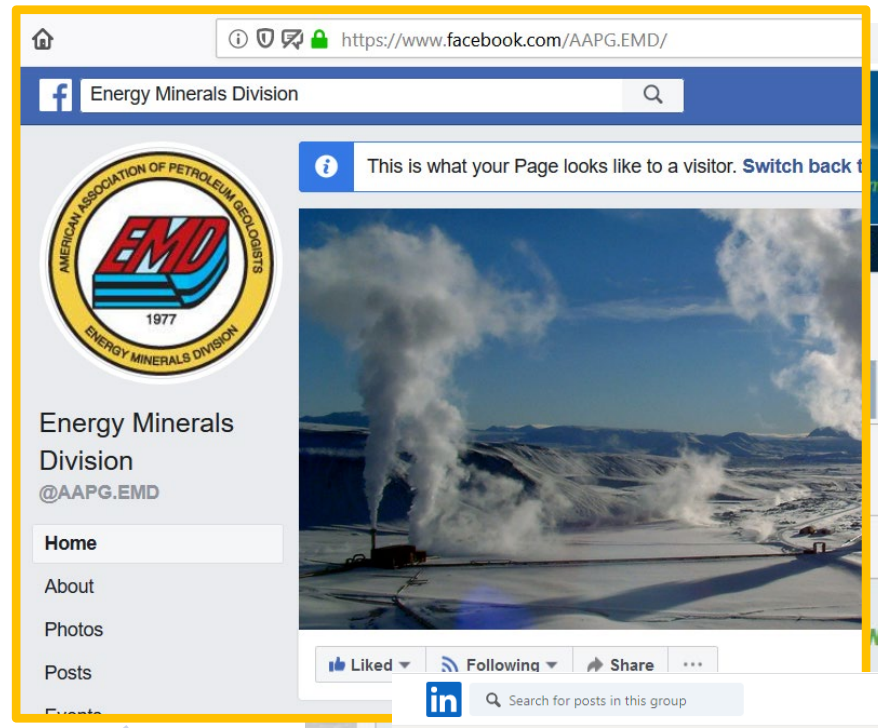
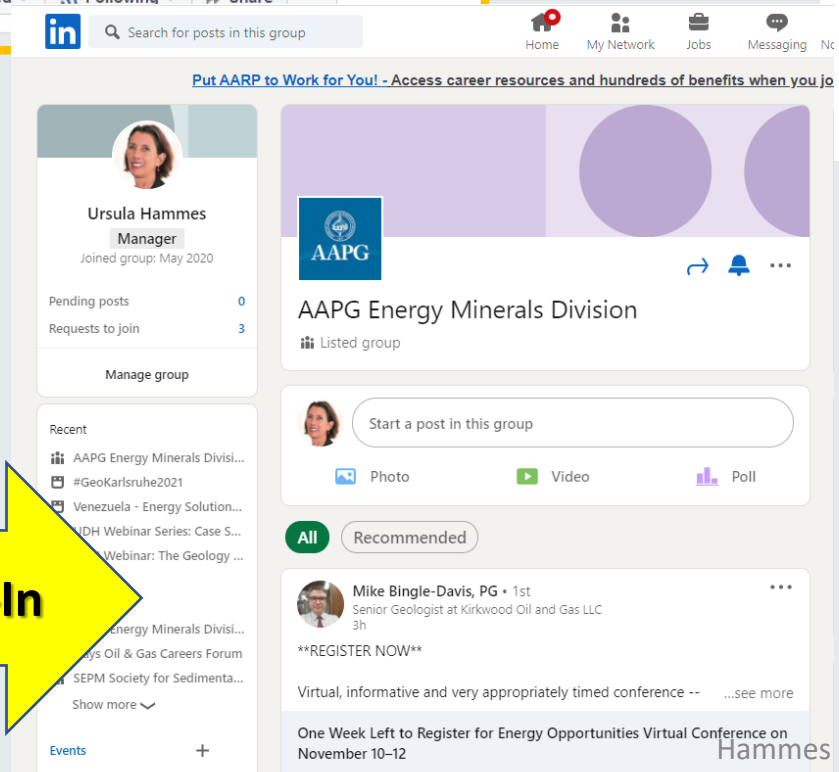
At EMD, we focus on opportunities outside of the traditional oil field to provide efficient and economic energy to the world. We provide a forum for keeping abreast of the latest developments in geology and technology related to critical minerals and rare earth elements for battery storage, geothermal, hydrates, hydrogen, uranium for nuclear generation, new technology in oil and gas shales and tight reservoirs, bitumen, and coal/coal-bed methane. EMD works in concert with the Division of Environmental Geosciences to serve energy resource and environmental geoscientists.

AAPG

Energy Minerals Division



EMD Facebook



EMD Linked-In

EMD Committees
EMD Reports
EMD Honors and Awards
EMD-Related Articles
EMD Newsletter
EMD Events
EMD Publications & Store Products
EMD Resources
EMD Blog

Headquarters Contacts

EMD YouTube Channel

Non-carbon alternative energies

- Critical minerals and RRE
- Uranium
- Geothermal
- Hydrogen (green, blue-CCUS)

Critical Minerals and REE

Committee Chair: Ashley Douds, Wildlands Research

Critical minerals (elements) vital to aerospace/defense and energy storage technologies like rare earth elements, graphite, lithium, cobalt, and vanadium. Our committee is interested in the professional opportunities this emerging industry presents to our organization, specially those related to the rapidly growing green energy market.

Spodumene (Lithium) (Image from USGS)

Cobalt (Image from USGS)

Uranium

Committee Chair: tbd

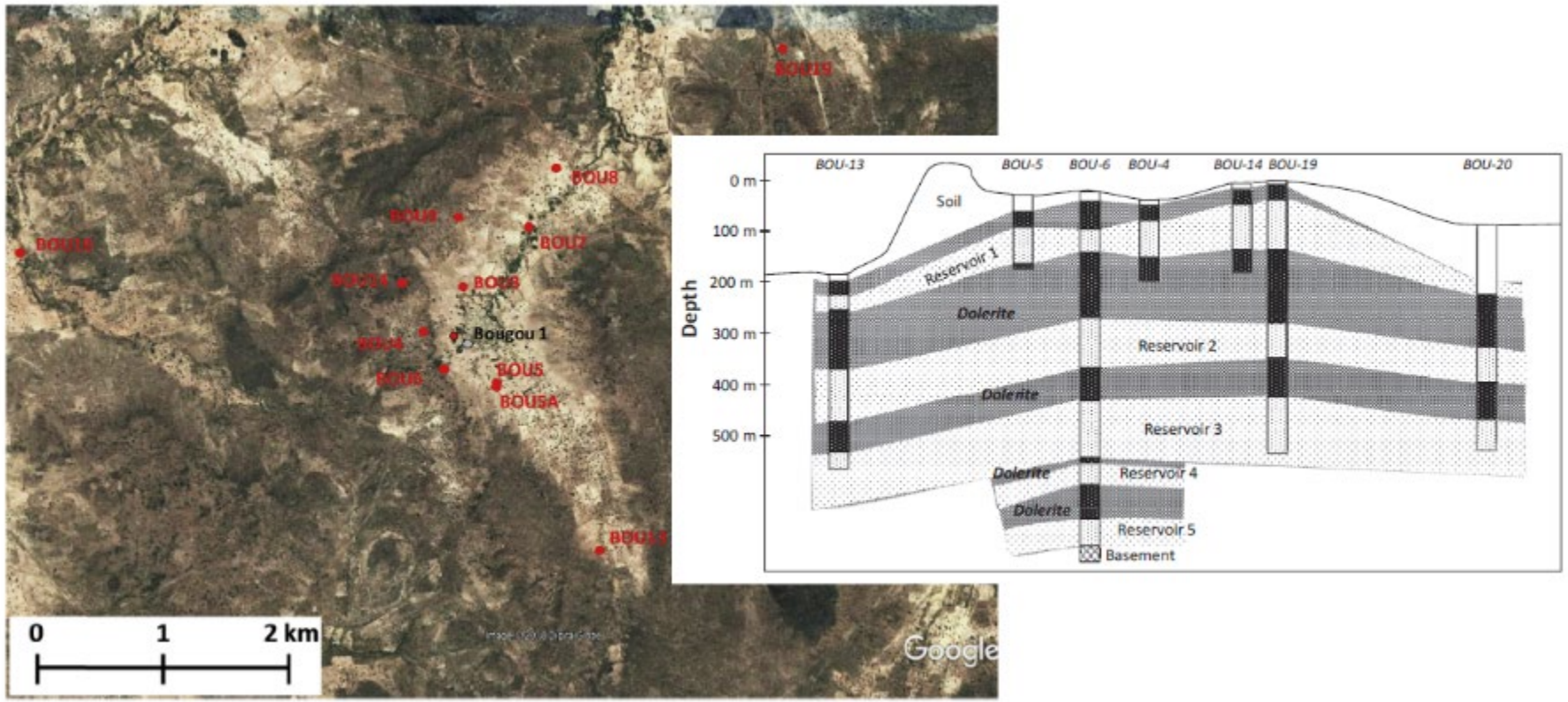
Geothermal energy

Committee Chair: **Bruce Cutright, Thermal EP**

Hydrogen

Committee chair: Geoff Ellis, USGS

Discovery of >97% hydrogen in shallow gas field in Mali, W. Africa (Prinzhofer et al., 2018)



Other EMD Committees

Heavy oil/bitumen (Ian Kirkland, Sproule)

Coal/Coalbed Methane (Bill Ambrose, BEG)

Gas Hydrates (Tim Collett, USGS)

Tight Oil and Gas (Lucy Ko, BEG)

“…the world is overrun by cheap and plentiful clean energy… how do we adapt?”

- Dan Frey, THG Energy Solutions, 2017

DEVELOPING A WORKFLOW TO QUANTIFY CRITICAL MINERAL CONTENT IN FINE-GRAINED SEDIMENTS:

CASE STUDY OF THE DUNKIRK SHALE EXPOSED ALONG THE LAKE ERIE SHORELINE

WILDLANDS RESEARCH

ASHLEY SB DOUDS DAVID R BLOOD SCOTT D MCCALLUM

OU CRITICAL MINERALS WORKSHOP

NOVEMBER 10, 2021

ACKNOWLEDGEMENTS

CHEMOSTRAT

DATA • ANALYSIS • SOLUTIONS

AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
EMD
1977
ENERGY MINERALS DIVISION

Shaw BACKPACK Drill

CGS MULE
COMPLETE GEOLOGICAL SUPPLIES

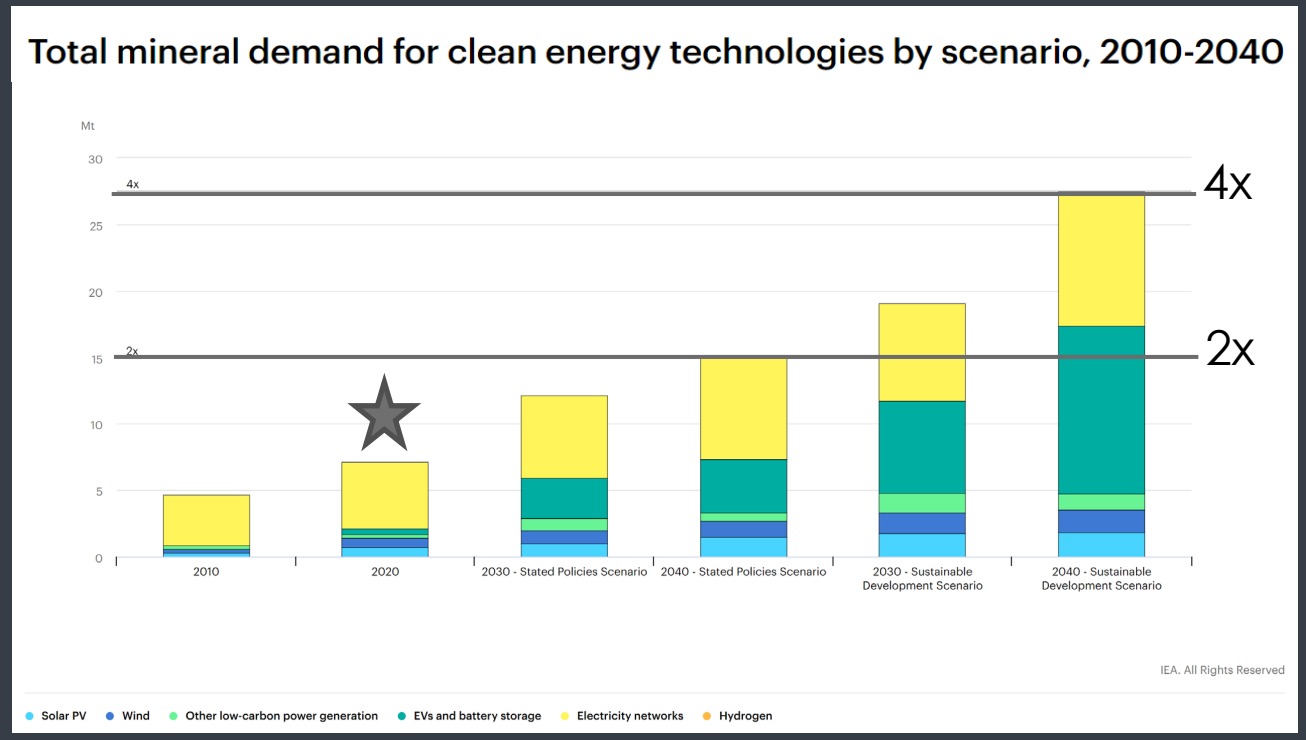
USGS
science for a changing world

OUTLINE

- Why we're doing it
- What data are available
- How we are tackling the project
- What we know right now
- The path forward

CM-REE AND SEDIMENTARY DEPOSITS

The Role of Critical Minerals in Clean Energy Transitions, International Energy Agency (IEA)



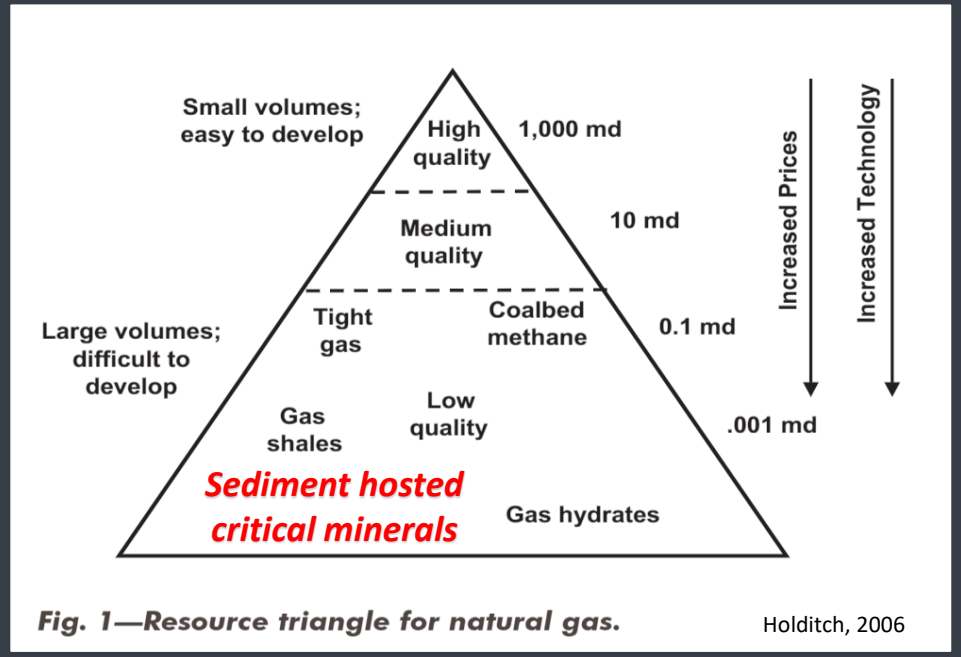


Fig. 1—Resource triangle for natural gas. Holditch, 2006

- PROJECTIONS OF CM-REE SUPPLY NEEDED FOR THE ENERGY TRANSITION ARE DIFFICULT TO ATTAIN WITH EXISTING KNOWN SUPPLIES
- THE HIGH-QUALITY DEPOSITS IN HARD ROCKS HAVE BEEN FOUND
- MORE EMPHASIS IS BEING PLACED ON CMS HOSTED IN SEDIMENTARY ROCKS

* Based on 7000' lateral and 8.75" whole with an average density of 2.5 gm/cc

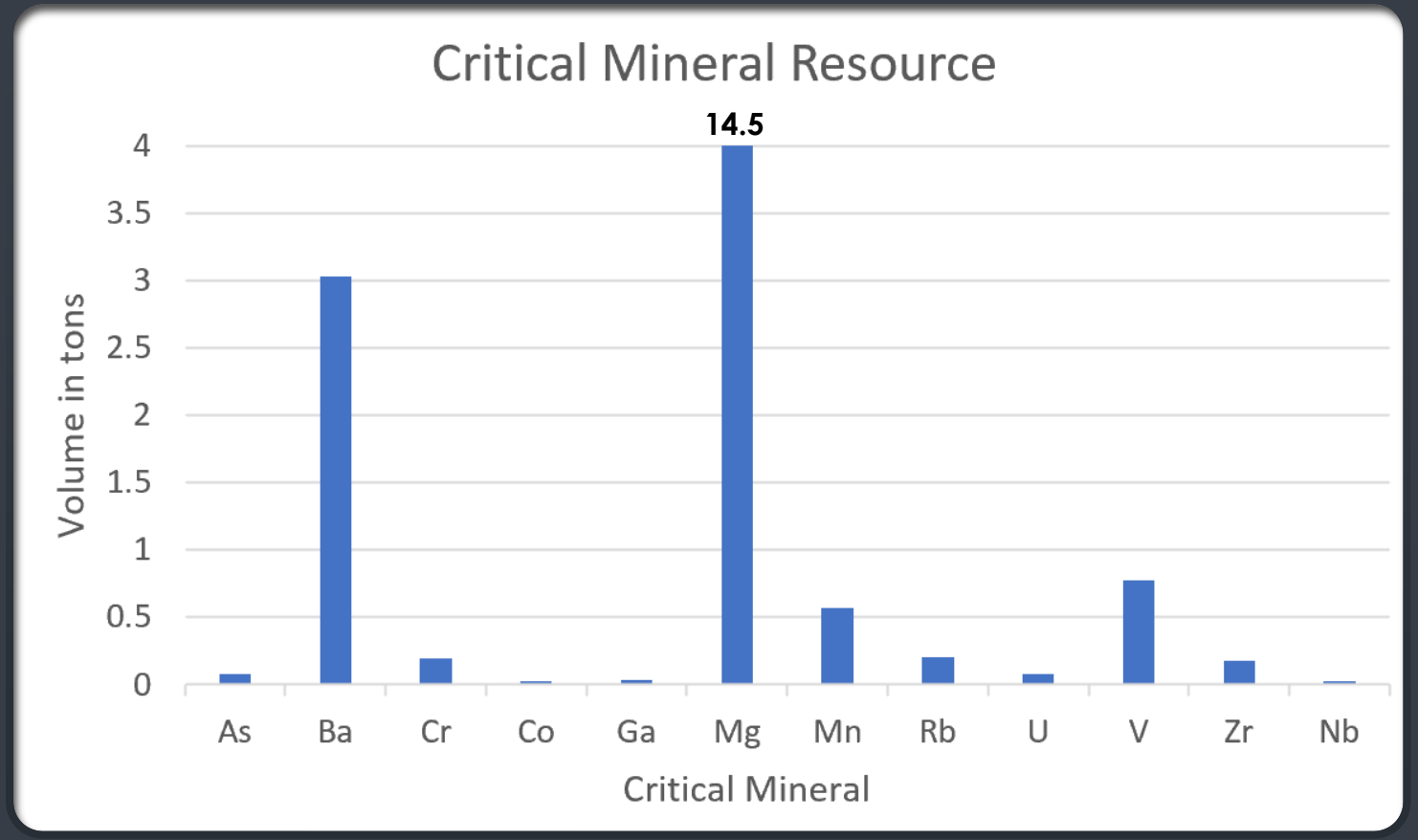
THE INDUSTRY IS ALREADY "MINING"

- IN THE PROCESS OF DRILLING OIL AND GAS SHALE WELLS, AN AVERAGE OF 228 TONS OF CUTTINGS ARE GENERATED PER LATERAL.*
- ON A 10 WELL PAD OF 7000' LATERALS , THIS EQUALS NEARLY 1,000 TONS OF 'MINED' CUTTINGS

THESE BLACK SHALES, HISTORICALLY REFERRED TO AS

METALLIFEROUS BLACK SHALES

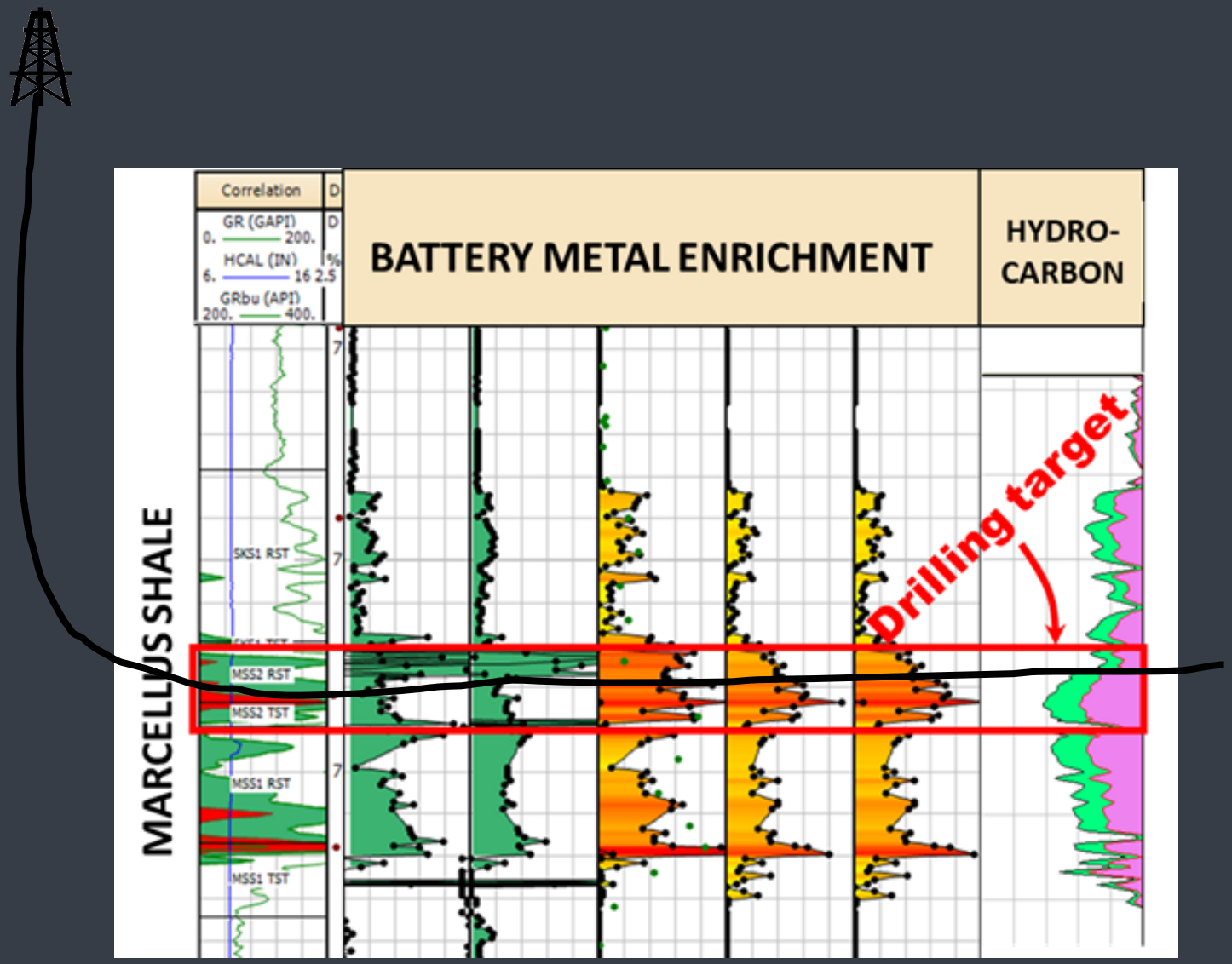
IN THE LITERATURE, CONTAIN METALS NEEDED FOR ENERGY STORAGE USING BATTERIES.



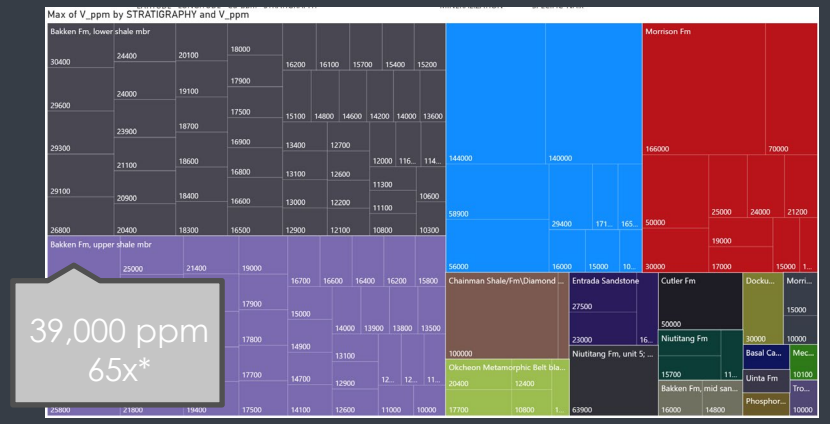
*example critical mineral content using values from Beaver Meadows Marcellus core
And 10 well pad estimate from previous page

OFTEN, THE DRILLING TARGET IS DEFINED BY HYDROCARBON SATURATION, ORGANIC CONTENT, AND FAVORABLE POROSITY

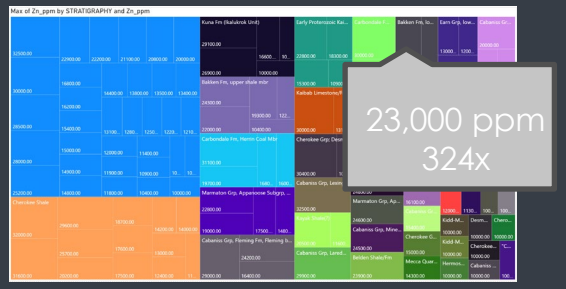
THESE RESERVOIR TRAITS ARE CO-LOCATED WITH ENRICHED BATTERY METAL CONTENT



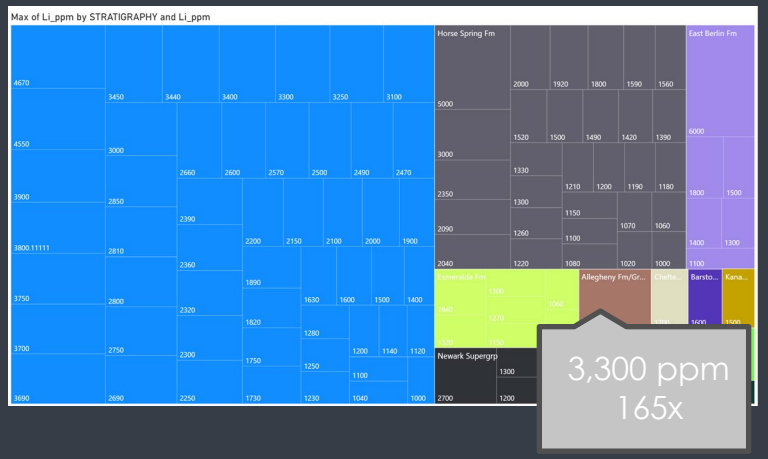
Vanadium



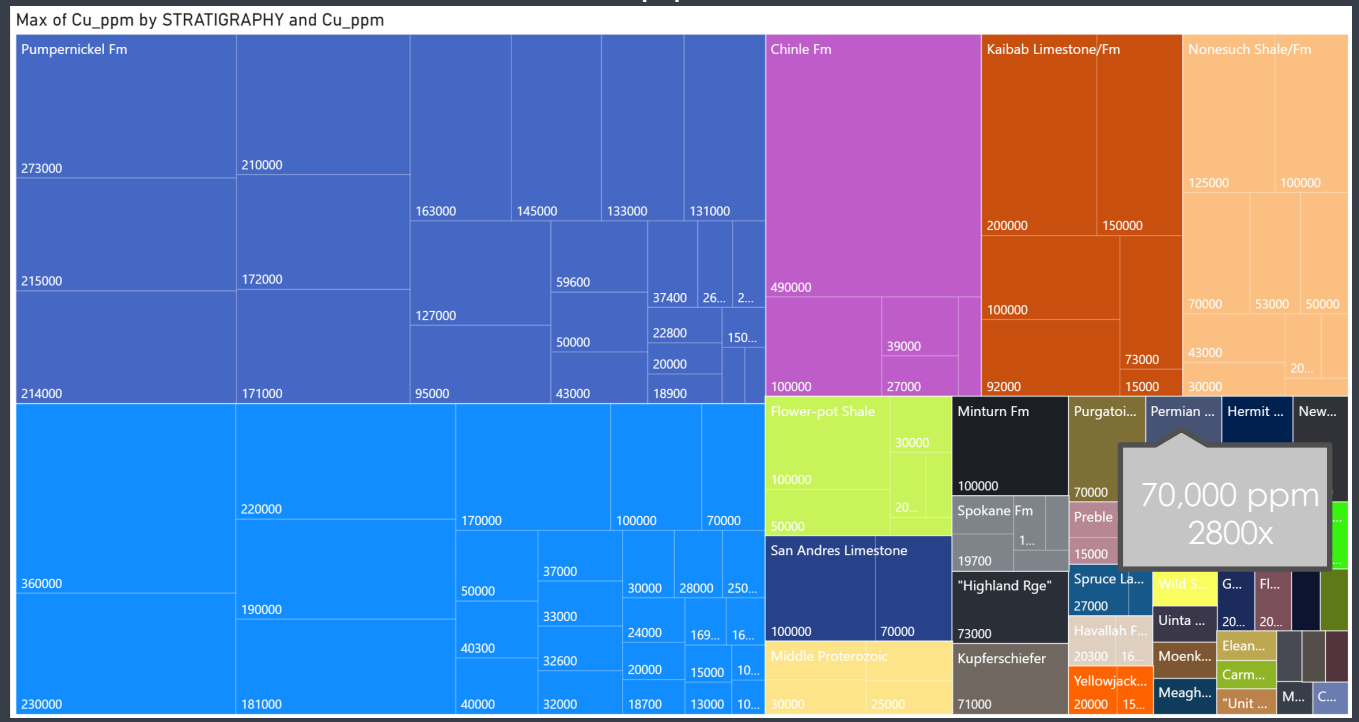
Zinc



Lithium

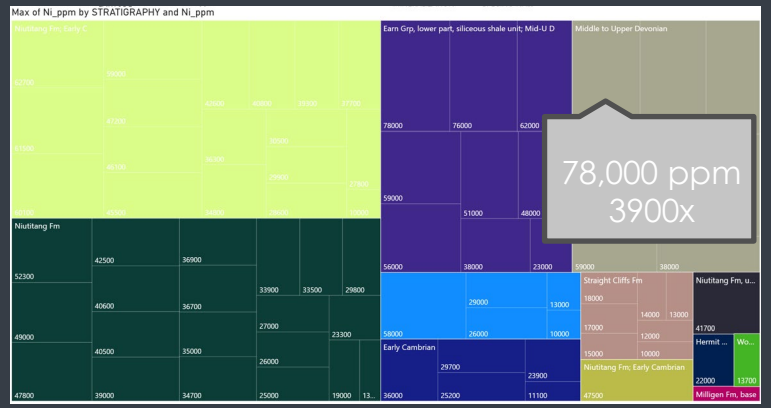


Copper



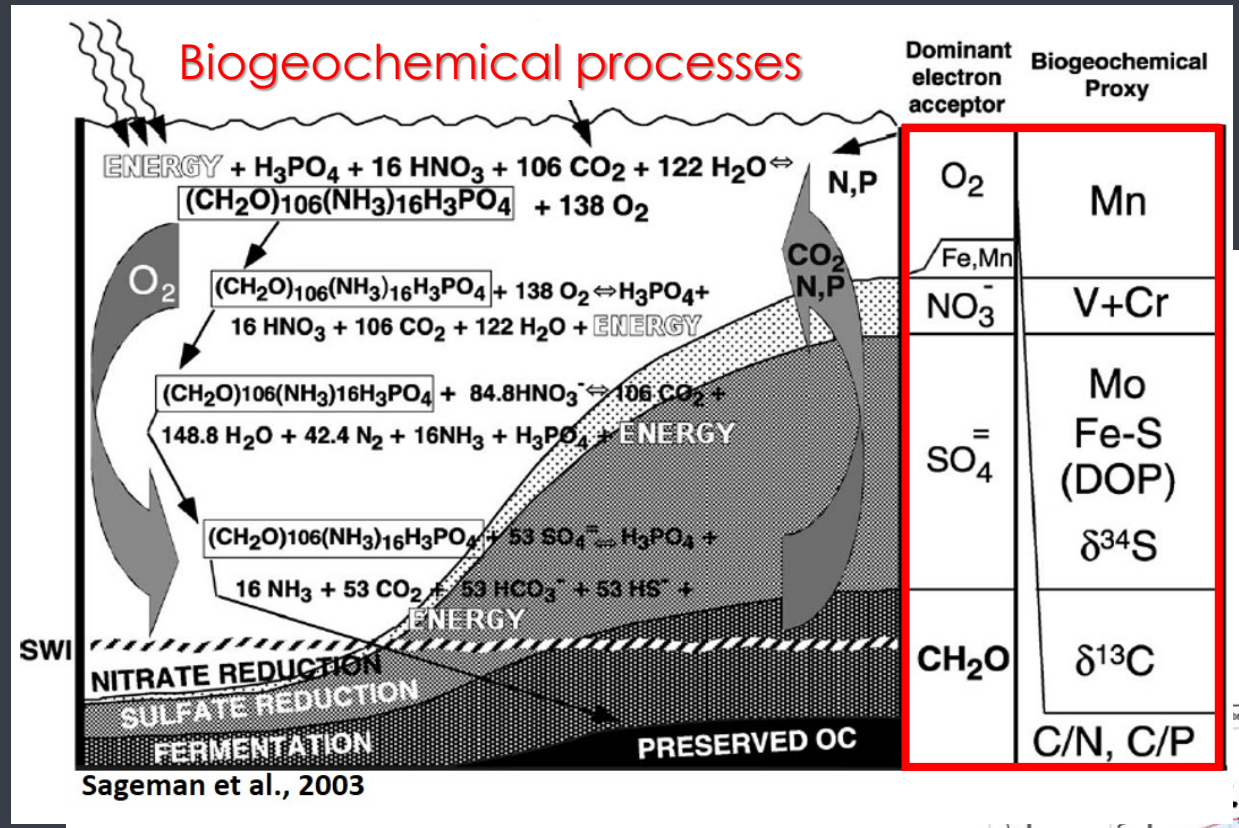
Selected CM content from USGS Black Shale database
(Granitto et al, 2017)

Nickel



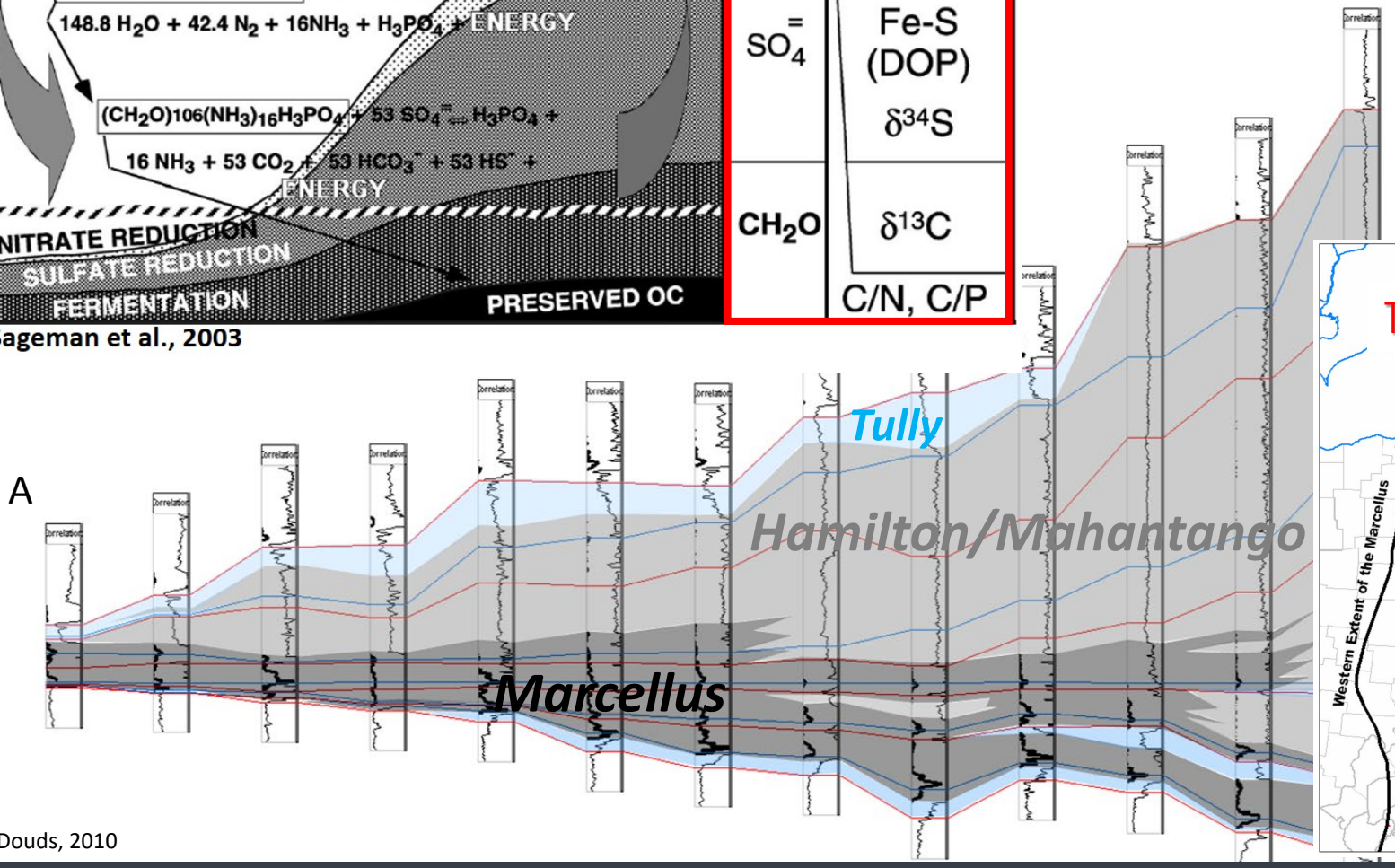
*Values are normalized to PAAS

USING OUR SHALE GEOLOGIC KNOWLEDGE TO PREDICT CRITICAL MINERAL DISTRIBUTION

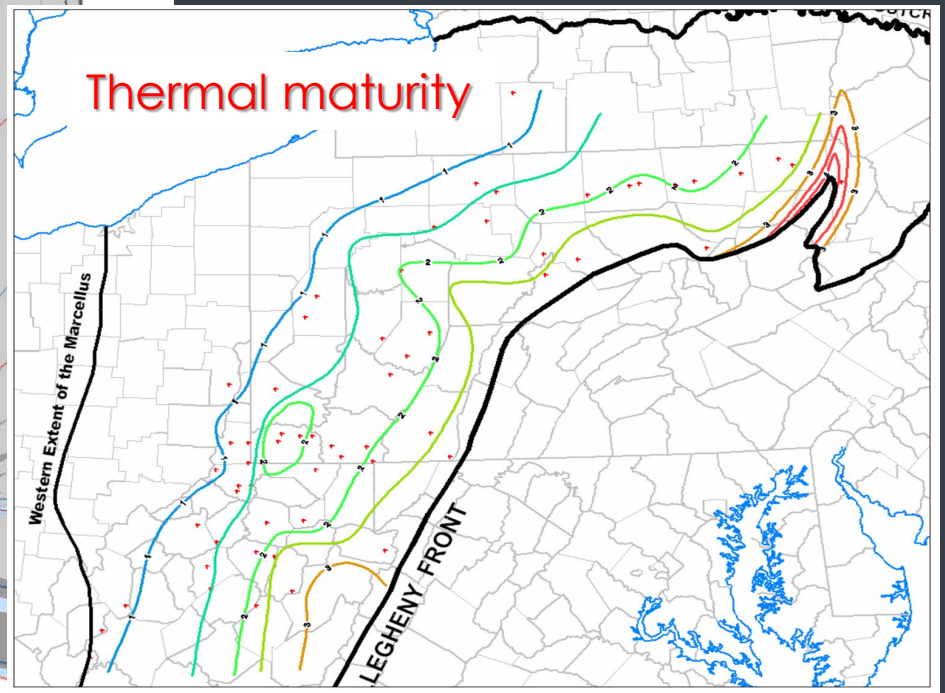


Sageman et al., 2003

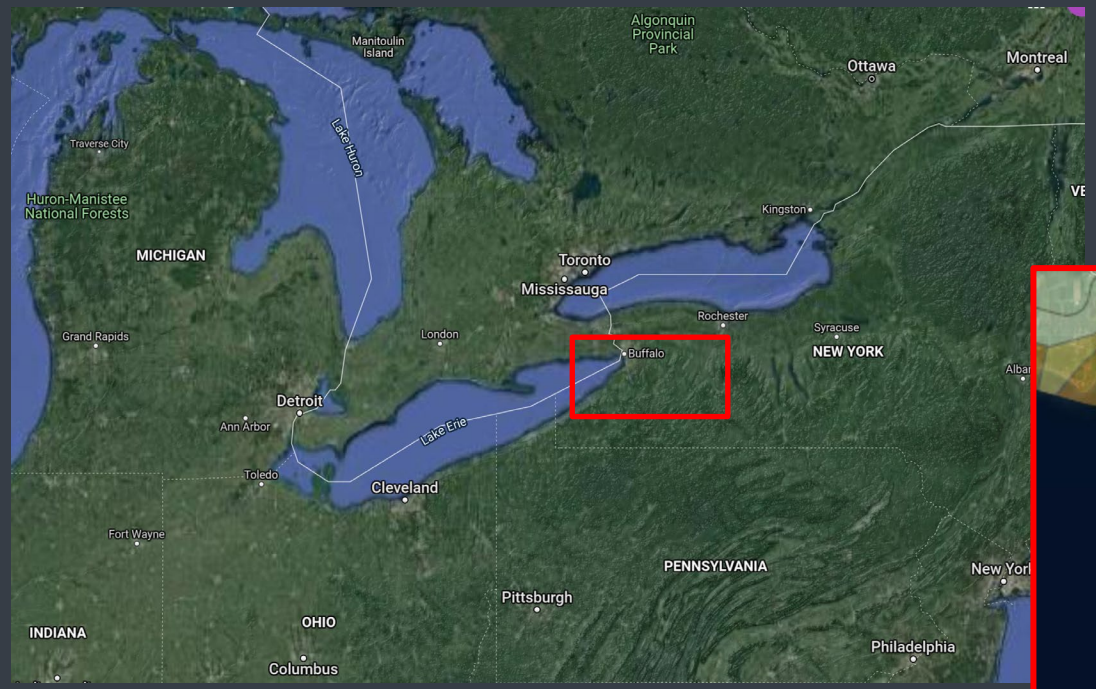
Sequence Stratigraphy



Douds, 2010



CRITICAL MINERALS IN SHALE : THE DUNKIRK SHALE

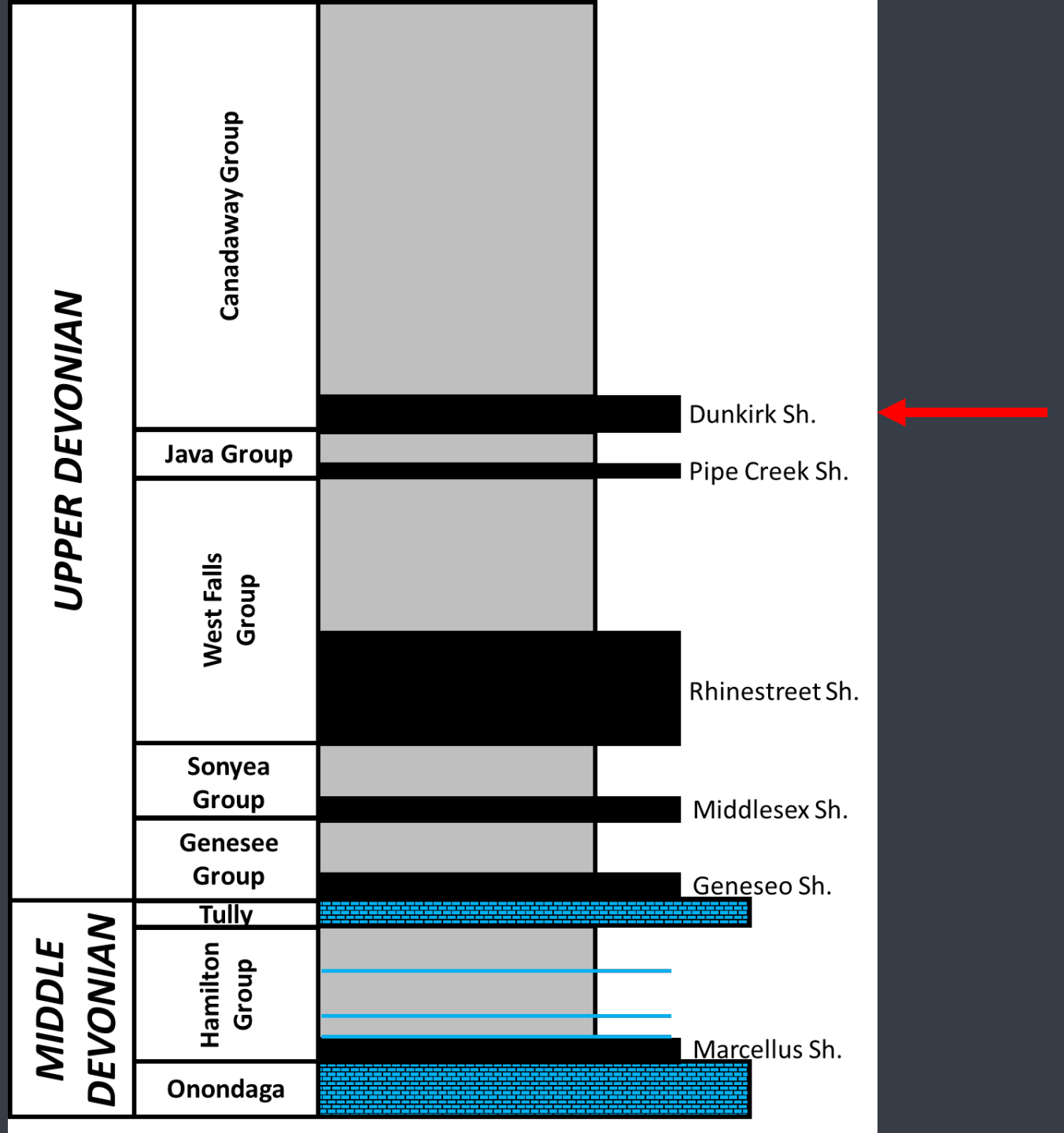


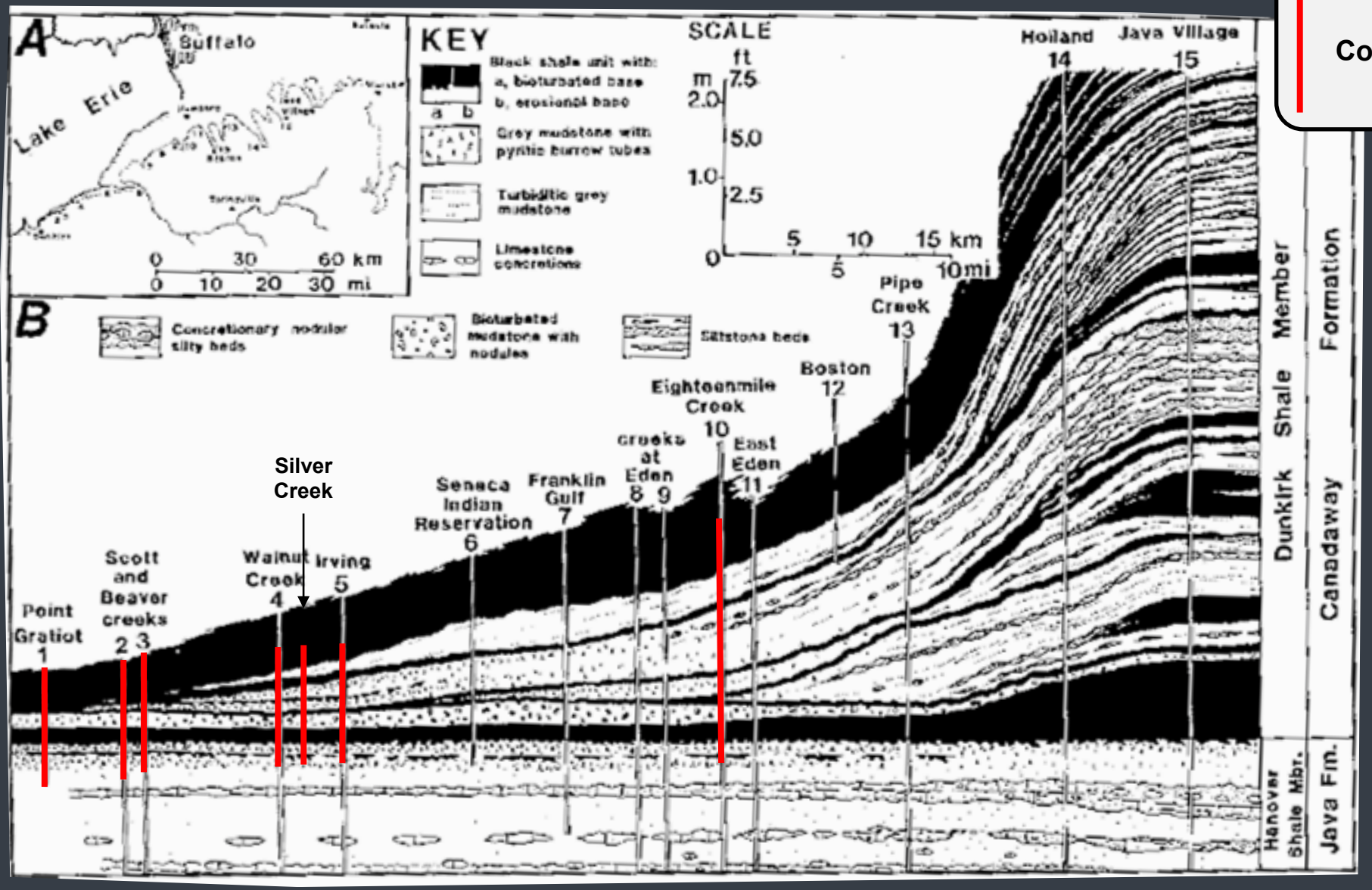
Our study area runs from the type section at Dunkirk, NY at its westernmost extent to Java Village, NY in the east.

In the study area the Dunkirk Shale outcrops in creeks and ravines along a roughly northeast trending outcrop belt

DEVONIAN STRAT

- Devonian stratigraphy of western and central New York
- Of interest to this study is the interbedded black and grey shale succession of the Upper Devonian.
- Specifically, the Dunkirk shale





Cored Interval

Baird and Brett, 1991

Collect two continuous cores

- One core is boxed and preserved for reference
- One core is sectioned into 1 cm intervals for analysis

- Where localities allow, we also collect as many as 10 hand samples per beds of interest for robust statistical analysis

CMS STATISTICS SUMMARY

Phase 1 (we are here):

- Determine ideal sample size for a given statistical power
- Descriptive univariate statistics
- Exploratory multivariate statistics (PCA, K-means, etc.)

Phase 2:

- Test a variety of statistical models for predicting variance in elements
- Select ideal model based on consistency with geologic model, parsimony and error minimization

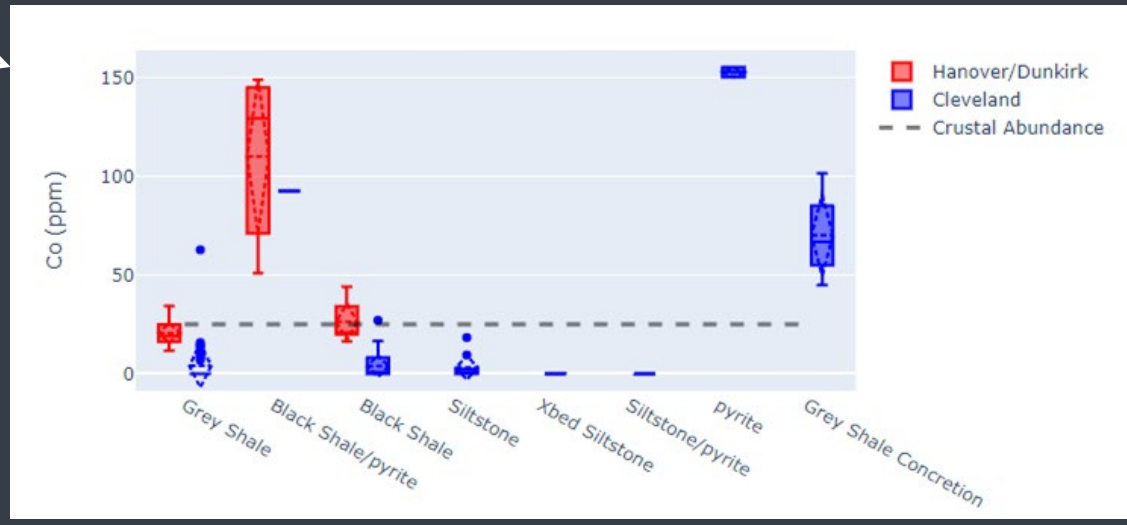
Phase 3:

- Monte Carlo simulation using model(s) from Phase 2 to yield CM abundance by formation and lithology.

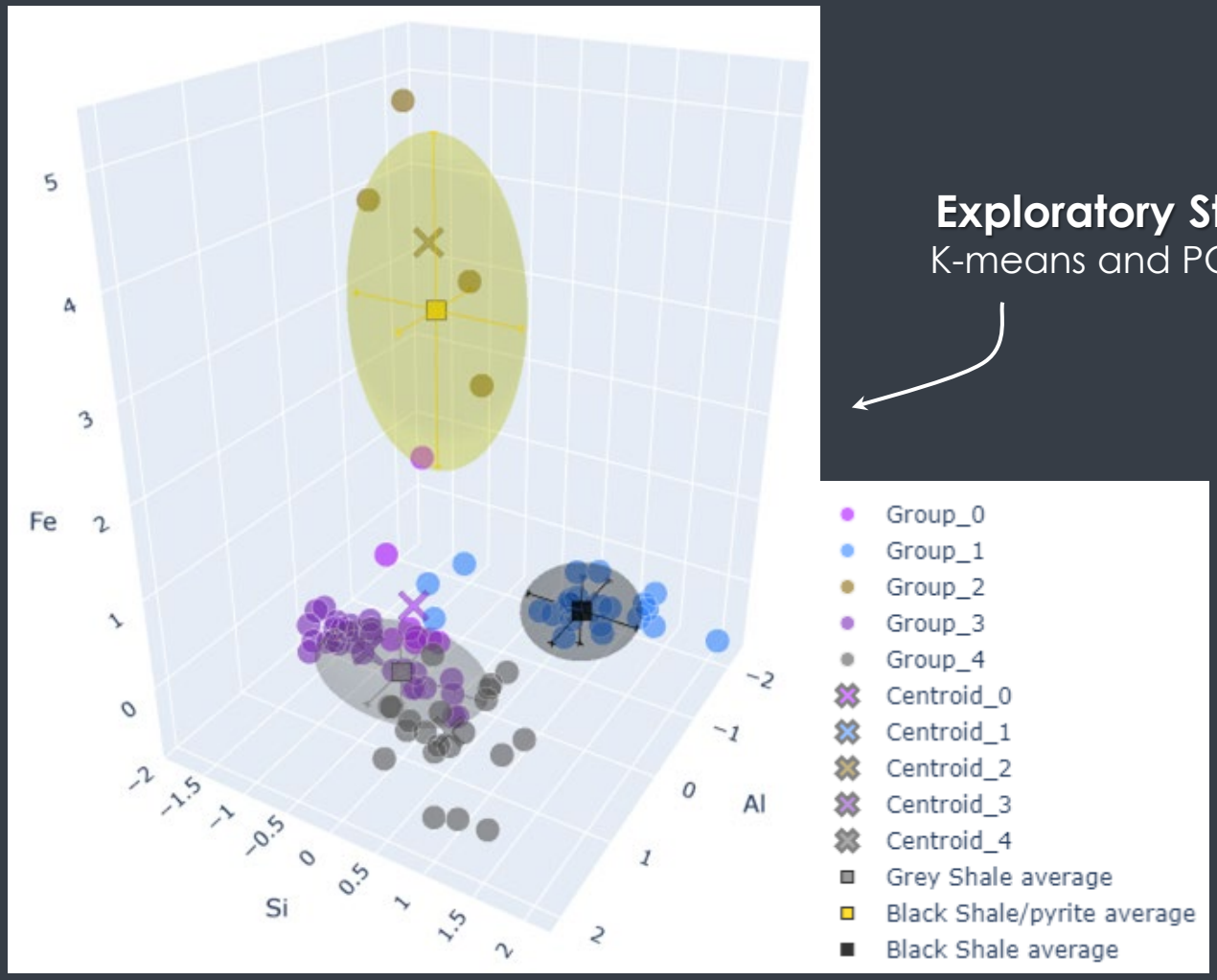
CURRENT STATUS

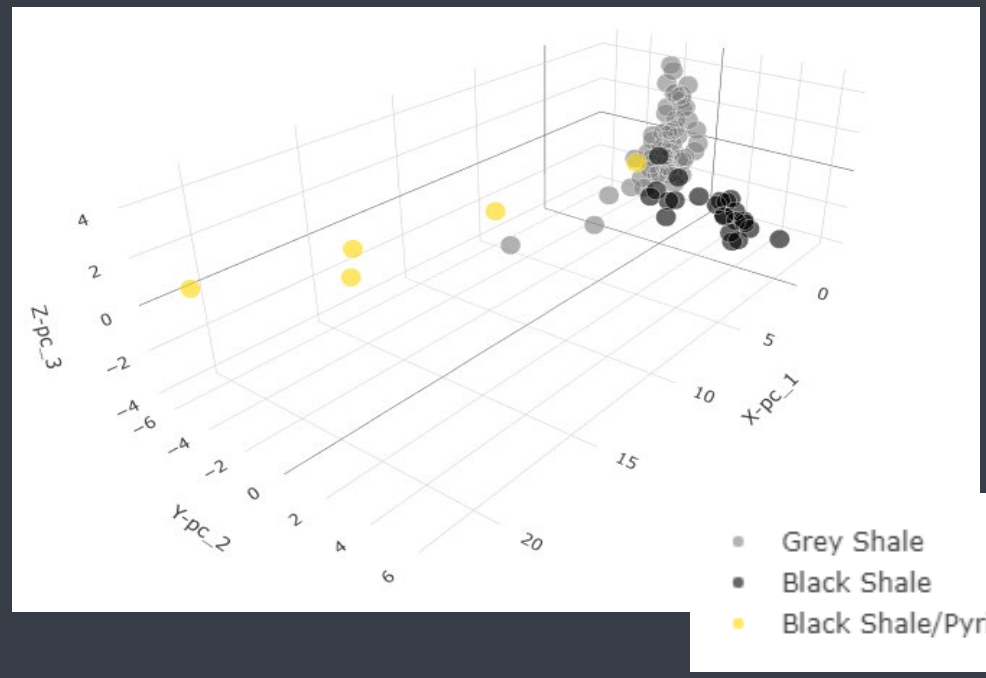
Web-based set of dashboards

Descriptive Statistics
Elements by formation and lithology



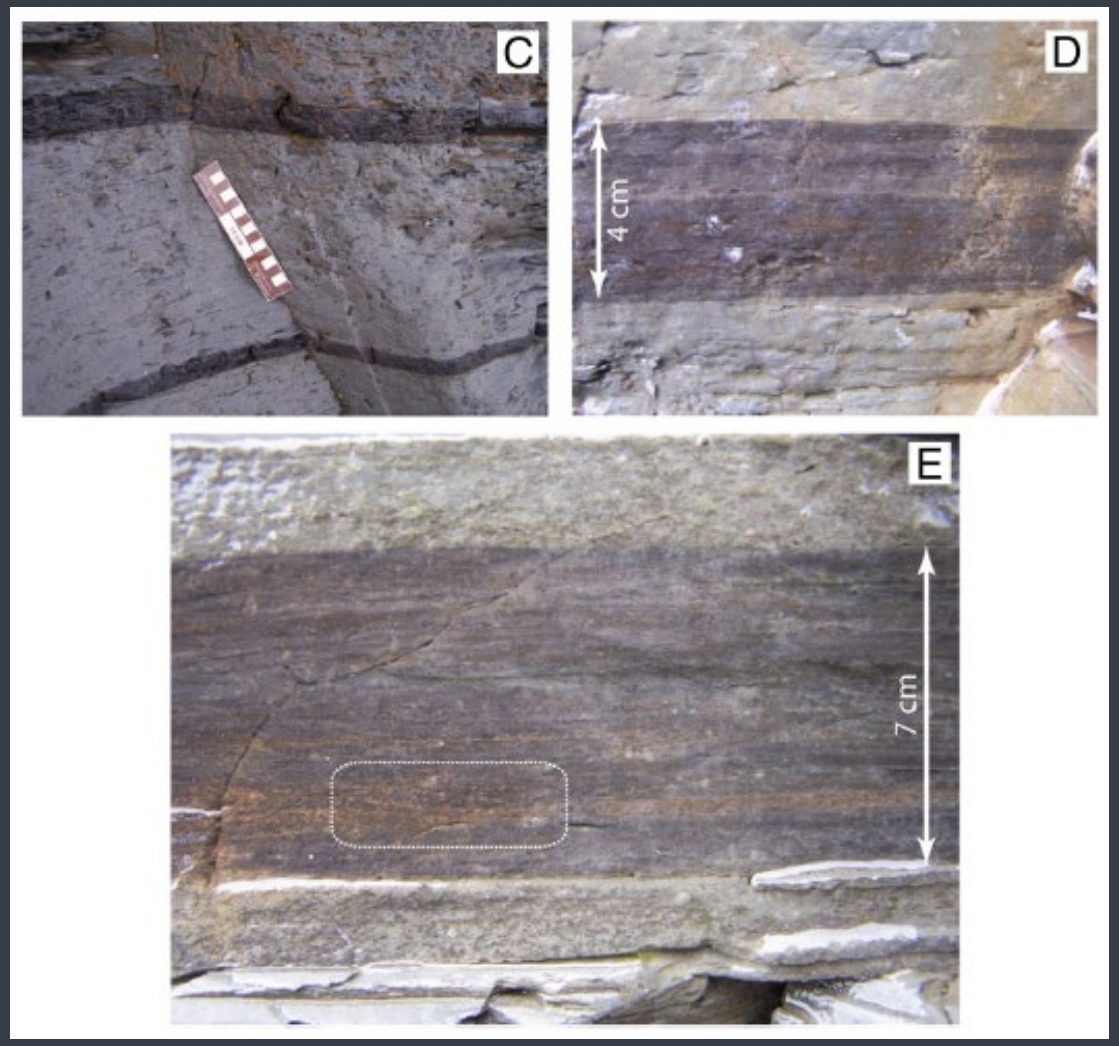
Exploratory Statistics
K-means and PCA



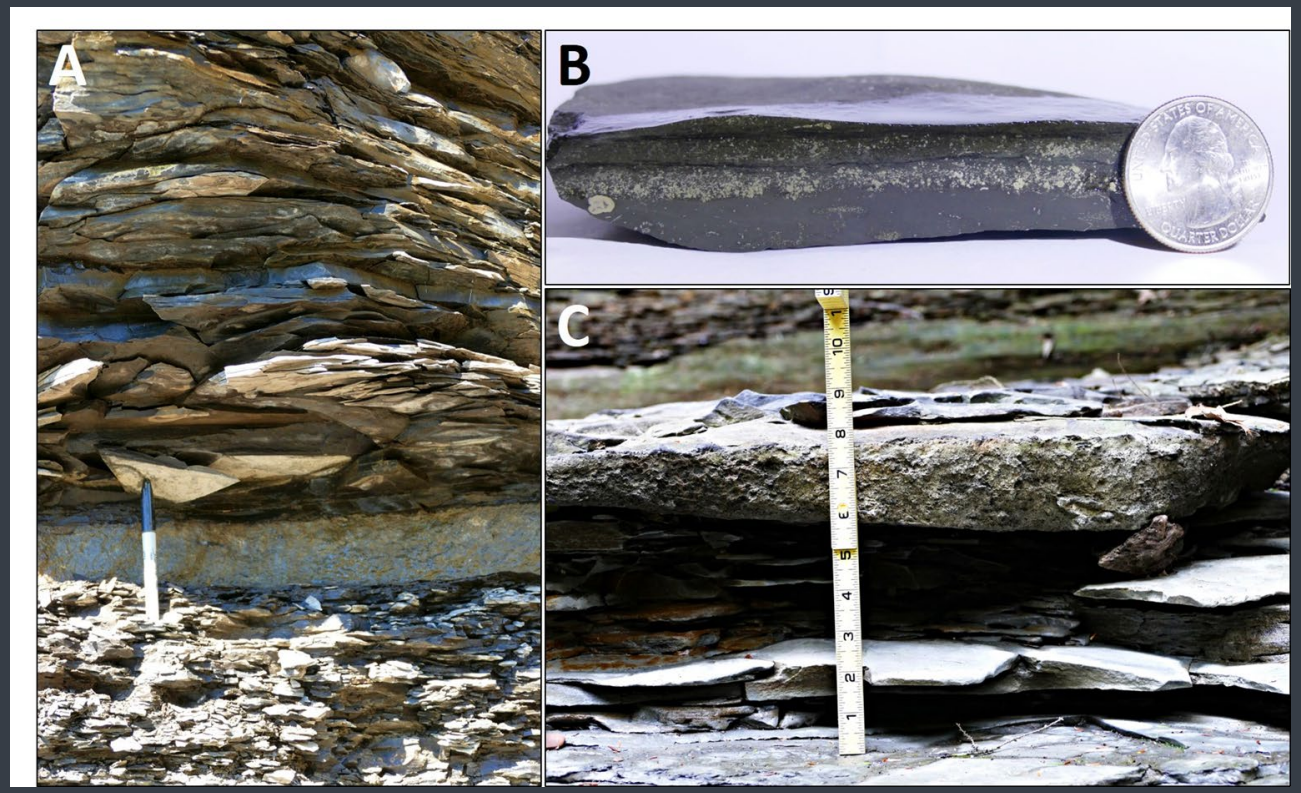


PROCESSES THAT MAY CONCENTRATE CMS IN SHALE

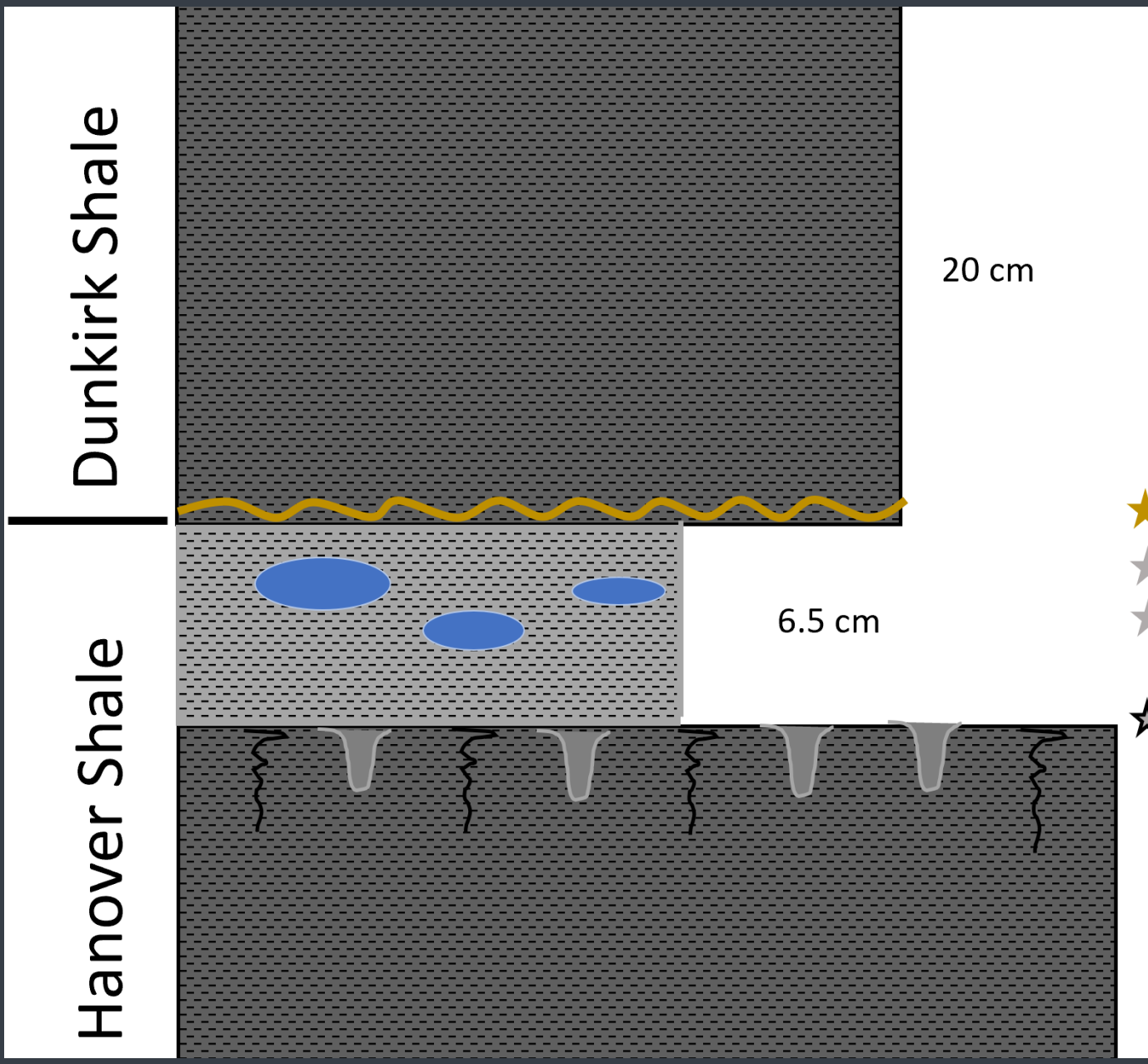
Diagenetic – Burn down

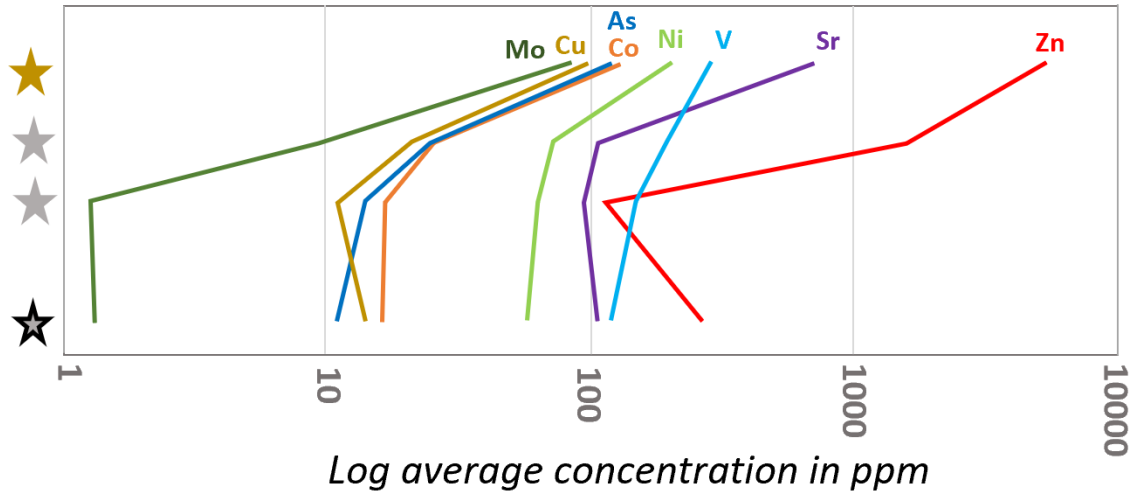


Sedimentologic – lag deposits



Stratigraphic variability highlighting importance of sampling within a geologic context

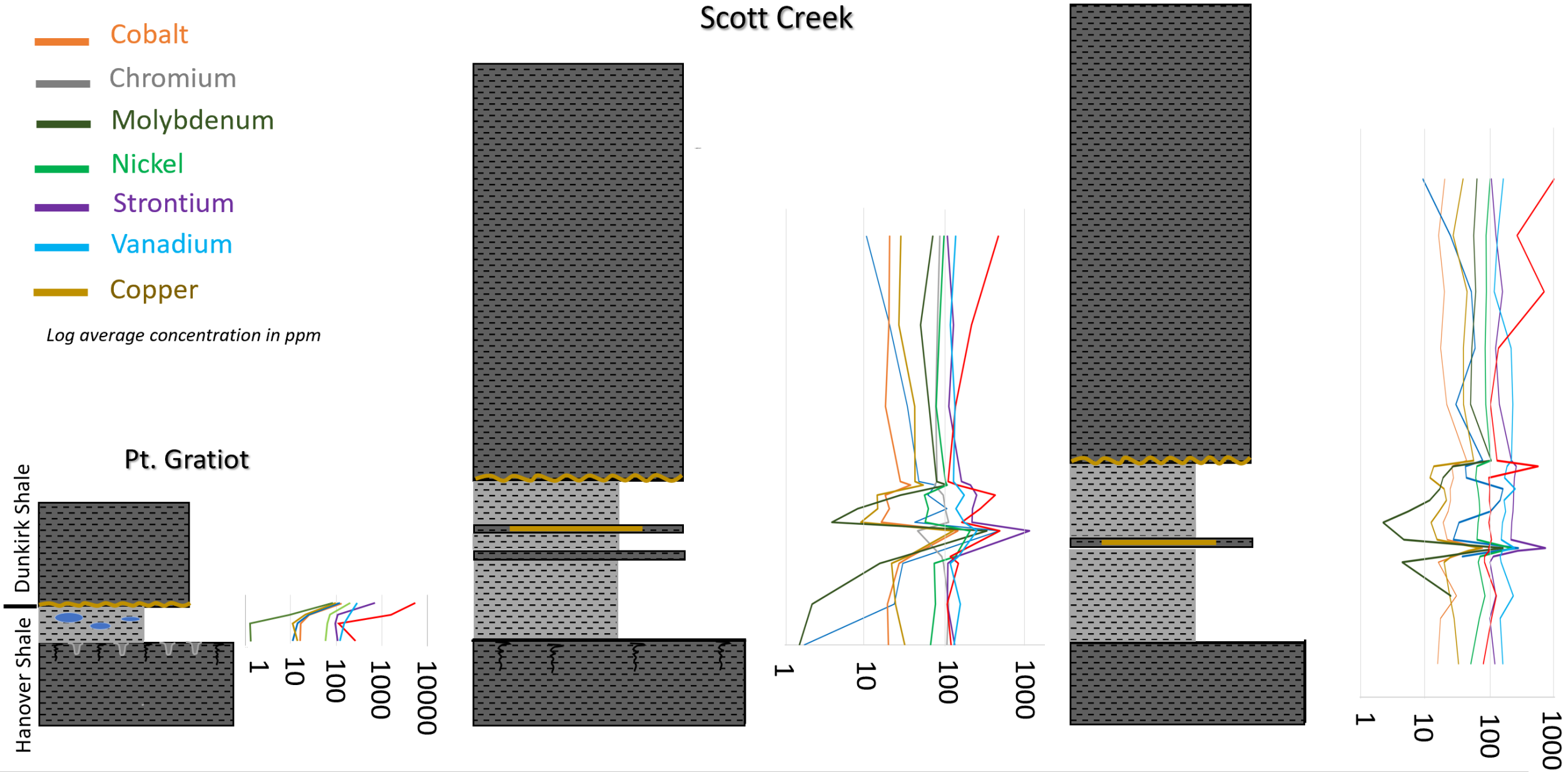




Hanover and Dunkirk Cross-Section

- Arsenic
- Zinc
- Cobalt
- Chromium
- Molybdenum
- Nickel
- Strontium
- Vanadium
- Copper

Log average concentration in ppm

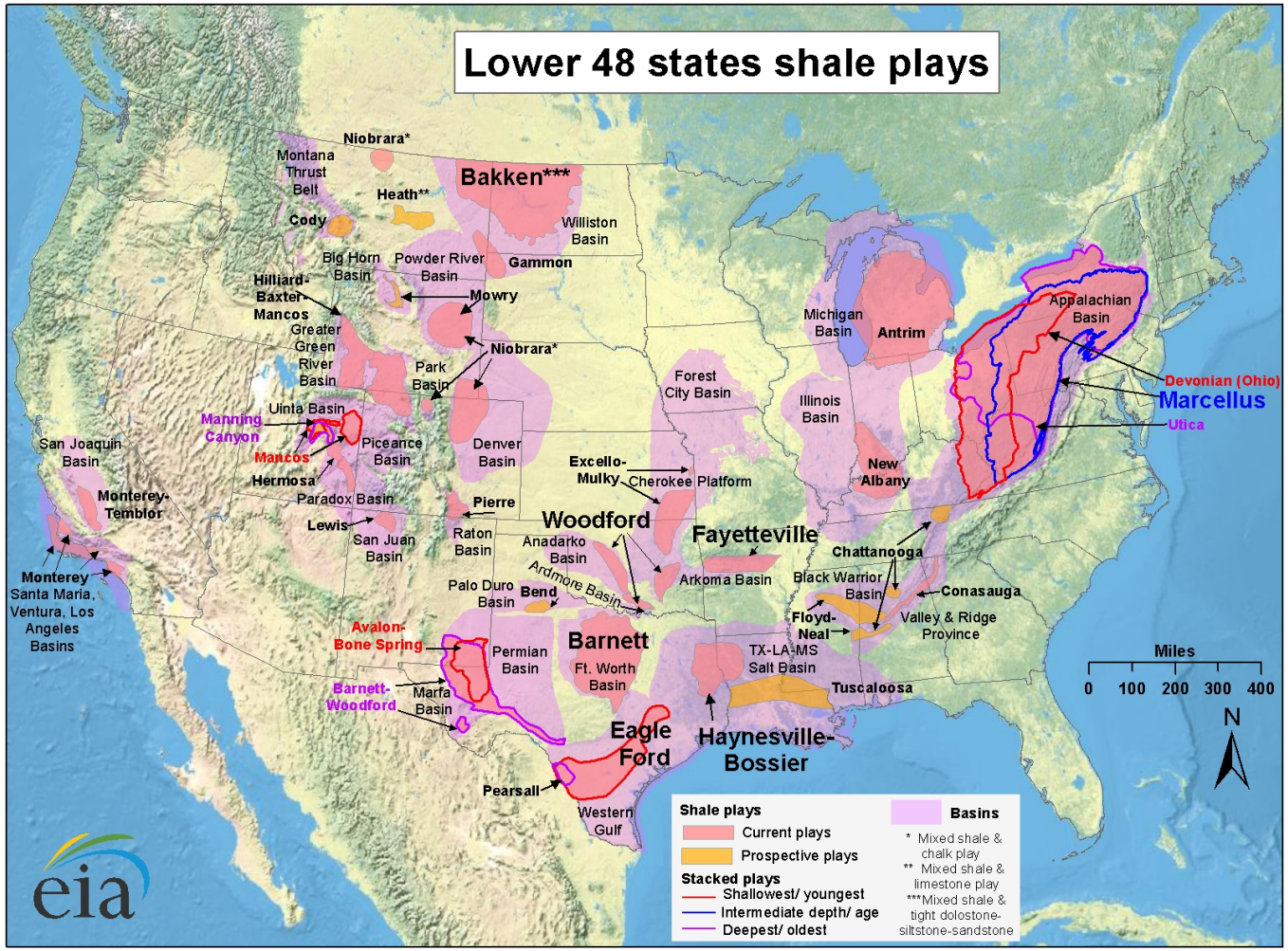


SUMMARY

SEDIMENTARY BASINS ARE LARGELY UNEXPLORED FOR CRITICAL MINERALS

WITH THE KNOWLEDGE WE HAVE GAINED IN THE LAST DECADE ABOUT SHALES, NOW IS THE TIME TO APPLY THIS KNOWLEDGE TO THESE RESERVOIRS FOR CRITICAL MINERAL EXPLORATION

BUILDING A WORKFLOW THAT CAN BE APPLIED TO PREDICT CRITICAL MINERAL CONCENTRATION IN FINE-GRAINED STRATA



Source: Energy Information Administration based on data from various published studies.
Updated: May 9, 2011

WILDLANDS RESEARCH

Connect with us at www.wildlandsresearch.com