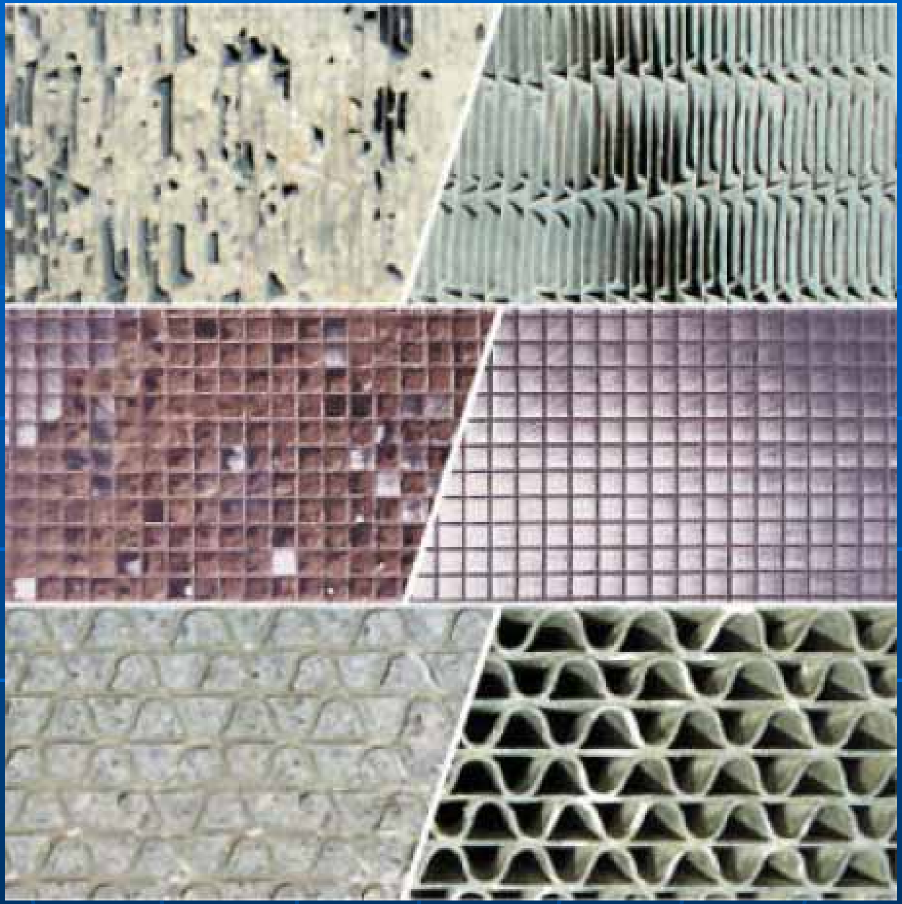
SCR CATALYST POISONING



2006 NOx/PCUG Conference, January 23-26

Presented by: W. Scott Hinton, Ph.D., P.E.

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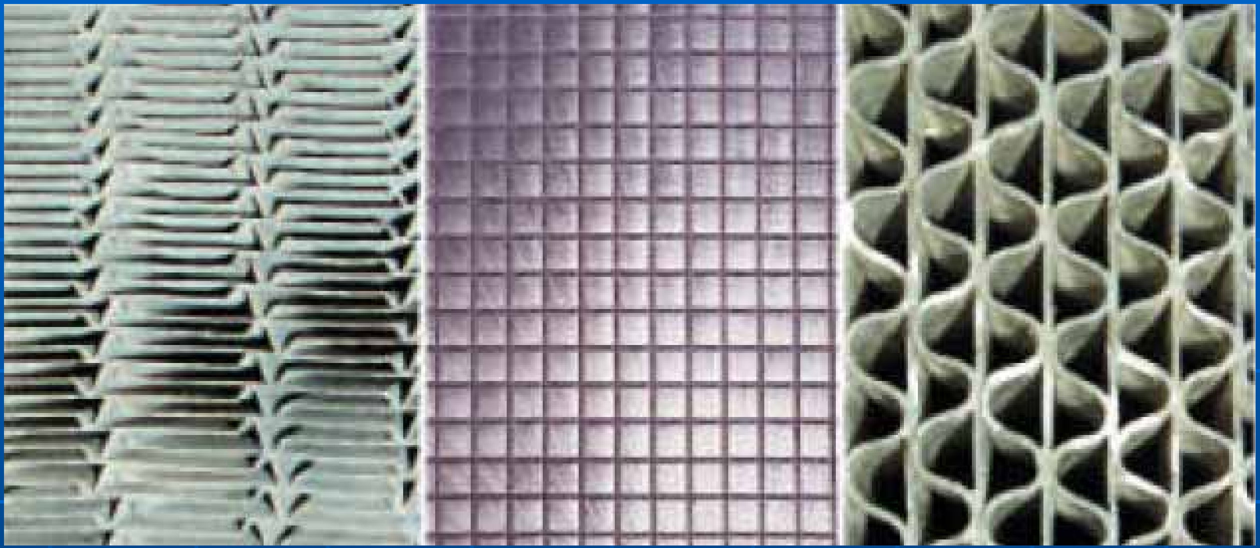
SOUTHERN RESEARCH INSTITUTE

OUTLINE

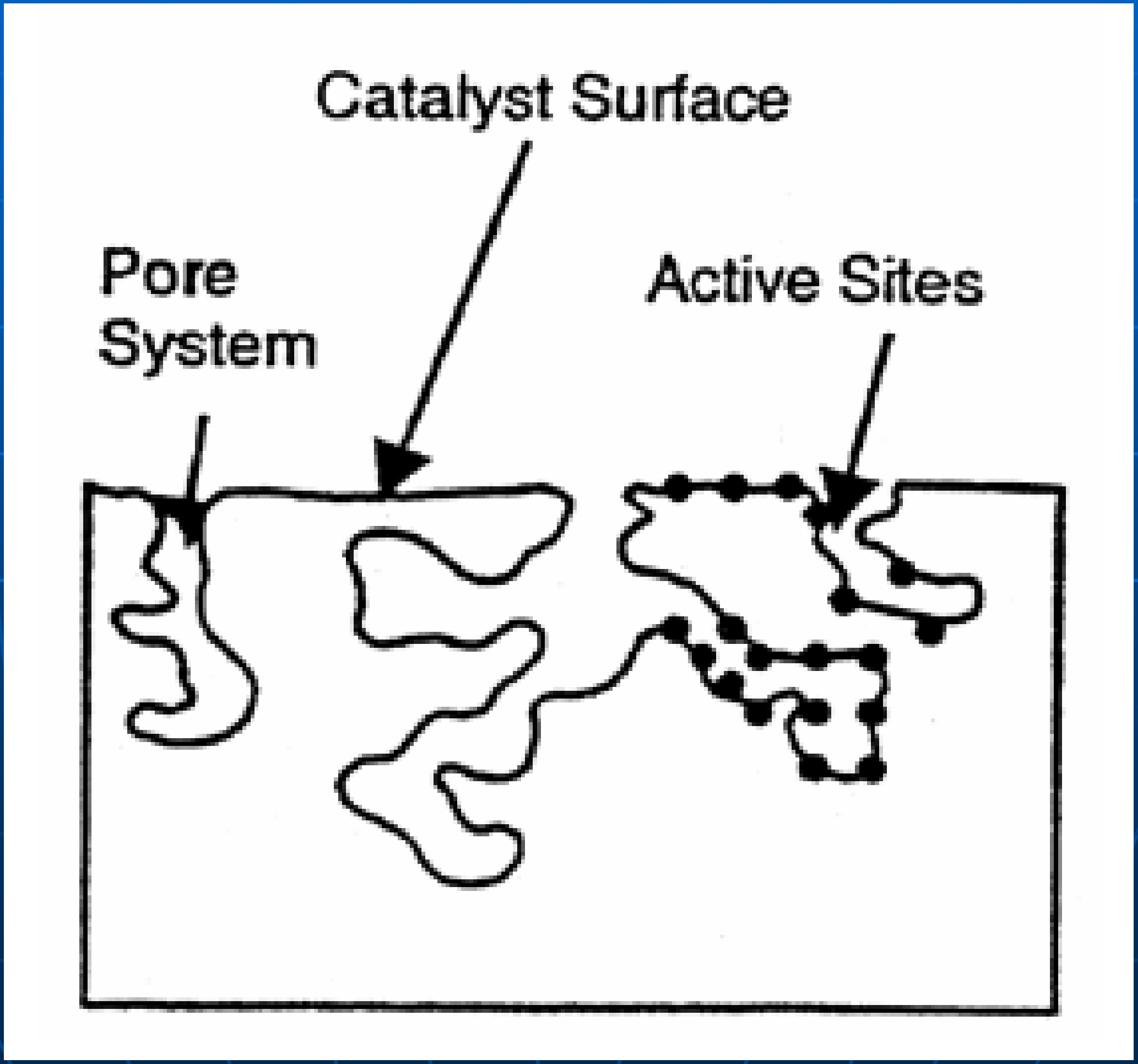
- CATALYST BASICS
- POISONING MECHANISMS
- EASTERN BITUMINOUS COALS
- POWDER RIVER BASIN COALS
- SPECIAL POISONS AND FUELS
- UPDATE: MERCURY AND SCR CATALYSTS

CATALYST BASICS



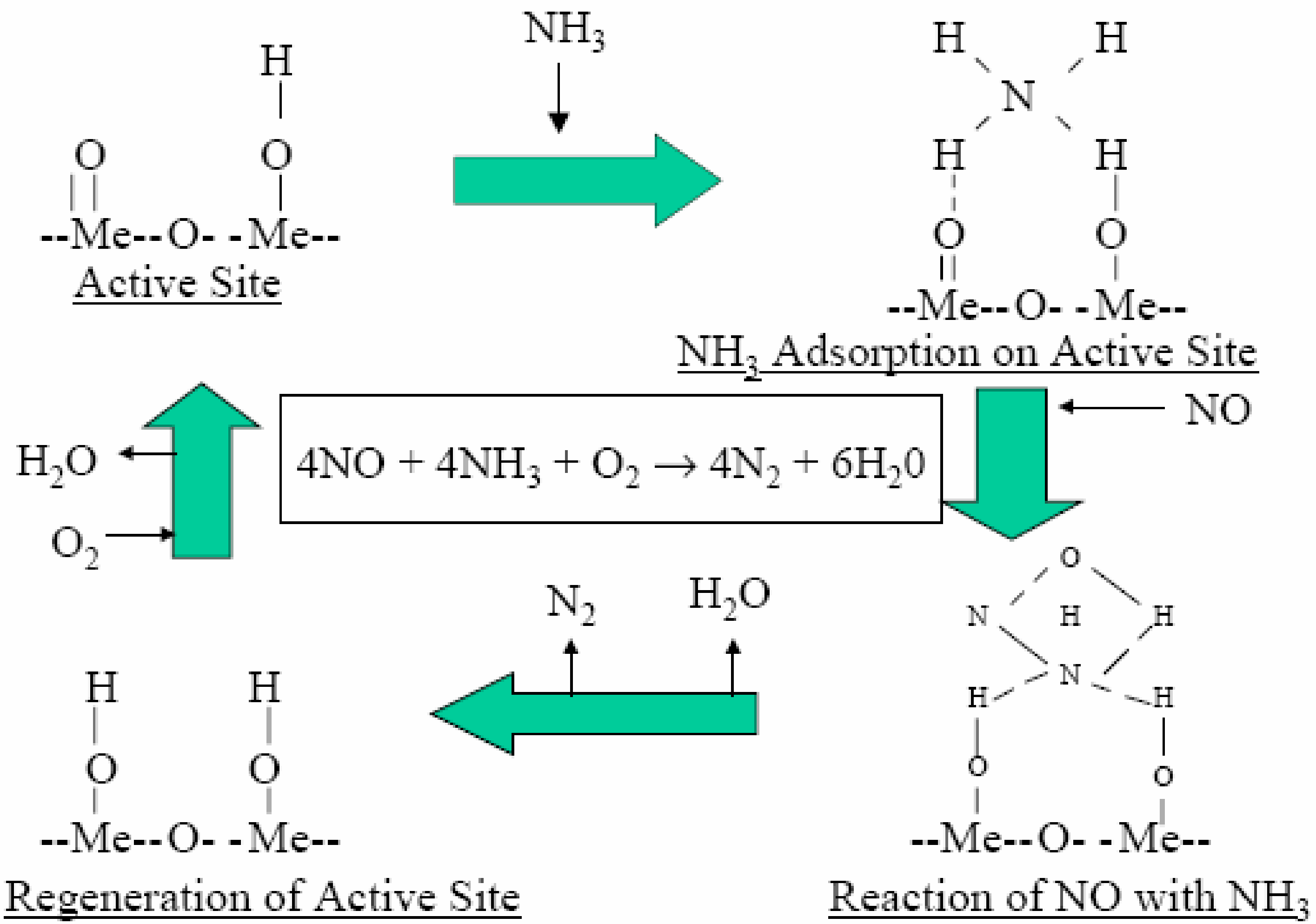
- Three General Geometries; Plate, Honeycomb, Composite/Hybrid
- Composition; Titania catalyst support with Vanadium as principal active component, other promoters, etc. added (Tungsten, etc.)
- Physical strengthening with screens, fibers, etc. in some designs

MICROSCOPIC CATALYST PROPERTIES



See Reference # 1

MECHANISM OF NOx REDUCTION



POISONING/DEACTIVATION MECHANISMS

- **PHYSICAL**

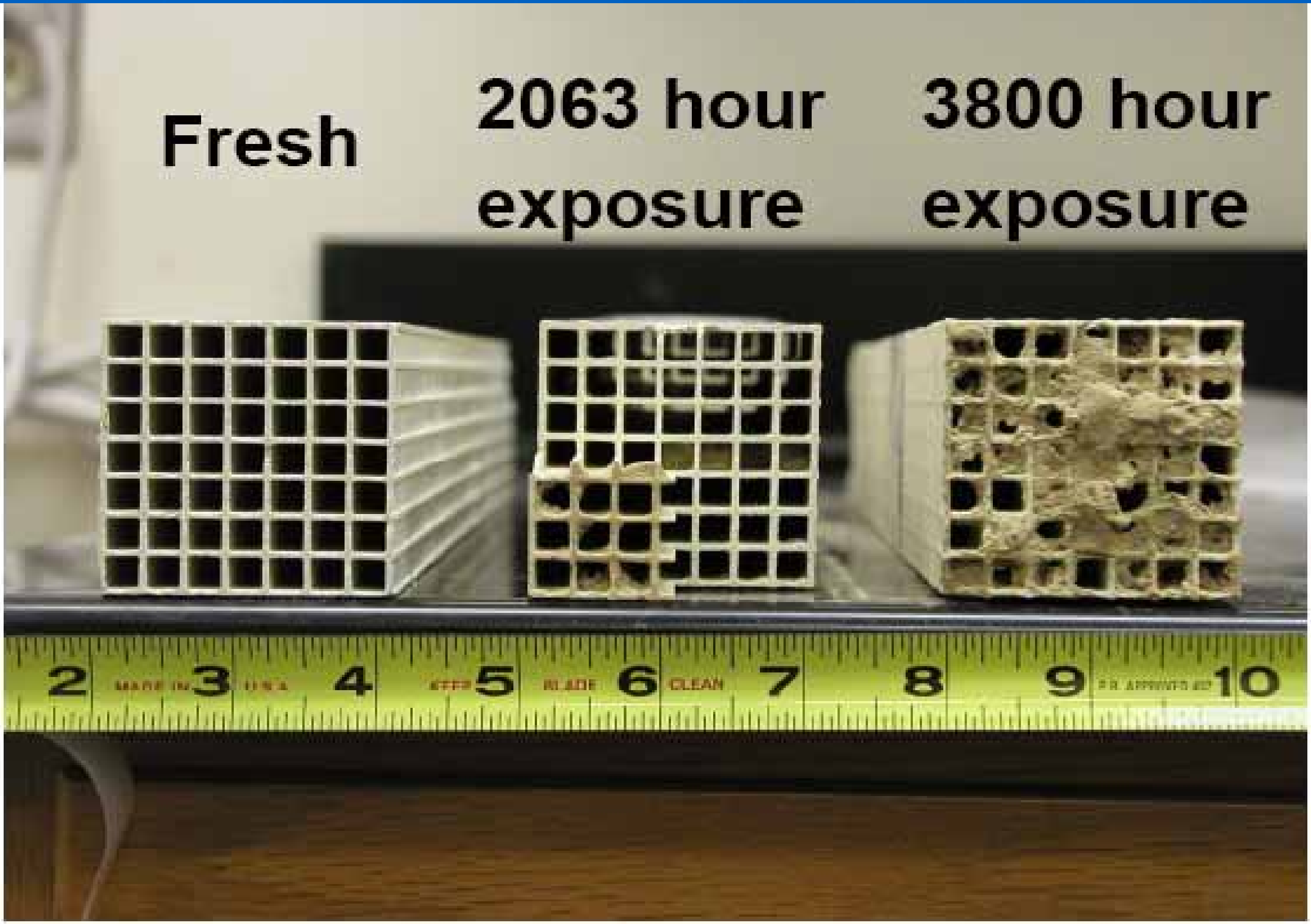
Characterized by physical blockage of pores or channels preventing reactants from accessing the catalyst active sites. Examples; general fouling, calcium sulfate masking

- **CHEMICAL**

Characterized by chemical attack on active vanadium sites. Examples; arsenic poisoning, sodium, potassium, and phosphorus poisoning

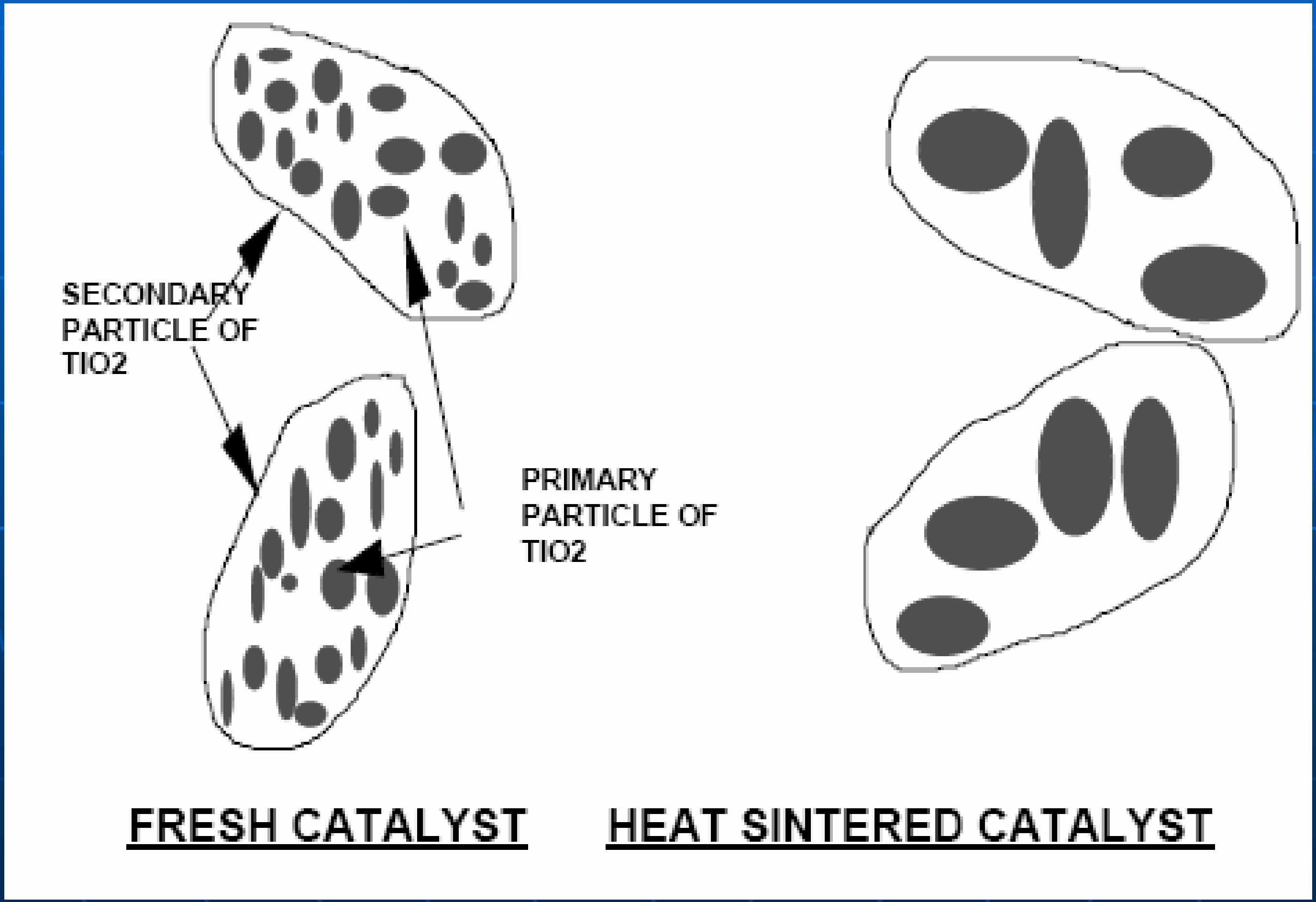
See Reference #1

GENERAL FOULING



See Reference. #1

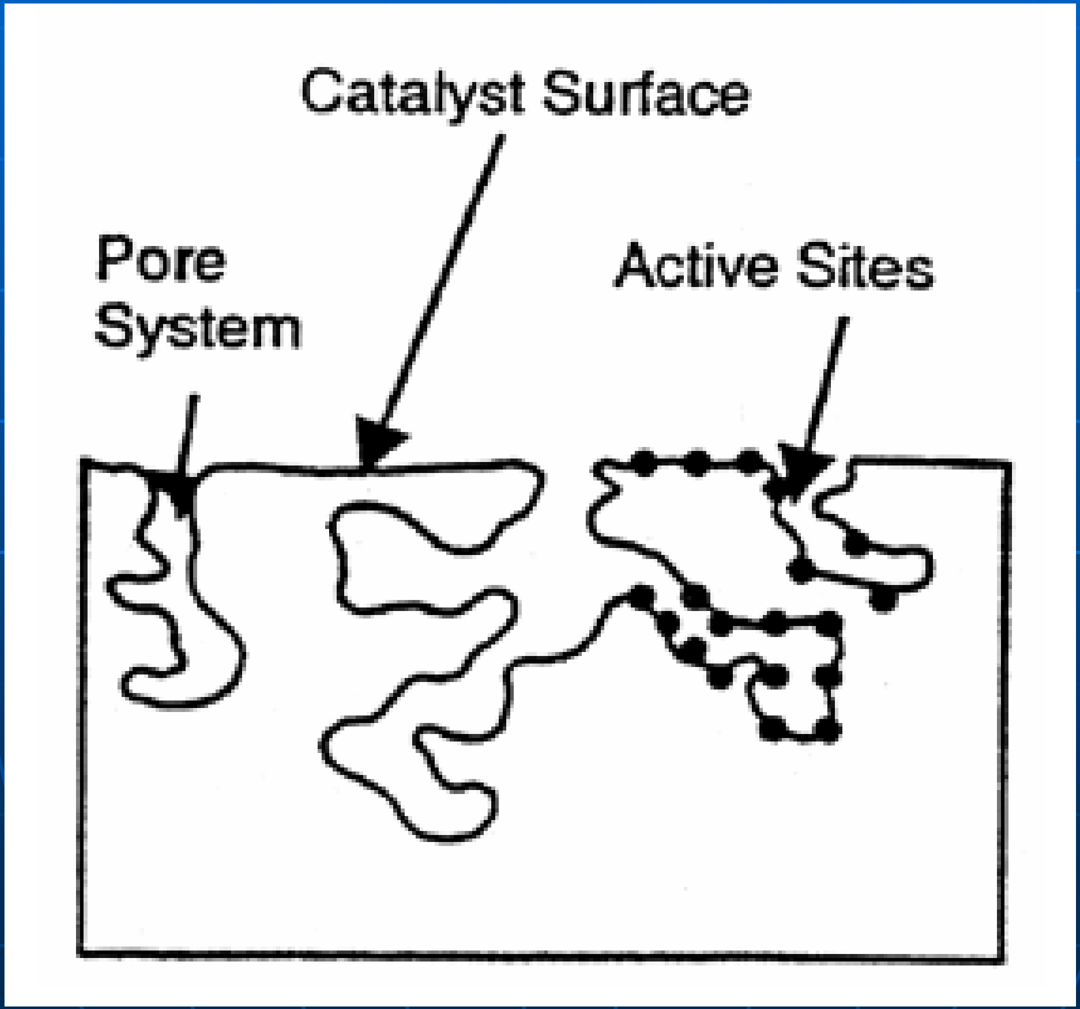
HEAT SINTERING



See Reference. #2

CHEMICAL POISONING

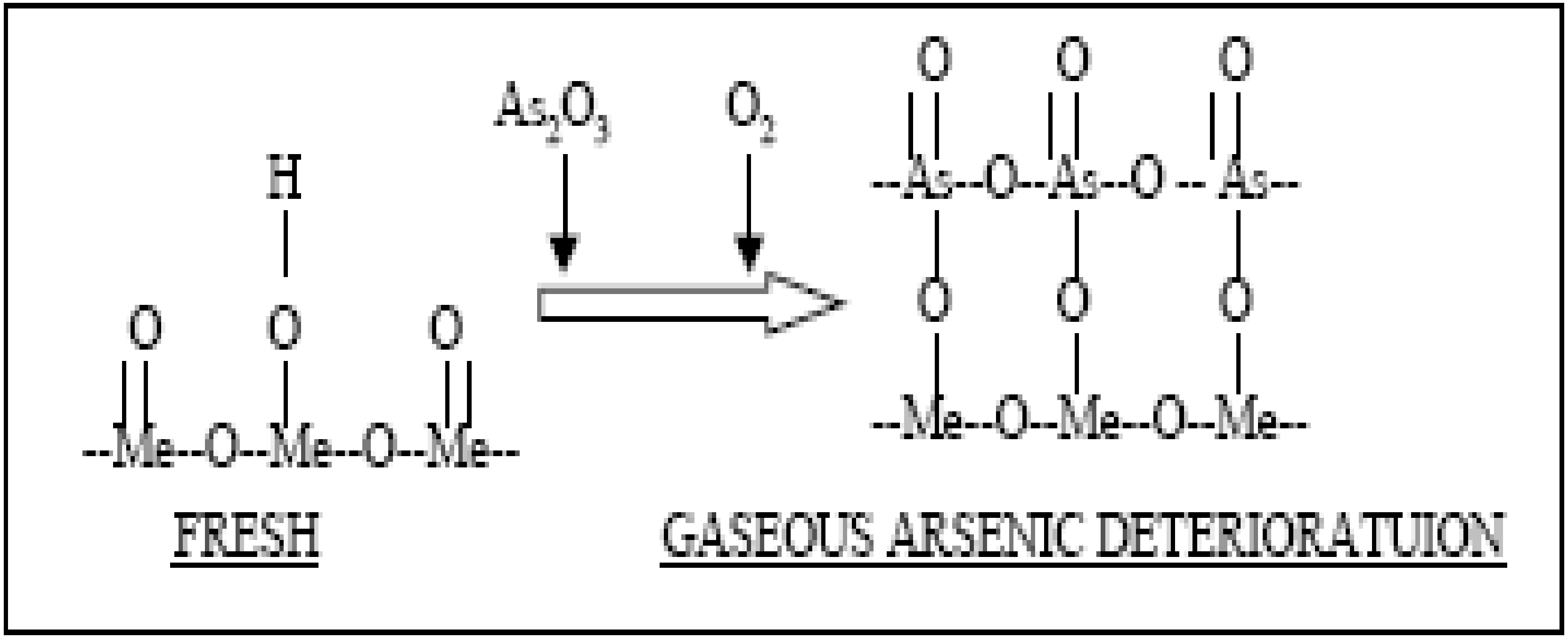
-Gaseous compounds attack active sites-



See Reference. #1

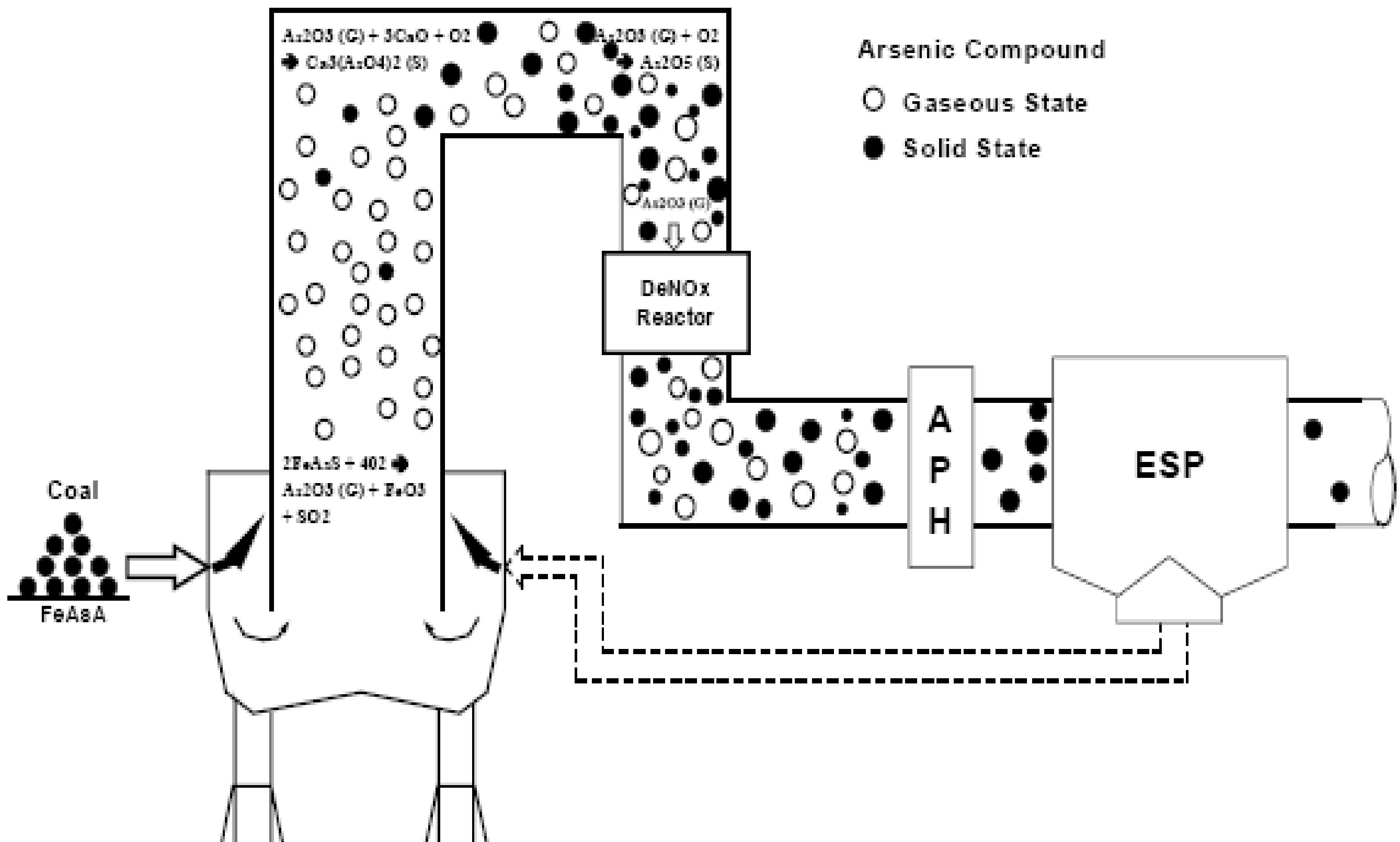
EASTERN BITUMINOUS COAL

CHEMICAL POISONING - ARSENIC

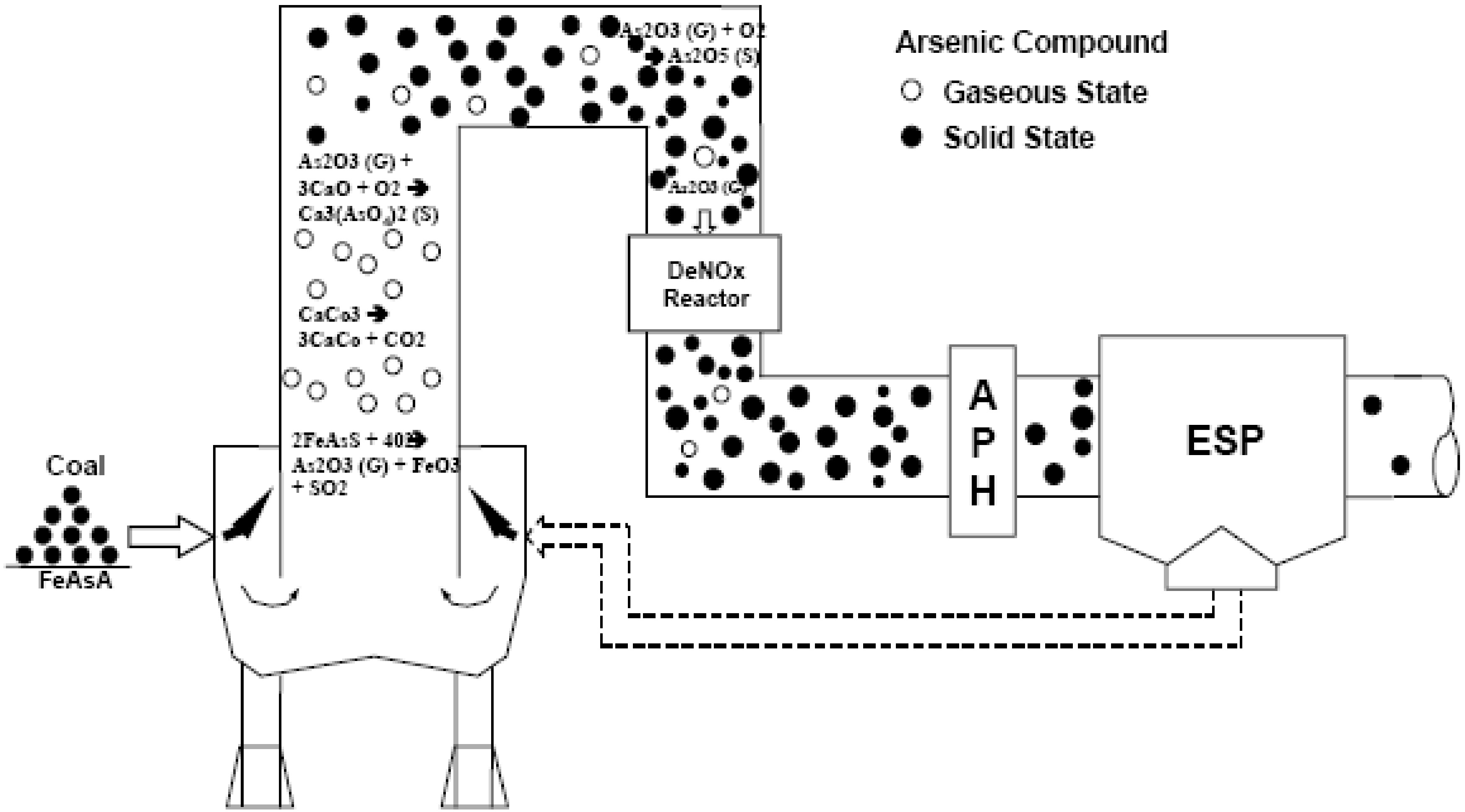


See Reference. #2

GASEOUS ARSENIC IN FLUE GAS TRAIN

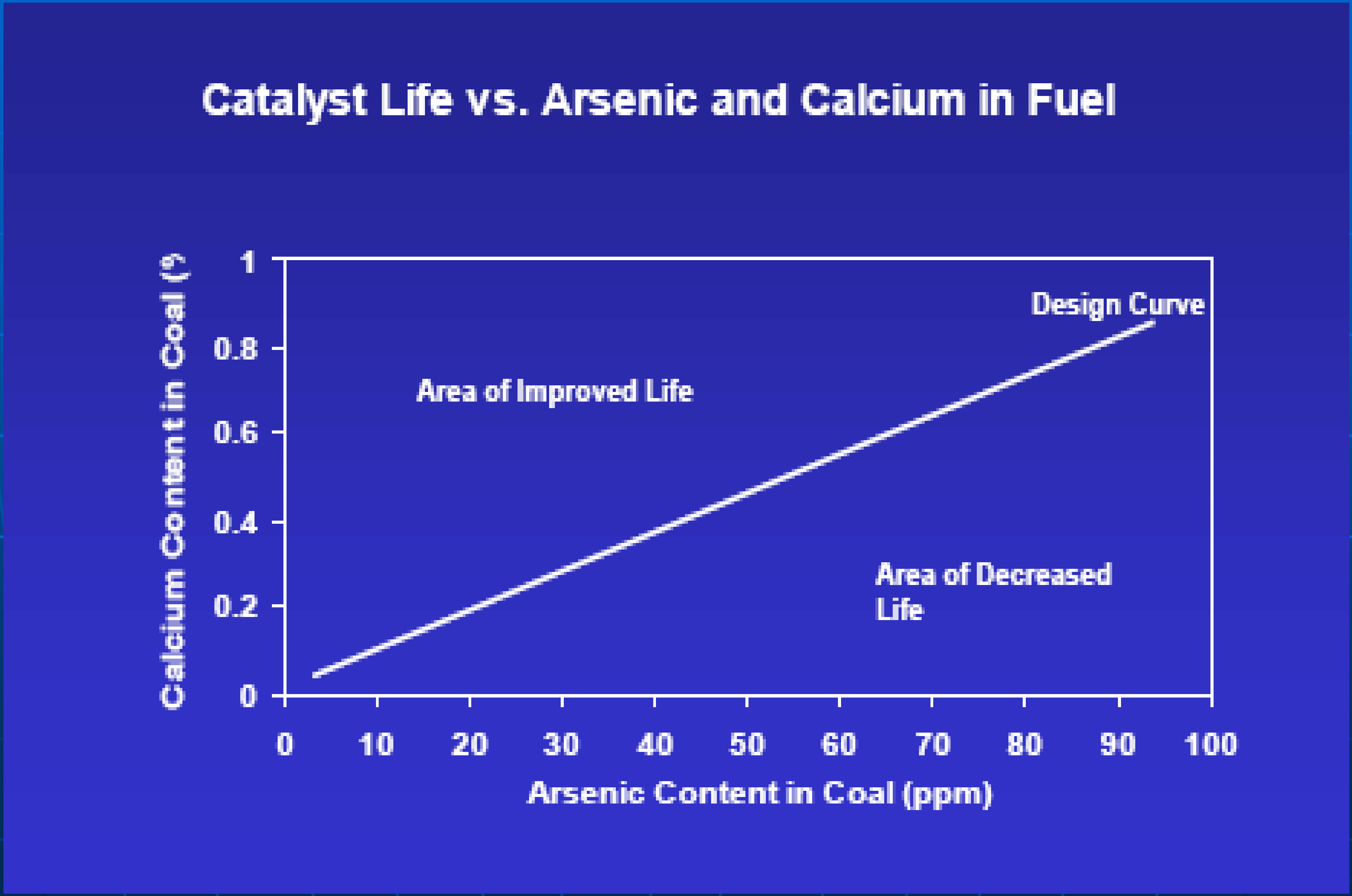


EFFECT OF CALCIUM ON GASEOUS ARSENIC



See Reference. #2

Effect of Calcium on Arsenic Poisoning and Catalyst Life

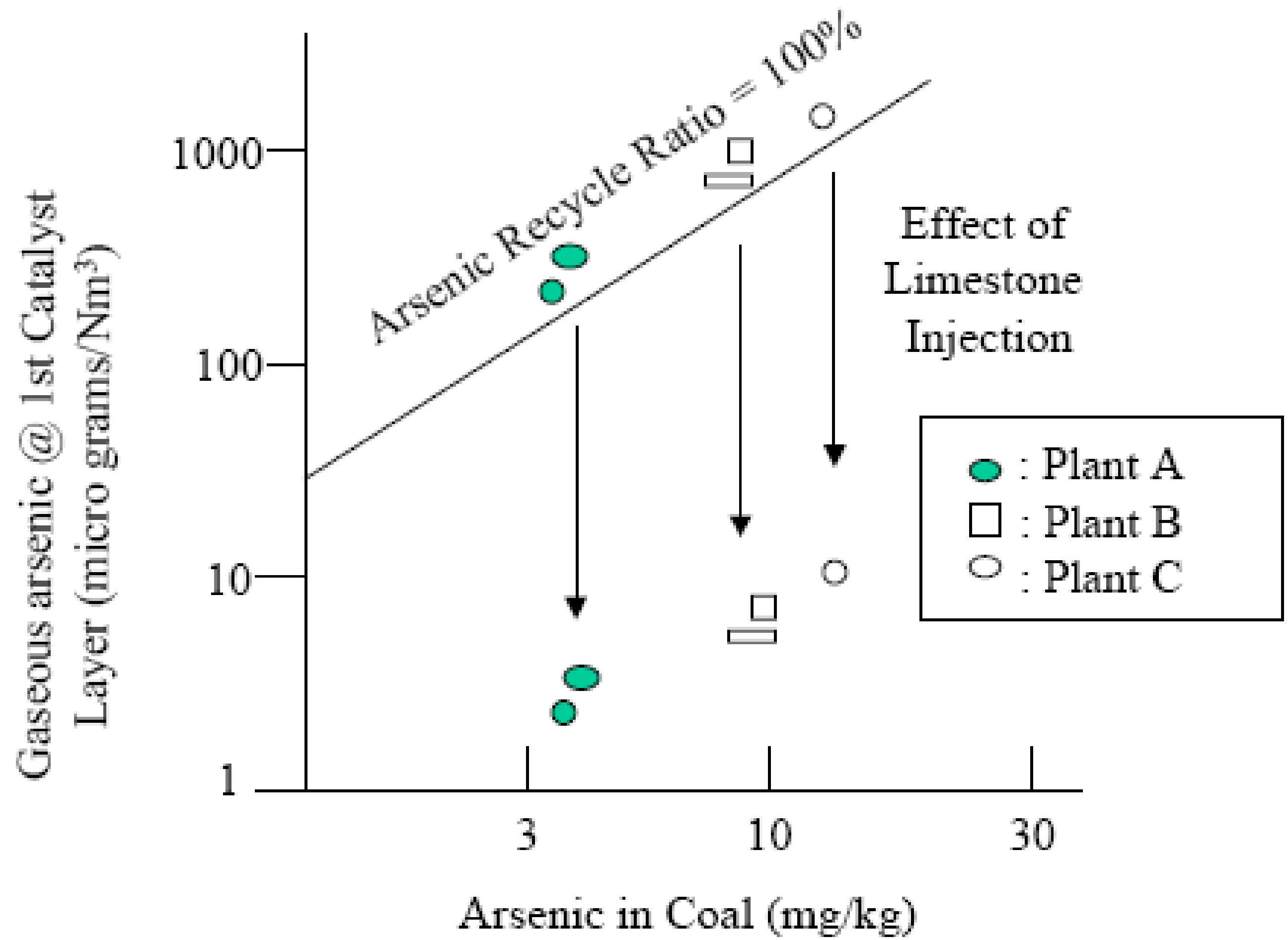


MITIGATION STEPS FOR ARSENIC POISONING

- MORE CATALYST VOLUME and/or ACTIVITY (MARGIN)
- POISONING RESISTANT CATALYST DESIGN
- FUEL SELECTION
- CALCIUM/LIMESTONE ADDITION

See Reference #1

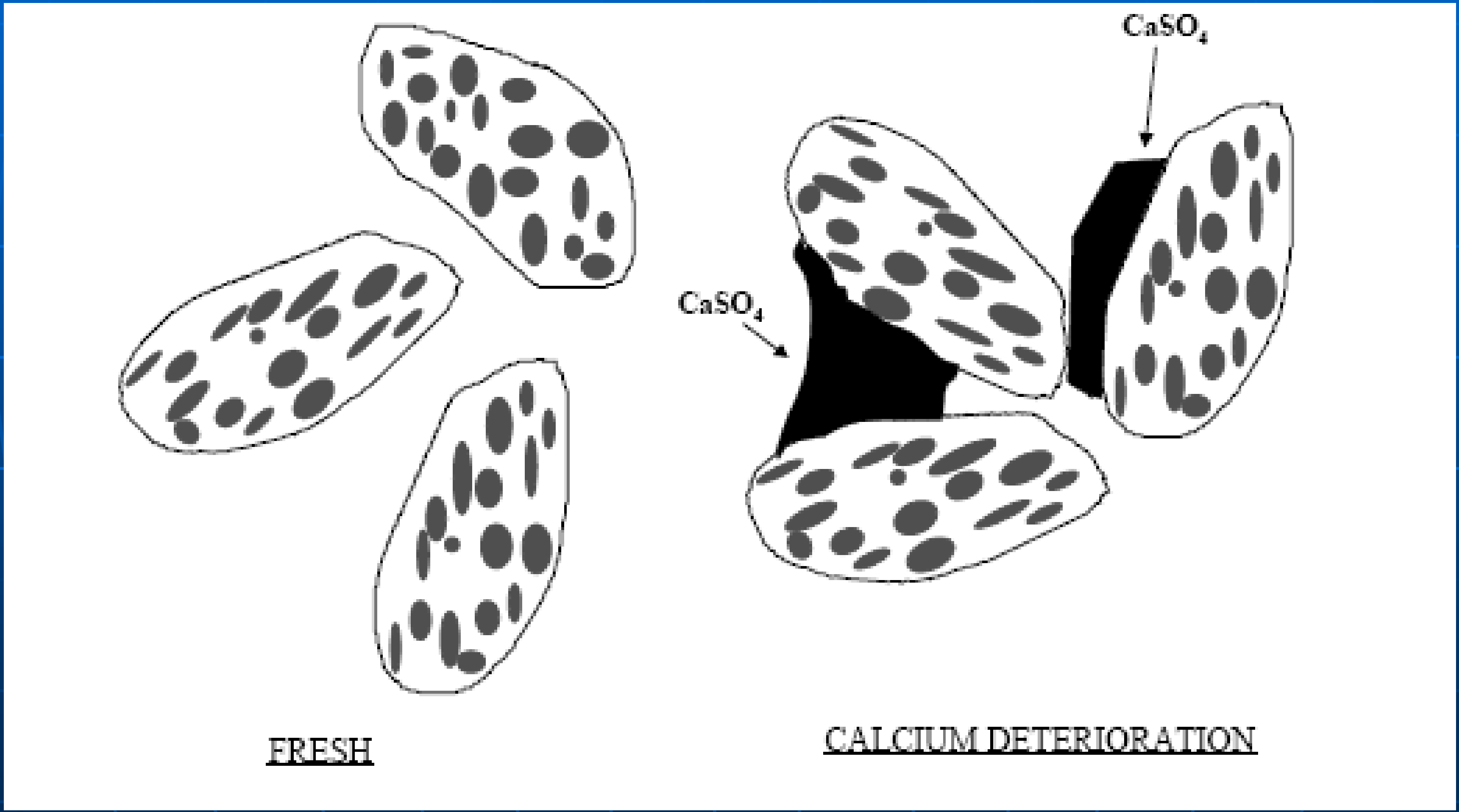
EFFECT OF LIMESTONE ADDITION



See Reference. #2

POWDER RIVER BASIN COAL

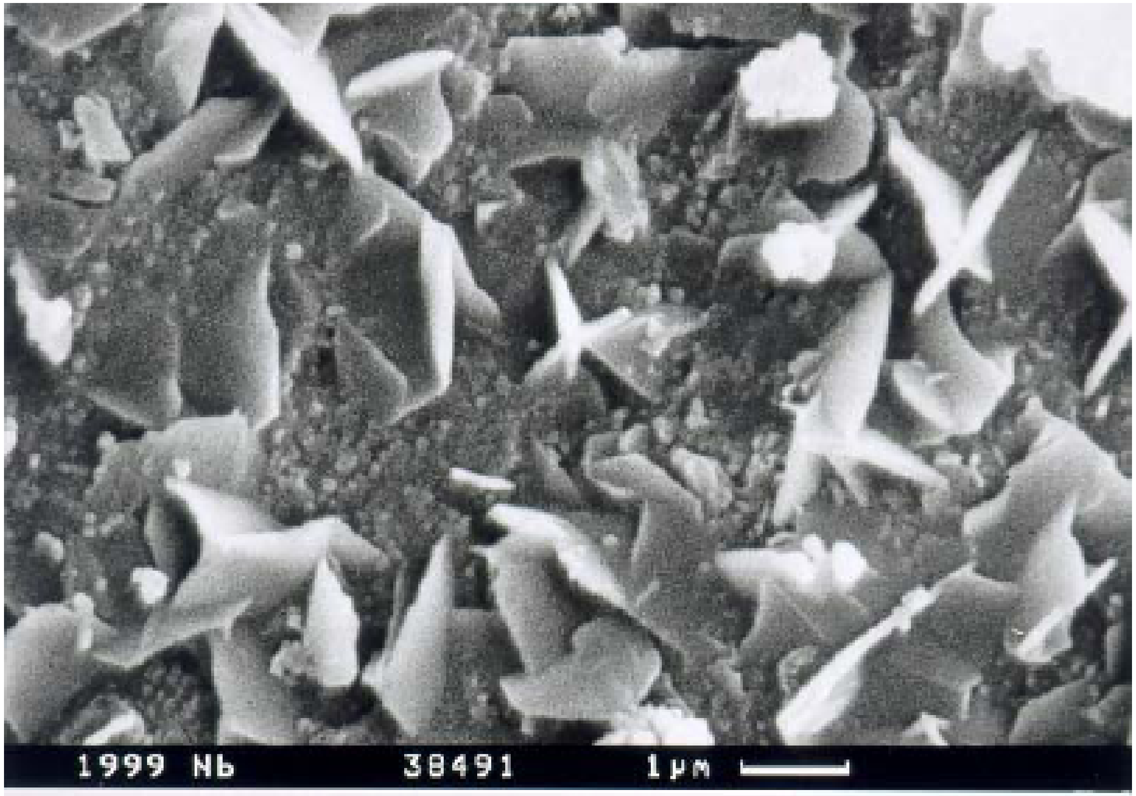
PSEUDOCHEMICAL POISONING - CALCIUM

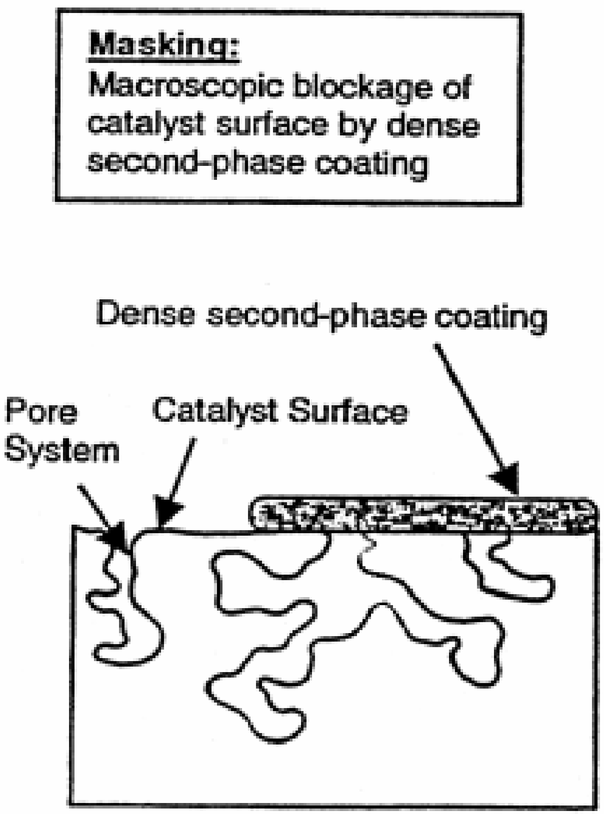


See Reference. #2

"PRB POISONING" MECHANISM

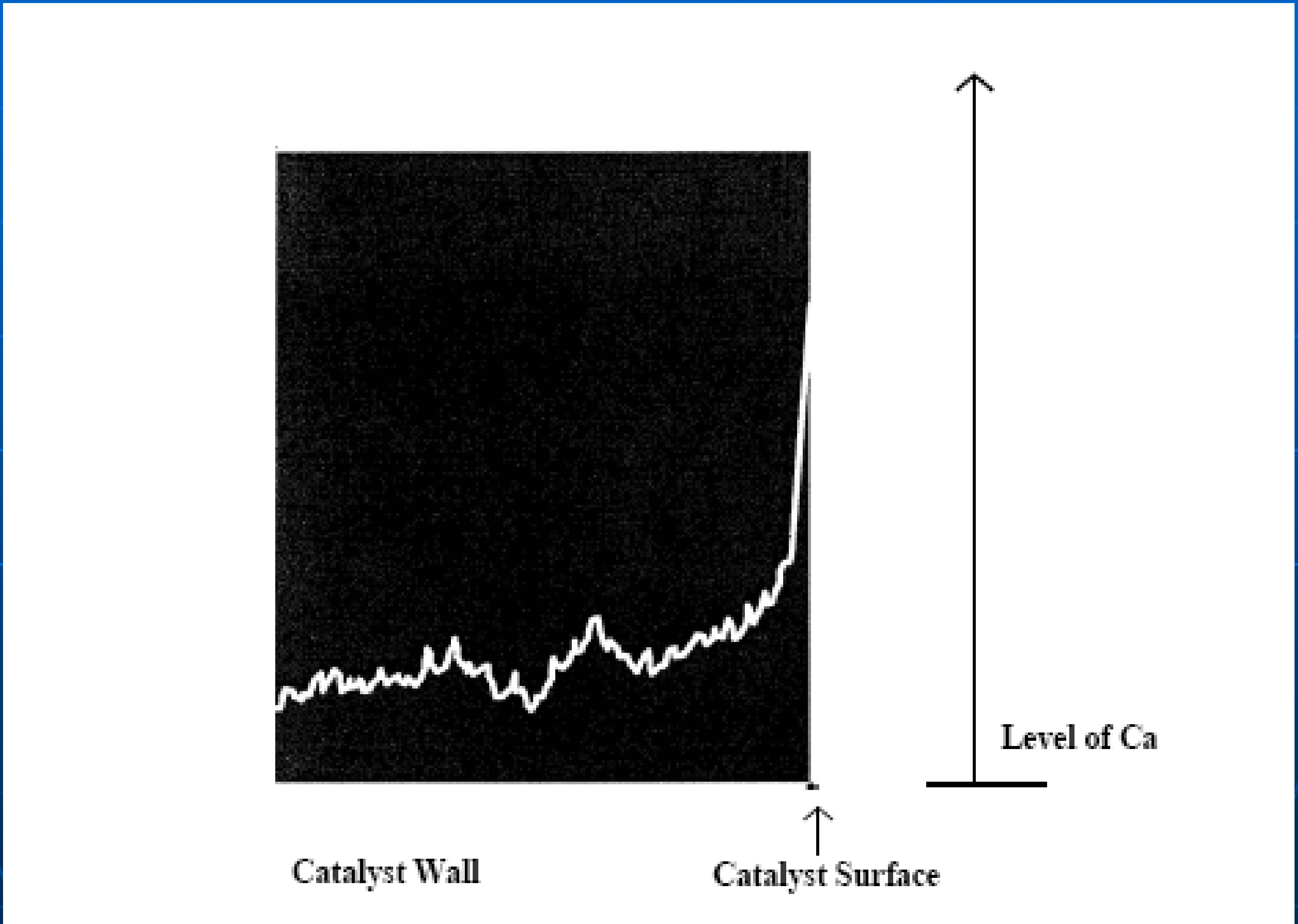
Calcium sulfate coating on catalyst surface





See Reference. #1

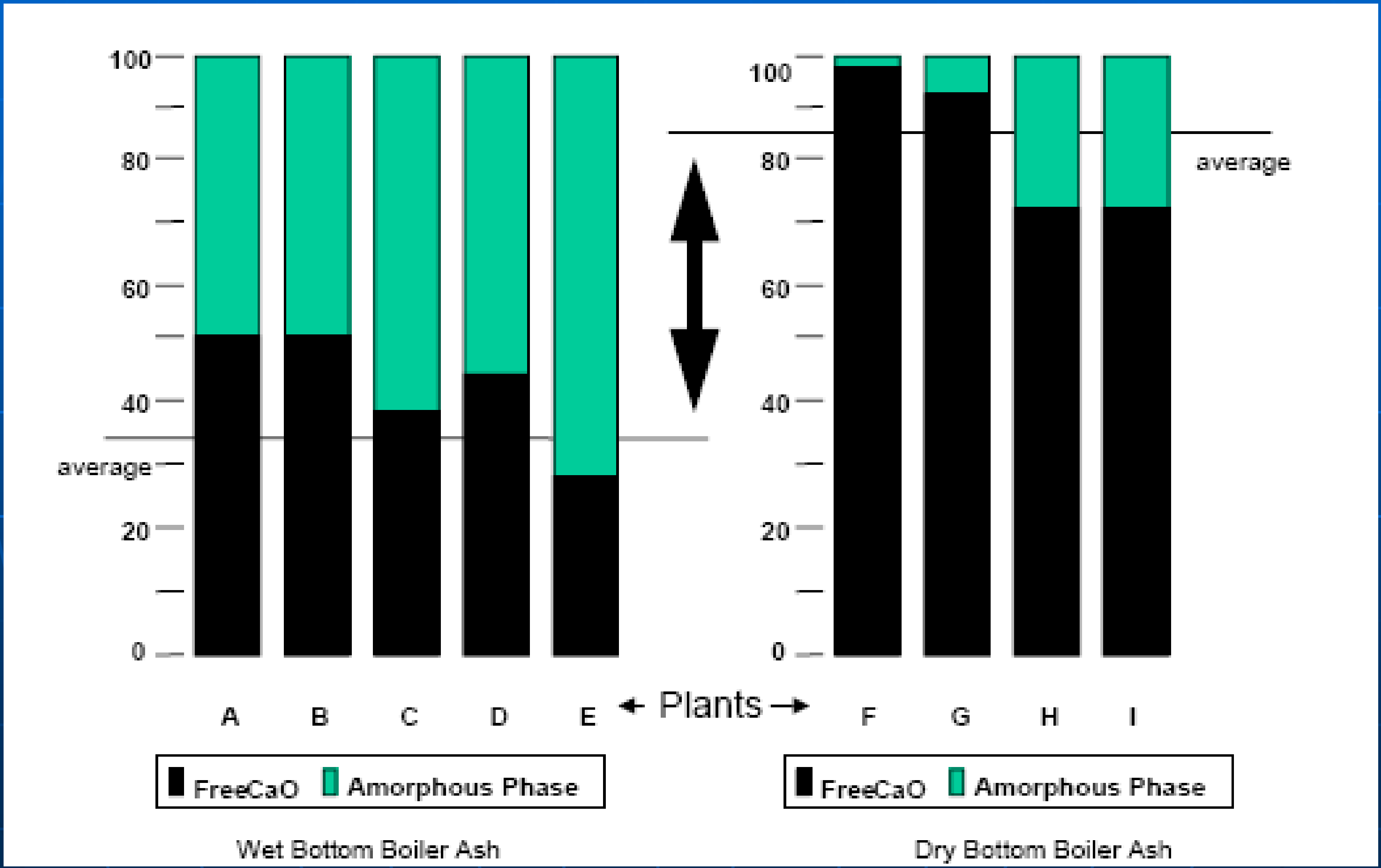
ENRICHMENT OF CALCIUM AT CATALYST SURFACE



See Reference. #2

DRY BOTTOM vs. WET BOTTOM BOILERS

(PRB COALS)



See Reference. #2

MITIGATION STEPS FOR PRB/CALCIUM SULFATE POISONING

- MORE CATALYST VOLUME and/or ACTIVITY (MARGIN)
- POISONING RESISTANT CATALYST DESIGN

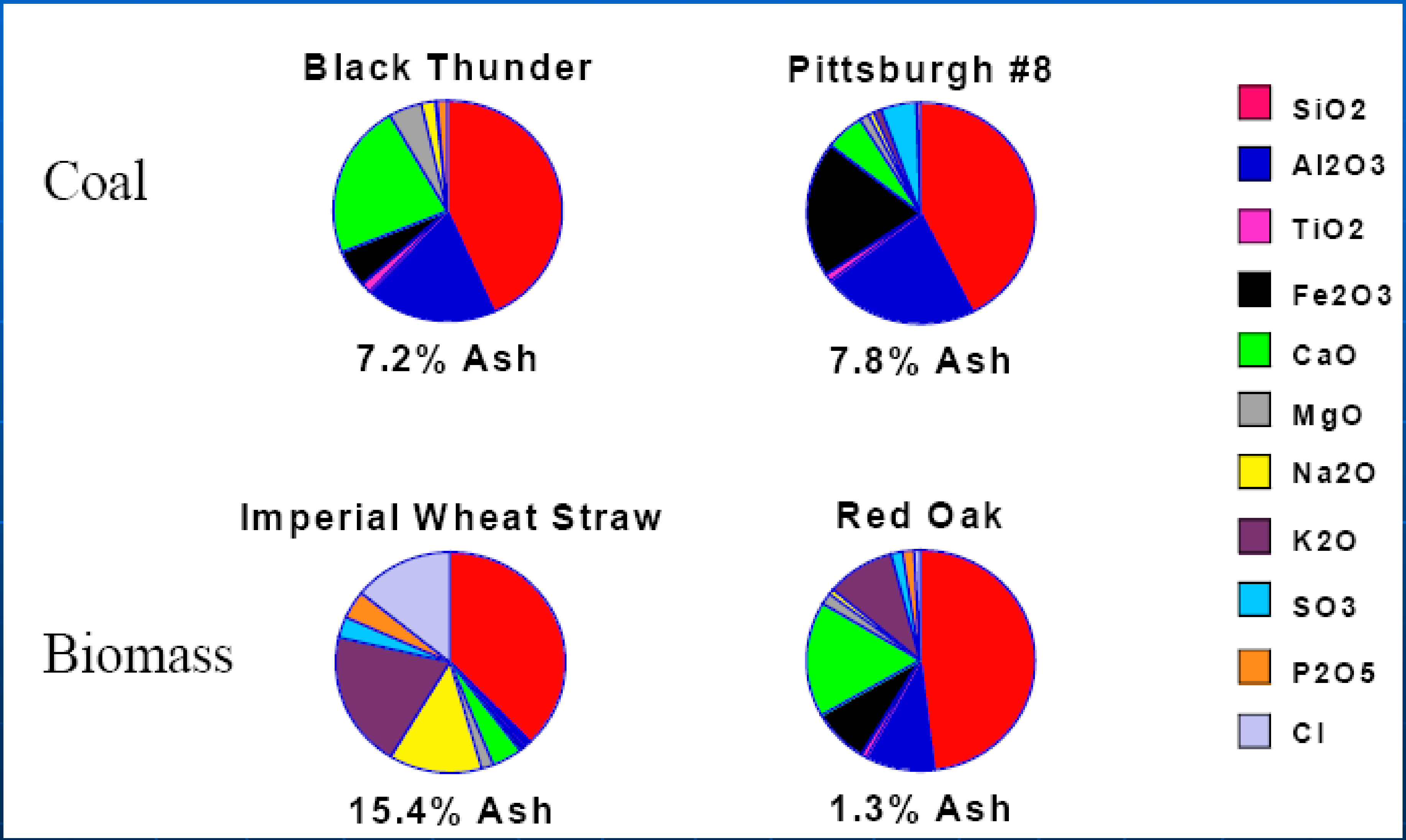
OTHER CHEMICAL POISONING SPECIES

- SODIUM (Na)
- POTASSIUM (K)
- PHOSPHORUS (P)

SOURCES OF SODIUM, POTASSIUM, AND PHOSPHORUS POISONING

- **PRIMARY FUEL**
- **BIOMASS CO-FIRING**
- **PROCESS SOURCES** (boiler water, wash water, fuel additives, paints, lubricants, etc.)

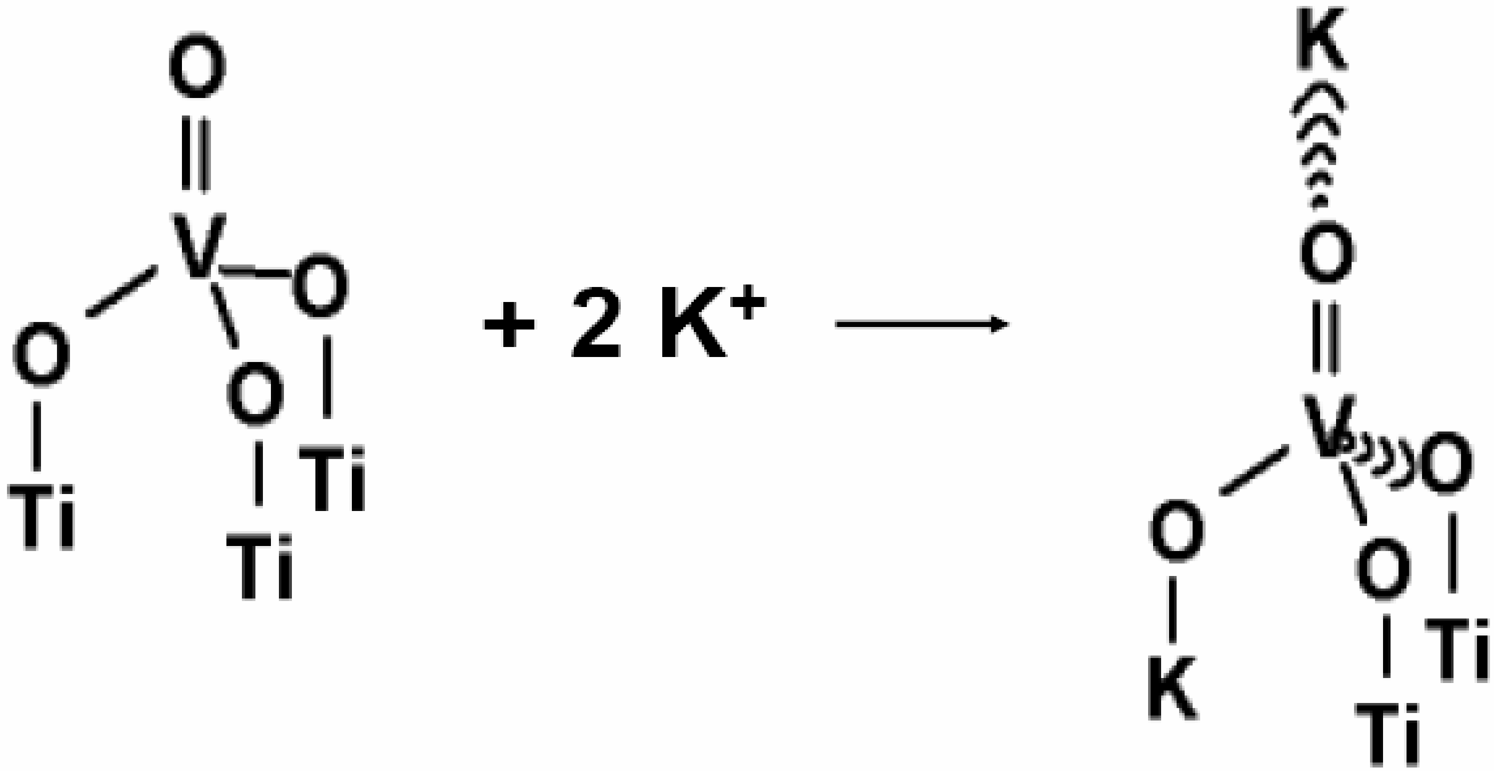
COMPARISON OF ASH CONSTIUENTS FOR DIFFERENT FUELS



See Reference. #1

MECHANISM OF CHEMICAL POISONING BY SODIUM AND POTASSIUM

Alkalis: Reactions with the acid V_2O_5 sites



See Reference. #3

SODIUM AND POTASSIUM POISONING - SOURCES

- **PRIMARY FUEL:** usually small deactivation compared to primary mechanism of arsenic poisoning or calcium sulfate masking
- **BIO-MASS:** vegetation can have large amounts of Na and K.
- **PROCESS SOURCES:** additives, etc.

*MBM – Meat and Bone Meal

See Reference. #3

PHOSPHORUS POISONING

SOURCES: Primary Fuel, Process Sources

Fuel Types

		hard coal	Lignite	sewage sludge	MBM	PRB coal (Wyodak)
Na as Na_2O	[wt-%]	1.51	2.7	0.4	5.9	0.9
K as K_2O	[wt-%]	2.91	1.6	0.7	2.75	0.7
P as P_2O_5	[wt-%]	0.19	0.1	14.2	36.2	1.1

*MBM – Meat and Bone Meal

See Reference. #3

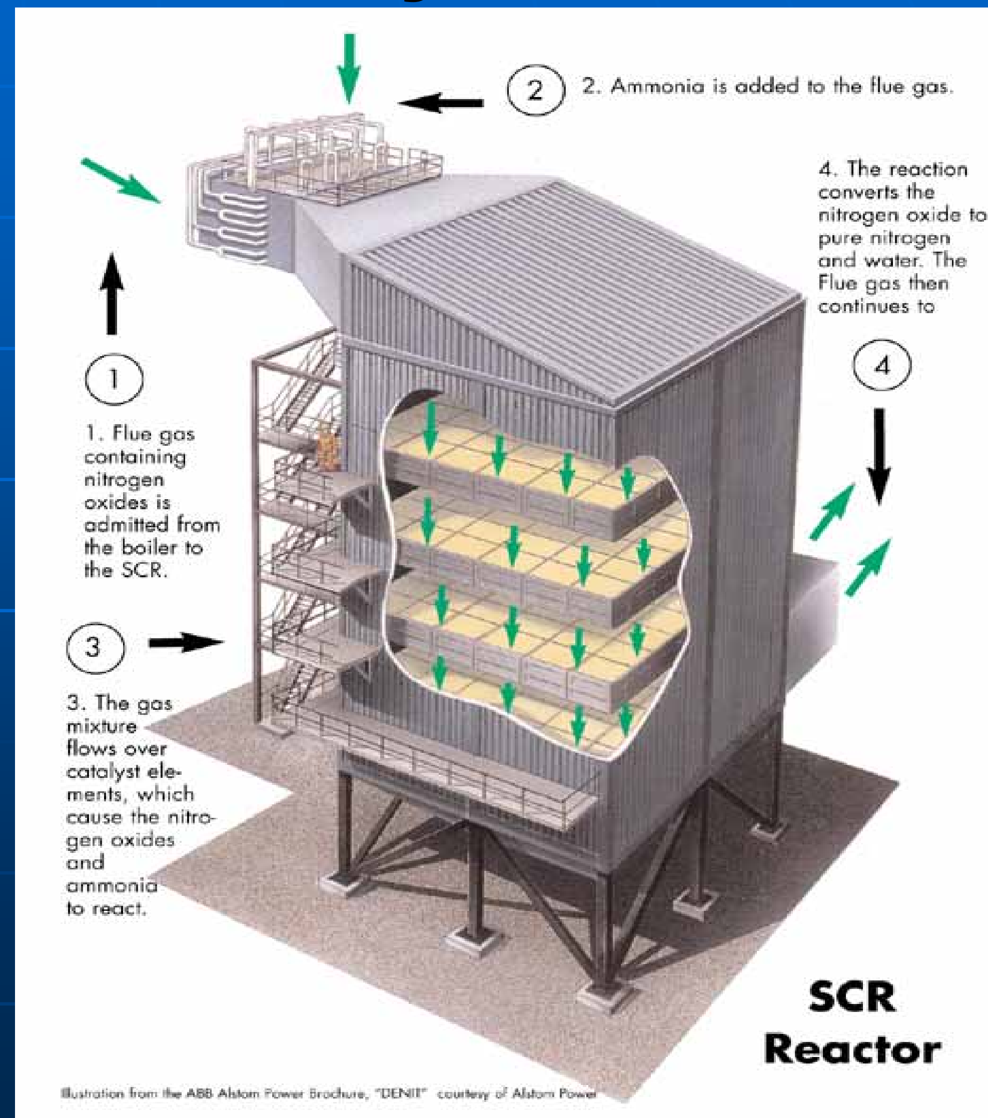
Reported Effects on SCR Activity during Co-Combustion

Coal + 4 wt-% Sewage Sludge	Coal + 4 wt-% MBM
Higher deactivation High P surface concentrations (up to 4 wt-%)	Rapid decrease in activity (30 % in 4000 h) High P surface concentrations (up to 5 wt-%) High amount of Na (bulk and surface) Reduced surface area

*MBM – Meat and Bone Meal

See Reference. #3

UPDATE: Mercury Oxidation Across SCR Catalysts



SCR – Mercury Behavior Details

- Provides more residence time
- SCR catalyst are known to promote the oxidation of mercury
- Oxidation characteristics poorly understood
- Dependent on catalyst specifics, also time, temperature, ammonia, etc. ???
- Heavily influenced by flue gas constituents, especially chlorine

CATALYST DEVELOPMENTS FOR MERCURY CONTROL

- Better understand details of mercury chemistry and catalyst behavior
- Develop predictive methods for mercury oxidation behavior
- Improve Hg oxidation
- Maintain oxidation ability throughout life
- Offer guarantees for Hg oxidation

REFERENCES

1. “Deactivation of SCR Catalysts,” Guo, X., et.al., ACERC Conference, February 17, 2005, Provo, UT.
2. “Optimizing SCR Catalyst Design and Performance for Coal-Fired Boilers, Pritchard, S., Cormetech, Inc.
3. “Deactivation Mechanisms of SCR Catalysts During the Co-Combustion of Bio-Residues,” Beck, K., Universitat Stuttgart.

QUESTIONS ???