

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

Daven P. Quinn¹, Shanan E. Peters¹, Shivaram Venkataraman², Brian Bockelman³

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

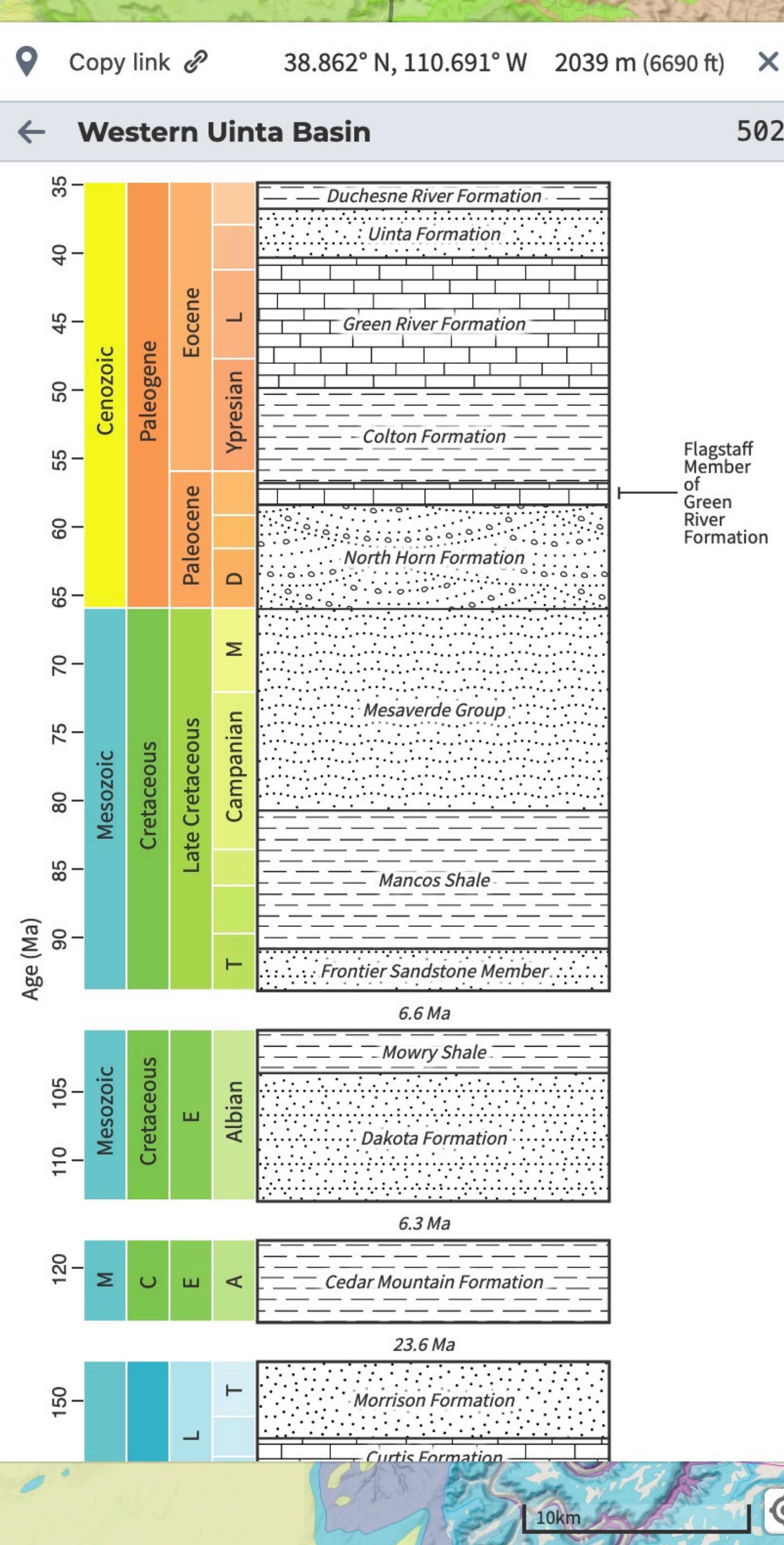
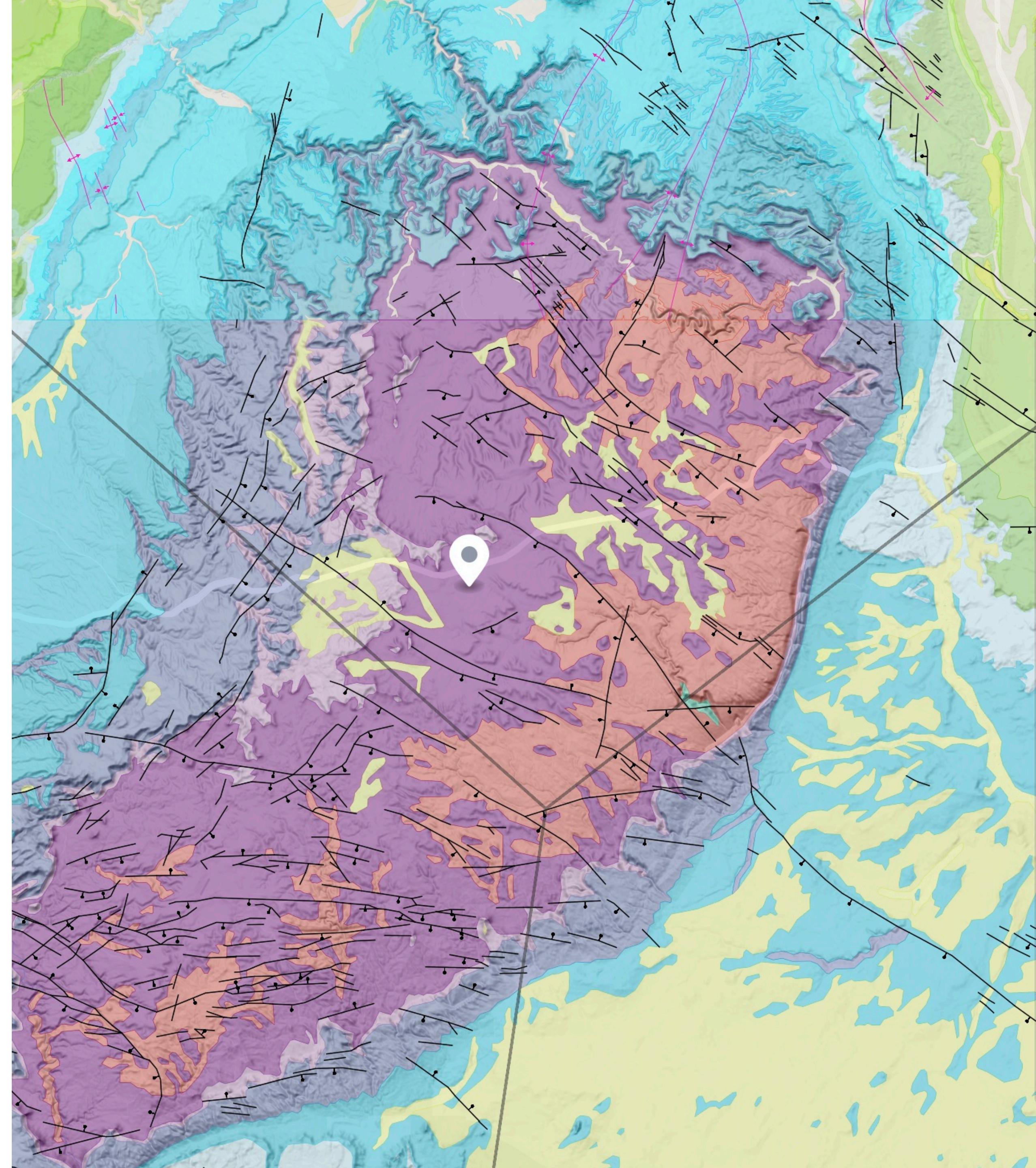
xDD/Literature data extraction/Entity canonicalization

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



MACROSTRAT

A quantitative,
descriptive data
system for
geological
information



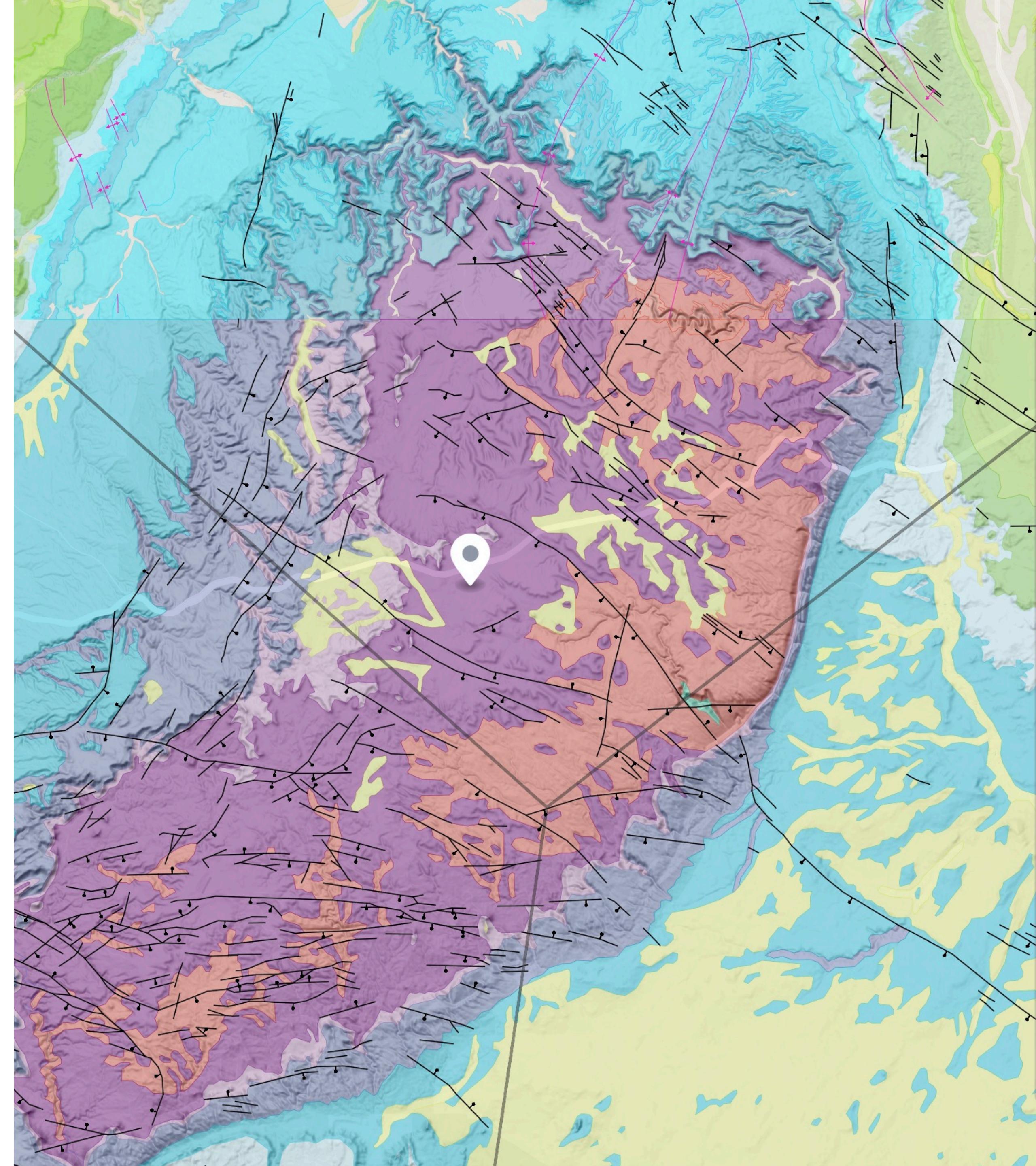
MACROSTRAT

A quantitative,
descriptive data
system for
geological
information



MACROMAAS

Macrostrat
extended for
Critical Minerals
assessment

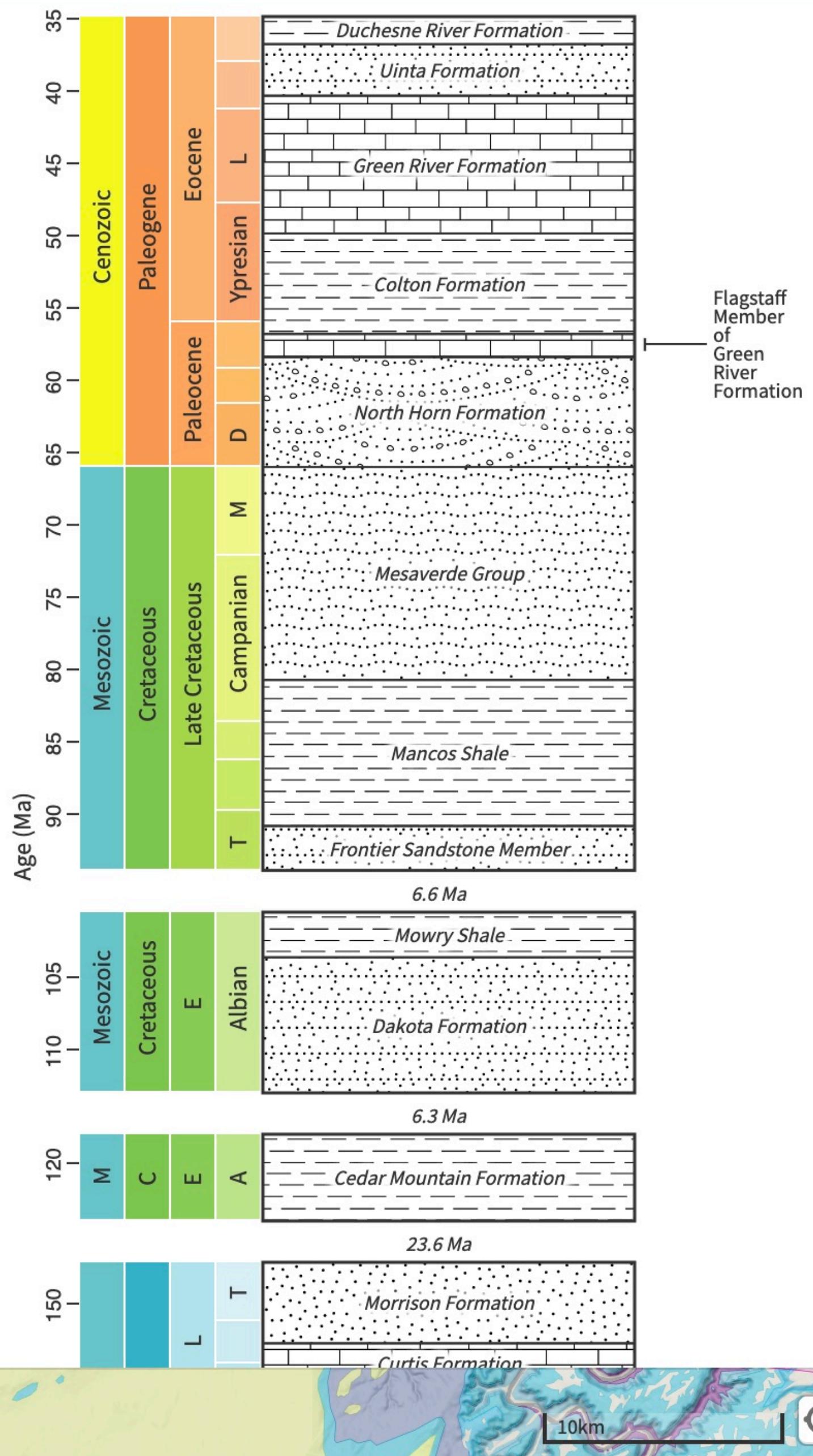


Copy link

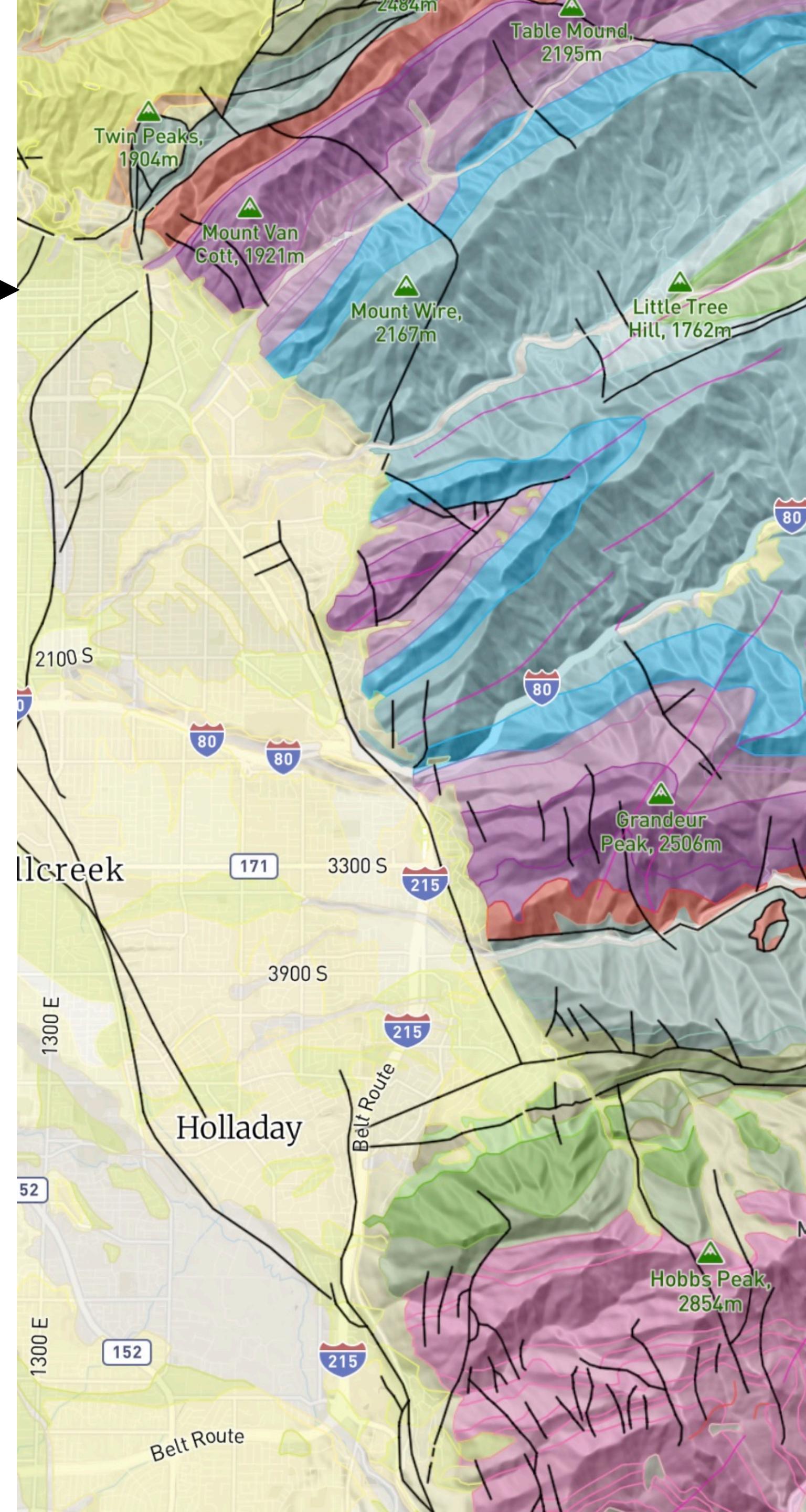
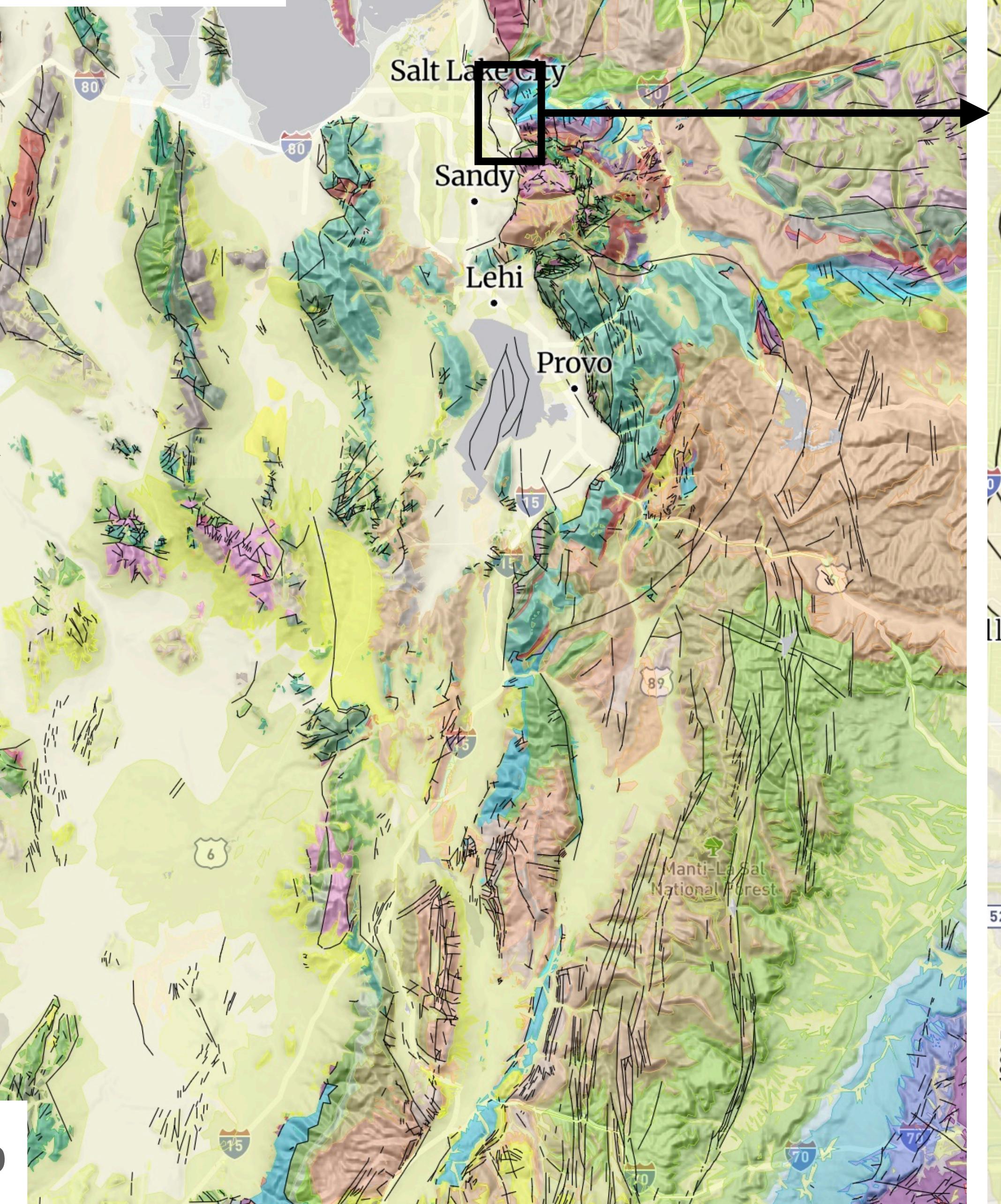
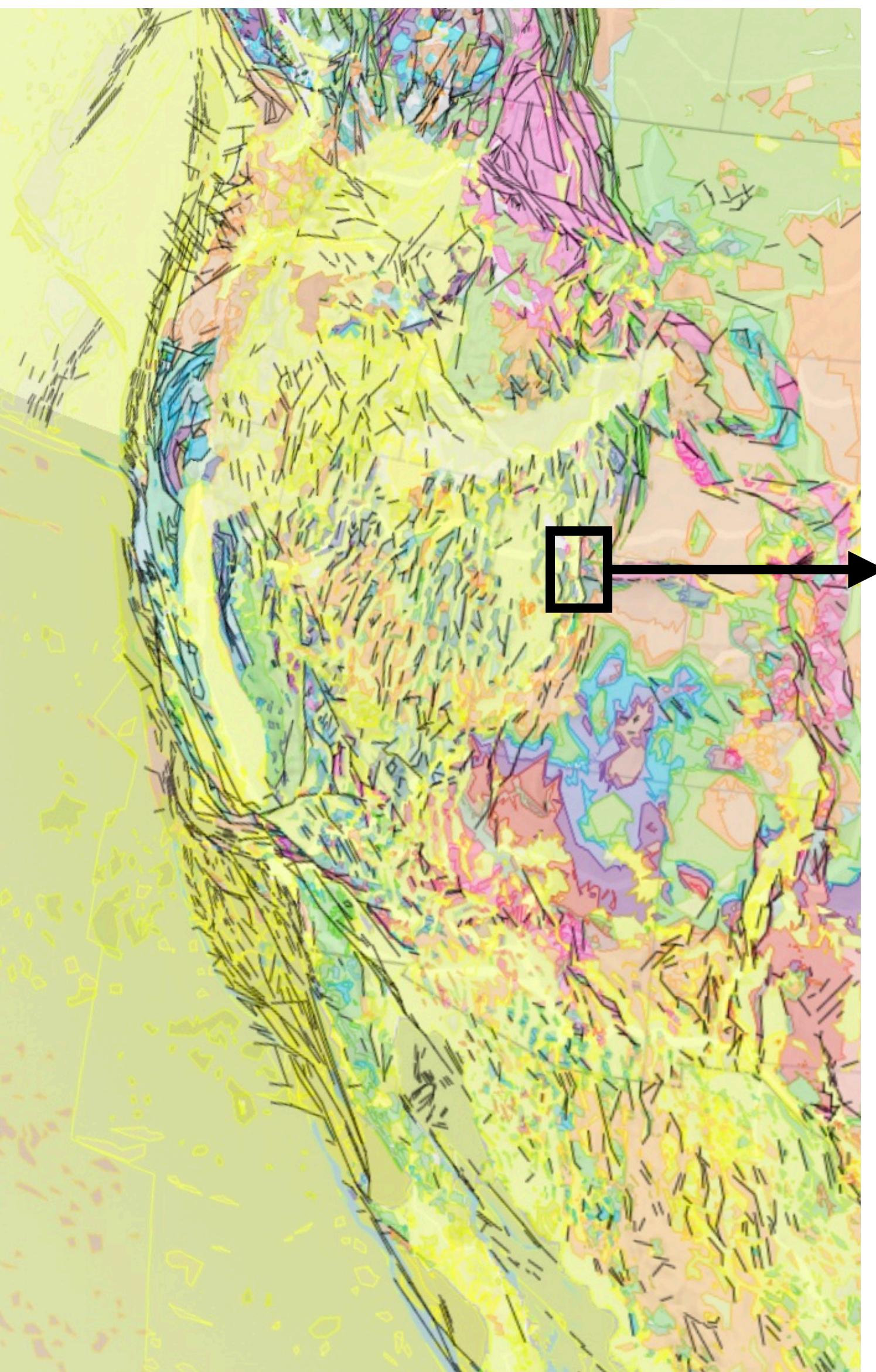
38.862° N, 110.691° W 2039 m (6690 ft) X

← Western Uinta Basin

502

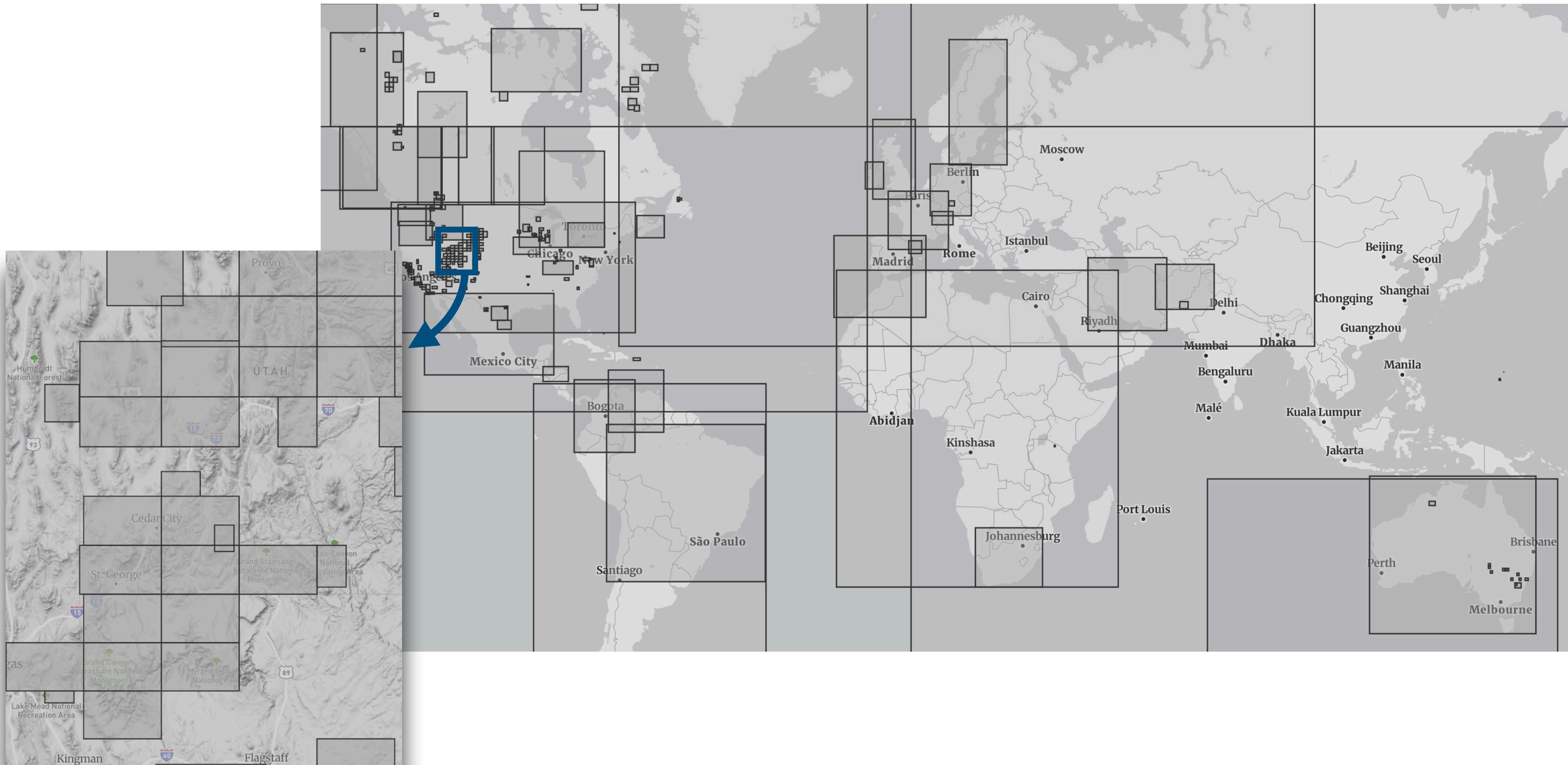


MACROSTRAT'S GEOLOGIC MAP



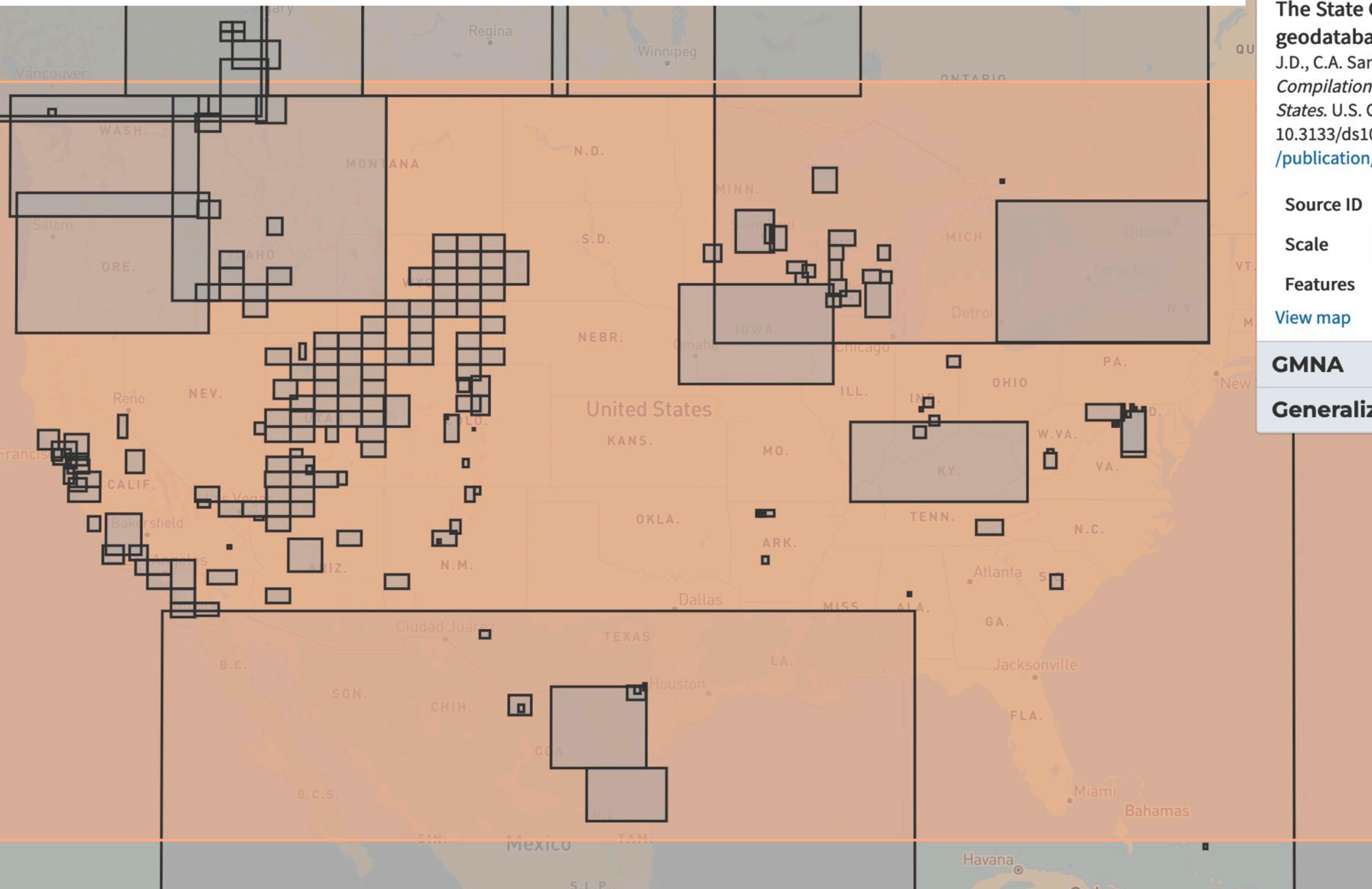
MACROSTRAT'S GEOLOGIC MAP

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

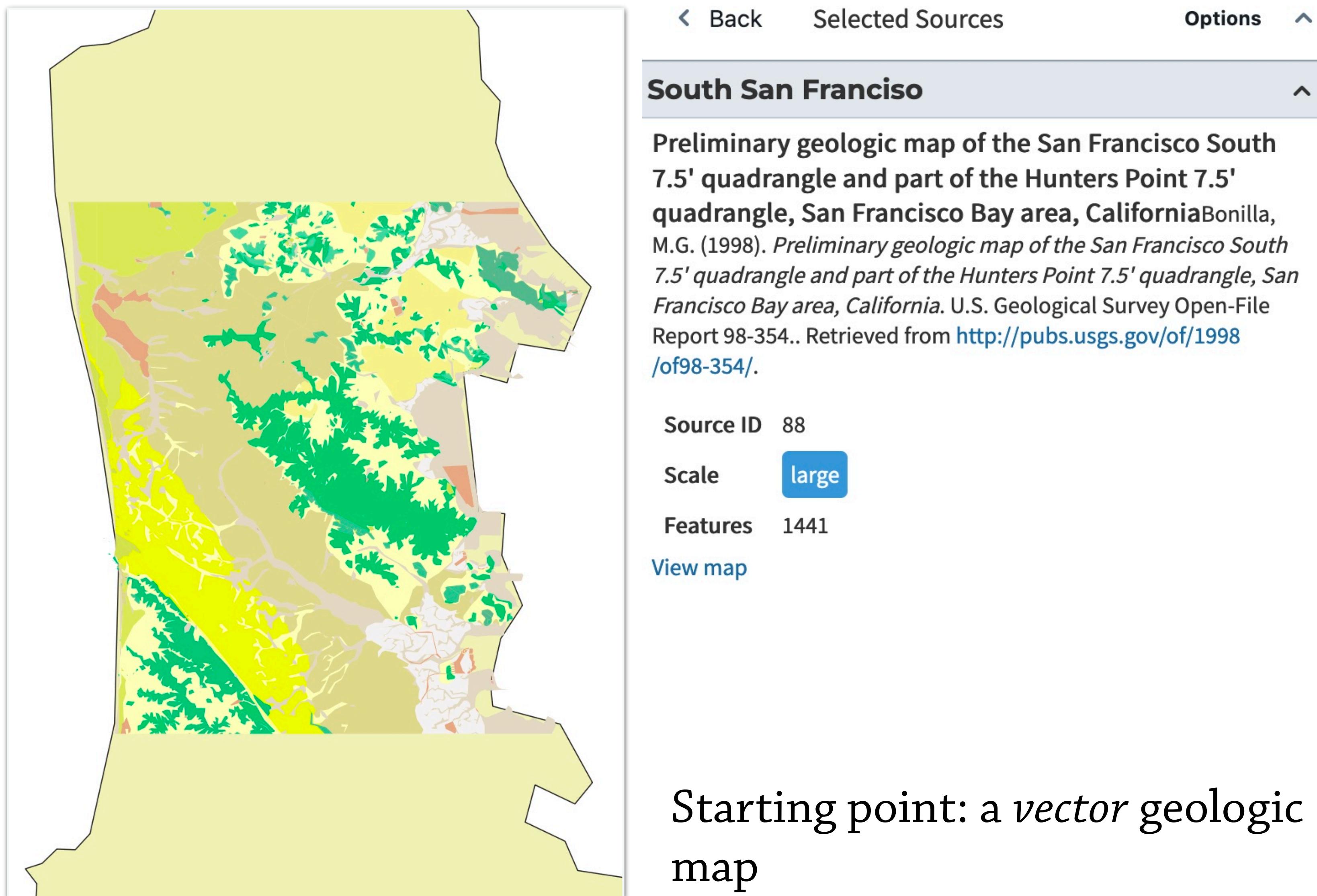
Features 312304

[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**

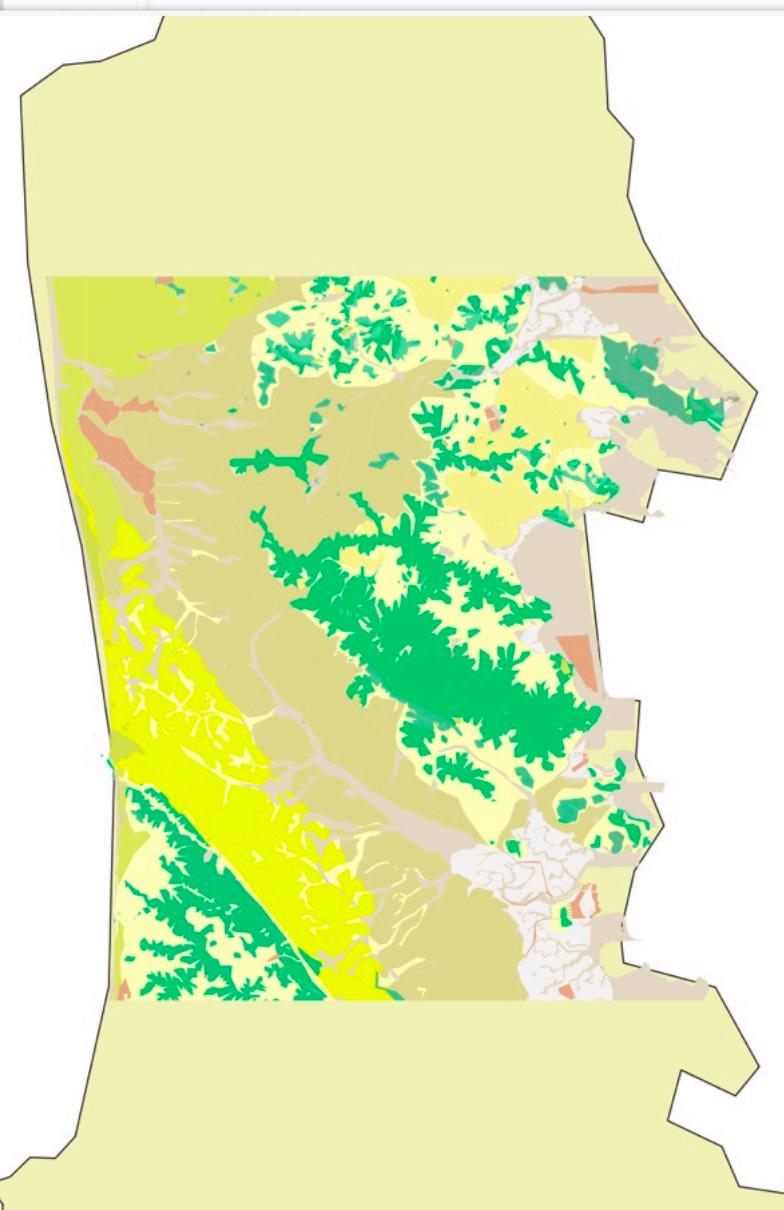
Features 1441

[View map](#)

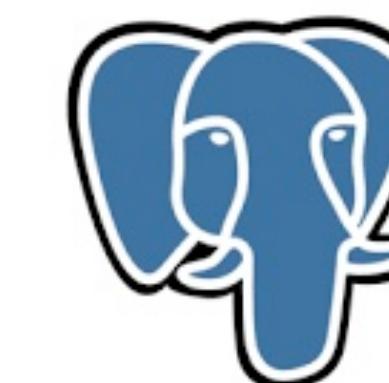
Starting point: a *vector* geologic map

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 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	4	3	Landslide de
		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

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

[View map](#)

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

[View map](#)

GMNA

Generalized Geology of the World

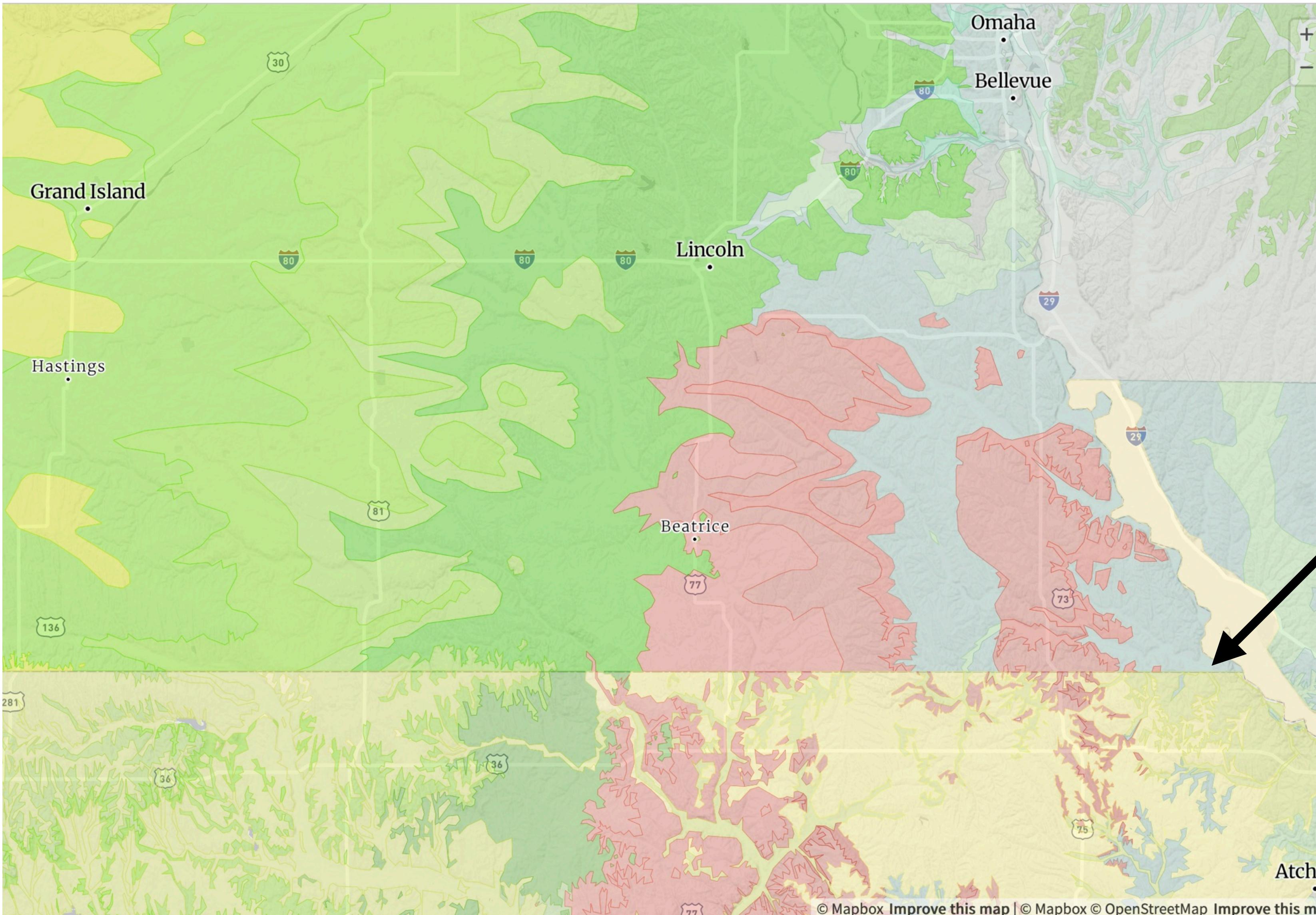
large

medium

small

tiny

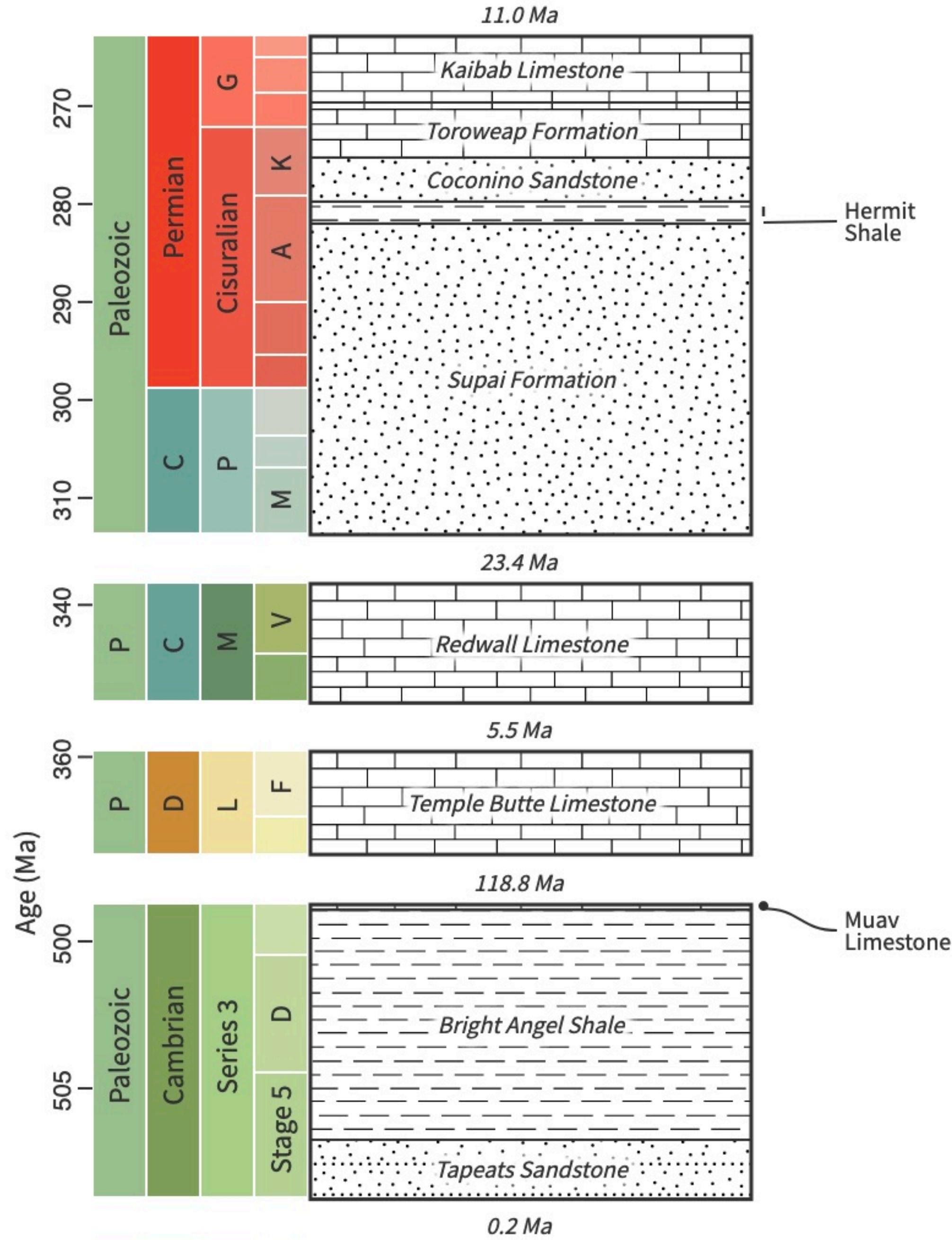
Macrostrat's geologic map: Ingestion and harmonization



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

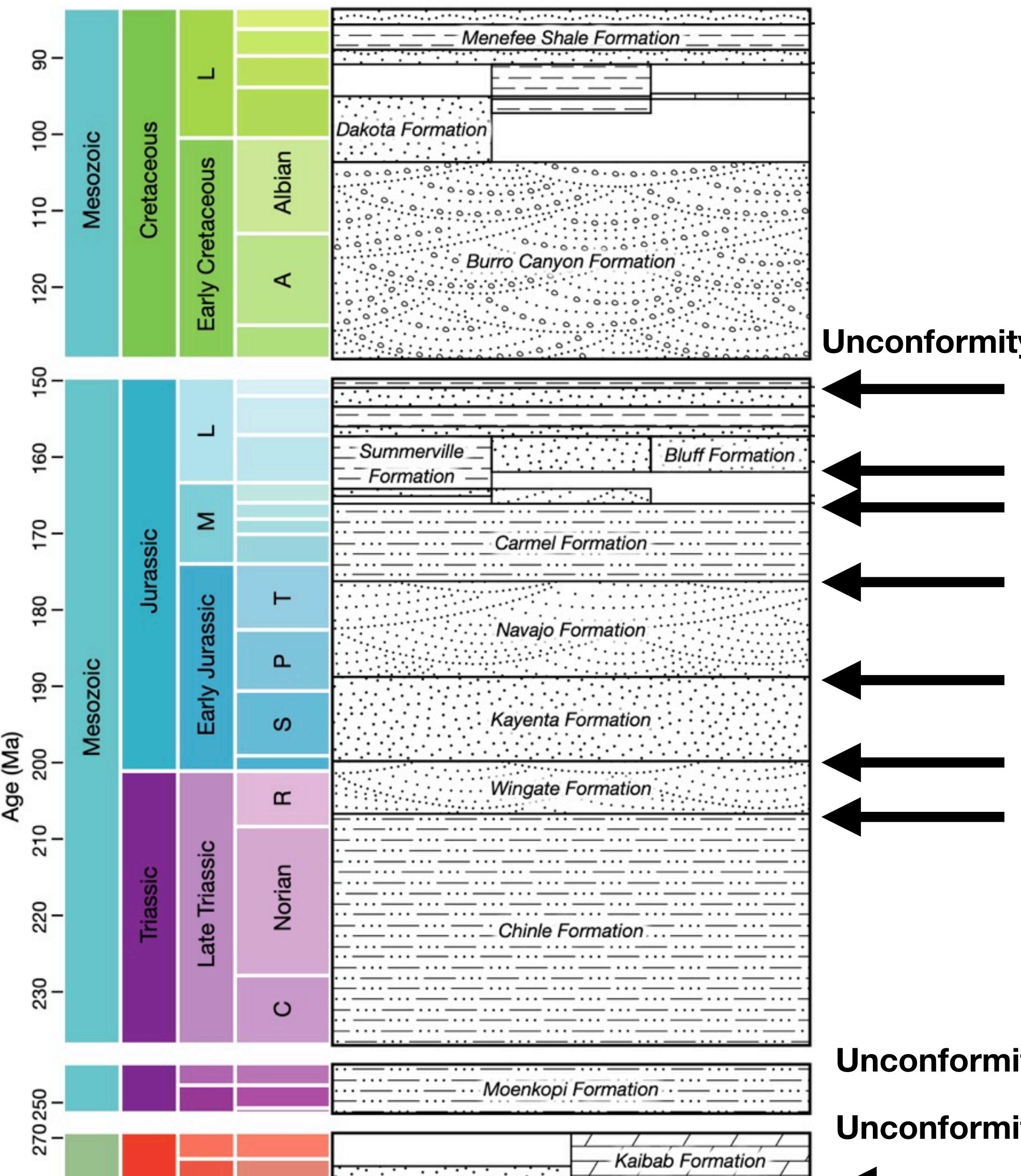
It is not a single map...it is a harmonized “view” of many maps with some standardization

Stratigraphy: another representation of geological framework



Macrostrat stratigraphic column database: continuous time age model

Paradox Basin



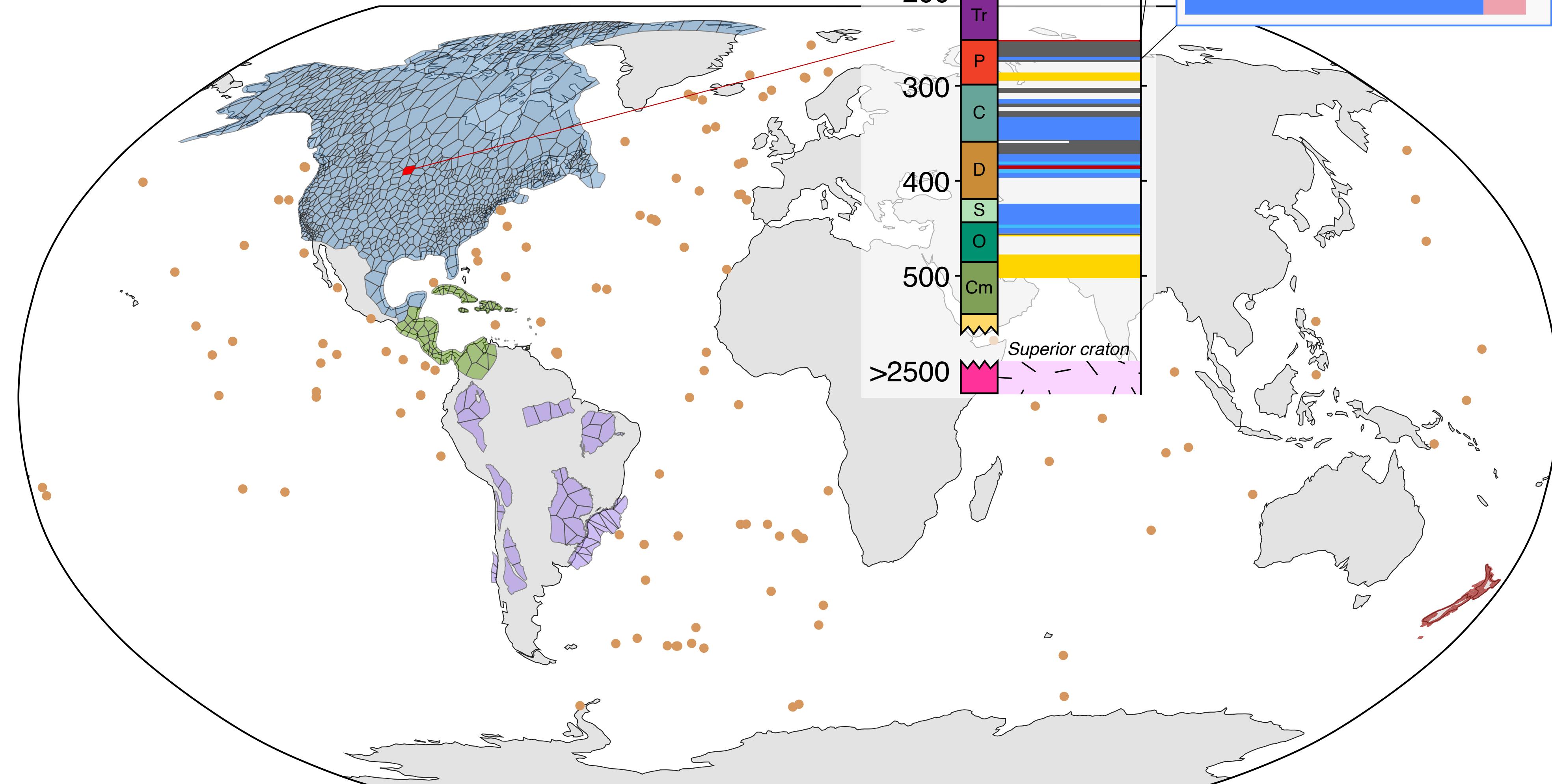
boundaries between units acquire a unique chronostratigraphic identity:

- 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

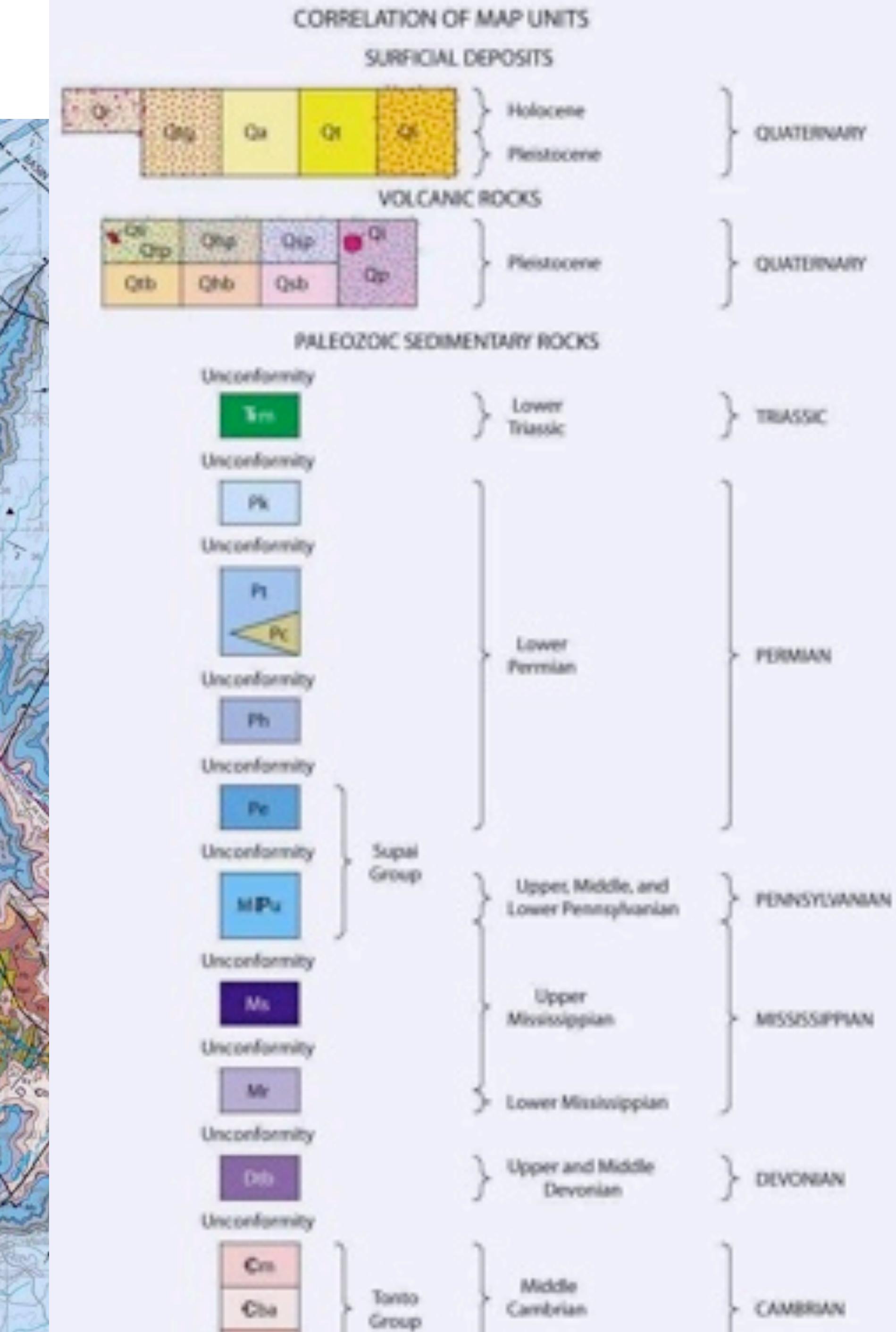
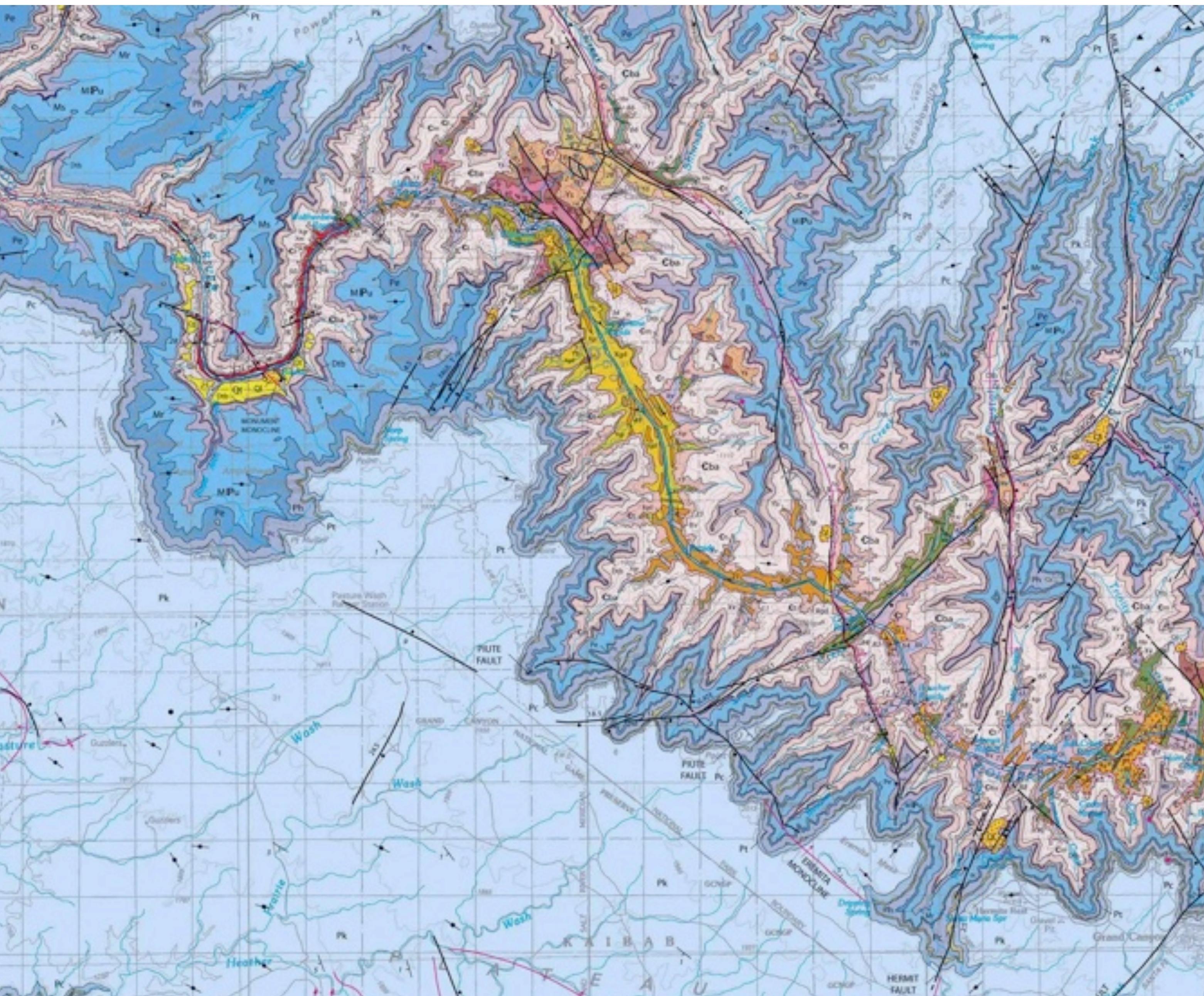
Macrostrat column database

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

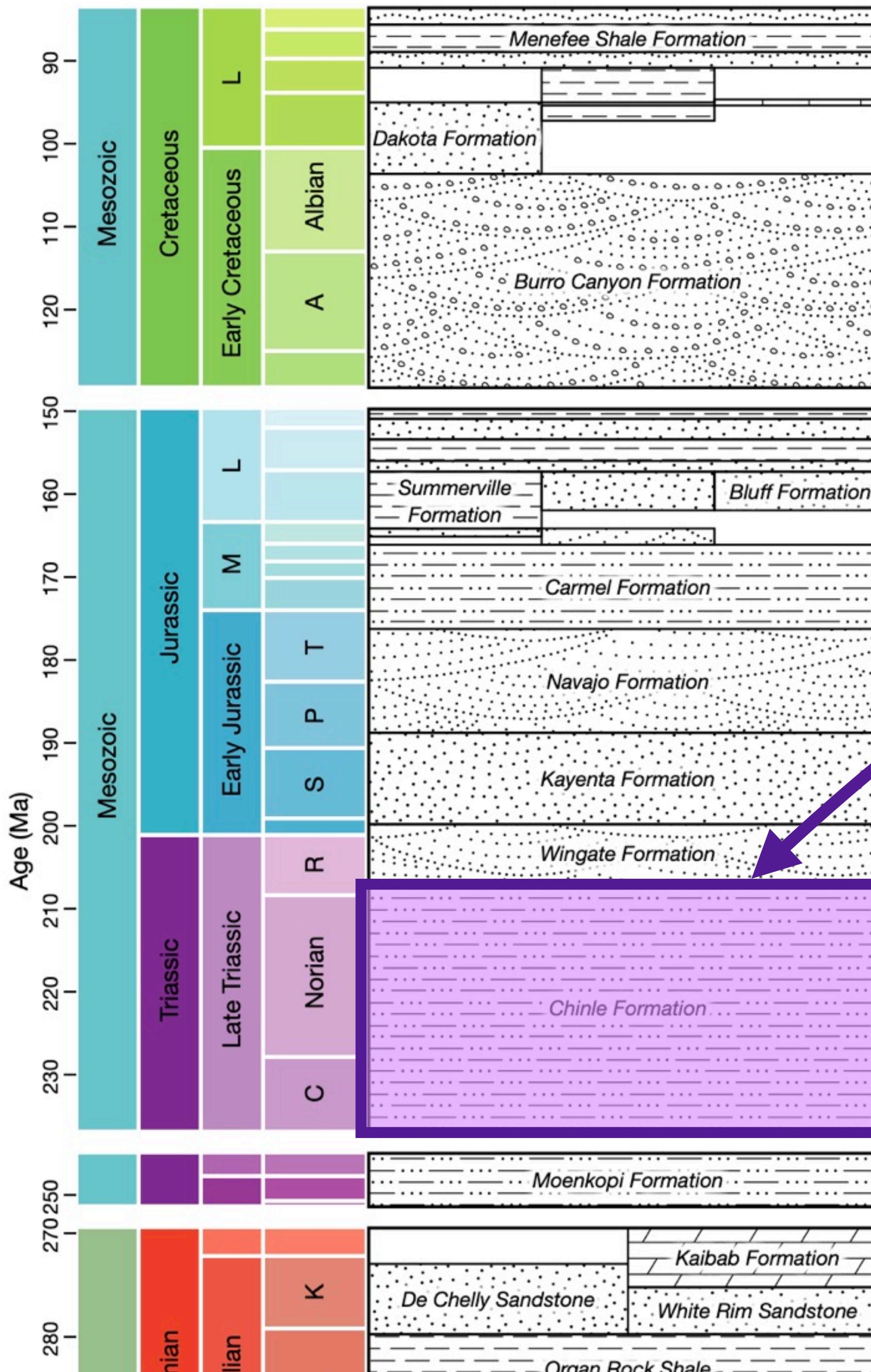
sedimentary lithologies key	
conglomerate	limestone
sandstone	dolostone
siltstone	anhydrite
shale	halite



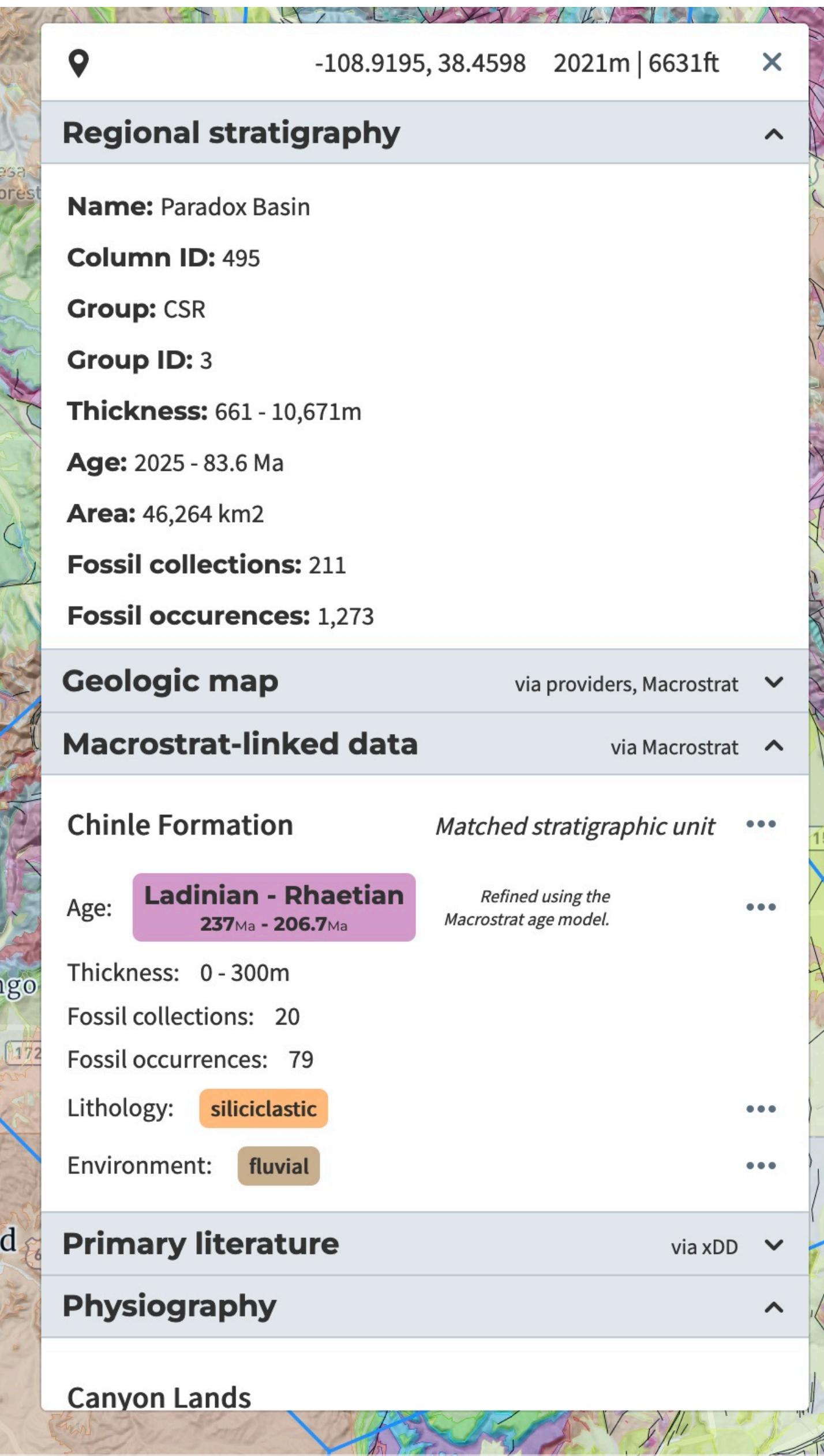
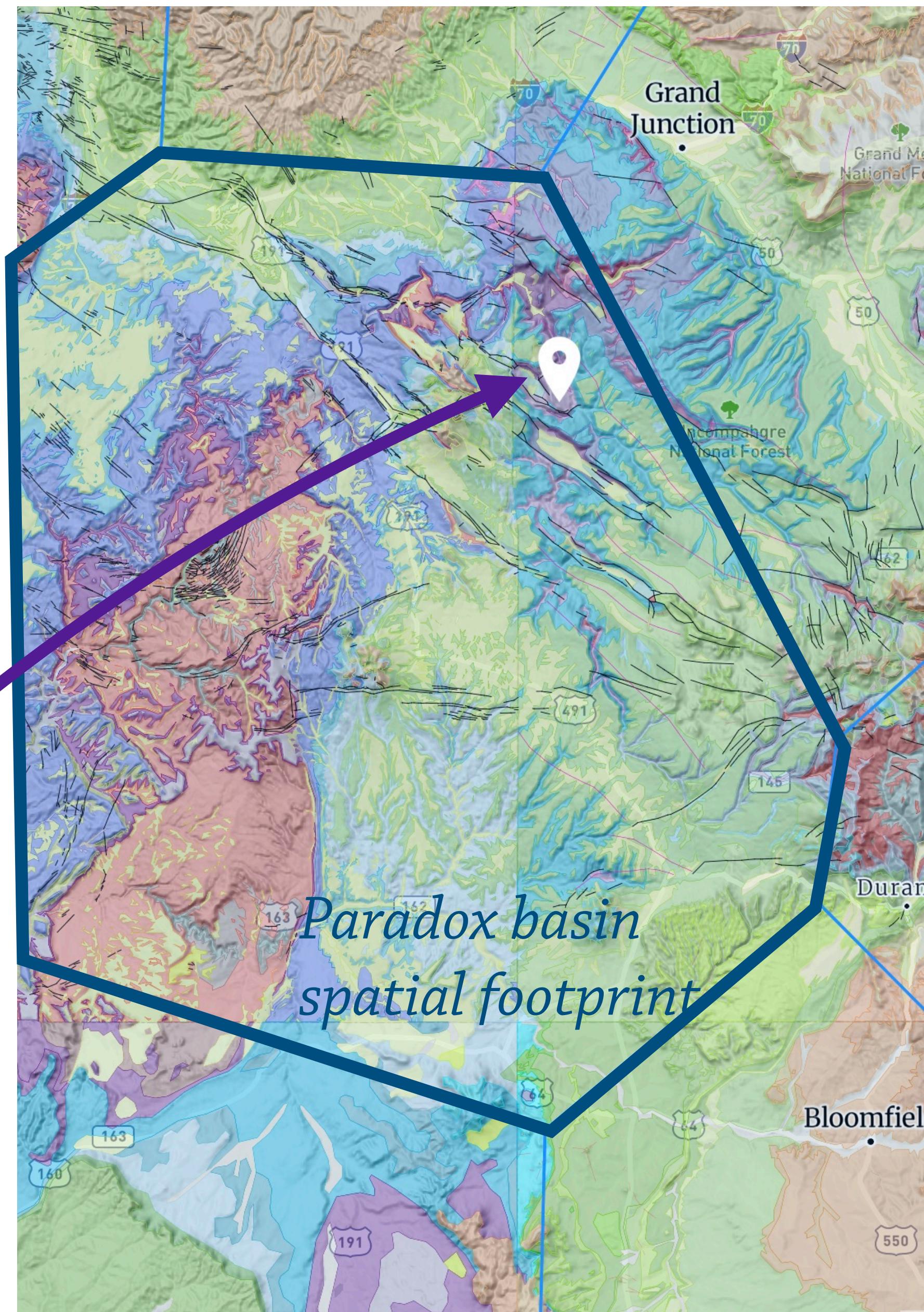
Geologic maps have a stratigraphic representation



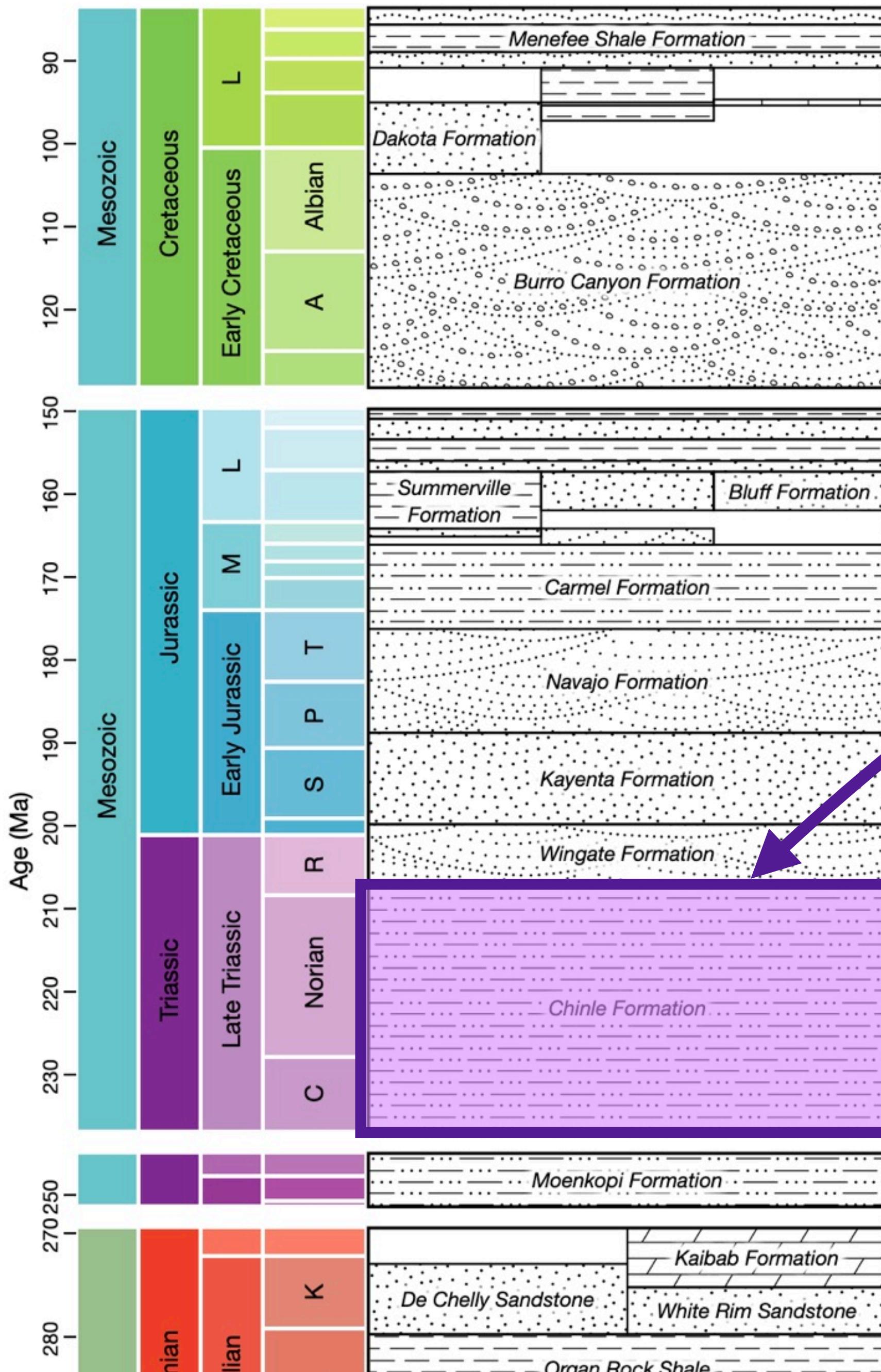
Paradox Basin



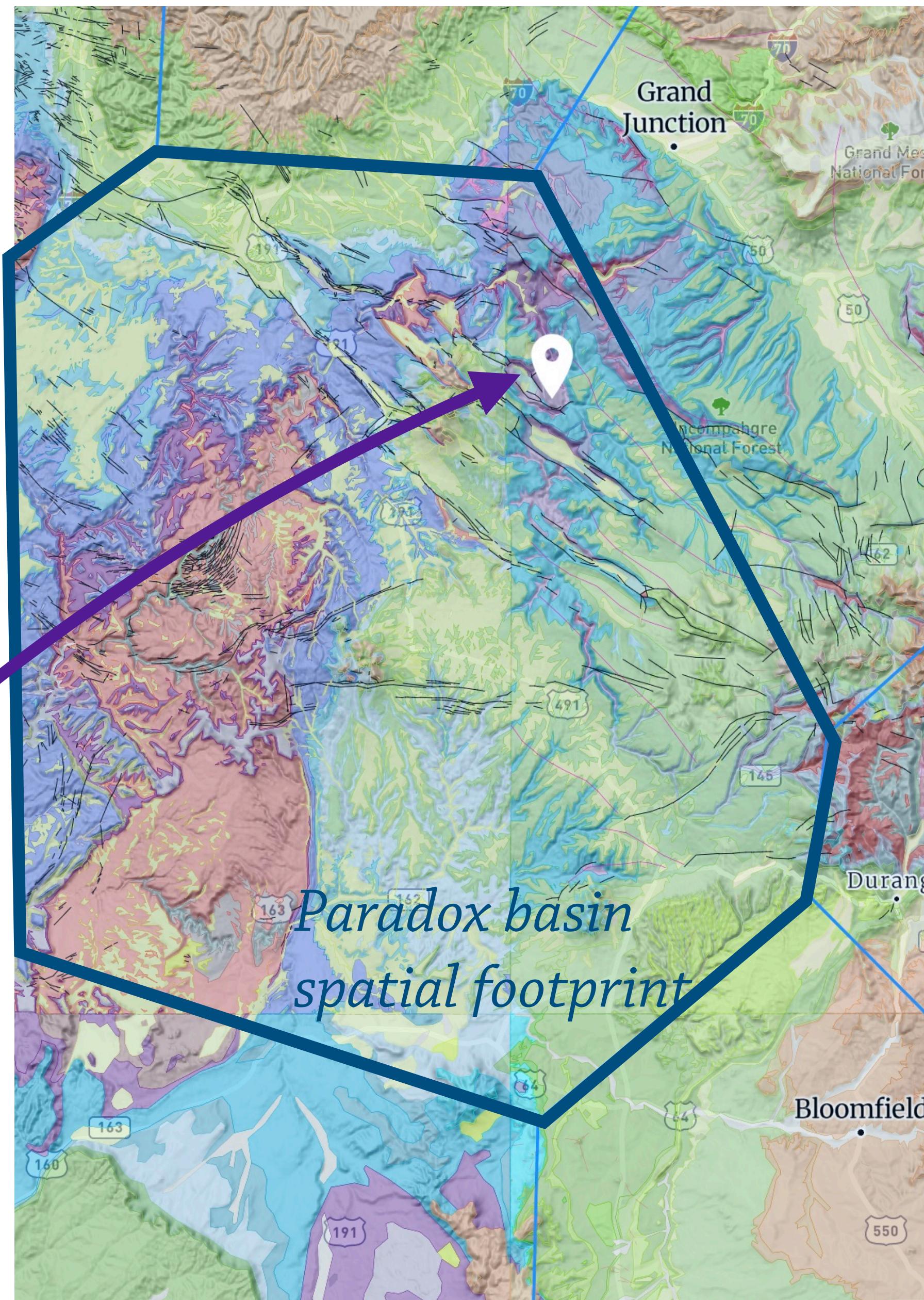
Map harmonization: Linking columns to maps



Paradox Basin



Map harmonization: Linking columns to maps



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



COLUMNS + MAPS + GEOCHRONOLOGY

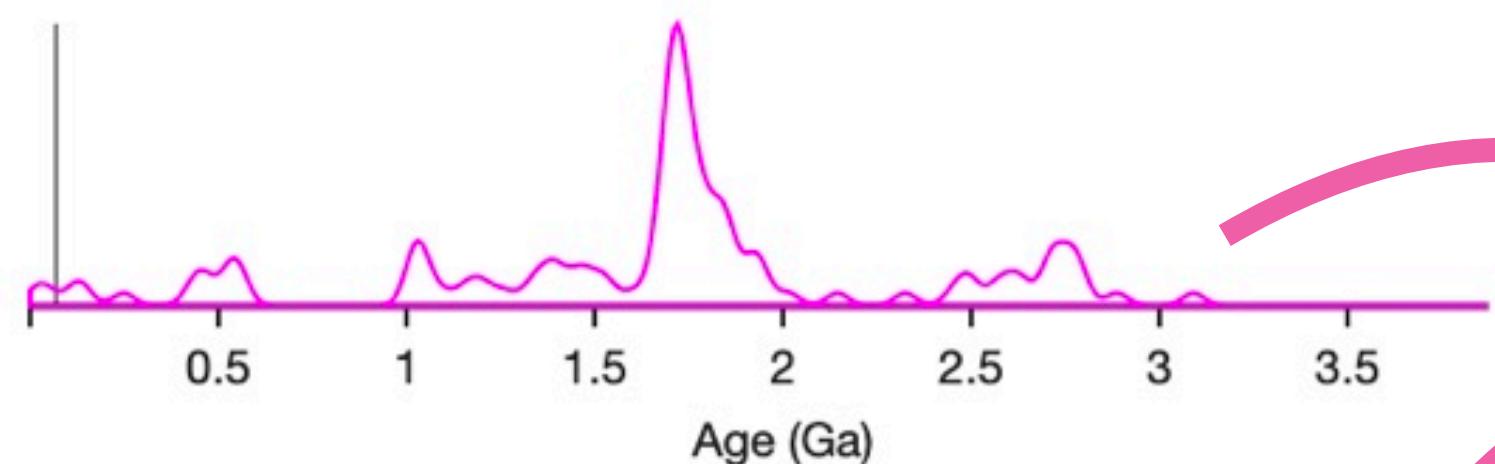
RESEARCH ARTICLE | JUNE 24, 2021

Igneous rock area and age in continental crust

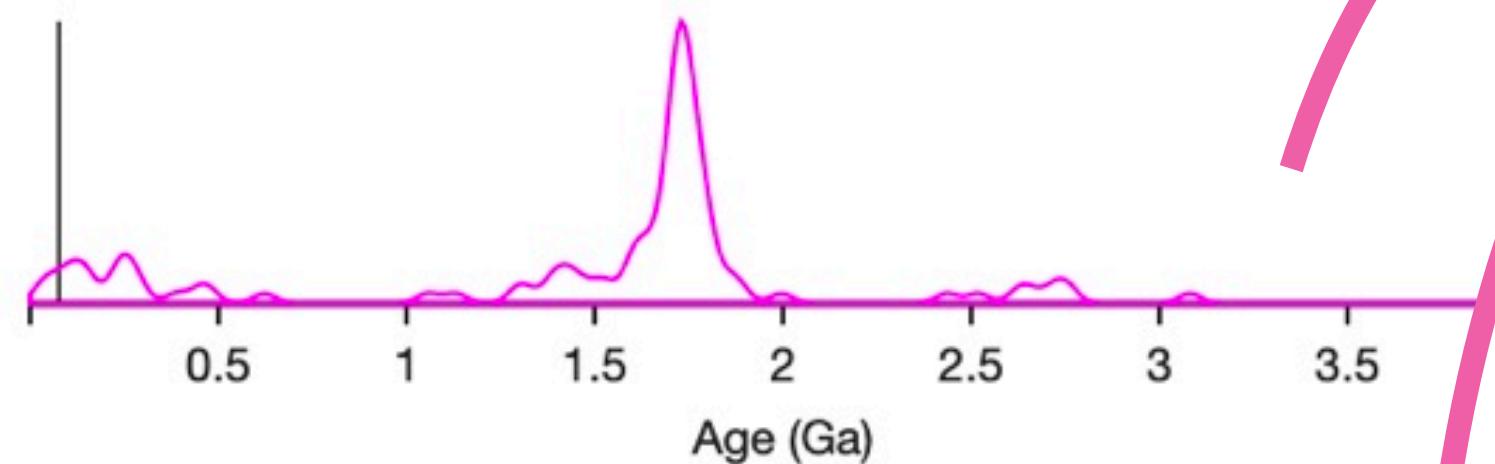
Shanan E. Peters; Craig R. Walton; Jon M. Husson; Daven P. Quinn; Oliver Shorttle; C. Brenhin Keller; Robert R. Gaines

Geology (2021) 49 (10): 1235–1239.

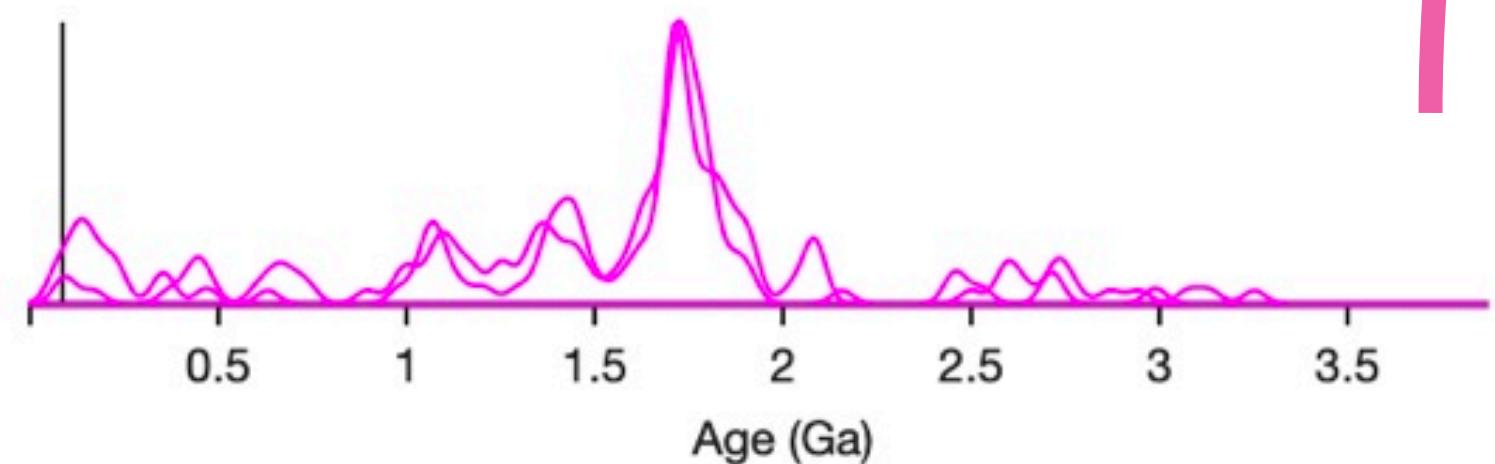
Lance Formation



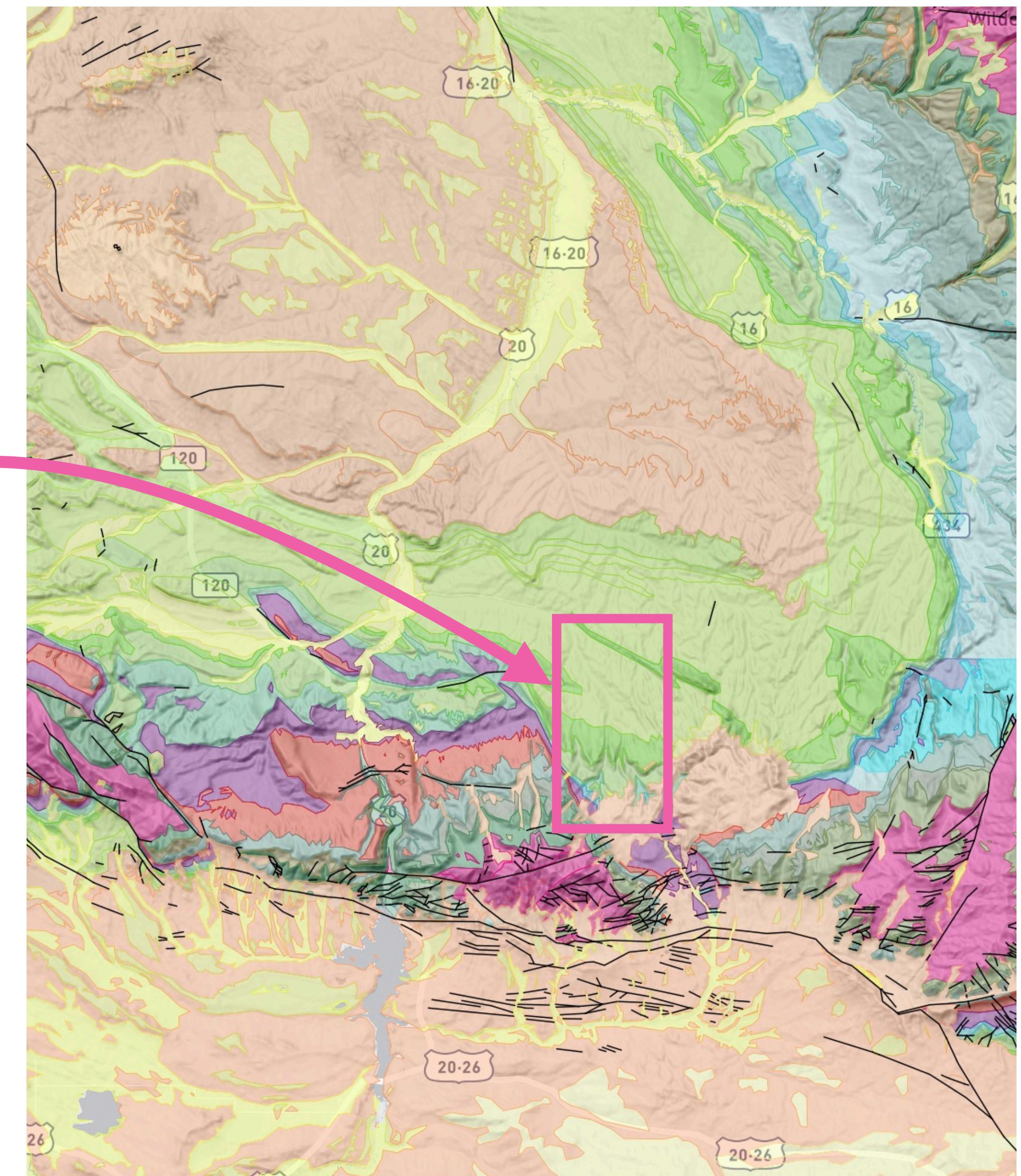
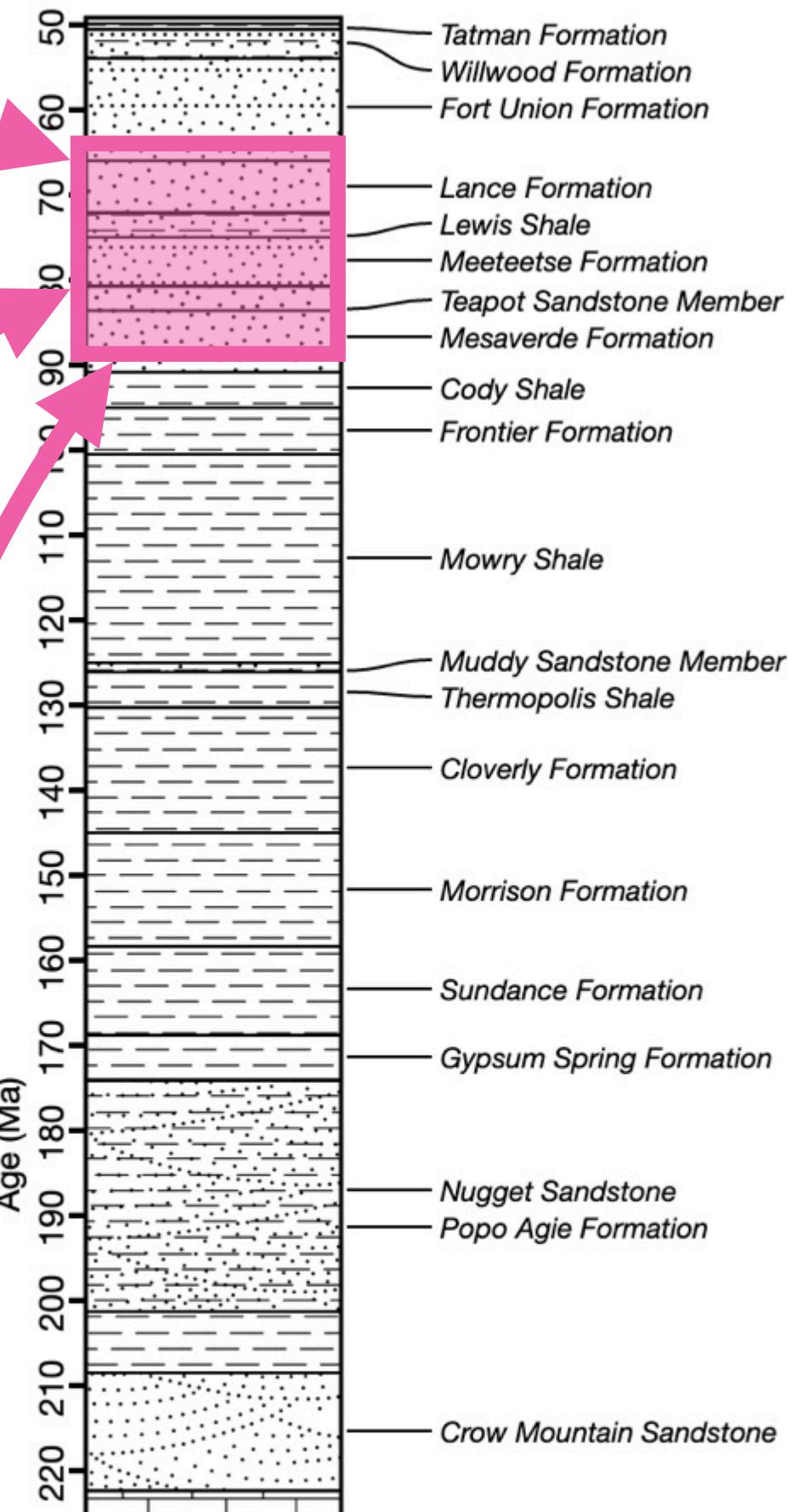
Meeteetse Formation



Mesaverde Formation



Bighorn Basin



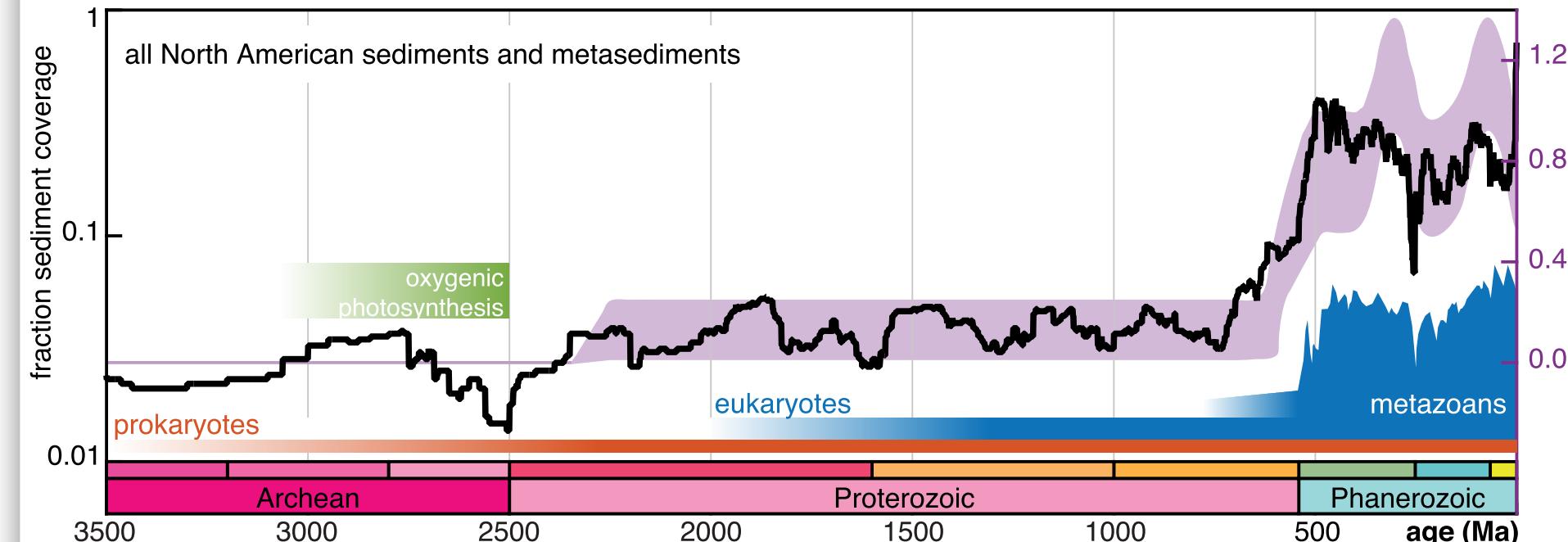
MACROSTRAT'S ORIGINAL GOAL

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

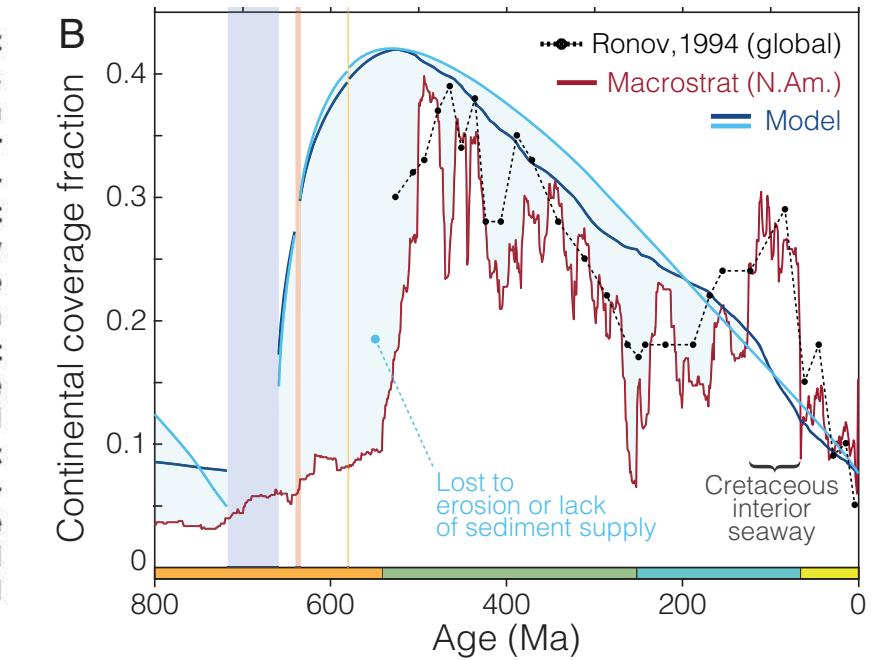


Neoproterozoic glacial origin of the Great Unconformity

C. Brenhin Keller^{a,b,1}, Jon M. Husson^c, Ross N. Mitchell^d, William F. Bottke^e, Thomas M. Gernon^f, Patrick Boehnke^{g,h}, Elizabeth A. Bellⁱ, Nicholas L. Swanson-Hysell^b, and Shanan E. Peters^j

^aBerkeley Geochronology Center, Berkeley, CA 94709; ^bDepartment of Earth and Planetary Science, University of California, Berkeley, CA 94720; ^cSchool of Earth and Ocean Sciences, University of Victoria, Victoria, BC V8W 2Y2, Canada; ^dDepartment of Applied Geology, Curtin University, Perth, WA 6845, Australia; ^eSouthwest Research Institute, Boulder, CO 80302; ^fOcean and Earth Science, University of Southampton, Southampton SO17 1BJ, United Kingdom; ^gDepartment of the Geophysical Sciences, The University of Chicago, Chicago, IL 60637; ^hChicago Center for Cosmochemistry, Chicago, IL 60637; ⁱDepartment of Earth, Planetary, and Space Sciences, University of California, Los Angeles, Los Angeles, CA 90095; and ^jDepartment 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.



LETTER

doi:10.1038/nature10969

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

Shanan E. Peters¹ & Robert R. Gaines²

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 period¹. 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^{2–5}, but the mechanisms responsible for those perturbations remain uncertain^{1,2}. 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

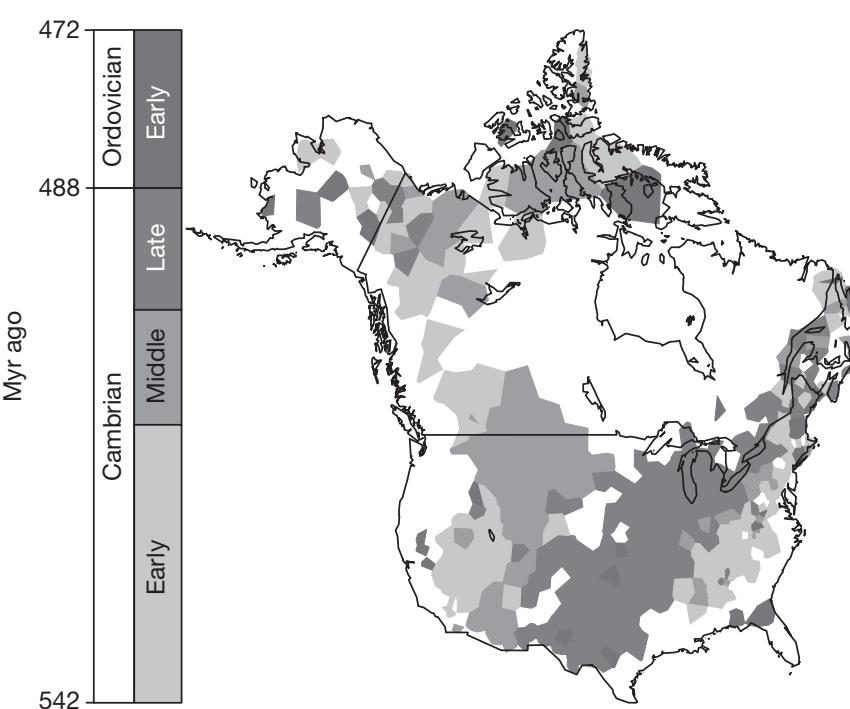
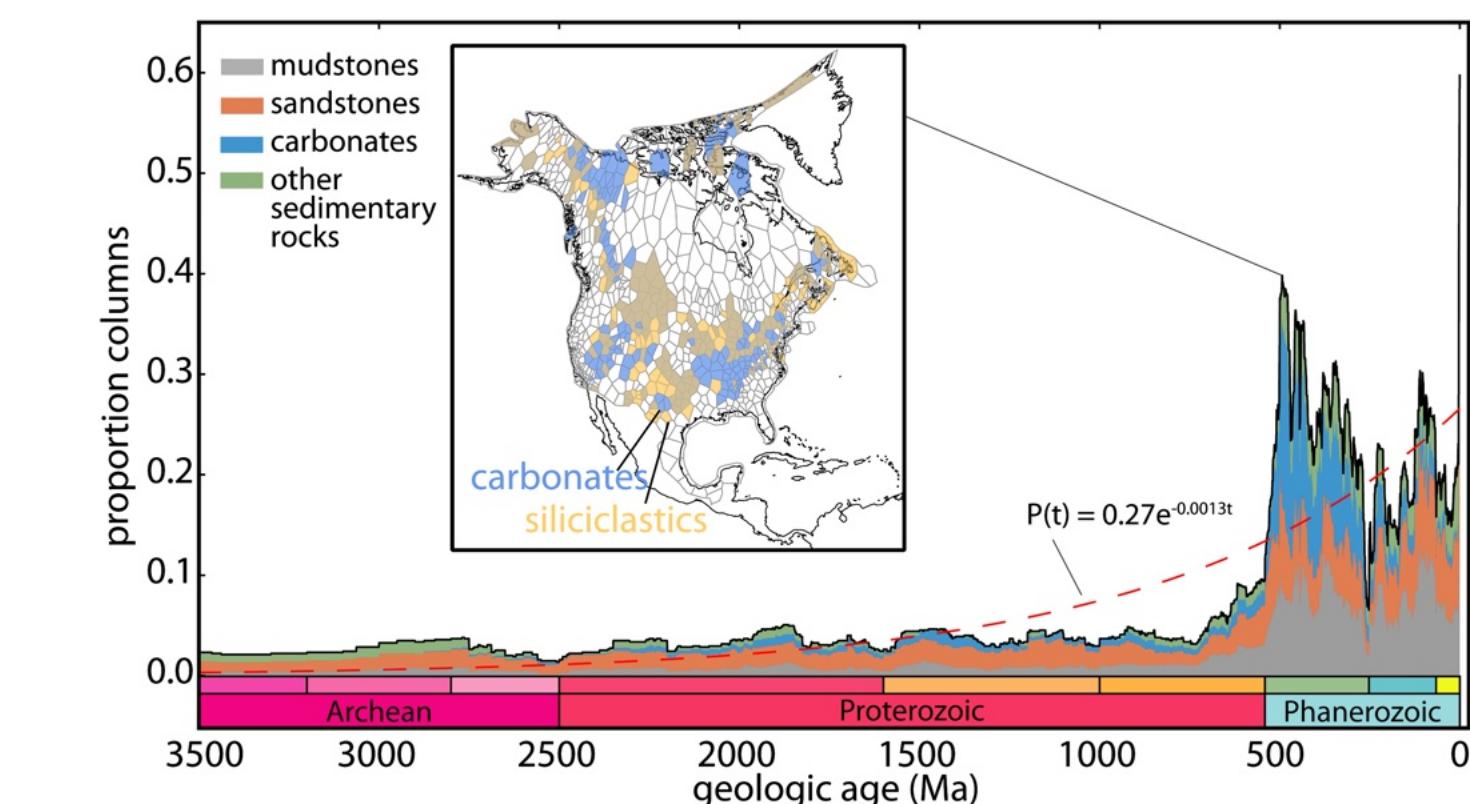


Figure 1 | Sauk Sequence in North America. Distribution and age of the oldest Phanerozoic sedimentary rocks in North America.

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

Jon M. Husson¹ and Shanan E. Peters²

¹School of Earth and Ocean Sciences, University of Victoria, Victoria, Canada; ²Department 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

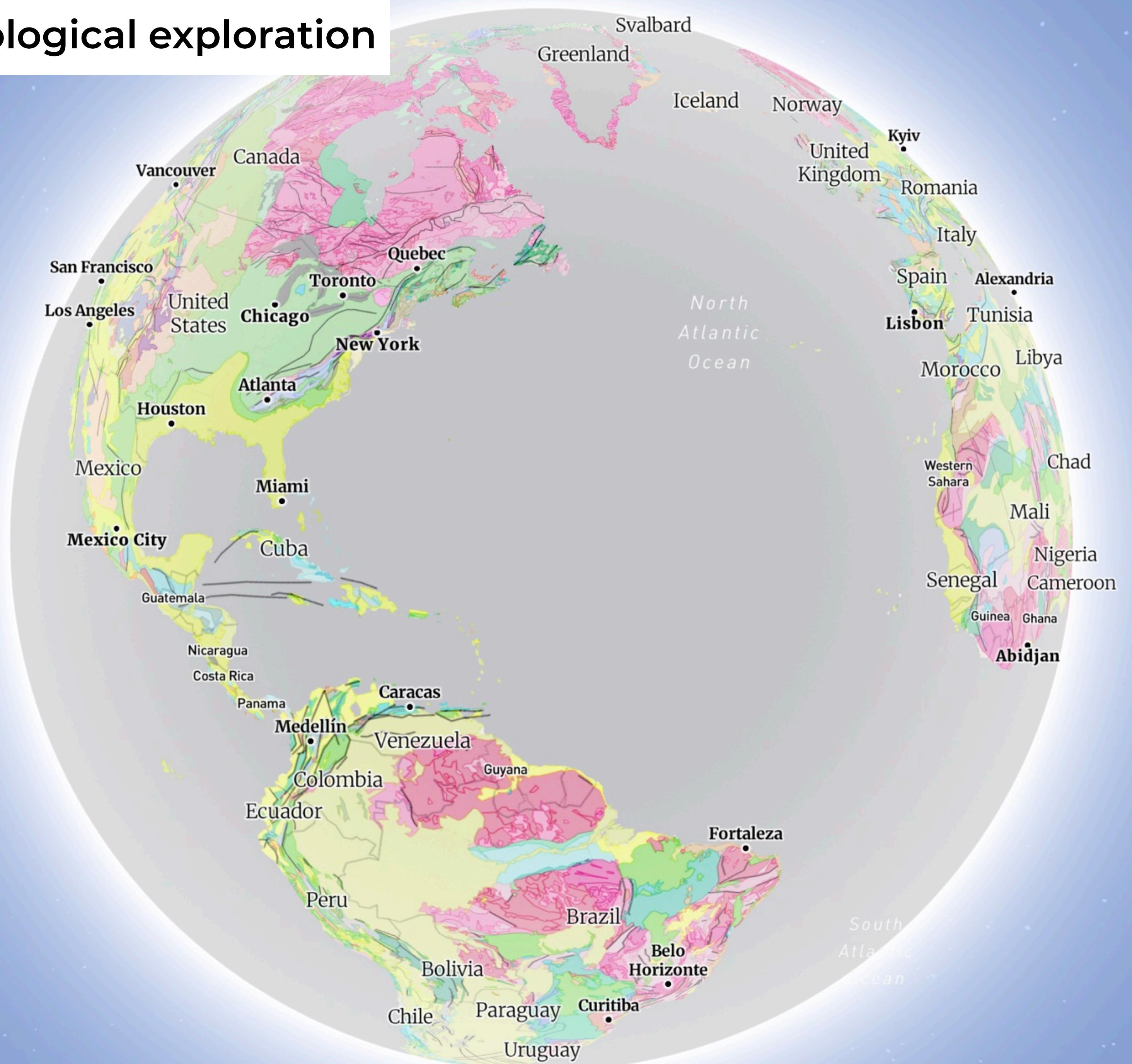
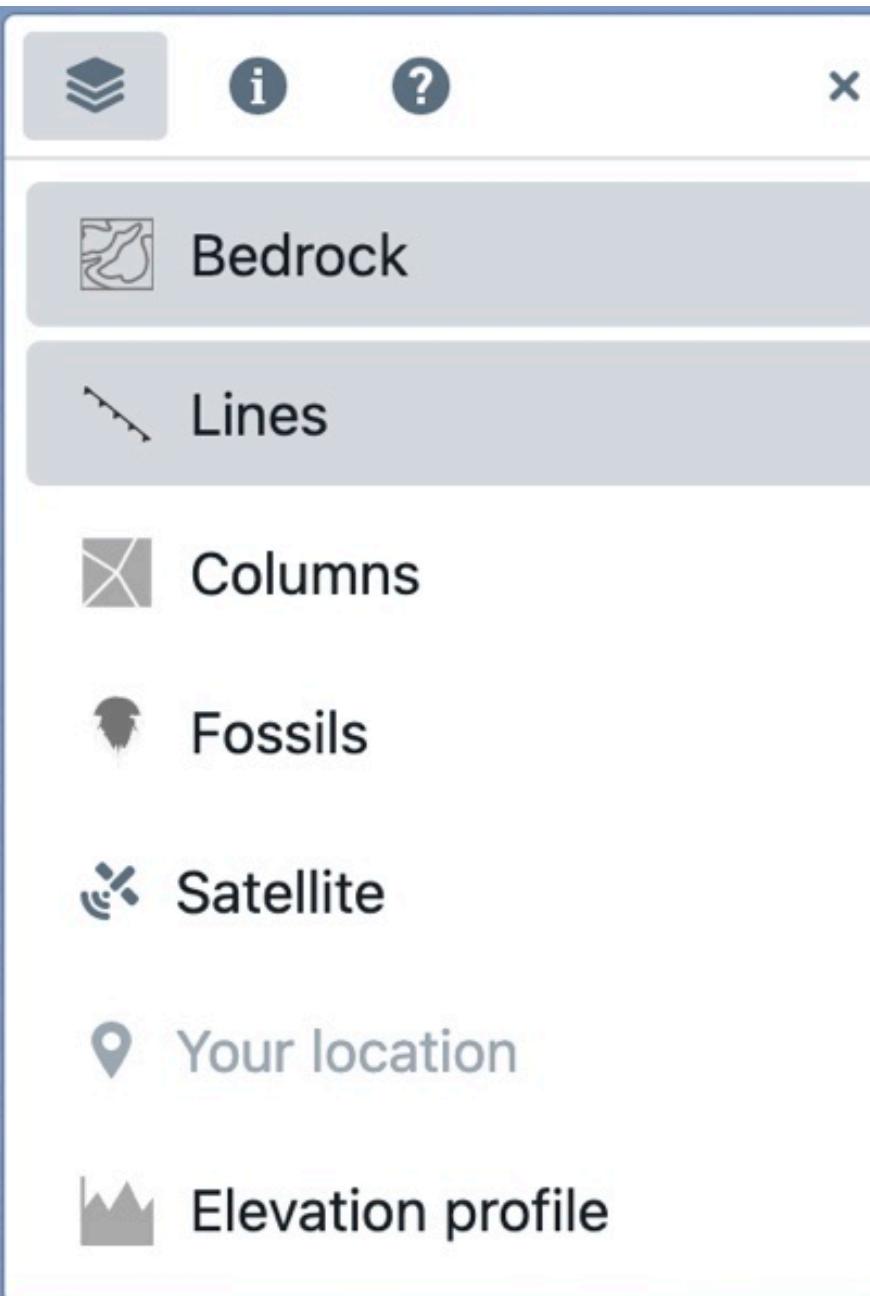
```
{  
  "unit_id": 16008,  
  "section_id": 4229,  
  "col_id": 515,  
  "project_id": 1,  
  "col_area": 26704.309,  
  "unit_name": "Mesaverde Fm",  
  "strat_name_id": 1281,  
  "Mbr": "",  
  "Fm": "Mesaverde",  
  "Gp": "",  
  "SGp": "",  
  "t_age": 80.725,  
  "b_age": 90.825,  
  "max_thick":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

+

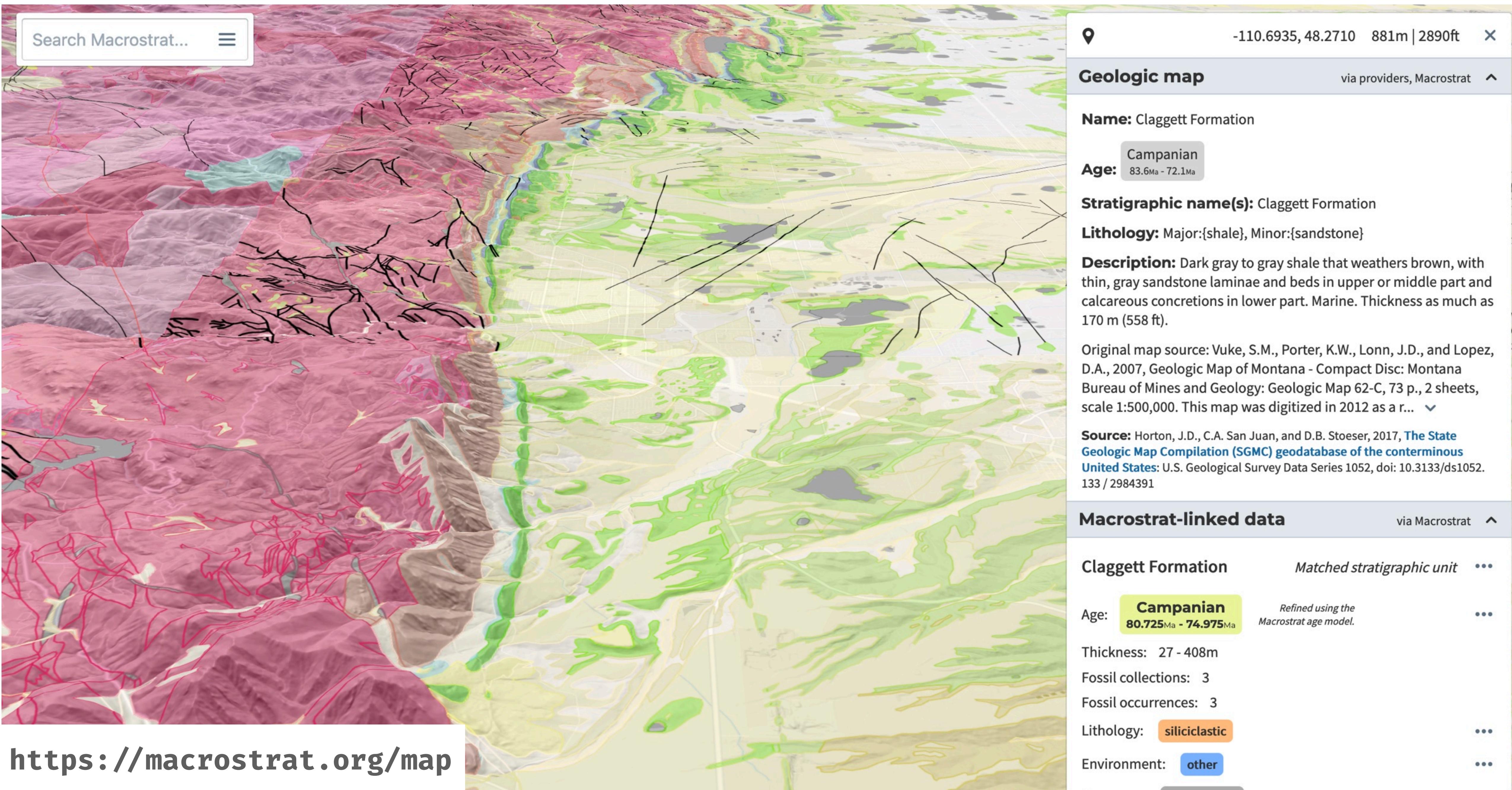
-



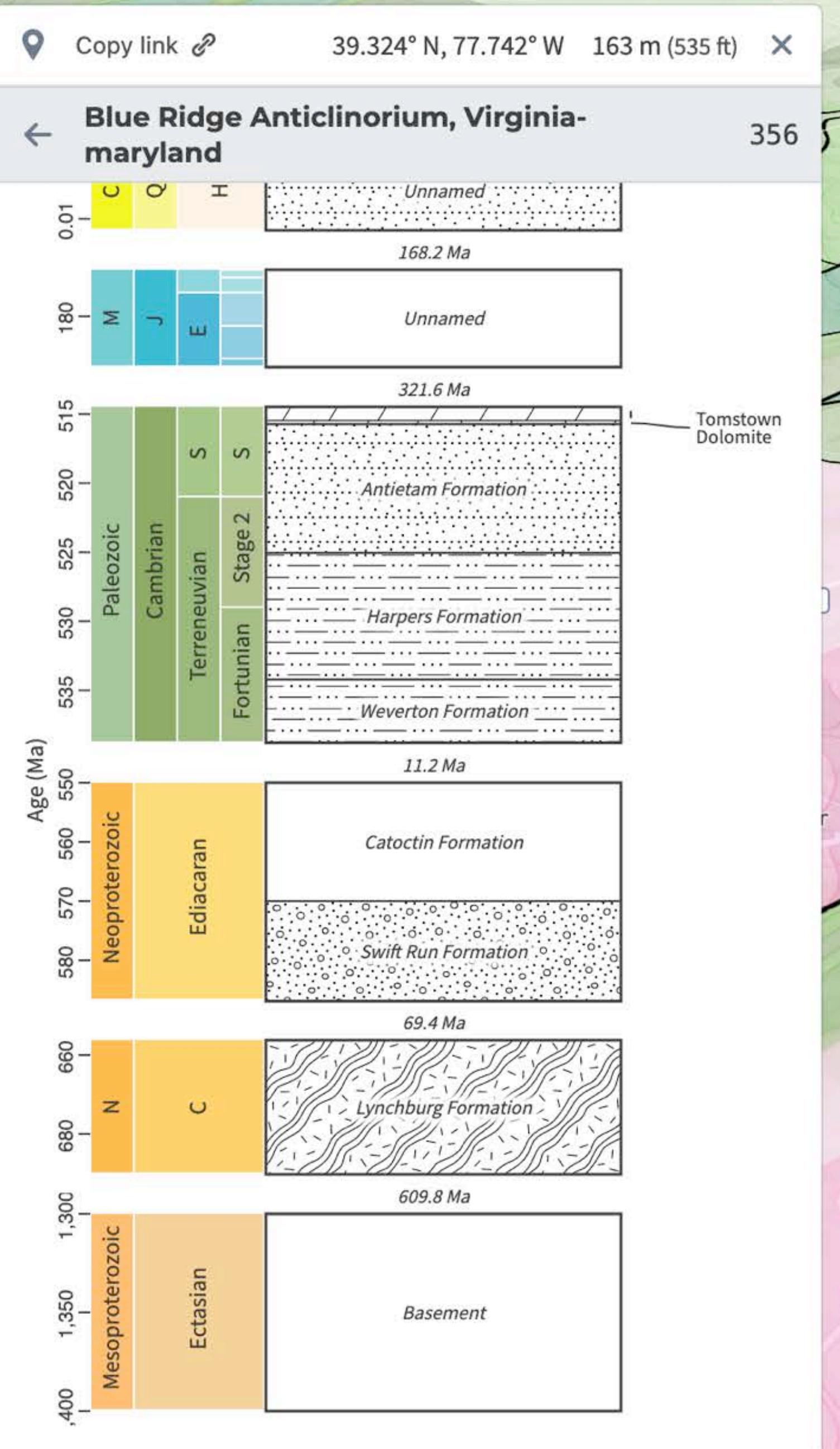
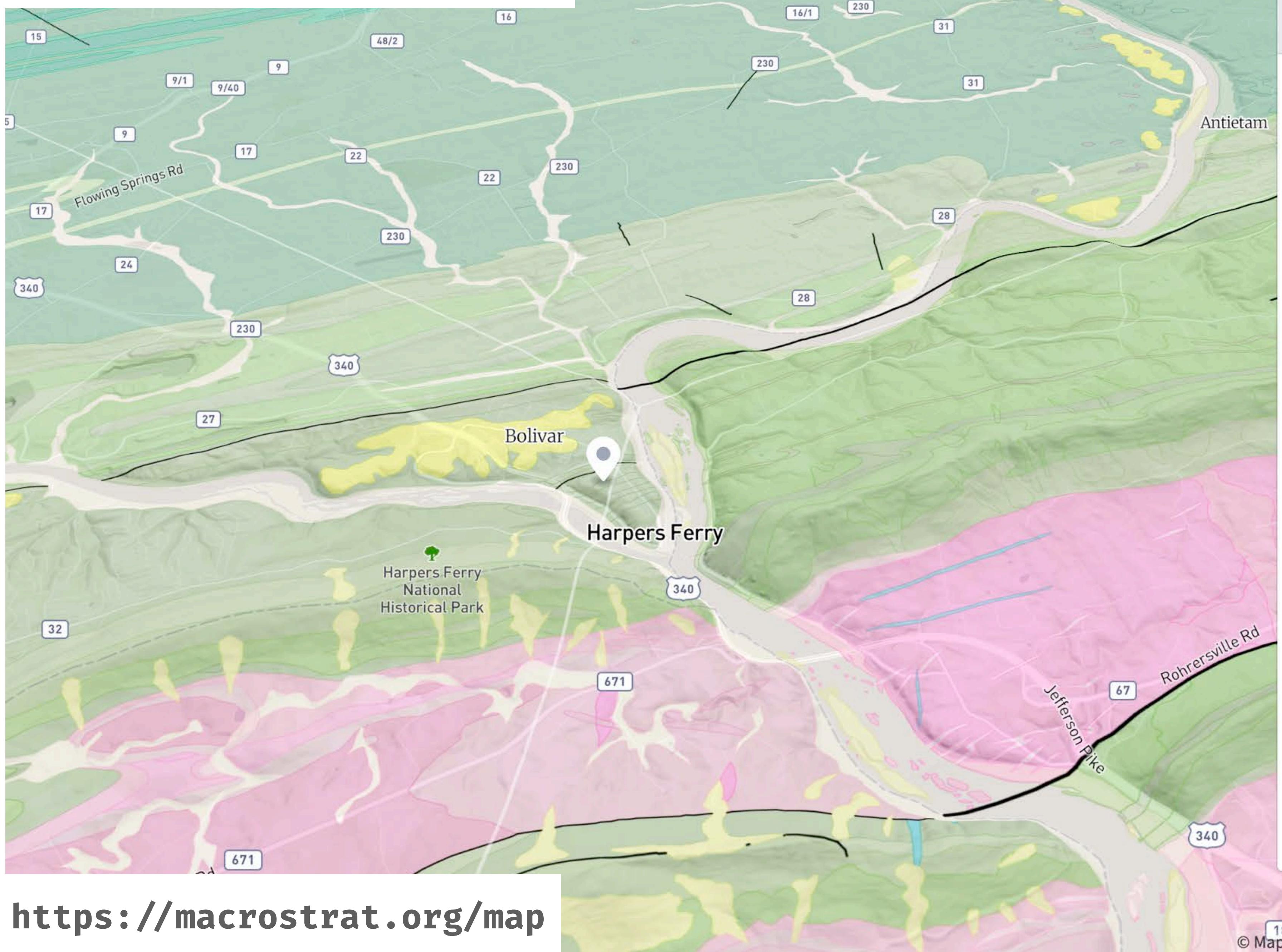
Map

Macrostrat – A platform for geological exploration

Web interface



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

140 130 120 110 100

Age (Ma)

Thickness: 46 - 209m

Fossil collections: 22

Fossil occurrences: 38

<https://macrostrat.org/map>

Macrostrat – A platform for geological exploration

Search Macrostrat... ≡

Filtering by: Cretaceous remove all

Bedrock

Lines

Columns

Fossils

Satellite

Your location

Elevation profile

Info Occurrences (5)

Age: Albian (93.5 - 93.5Ma)

Group: Dakota

Formation: Muddy Sandstone

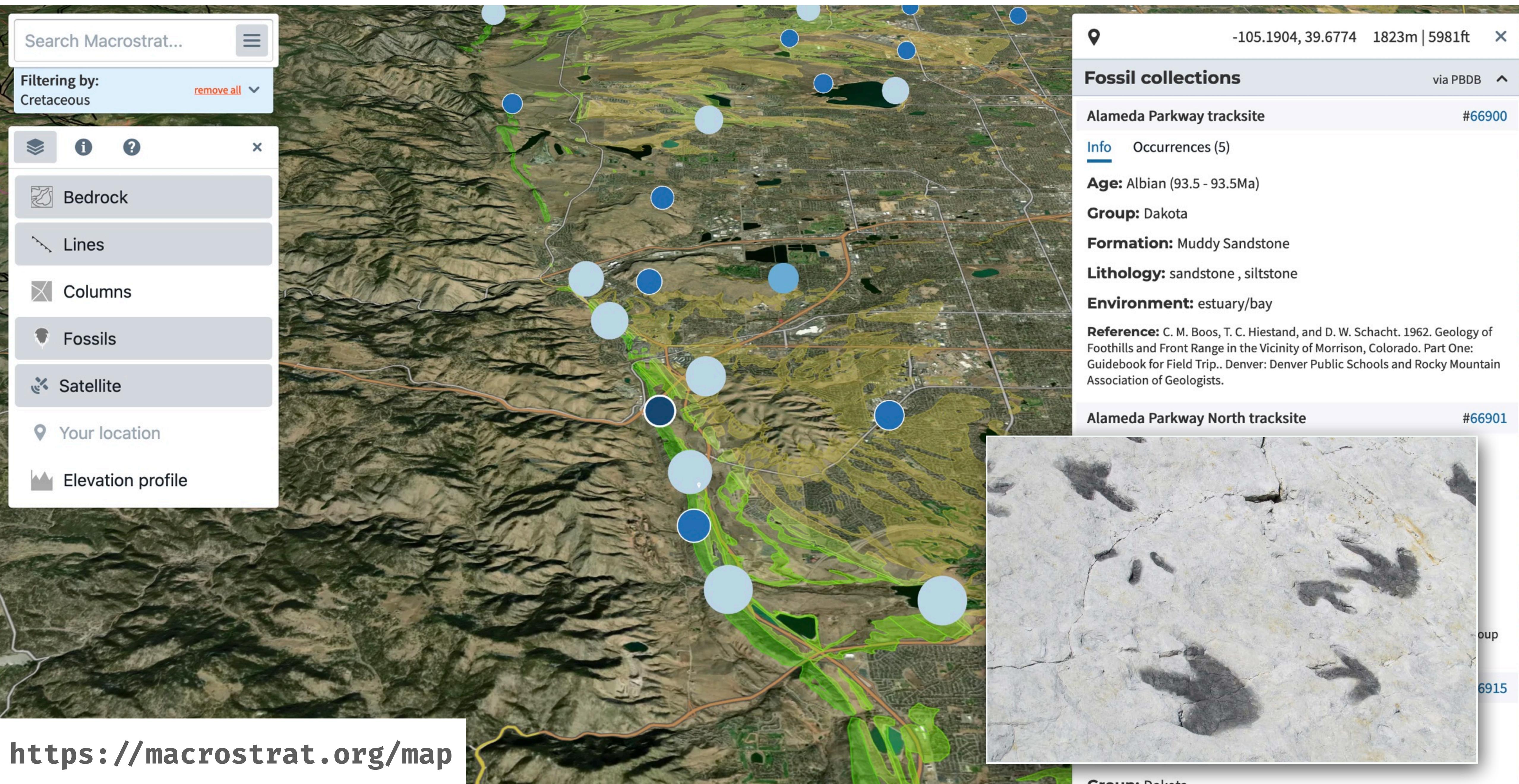
Lithology: sandstone , siltstone

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 tracksite #66900

Alameda Parkway North tracksite #66901



Macrostrat API – provides mapping data to other projects

Rockd – *our own app!*

<https://rockd.org>



Mancos



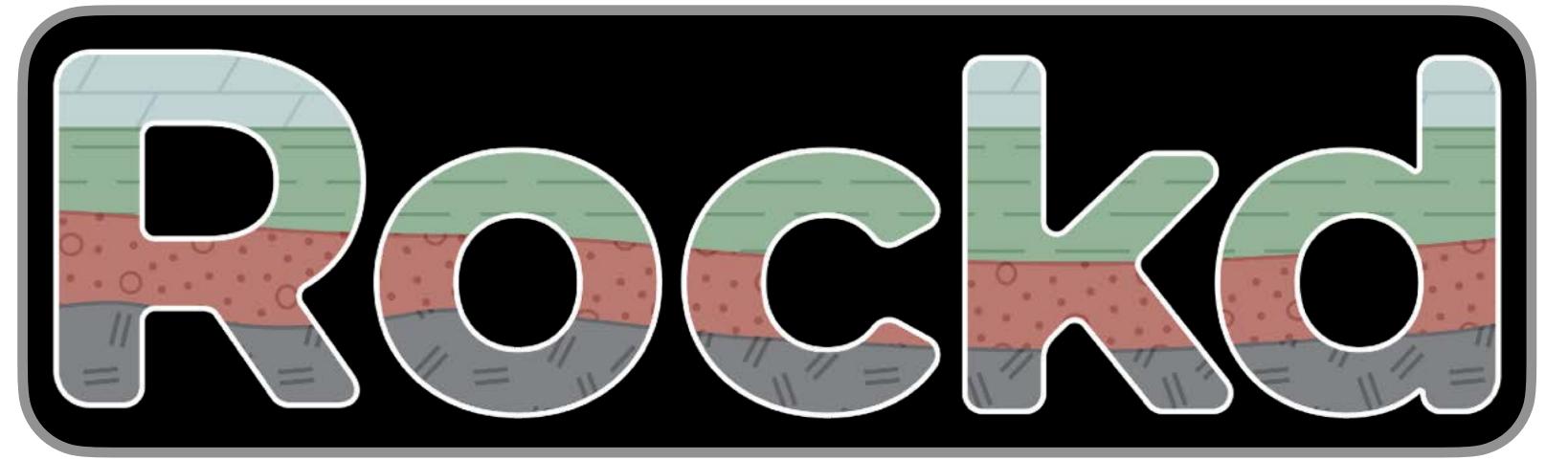
Flyover Country



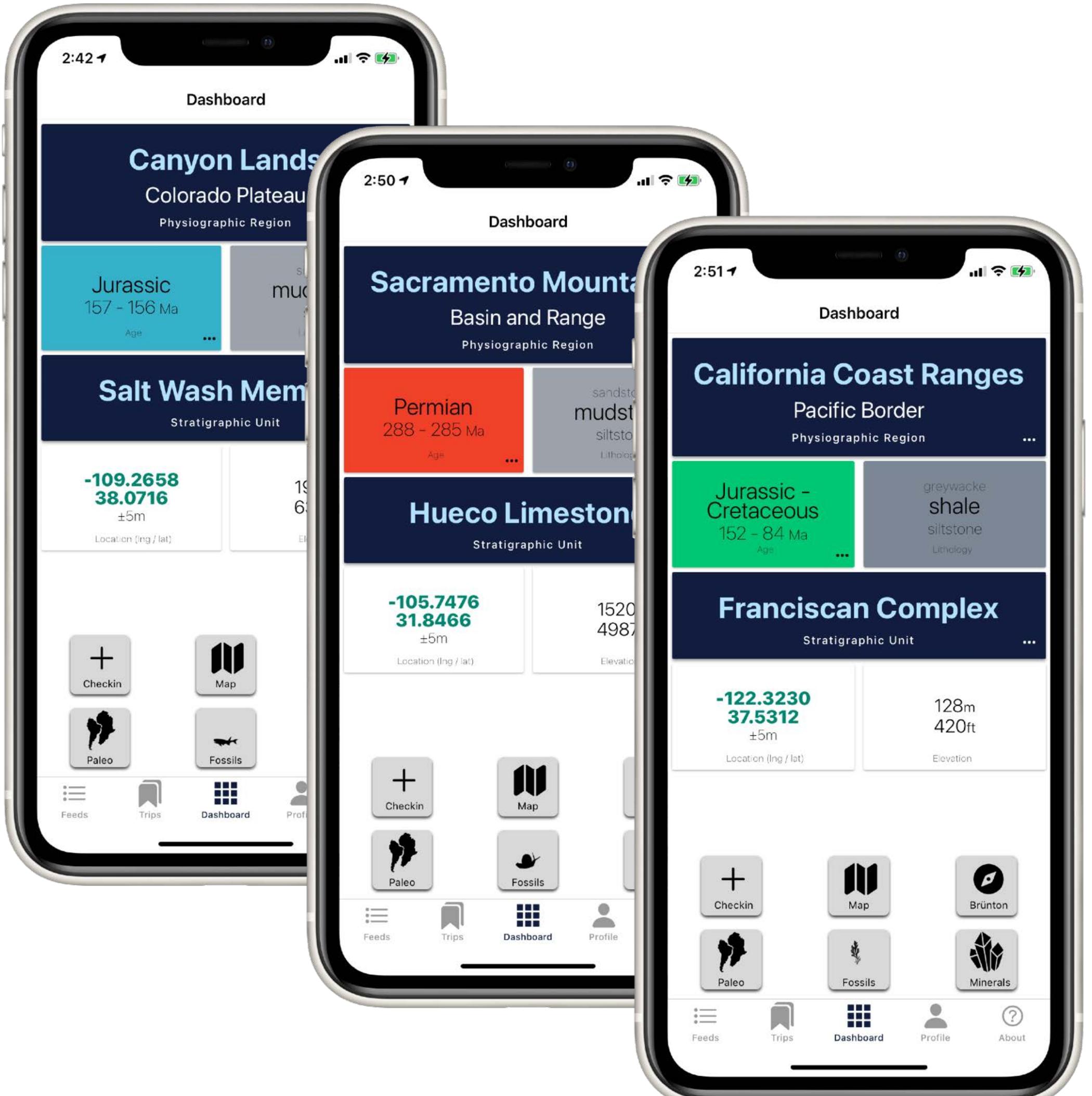
StraboSpot



...and many more!

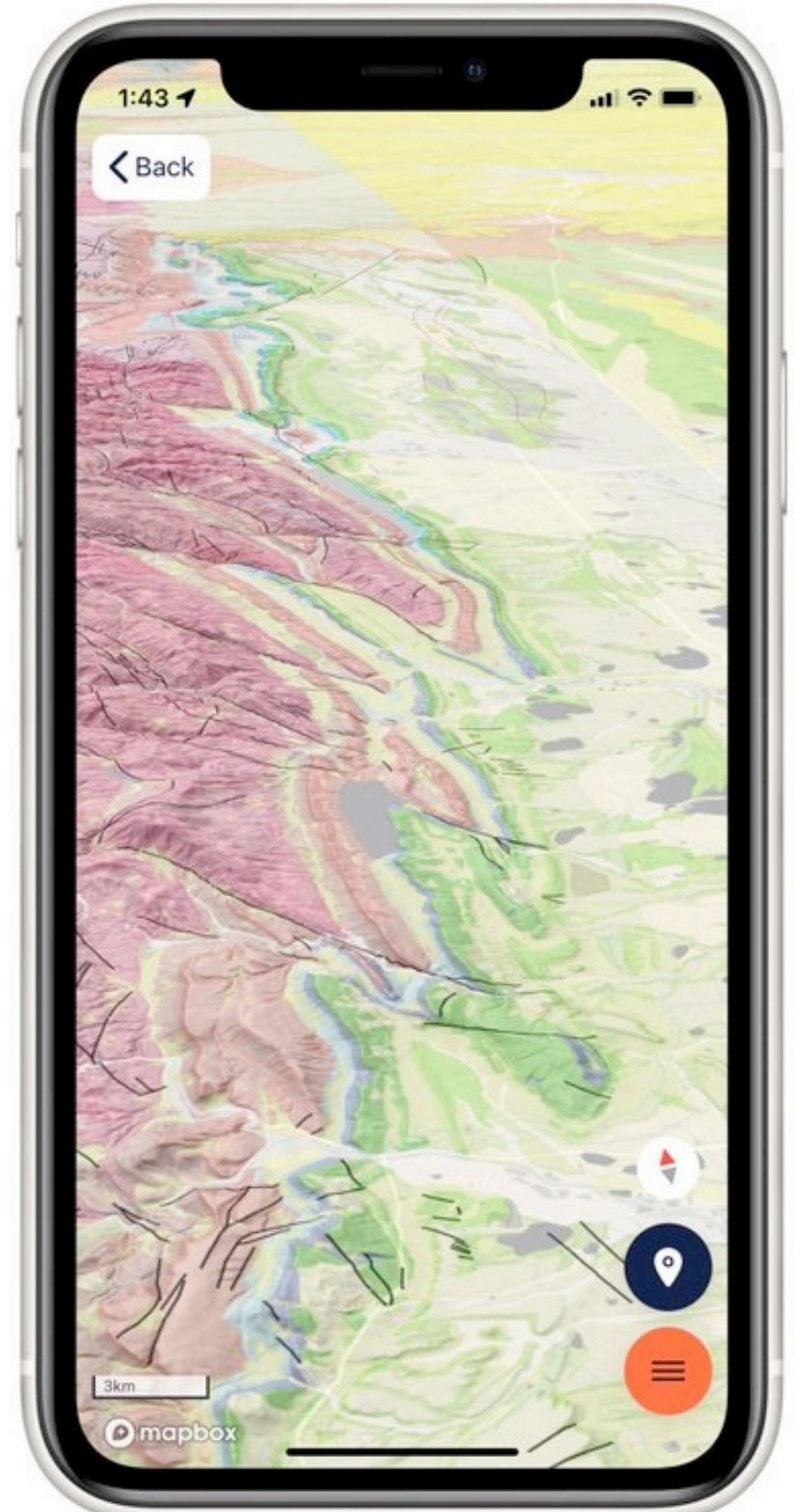
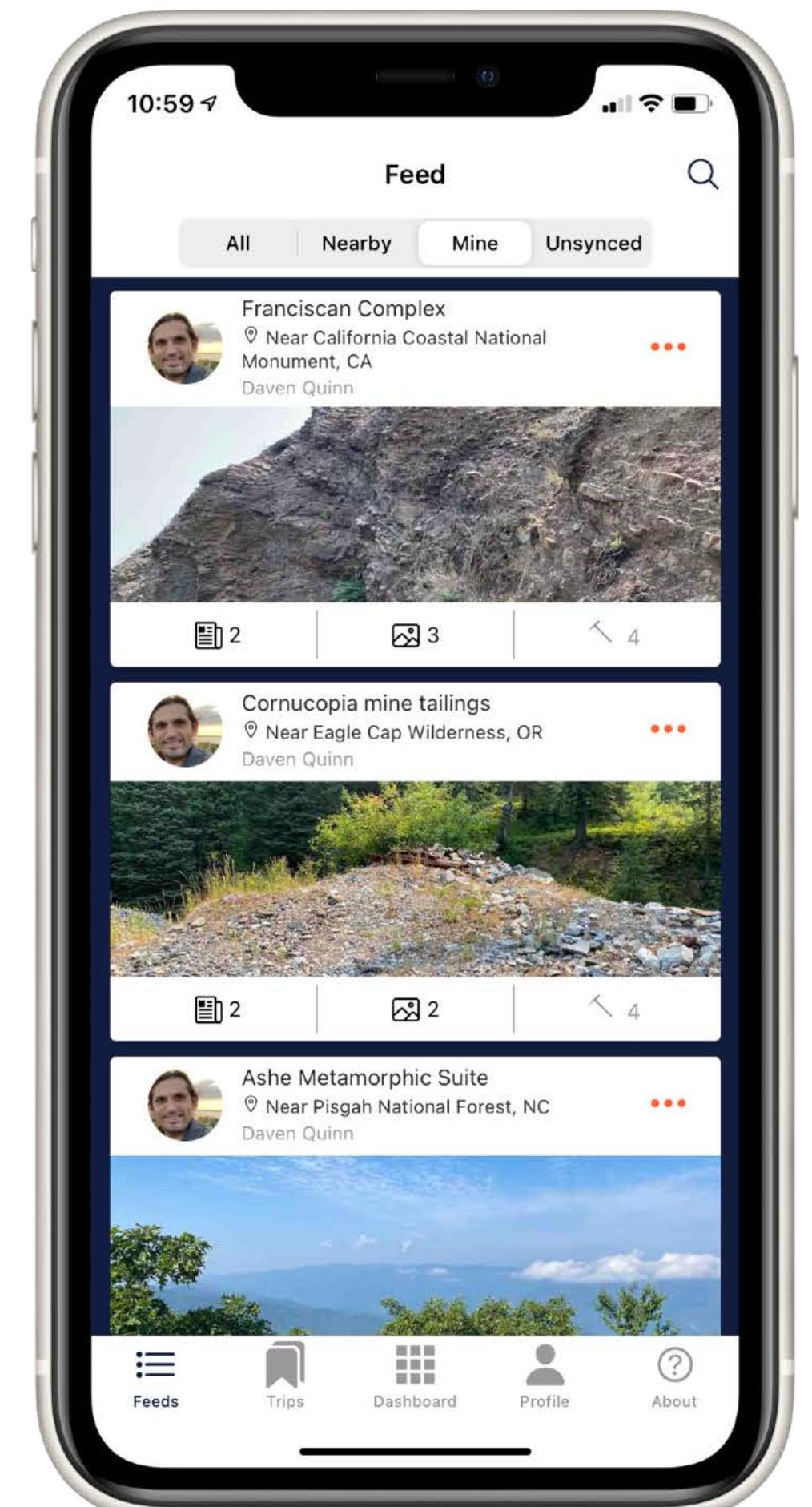


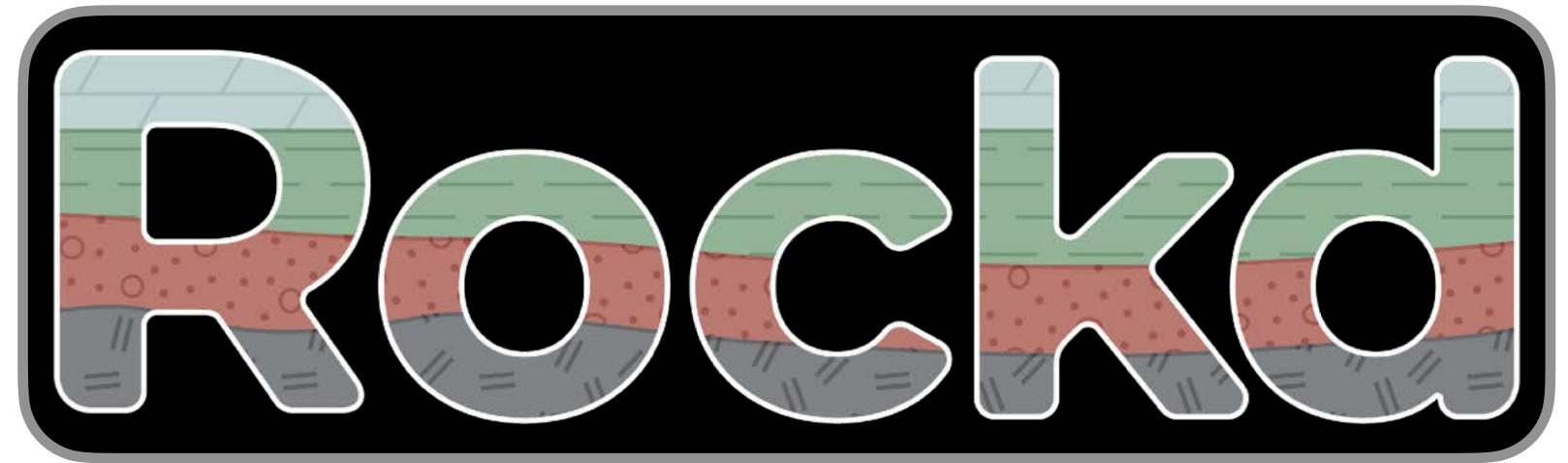
EXPLORE THE GEOLOGY AROUND YOU



<https://rockd.org>

COLLECT AND VIEW
LOCAL OBSERVATIONS



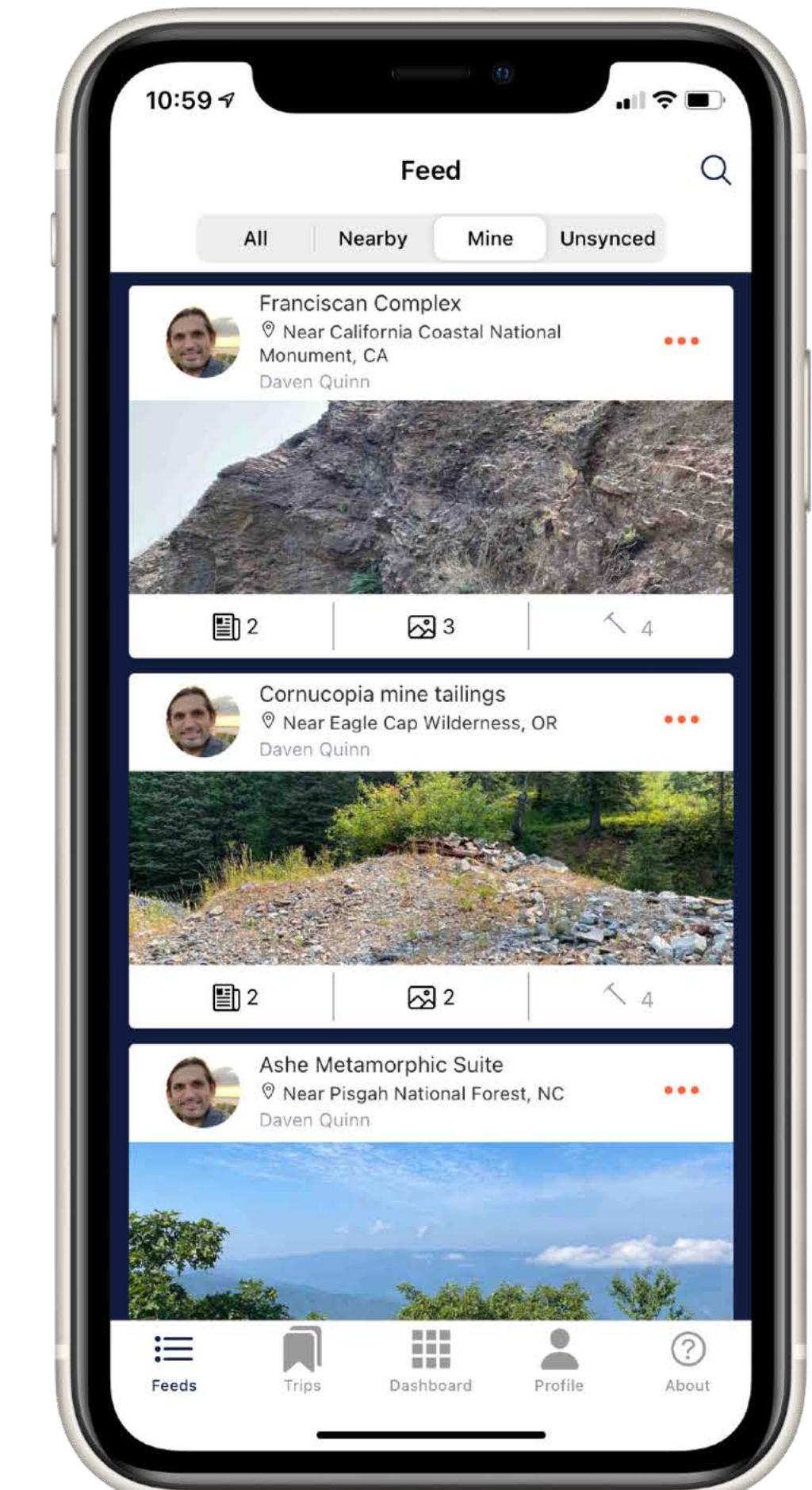


EXPLORE THE GEOLOGY AROUND YOU



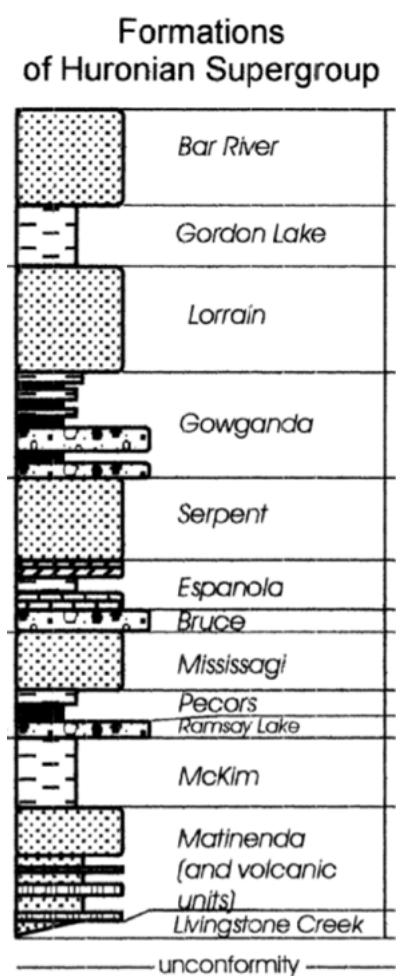
<https://rockd.org>

COLLECT AND VIEW
LOCAL OBSERVATIONS



Macrostrat system architecture

Geologic maps



from

National agencies



State surveys

Academic curators



...and other sources

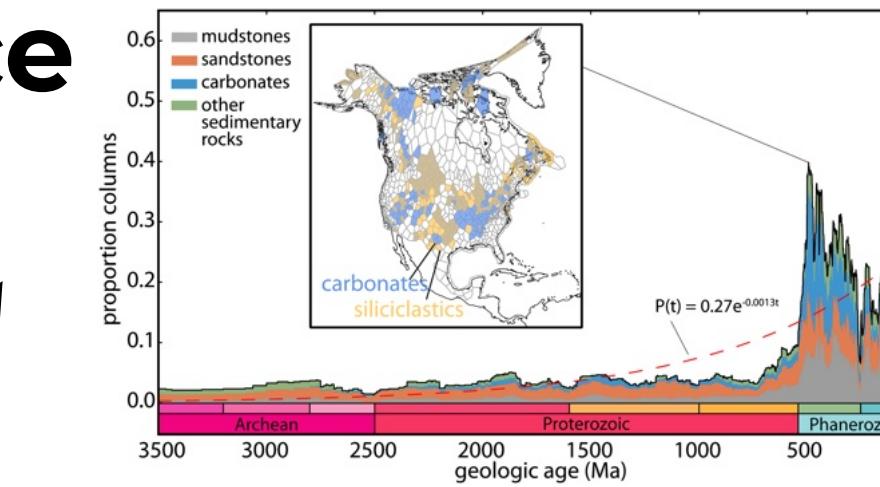
Stratigraphic columns

PostGIS relational geodatabase

Macrostrat software platform

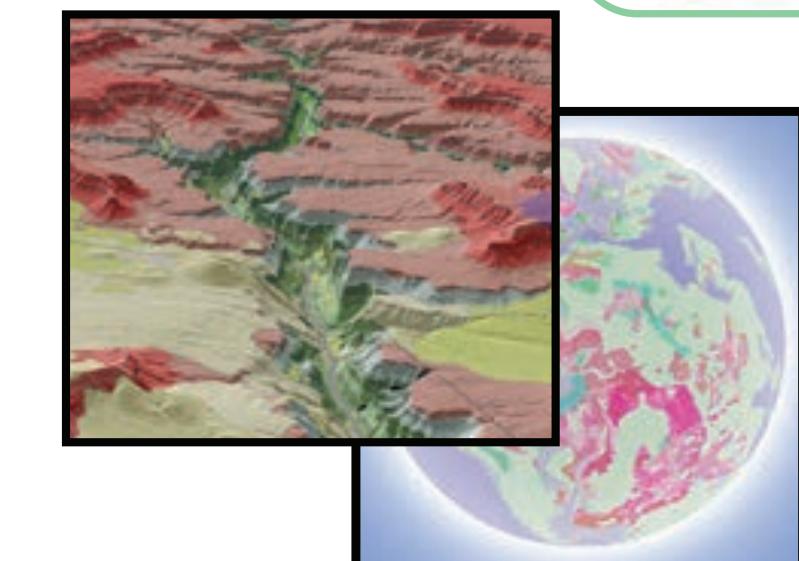
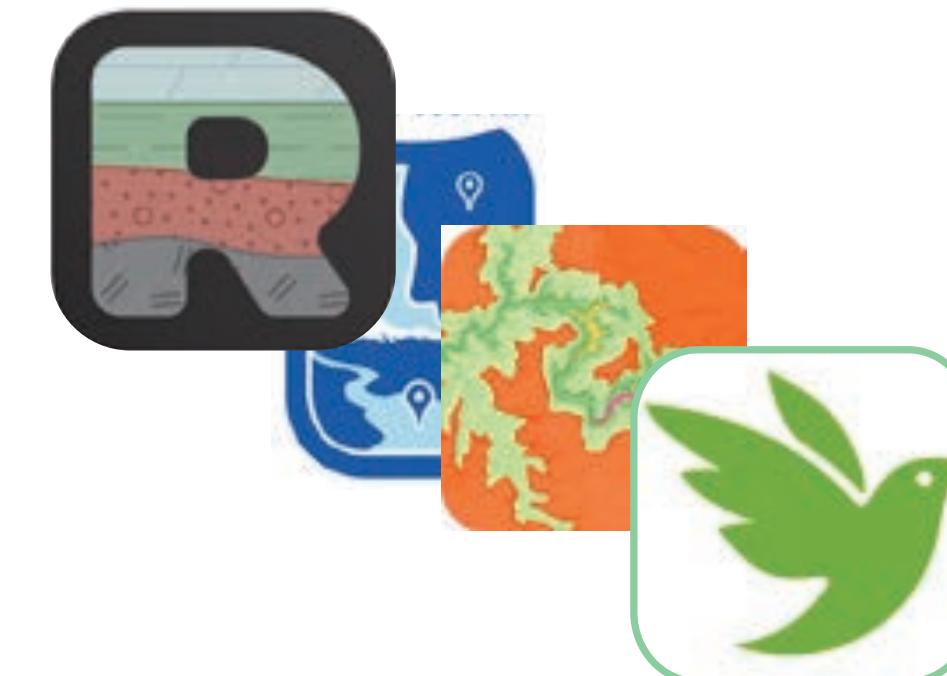
Ingestion + harmonization
Partially automated

Global, integrative science



Open APIs
Automated

Apps + web viewers



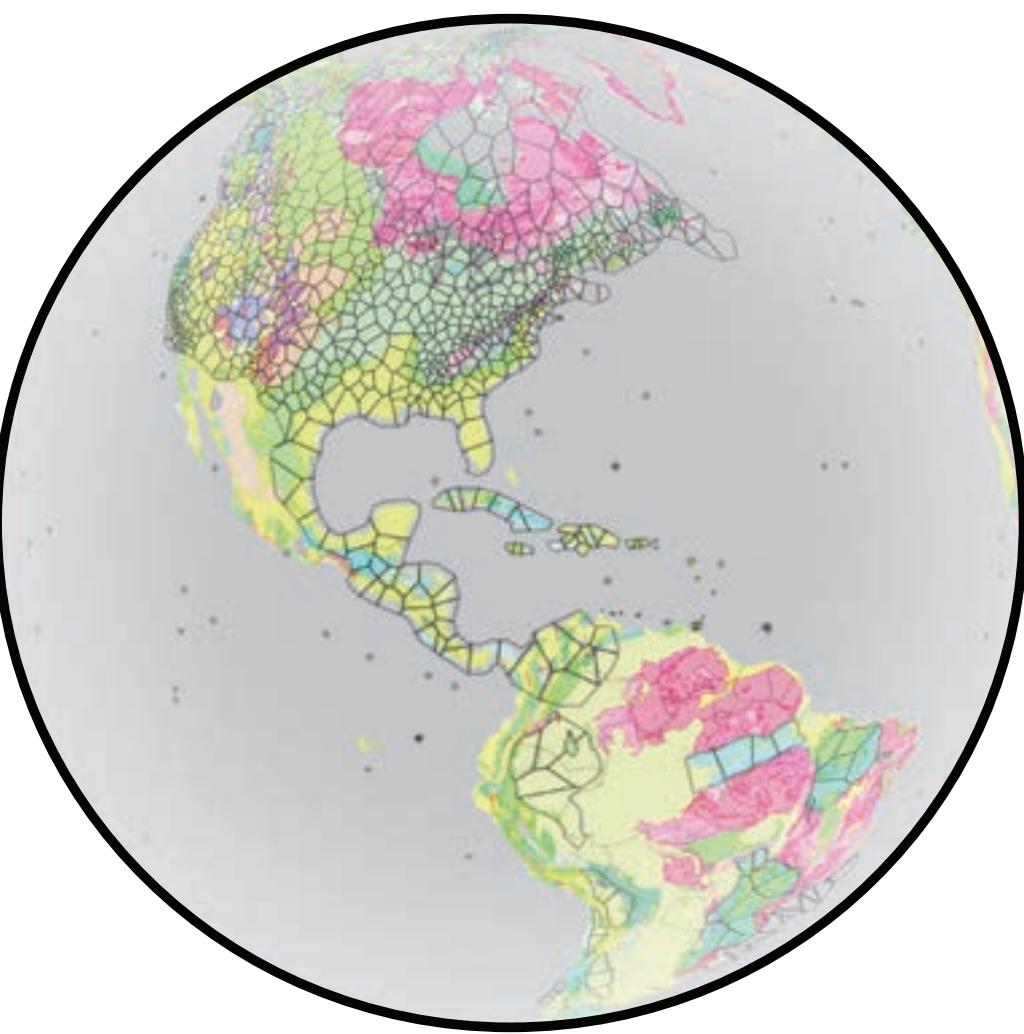
GIS platforms



QGIS

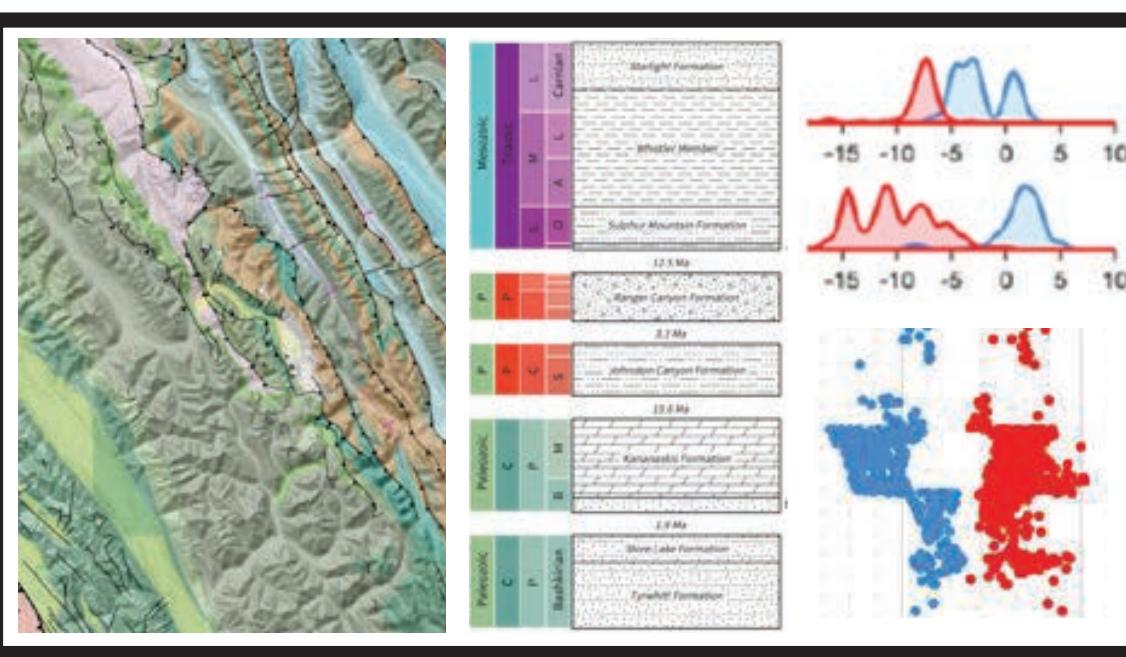
Macrostrat

- 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



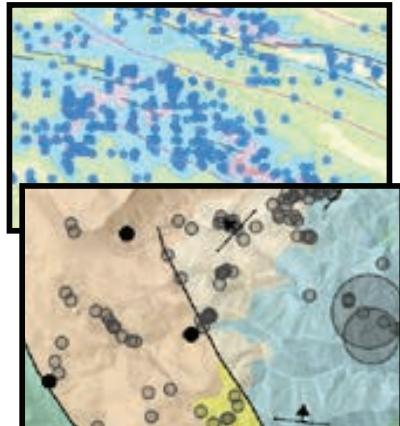
MacroMAAS

Proposed system architecture

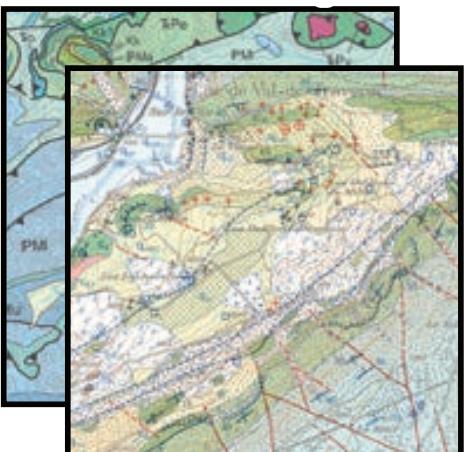
New data sources



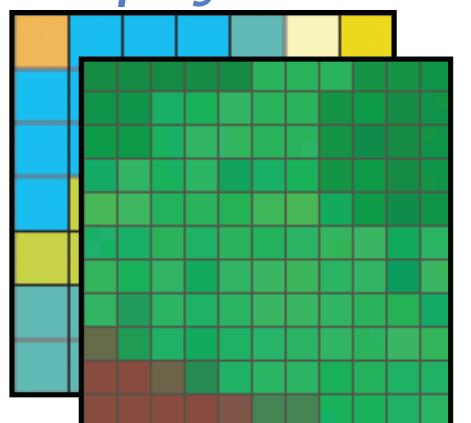
Measurements



Raster maps



Geophysics



Literature extractions

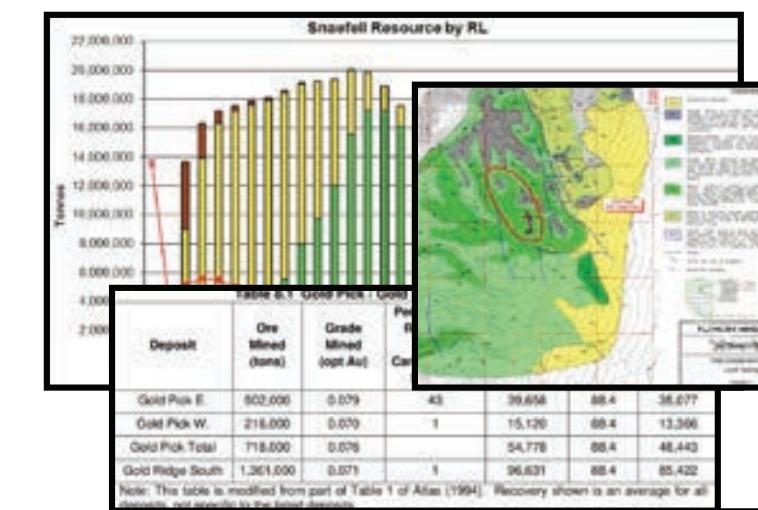


Table 8.1. USGS PEC: Gold

Deposit | Ore Mined (tonne) | Grade Mined (g/t Au) | Count

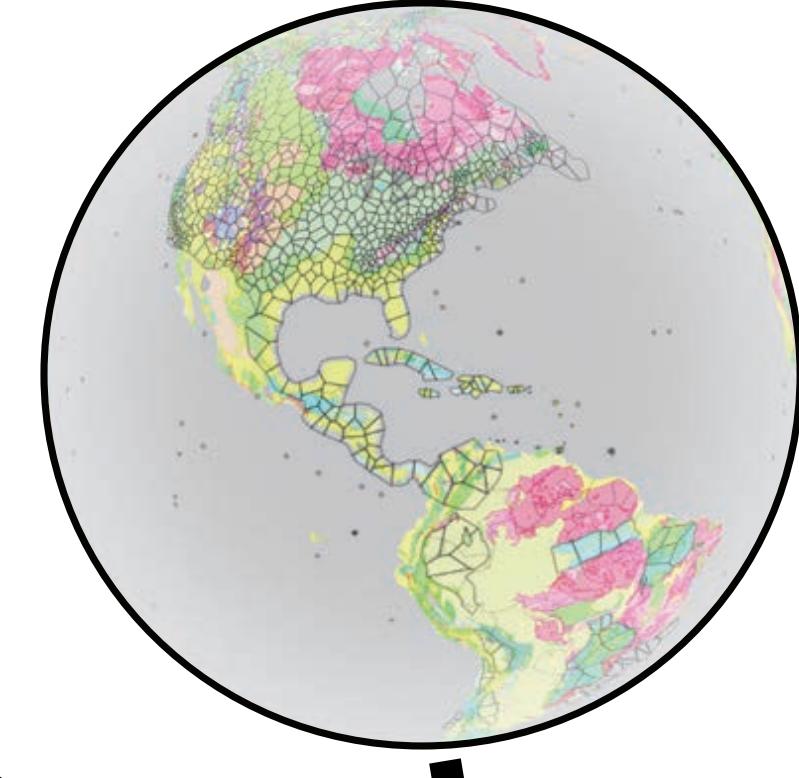
Gold Pick E. | 802,000 | 0.079 | 43 | 39,658 | 88.4 | 36,677

Gold Pick W. | 218,000 | 0.079 | 1 | 15,120 | 88.4 | 13,066

Gold Pick Total | 1,061,000 | 0.079 | 1 | 54,778 | 88.4 | 49,432

Note: This table is modified from part of Table 1 of Atlas (1994). Recovery shown is an average for all

Macrostrat



TA3

Tile server

PostGIS relational geodatabase

Macrostrat software platform

Ingestion + harmonization

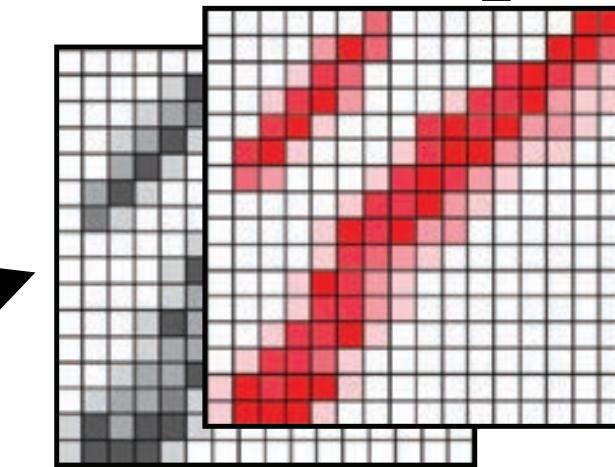
~~Partially automated~~

Fully automated

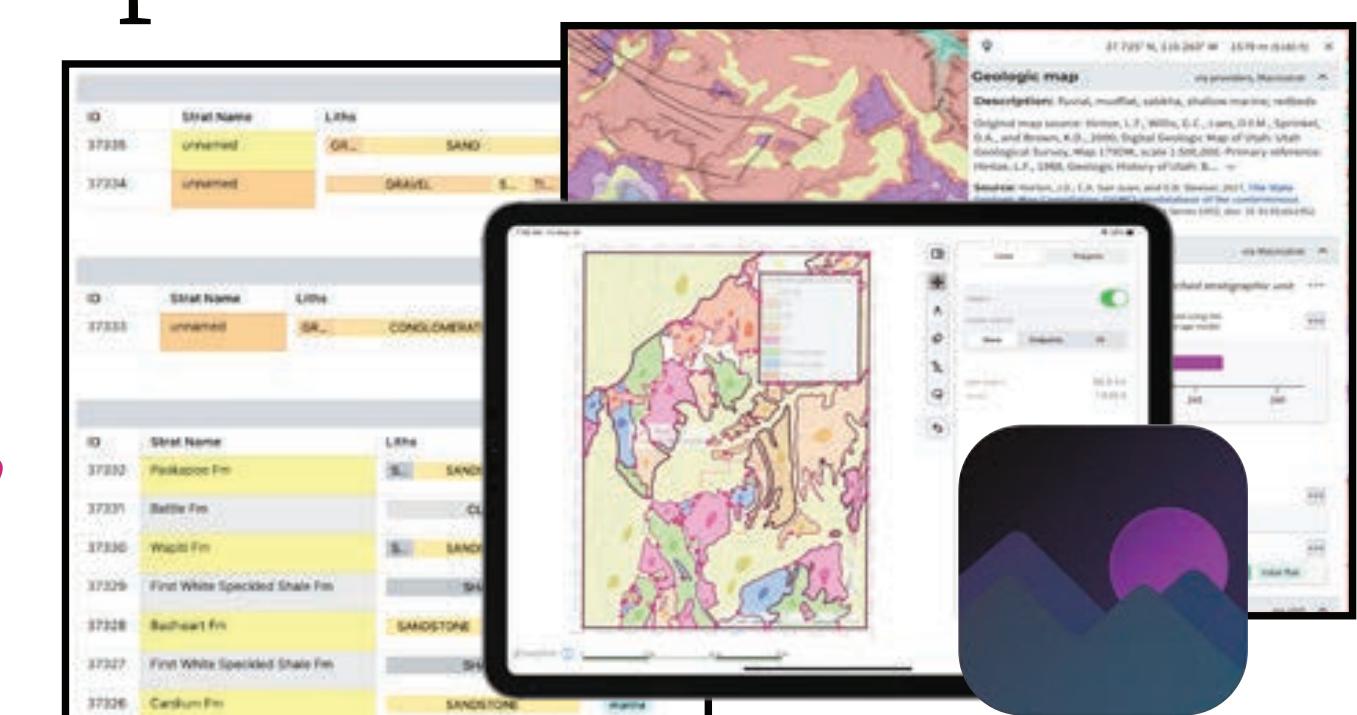
Feedback

“Human in the loop”

Predictive mineral maps



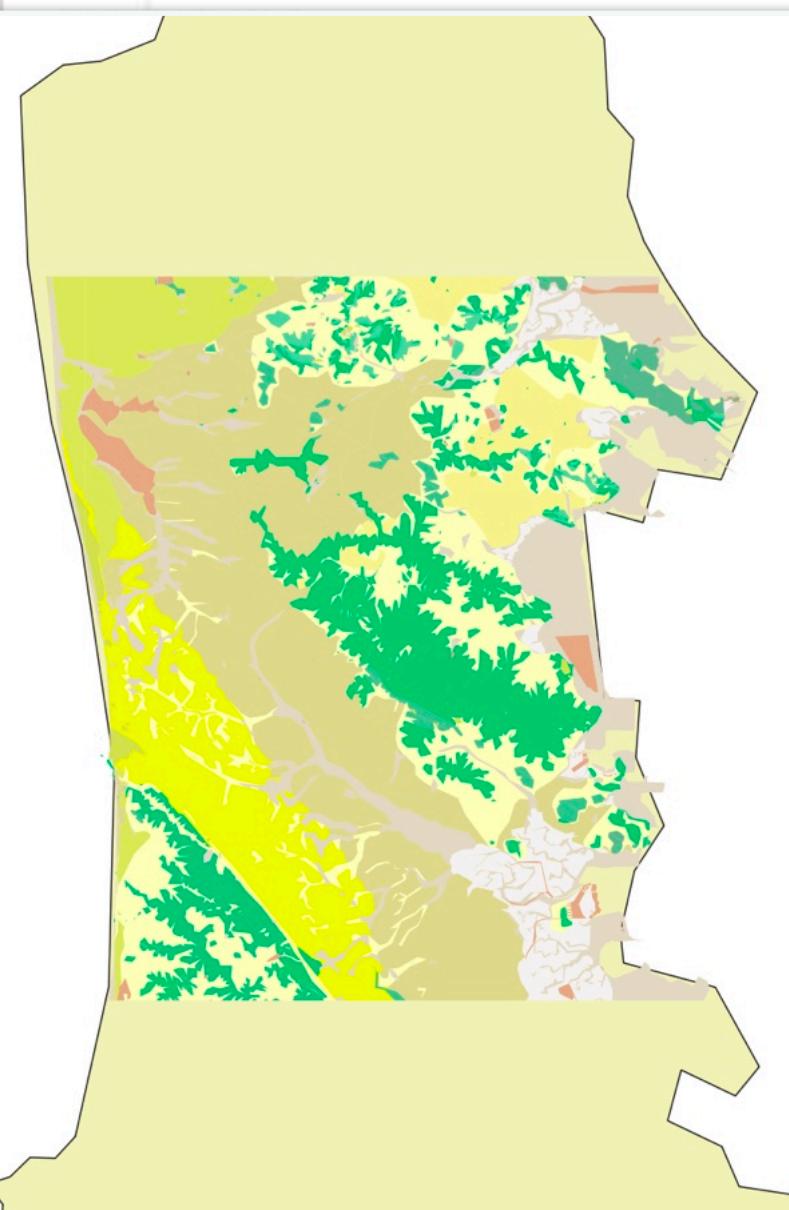
GIS platforms



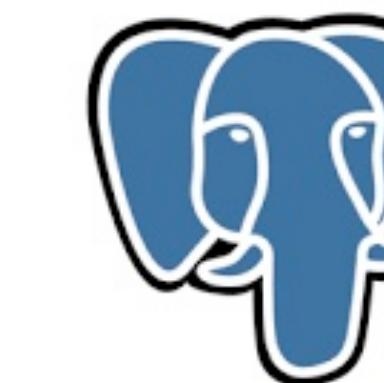
Ingestion of AI-generated candidate map datasets (TAI output)

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					
Holocene and Pleistocene					
Holocene and late Pleistocene					
Holocene and Pleistocene					
Cretaceous					
Holocene and late Pleistocene					
Holocene and Pleistocene					
early Pliocene and late Miocene					
Holocene and Pleistocene					
21	Qls	Holocene and Pleistocene	4	3	Landslide de
Holocene and Pleistocene					



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~~

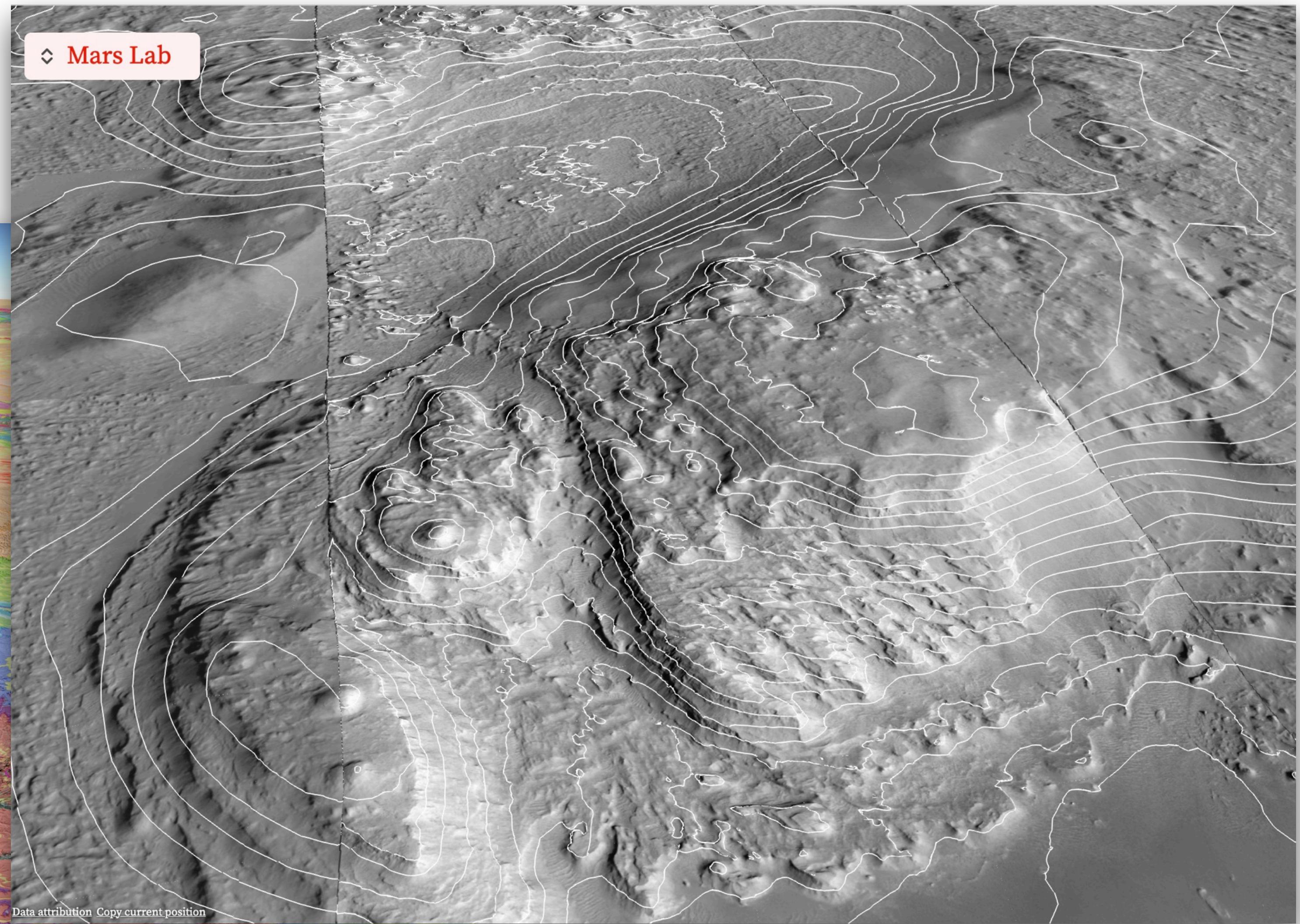
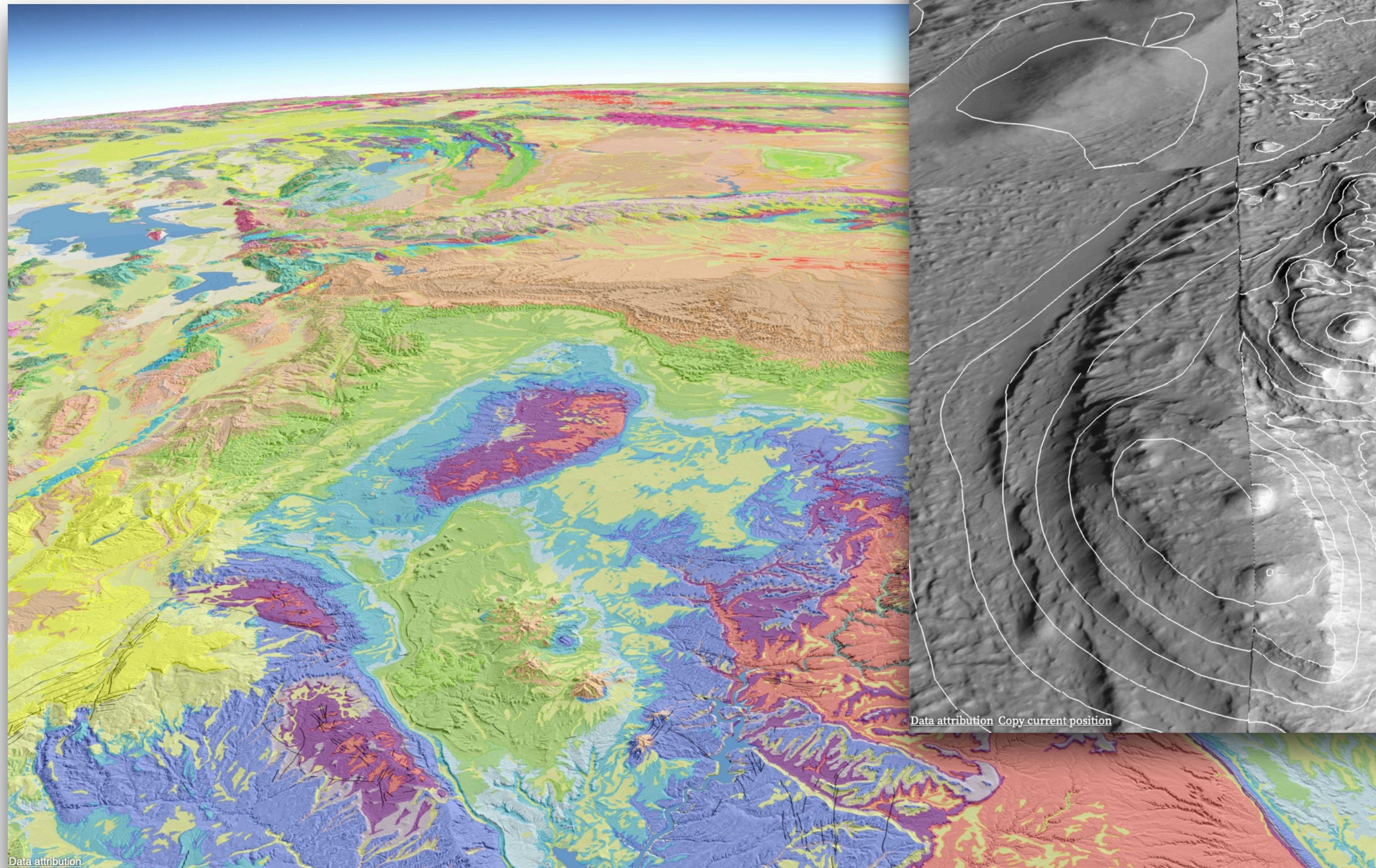
Automated “best-effort” ingestion

Integrating new contextual data sources

A dynamic tile server for raster datasets

Prototype capability

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



In collaboration with

JPL
Jet Propulsion Laboratory
California Institute of Technology

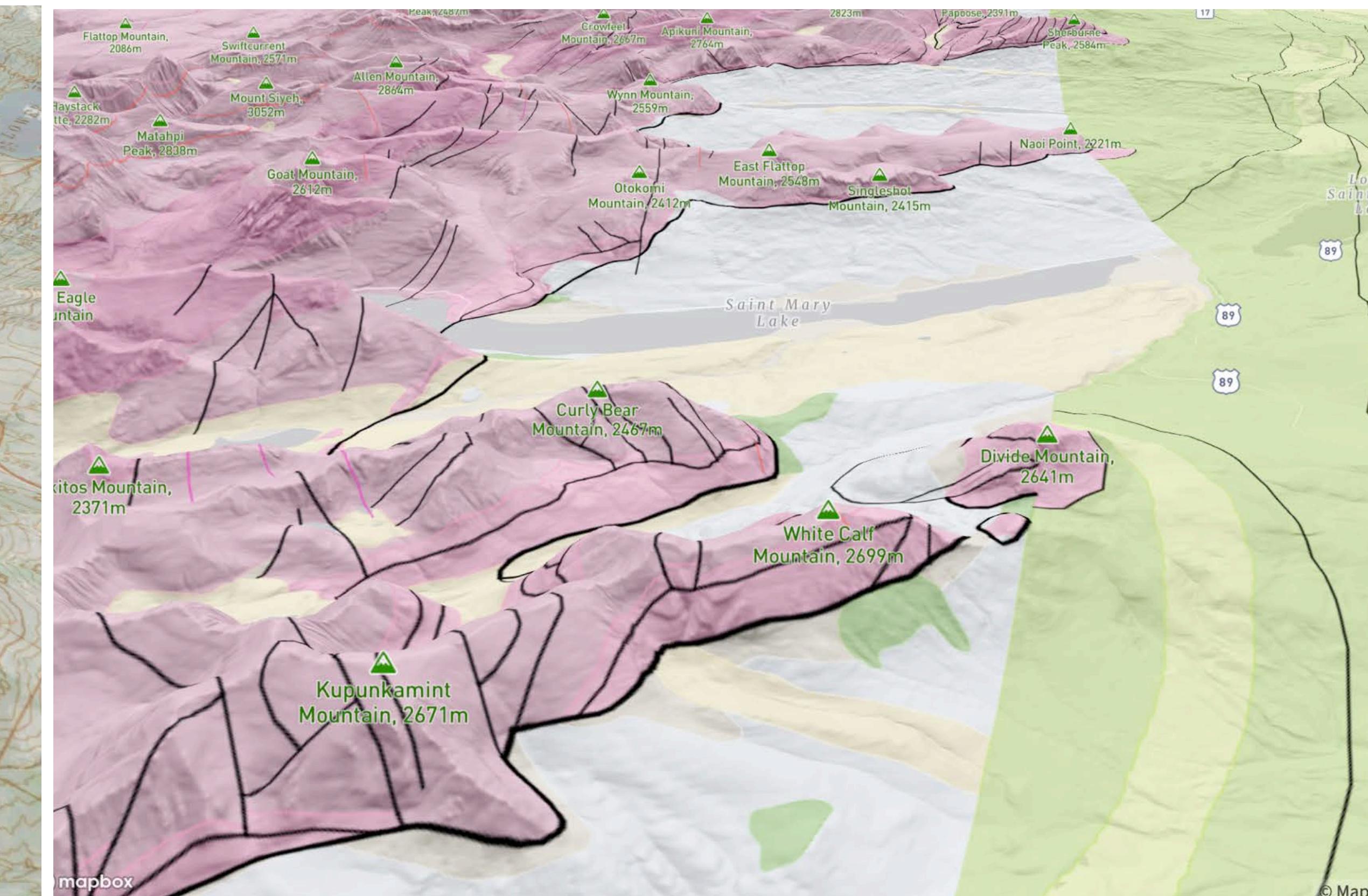
Integrating new contextual data sources

A dynamic tile server for raster datasets

Prototype capability



Macrostrat web interface showing raster geologic map

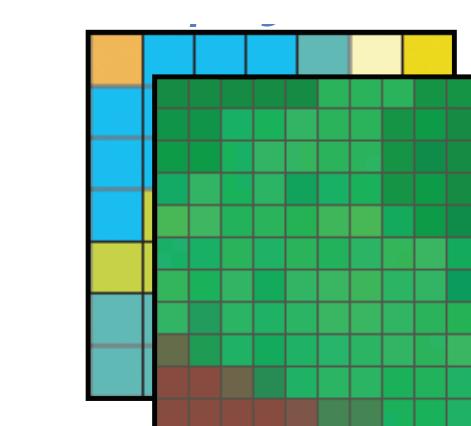


Vectorized version of same map

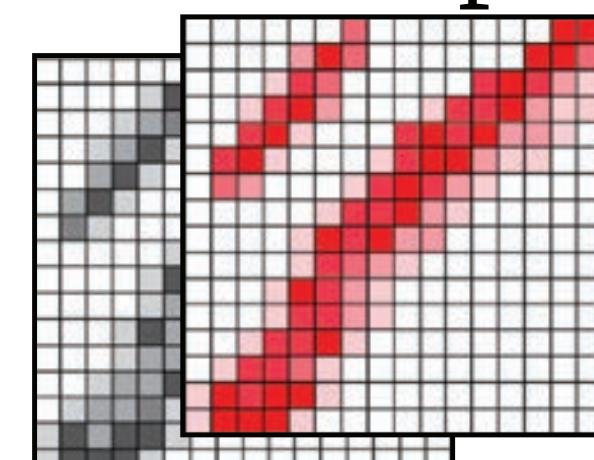
Critical for surfacing
Geologic basemaps



Geophysical
evidence layers



Predictive
mineral maps

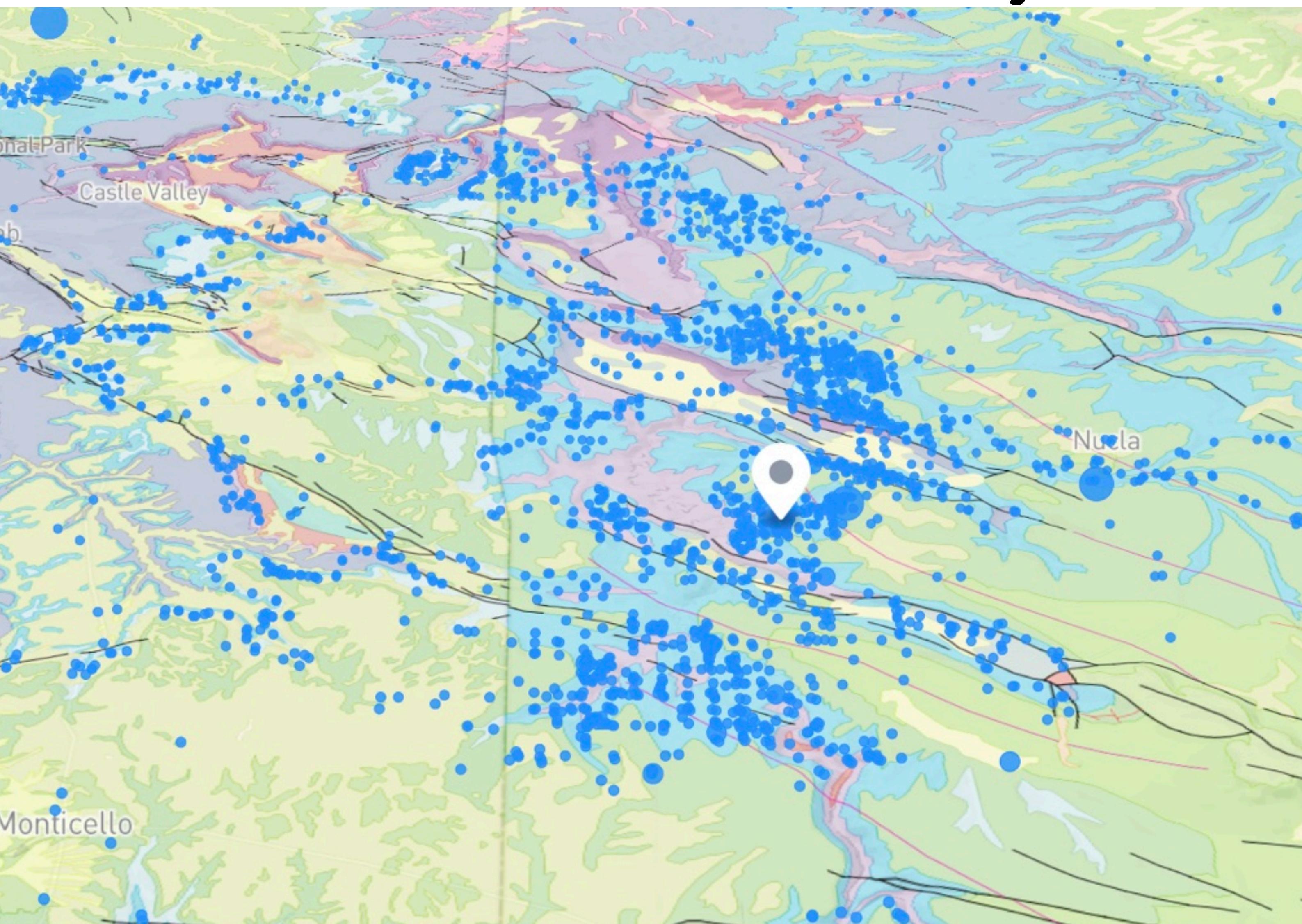


Integrating new contextual data sources

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)

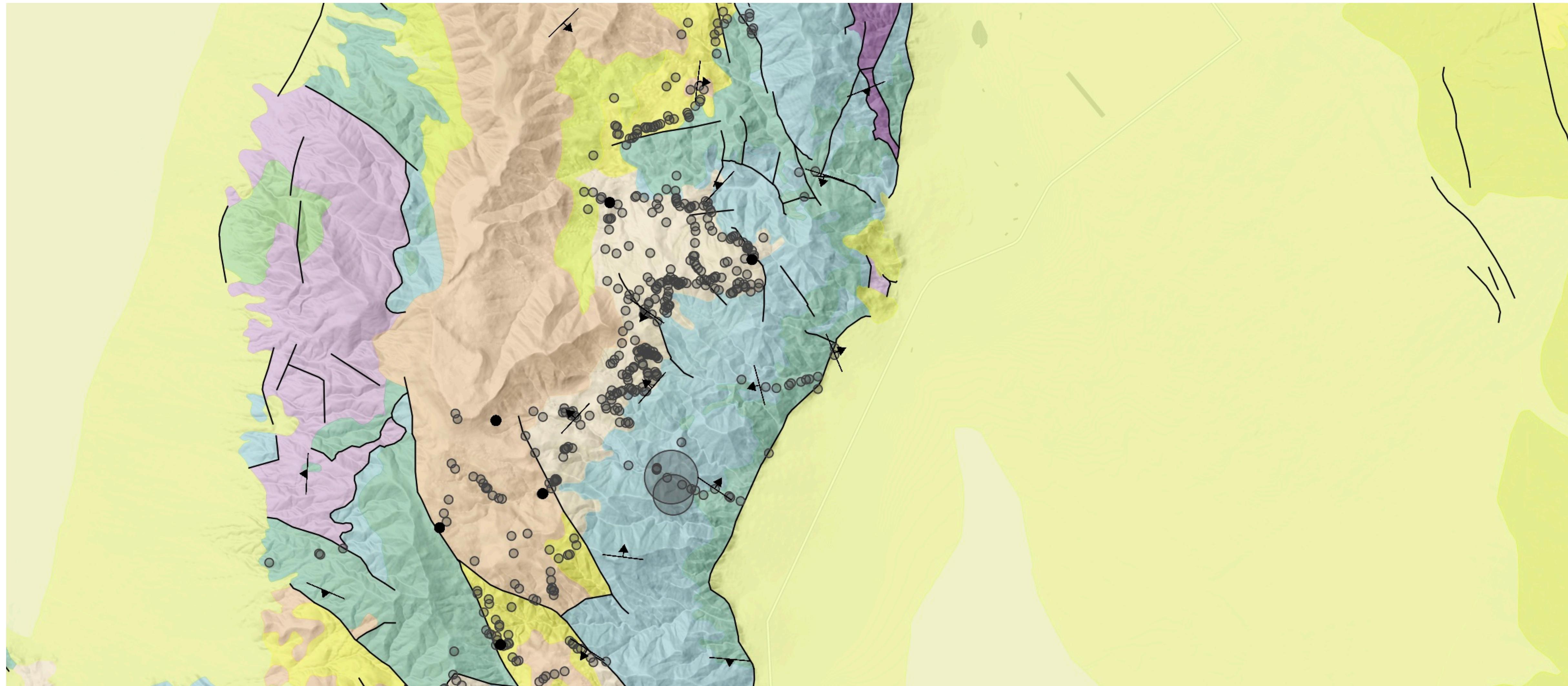
Political divisions (FIPS codes)
Montrose (county)

Integrating new contextual data sources

Prototype capability

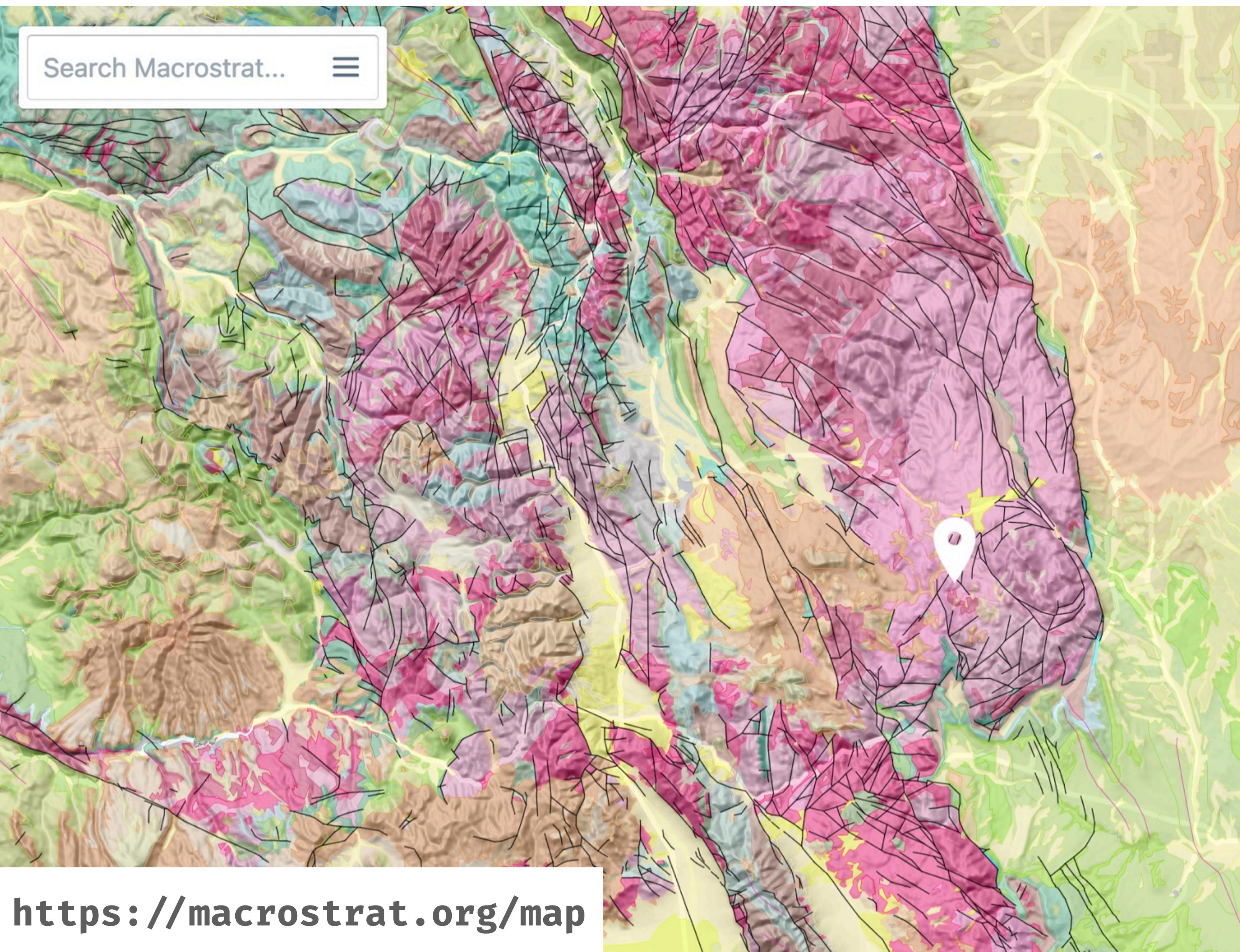
A flexible system for integrating/representing station-based data

Structural data from StraboSpot



Integrating contextual data from the geologic literature

Established capability



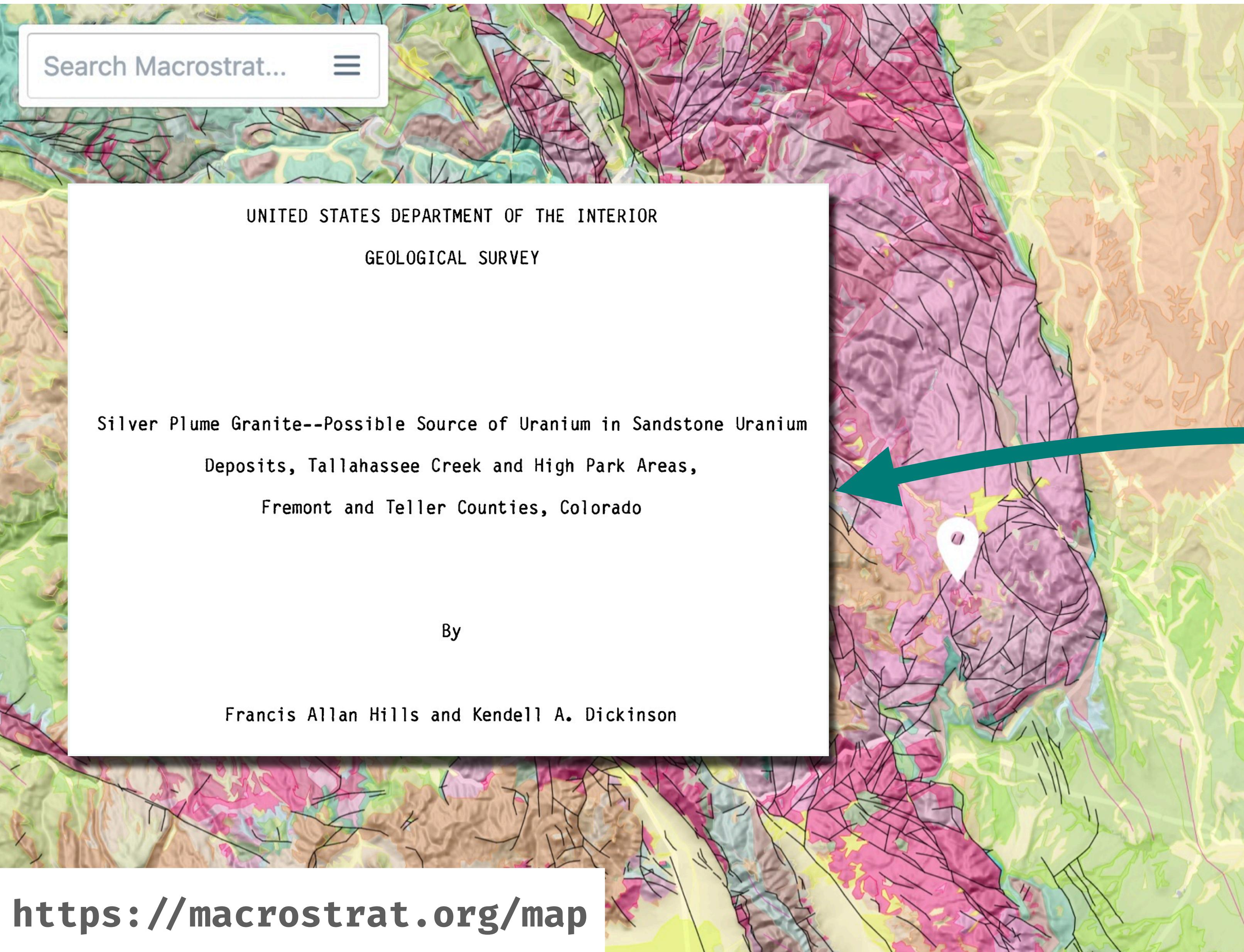
-105.2245, 38.7848 2737m | 8980ft X

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

Location: -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

Young, E. J., [Basic-rationals and use of the Laramide upthrust](#)

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

Finch, Warren Irving, [Uranium in the Tertiary volcanic rocks of the Rocky Mountains](#)

Braddock, William A., [Uranium in the Tertiary volcanic rocks of the Rocky Mountains](#)

Snyder, George L., [Uranium in the Tertiary volcanic rocks of the Rocky 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



108,486 added this month

25,112 added this week

3,683 added in the last 24 hours



SEPM



108,486 added this month

25,112 added this week

3,683 added in the last 24 hours

<https://xdd.wisc.edu>

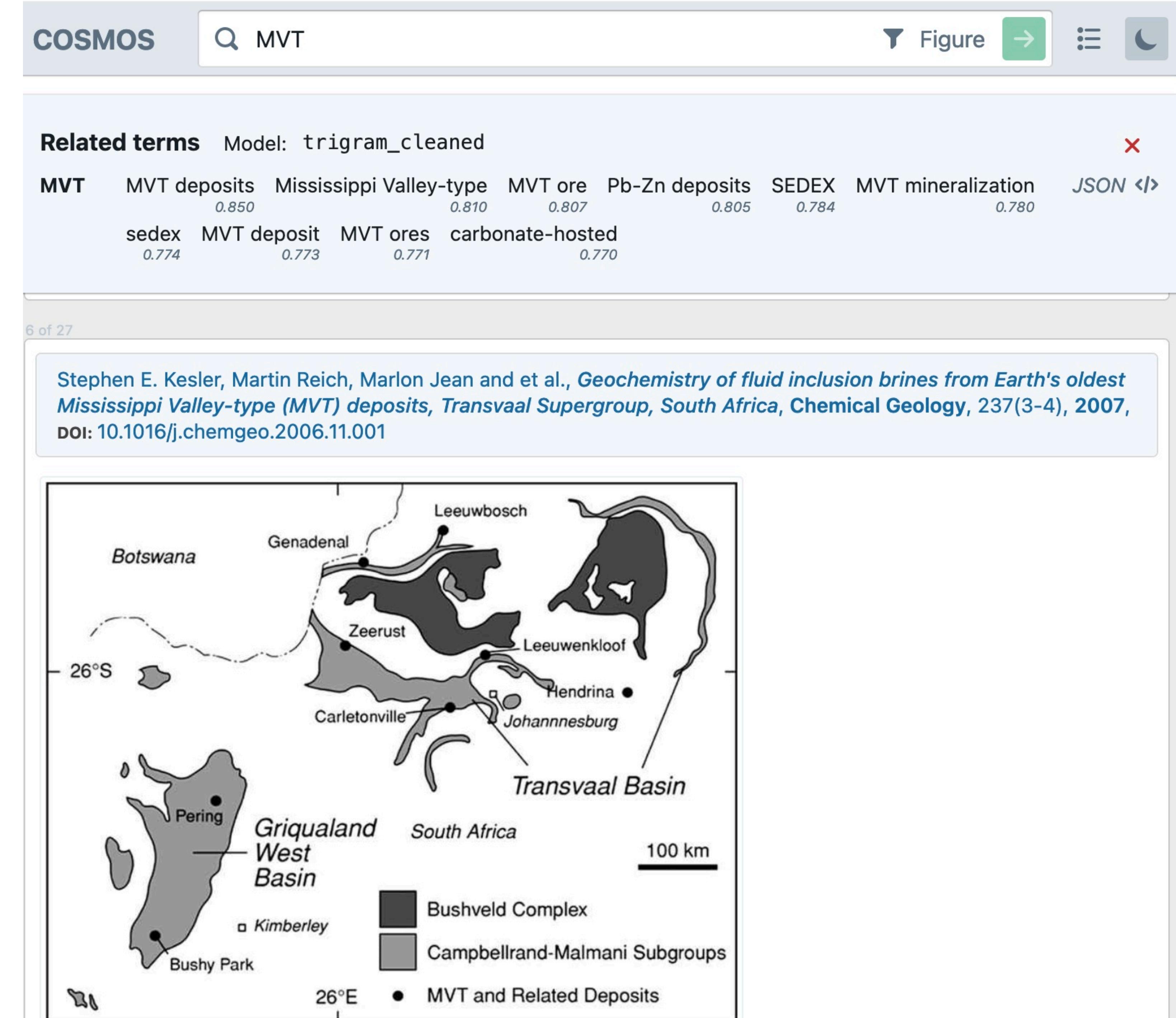
Established capability

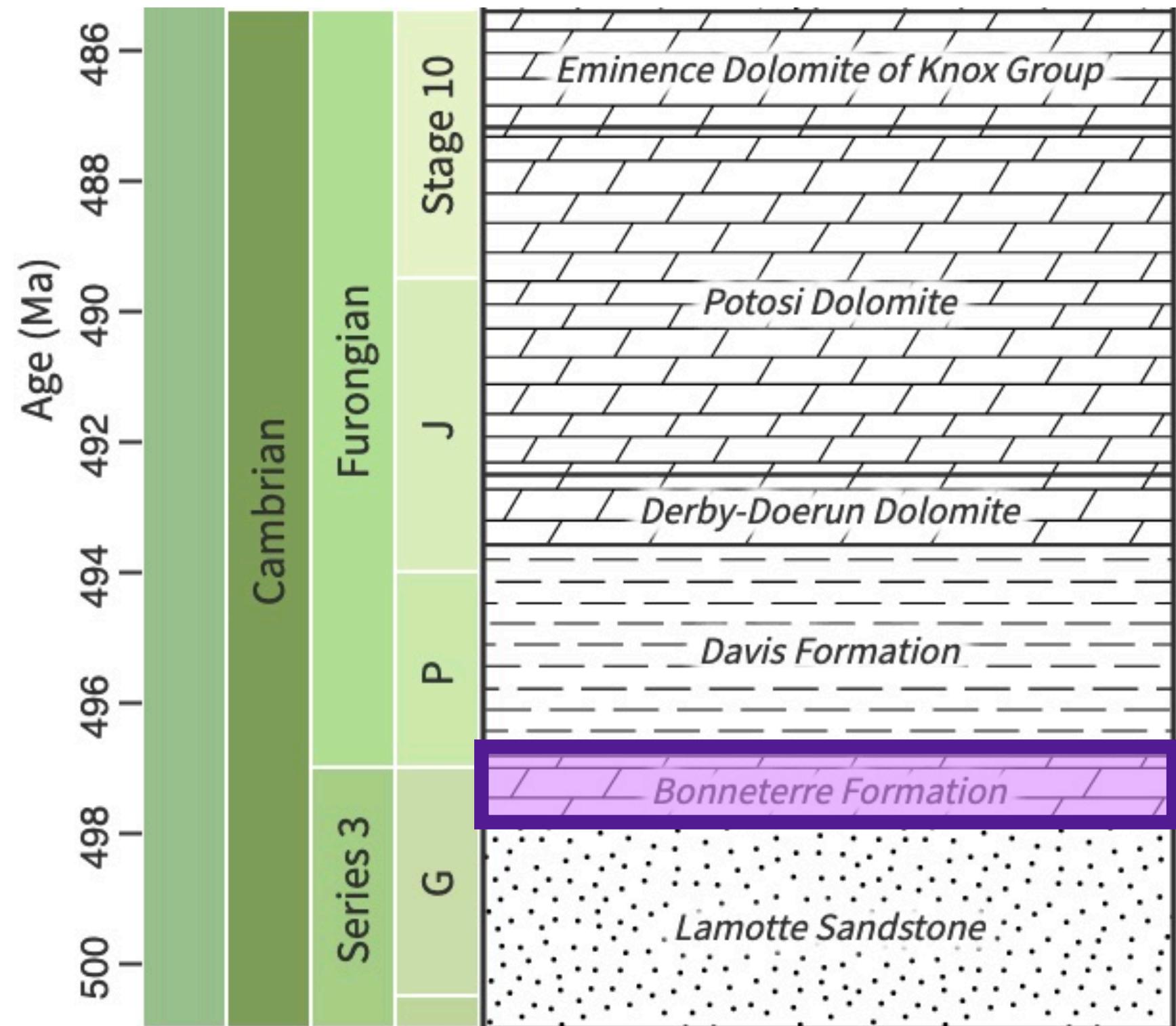
Surface relevant information from the geologic literature

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





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

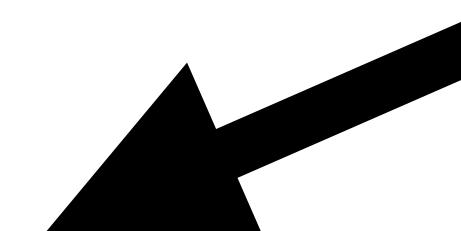
Improve the quality of structured geological information by “canonicalizing” literature mentions

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

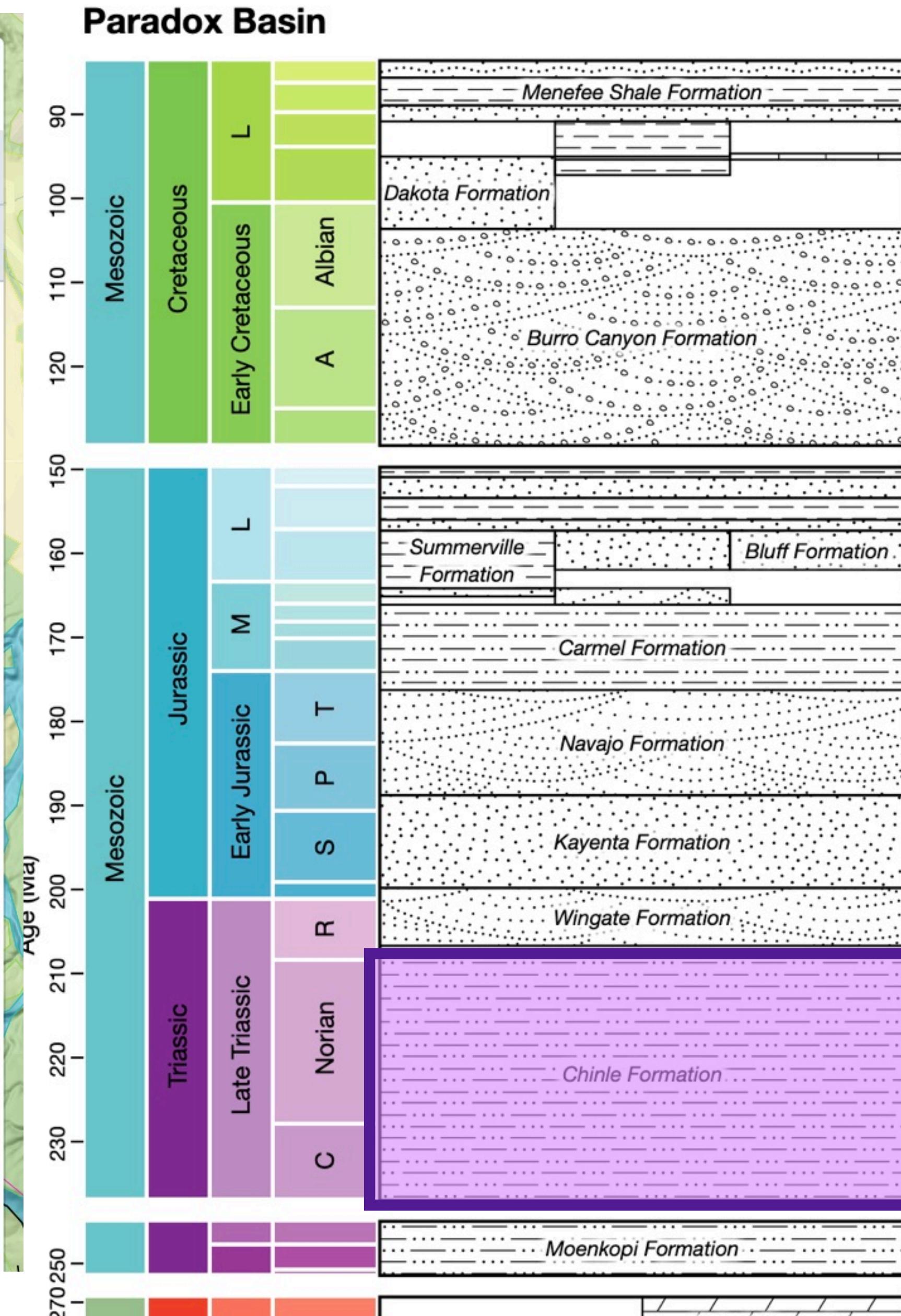
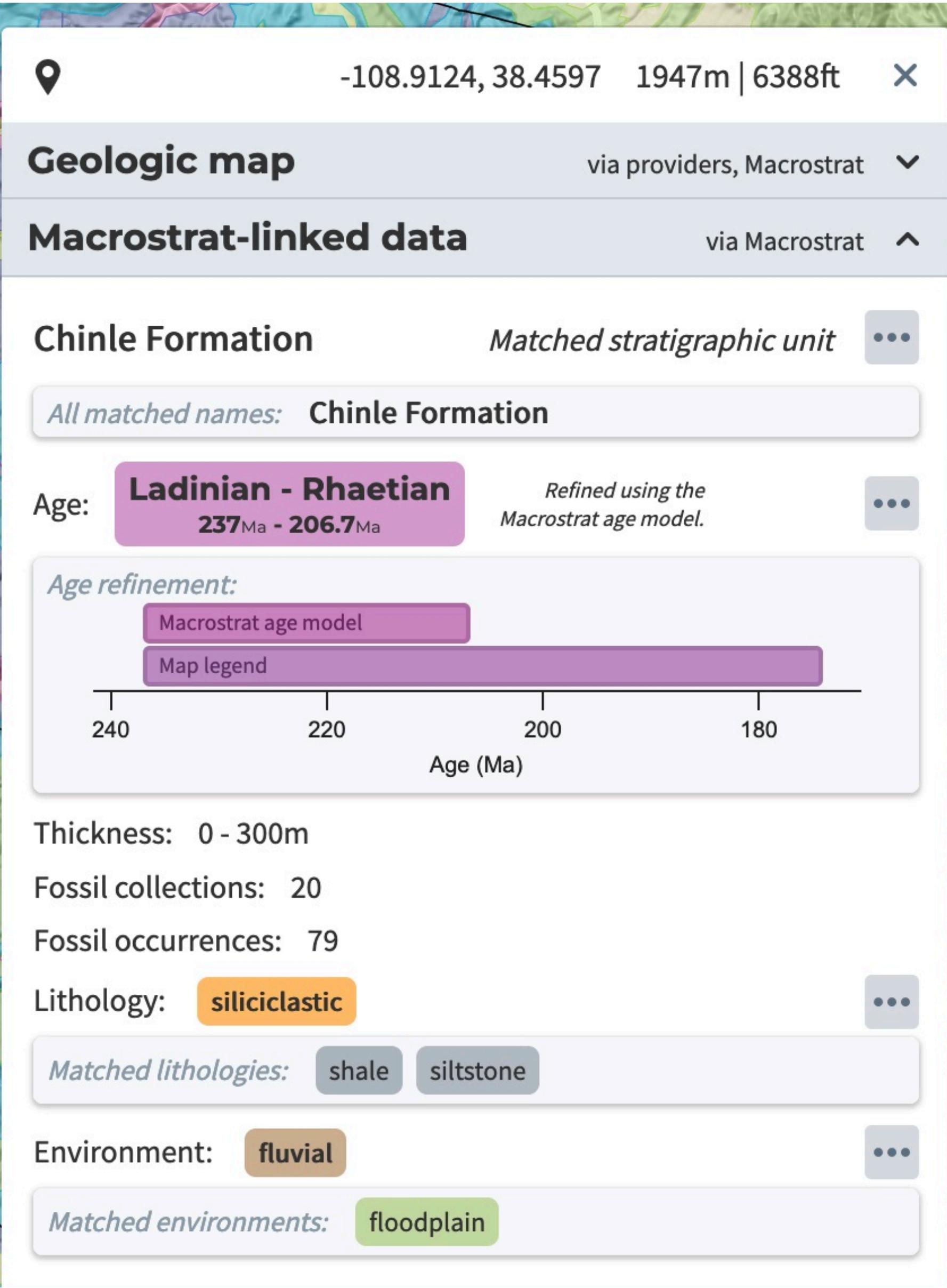
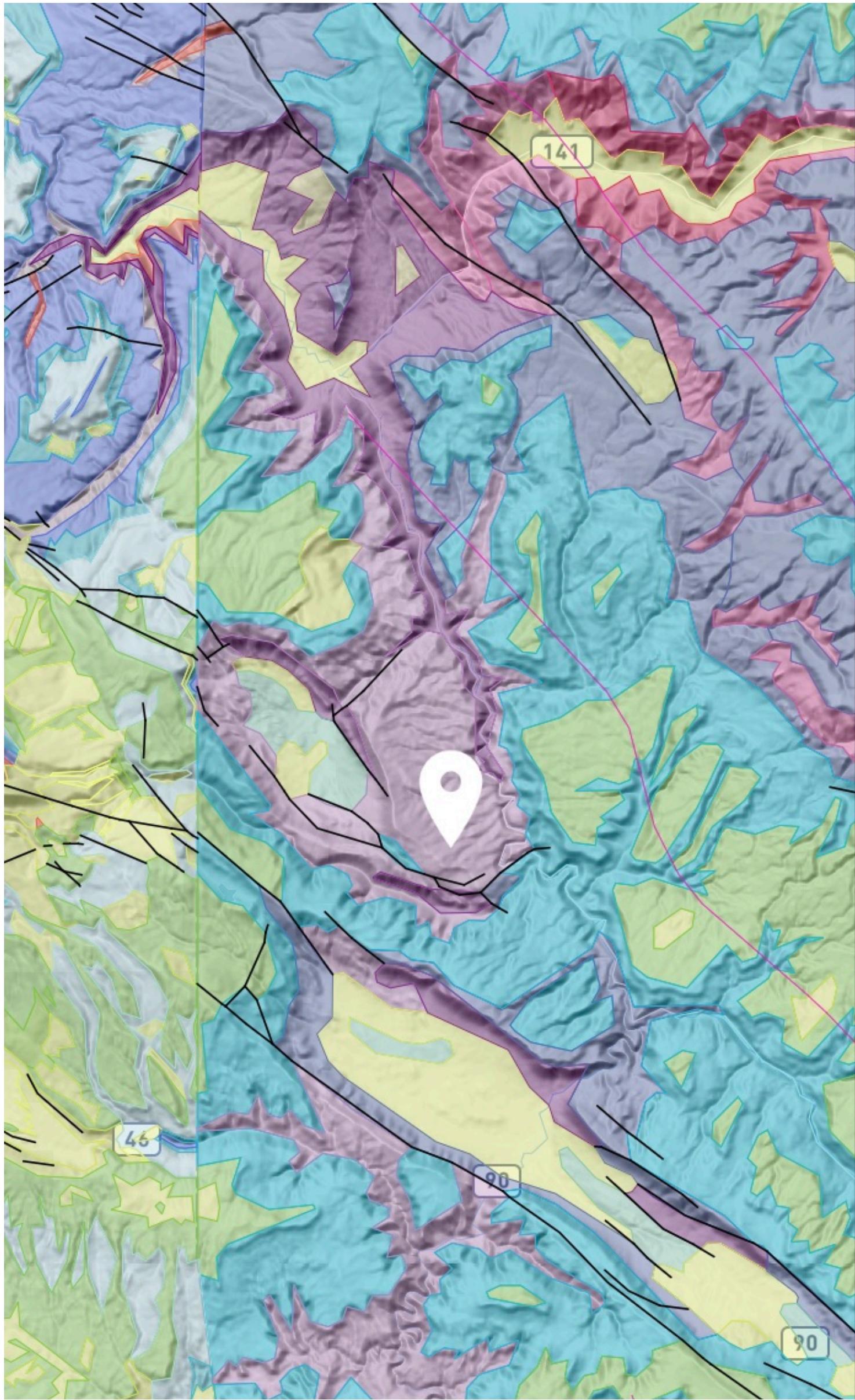
1972). The **backreef** or **nearshore** facies consists of interbedded planar **stromatolites** and mudstones, probably representative of **lagoonal**, **high intertidal**, and **supratidal** environments

(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

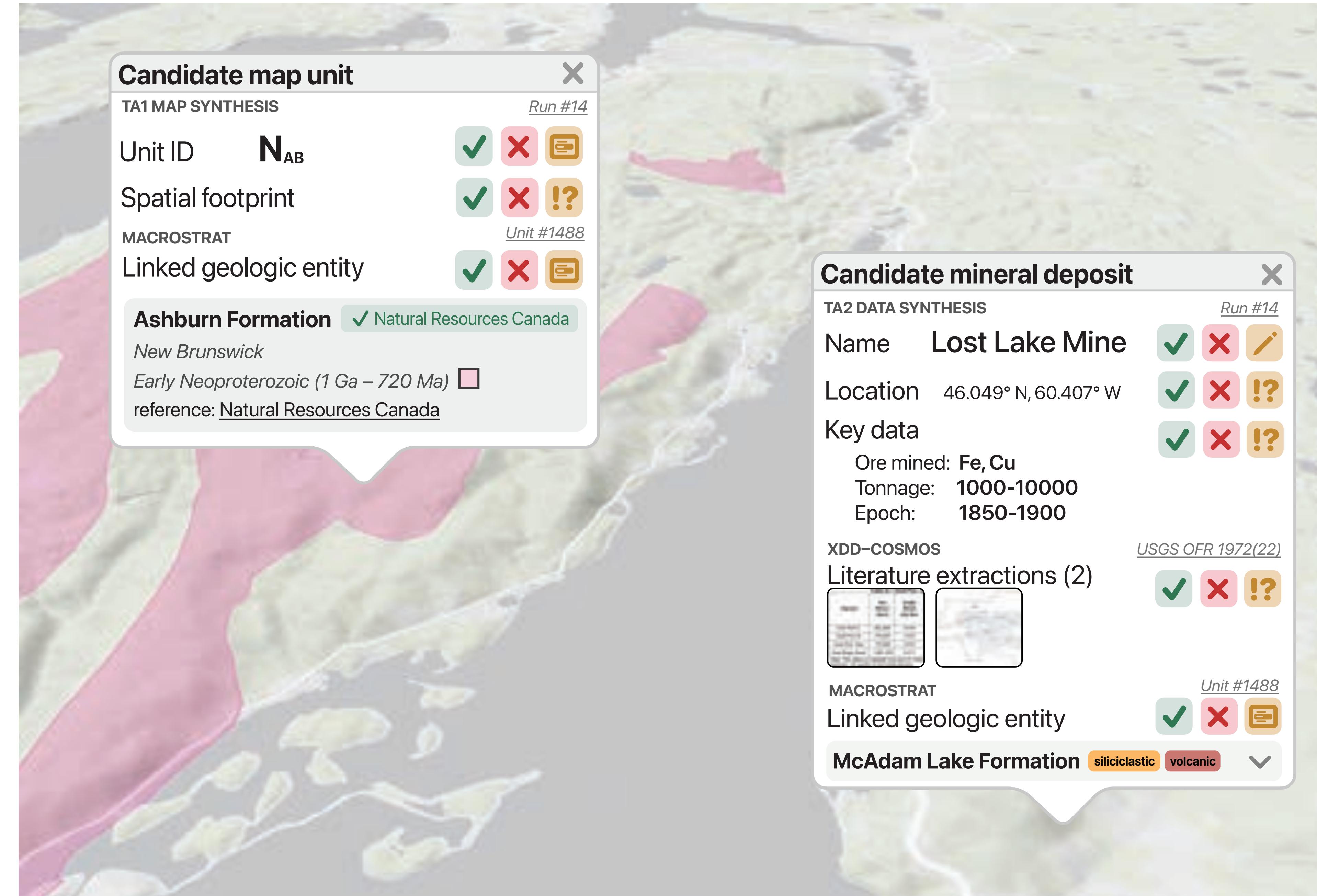


Map assessment widgets

for evaluation of
TA1-3 outputs in
geologic context

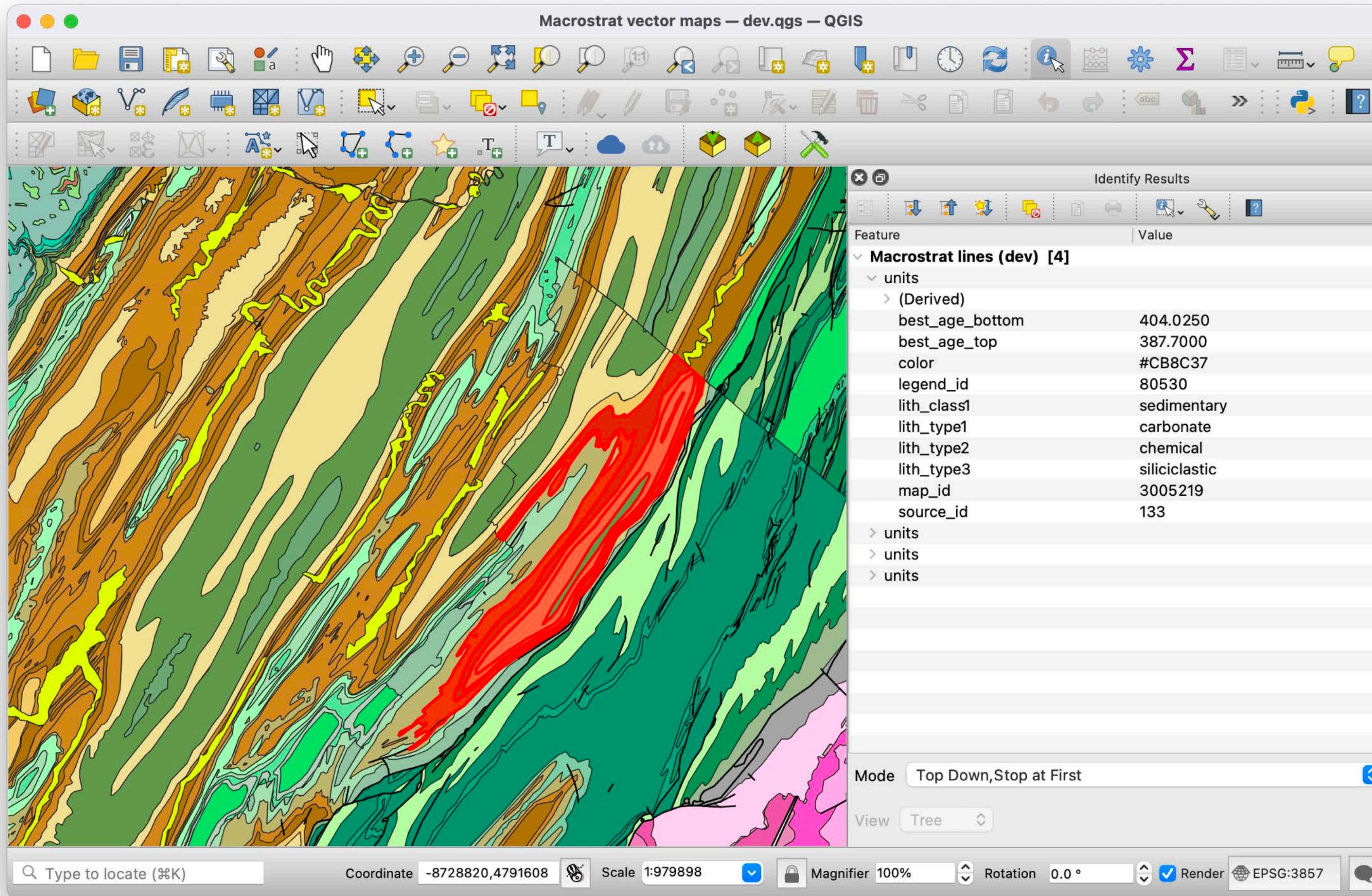
Will sit within
Macrostrat web
interface and benefit
from context

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

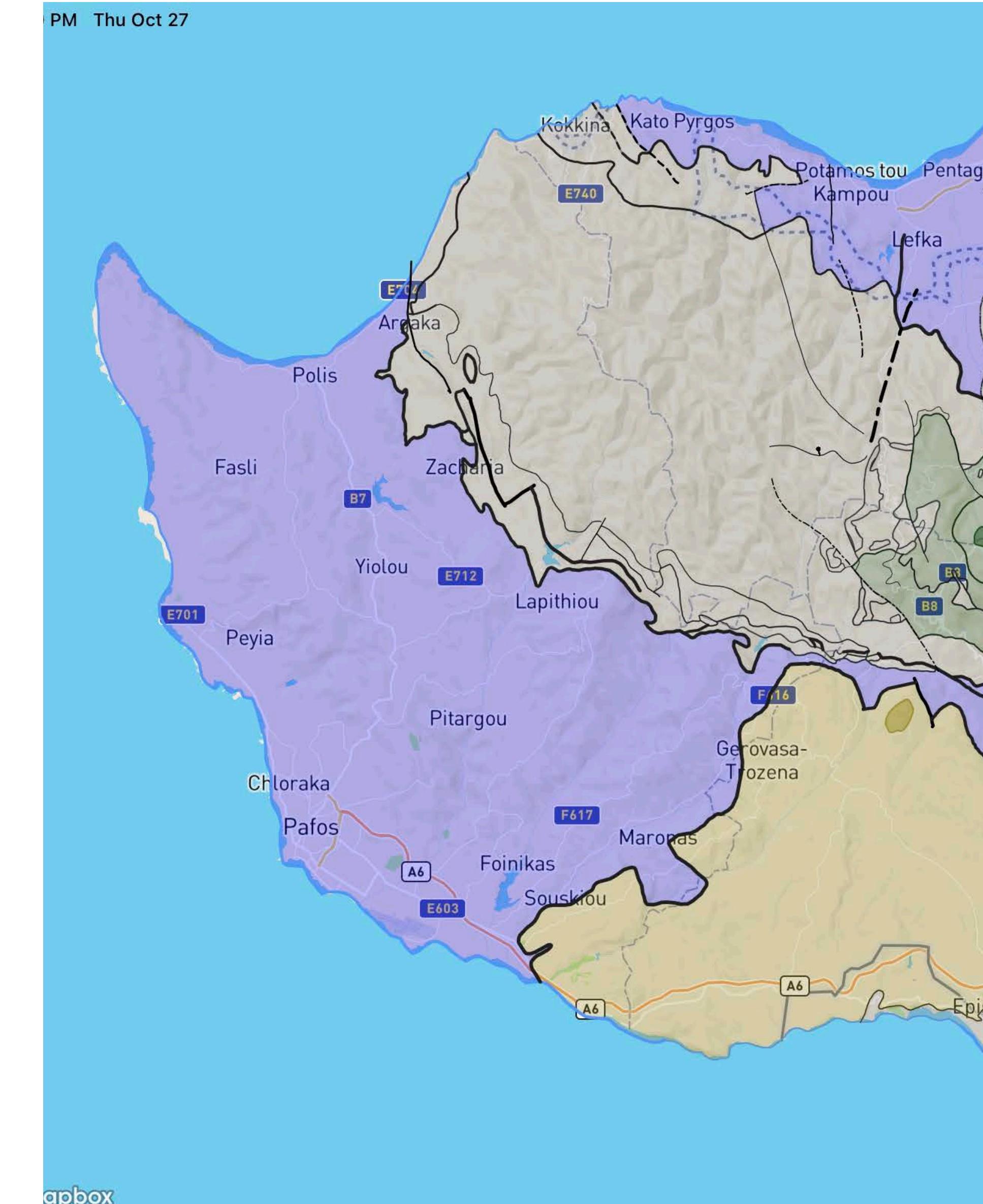
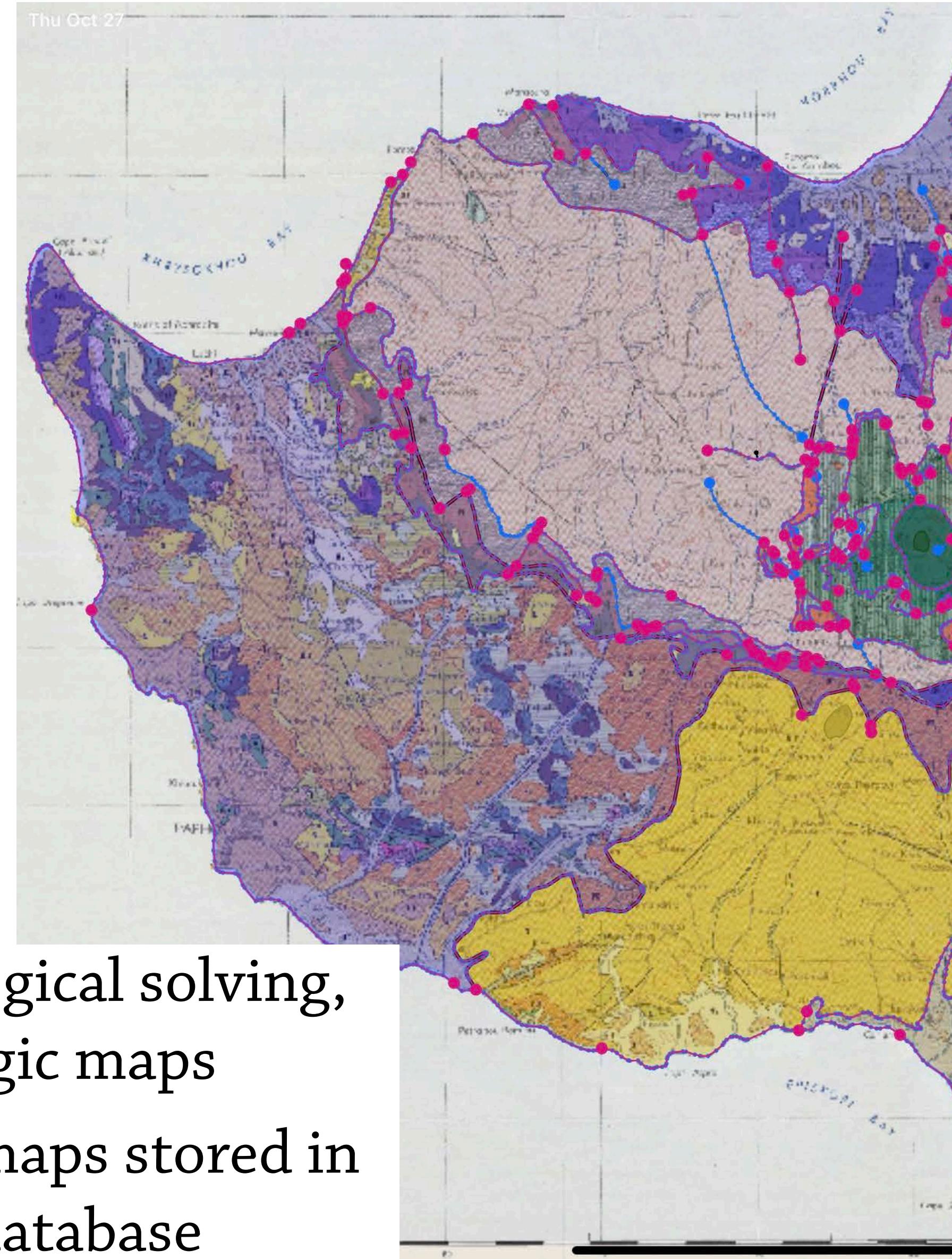


Integrate with
Mapboard GIS
iPad app

<https://mapboard-gis.app>

Planned

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



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

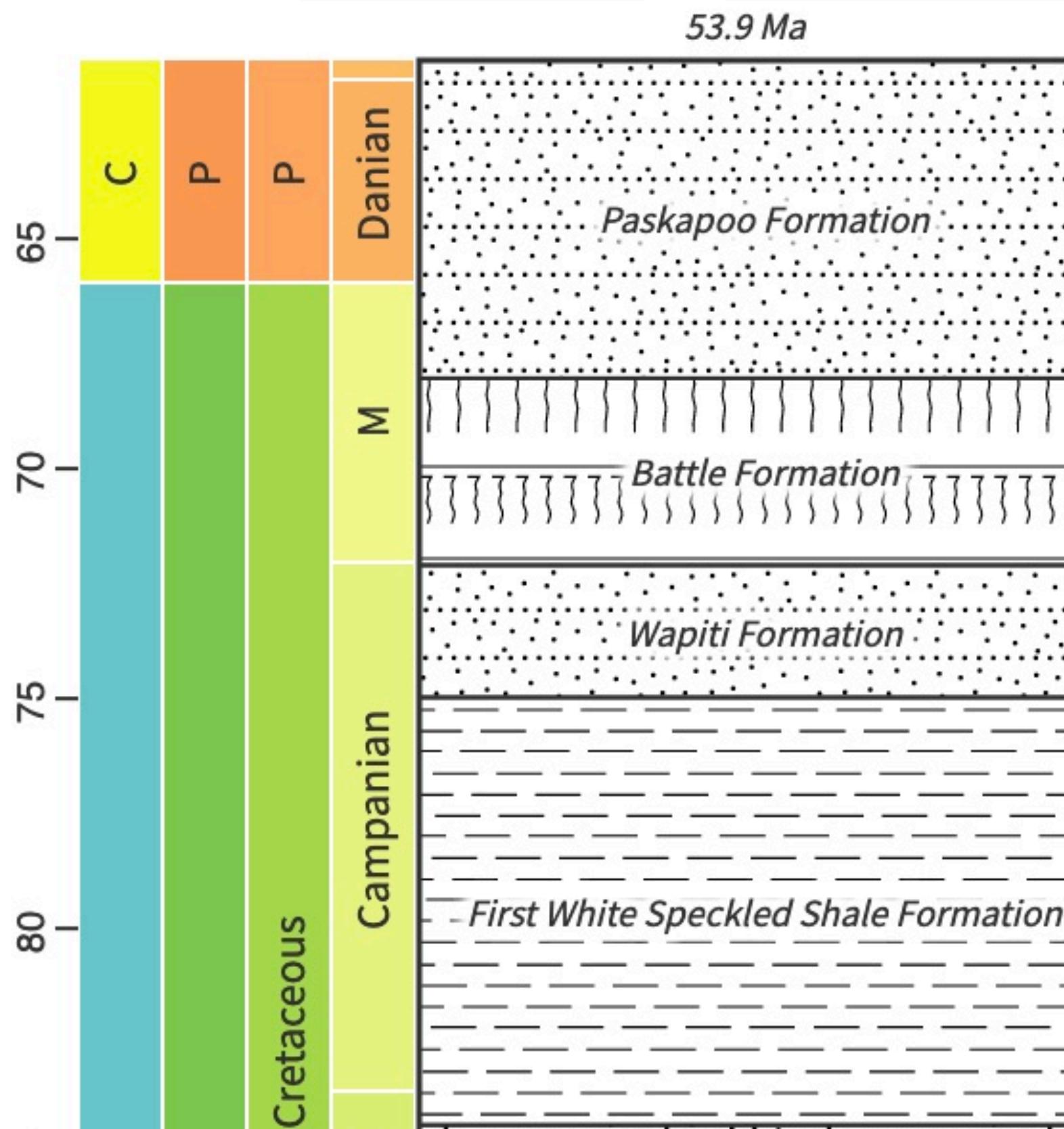
Allows correction of the time-stratigraphic component of geologic maps

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

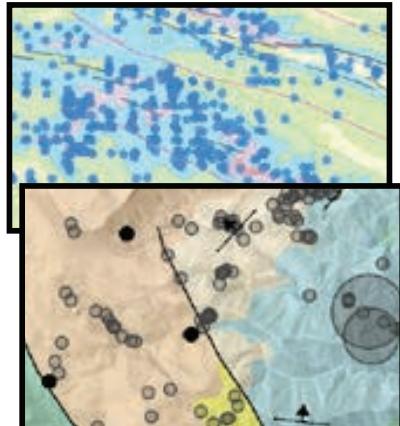
ID	Strat Name	Liths	Envs	Interval	Thickness
37332	Paskapoo Fm	S... SANDSTONE C...	non-marine	Maastrichtian - Paleocene	30
37331	Battle Fm	CLAY	non-marine	Maastrichtian	3
37330	Wapiti Fm	S... SANDSTONE C...	non-marine	Campanian - Maastrichtian	350
37329	First White Speckled Shale Fm	SHALE	inferred marine	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?

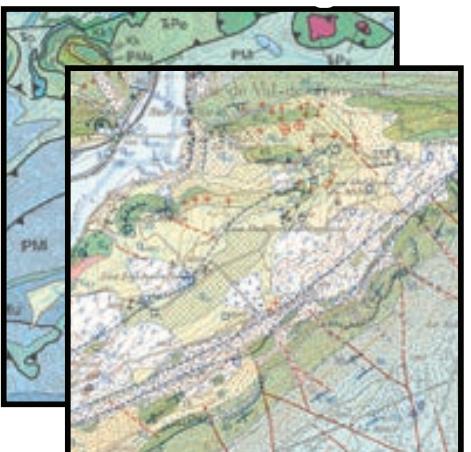
New data sources



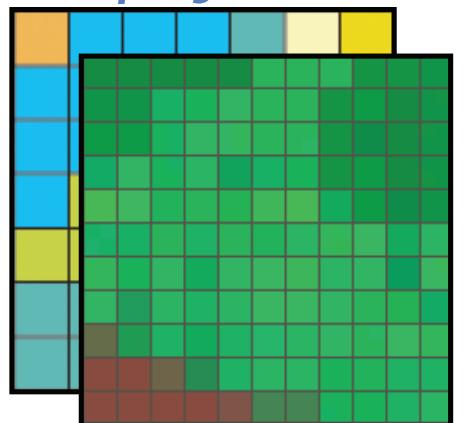
Measurements



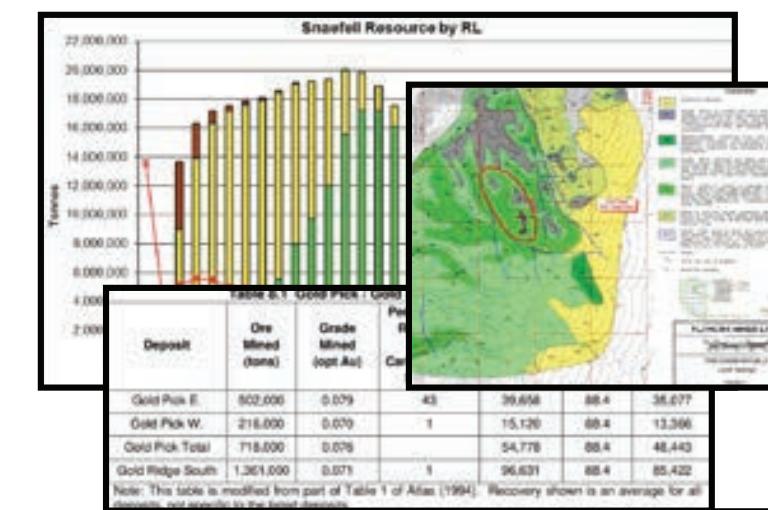
Raster maps



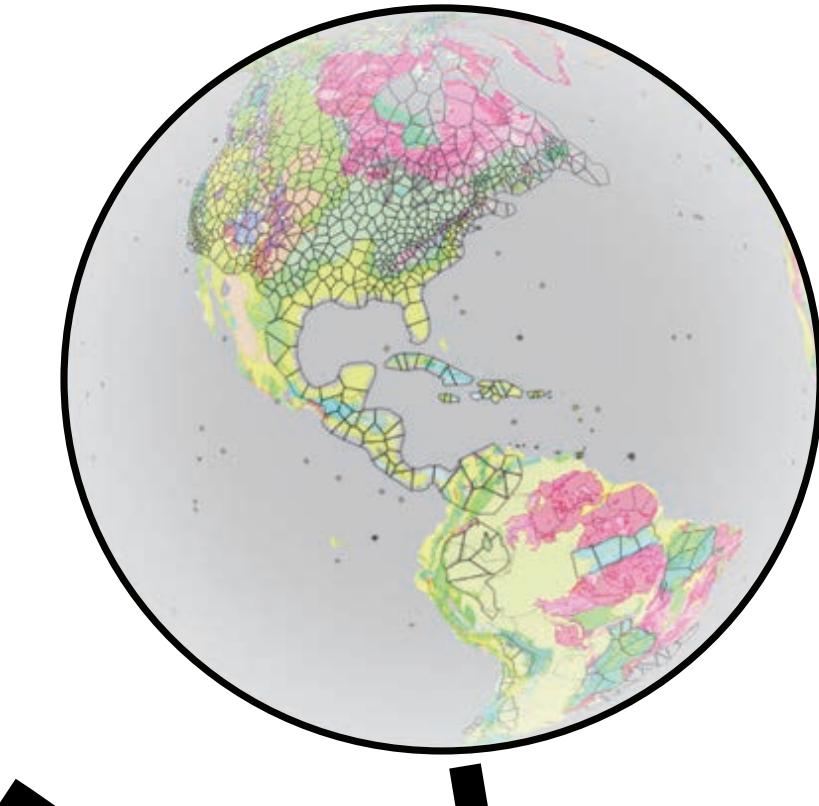
Geophysics



Literature extractions



Macrostrat



PostGIS relational geodatabase

Macrostrat software platform

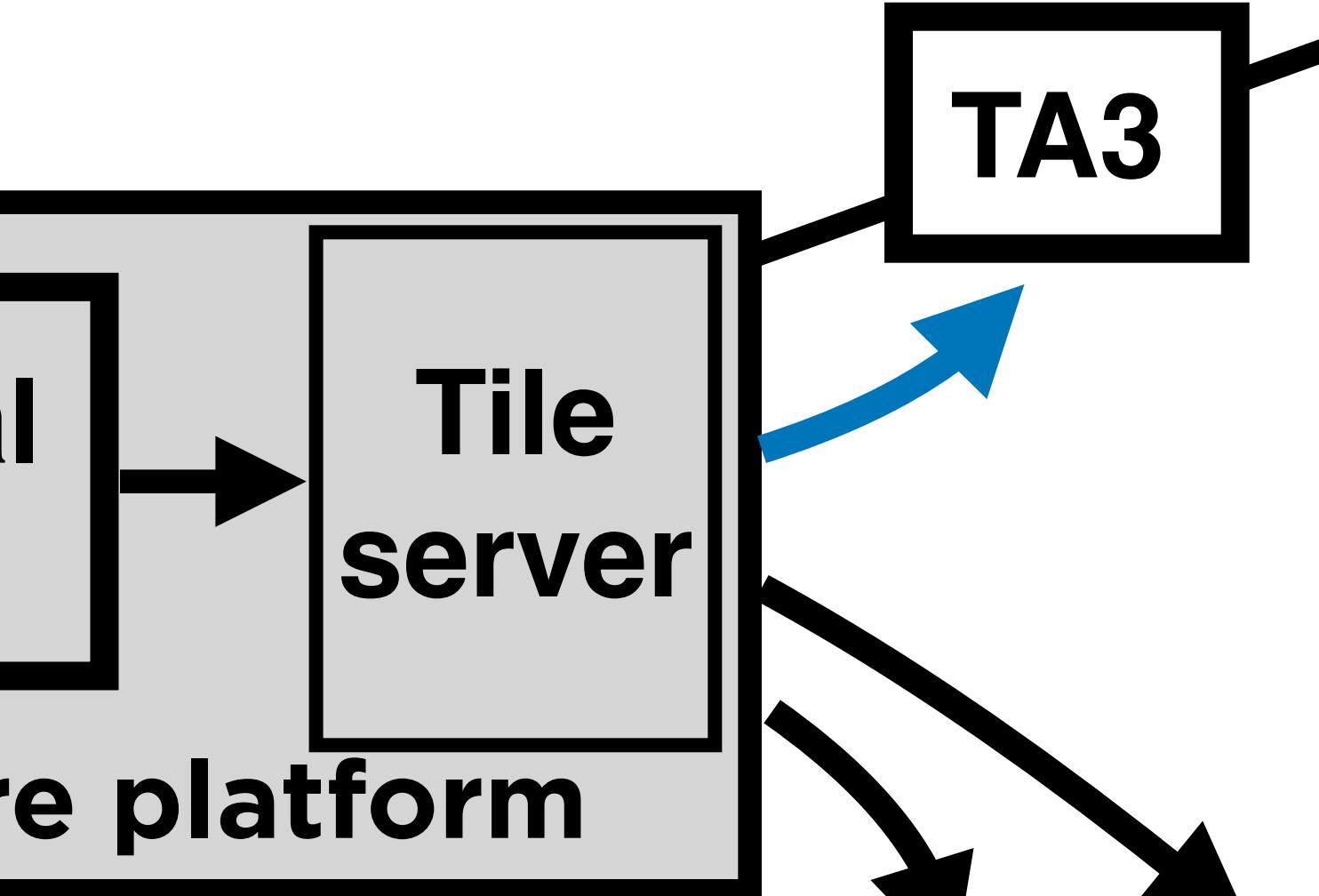
Ingestion + harmonization

~~Partially automated~~

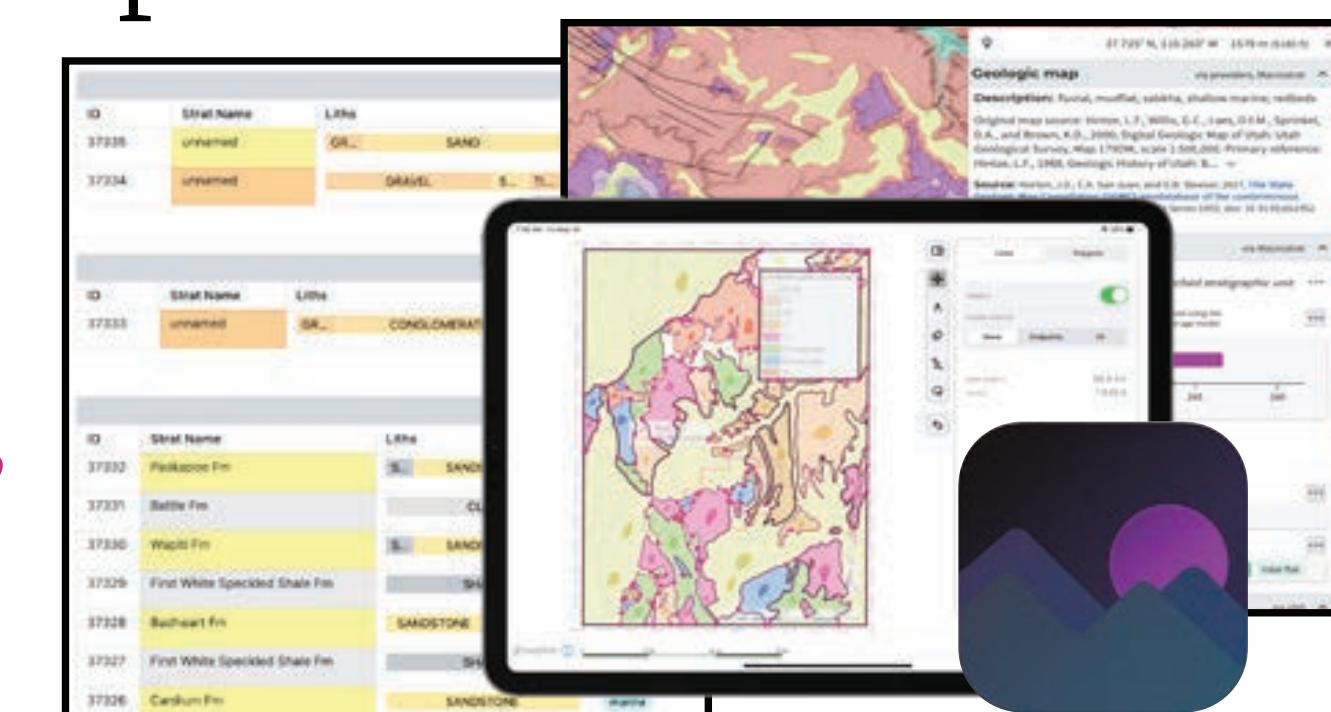
Fully automated

Feedback

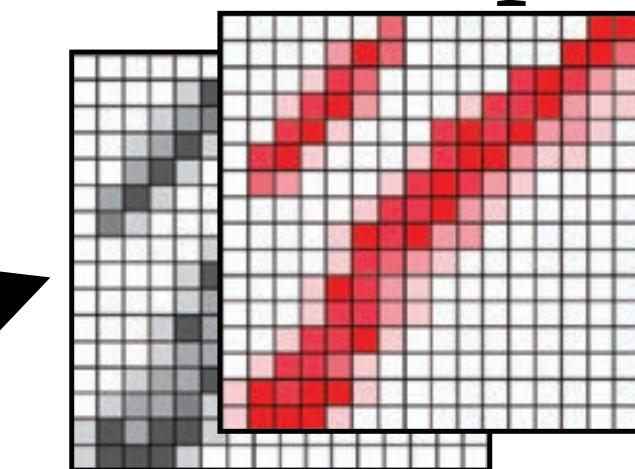
“Human in the loop”



Expert feedback interfaces



Predictive mineral maps



GIS platforms

