Coal Combustion Inc.

Understanding the business of coal

Member:

American Society of Mechanical Engineers

American Chemical Society

Society for Mining, Metallurgy, and Exploration

North Carolina Coal Institute

sponsor

PRB COAL USERS' GROUP

Contacts:

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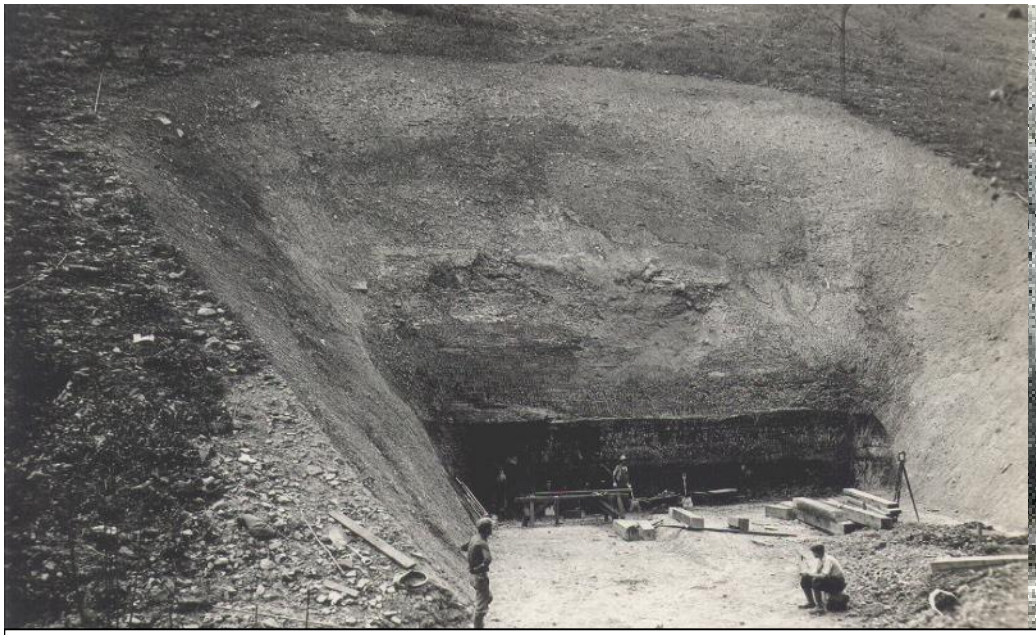
ISLAND GREEN
SINCE 1908
CCI


Spinach Pie
สปิแนชพาย
I'm lovin' it
ความอร่อยที่ใครๆ ก็คิดถึง
The return of an all-time favorite pie
29.-
พายกรอบอร่อย
อัดแน่นผักโขมชุ่มชีส
มอสซาเรลล่าเข้มข้นเต็มคำ
A crispy golden brown pie deliciously filled
with spinach and mozzarella cheese.



This is where coal comes from.

Terms

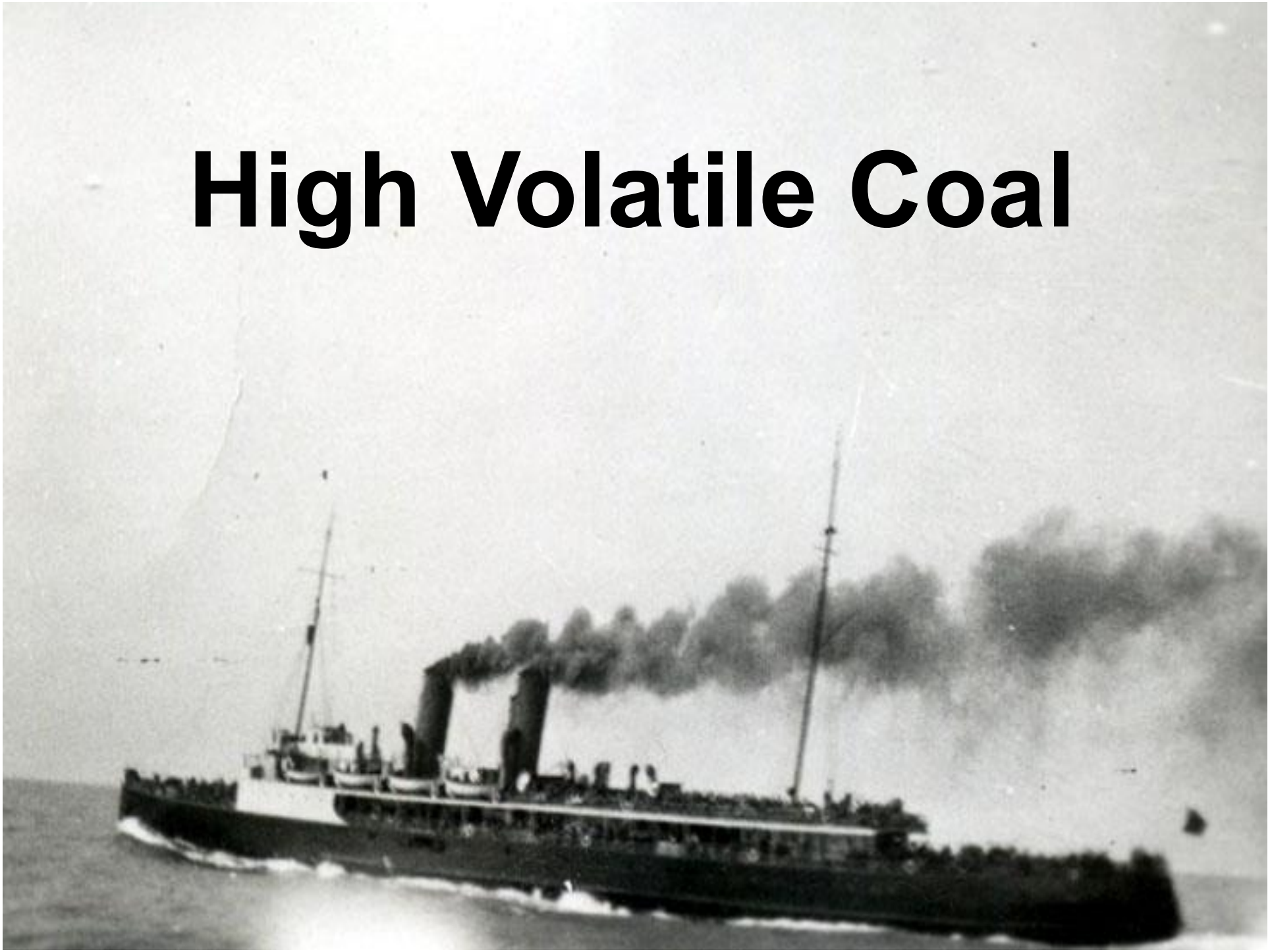
Proximate means Approximate

Proximate

Moisture
Ash
Volatile - important to smoke

Fixed Carbon (by Difference)

High Volatile Coal



Denbigh - 1863 Blockade runner fueled with low volatile
Did captain use ap**proximate** test?

Terms

As Received

Air Dry Basis or As determined
ADB – Totally useless (lab sample)

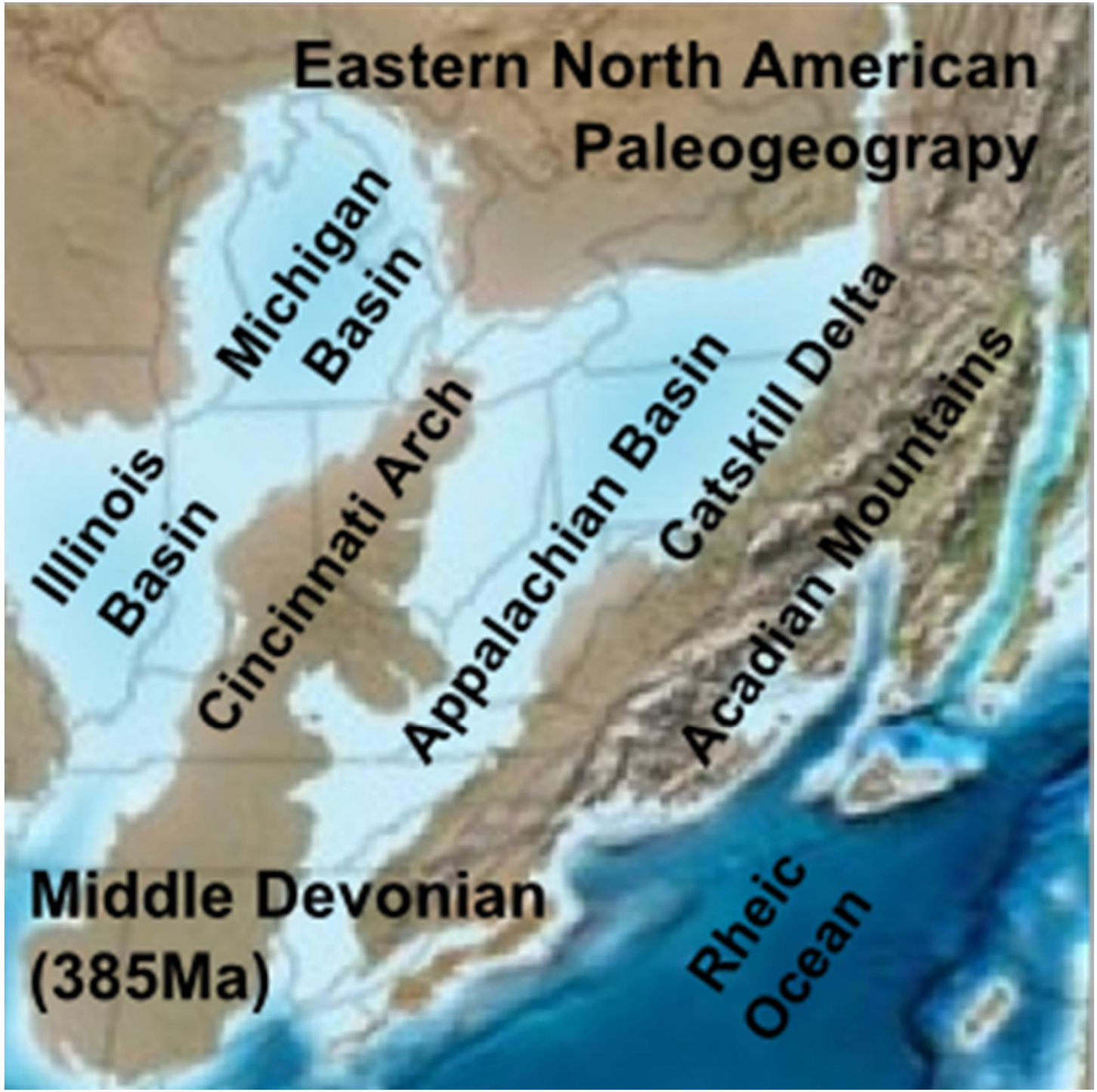
Dry Basis, DB

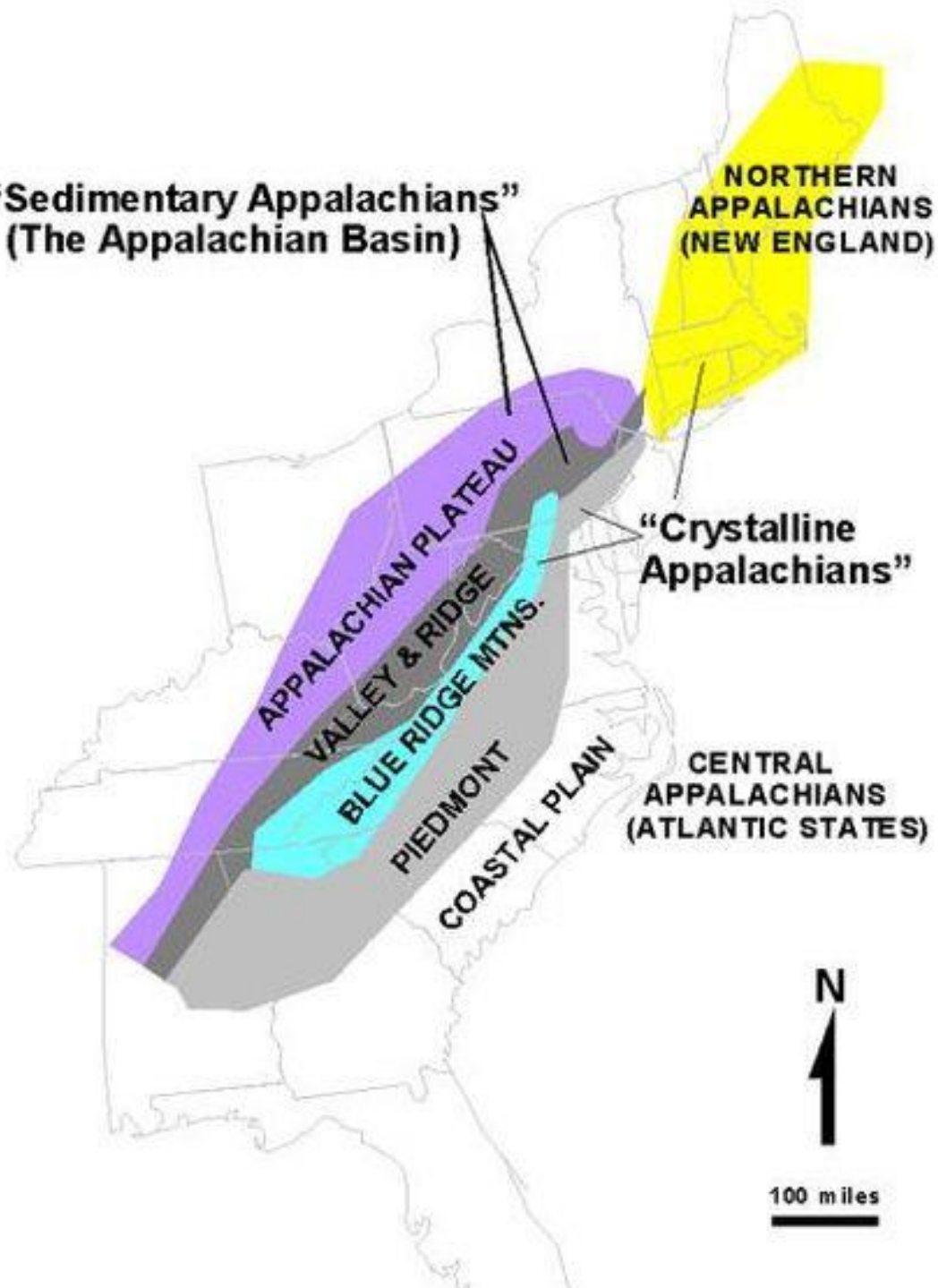
Moisture Ash Free, MAF

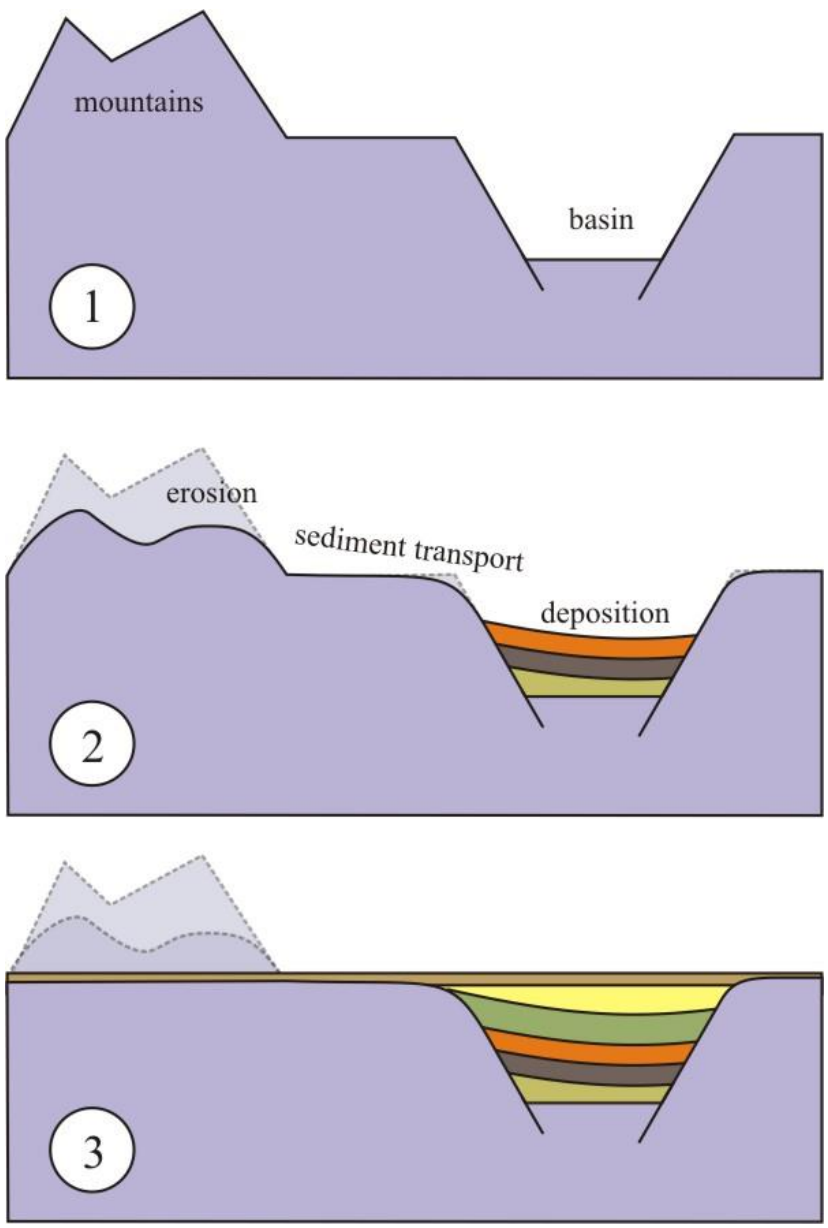
Moisture Mineral Matter Free, MMMF

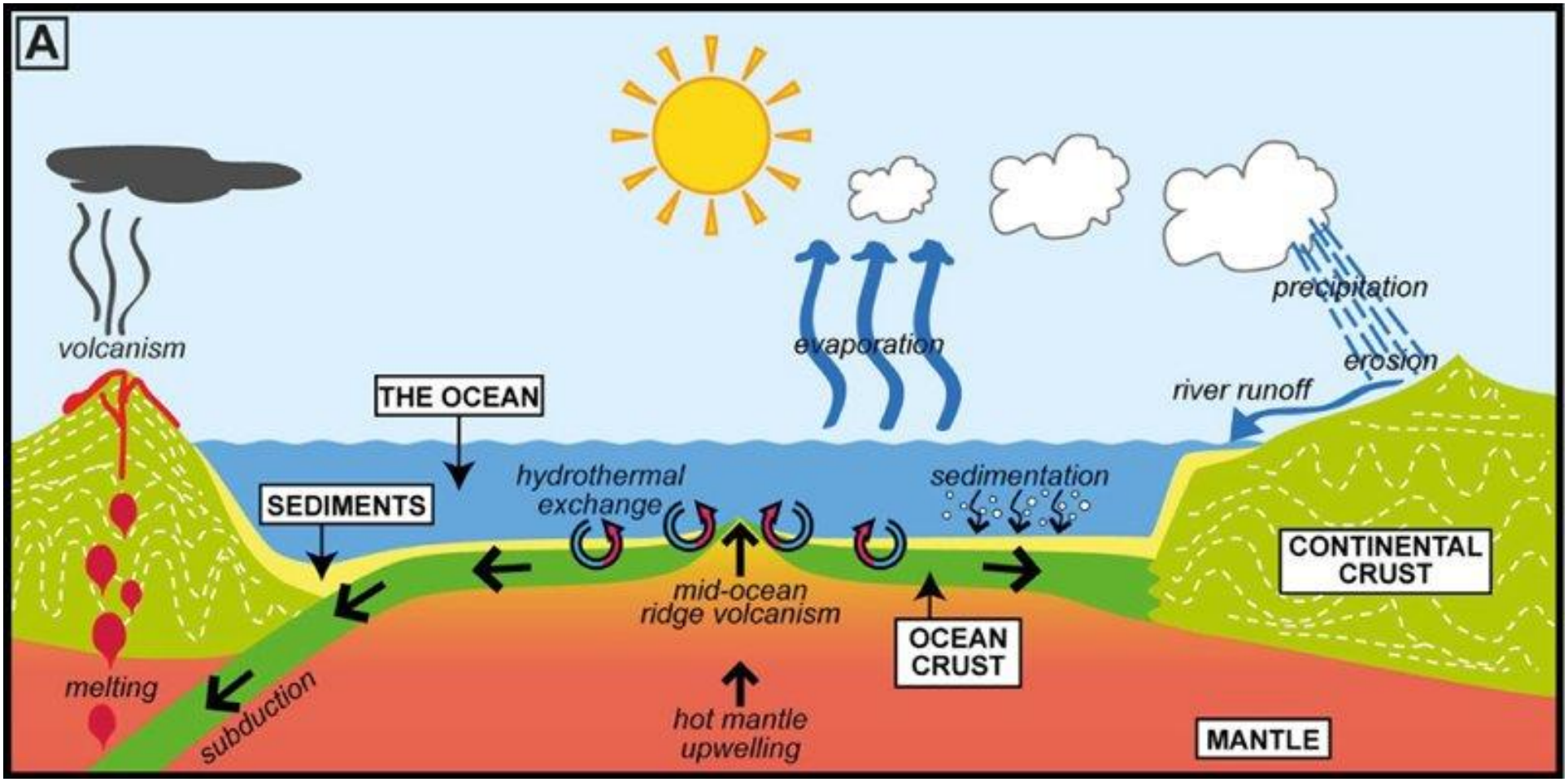
Dry Ash Free, DAF

Coal Swamps and Rain Forest


Eastern North American
Paleogeograpy
Michigan
Basin
Illinois
Basin
Cincinnati Arch
Appalachian Basin
Catskill Delta
Acadian Mountains
Middle Devonian
(385Ma)
Rheic
Ocean


"Sedimentary Appalachians"
(The Appalachian Basin)
NORTHERN
APPALACHIANS
(NEW ENGLAND)
"Crystalline
Appalachians"
APPALACHIAN PLATEAU
VALLEY & RIDGE
BLUE RIDGE MTNS.
PIEDMONT
COASTAL PLAIN
CENTRAL
APPALACHIANS
(ATLANTIC STATES)
N
100 miles


mountains
basin
1
erosion
sediment transport
deposition
2
3


A
volcanism
evaporation
precipitation
erosion
river runoff
THE OCEAN
SEDIMENTS
hydrothermal
exchange
sedimentation
CONTINENTAL
CRUST
mid-ocean
ridge volcanism
OCEAN
CRUST
melting
subduction
hot mantle
upwelling
MANTLE

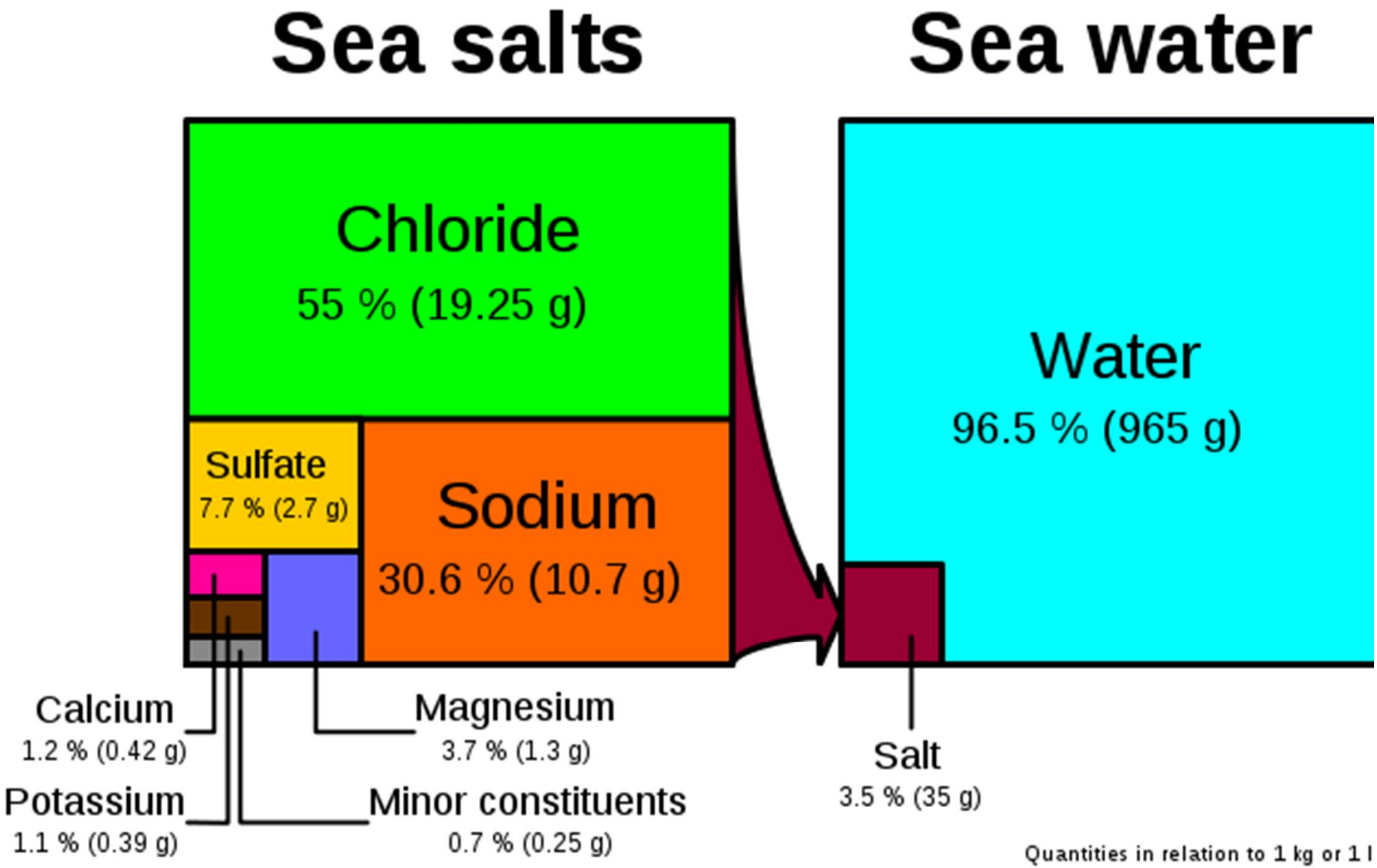
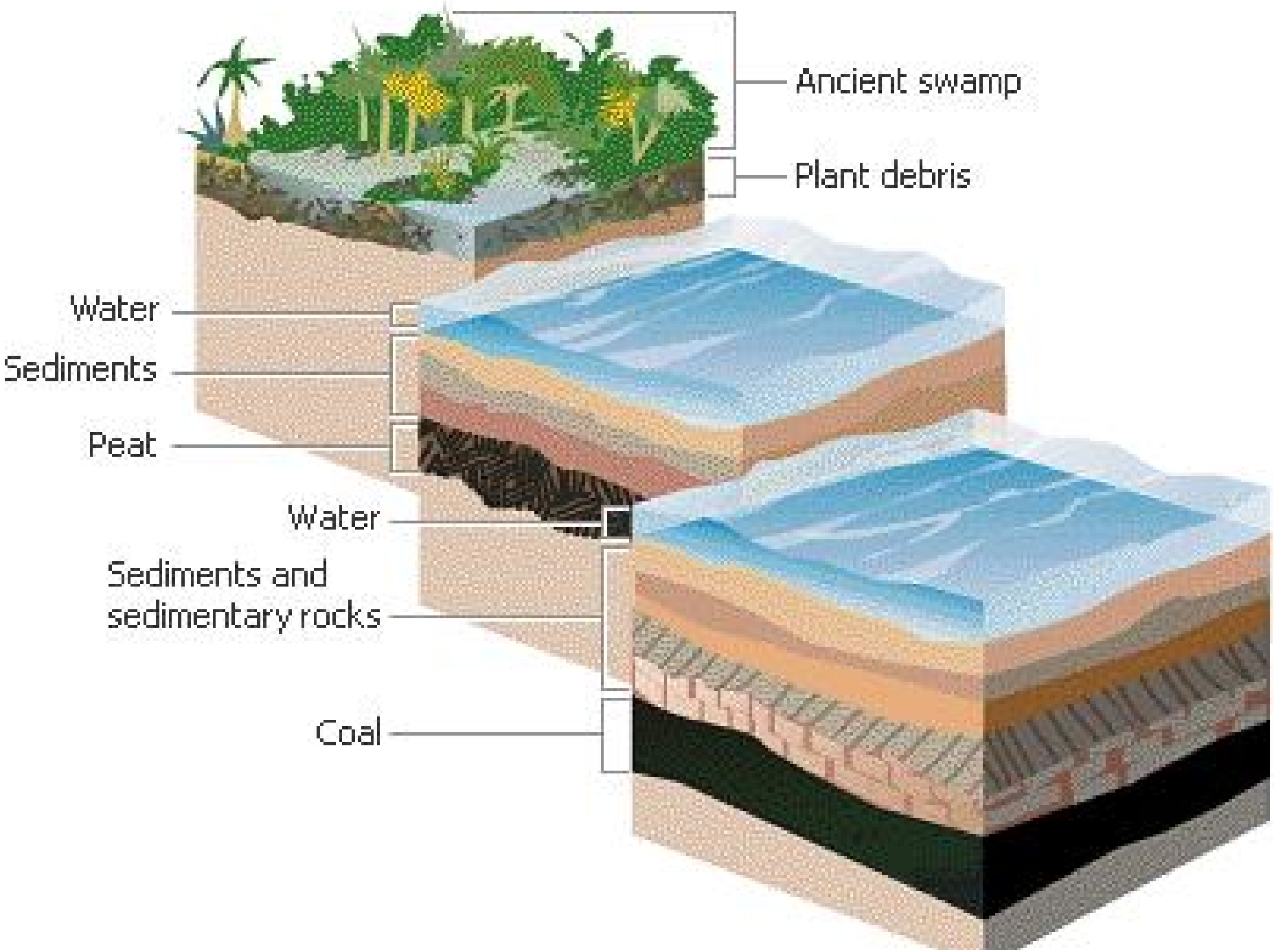

Sea salts
Sea water
Chloride
55 % (19.25 g)
Sulfate
7.7 % (2.7 g)
Sodium
30.6 % (10.7 g)
Water
96.5 % (965 g)
Calcium
1.2 % (0.42 g)
Potassium
1.1 % (0.39 g)
Magnesium
3.7 % (1.3 g)
Minor constituents
0.7 % (0.25 g)
Salt
3.5 % (35 g)
Quantities in relation to 1 kg or 1 l

Table of Top 14 Out of 70 Trace Elements in Natural Sea Water

Parts per million (ppm) and milligrams per liter (mg/l) are relatively the same in sea water, therefore the measurements shown are used synonymously.

Chromium (Cr) 0.00005
Cobalt (Co) 0.0005
Copper (Cu) 0.003
Fluorine/Fluoride (F) 1.3
Iodine/Iodide (I) 0.05
Iron (Fe) 0.01
Manganese (Mn) 0.002
Molybdenum (Mo) 0.01
Nickel (Ni) 0.0005
Phosphorus/Phosphate (P) 0.07
Selenium (Se) 0.0002
Tin (Sn) 0.003
Vanadium (V) 0.002
Zinc (Zn) 0.01

References: Periodic Table of Elements from Faculty of Chemical


Ancient swamp
Plant debris
Water
Sediments
Peat
Water
Sediments and
sedimentary rocks
Coal

Pyritic

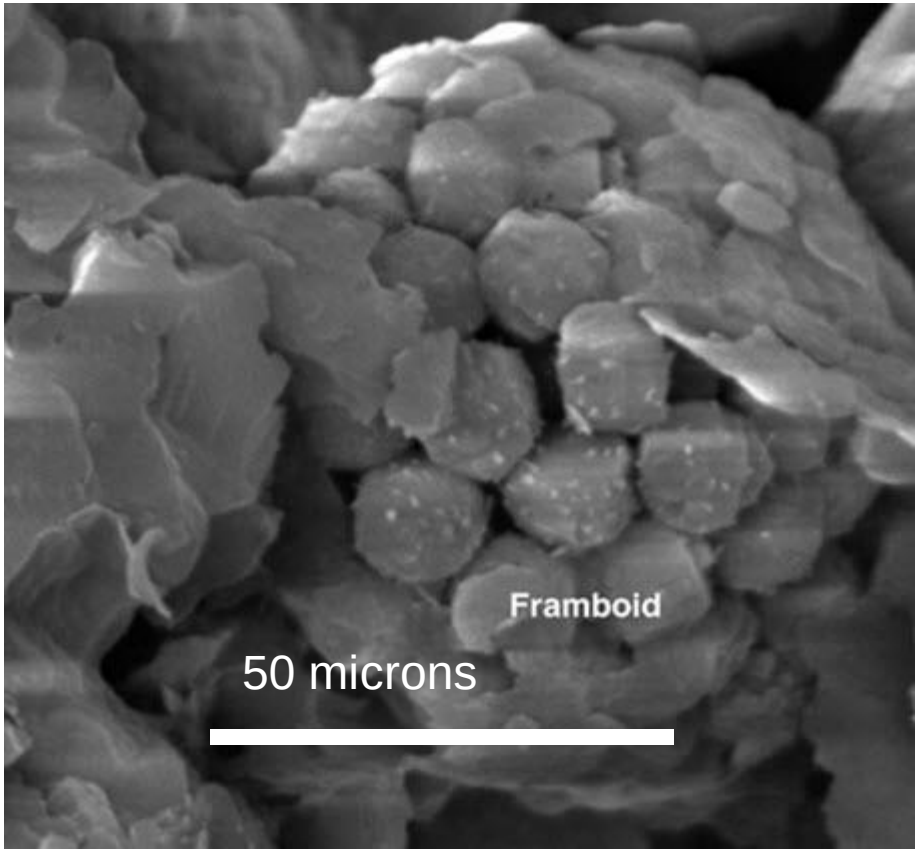
FeS_2

sulfur is attached to iron in fool's gold


FeS_2

Large sulfur balls can be washed out or rejected by pulverizers

Small framboids (raspberries) of pyrite are mixed in with the coal



Cleat

pyrite has to be ground up

Chemistry Issues

Low NOx
Poor Fineness

$$FeS_2 \longrightarrow H_2S + FeO$$

High Sulfur Coal

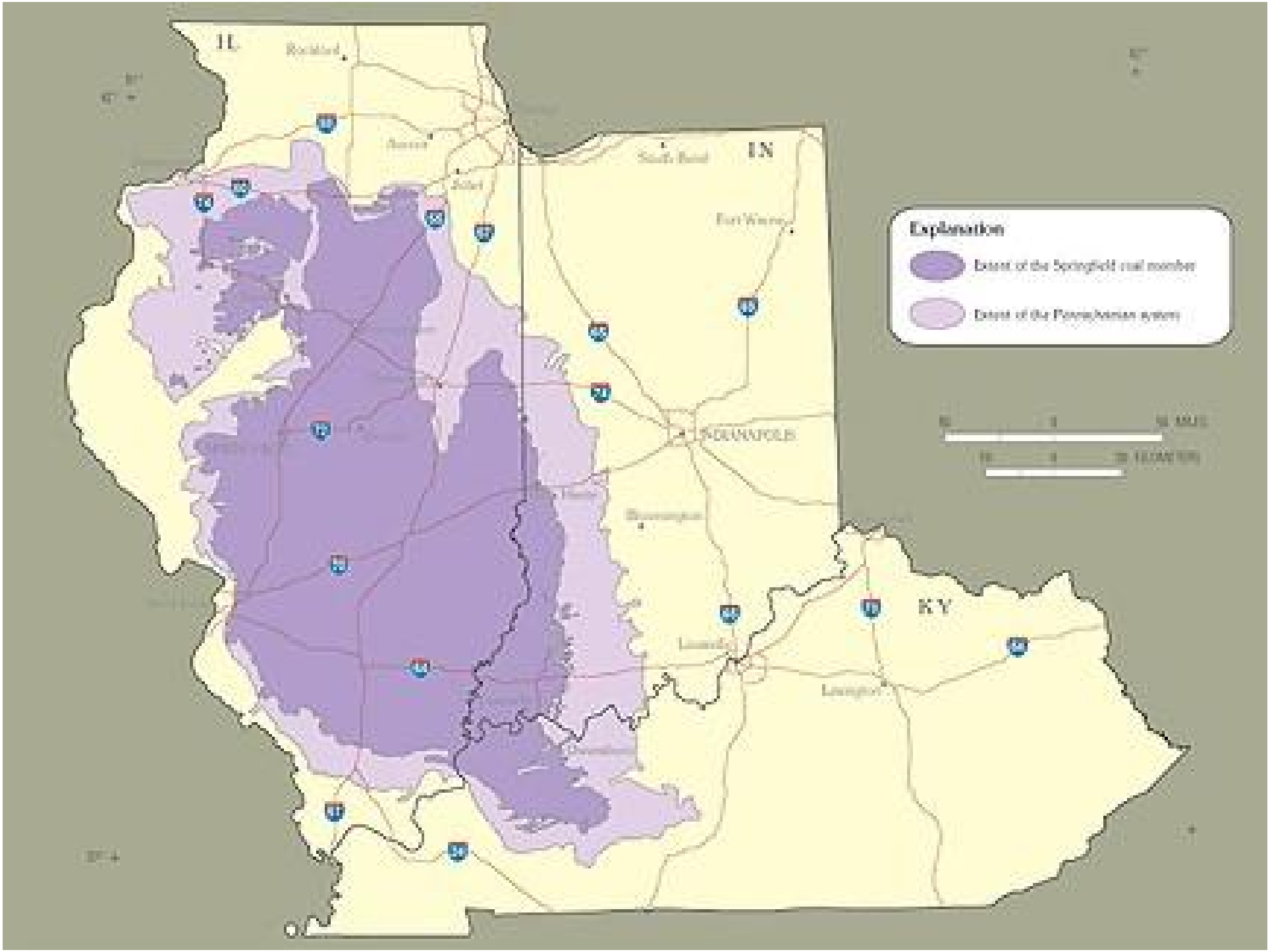
Corrosion and Slag

Chemistry Issues

Sulfur & FeS_2 → $SO_2 + SO_3$

SO_3 + NH3 ⟶

Air Heater Pluggage


IL
IN
KY
Explanation
Extent of the Springfield coal member
Extent of the Pennsylvanian system

Chemistry Issues

$Cl \longrightarrow HCl + H_2O \longrightarrow$

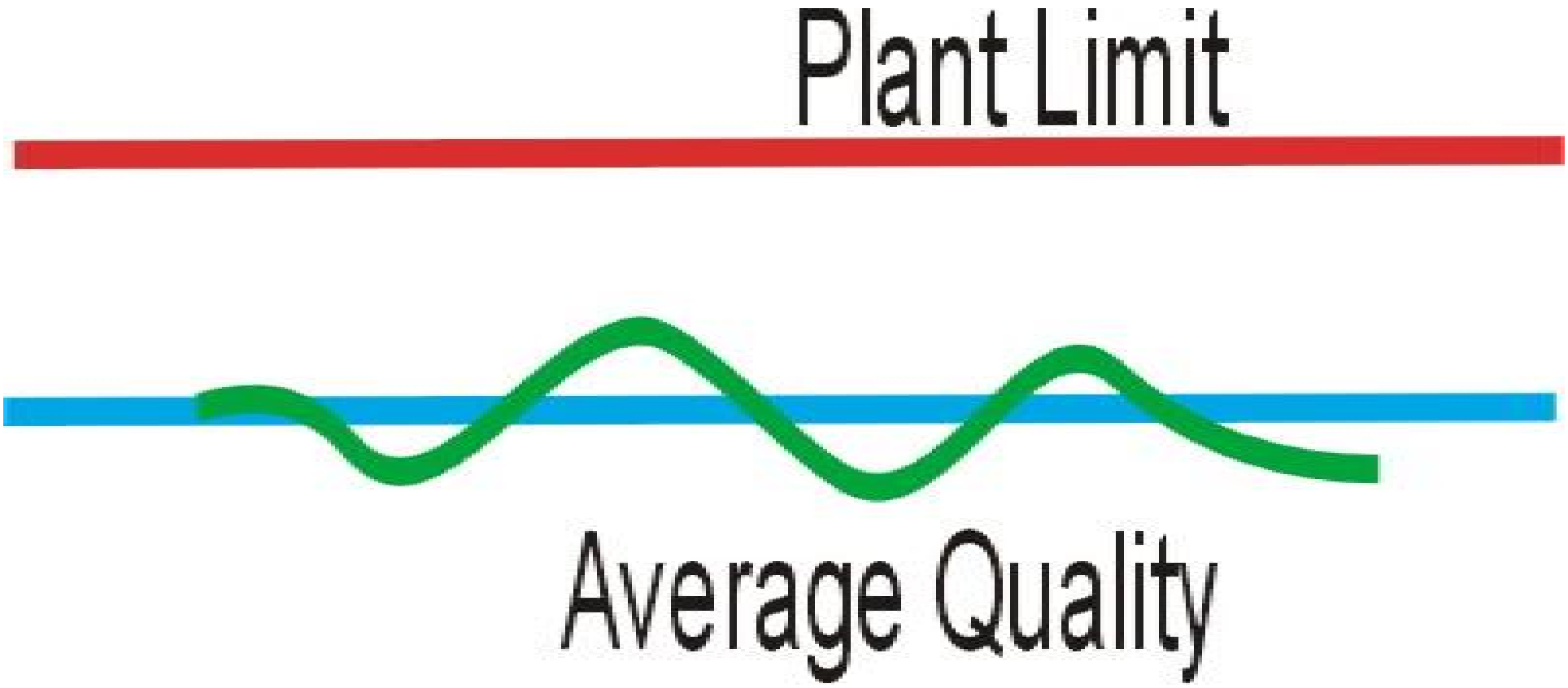
Cl^- = Soluble Chlorides

Scrubber Blowdown $\longrightarrow$
Ponds $\longrightarrow$ Release

Measuring Coal Quality

Standards-ASTM only produces average data

Power plants respond to swings in quality



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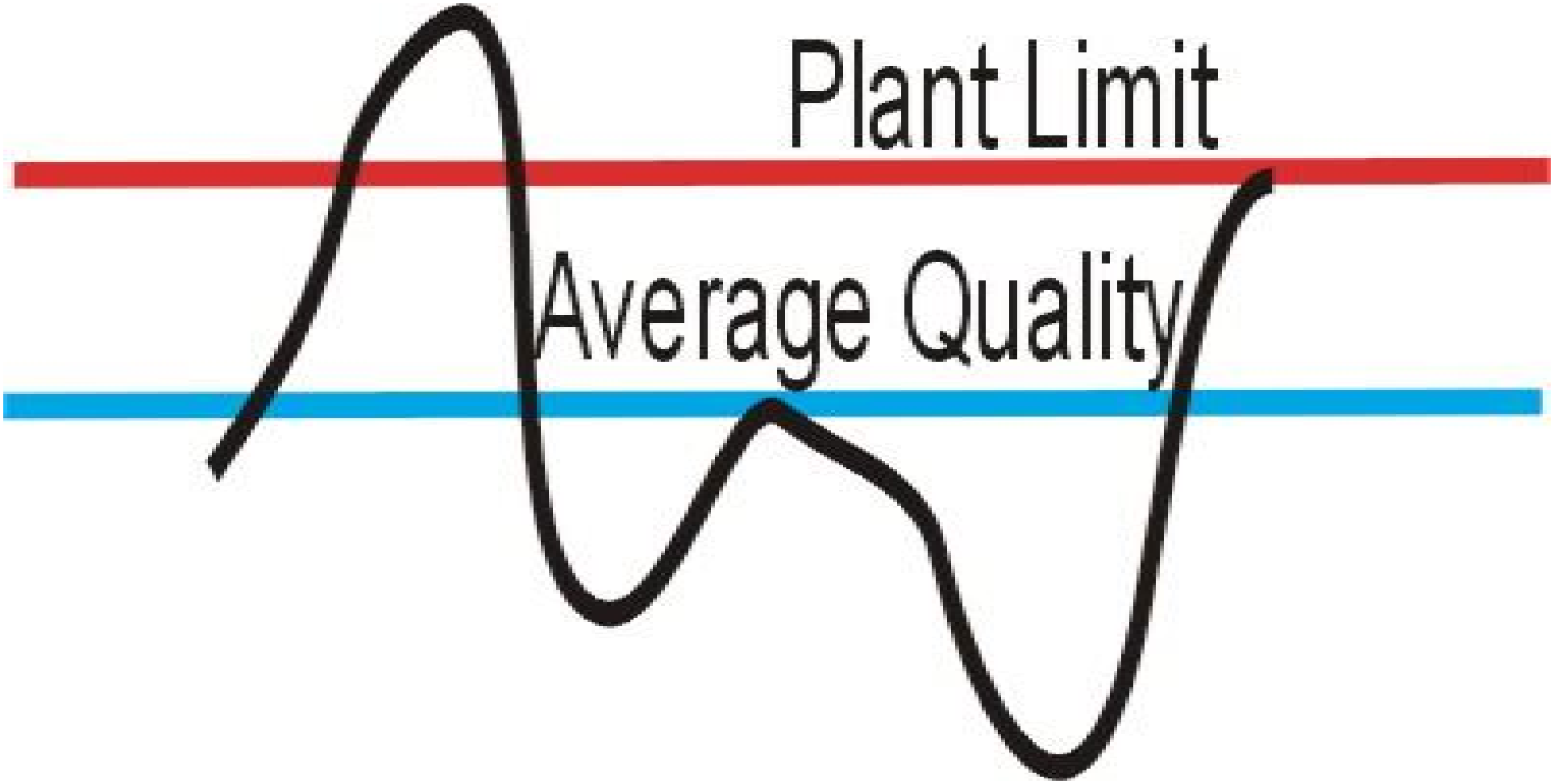

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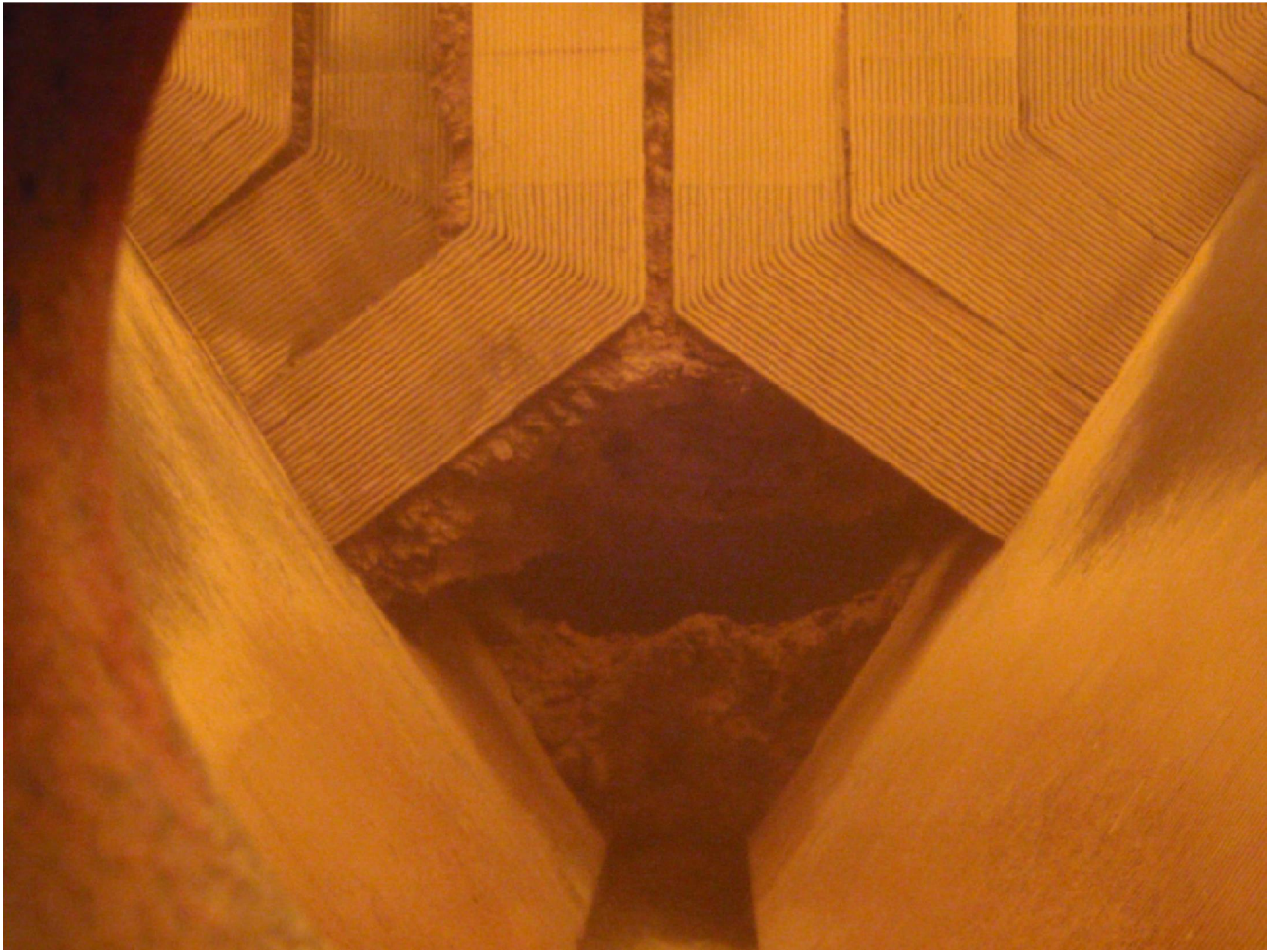
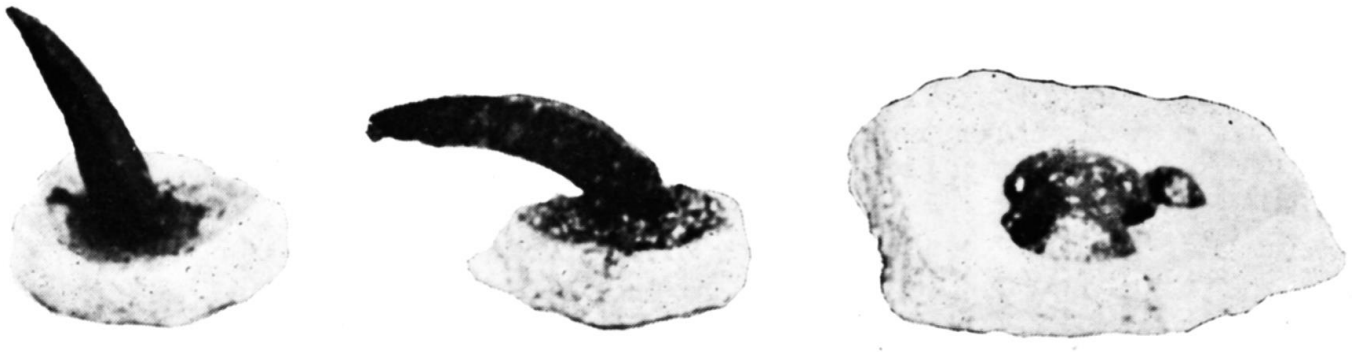
One step over the line...

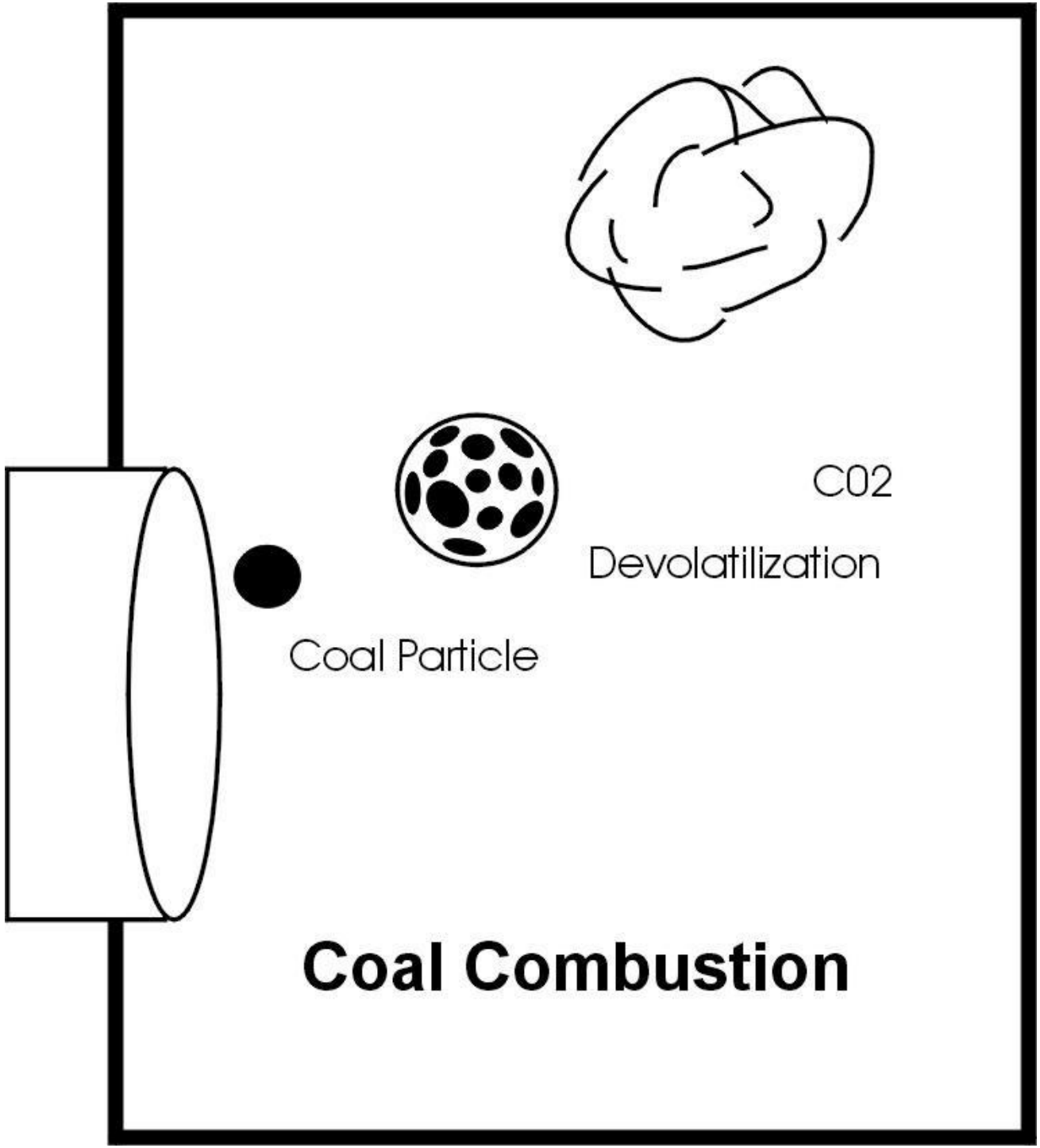


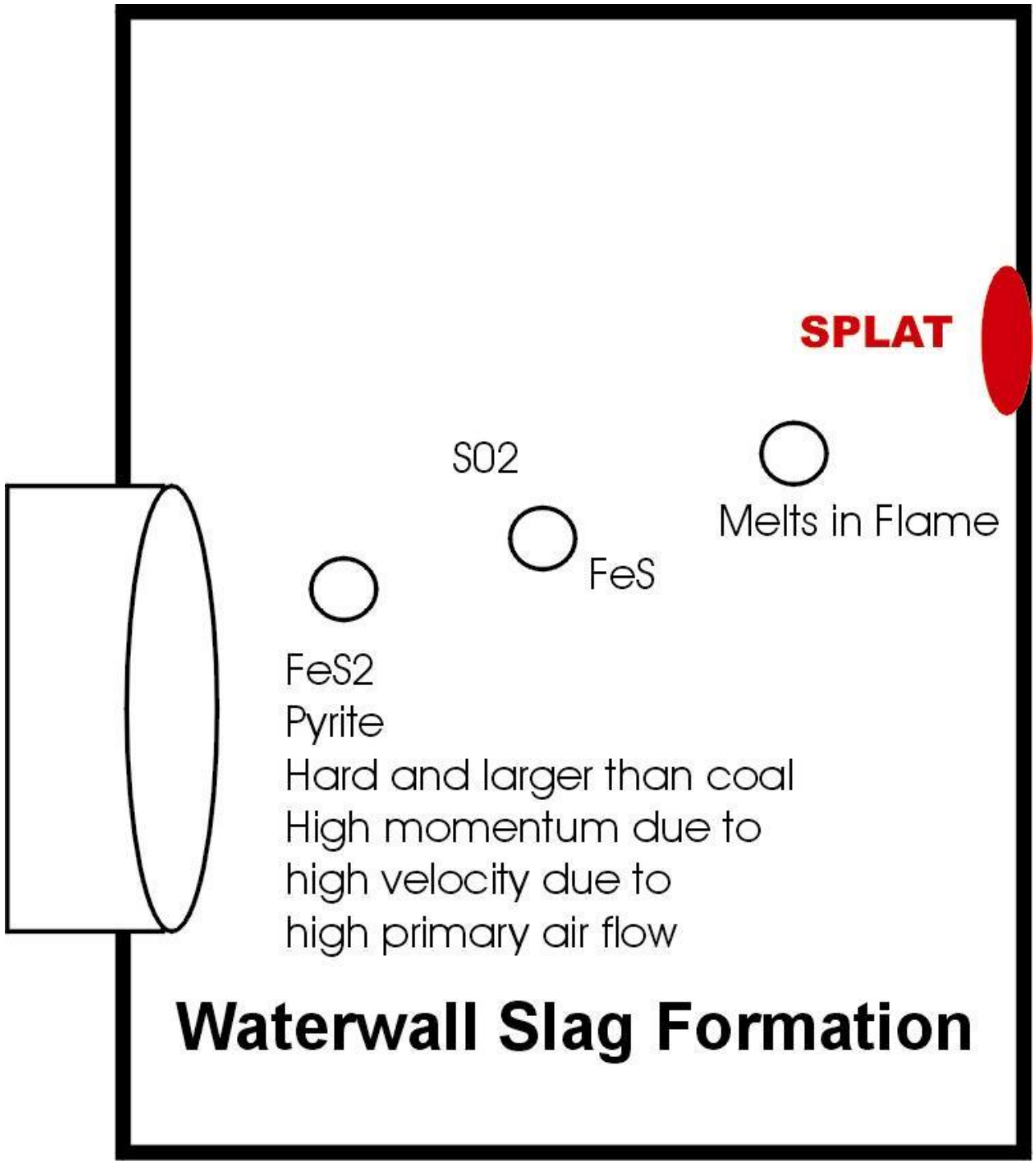
Why are we using fusion temperatures?



Test for stoker type boilers
No mineralogical data
Not the same reactions for all coals


Rod Hatt
Splat Factor


C02
Devolatilization
Coal Particle
Coal Combustion


SPLAT
S02
Melts in Flame
FeS
FeS2
Pyrite
Hard and larger than coal
High momentum due to
high velocity due to
high primary air flow
Waterwall Slag Formation

Customer : X

Station : X

Unit No. : X

SPLAT FACTOR II **2.86**

<Air (RI) Heat Balance @ Air-Fuel Ratio of 2 (Lbs/Hour)

Coal Flow Dry 140000

Input Parameters Bulettes coal flow based on change in CV when moisture is varied from 4 %

Coal Flow Wet :	80,000 Lbs./hr.	Ambient Temp. of Coal :	70°F		
Air to Fuel Ratio :	2.000 # air/ # Coal	Coal Moisture :	12.0%	This is surface moisture or the difference between total and EQ moisture	
Primary Air Flow:	160,000 Lbs./hr.	Cp of air :	0.24		
Mill Outlet Temperature :	140 °F	Cp of Coal :	0.30		
		Barometric Pressure:	29.81 "Hg		
			0.07183858		
h (water) @ ambient =	43 Btu/Lb.				
h (vapor) @ mill outlet =	1122 Btu/Lb.				
Enthalpy Rise =	1079 Btu/Lb.				

Heat Required to Dry Coal (BtU's)

Enthalpy Rise of Coal = Coal Flow = [0.30 (Tin - Tout) + [Coal Moisture = (Enthalpy Rise)]]

= 14,153,100 Btu/hr.

Heat Content of Primary Air (BtU's)

Heat Req'd. to Dry Coal = Cp (air) + Cp (air) = Mass PA Flow = (Tin - Tout)

= 480.38 °F

	Typical Coal Spec	Actual Coal Spec
Total Moisutre in Coal	14	12
EQ Equilibrium Moistur	10	
Surface Moisture	4	12
Btu/lb	25000	25000
Ash %	9	9
SiO2	48	48
Al2O3	20	20
Fe2O3	20	20
Lbs Ash	3.60	3.60
Lbs Quartz	0.85	0.85
Lbs Pyrite	0.89	0.89

50 mesh momentum
Momentum = mass x velocity

Mass of 50 mesh pyrite	2.97E-04 lbs
Mass of 50 mesh quartz	1.55E-04 lbs
Mass of 50 mesh coal	7.73E-05 lbs
Mass of 100 mesh ash	2.01E-05 lbs
Mass of 100 mesh coal	9.09E-06 lbs
Mass of 200 mesh ash	2.51E-06 lbs
Mass of 200 mesh coal	1.21E-06 lbs

Momentum lbs-ft/sec	0.00	200 mesh coal
Momentum lbs-ft/sec	0.00	200 mesh ash
Momentum lbs-ft/sec	0.00	100 mesh coal
Momentum lbs-ft/sec	0.00	100 mesh ash
Momentum lbs-ft/sec	0.01	50 mesh coal
Momentum lbs-ft/sec	0.01	50 mesh quartz
Momentum lbs-ft/sec	0.02	50 mesh pyrite
Kinetic Energy ft-lbs	0.00	200 mesh coal
Kinetic Energy ft-lbs	0.01	200 mesh ash
Kinetic Energy ft-lbs	0.03	100 mesh coal
Kinetic Energy ft-lbs	0.07	100 mesh ash
Kinetic Energy ft-lbs	0.26	50 mesh coal
Kinetic Energy ft-lbs	0.52	50 mesh quartz
Kinetic Energy ft-lbs	1.00	50 mesh pyrite

Largest Pipe Diameter Inches		20 PCI of burner	2.2
Number of Pipes		5 total ft 2 of burners	10.8
PA Flow Lb/min	3188.7		
Temp Adjust	3584.9		Dry Air
PA Flow ft/min	69945	Pipe Velocity ft/min	4,497
		Wet Air	
Lbs Moisture/Hr	1140		
Lbs Moisture/Min	19		
Moisture Ft /min	468		

Total Pipe Velocity **82 ft/sec**

SPLAT FACTOR

Coal Sizing	
Pass 200	75
Retained 100	5
Retained 50	2

SF = ((KE 50Q x Lbs Q)+ (KE Pyrite x Lbs P)) x % 50 mesh

Pulverizer Capacity

~~HGI~~

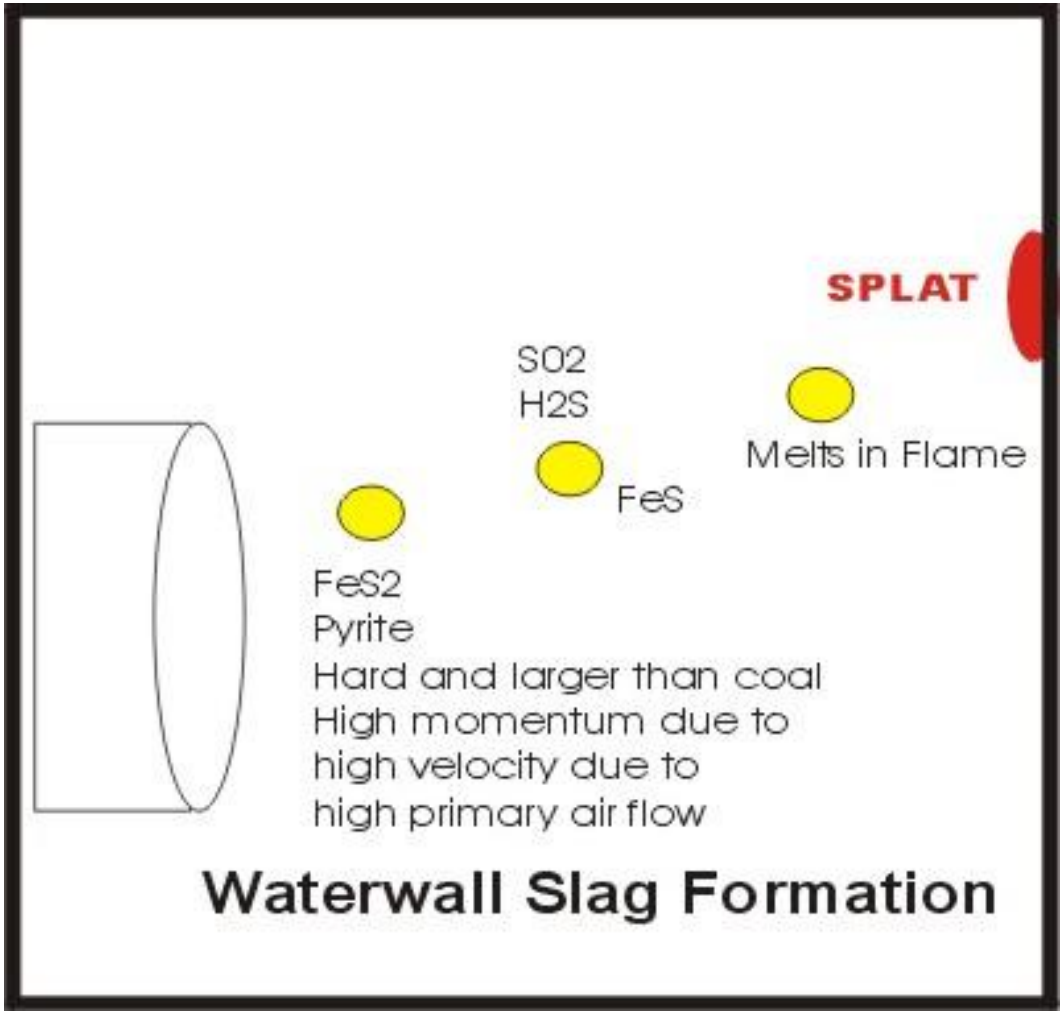
Btu/lb

Moisture

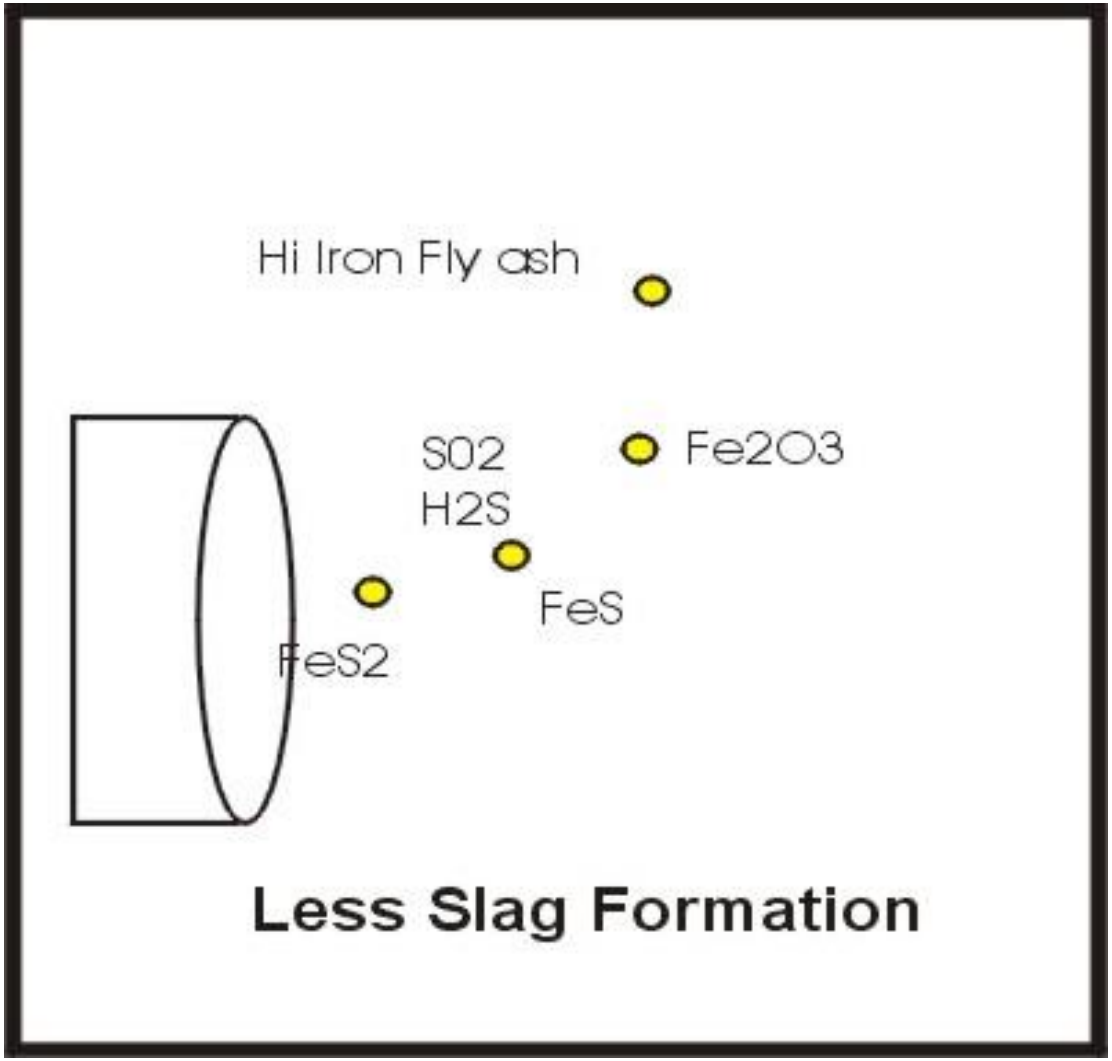
Inlet Coal Size

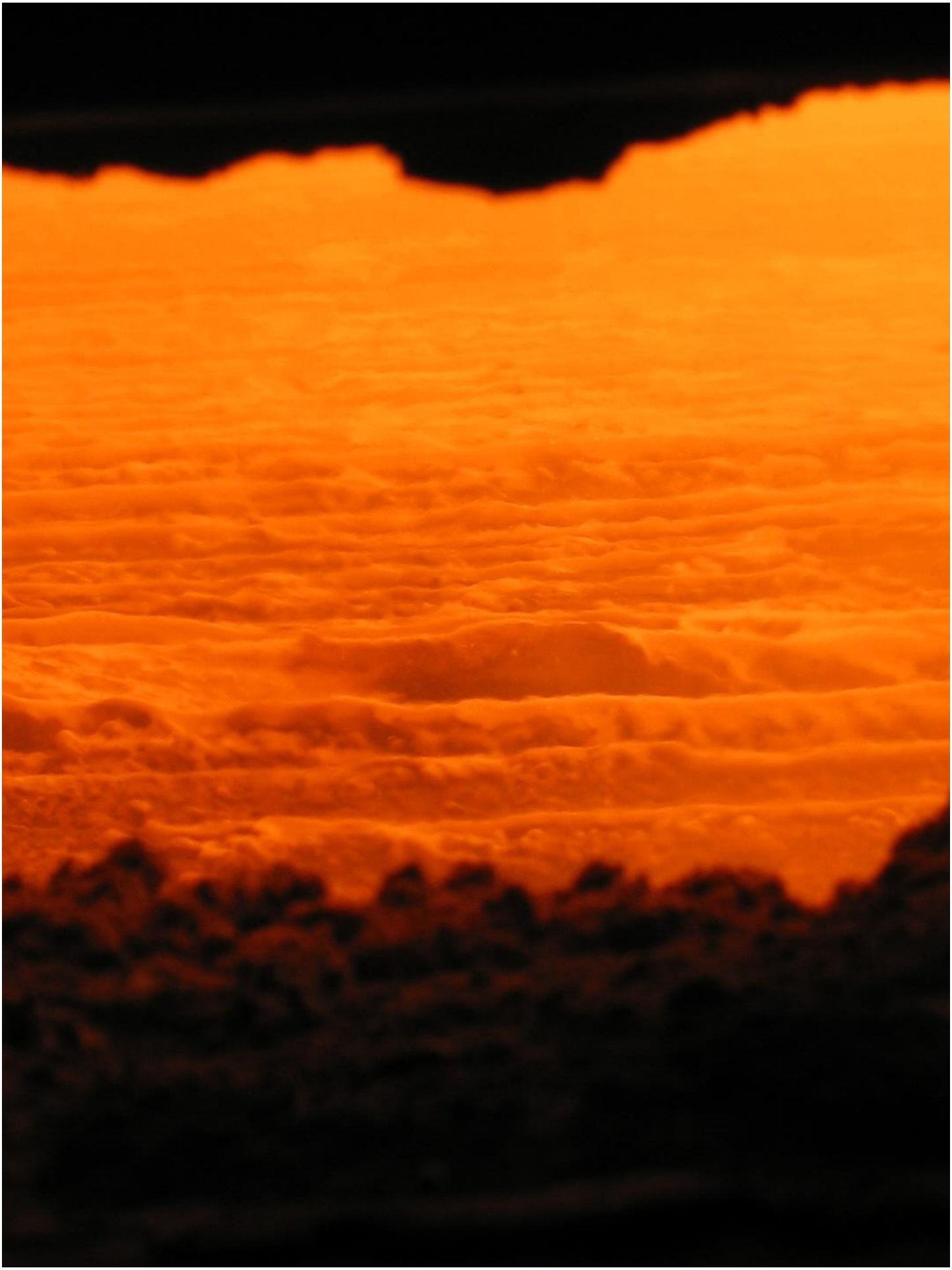
Pulverized Coal Size

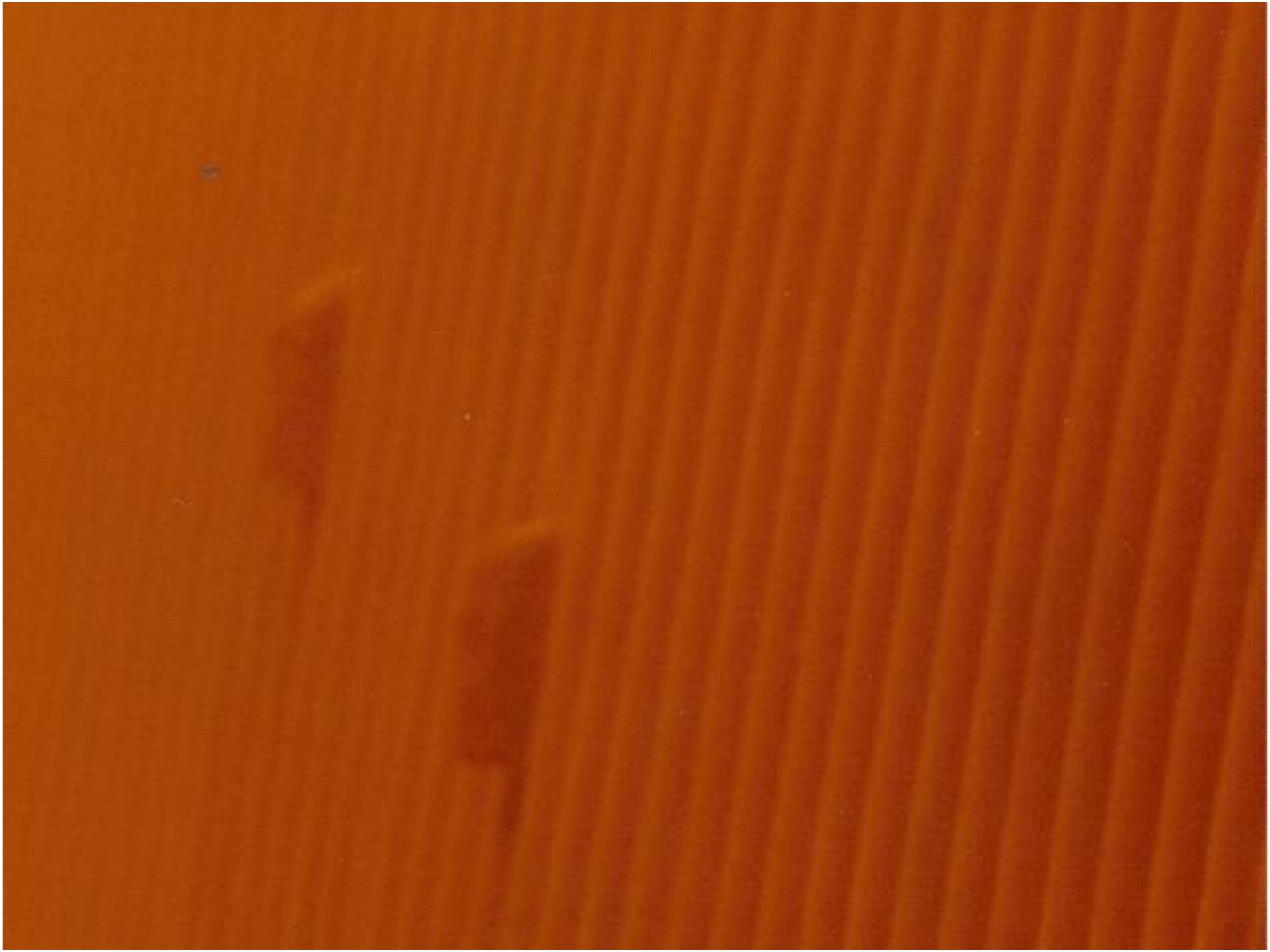
Coal Combustion



Coal Combustion








SINGHA
LAGER BEER
THE ORIGINAL THAI BEER
SINCE 1933
SINGHA CORPORATION Co.,Ltd. BANGKOK, THAILAND

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Thank you!