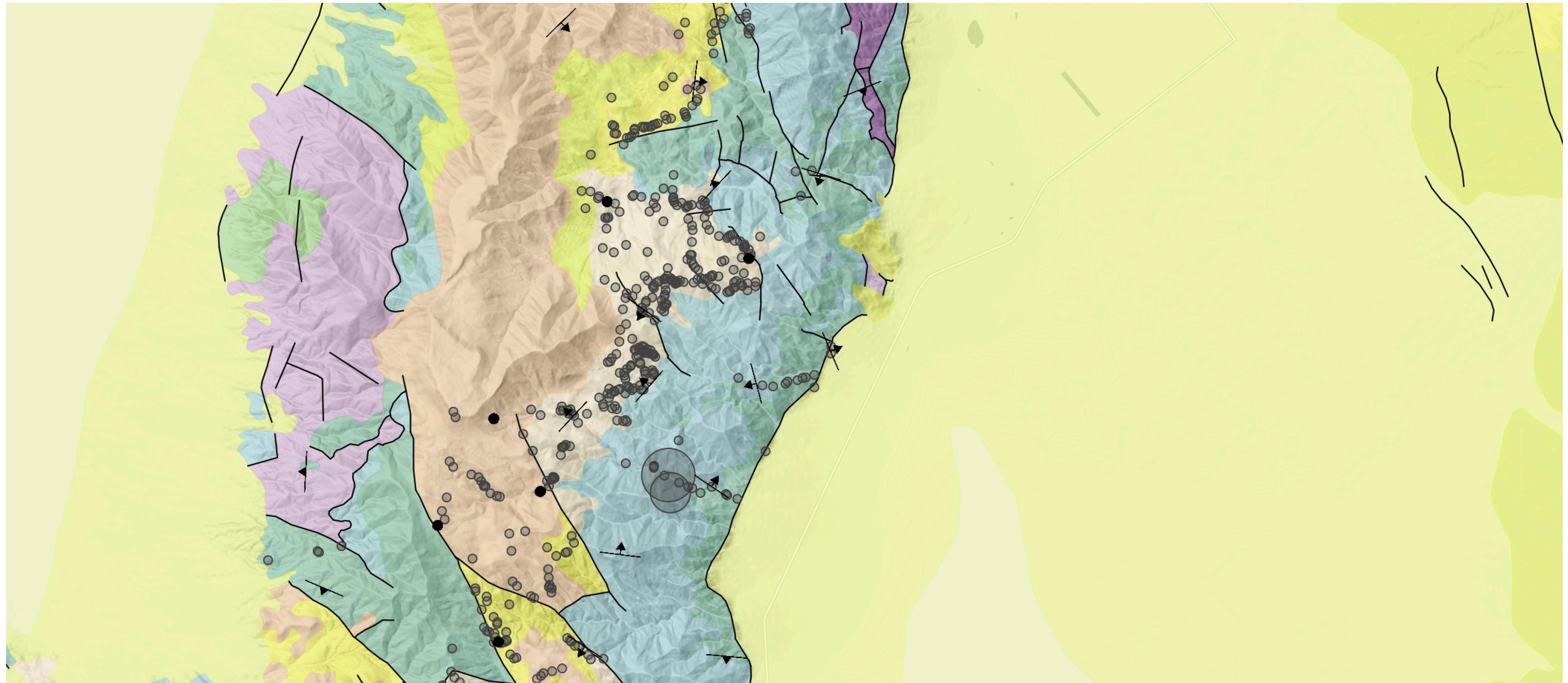
Point of reference	Main Entrance
Geographic coordinates:	-108.78288, 38.39079 (WGS84)
Elevation	1701
Location accuracy	10 (meters)
Political divisions (FIPS codes)	Montrose (county)

**Integrating new contextual data sources**

*Prototype capability*

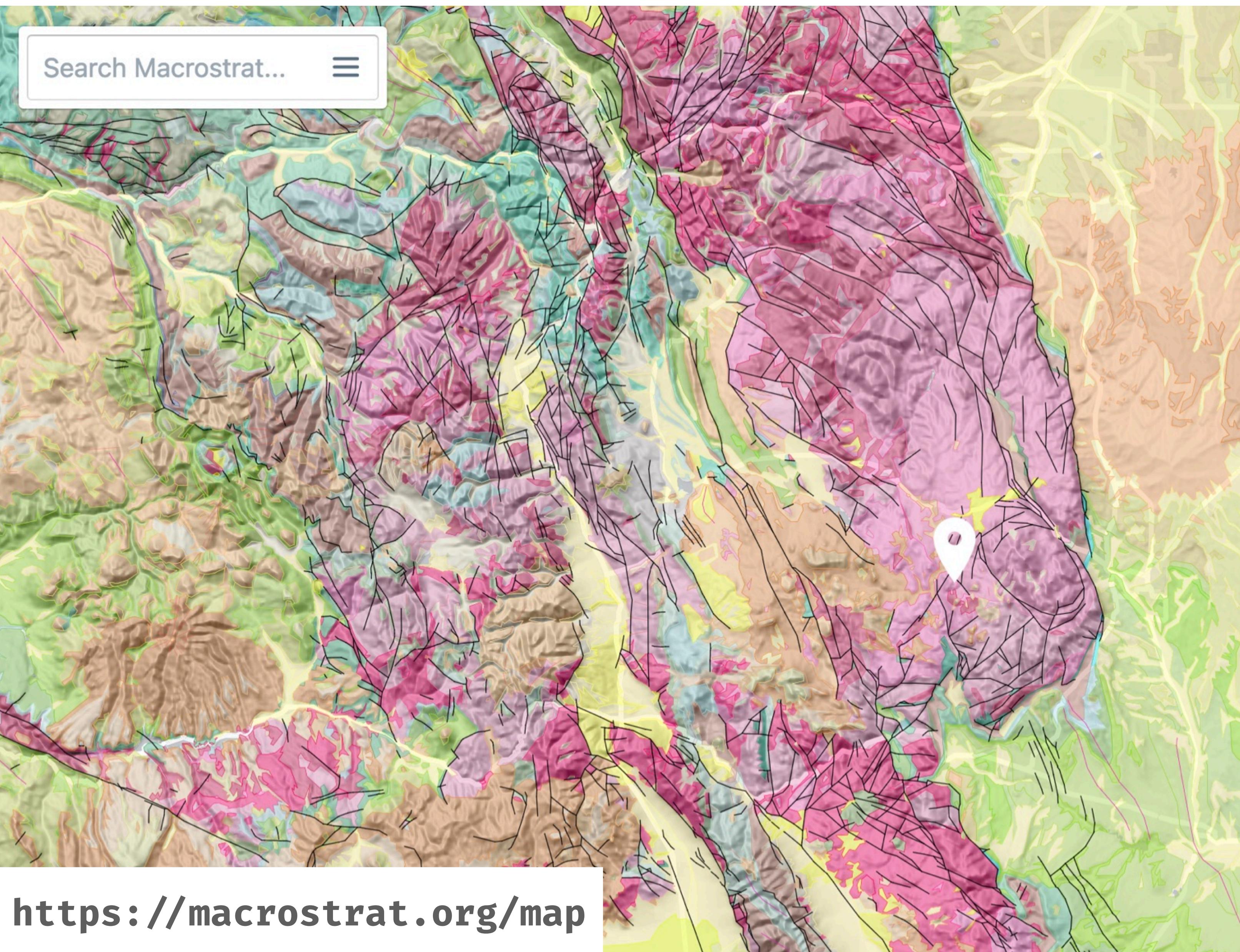
**A flexible system for integrating/representing station-based data**

## **Structural data from StraboSpot**



# Integrating contextual data from the geologic literature

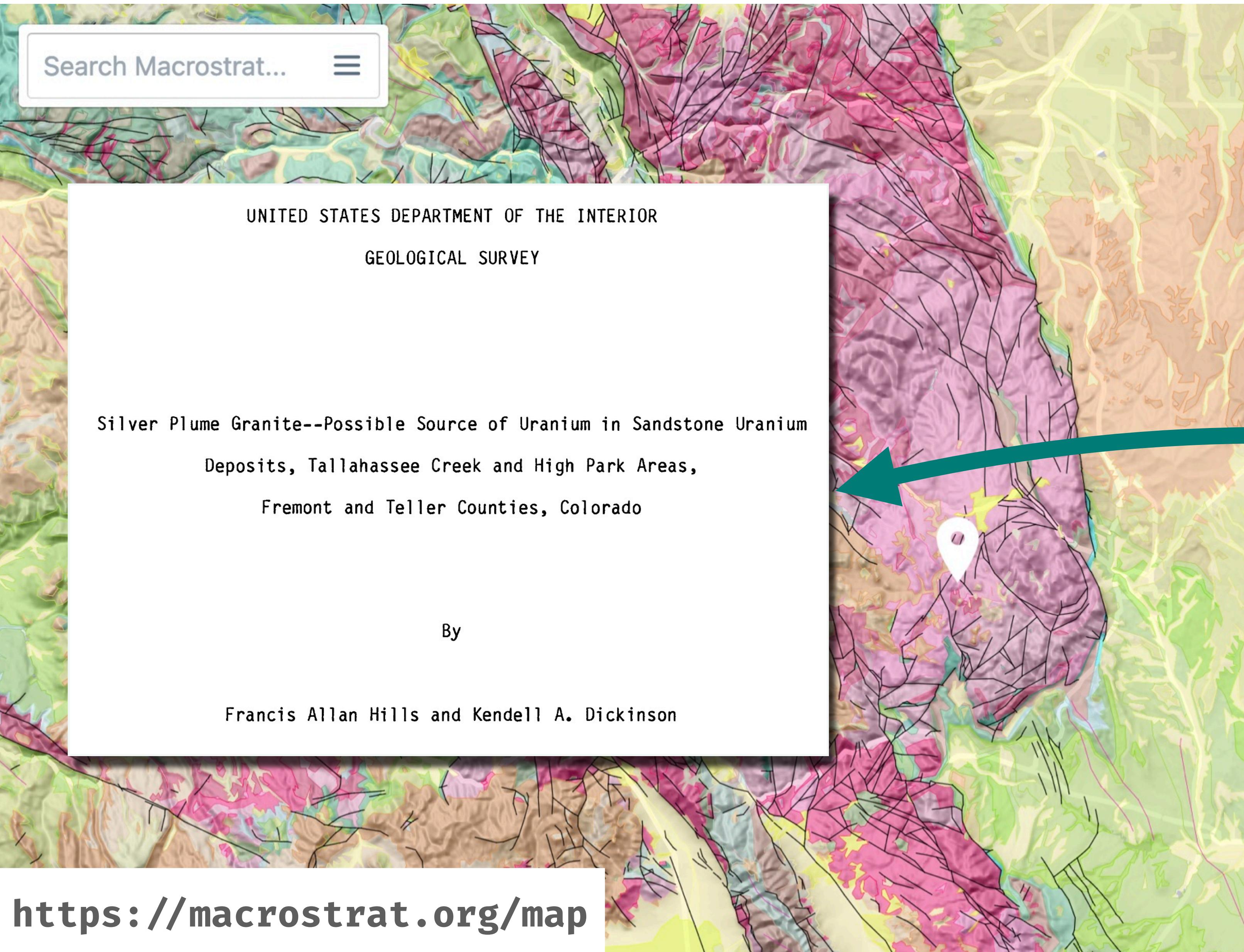
*Established capability*



- 105.2245, 38.7848 2737m | 8980ft X
- ### Primary literature
- via xDD ^
- Robinson, Charles Sherwood, [Geology and ore deposits of the Whitepine area, Tomichi mining district, Gunnison County, Colorado.](#) ▾
  - Nash, J. Thomas, [Supergene uranium deposits in brecciated zones of Laramide upthrusts; concepts and applications.](#) ▾
  - Young, E. J., [Felsic-mafic ratios and silica saturation ratios; their rationale and use as petrographic and petrologic indicators.](#) ▾
  - Hills, F. A., Dickinson, K. A., [Silver Plume Granite; possible source of uranium in sandstone uranium deposits, Tallahassee Creek and High Park areas, Fremont and Teller counties, Colorado.](#) ▾
  - Finch, Warren Irvin, [Stratigraphic distribution of uranium clusters in the Rocky Mountain and Intermontane Basins Uranium Province.](#) ▾
  - Braddock, William A., Cole, James C., [Preliminary geologic map of the Greeley 1 degree by 2 degrees Quadrangle, Colorado and Wyoming.](#) ▾
  - Snyder, George L., [Preliminary geologic map of the central Laramie Mountains, Albany and Platte counties, Wyoming.](#) ▾
  - McCallum, M. E., Burch, A. L., [Uranium and thorium in Precambrian crystalline rocks of the Medicine Bow Mountains, north-central Colorado.](#) ▾
  - Stuckless, J. S., Hedge, C. F., Wenner, D. B., Nkomo, J. T., [Isotopic studies](#)

# Integrating contextual data from the geologic literature

*Established capability*



- 105.2245, 38.7848 2737m | 8980ft X
- Primary literature** via xDD ▾
- Robinson, Charles Sherwood, [Geology and ore deposits of the Whitepine area, Tomichi mining district, Gunnison County, Colorado.](#) ▾
- Nash, J. Thomas, [Supergene uranium deposits in brecciated zones of Laramide upthrusts; concepts and applications.](#) ▾
- Young, E. J., [Felsic-mafic ratios and silica saturation ratios; their rationale and use as petrographic and petrologic indicators.](#) ▾
- Hills, F. A., Dickinson, K. A., [Silver Plume Granite; possible source of uranium in sandstone uranium deposits, Tallahassee Creek and High Park areas, Fremont and Teller counties, Colorado.](#) ▾
- Finch, Warren Irvin, [Stratigraphic distribution of uranium clusters in the Rocky Mountain and Intermontane Basins Uranium Province.](#) ▾
- Braddock, William A., Cole, James C., [Preliminary geologic map of the Greeley 1 degree by 2 degrees Quadrangle, Colorado and Wyoming.](#) ▾
- Snyder, George L., [Preliminary geologic map of the central Laramie Mountains, Albany and Platte counties, Wyoming.](#) ▾
- McCallum, M. E., Burch, A. L., [Uranium and thorium in Precambrian crystalline rocks of the Medicine Bow Mountains, north-central Colorado.](#) ▾
- Stuckless, J. S., Hedge, C. F., Wenner, D. B., Nkomo, J. T., [Isotopic studies](#)

# xDD: Integrating contextual data from the geologic literature

*Established capability*

📍 -105.2245, 38.7848 2737m | 8980ft ✖

**Primary literature** via xDD ^

Robinson, Charles Sherwood, [Geology and ore deposits of the Whitepine area, Tooele County, Utah](#)

Hills, F. A., Dickinson, K. A., [Silver Plume Granite; possible source of uranium in sandstone uranium deposits, Tallahassee Creek and High Park areas, Fremont and Teller counties, Colorado.](#) ^

...Anomalously high concentrations of thorium and of the light rare earth elements lanthanum and cerium suggest that the actinides and light lanthanides were enriched to an abnormal degree by the magmatic processes that formed the Proterozoic Y [Silver Plume Granite](#) in areas adjoining Tallahassee Creek and High Park ....

...Although a significant contribution of uranium from Tertiary volcanic rocks can not be ruled out and is even probable ( Dickinson and Hills , 1982 ) , it appears probable that some of the uranium in deposits of the Tallahassee Creek area was derived from [Silver Plume Granite](#) ....

...Although uranium presently does not appear to be significantly enriched in sampled outcrops of [Silver Plume Granite](#) , a large part of the original uranium content of Silver Plume may have been removed by oxidizing ground waters , leaving behind mainly the uranium bound in resistate minerals such as zircon and monazite ....

...Creek area was [Silver Plume Granite](#) , and Tertiary volcanic rocks also probably supplied significant amounts of uranium ( Dickinson and Hills , 1982 ) , the inferred fertility of the [Silver Plume Granite](#) , its abundance in areas adjoining Tallahassee Creek , and the demonstrated former existence of an appropriate paleohydrologic system for transporting lead from the Silver Plume and depositing it in the Tallahassee Creek area make highly probable that the [Silver Plume Granite](#) supplied part of the uranium now found in the Tallahassee Creek deposits ....

Nash, J. Thomas, [Structural evolution of the Laramide upthrust belt, Colorado](#)

Young, E. J., [Basic principles of mineral resource assessment and use : a guide for environmental impact statements](#)

Hills, F. A., Dickinson, K. A., [Uranium in sandstone deposits of the Tallahassee Creek and High Park areas, Fremont and Teller counties, Colorado](#)

Finch, Warren Irving, [The geological evolution of the Rocky Mountains](#)

Braddock, William A., [Greeley 1 degree block](#)

Snyder, George L., [Mountains, Albany and Platte counties, Wyoming.](#) ▾

Macrostrat is linked to the xDD (formerly, GeoDeepDive) machine reading library, data infrastructure, and API

**16,909,371 documents**



SEPM  
108,486 added this month

AGU  
25,112 added this week

Taylor & Francis  
3,683 added in the last 24 hours



<https://xdd.wisc.edu>

# xDD + COSMOS

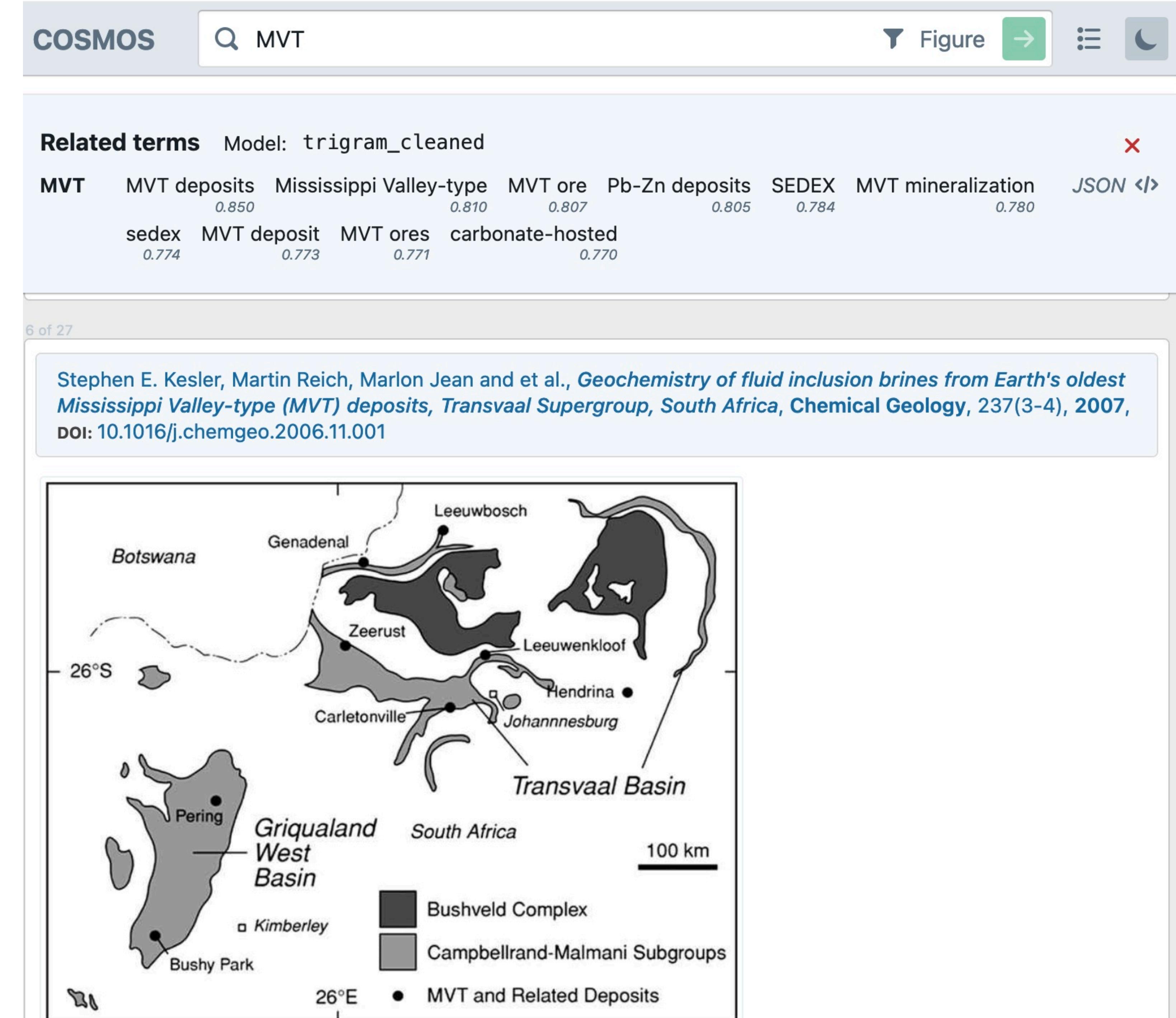
## Established capability

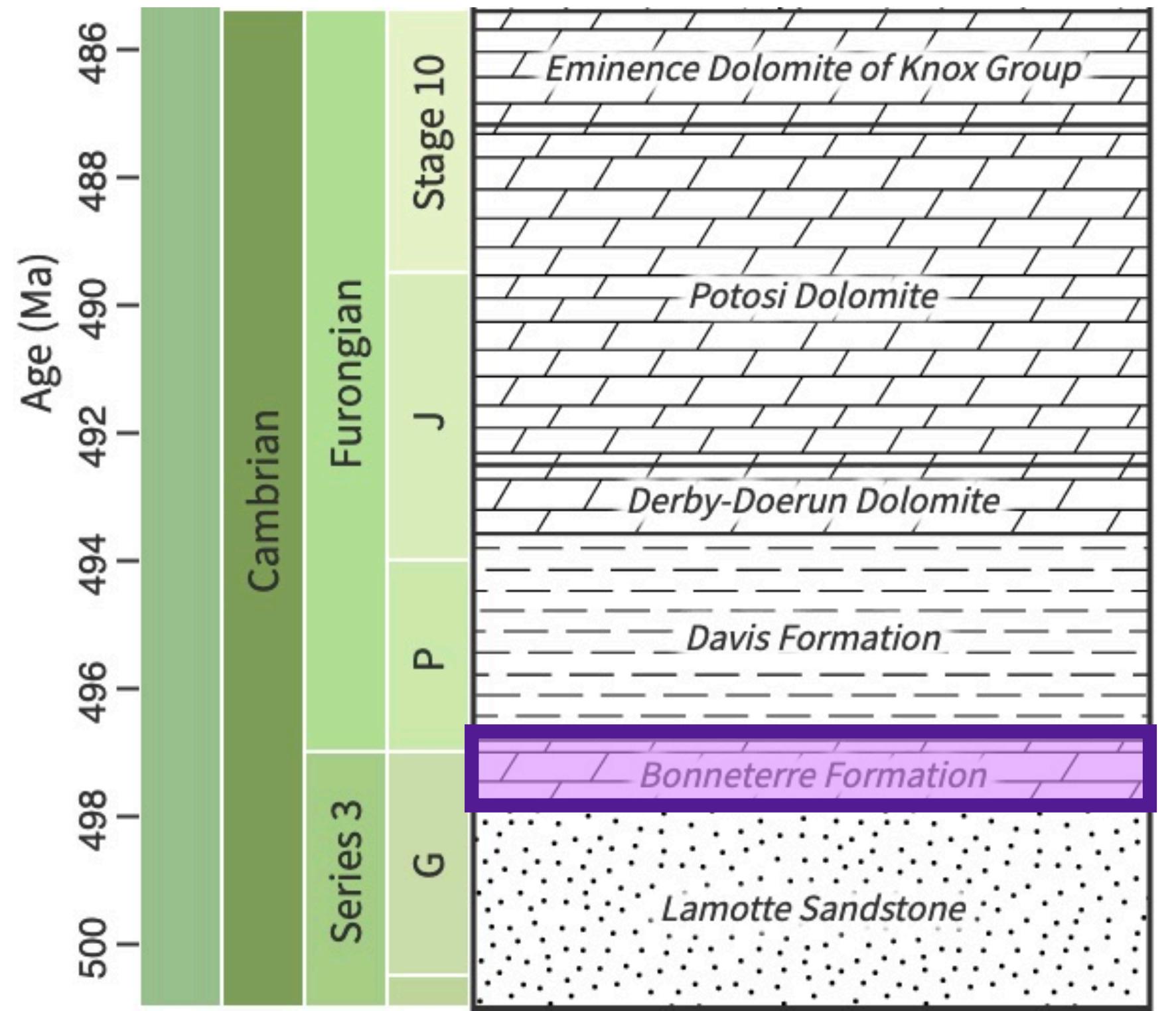
Surface relevant information from the geologic literature

Example: Mississippi Valley-type ore deposits

- Surface source data for TA1-3
- Datasets filtering on arbitrary criteria can be created on demand (ex. dolomite)

[https://xdd.wisc.edu/set\\_visualizer/sets/dolomites?query=MVT&type=Figure](https://xdd.wisc.edu/set_visualizer/sets/dolomites?query=MVT&type=Figure)





## Macrostrat-linked data

via Macrostrat ▾

### Bonneterre Formation

Matched stratigraphic unit

...

Age: Guzhangian - Jiangshanian  
497.85 Ma - 492.5 Ma

Refined using the  
Macrostrat age model.

...

Thickness: 0 - 228m

Fossil collections: 60

Fossil occurrences: 172

Lithology: siliciclastic carbonate

...

Environment: other

...

Economy: mineral aquifer construction

...

## xDD + COSMOS

*Planned capability*

## IMPROVE MACROSTRAT GEOLOGIC ENTITIES

*Improve the quality of structured geological information by “canonicalizing” literature mentions*

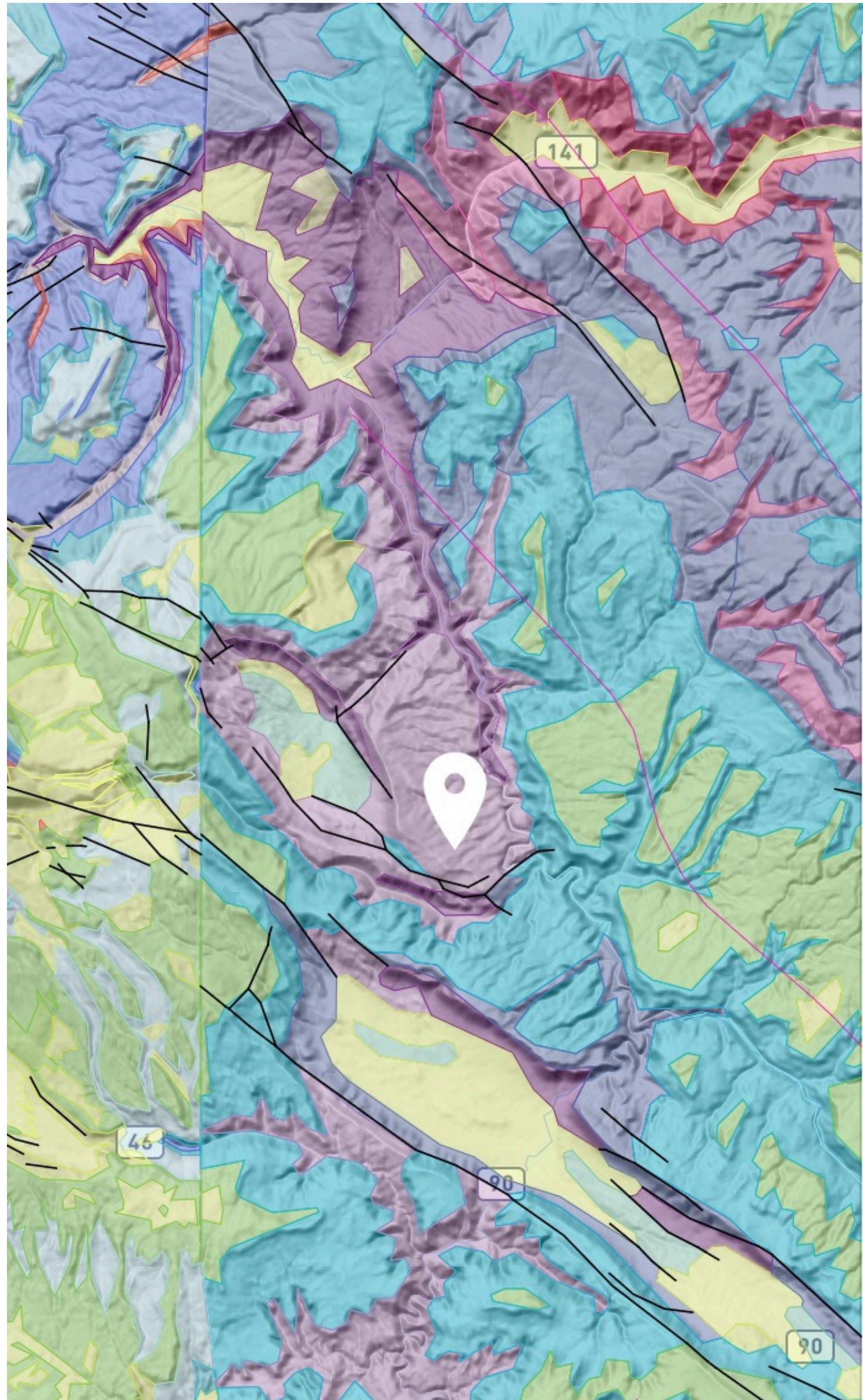
Regional epigenetic dolomitization in the Bonneterre Dolomite (Cambrian), southeastern Missouri

1972). The backreef or nearshore facies consists of interbedded planar stromatolites and mudstones, probably representative of lagoonal, high intertidal, and supratidal environments

(Howe, 1968). The stromatolite reef complex is pervasively dolomitized and is the host rock of the Mississippi Valley-type lead and zinc sulfide ores of the Viburnum Trend (Gerdemann and Myers, 1972).

West of the reef complex the Bonneterre grades into an offshore limestone facies of argil-

# FEEDBACK AND ASSESSMENT TOOLS BASED ON MACROSTRAT WEB INTERFACES



-108.9124, 38.4597 1947m | 6388ft X

Geologic map via providers, Macrostrat

Macrostrat-linked data via Macrostrat

**Chinle Formation** Matched stratigraphic unit

All matched names: Chinle Formation

Age: **Ladinian - Rhaetian** 237 Ma - 206.7 Ma Refined using the Macrostrat age model.

Age refinement: Macrostrat age model Map legend

Thickness: 0 - 300m

Fossil collections: 20

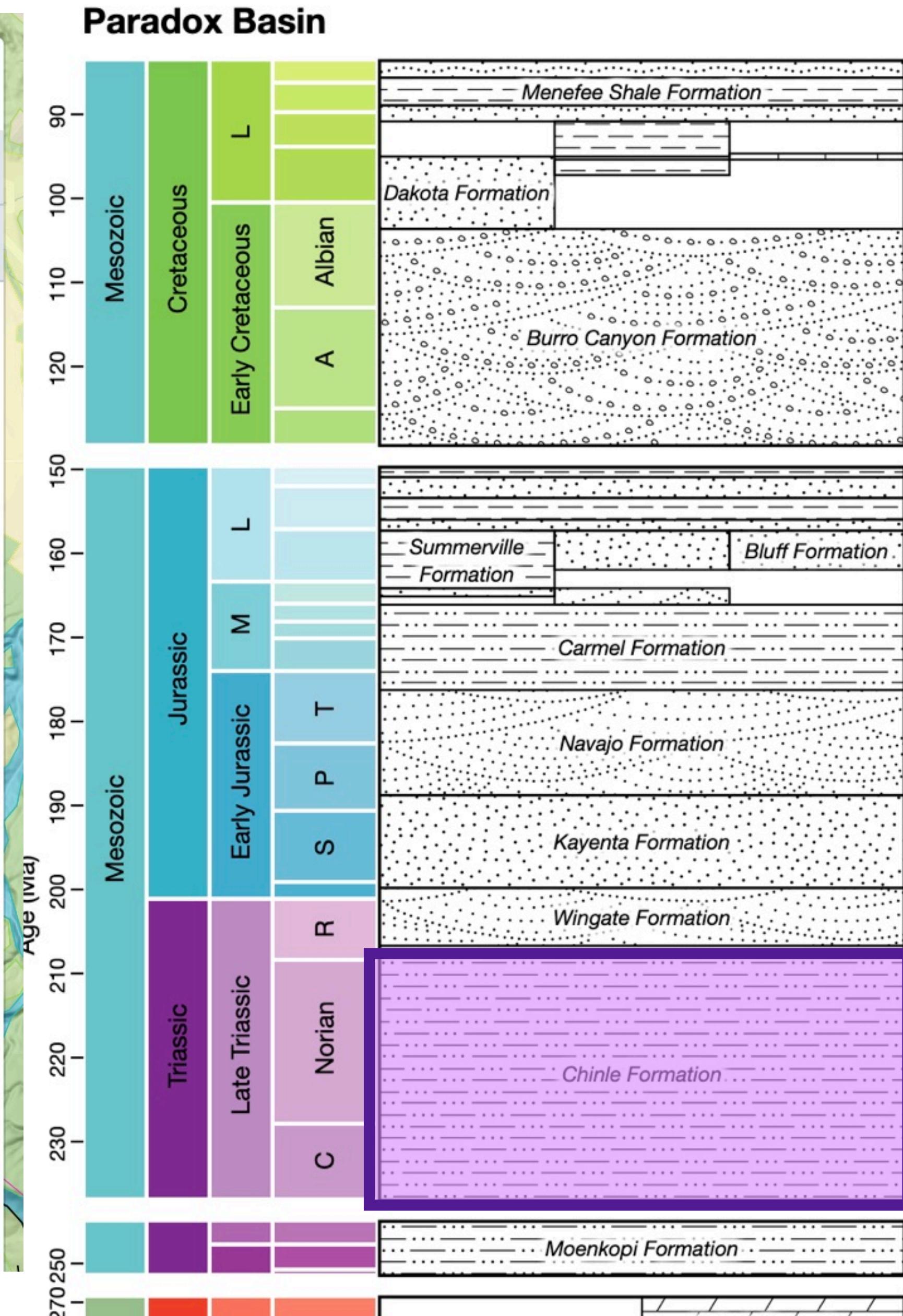
Fossil occurrences: 79

Lithology: siliciclastic

Matched lithologies: shale siltstone

Environment: fluvial

Matched environments: floodplain

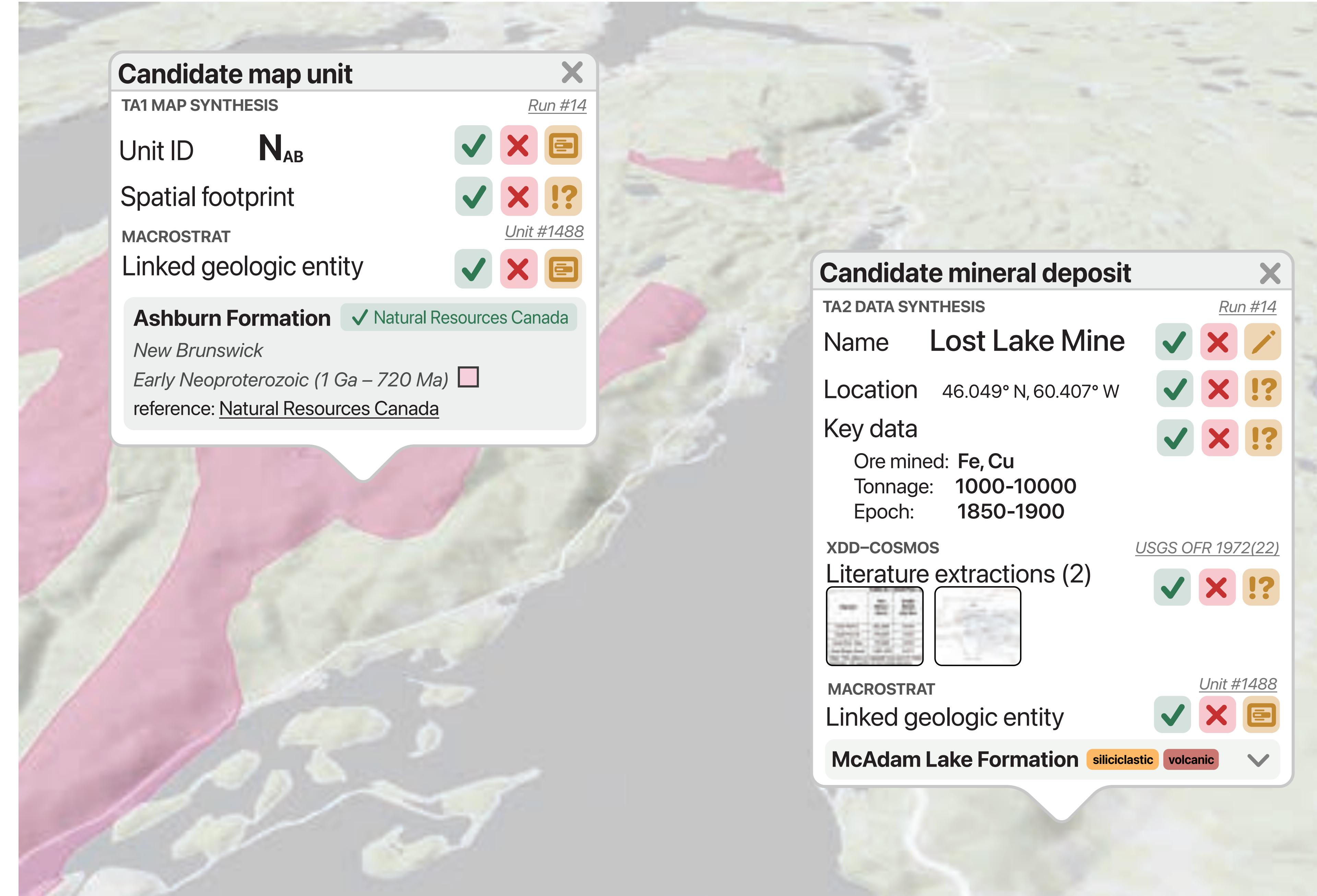


# Map assessment widgets

for evaluation of  
TA1-3 outputs in  
geologic context

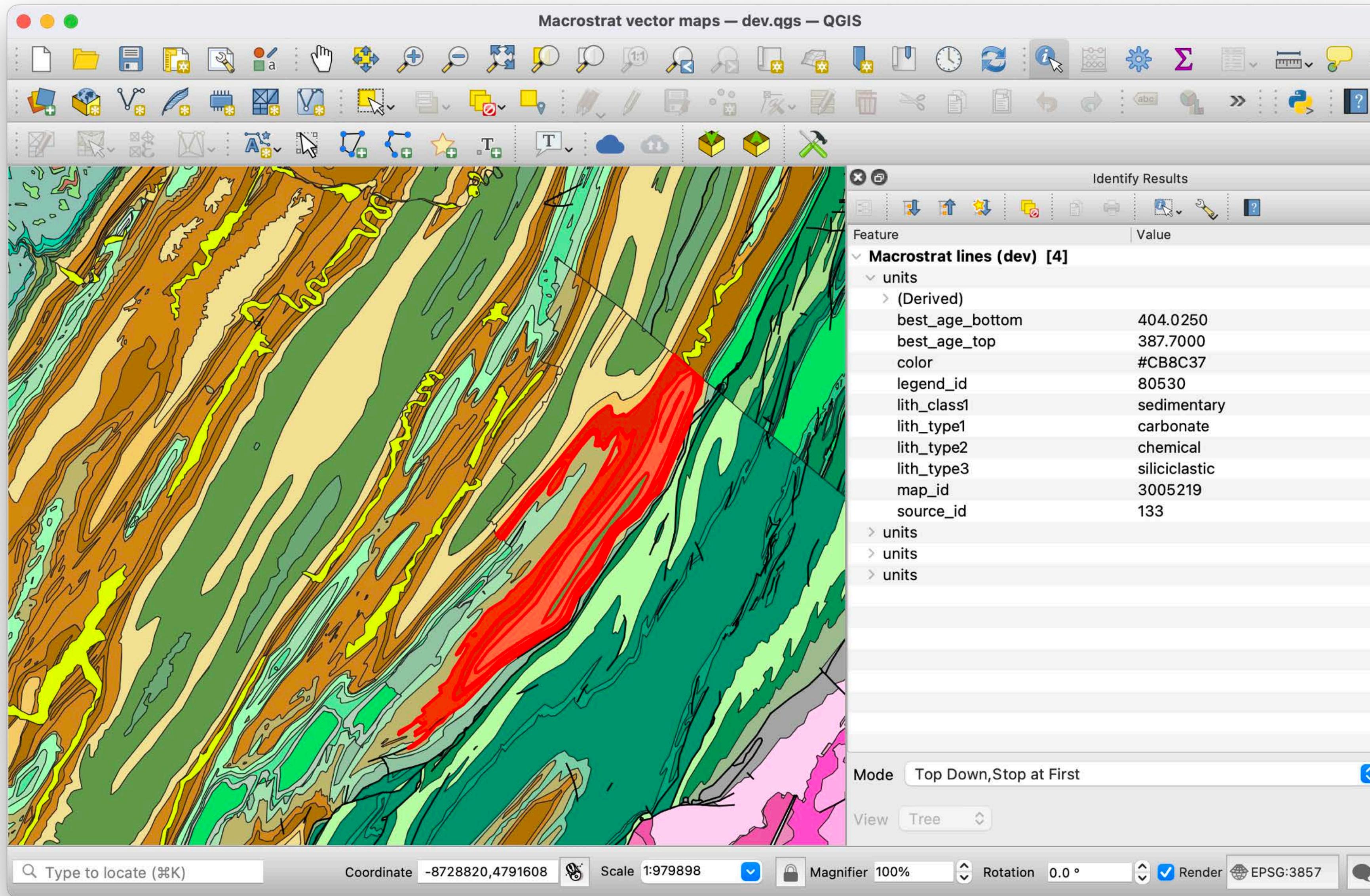
Will sit within  
Macrostrat web  
interface and benefit  
from context

Planned



# Expert feedback/correction interfaces: Compatibility with GIS tools

*Prototype capability*



QGIS

- Macrostrat works well with standard GIS tools (especially QGIS)
- Compatibility will be maintained for CriticalMAAS outputs

# Expert feedback/correction interfaces: Rapid geologic map capture/correction

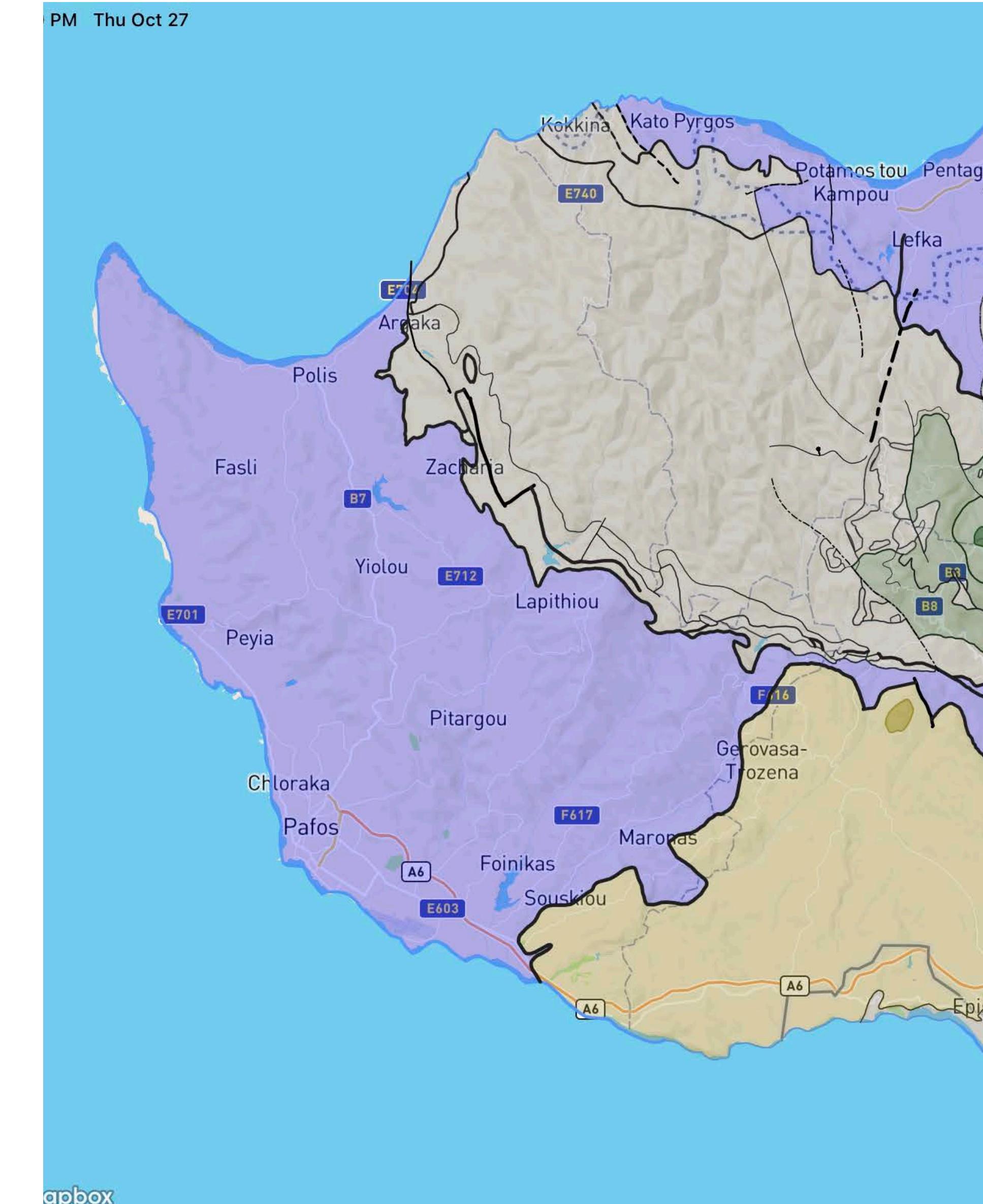
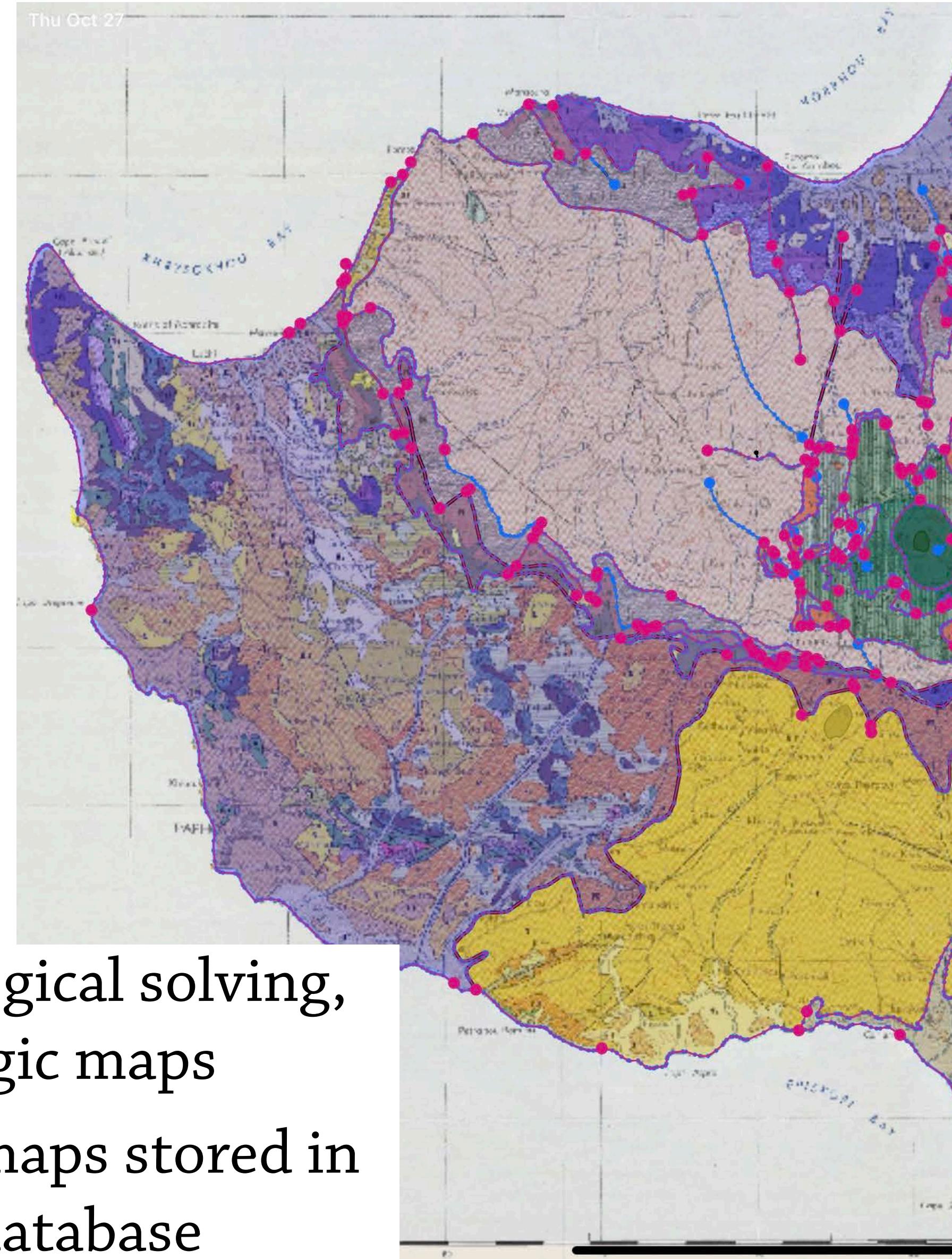


**Integrate with  
Mapboard GIS  
iPad app**

<https://mapboard-gis.app>

*Planned*

- Fluid drawing, topological solving, and revision of geologic maps
- Works directly with maps stored in Macrostrat PostGIS database



apbox

# Expert feedback/correction interfaces: Data entry tools for geologic columns

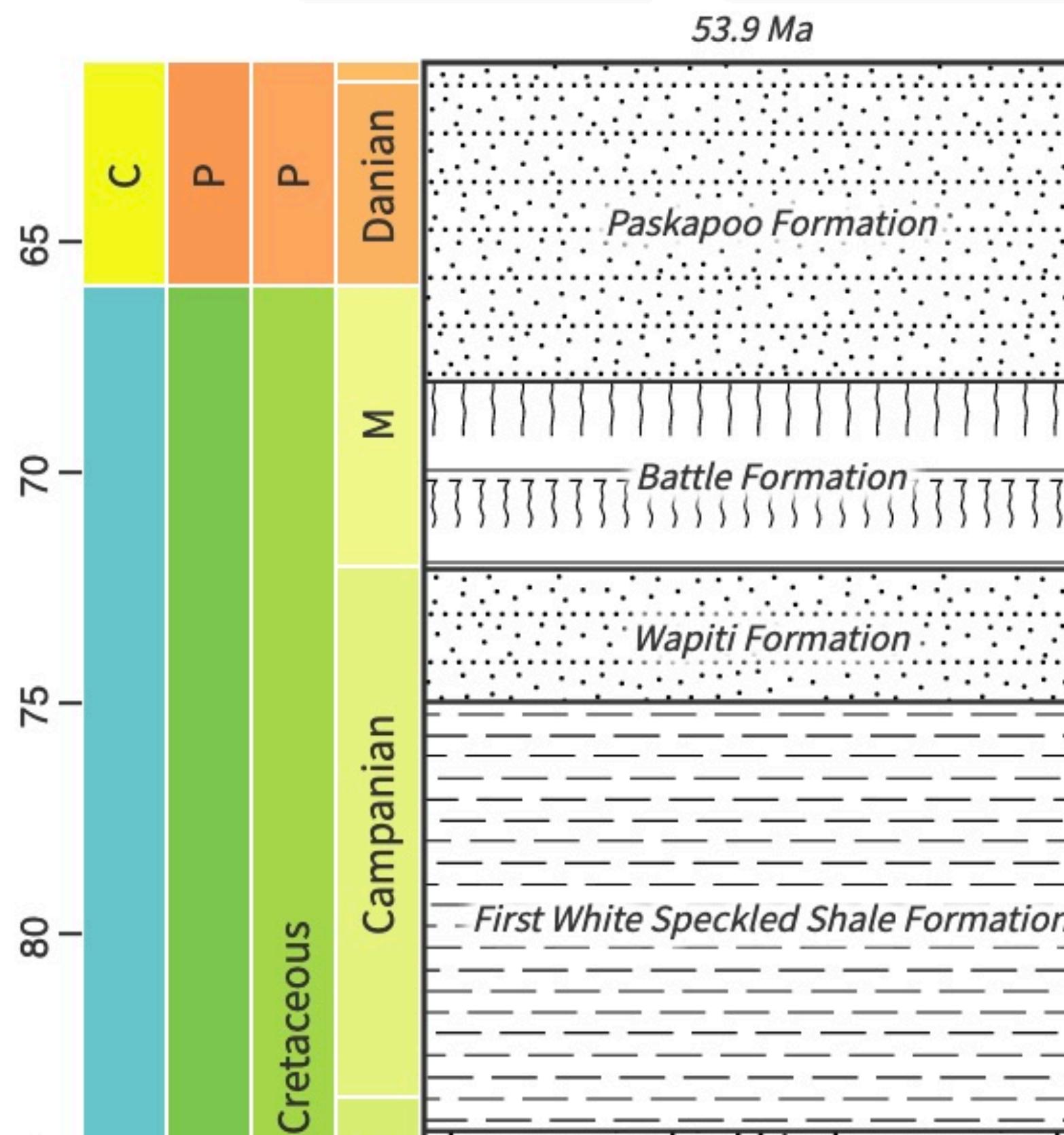
Allows correction of the time-stratigraphic component of geologic maps

*Prototype*

Projects > Column Groups > Column

Sections for Column: Swan Hills 

Unit view Section View Reorder Units



+ Add Section

Section #9560

ID	Strat Name	Liths	Envs	Interval	Thickness
37335	unnamed	GR... SAND	fluvial indet.	Holocene	0
37334	unnamed	GRAVEL S... TI...	glacial indet.	Pleistocene	0

+ Add Section

Section #9561

ID	Strat Name	Liths	Envs	Interval	Thickness
37333	unnamed	GR... CONGLOMERATE	inferred marine	Messinian - Pliocene	0

+ Add Section

Section #9562

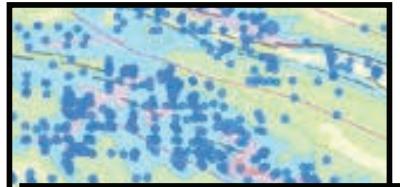
ID	Strat Name	Liths	Envs	Interval	Thickness
37332	Paskapoo Fm	S... SANDSTONE C..	non-marine	Maastrichtian - Paleocene	30
37331	Battle Fm	CLAY	non-marine	Maastrichtian	3
37330	Wapiti Fm	S... SANDSTONE C..	non-marine	Campanian - Maastrichtian	350
37329	First White Speckled Shale Fm	SHALE	inferred marine	Santonian - Campanian	100
37328	Badheart Fm	SANDSTONE IRONSTONE	marine	Santonian	50
37327	First White Speckled Shale Fm	SHALE	inferred marine	Coniacian - Santonian	100

Thanks! Any questions?

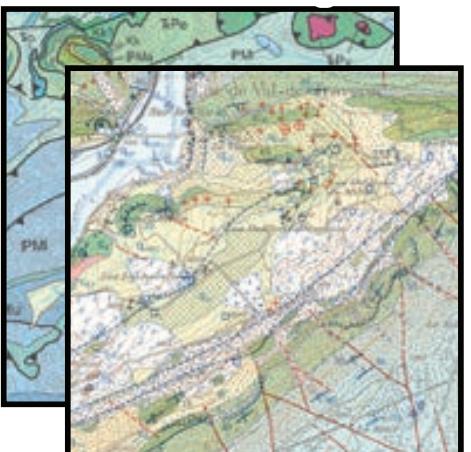
## New data sources



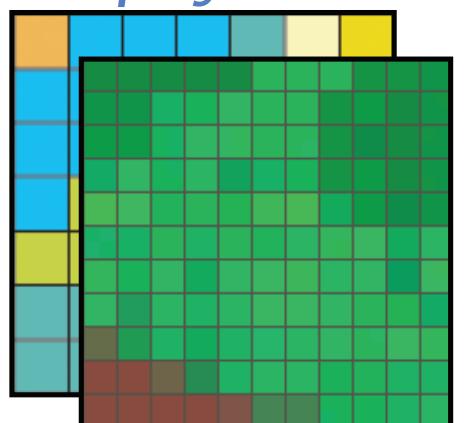
Measurements



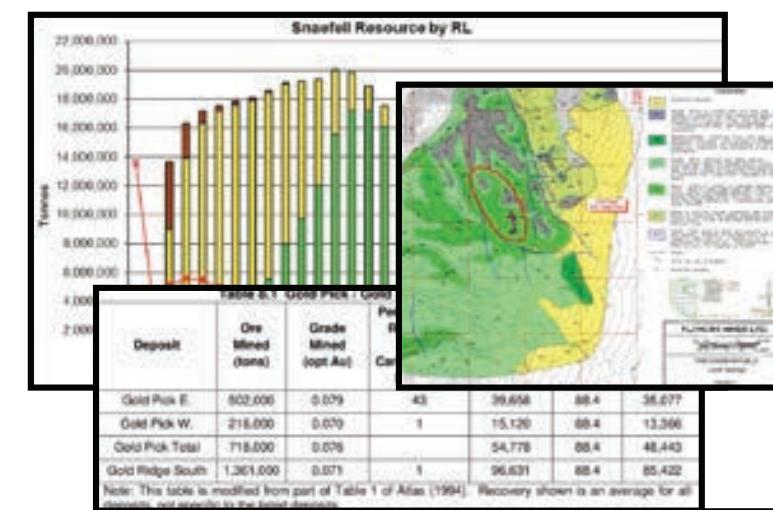
Raster maps



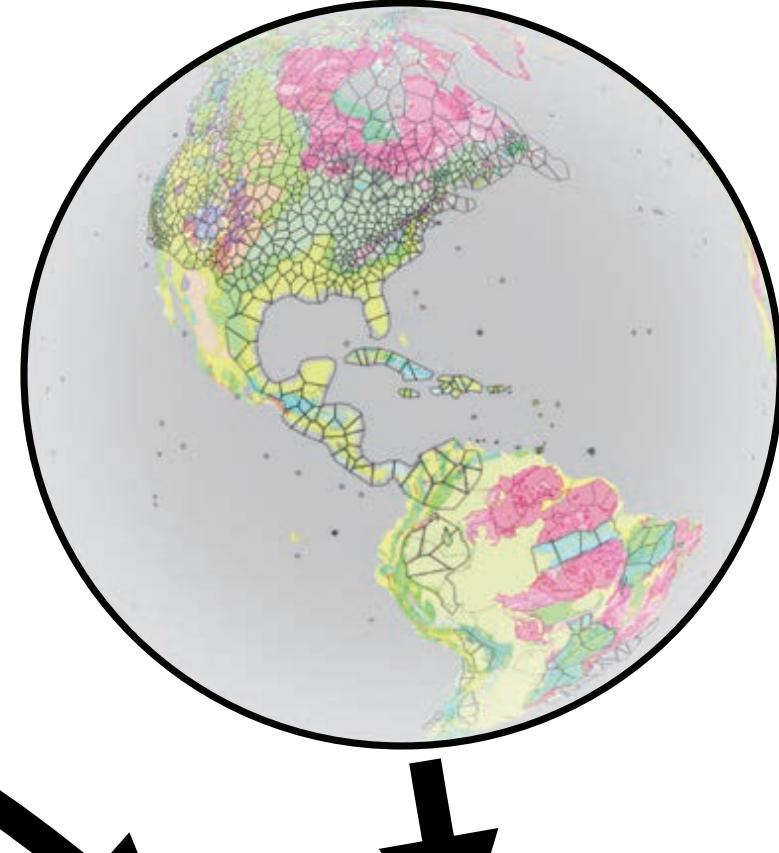
Geophysics



Literature extractions



Macrostrat



PostGIS relational  
geodatabase

Macrostrat software platform

Ingestion + harmonization

~~Partially automated~~

Fully automated

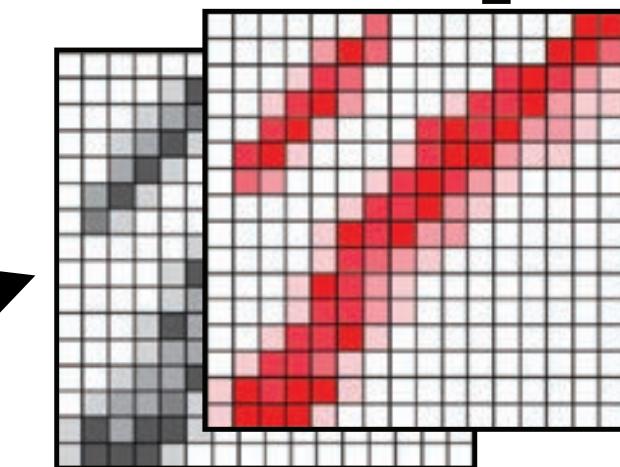
Feedback

*“Human in the loop”*

TA3

Tile  
server

Predictive  
mineral maps



GIS platforms

