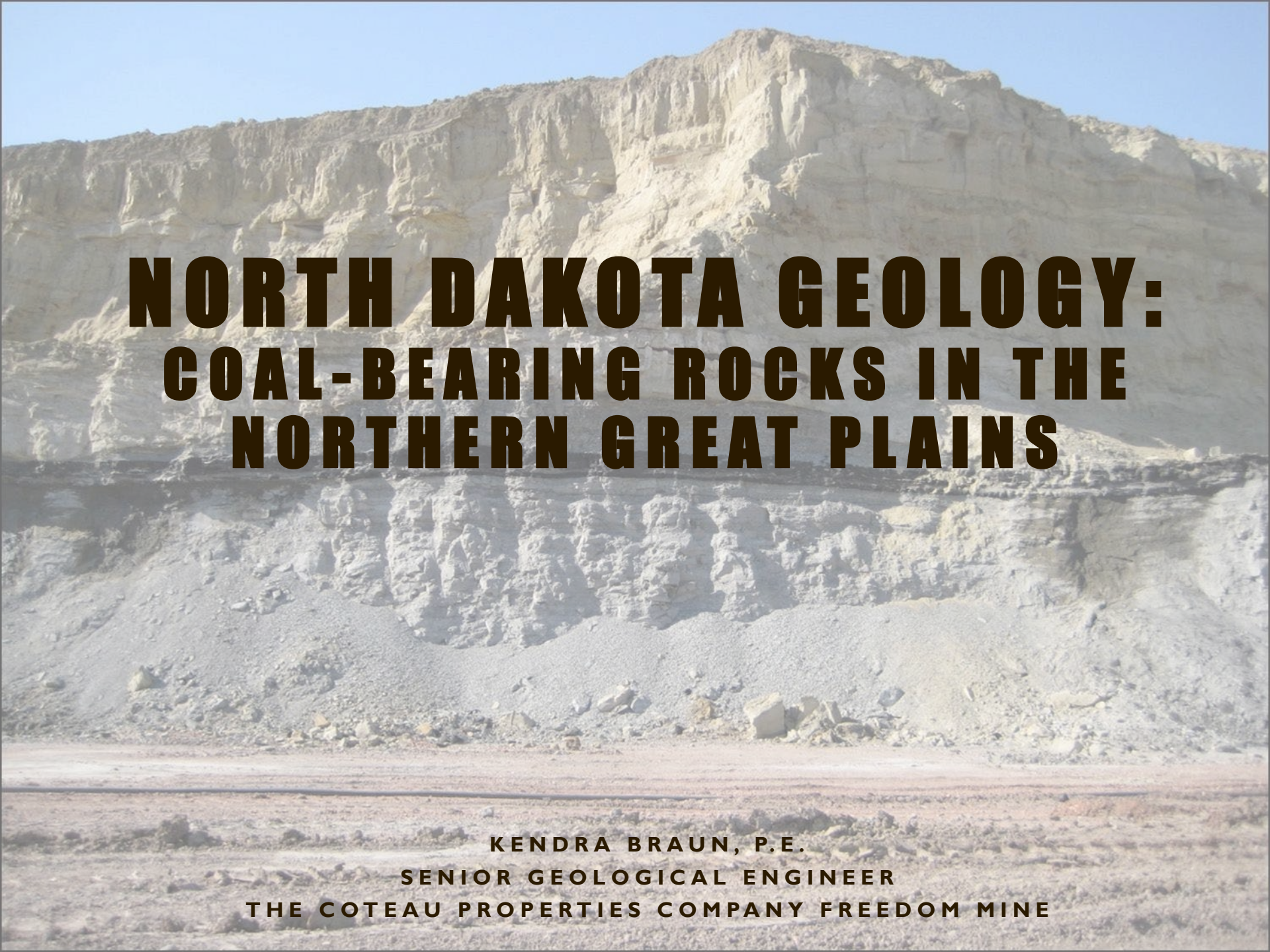


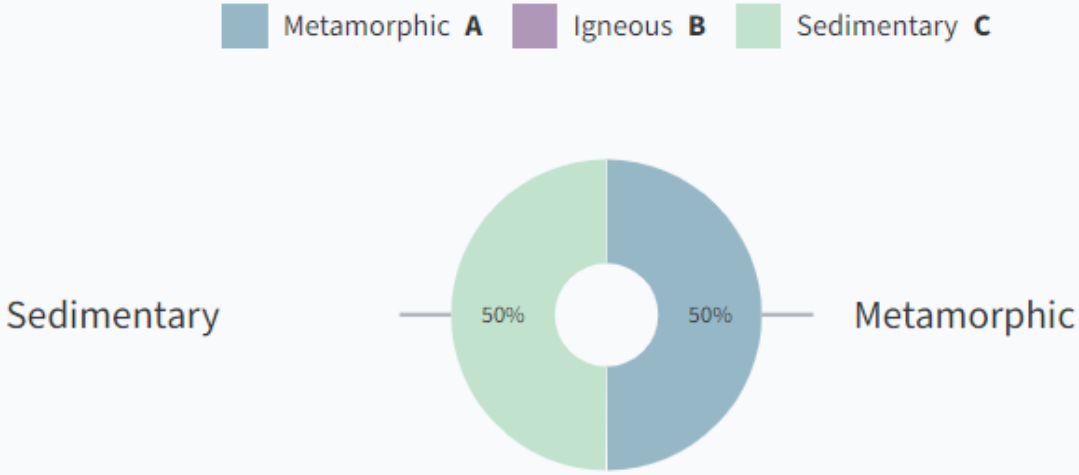
NORTH DAKOTA GEOLOGY:
COAL-BEARING ROCKS IN THE NORTHERN GREAT PLAINS

KENDRA BRAUN, P.E.
SENIOR GEOLOGICAL ENGINEER
THE COTEAU PROPERTIES COMPANY FREEDOM MINE

When poll is active, respond at **PollEv.com/ligniteenergy220**

Text **LIGNITEENERGY220** to **22333** once to join

What type or class of rock is coal?



DEFINITION OF COAL

A dark brown to black, combustible rock of organic origin formed by the partial decomposition of plant material that accumulated in an oxygen deficient environment, and underwent increased pressure and temperature over millions of years

CONDITIONS NECESSARY FOR PEAT FORMATION

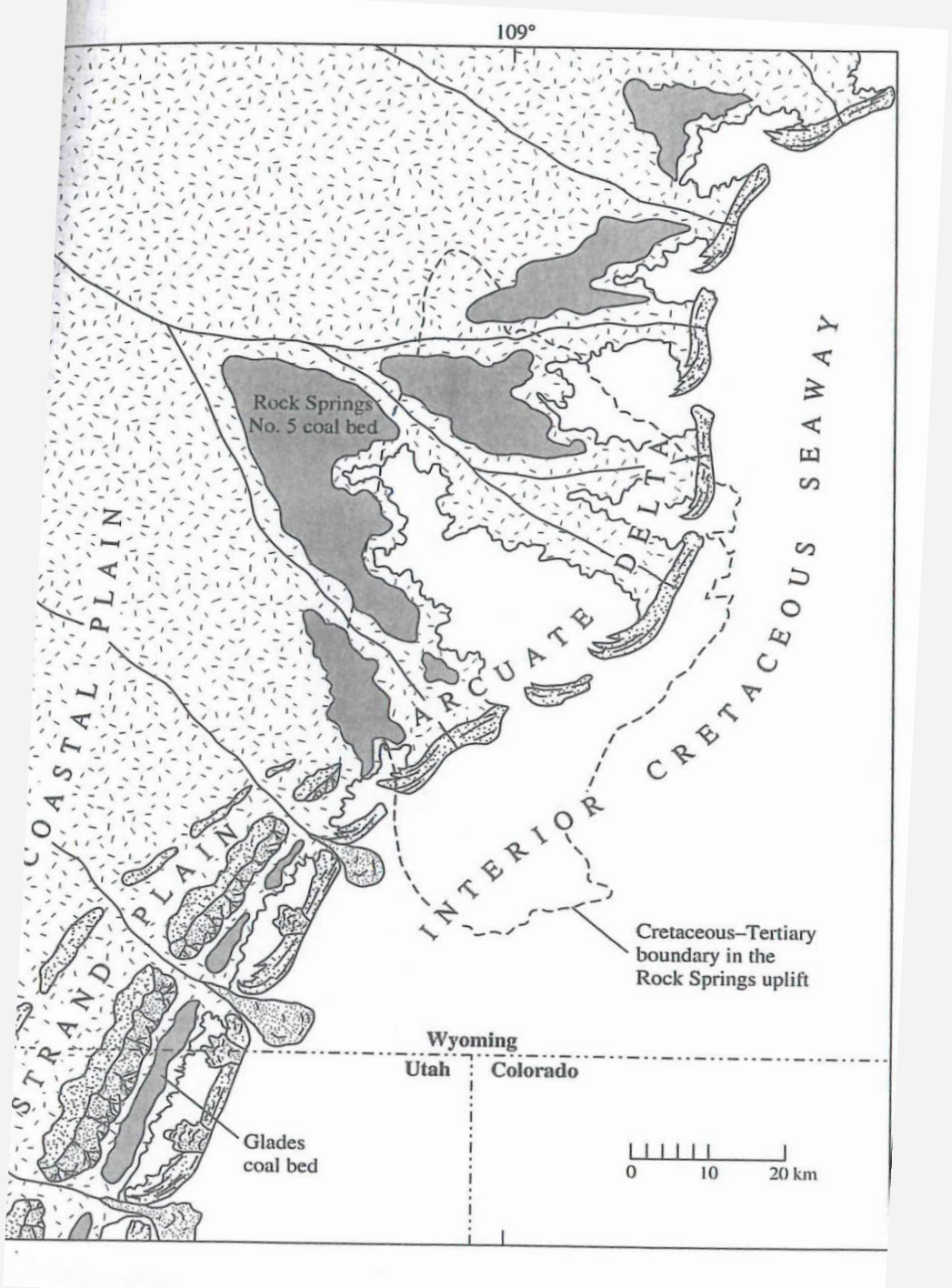
-Moderate to abundant plant growth

-Brackish to fresh water

-Lack of notable current activity

-Water table that prevents drowning of the environment but promotes preservation

-Stability of the depositional system through time



DELTA ENVIRONMENT

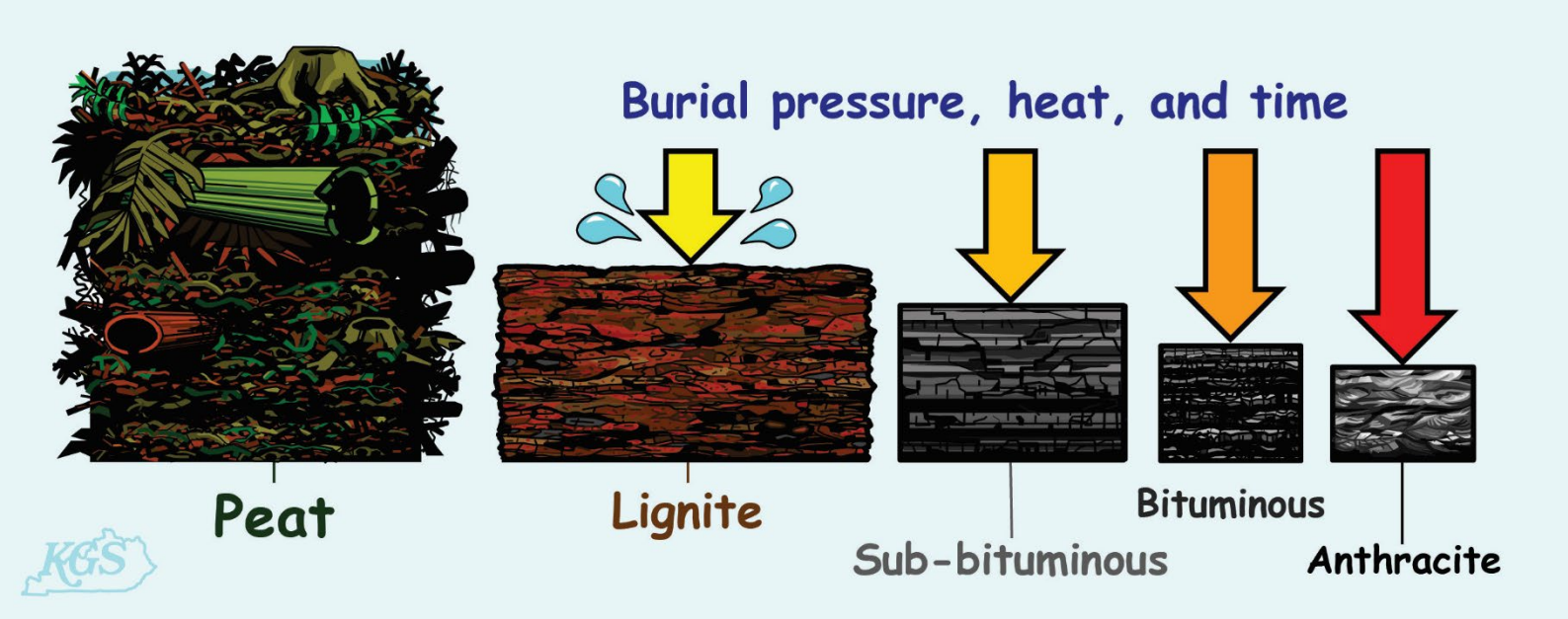
-Swamps formed within the delta

-Plant material in swamps turned to peat

-The peat and swamps were covered by clay or sand-due to floods or rising of sea level

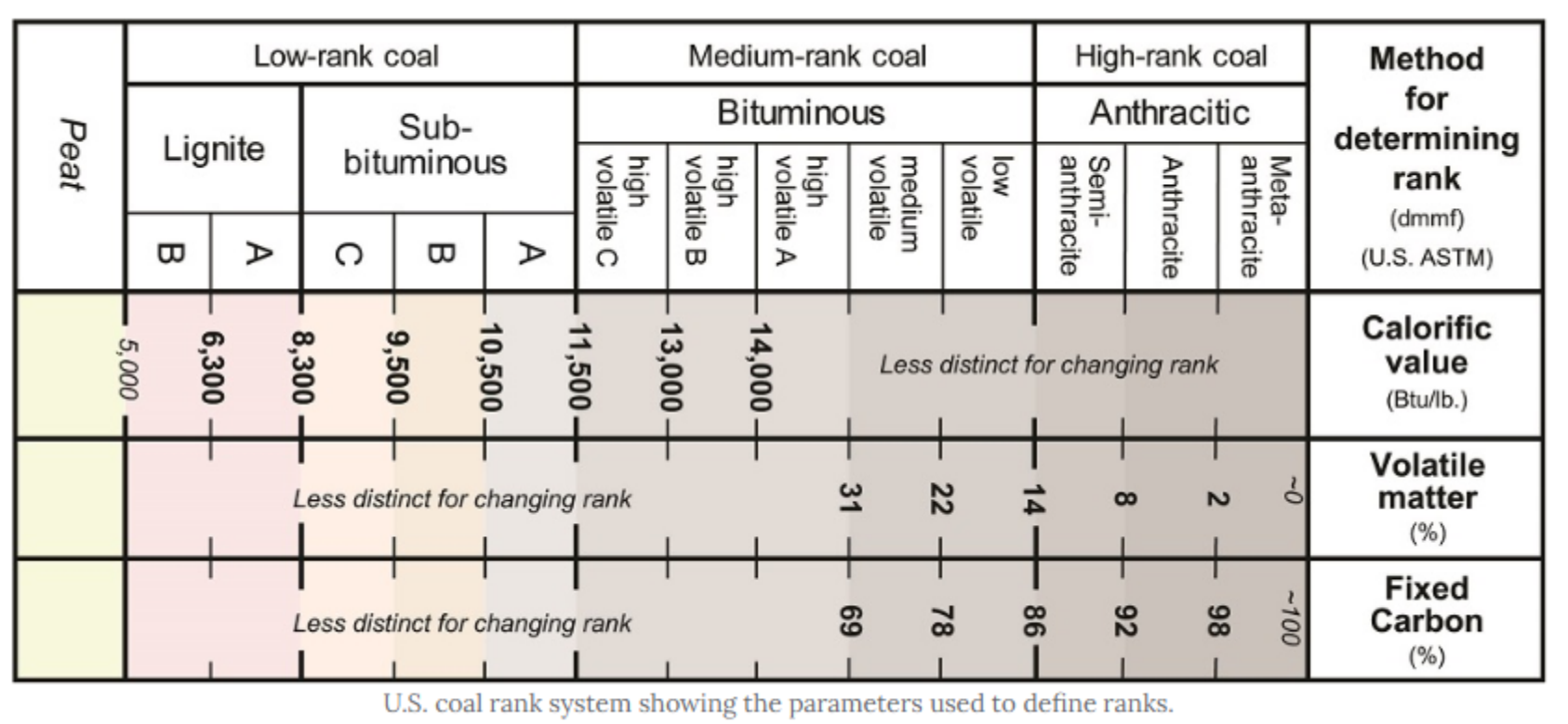
- More and more sediment accumulated and compressed the peat into coal

COALIFICATION PROCESS



- Generally takes 10 feet of plant material to make 1 foot of coal

COMMON U.S. COAL RANKS



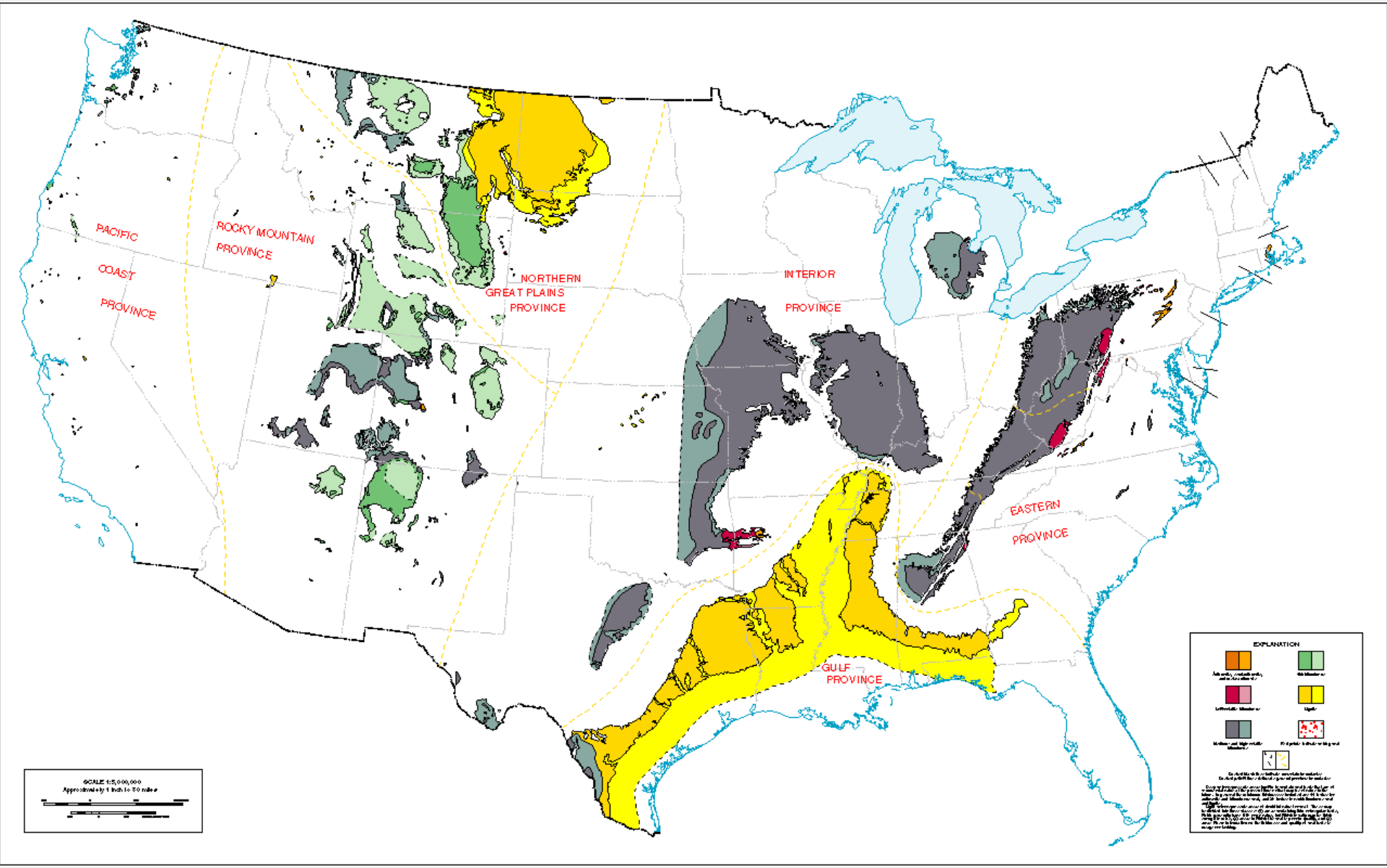
U.S. coal rank system showing the parameters used to define ranks.

- Rank increases with increased pressure, heat, and time.

COAL RESERVES

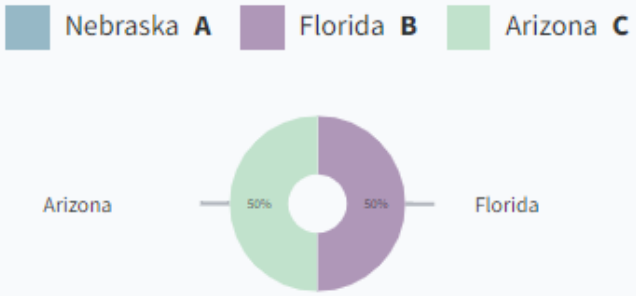
- In the United States, there is an estimated 252 billion short tons of recoverable coal reserves

- North Dakota contains an estimated 25 billion tons of economically mineable coal, enough to last for over 800 years at the present rate of about 30 million tons per year.


PACIFIC
COAST
PROVINCE
ROCKY MOUNTAIN
PROVINCE
NORTHERN
GREAT PLAINS
PROVINCE
INTERIOR
PROVINCE
EASTERN
PROVINCE
GULF
PROVINCE
EXPLANATION

Respond at **PollEv.com/ligniteenergy220**
Text **LIGNITEENERGY220** to **22333** once to join, then **A, B, or C**

What modern state has a climate that was similar to North Dakota's climate during peat formation 55-60 million years ago?



Our coal is located here-

Sentinel Butte Formation of the Fort Union Group

(55-60 million years old)

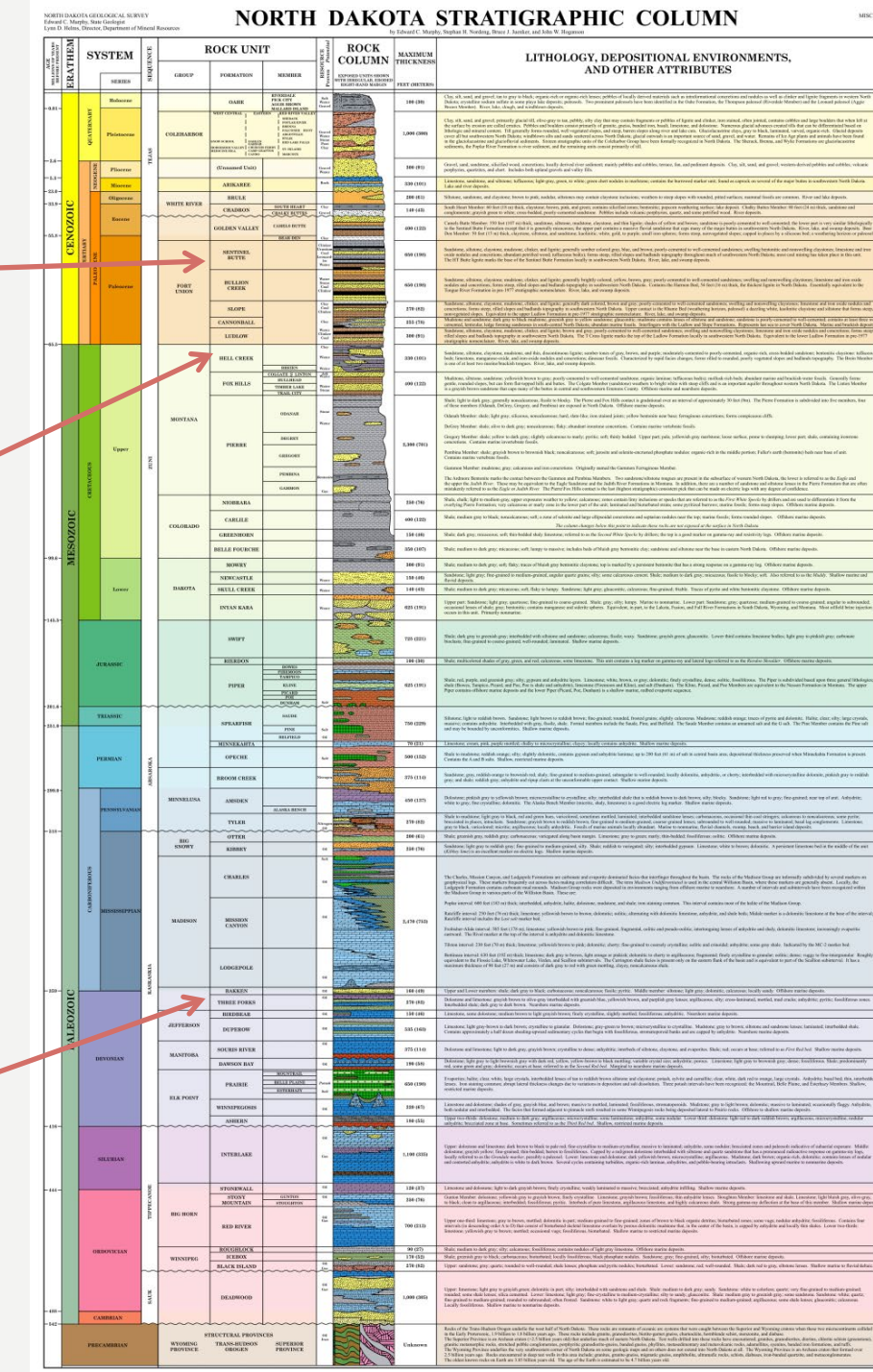
Latest Dinosaurs-

Hell Creek Formation

(65.5 million years and older)

Bakken Formation is located here

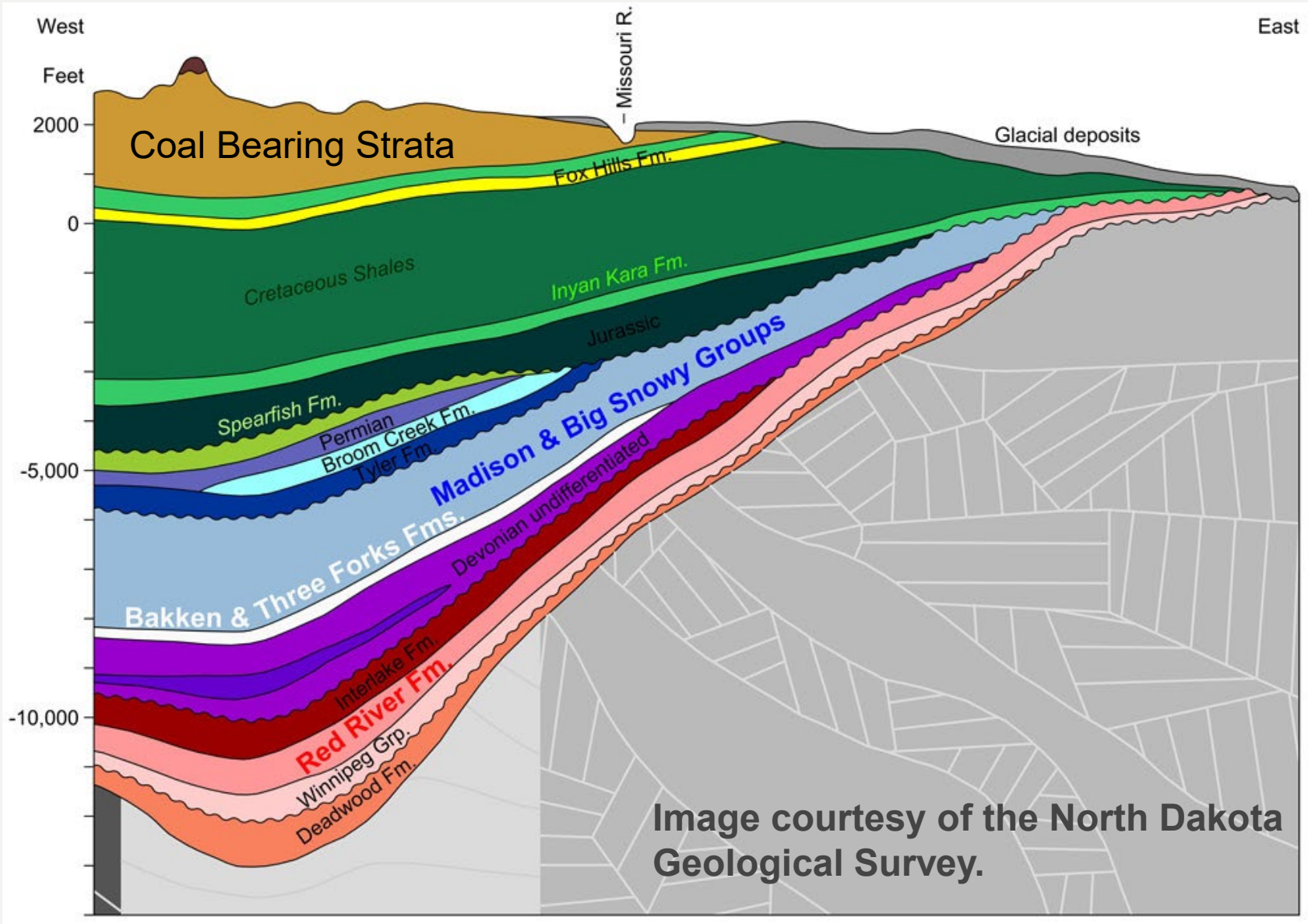
(359 million years Old)



SENTINEL BUTTE FORMATION

- Part of the Fort Union Group (age 55-65.5 million years)
- River, lake, and swamp deposits
- Located in the Williston Basin

WILLISTON BASIN



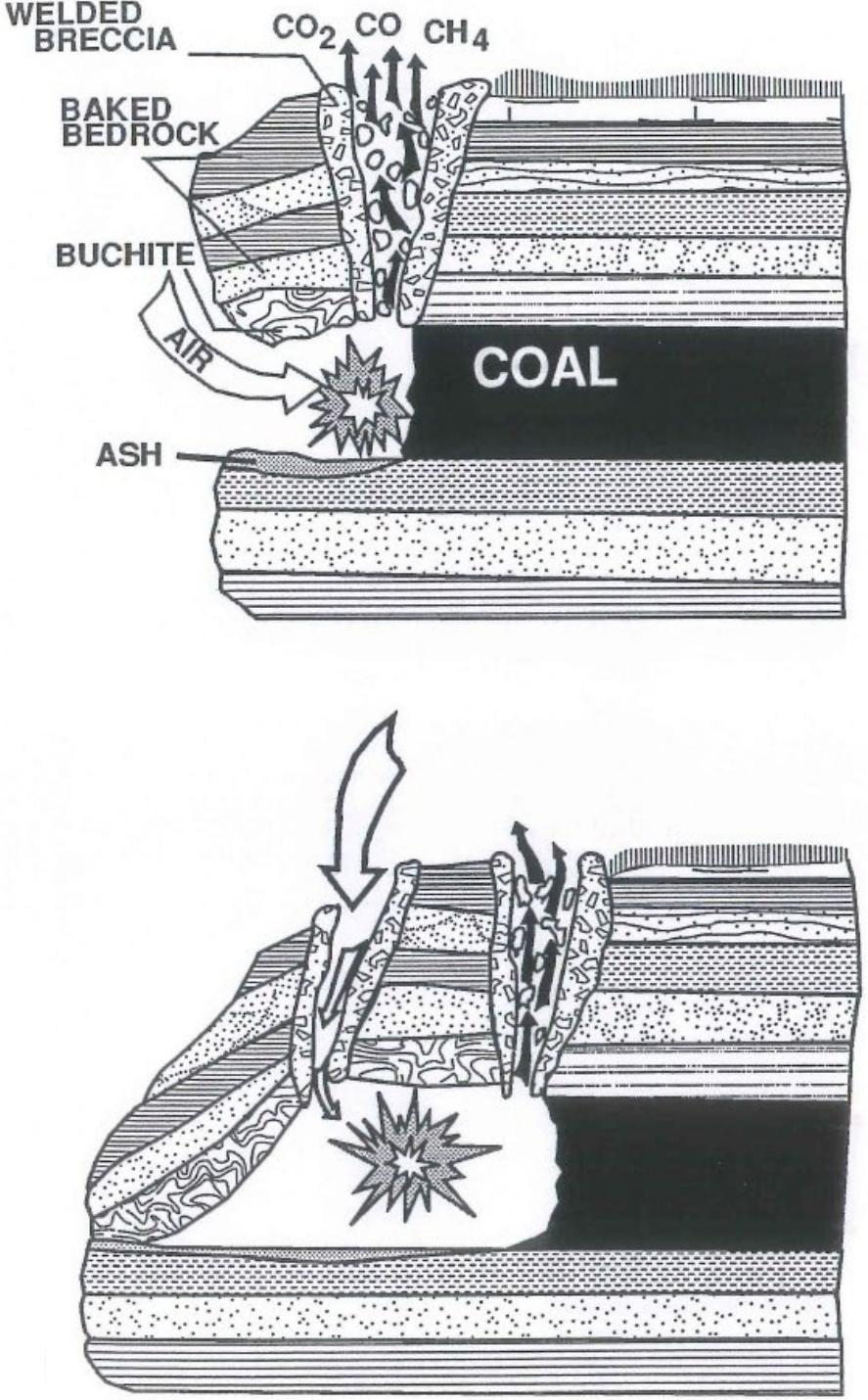
GLACIATION

- Three Glaciation Episodes
  - Latest was 18,000-25,000 years ago

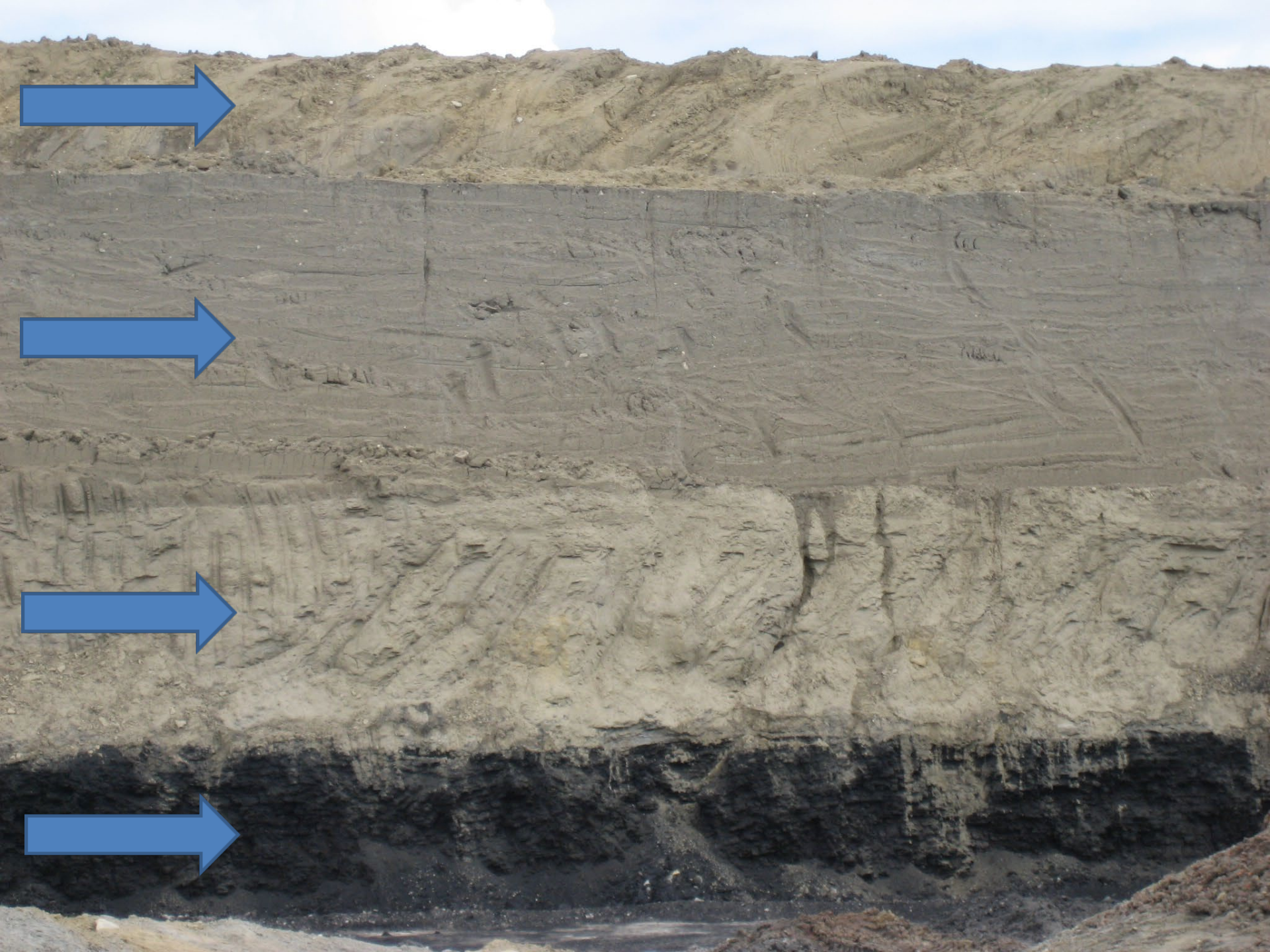
NDGS 2010

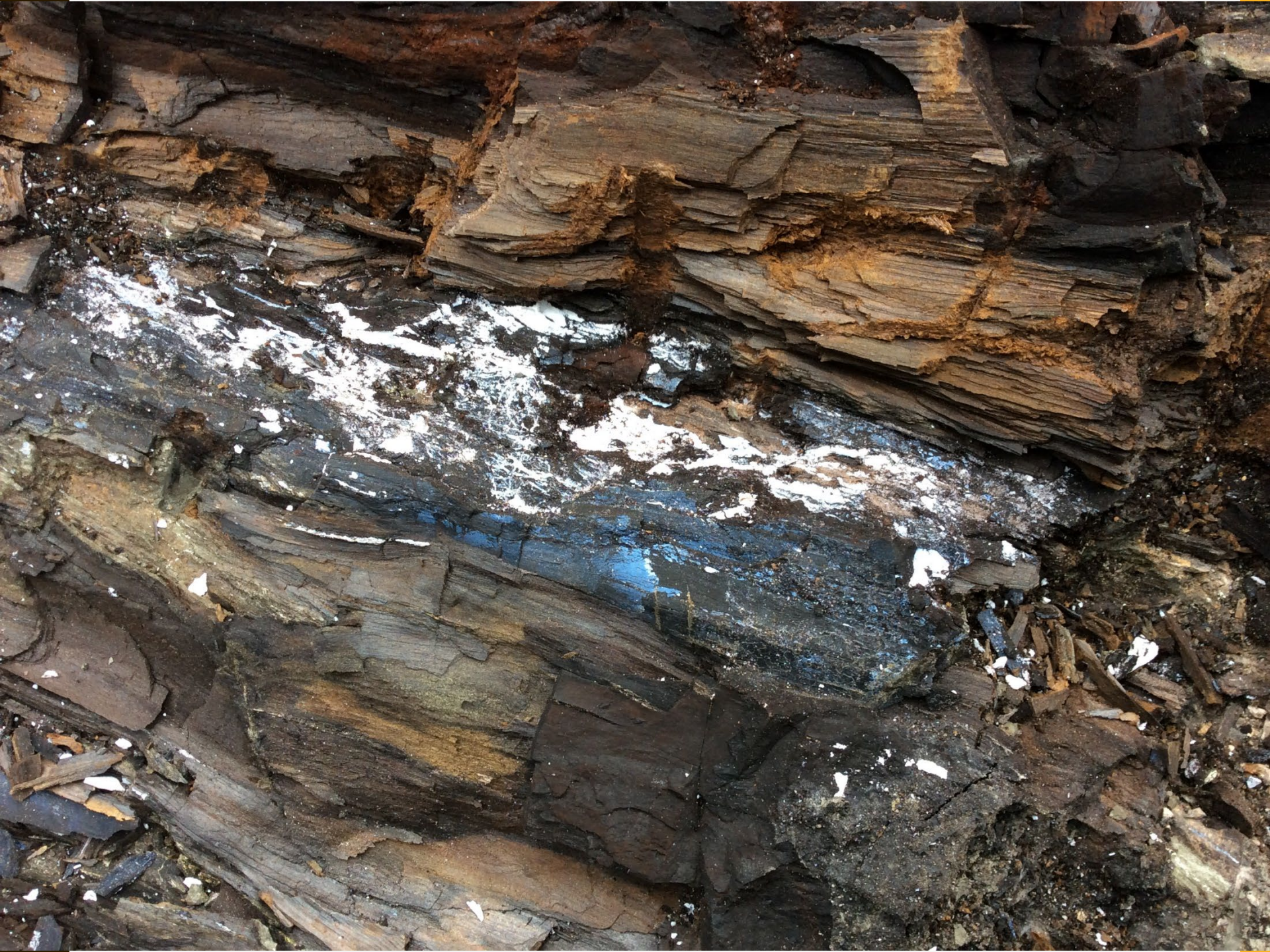

LAKE SAKAKAWEA
Fort Berthold
Reservation
Beaver Creek Bay
Beaver Bay
1806
Freedom
Mine
North Star Mine
Antelope
Creek
200
49
Zap
Beulah
Hazen
Indian
Head
(By Edward C. Murphy, 2007 NDGS)

CLINKER "SCORIA" FORMATION



Field Observations





GREEN CLAY/SAND

- Glauconite-mineral that makes the material green-deposited in reducing (oxygen deficient) marine environments-organic influence

- Paleosol-ancient soils that the trees of the swamp grew in

- This area was the outer limit of the Schoolhouse seam swamp

- There was not enough tree material here to accumulate enough peat to make a coal seam-

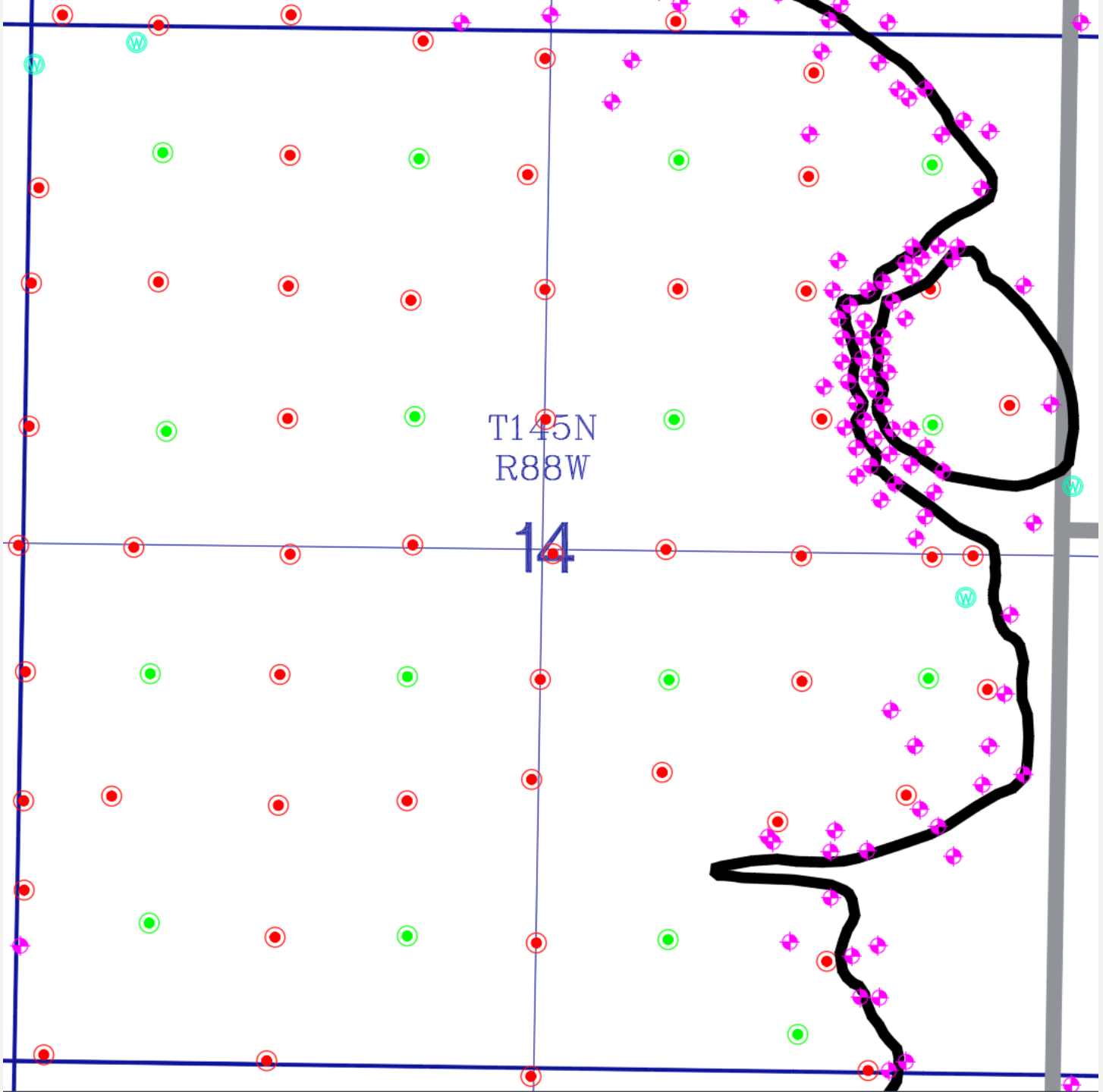
GEOLOGY OBJECTIVES

- Define Mining Limits
- Croplines-coal/no coal, hard/soft coal
- Characterize OB type and thickness
- Characterize coal thickness and quality
- Develop Geologic Model of stratigraphy and coal quality
- Predict coal quality for customers
- Collect data for regulatory requirements
- Explore New Areas

GEOLOGIC DRILLING

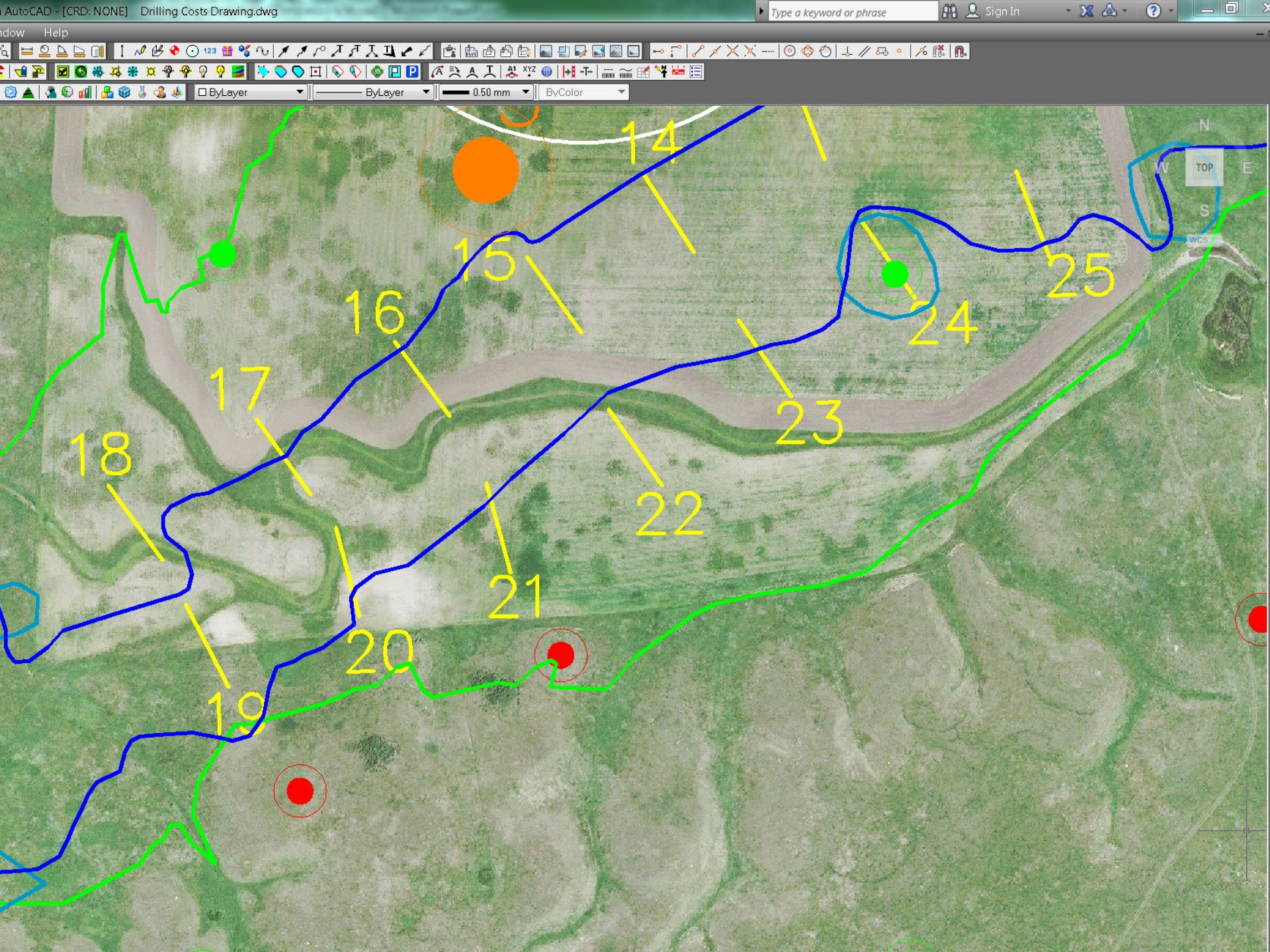
EXPLORATION DRILLING PROCEDURE

- New Area-Drill 1 core hole every mile
- Permitting-Drill 1 OB core hole every 40 acres-16 per Section
- Fill in for better modeling for quality and OB characteristics-1320’ spacing pattern
- Fill in for even better modeling for more accurate mine plan projections-660’ spacing pattern-3yrs ahead of mining-


T145N
R88W
14

CROPLINING PROCEDURE

- Cropline=edge of mineable coal
- Start with estimated cropline
- Locate traverses every 300’ along the estimated cropline
- Drill rotary holes along traverse perpendicular to cropline at a 100’ spacing
- Find complete profile of full thickness hard coal, and no coal
- Adjust cropline accordingly-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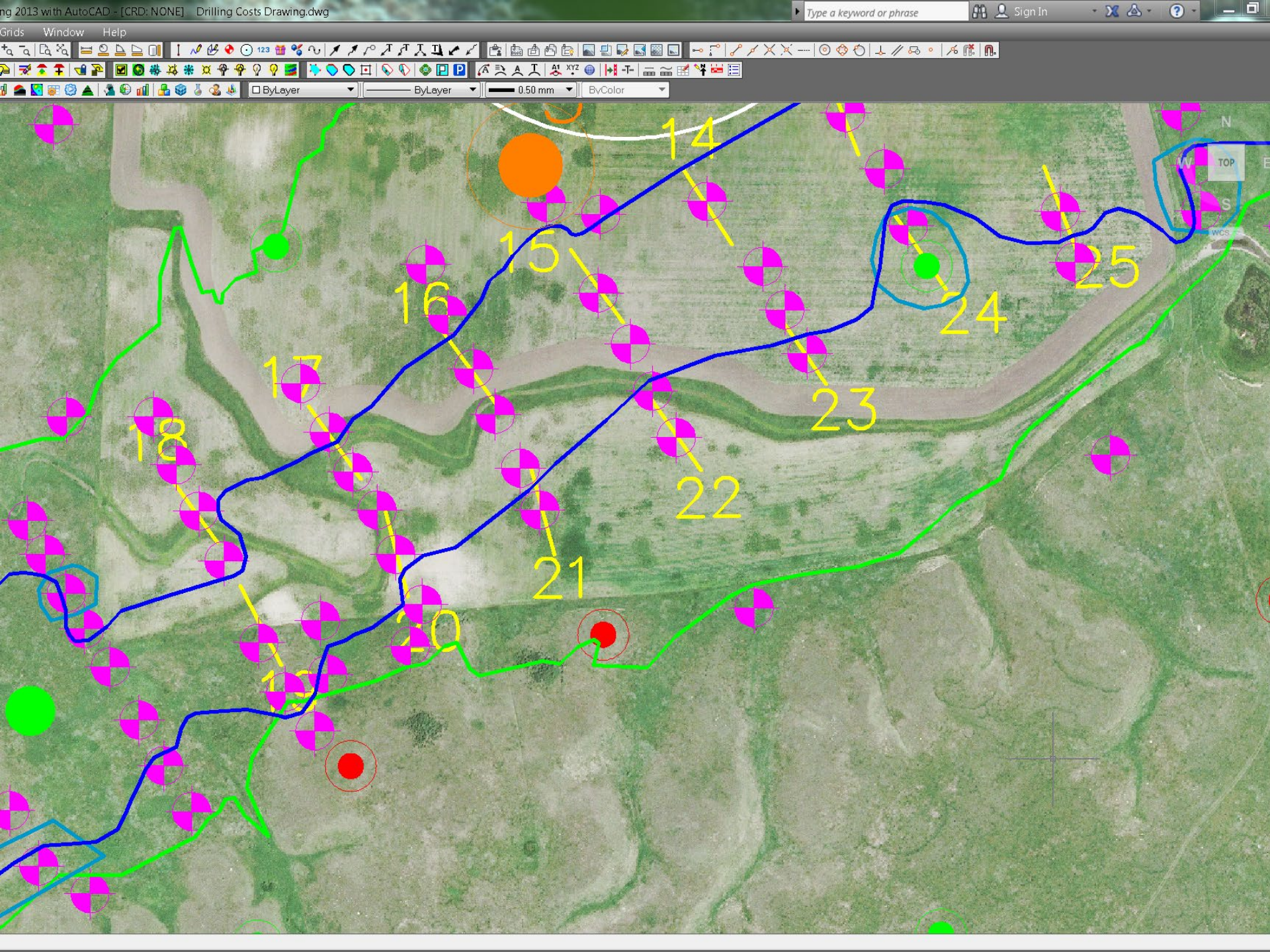
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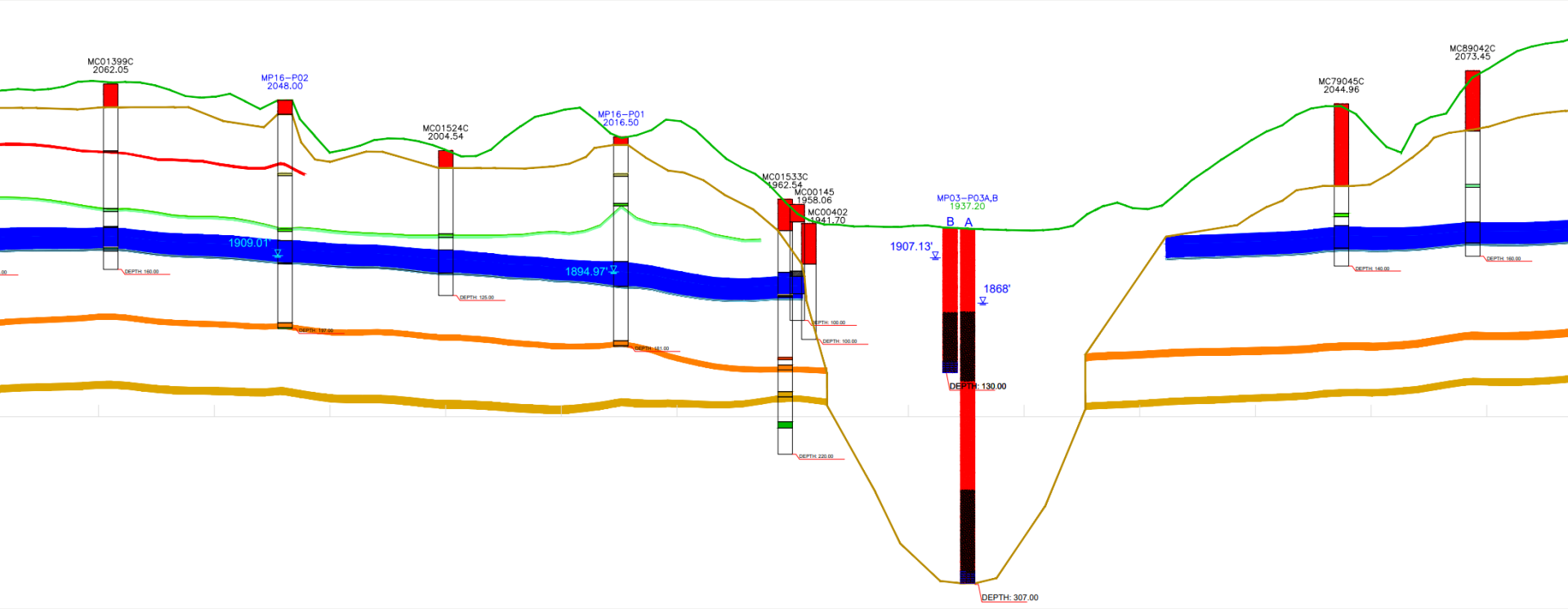
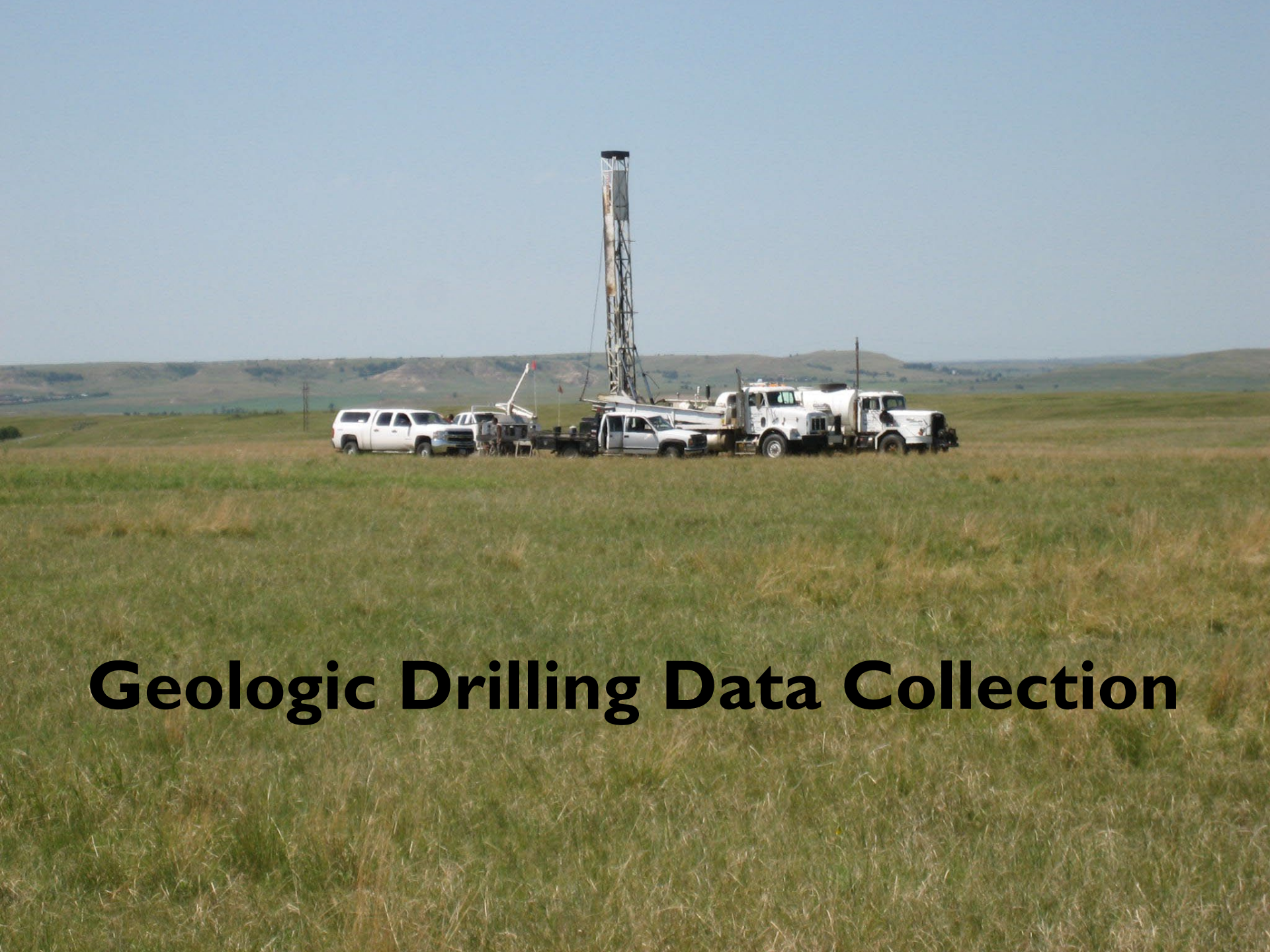
CROSS-SECTION





Geologic Drilling Data Collection

Geologist's Drilling Log

GEOLOGIST'S DRILLING LOG

Drill Hole Designation CC1247C Date 10 / 30 / 12

Geologist K. Kruger Driller Mohl / Jason Logger Century / Keith

Location SE4 Section 23

T 143 R 89 Elevation

Grid Coordinates

Landowner Unrun

Surface Lease ☐ Yes ☐ No Coal Lease ☐ Yes ☐ No

N ↑ (23)

Depth From	Depth To	Strata Thickness	Description
0	5		till, brown silty sandy clay w/ few pebbles soft
5	10		till, brown orange silty sandy clay, damp
10	15		till, brown orange silty sandy clay - soft
15	20		till brown sandy silty clay w/ few small gravel
20	25		clay, brown, orange & brown rocky
25			coal, soft, black - carby clay?
	35		clay, gray orange brown, rooted w/ iron froth
35	40		clay, gray orange brown silty w/ organics & some iron staining
40	46.4		clay, dark gray micaceous
46.4	56.75	10.35	coal, hard, black vbev
			clay, dark gray, rocky rooted
56.75	60		clay, gray, silty w/ micaceous w/ gray froth
60	70		clay, gray
			coal

T. D. 70

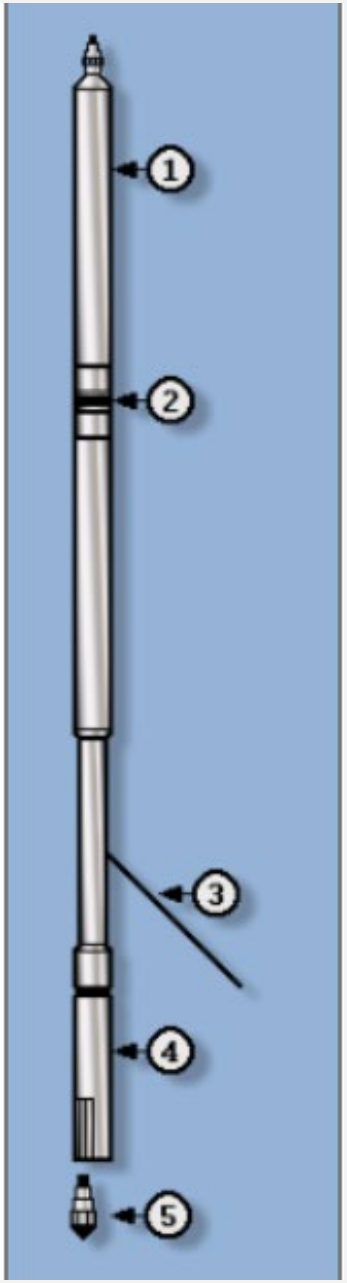
E-Log Coal Tree

Land Use: prairie / pasture

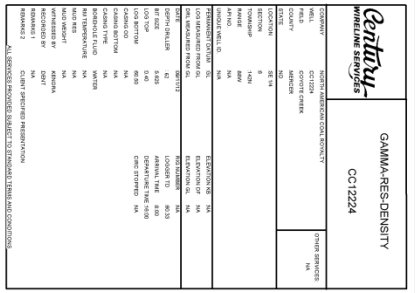
No. OB Samples:

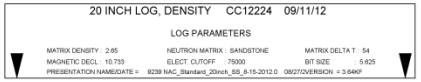
Remarks:

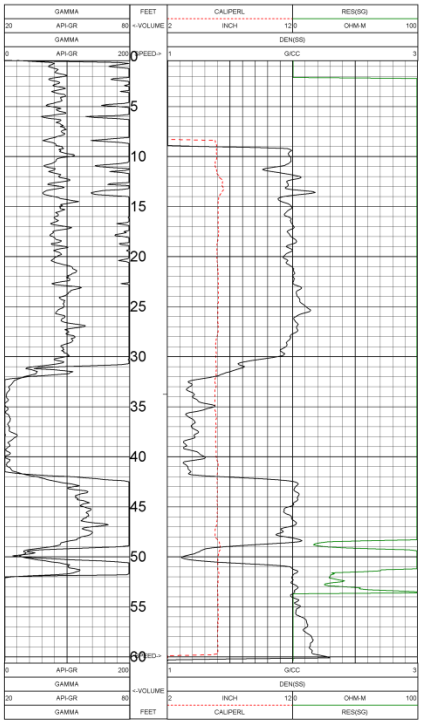
Revised 11/09

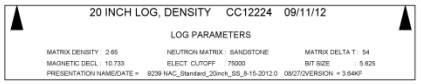


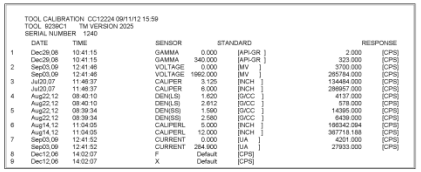
Geophysical Log











Core Descriptions/ Observations

Page 1 of 2

Geologist's Coring Log

Date 10 / 30 / 12

Core Hole Designation CC12471C Seam Designation Upper Pittsburgh

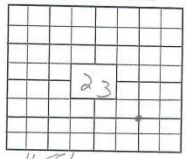
Geologist Kirkman Driller Mohi / Jason Logger Centry / Kathy

Location SE4 Section 23

T 143 R 89 Elevation

Grid Coordinates

Landowner Unruh



Surface Lease ☐ Yes ☐ No Coal Lease ☐ Yes ☐ No

Coring Interval From 40 To 58 (Depth From Surface) Total Recovery 11.55'

Total Coal Recovered 10.35' Percent Coal Recovered 100%

Core Size 3" Drilling Fluid mist Percent Core Recovered 96%

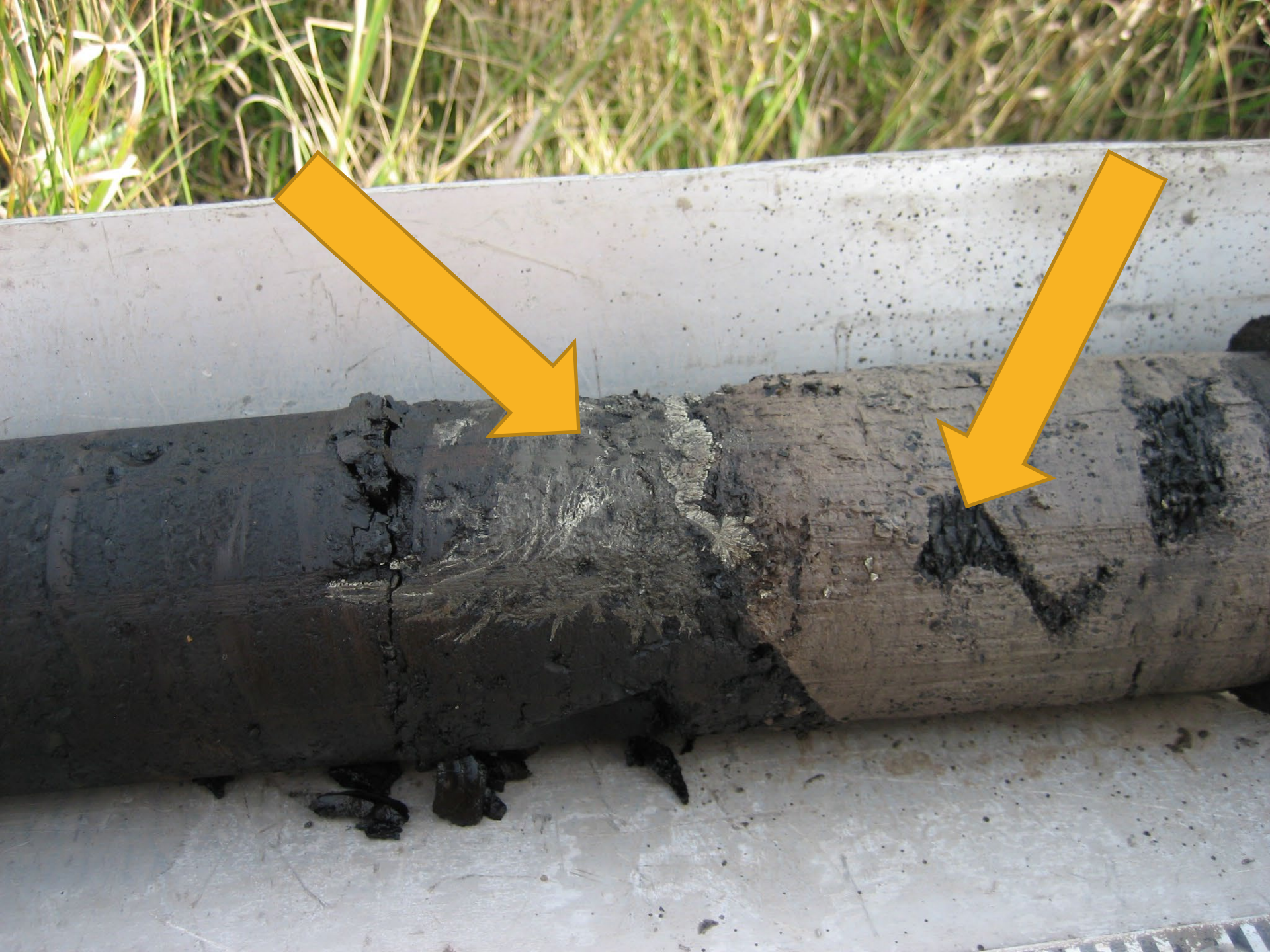
% Core Recovery	Sampled Intervals	Depth	Joints	Strat Column	Visual Description	Coal Quality % Moisture % Ash % Sulfur BTU % NA2O	Depth
					sticken silt in coal @ top		
					coal, hard, black, sl. shiny fractured		
					brown tiny woody notch @ 2.5, 3.35		
					bladed pyrite @ 3.85, 5.15		
					pyrite nods @ 4.3, 4.75, 6.5, 7.2		
					rare pyrite staining on face fract		

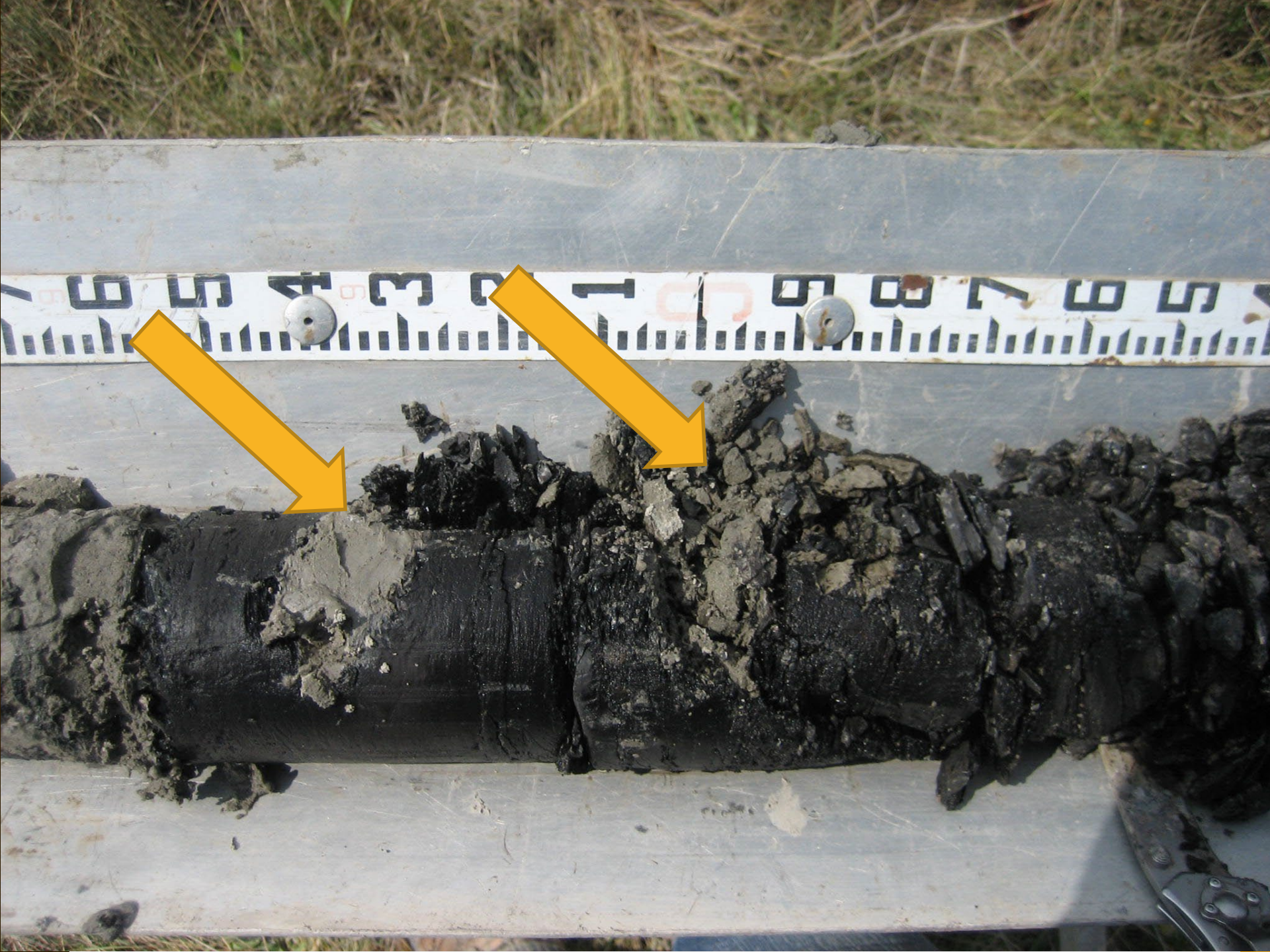
T. D. Land Use: No. OB Samples:

Pilot Hole #: prairie/pasture

Remarks: - cleaned up 1 cm - lots of horizontal & vert fractures

Revised 11/09





COAL ANALYSIS

-Based on Customer needs and requests

-Long Analysis-every mile

- -Full Prox, Ultimate, Trace Elements, Mineral Ash, Ash Fusion, Sulfur Forms

-Short Prox + Na and CaO and Sulfur Forms-all other holes

MINNESOTA VALLEY TESTING LABORATORIES, INC.

1126 North Front St. ~ New Ulm, MN 56073 ~ 800-782-3557 ~ Fax 507-359-2890
2616 East Broadway Ave. ~ Bismarck, ND 58501 ~ 800-279-6885 ~ Fax 701-258-9724
51 West Lincoln Way ~ Nevada, IA 50201 ~ 800-362-0855 ~ Fax 515-382-3885
www.mvtl.com

MEMBER ACIL

Sample Number: 12-C1089

Kendra Kungu
Coteau Properties Co
204 County Rd 15
Beulah ND 58523

Report Date: 8/ 3/12

Work Order #: 89-442
P.O. #: Coyote Creek
Date Collected: 7/12/12

Date Received: 7/13/12

Thickness: 3.4-13.0

Sample Description:
Hole #: CC12031C
Seam #: Upper Beulah

* PROXIMATE *

ANALYTE	AS RECEIVED		DRY BASIS	
Total Moisture	36.75	wt. %		
Ash	7.98	wt. %	12.62	wt. %
Volatile Matter	25.61	wt. %	40.49	wt. %
Fixed Carbon	29.66	wt. %	46.89	wt. %
BTU/lb	6869	BTU/lb	10860	BTU/lb
Total Sulfur	1.01	wt. %	1.60	wt. %

* ULTIMATE *

ANALYTE	AS RECEIVED		DRY BASIS	
Total Moisture	36.75	wt. %		
Ash	7.98	wt. %	12.62	wt. %
Carbon	42.68	wt. %	67.48	wt. %
Hydrogen	6.79	wt. %	4.23	wt. %
Nitrogen	0.55	wt. %	0.87	wt. %
Total Sulfur	1.01	wt. %	1.60	wt. %
Oxygen by Difference	40.99	wt. %	13.21	wt. %
Chlorine	20.6	ug/g	32.6	ug/g

* SULFUR FORMS *

ANALYTE	AS RECEIVED		DRY BASIS	
Sulfur Forms, Organic	0.32	wt. %	0.51	wt. %
Sulfur Forms, Pyritic	0.68	wt. %	1.08	wt. %
Sulfur Forms, Sulfate	0.01	wt. %	0.02	wt. %
Total Sulfur	1.01	wt. %	1.60	wt. %

* ASH FUSION *

ANALYTE	REDUCING		OXIDIZING	
Intial Def. Temp.	2095	Degrees F	2281	Degrees F
Softening Temp.	2198	Degrees F	2312	Degrees F
Hemispherical Temp.	2221	Degrees F	2340	Degrees F
Fluid Temp.	2290	Degrees F	2399	Degrees F

* MINERAL ANALYSIS OF ASH *

ANALYTE	DRY BASIS	
Silicon Dioxide in Ash	21.35	wt. %
Aluminum Oxide in Ash	10.28	wt. %
Titanium Dioxide in Ash	0.39	wt. %
Iron Oxide in Ash	16.05	wt. %
Calcium Oxide in Ash	17.18	wt. %
Magnesium Oxide in Ash	4.62	wt. %
Potassium Oxide in Ash	0.29	wt. %
Sodium Oxide in Ash	9.68	wt. %
SO3 in Ash	15.30	wt. %
P2O5 in Ash	0.20	wt. %
Strontium Oxide in Ash	0.60	wt. %
Barium Oxide in Ash	1.21	wt. %
Manganese Dioxide in Ash	0.02	wt. %

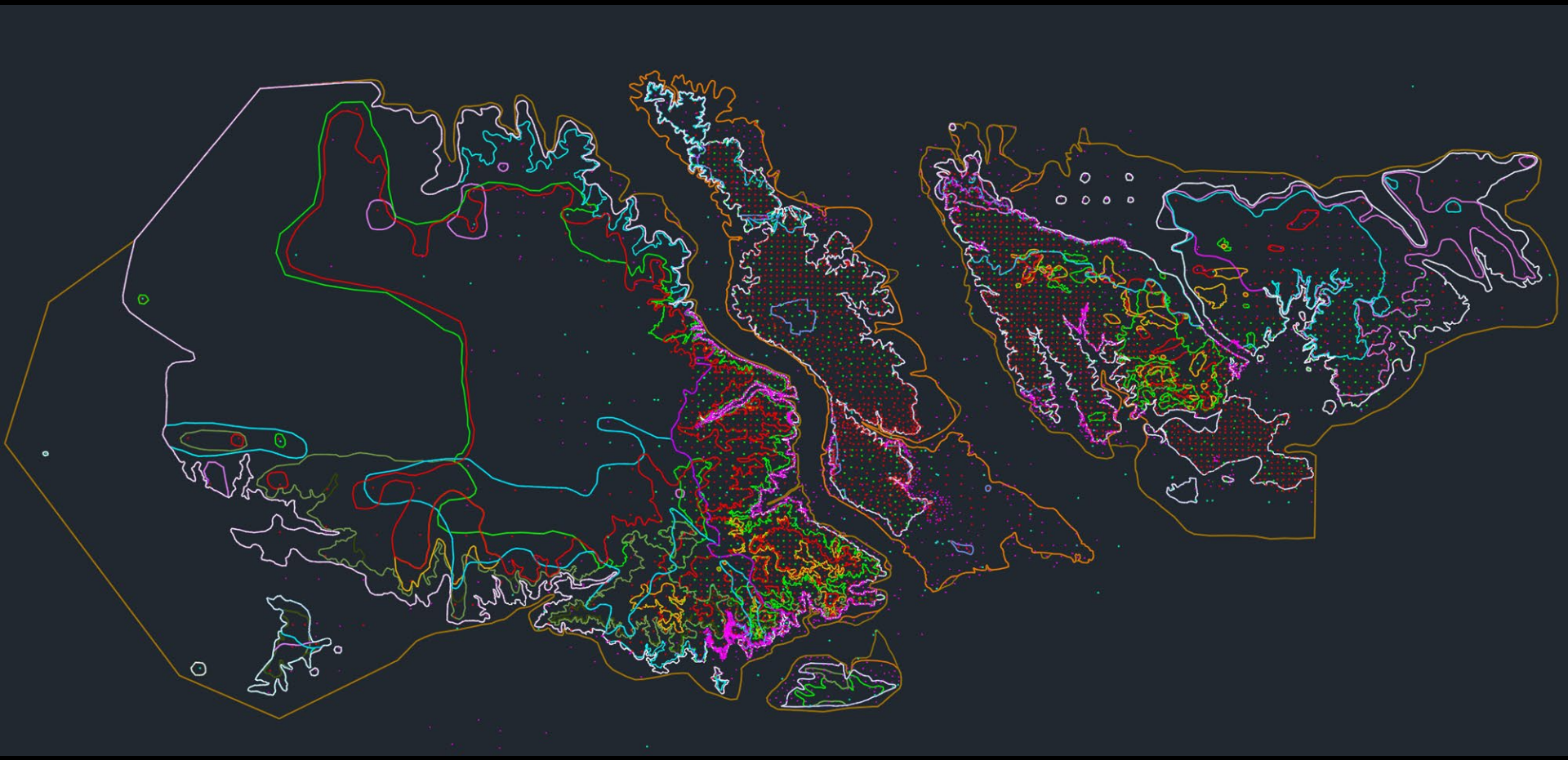
* MISCELLANEOUS *

ANALYTE	AS RECEIVED		DRY BASIS	
Beryllium, Air Dried Coal	0.82	ppm		
Cadmium, Air Dried Coal	< 0.11	ppm		
Chromium, Air Dried Coal	3.12	ppm		
Cobalt, Air Dried Coal	0.69	ppm		
Arsenic, Air Dried Coal	8.52	ppm		
Manganese, Air Dried Coal	8.83	ppm		
Nickel, Air Dried Coal	4.20	ppm		
Lead, Air Dried Coal	2.21	ppm		
Selenium, Air Dried Coal	< 0.54	ppm		
Uranium, Air Dried Coal	0.80	ppm		
Antimony, Air Dried Coal	< 0.54	ppm		
Mercury, Trace	0.103	ug/g	0.163	ug/g

Approved By: [signature]

GEOLOGIC MODEL

- All drilling data gets inputted into the geologic model
- It is the foundation for the entire mine
- It characterizes the thickness and type of overburden, the thickness and quality of the coal, and coal seam extent and splits
- Utilized for long range and short range mine planning, it tells the mining engineers:
  - How much dirt we need to move to get to a certain quantity and quality of coal based on customer needs
  - How much equipment we need to move the dirt and mine the coal
  - How many people we need to run the equipment, and the schedules for the equipment and employees
  - Helps predict geologic obstacles
  - Utilized to determine expansion areas and future resources




Questions?