Coal Combustion Inc.

Understanding the business of coal

Member:

sponsor

ASTM ASME

ACS SME

NCCI PRB USERS GROUP

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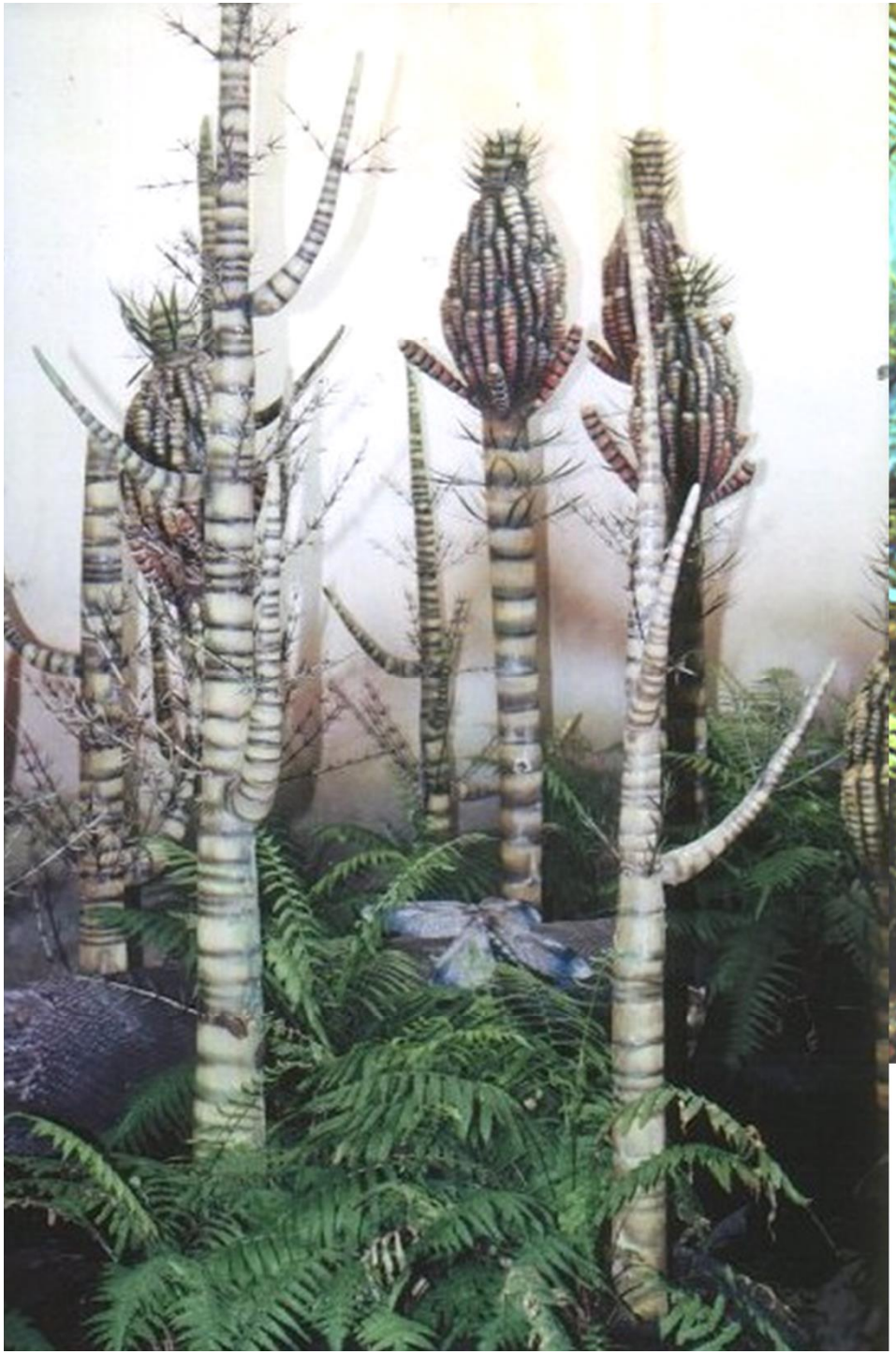
Coal Swamps and Rain Forest



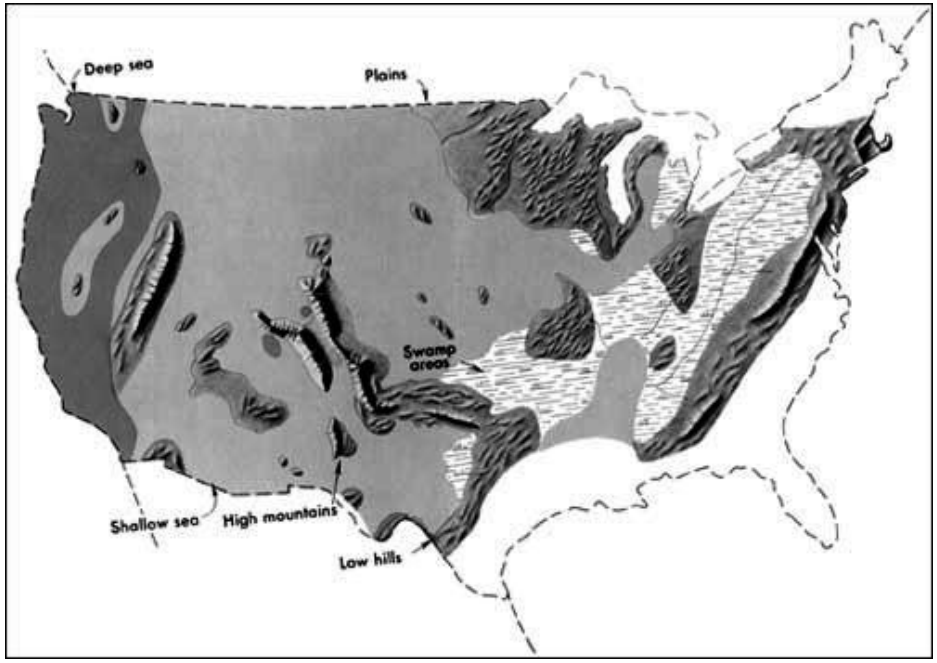
Eco-diversity

Not designed to make electricity

Geology

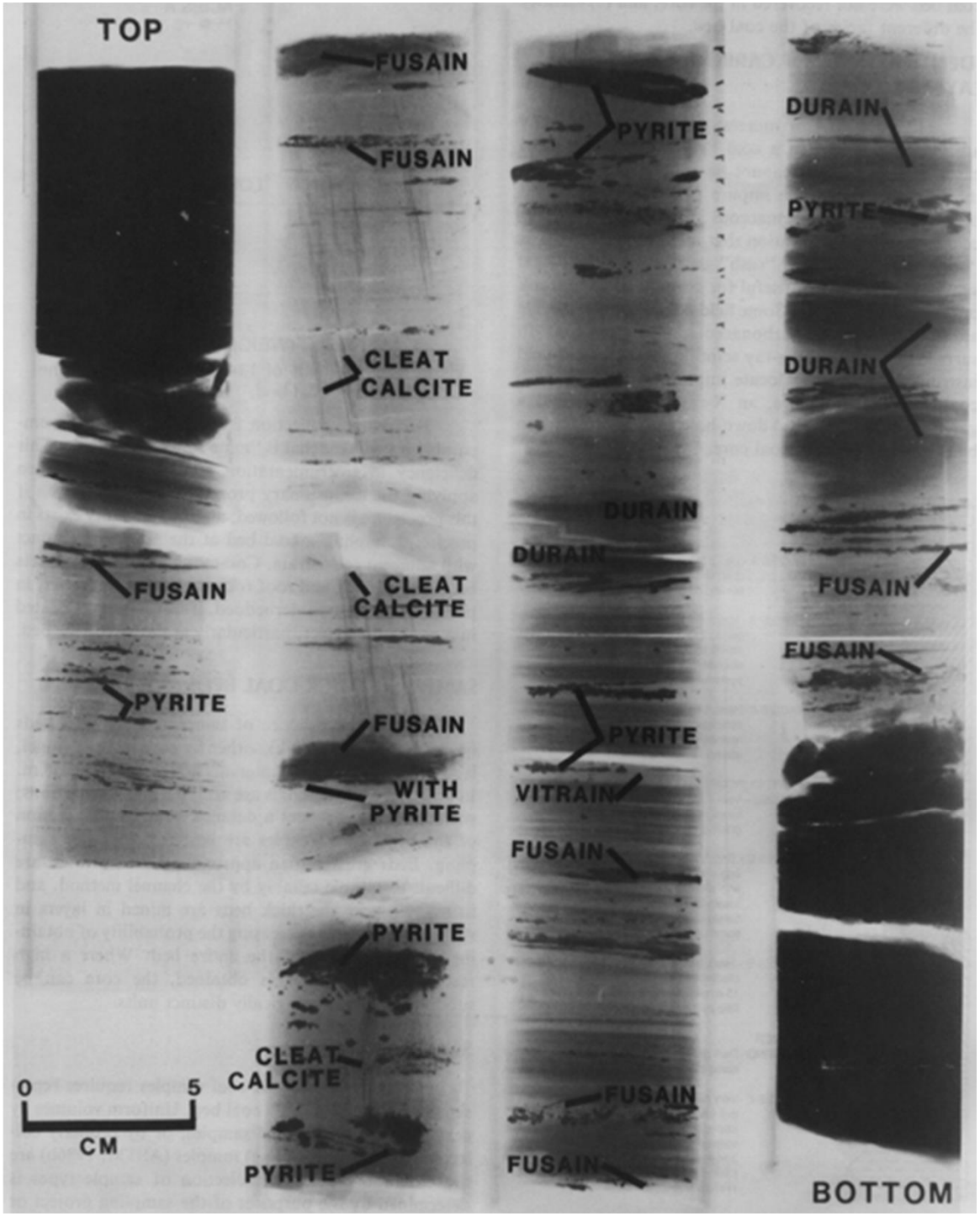
The world was different when Eastern US coal was growing:

- CO_2 levels were high ~7000 ppm.
- Most of America was under water.
- The Appalachian Mountains were up to 30,000 feet high.
- There was a big swamp from New York to Texas.

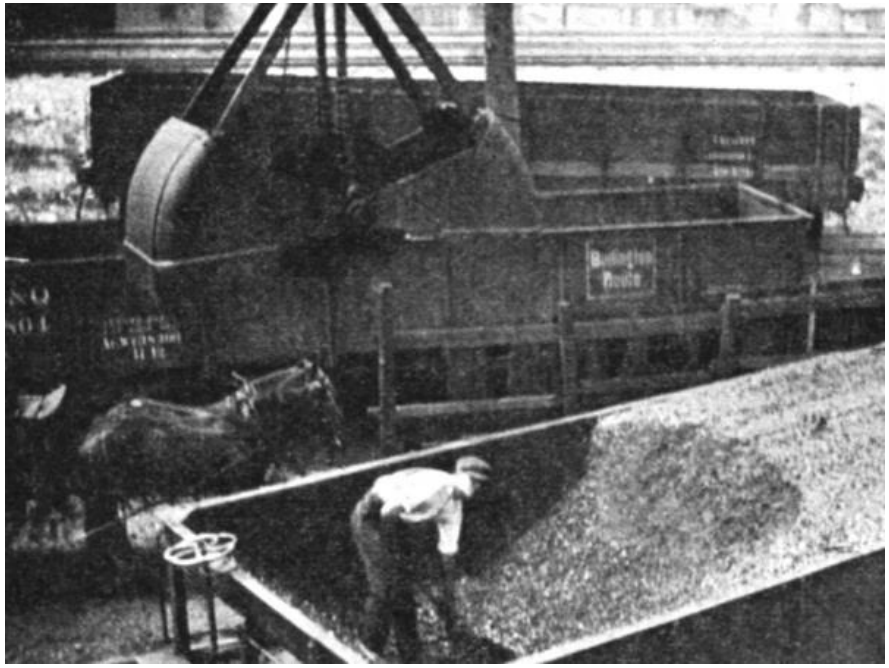


Major US Coal Fields

X-ray of Pure Coal



Coal Sampling is Hard Work and the lowest paid job in the coal industry.



Mechanical sampling is best

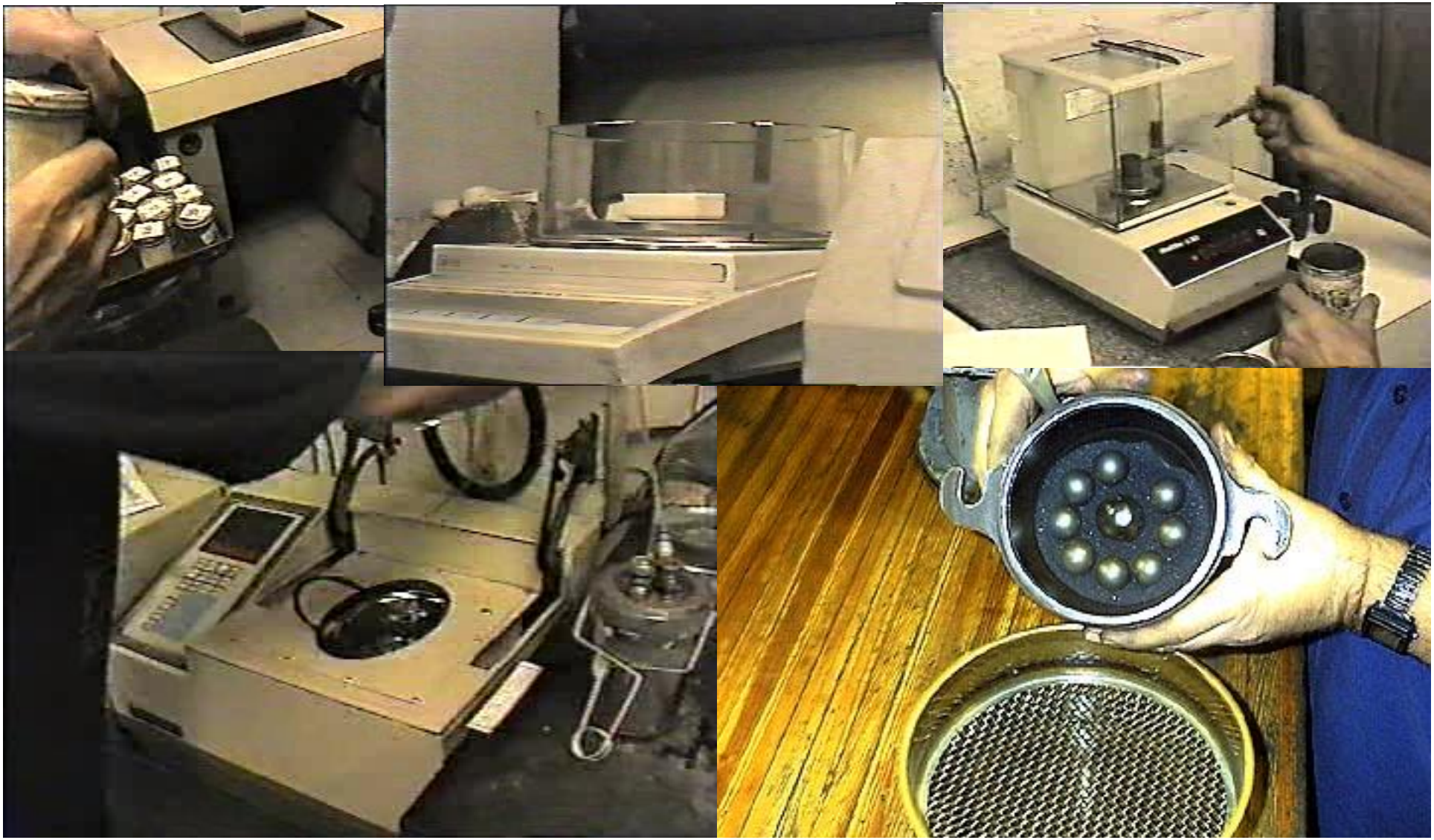
Sample Preparation

- Chain of Custody?
- Drying sample
- Most susceptible part of sampling to introduce errors
- Generally not well documented

Sample of coal goes to the laboratory results in about a day, maybe longer for some tests

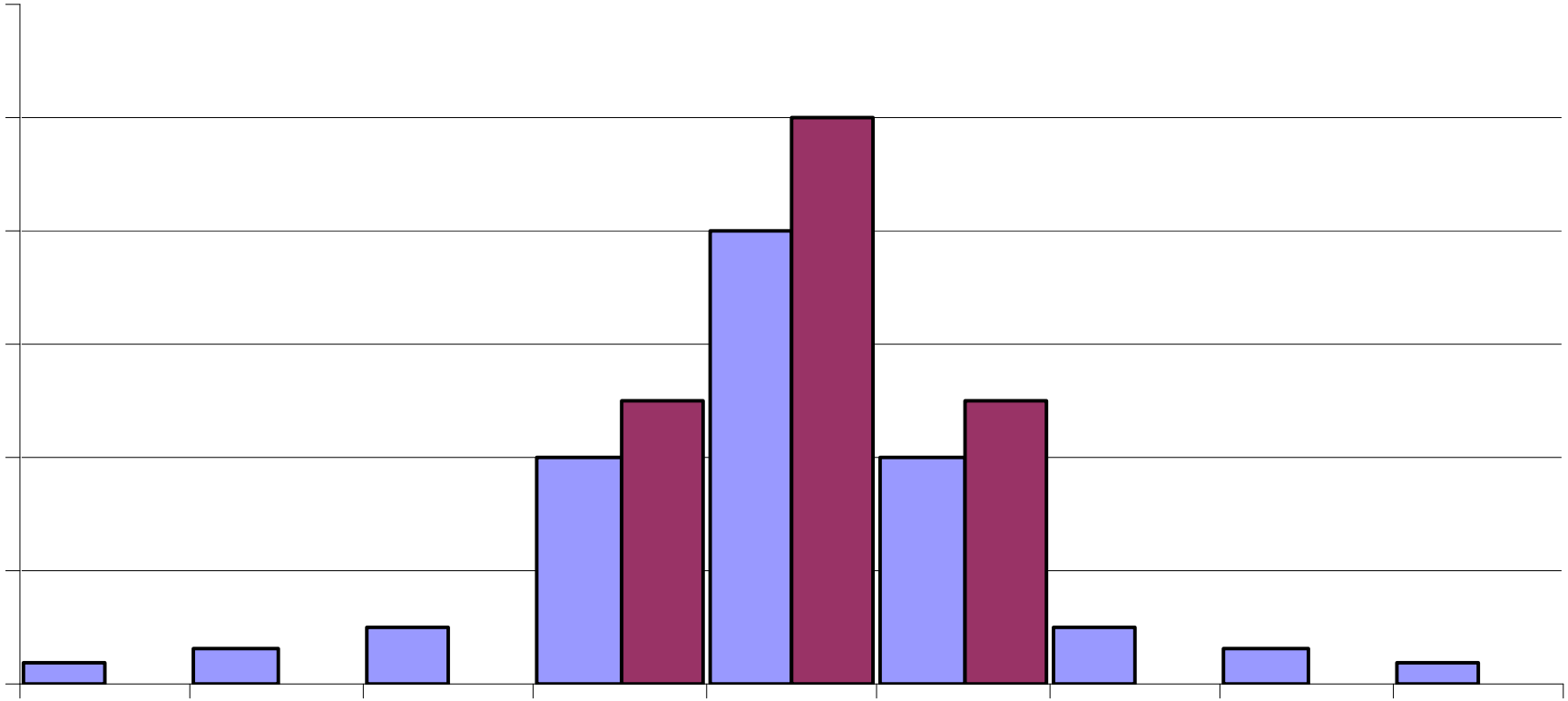

AUTION

Laboratory Analyses



1 / 12,768,000,000

Small and Large Variability



ASTM reports same ash level

Radio active Californium Nuclear On Line Analyzers

Over the belt

Ash, sulfur, Chemistry

of all the coal

Measures chemistry

not Moisture, Btu/lb

Needs regular calibration

Needs prior knowledge of coal

Good for coal mining industry

New technology measures

Carbon and Oxygen
One calibration
No Prior Knowledge of Coal

Maybe this or some other analyzer that measures C, O will finally provide what power plants and buyers need

CCI is developing software for power plant process control utilizing On-line analyses.

New technology will help us trade coal more timely and with less SURPISES

Boilers want Heat.

We understand the concept of buying Btus by pricing fuels In:

$/MBtu = ($/ton) / 2x(Btu/lb/10,000)

Example:

$40/ton coal 12,500 Btu/lb.

$/MBtu = (40)/2x(12,500/1,000)

$/MBtu = (40)/(2x12.5)

$/MBtu = 40/25 = $1.60 per MBtu

We understand the concept of buying Btus and,

Boilers want heat.

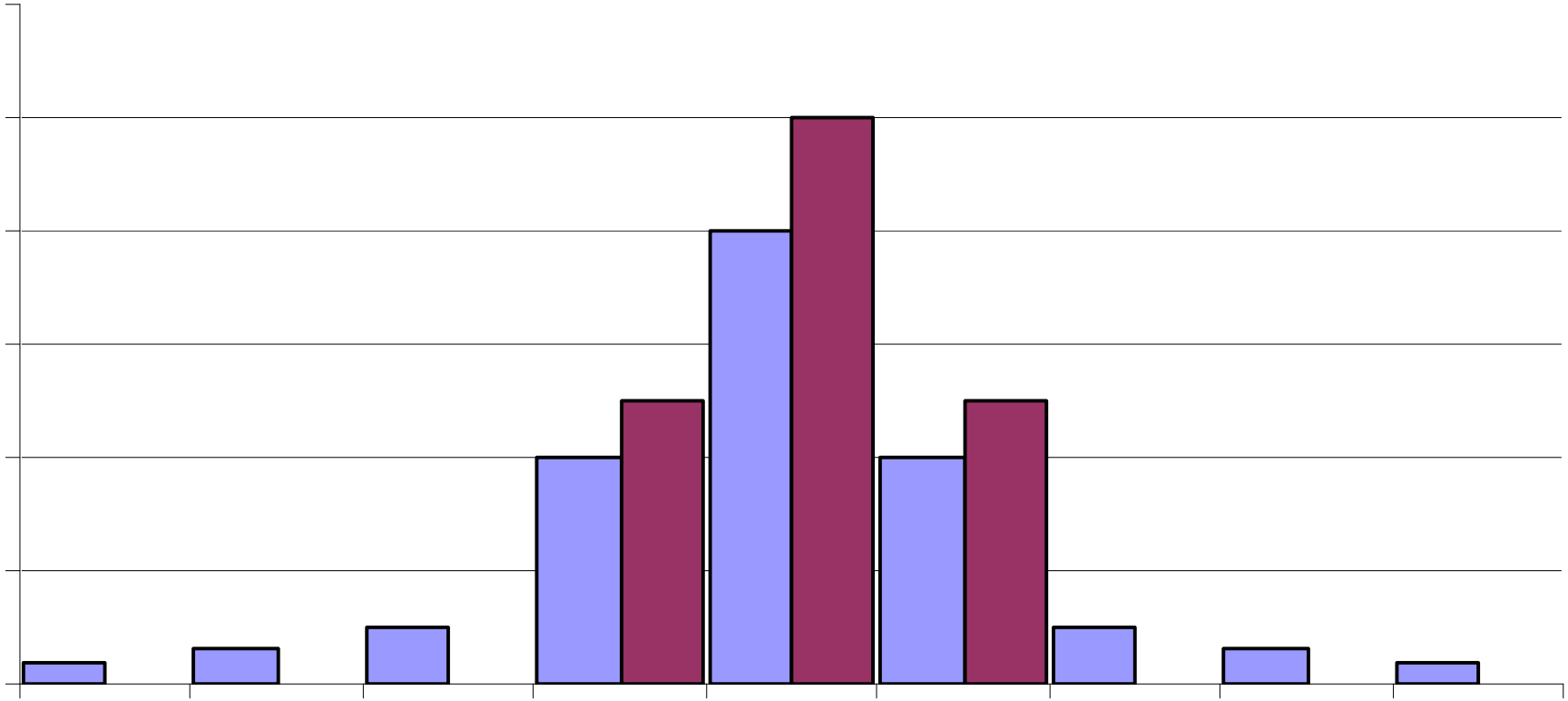
Lets look at all boiler related coal qualities on a heat basis; lets put all percentages on a per million Btu basis

LOADING LEVELS

The industry has used SO_2 emission levels expressed in lbs SO_2/MBtu for over 20 years

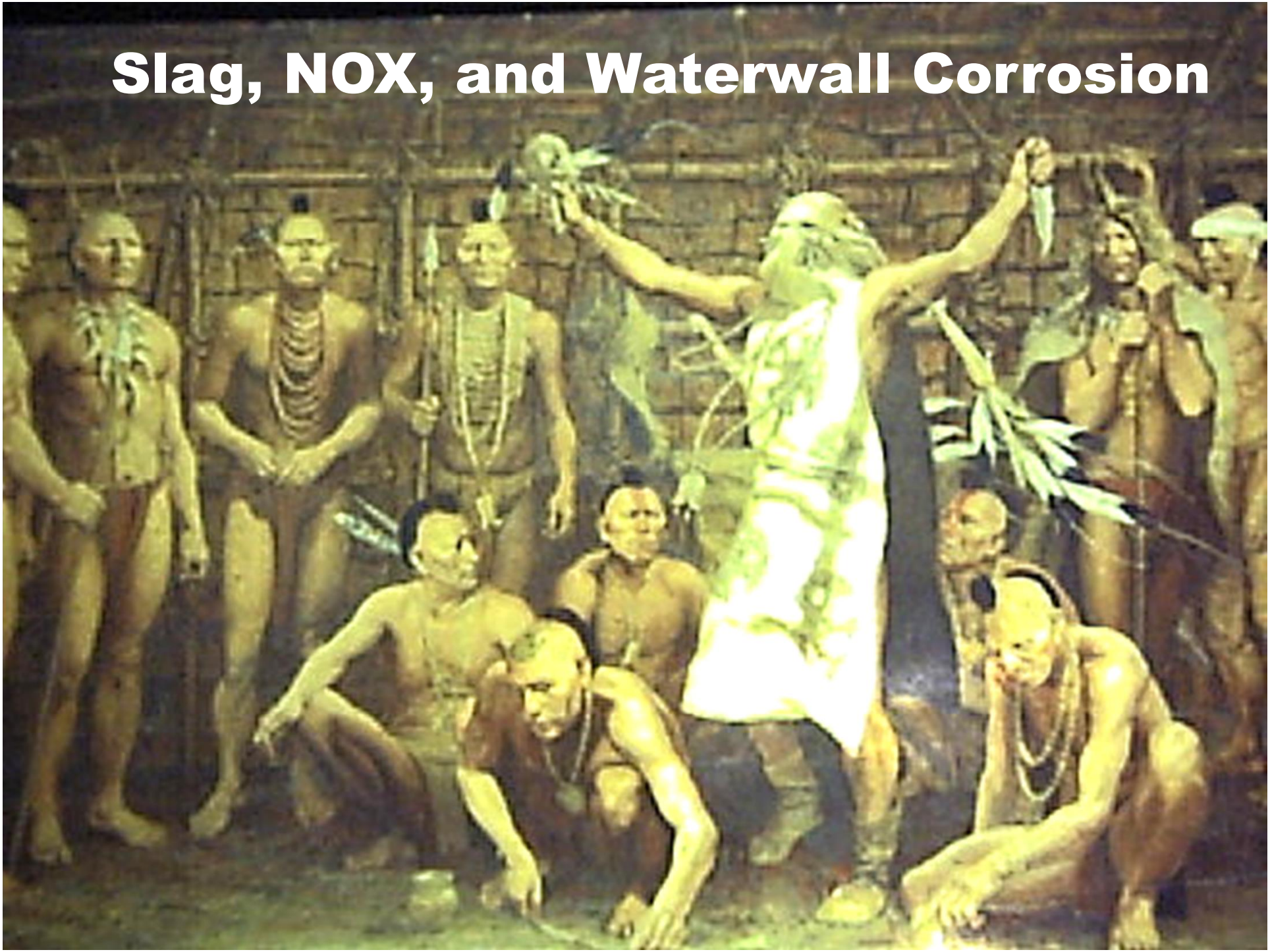
ESP performance is based on the lbs Ash/MBtu, Ash Loading, not percent ash.

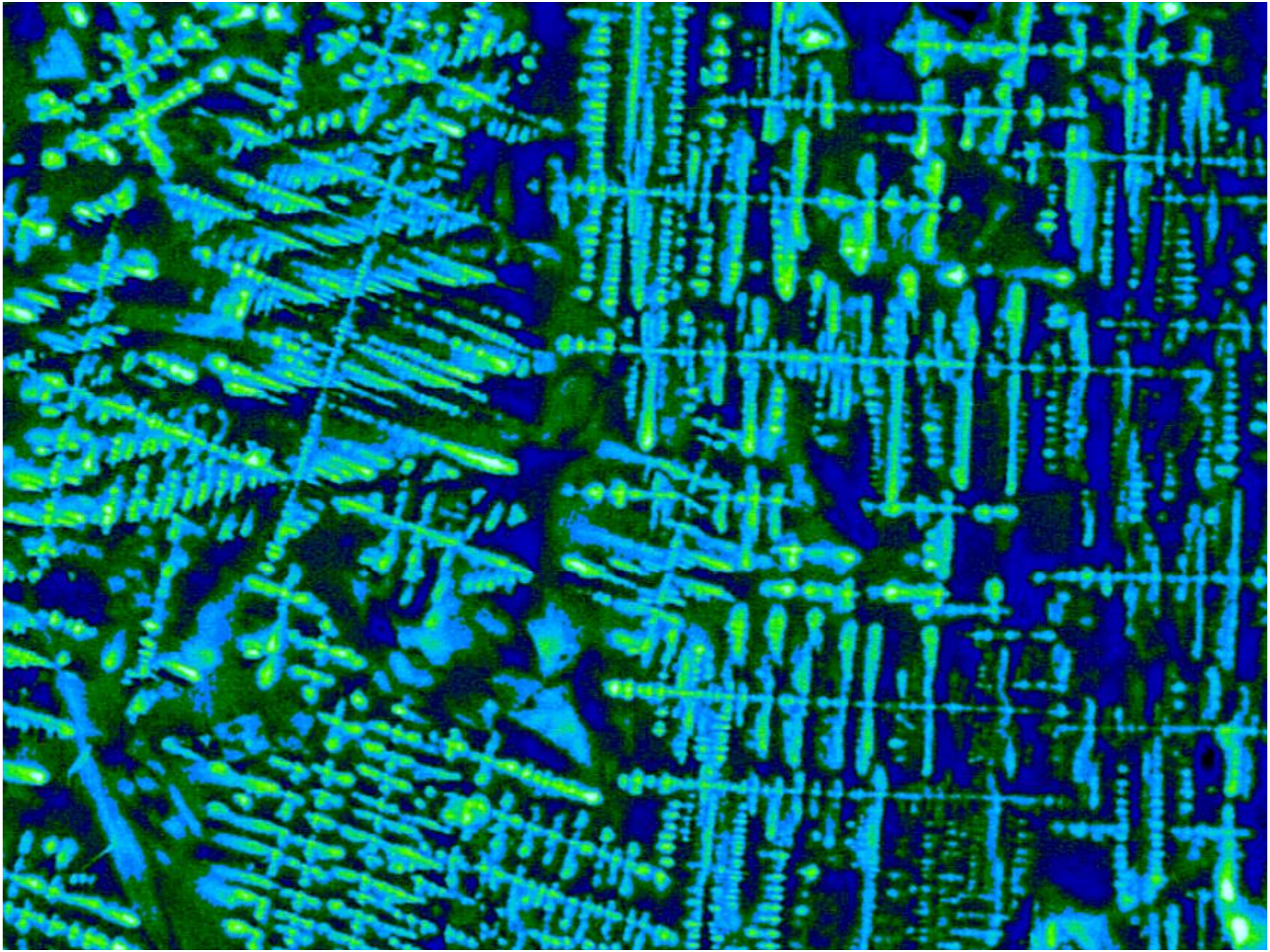
Small and Large Variability



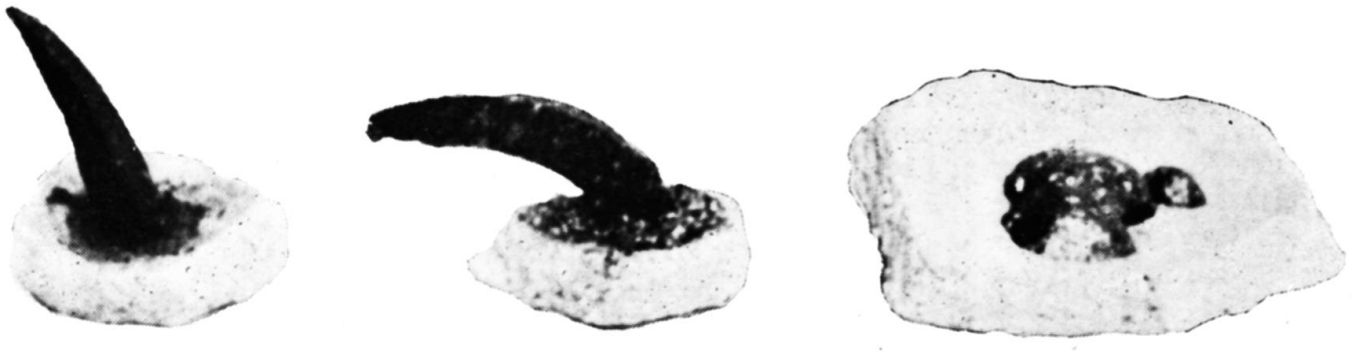
ASTM reports same ash level

Slag, NOX, and Waterwall Corrosion

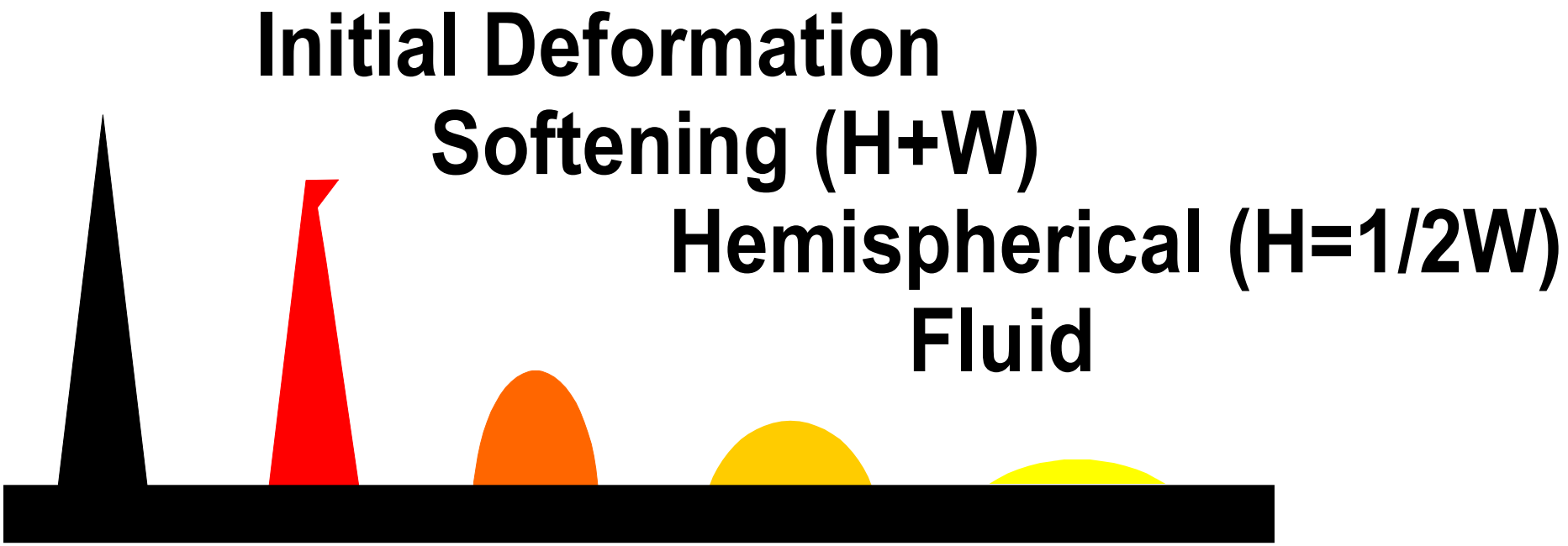




Why are we using fusion temperatures?



Test for stoker type boilers
No mineralogical data
Different reactions


Initial Deformation
Softening (H+W)
Hemispherical (H=1/2W)
Fluid

Sulfur exists in coal in two main forms:

ORGANIC
C-C-S-C-C
and

PYRITIC
FeS2

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Minerals include

Quartz
Pyrite
Clays and shales
Carbonates


FeS

Ash Chemistry
Major & Minor Elements

SiO_2
Al_2O_3
TiO_2

Fe_2O_3
CaO
MgO
K_2O
Na_2O

As the sulfur in coal goes up

The amount of pyrite goes up

Pyrite and other iron and sulfur minerals are the principle minerals responsible for slag in boilers using high sulfur coals.

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Our traditional slagging factor where the dry sulfur is multiplied by the base to acid ratio strongly suggests that when the sulfur and the amount of Fe_2O_3 in the ash increase, slagging increases.

Typically both the dry sulfur and the ash %Fe_2O_3 increase with higher sulfur coals.

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Slag Index = dry S x B/A

= dry S (~1/3 to 2/3 pyrite) x B/A

= dry S (FeS_2)xFe2O3+CaO+…/SiO2+…

Traditional Slagging Index

SI = $(Fe)^2$ (iron squared)

This means that as sulfur increases the slagging increases exponentially.

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The major cause of slagging for Midwestern coals is the selective deposition of segregated, low melting iron enriched constituents. Form of the iron in the slag is important.

Fully oxidized Fe_2O_3 melts at higher temperature than iron pyrites.

FeS_2, has a melting point of 2,140 deg F.

Reduced iron, FeO acts as a flux with silica to form a $FeSiO_2$ with a melting point of 2,096 deg F.

Lbs. of ash/MBtu

= %ash / (Btu/10,000)

Many slagging concerns have been addressed using Ash Loading and Elemental loading levels; especially

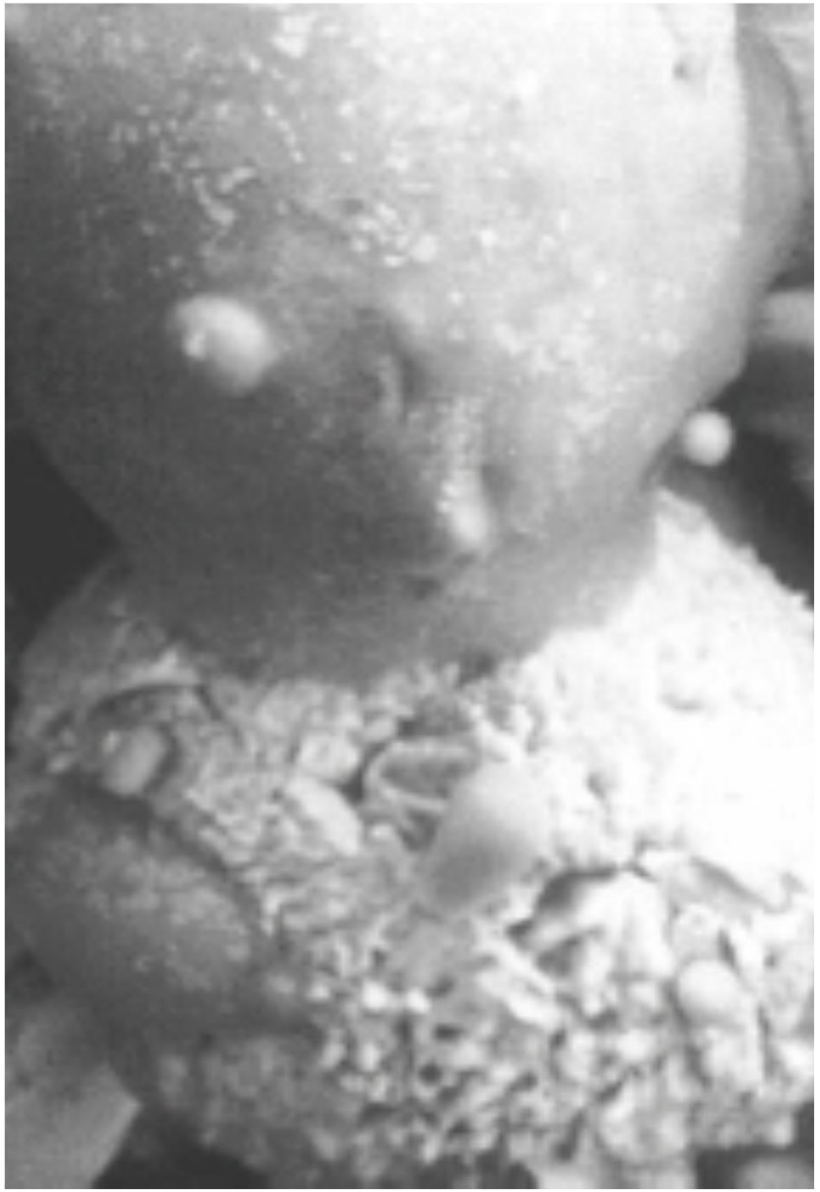
Fe_2O_3, CaO, Na_2O

The author has on numerous occasions found that the ash deposits formed in utility sized boilers correlates best with ash and elemental loading data, rather than fusion temperatures or traditional slagging and fouling indices.

- Elemental loading
  - Pounds of iron per million Btu
  - Pounds calcium, sodium, and other elements

POST MORTUM

Microscopic Investigation of Deposits



Coal Blending

Many qualities can be blended

Increases range of coal qualities considered

Use Loading values rather than laboratory percentages for more accurate predictions

Poor qualities can be minimized by blending with offsetting qualities

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Blends are produced to minimize cost or for environmental reasons

Sorry ASTM only gives bulk average

Calibrated scales and online analyzers for consistent and accurate blends

If you can't measure it how can you control it!

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The key to managing specs is to understand the relation between coal quality, and the cost and performance of the power station.


thank
you