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Mike Bingle-Davis, PG • 1st
Senior Geologist at Kirkwood Oil and Gas LLC
3h

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One Week Left to Register for Energy Opportunities Virtual Conference on November 10-12

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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)



Hammes - Douds - OCS2021



Cobalt (Image from USGS)

Uranium

Committee Chair: tbd



Geothermal energy

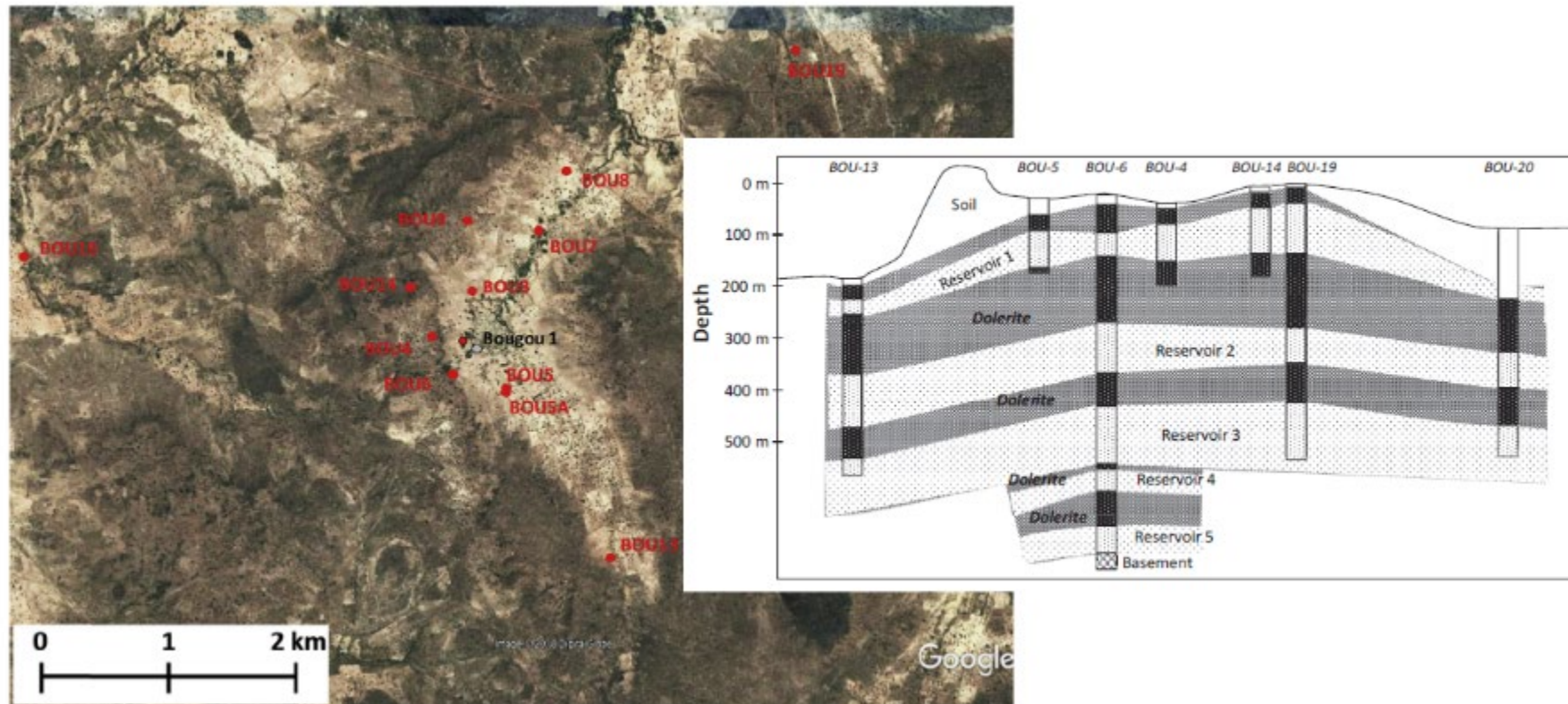
Committee Chair: **Bruce Cutright, Thermal EP**



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?”



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

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



ASHLEY SB DOUDS

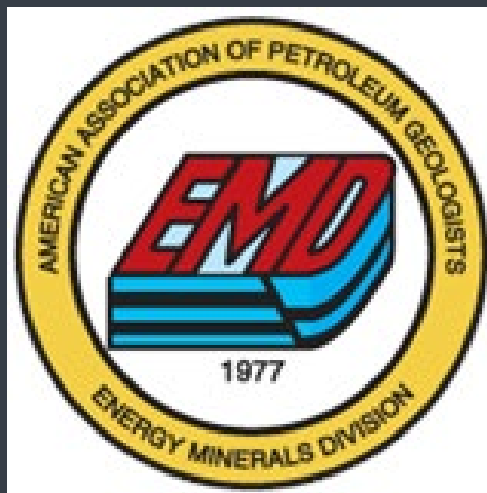
DAVID R BLOOD

SCOTT D MCCALLUM

OU CRITICAL MINERALS WORKSHOP

NOVEMBER 10, 2021

ACKNOWLEDGEMENTS



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)

Total mineral demand for clean energy technologies by scenario, 2010-2040

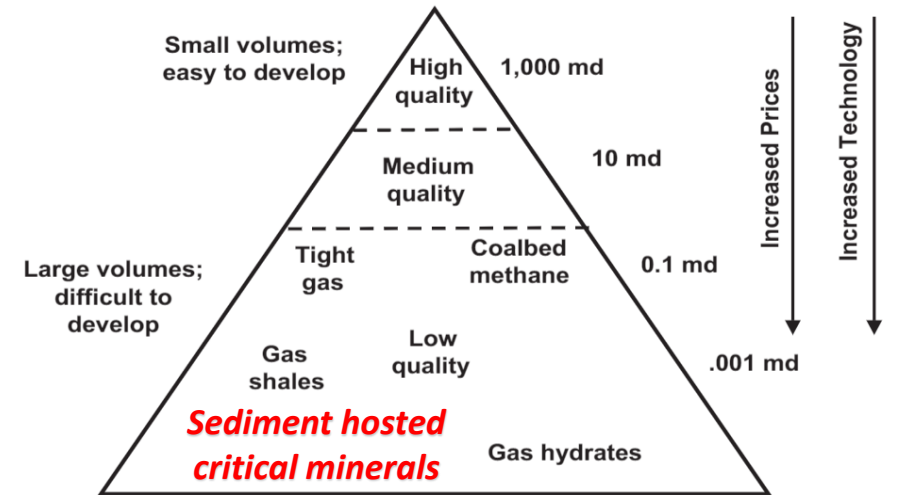
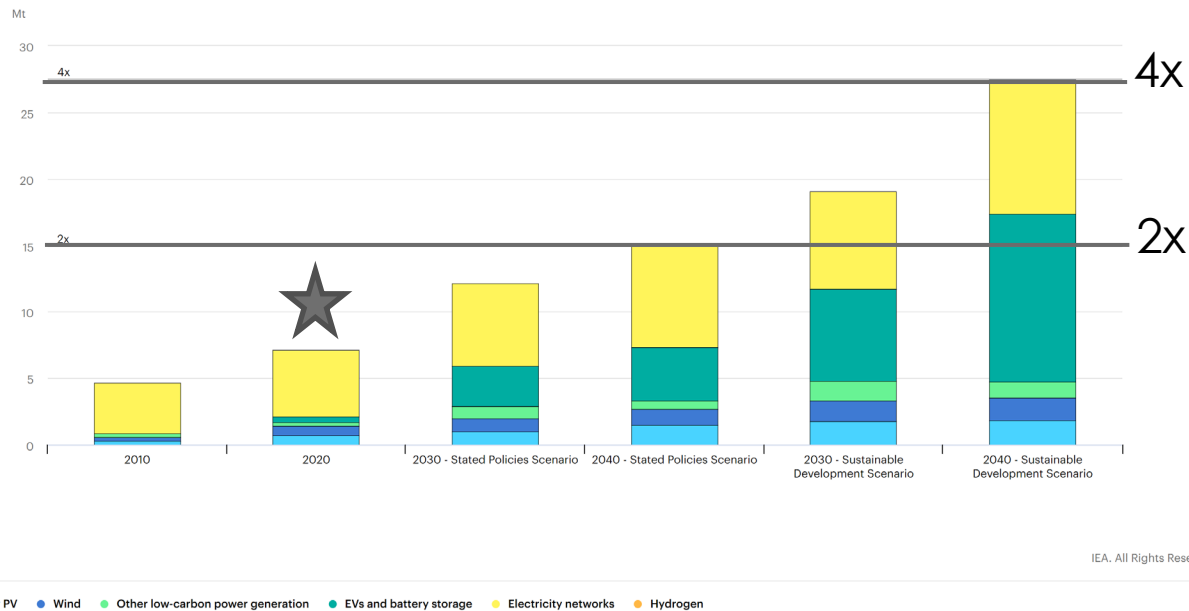


Fig. 1—Resource triangle for natural gas.

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

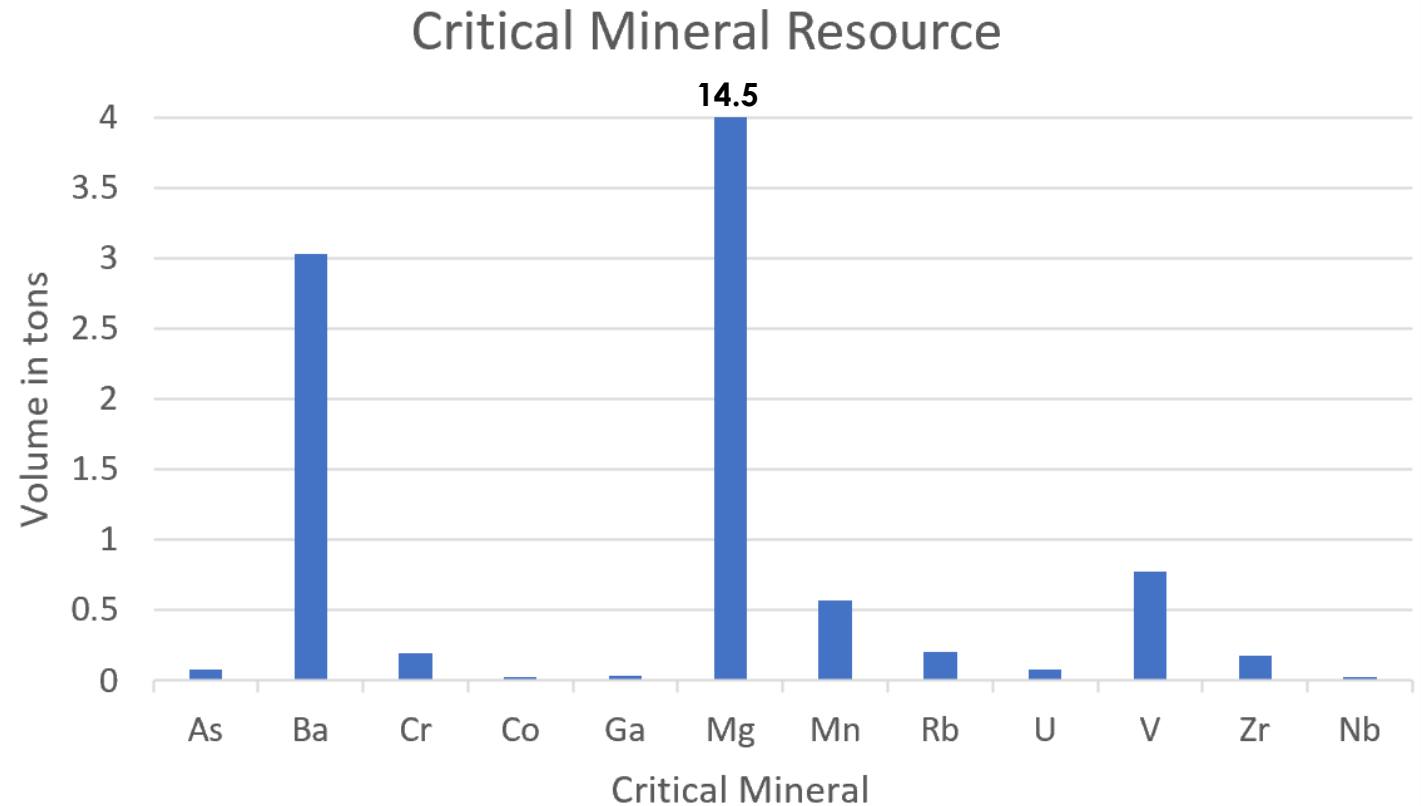
THE INDUSTRY IS ALREADY “MINING”

- 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



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

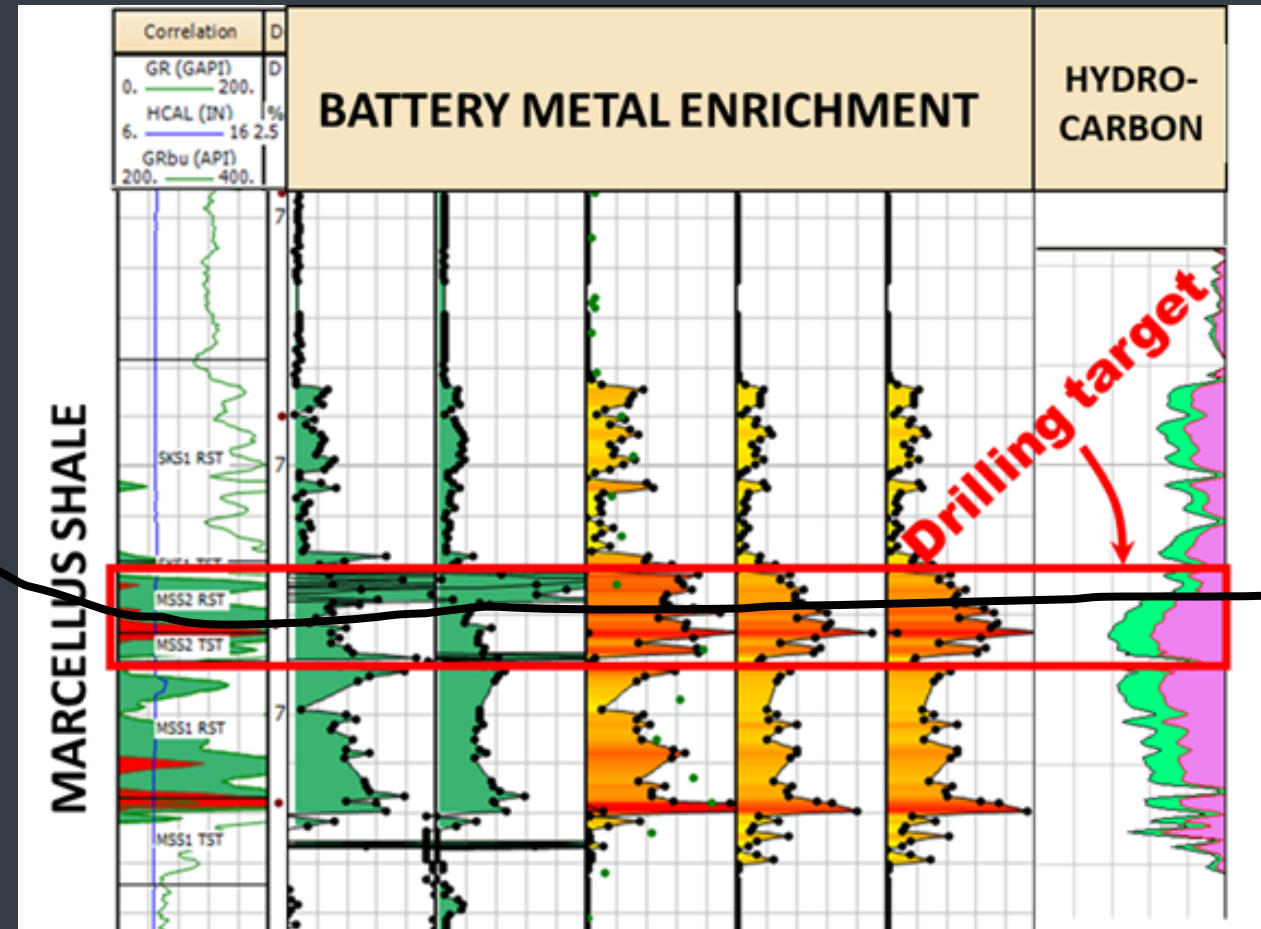
THESE BLACK SHALES,
HISTORICALLY REFERRED TO AS
METALLIFEROUS BLACK SHALES
IN THE LITERATURE, CONTAIN
METALS NEEDED FOR ENERGY
STORAGE USING BATTERIES.



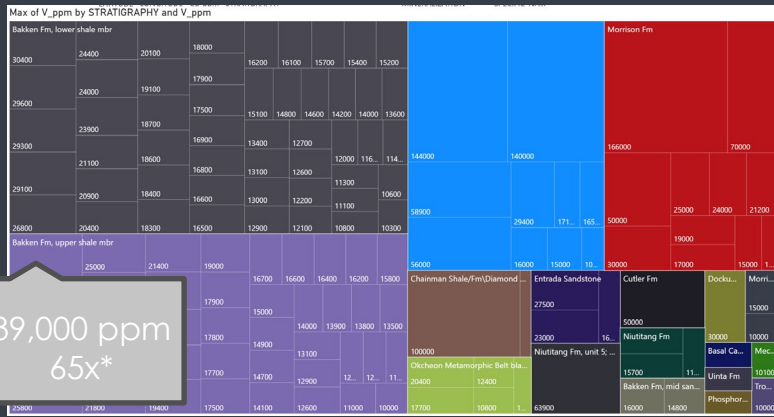
*example critical mineral content using values from Beaver Meadows Marcellus core
And 10 well pad estimate from previous page

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



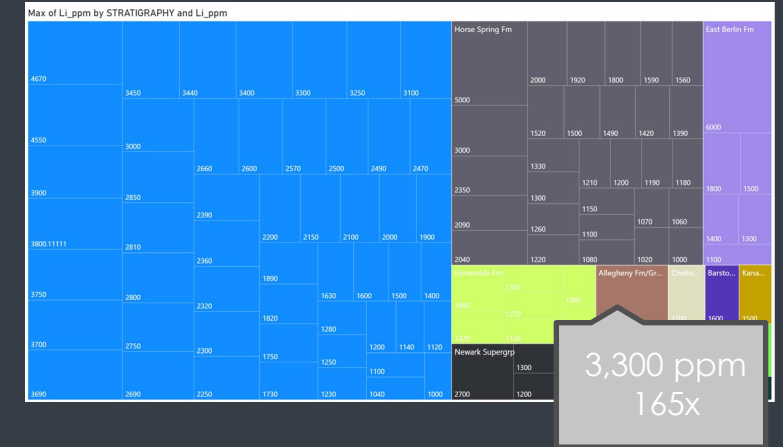
Vanadium



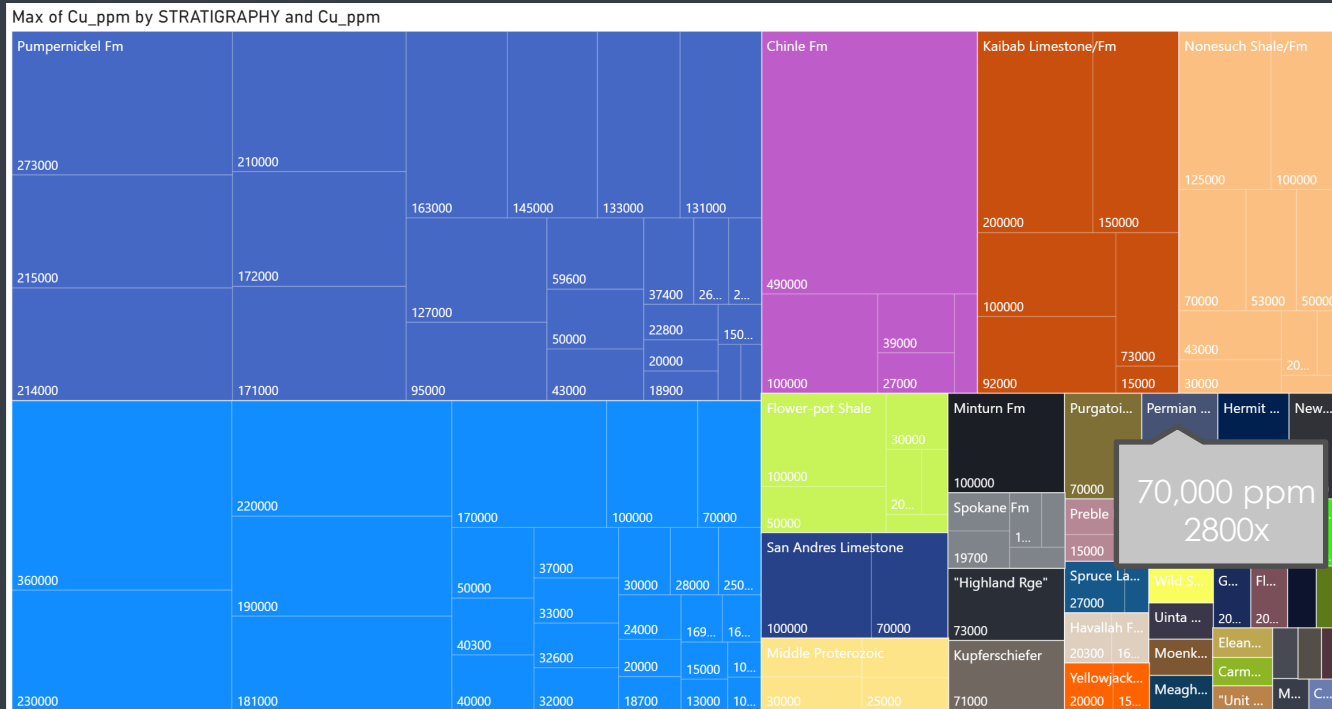
Zinc



Lithium

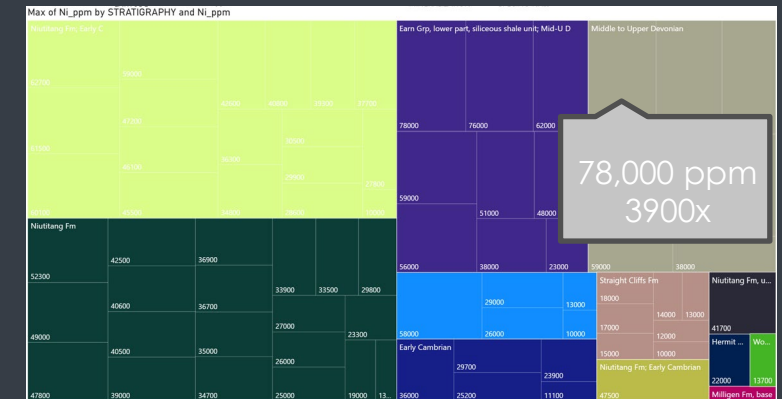


Copper



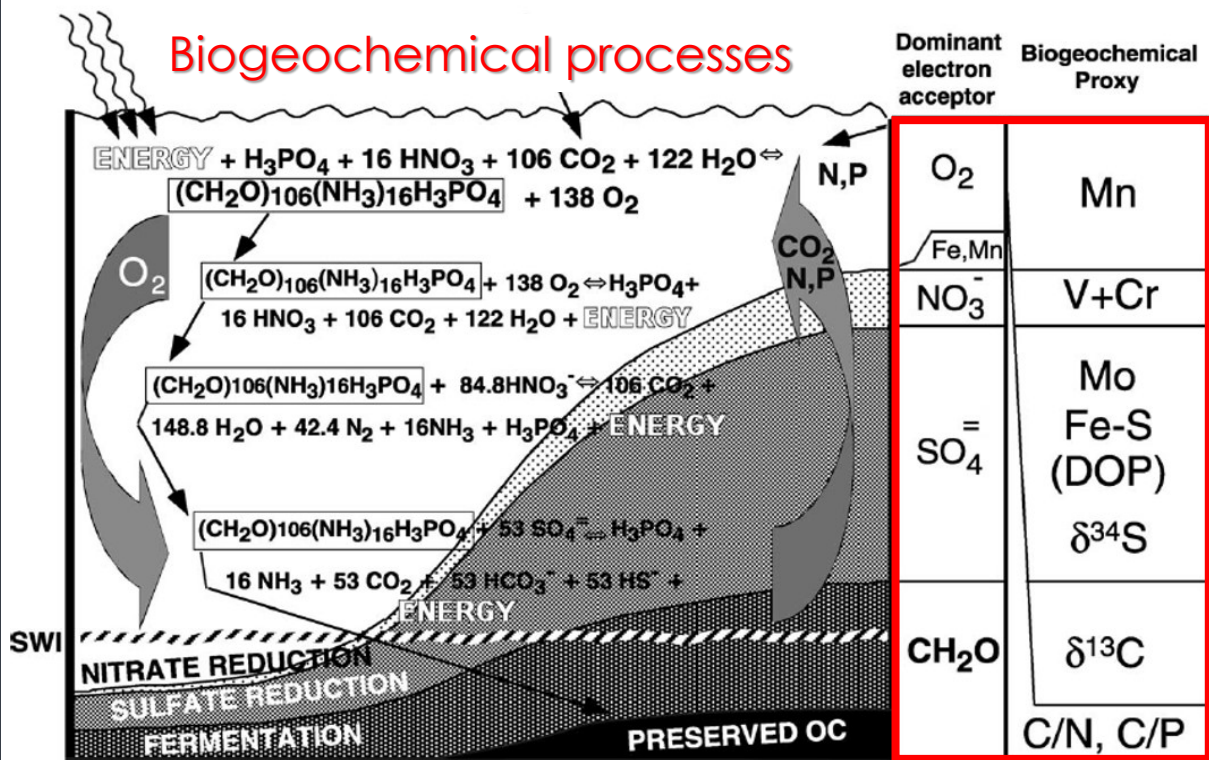
Selected CM content from
USGS Black Shale database
(Granitto et al, 2017)

Nickel



*Values are normalized to PAAS

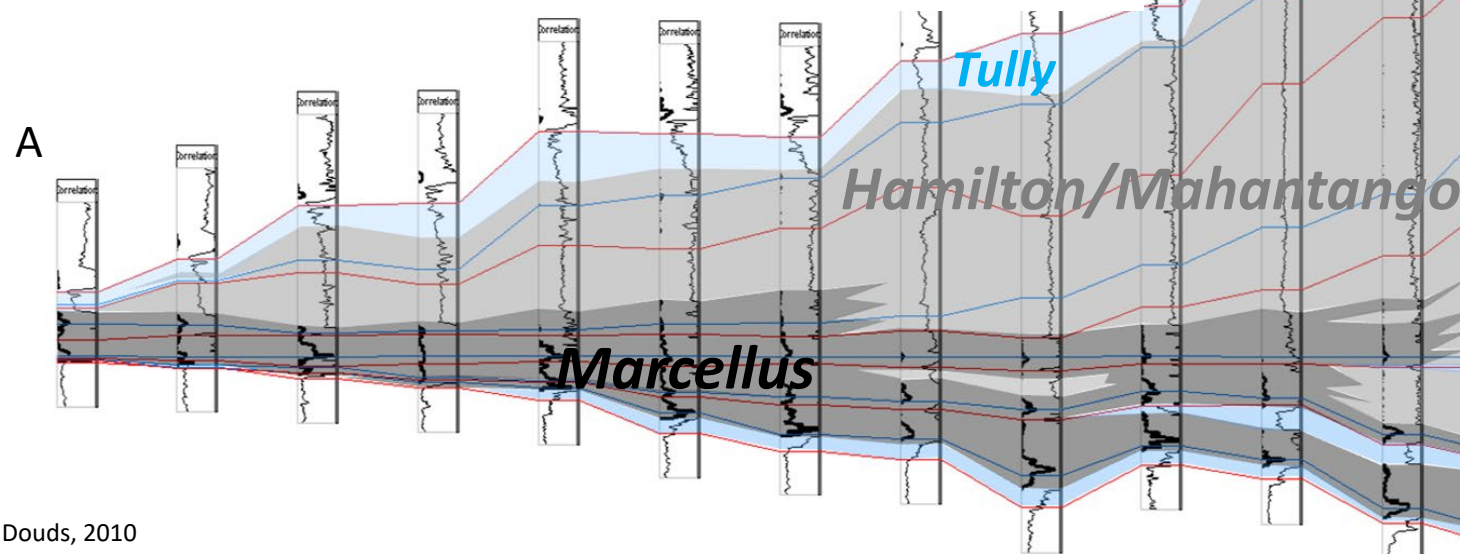
Biogeochemical processes



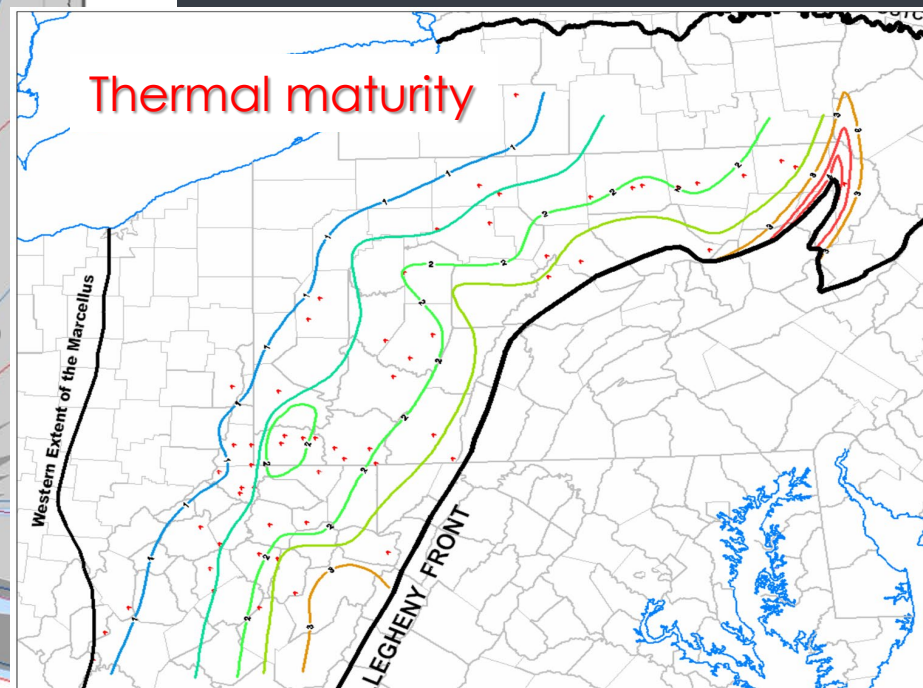
Sageman et al., 2003

Sequence Stratigraphy

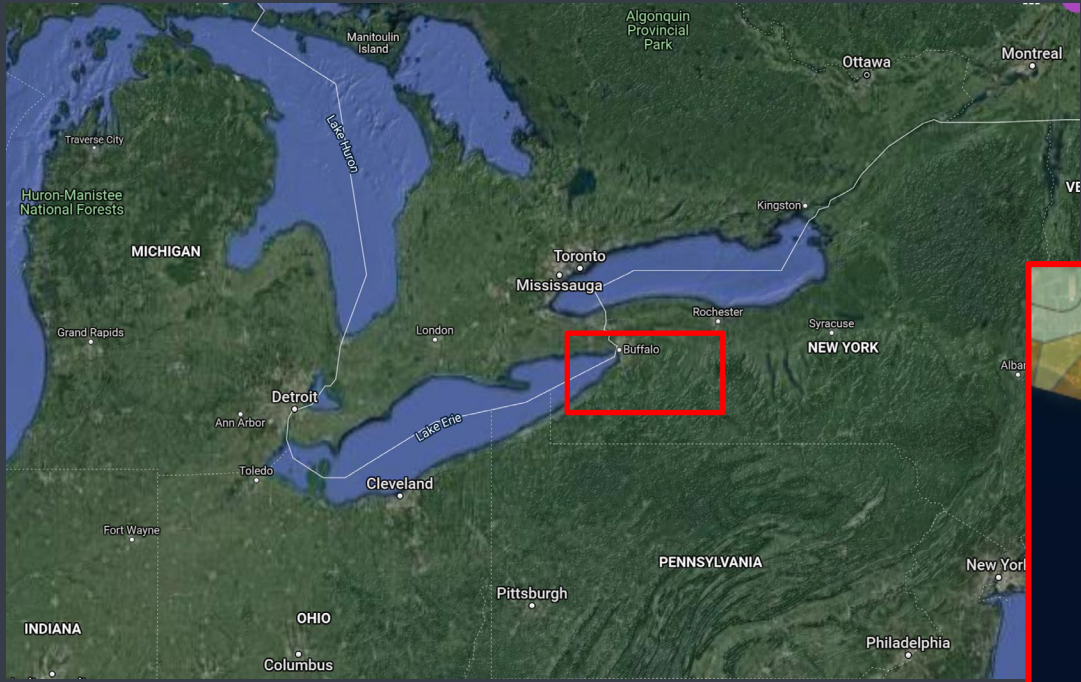
USING OUR SHALE GEOLOGIC KNOWLEDGE TO PREDICT CRITICAL MINERAL DISTRIBUTION



Douds, 2010



CRITICAL MINERALS IN SHALE : THE DUNKIRK SHALE



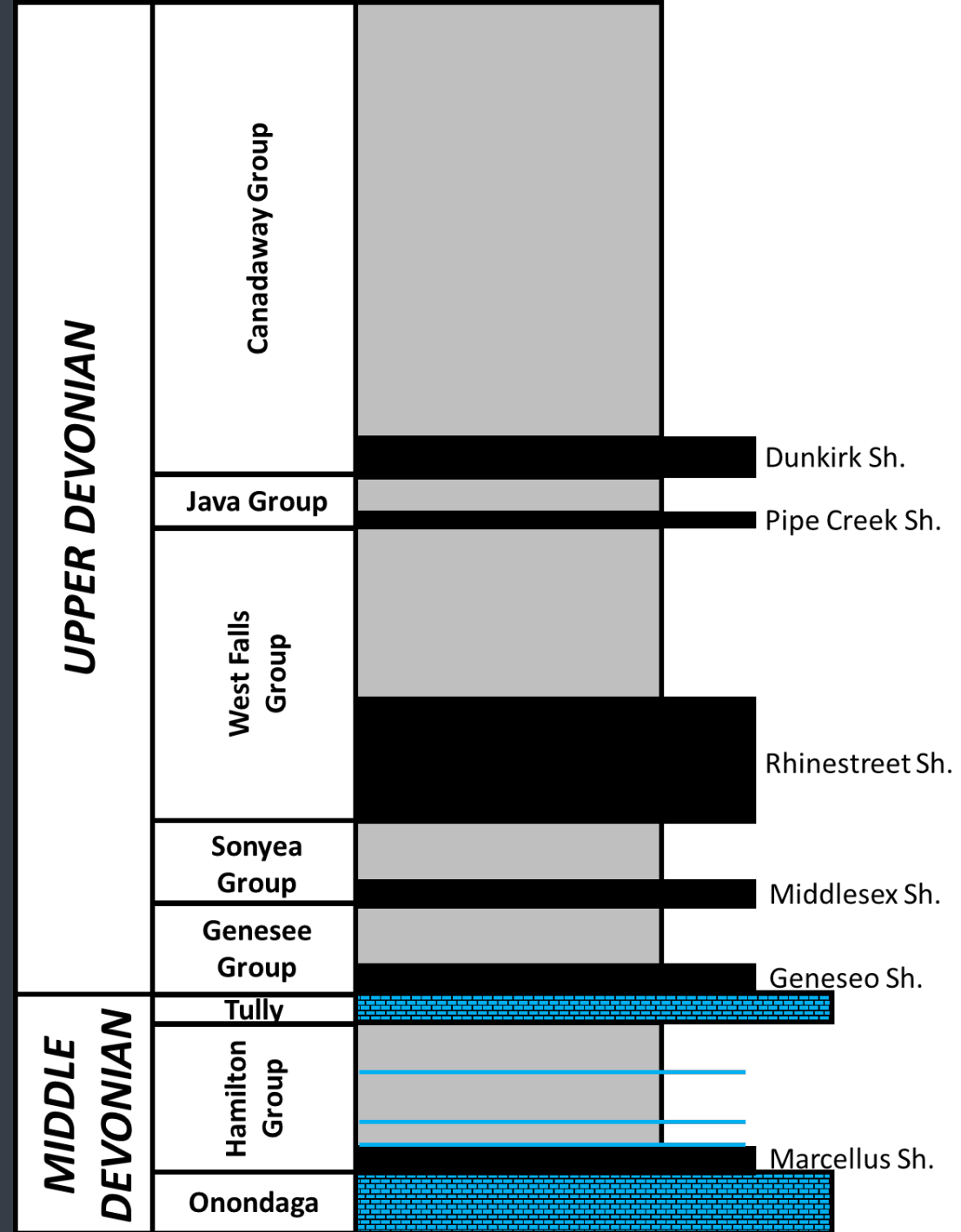
OUR STUDY AREA RUNS FROM THE TYPE SECTION AT DUNKIRK, NY AT ITS WESTERNMOST EXTENT TO JAVA VILLAGE, NY IN THE EAST.

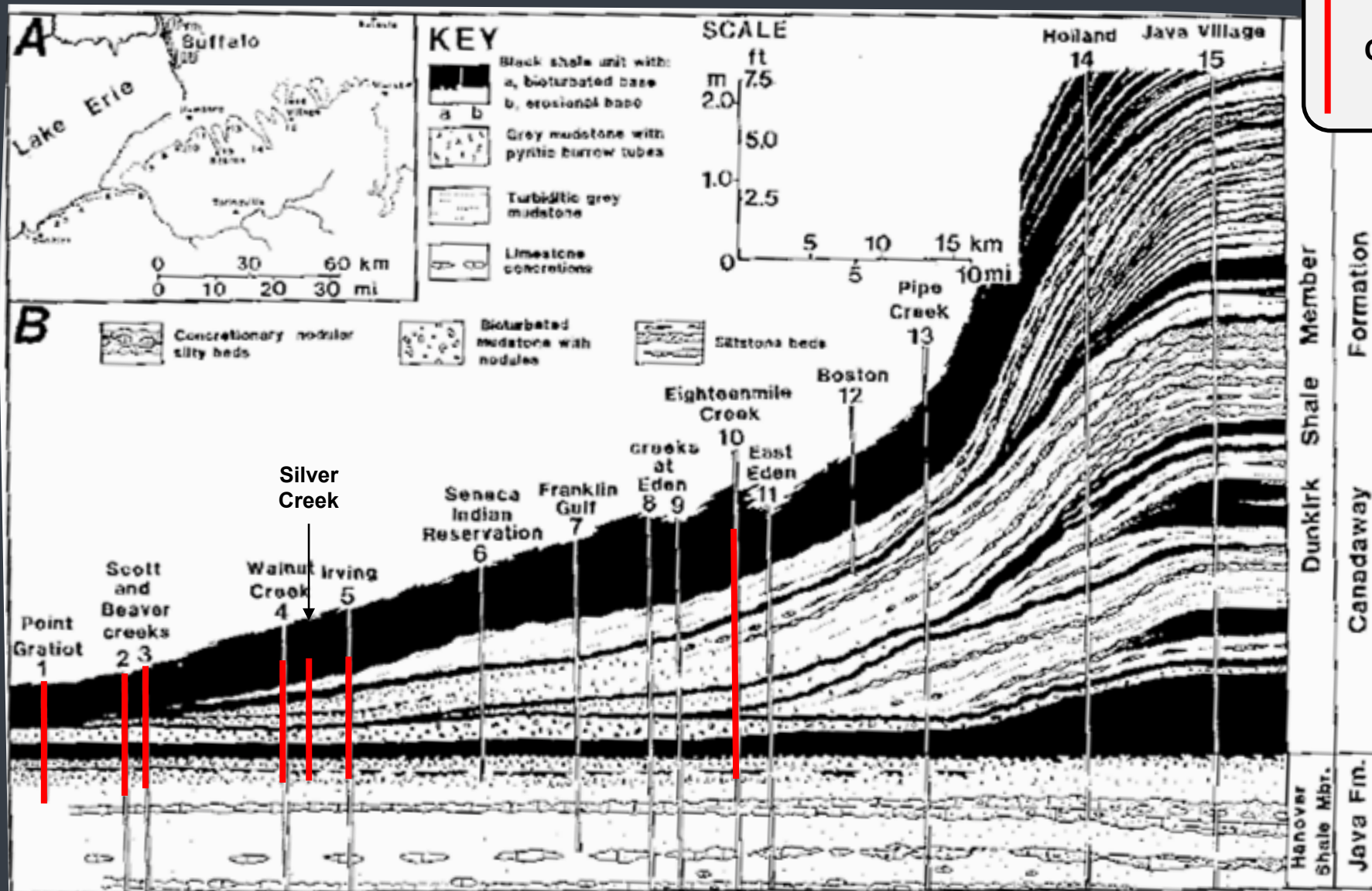


In the study area the Dunkirk Shale outcrops in creeks and ravines along a roughly northeast trending outcrop belt

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

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:

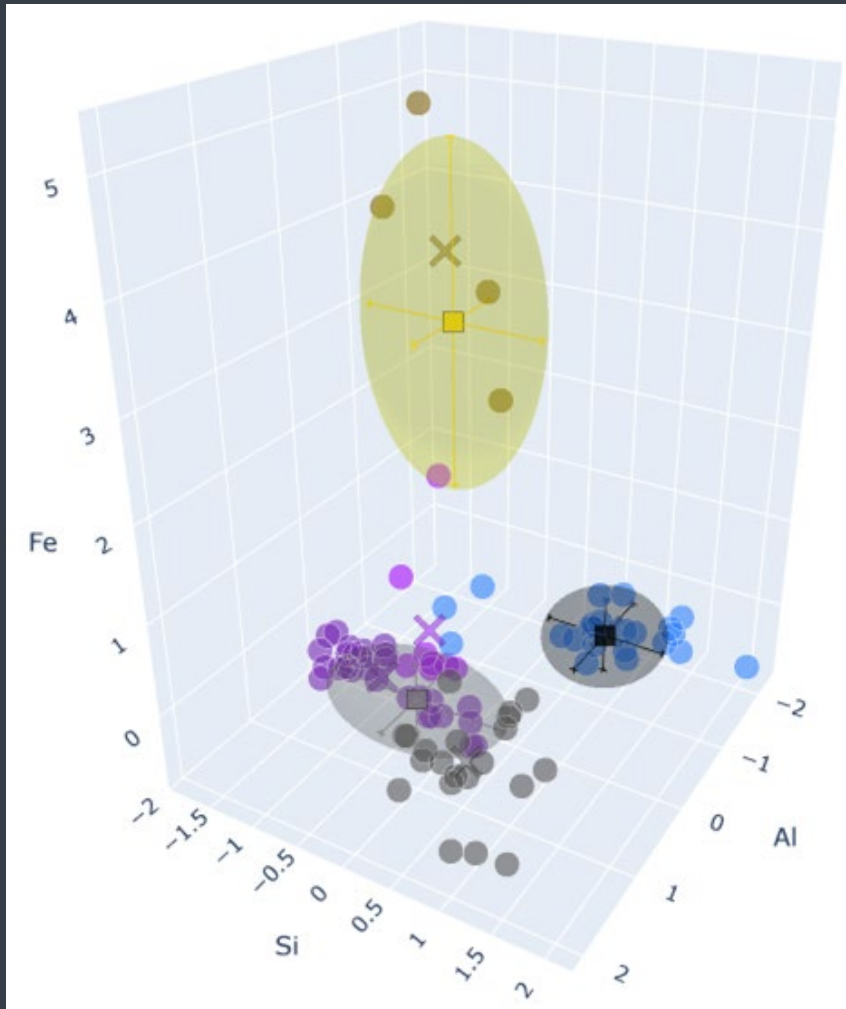
- TEST A VARIETY OF STATISTICAL MODELS FOR PREDICTING VARIANCE IN ELEMENTS
- SELECT IDEAL MODEL BASED ON CONSISTENCY WITH GEOLOGIC MODEL, PARSIMONY AND ERROR MINIMIZATION

PHASE 3:

- MONTE CARLO SIMULATION USING MODEL(S) FROM PHASE 2 TO YIELD CM ABUNDANCE BY FORMATION AND LITHOLOGY.

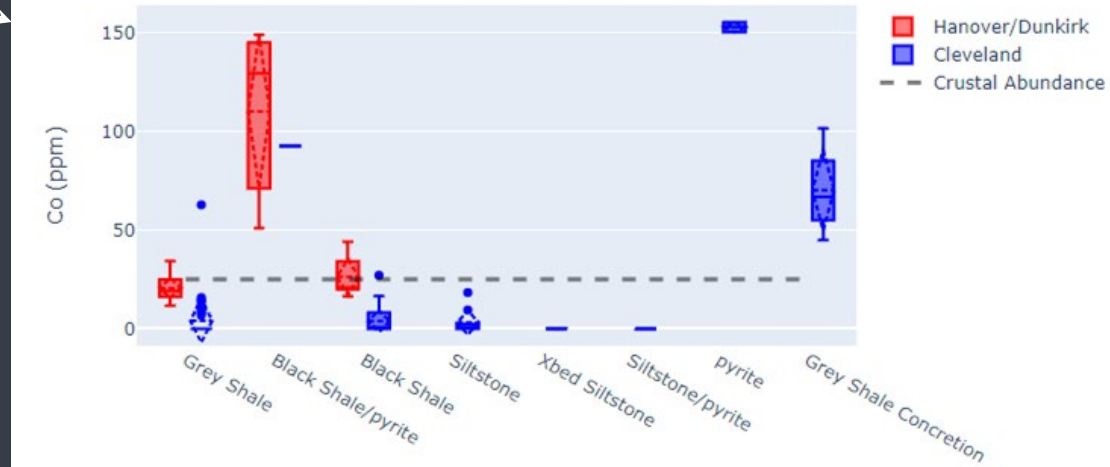
CURRENT STATUS

Web-based set of dashboards



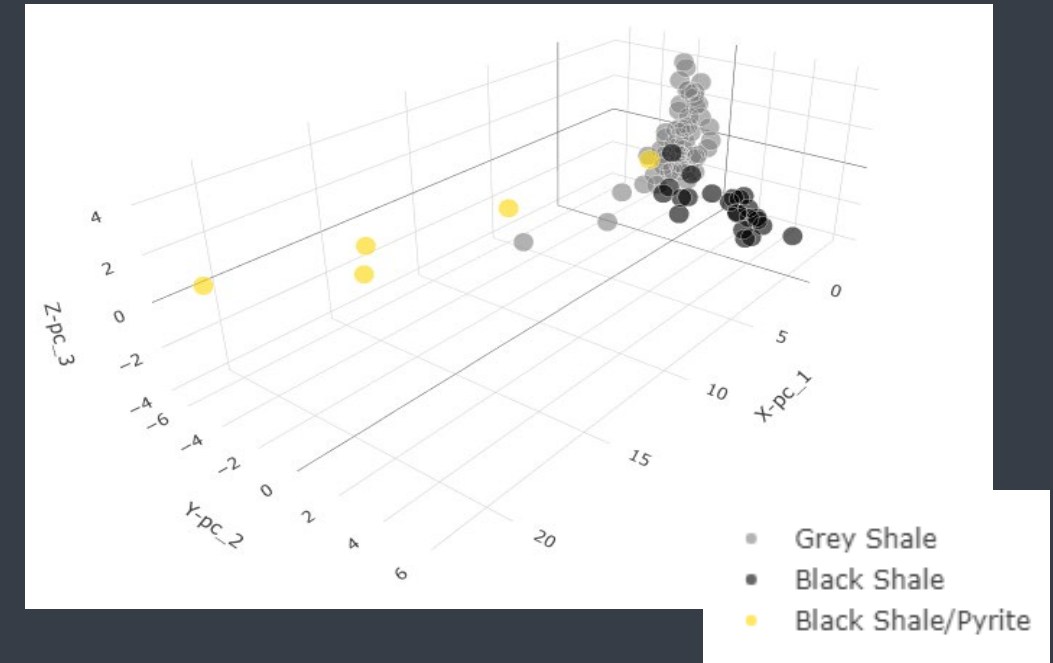
Descriptive Statistics

Elements by formation and lithology



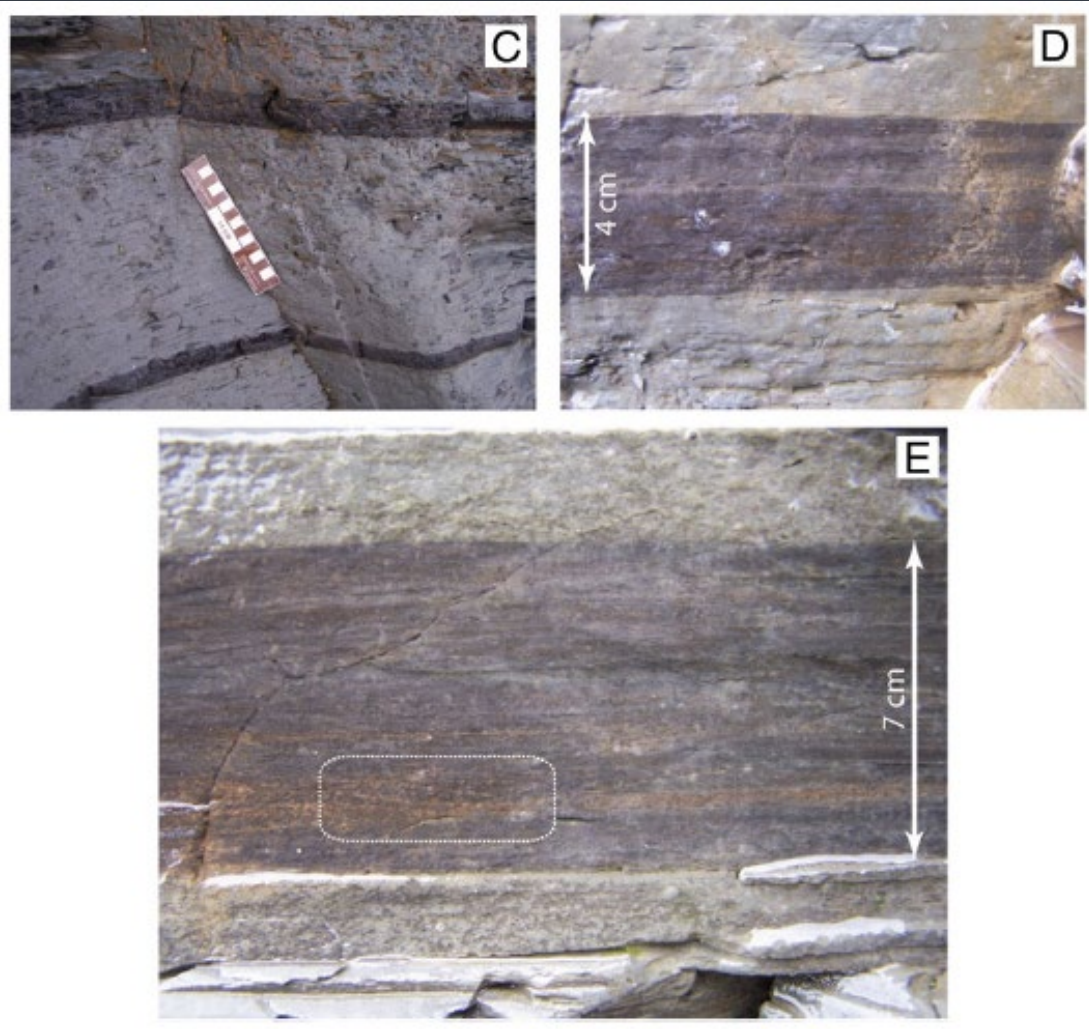
Exploratory Statistics

K-means and PCA

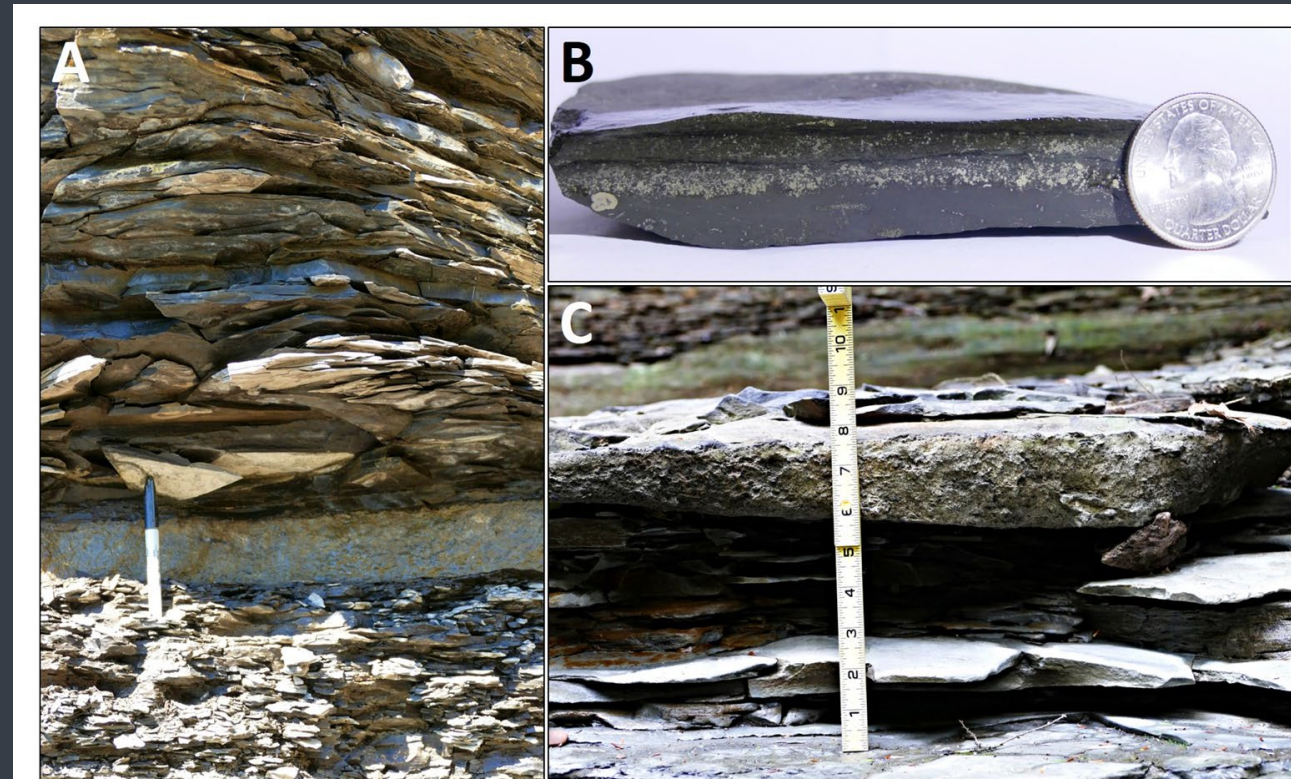


PROCESSES THAT MAY CONCENTRATE CMS IN SHALE

Diagenetic – Burn down



Sedimentologic – lag deposits



Dunkirk Shale

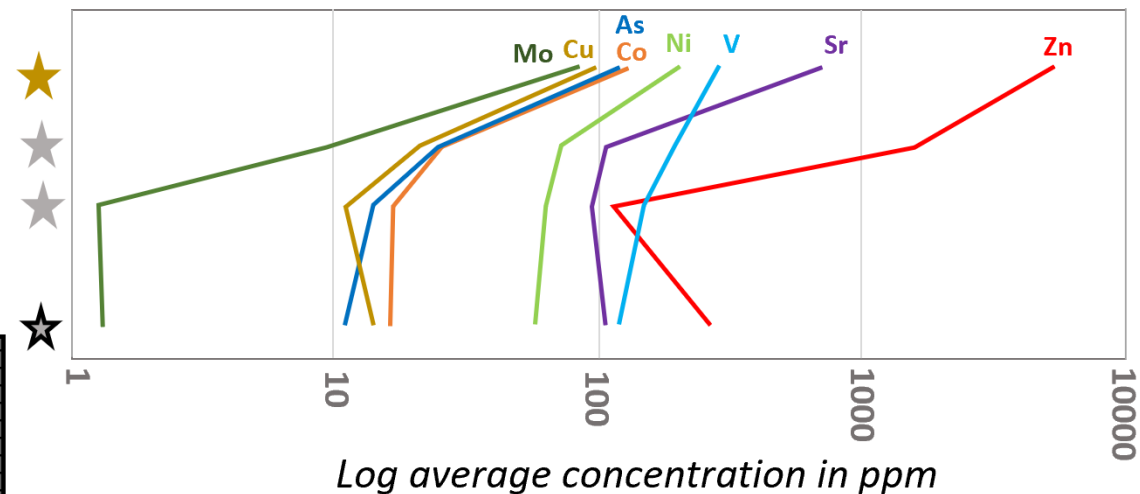
Hanover Shale

20 cm

6.5 cm

16.5 cm

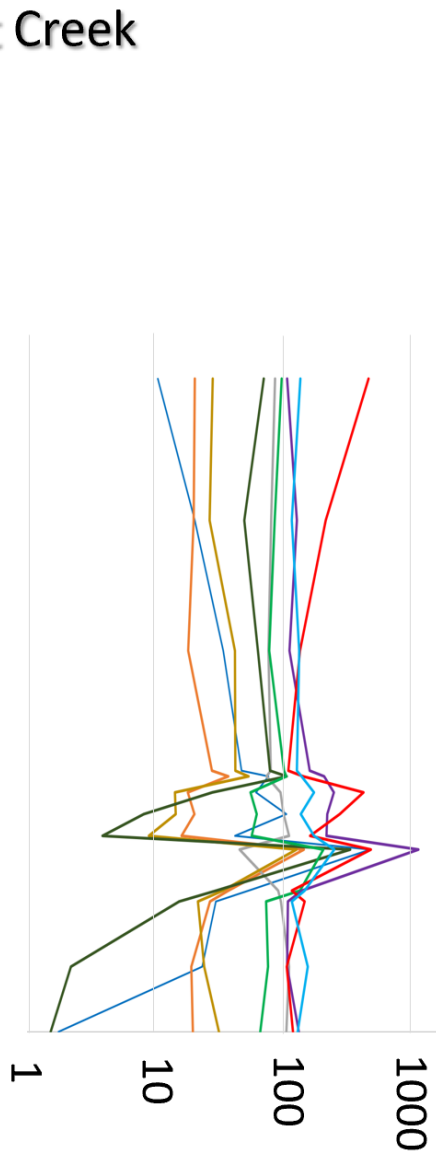
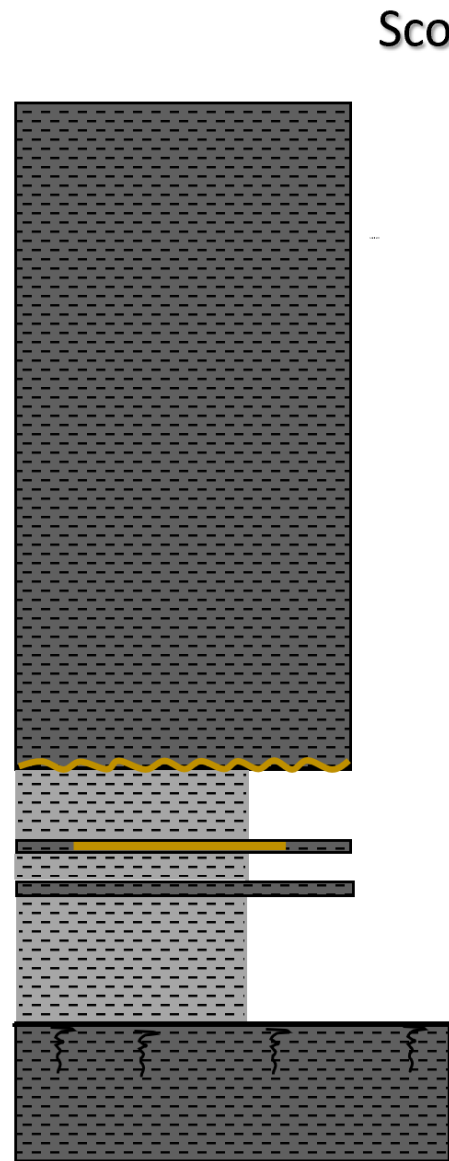
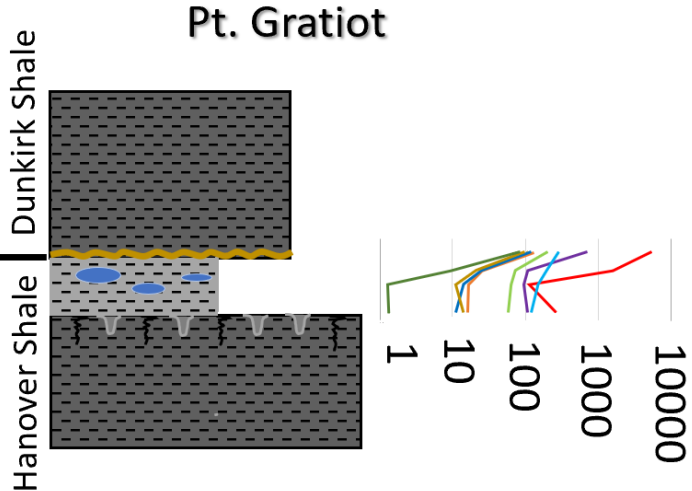
Stratigraphic variability highlighting
importance of sampling within a
geologic context



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

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