

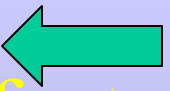


# Minnesota DNR's Coordinated Hg Research Effort: Mercury in Taconite Stack Emissions

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December 6, 2006

# Outline

- Taconite industry and Minnesota DNR's coordinated Hg research effort 
- Hg release mechanism during taconite processing
- Recent plant-scale Hg test results

# 2005 US Iron Pellet Supply

Million Gross Tons



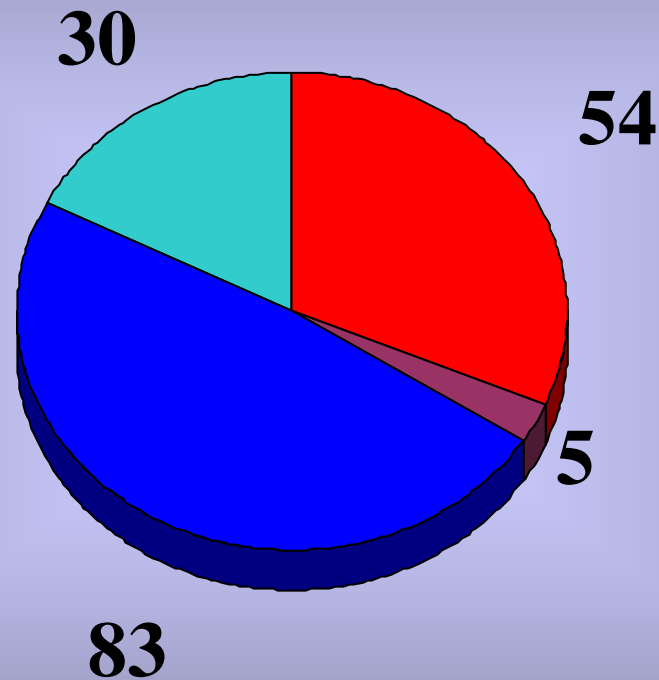
US Steel, Gary Works

## USA Production

Minnesota	41
Michigan	<u>13</u>
	54

# USA Steel Sources

Equivalent Gross Pellet Tons (millions)



**Iron Ore Pellets**

**Sinter Iron Ore Fines**

**Steel Scrap**

**Imported Steel**

# Economic Impact of Iron Ore Mining on Minnesota's Economy

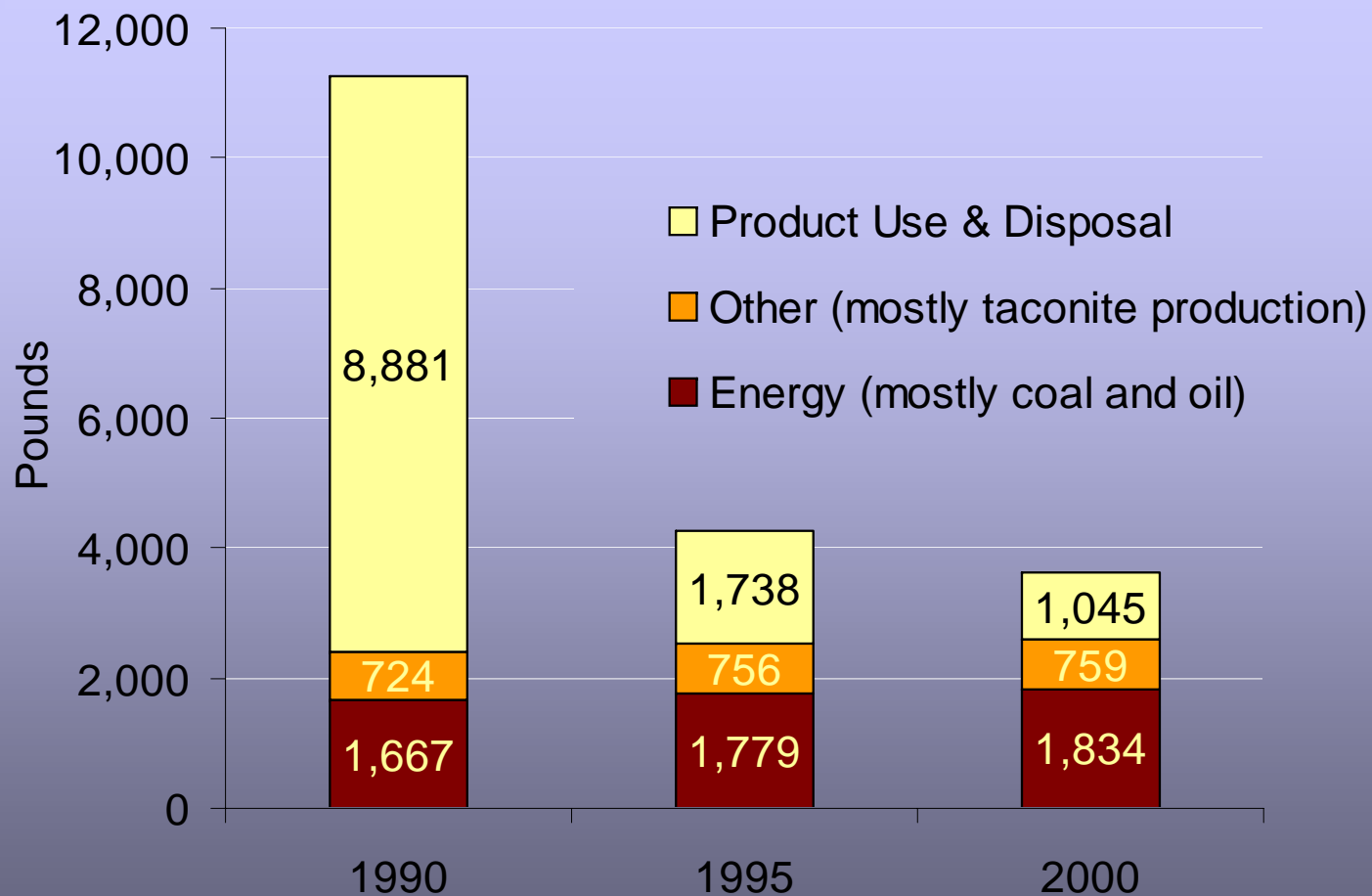
2005 Occupation Tax Reporting

- Wages and benefits                      \$ 181 million
- Purchases                                      792 million
- Royalties                                      87 million
- Taxes    114 million

Total \$1.174 Billion



# Mercury Emissions: Minnesota



Source: Swain, E. 2004. *Minnesota Mercury Emissions Inventory*



# DNR Mercury Research: History



- White Paper Study (2002-2003)
- Scrubber Water Hg Study (2003)
- “Coordinated Hg Research Effort”(2004-2007)

## **Funding:**

**MCC = Mins. Coordinating Committee**  
**MPCA= Minnesota Poll. Cont. Agency**  
**IOCR = Iron Ore Coop. Research**  
**GLNPO = Gt Lakes Nat. Prog. Off. (EPA)**  
**ECR = Environmental Coop. Research**  
**MMA = Minerals Management Account**

**IMA= Iron Mining Association**  
**Keewatin Taconite**  
**Hibbing Taconite**  
**Minntac**  
**United Taconite**  
**Mittal Steel**  
**Northshore Mining**





# Coordinated Hg Research Effort



## - Provide Supporting Hg Research Services

Research staff

Geochemistry laboratory

Cebam, Inc: Hg analysis in solids and water

U of MN-Geochem Lab: IC, ICP-MS

## - Coordinate Taconite Hg Research Activities

Prioritize research

Match funding resources to research groups

Communicate results to:

Study participants

Research community

Regulatory agencies

Public

# Coordinated Hg Research Effort: Contracted Studies

## *U of MN – NRRI:*

Bench-scale heating experiments (completed)  
FAMS Hg analysis in process gases (in progress)  
Scrubber solid characterization (in progress)

## *U of MN – IRM:*

Mossbauer spectroscopy (completed)

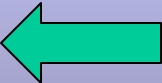
## *UND-EERC:*

Bench-scale heating experiments (completed)  
Importing power plant technology (in progress)  
Hg-monitoring for Cl injection tests (in progress)  
Hg-monitoring reliability study (in progress)

## *Carnegie Inst.:*

H<sub>2</sub>O<sub>2</sub> generation in wet scrubbers (contracting)

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Taconite processing plant

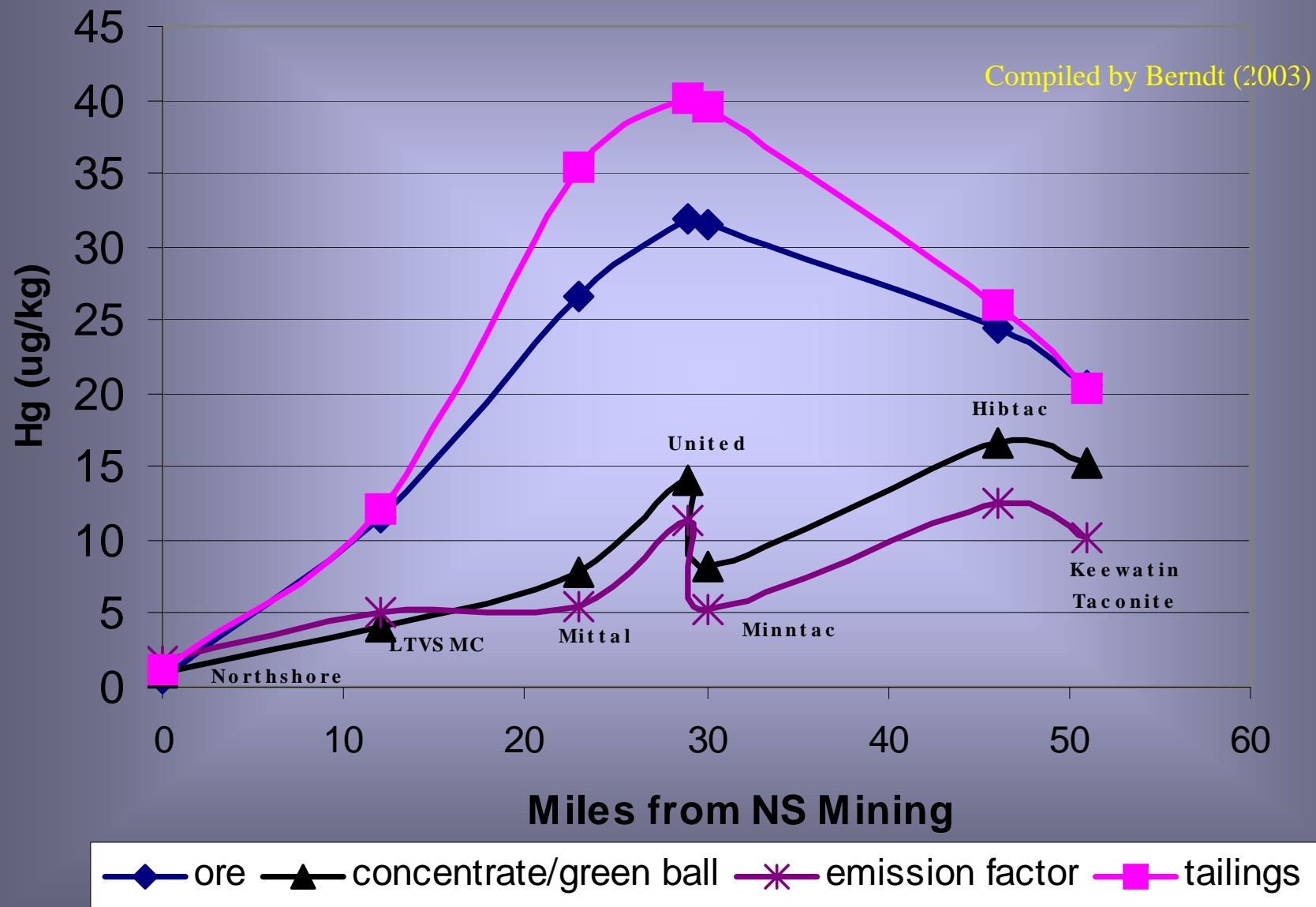
≠ (not equal to)

Coal-fired power plant

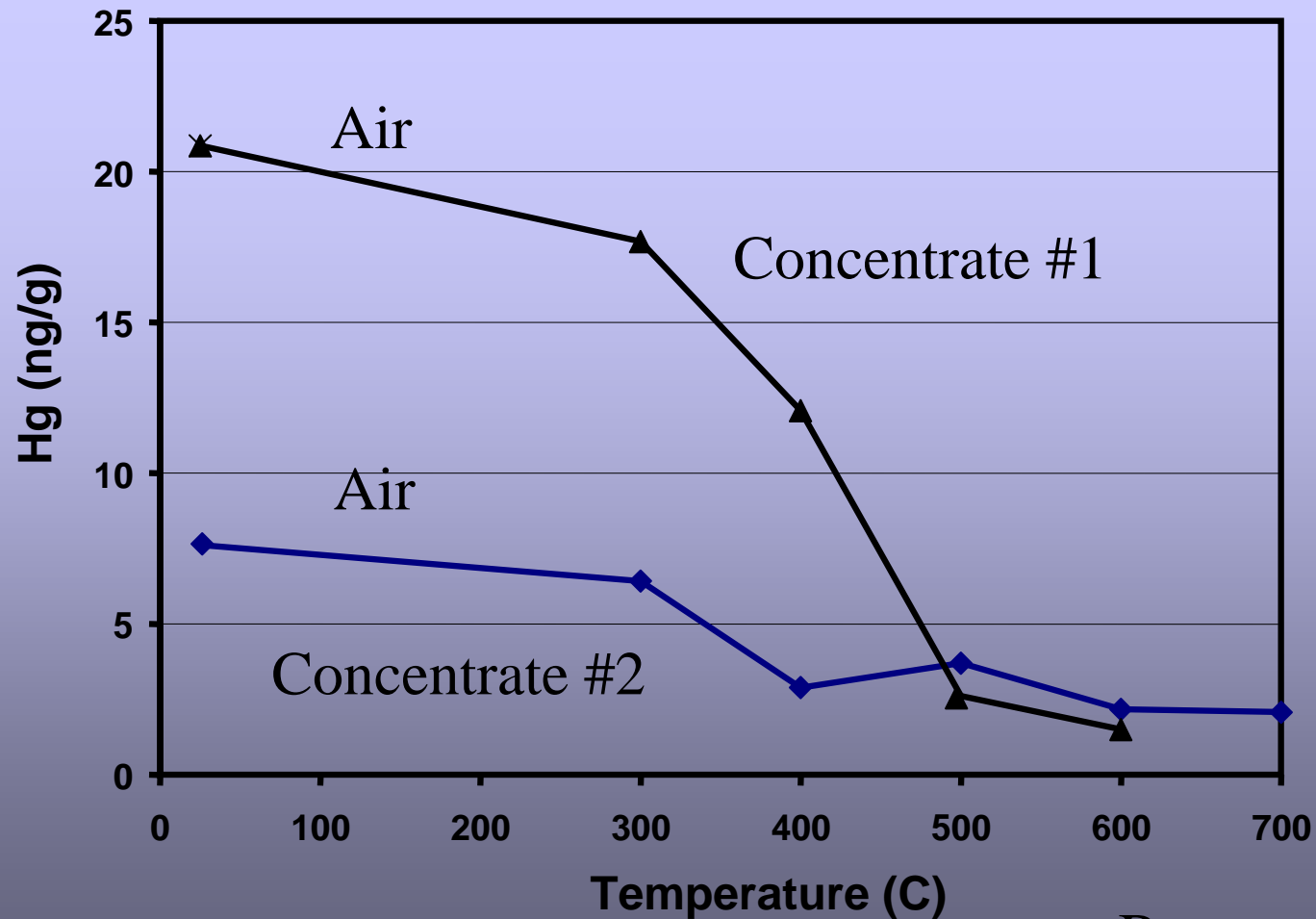
-Hg released from ore at lower T

-Reactive Fe-oxides are omnipresent

# Mercury and Taconite Processing

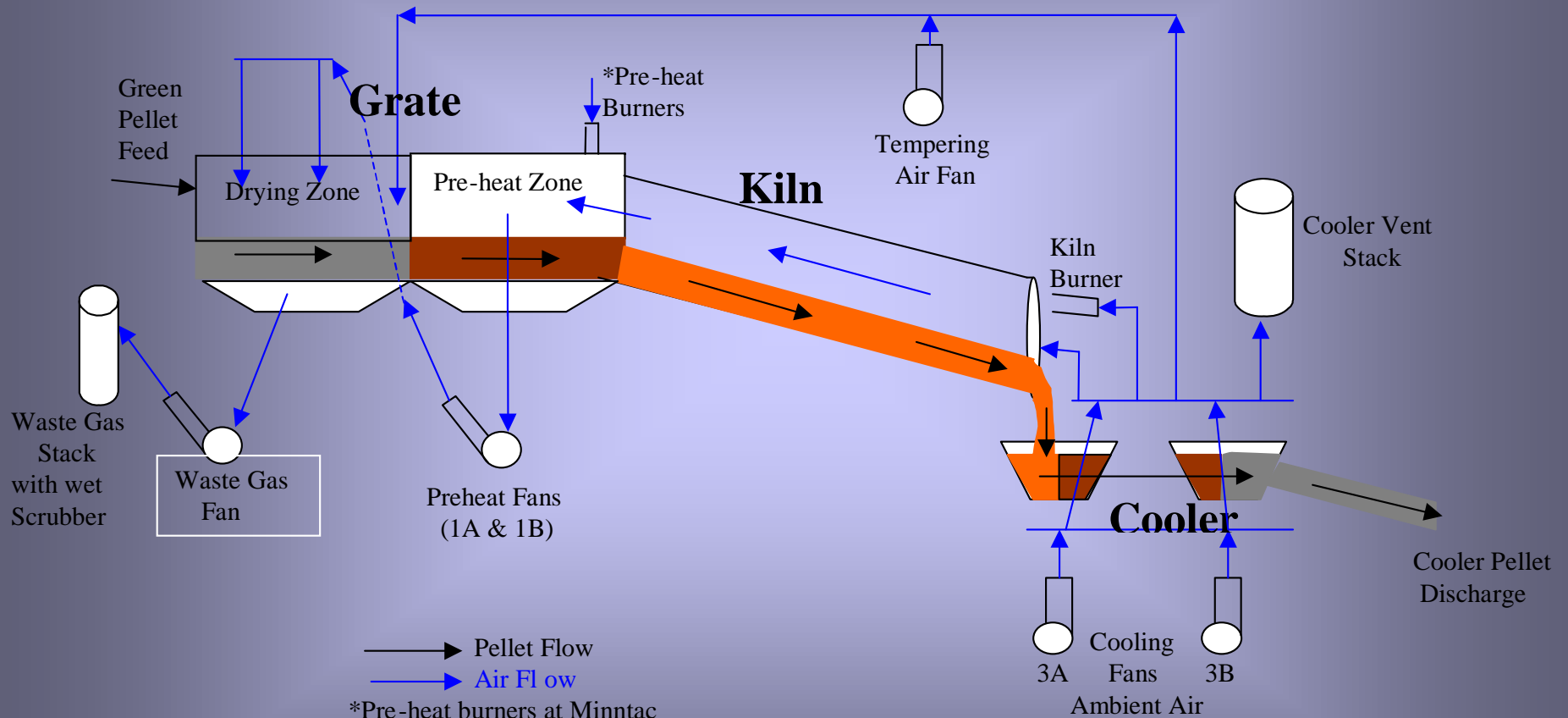


# Hg remaining in “greenball” when heated for 20 minutes

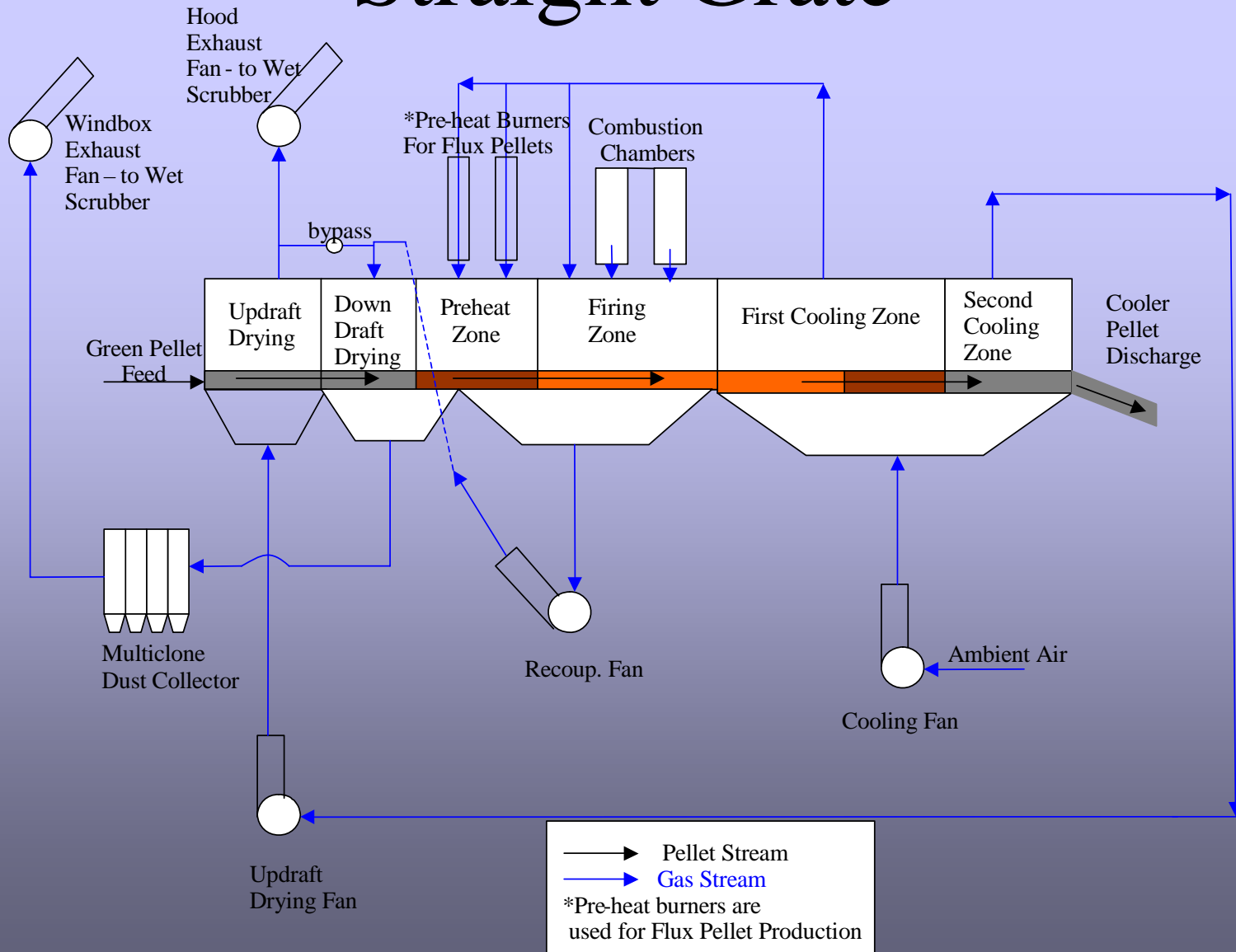


Benner (2005)

# Grate Kiln

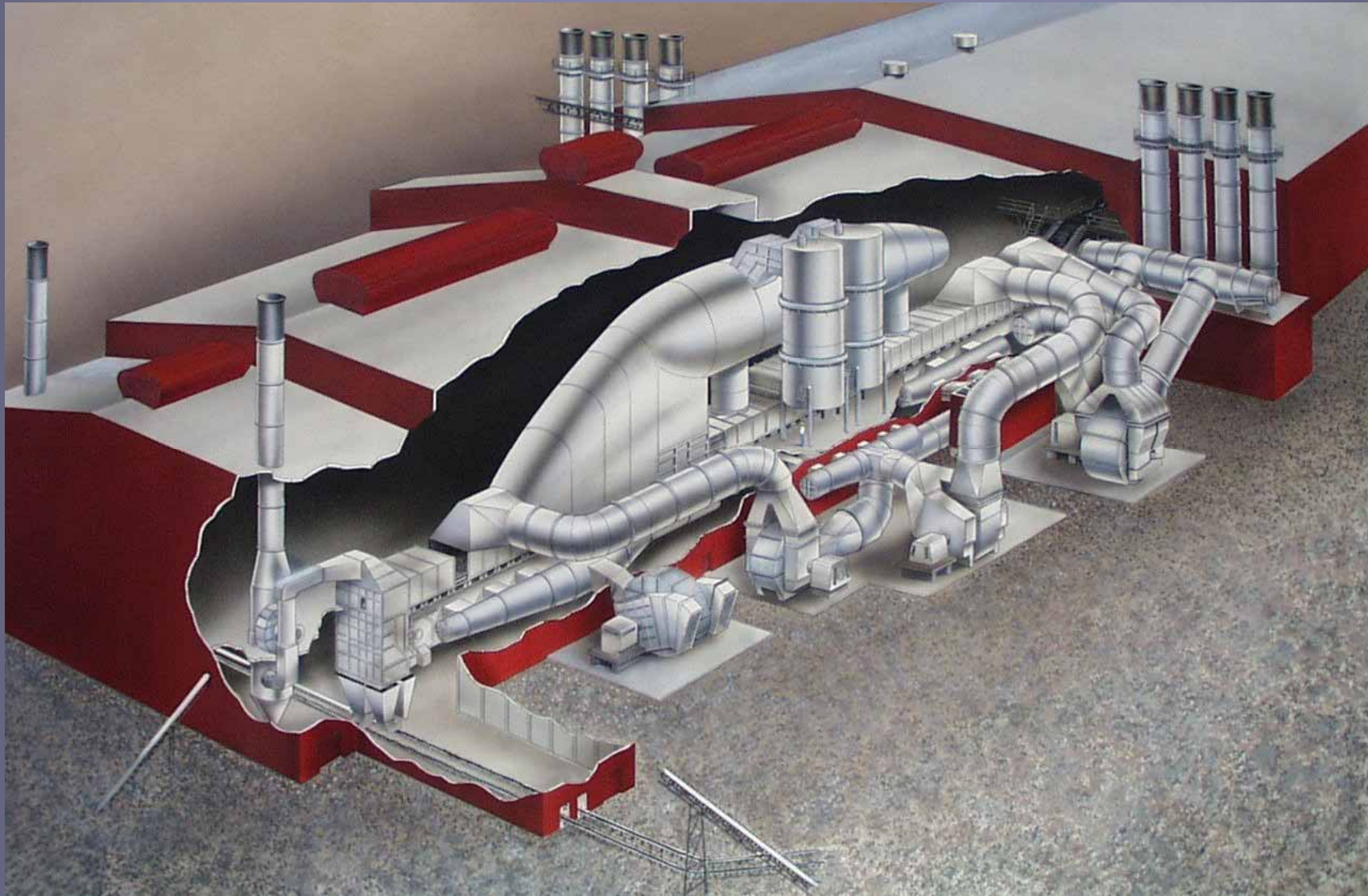


# Straight Grate

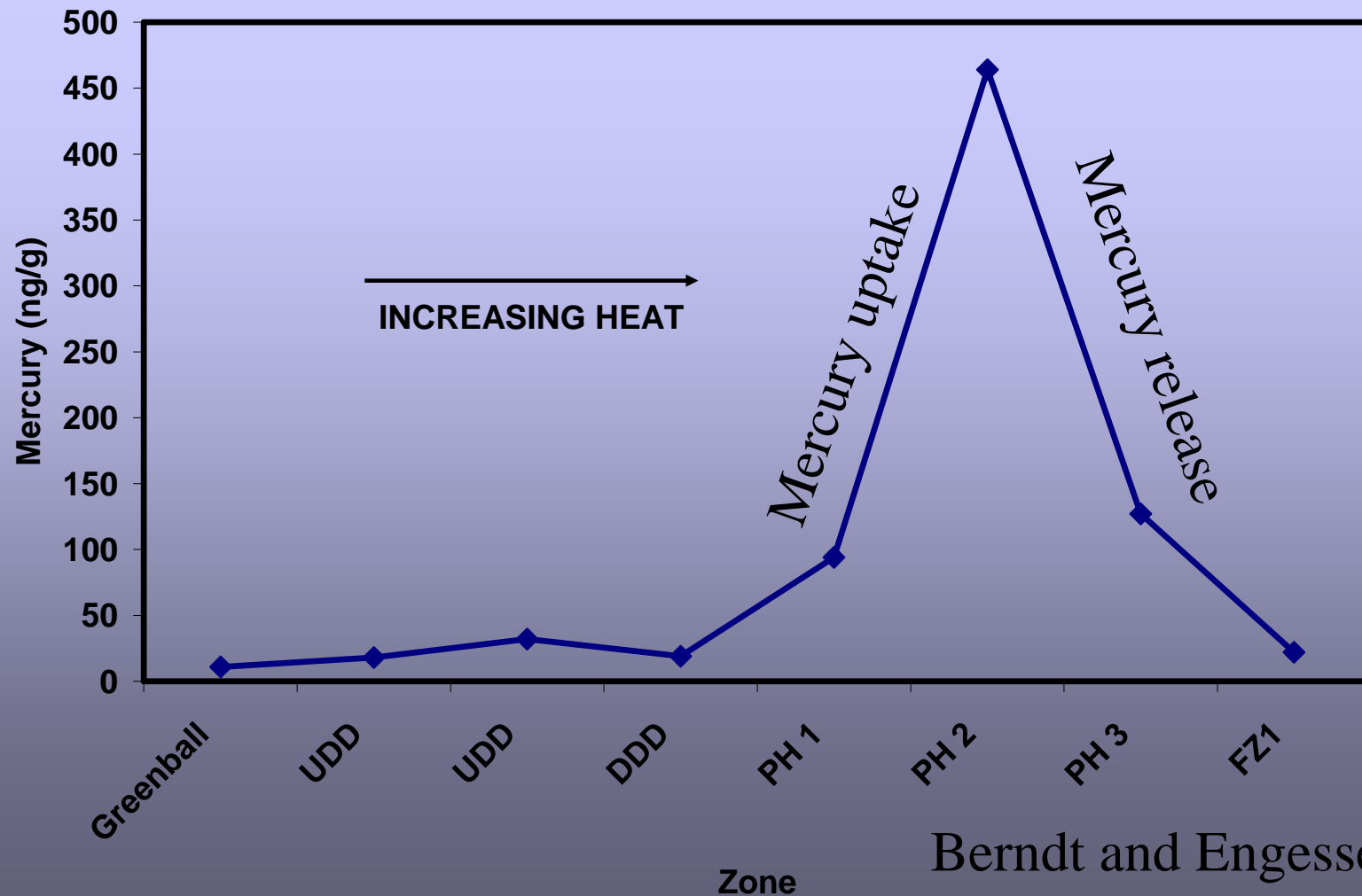




# Hibbing Taconite Cutaway (Straight-Grates)

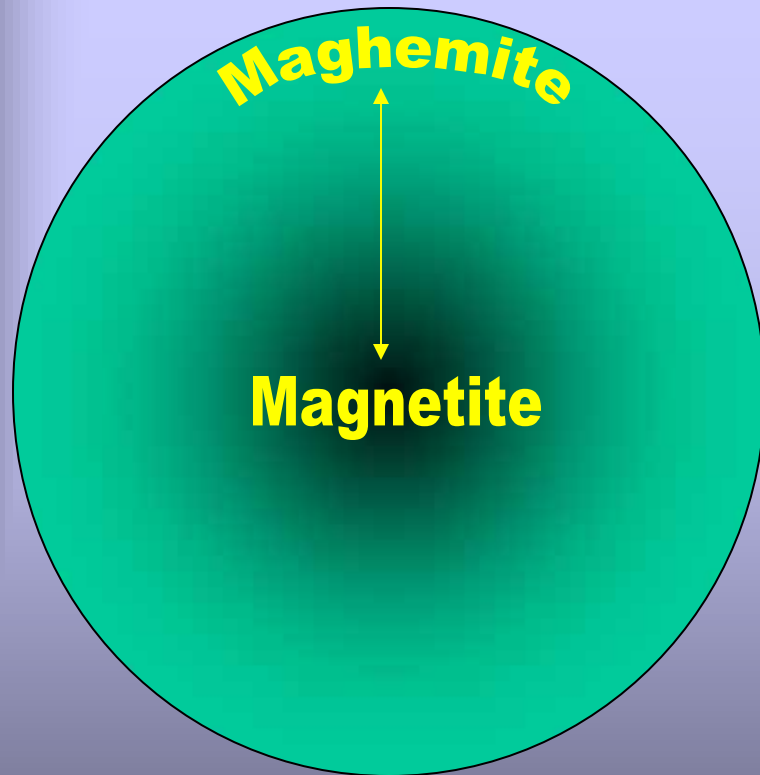


# Mercury in process dust

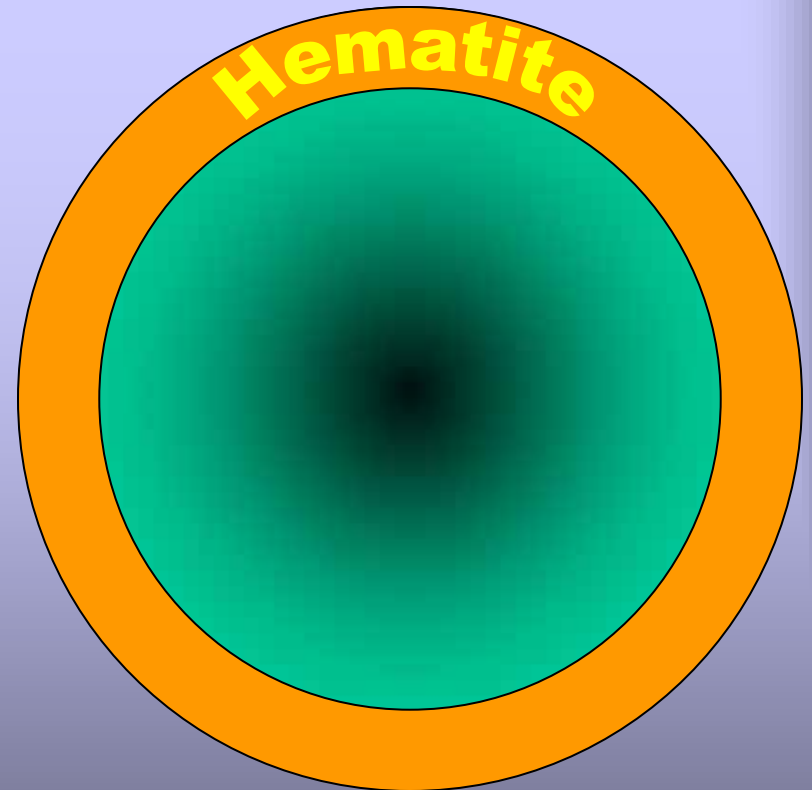


Berndt and Engesser (2005)

# Mineral Reactions

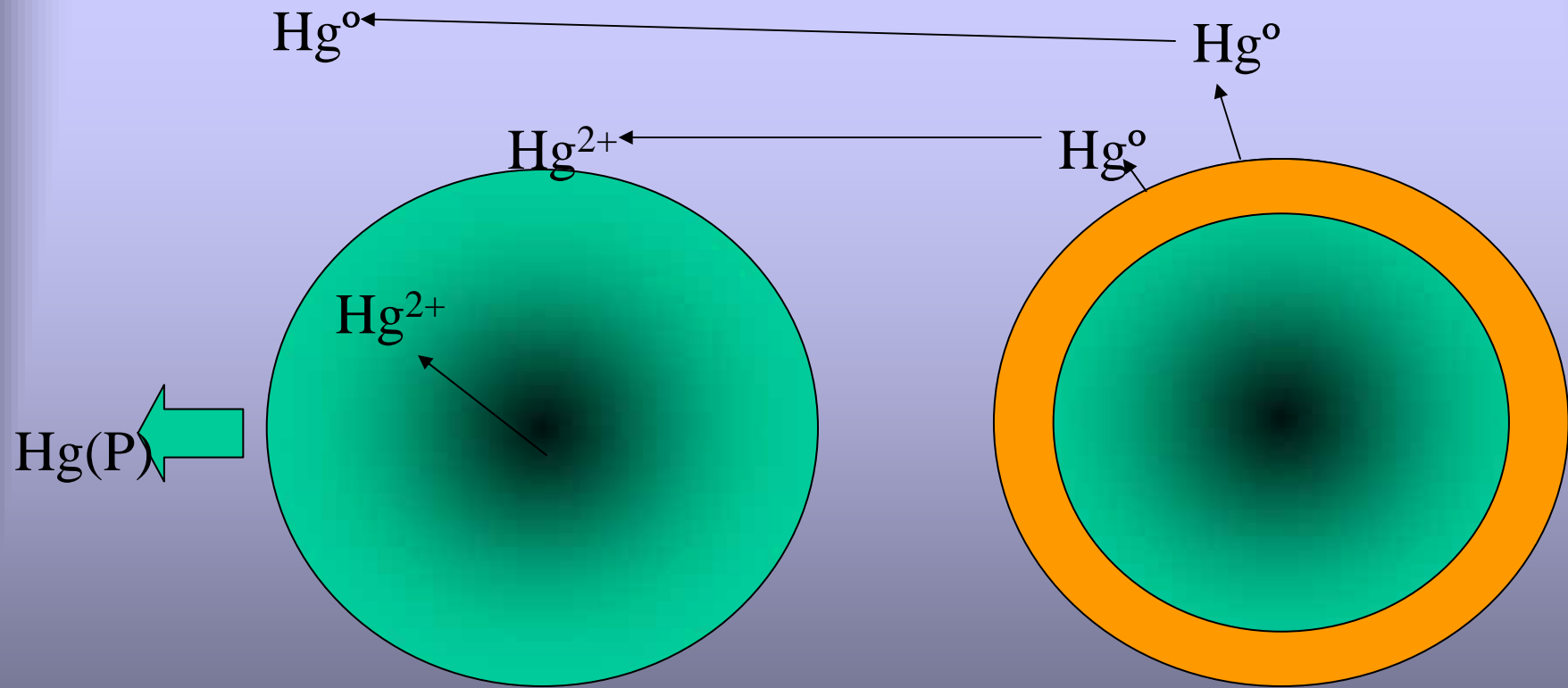


**PREHEAT ZONE**



**FIRING ZONE**

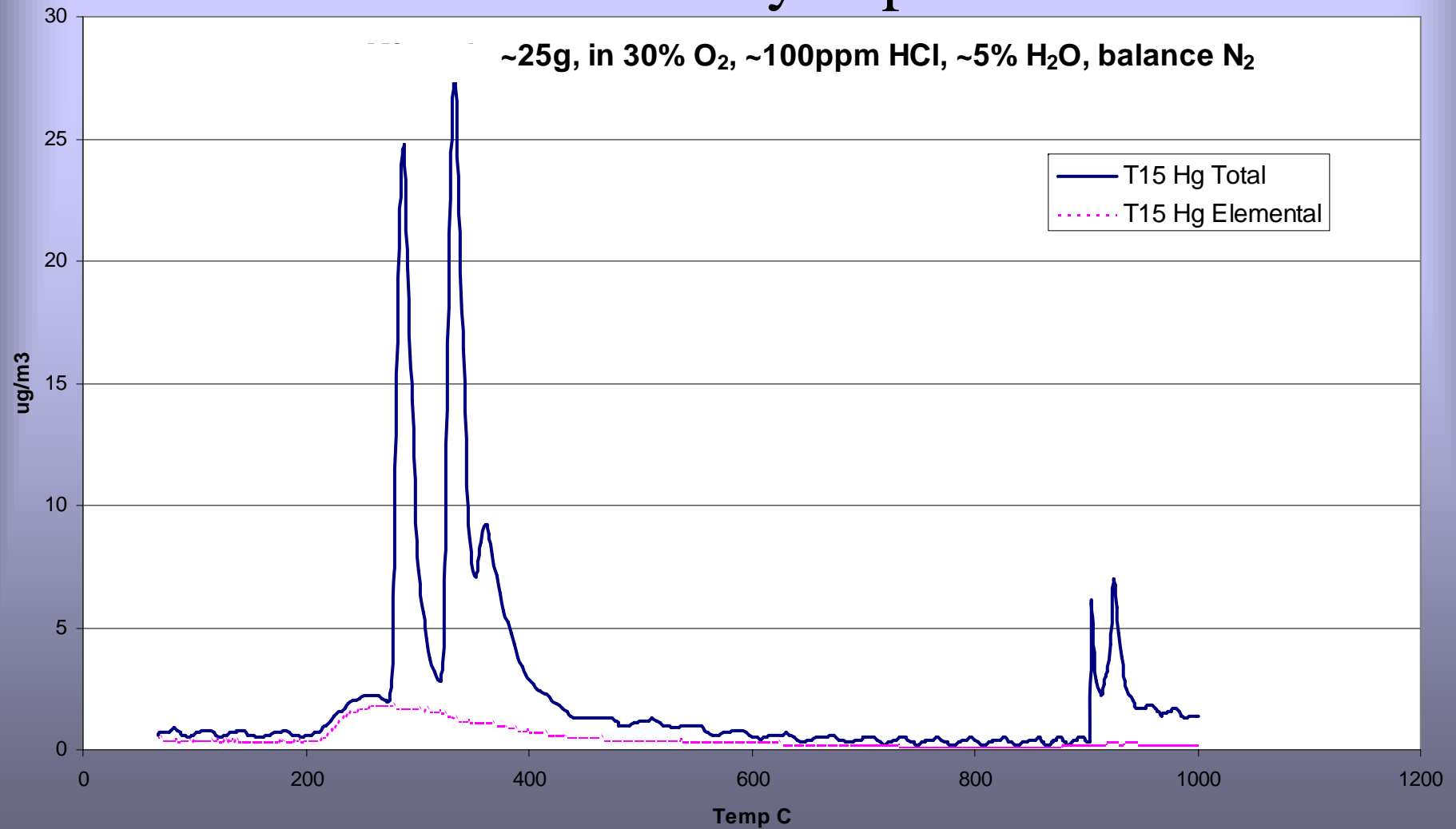
# Mineral Reactions Drive Mercury Release and Capture



**PREHEAT ZONE**

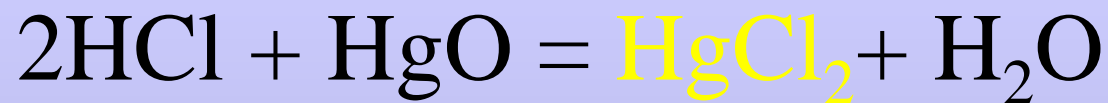
**FIRING ZONE**

# Mercury release from taconite in presence of HCl in laboratory experiments



(Galbreath, 2005)

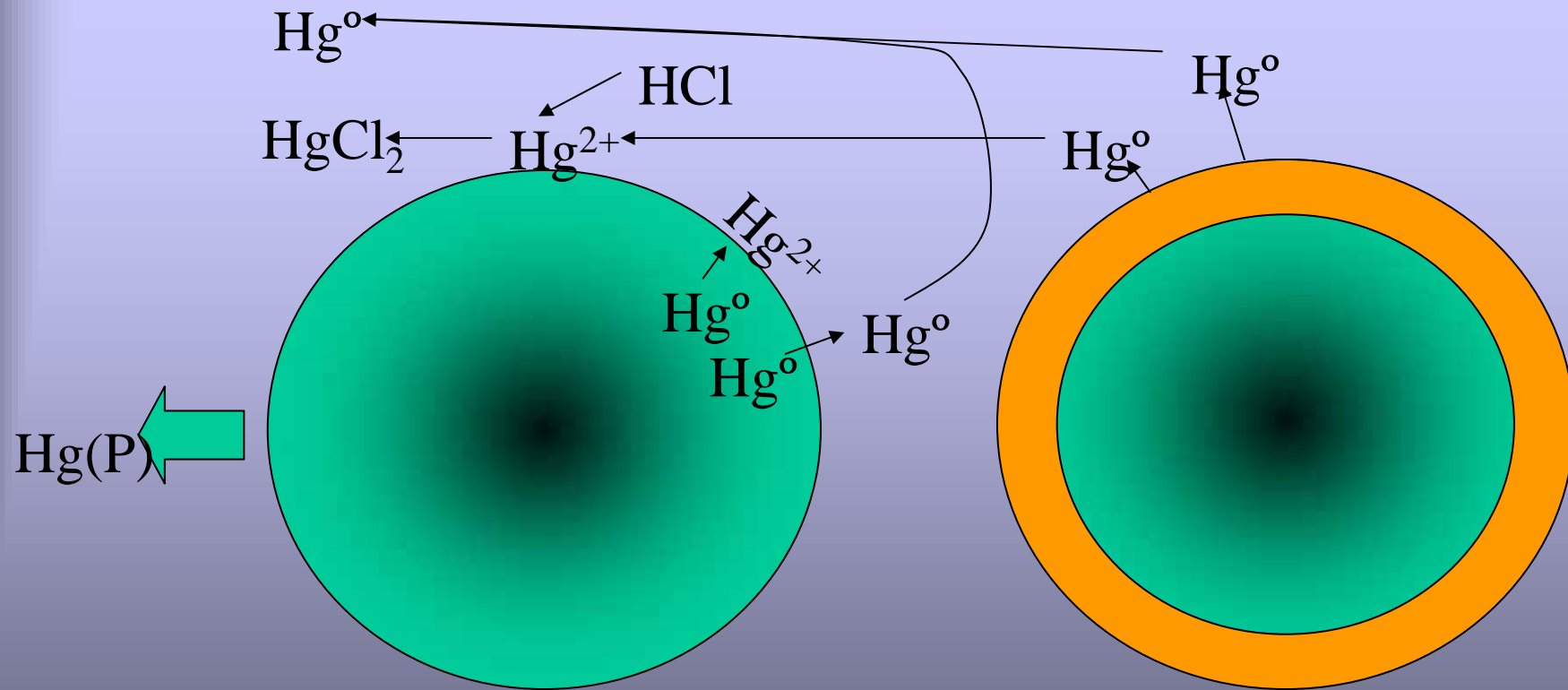
# Effect of HCl in Preheat Zone



↑  
Adsorbed  
on maghemite,  
Returns to furnace  
and converts to  
 $\text{Hg}^0$

↑  
Water-soluble volatile,  
Transported to wet scrubber  
and captured


# Mercury Reactions: With HCl



**PREHEAT ZONE**

**FIRING ZONE**

# Outline

- Taconite industry and Minnesota DNR's coordinated Hg research effort
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- Recent plant-scale Hg test results 



## Mercury Capture Efficiency:

Grate-Kilns:

$27 \pm 8\%$

$33 \pm 13\%$

Straight-Grates:

$11 \pm 6\%$

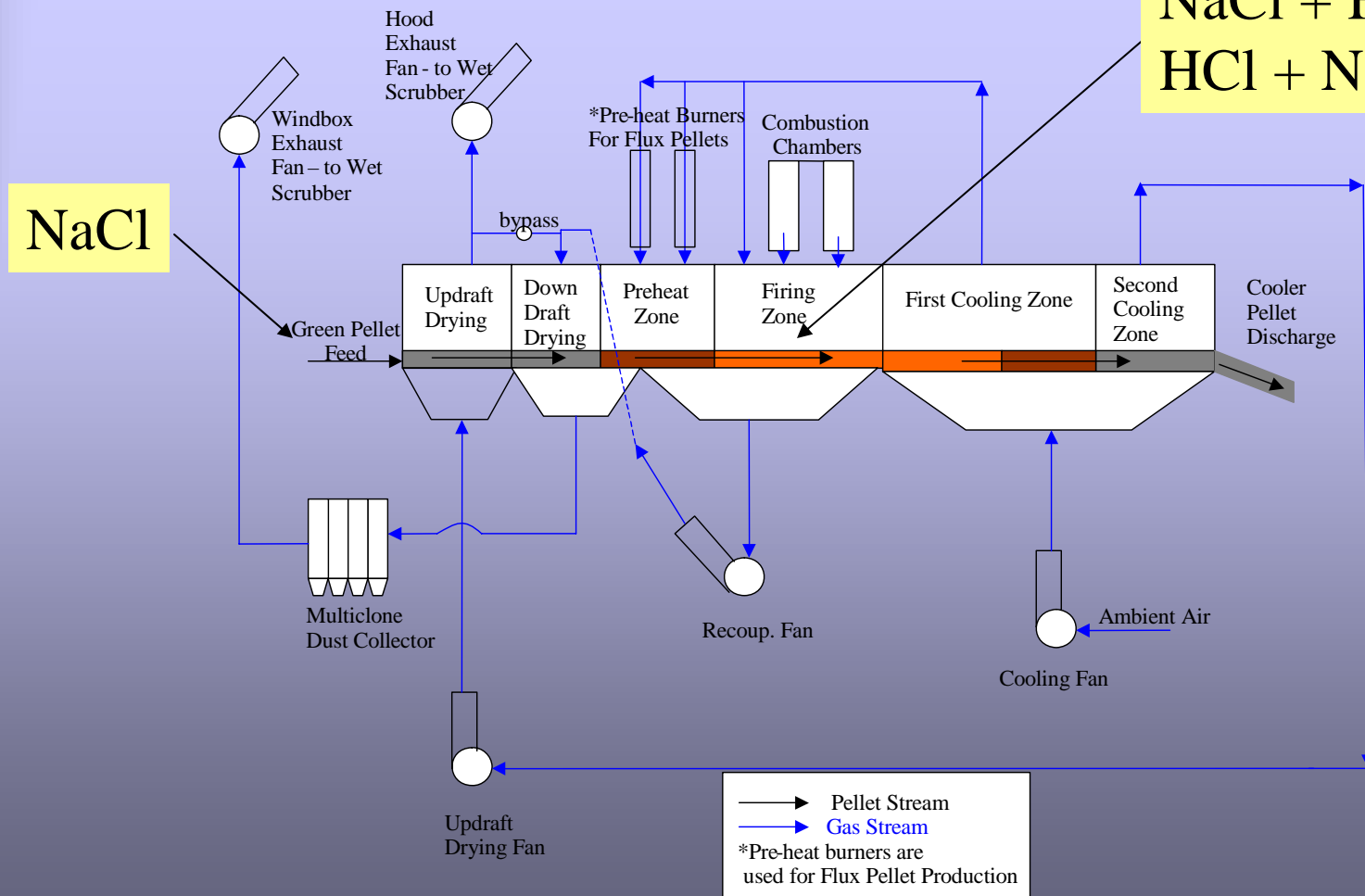
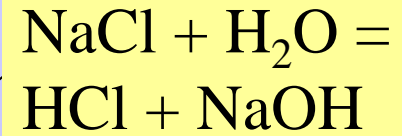
$14 \pm 6\%$

Berndt and Engesser (2005)

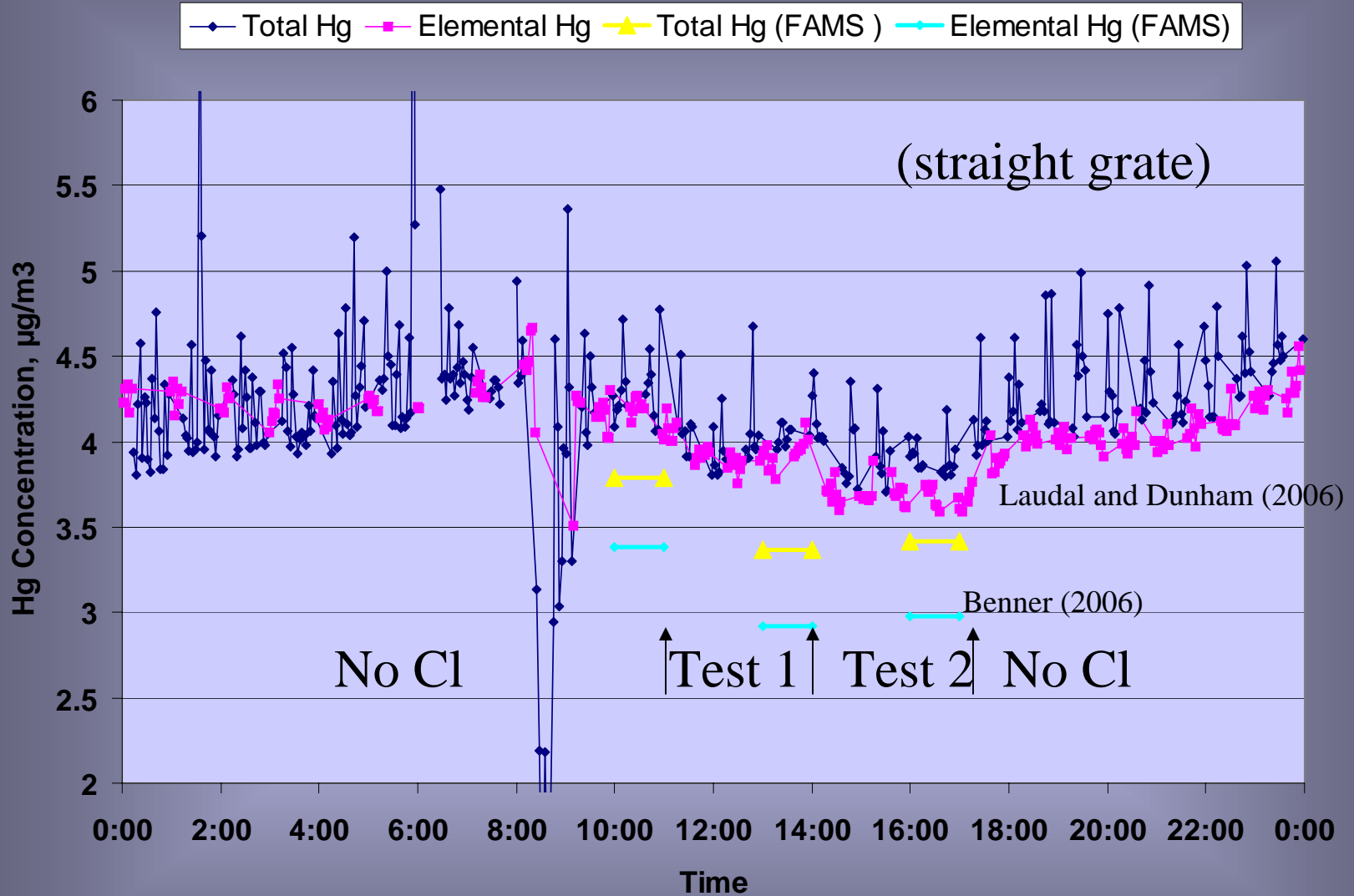
## Plant Scale Tests:

- (1) Hibbing Taconite Cl Injection (July, 2006)
- (2) United Taconite Cl Injection (September, 2006)
- (3) Keewatin Taconite Scrubber Tests (October, 2006)
- (4) Additional Testing at One Plant (Spring, 2007)

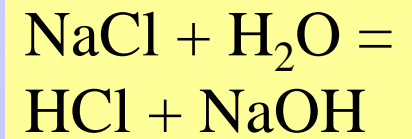
# Cl addition to Straight Grates



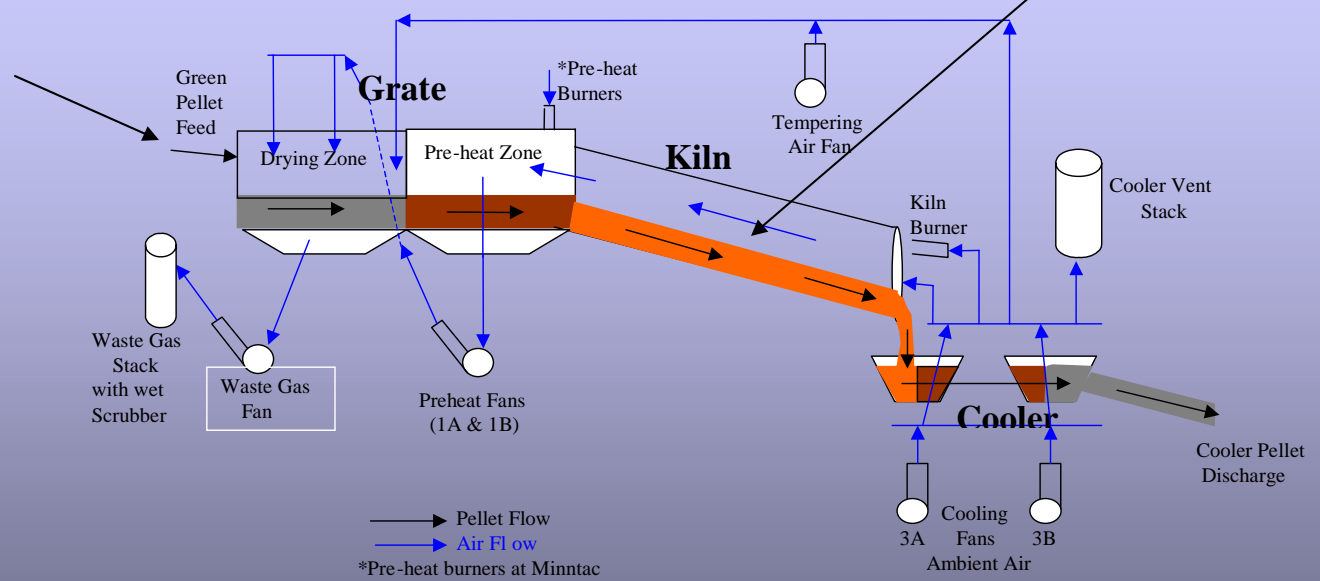
# July 18th, 2006 - Hibbing Taconite NaCl Injection Tests



# Cl injection to Grate-Kilns



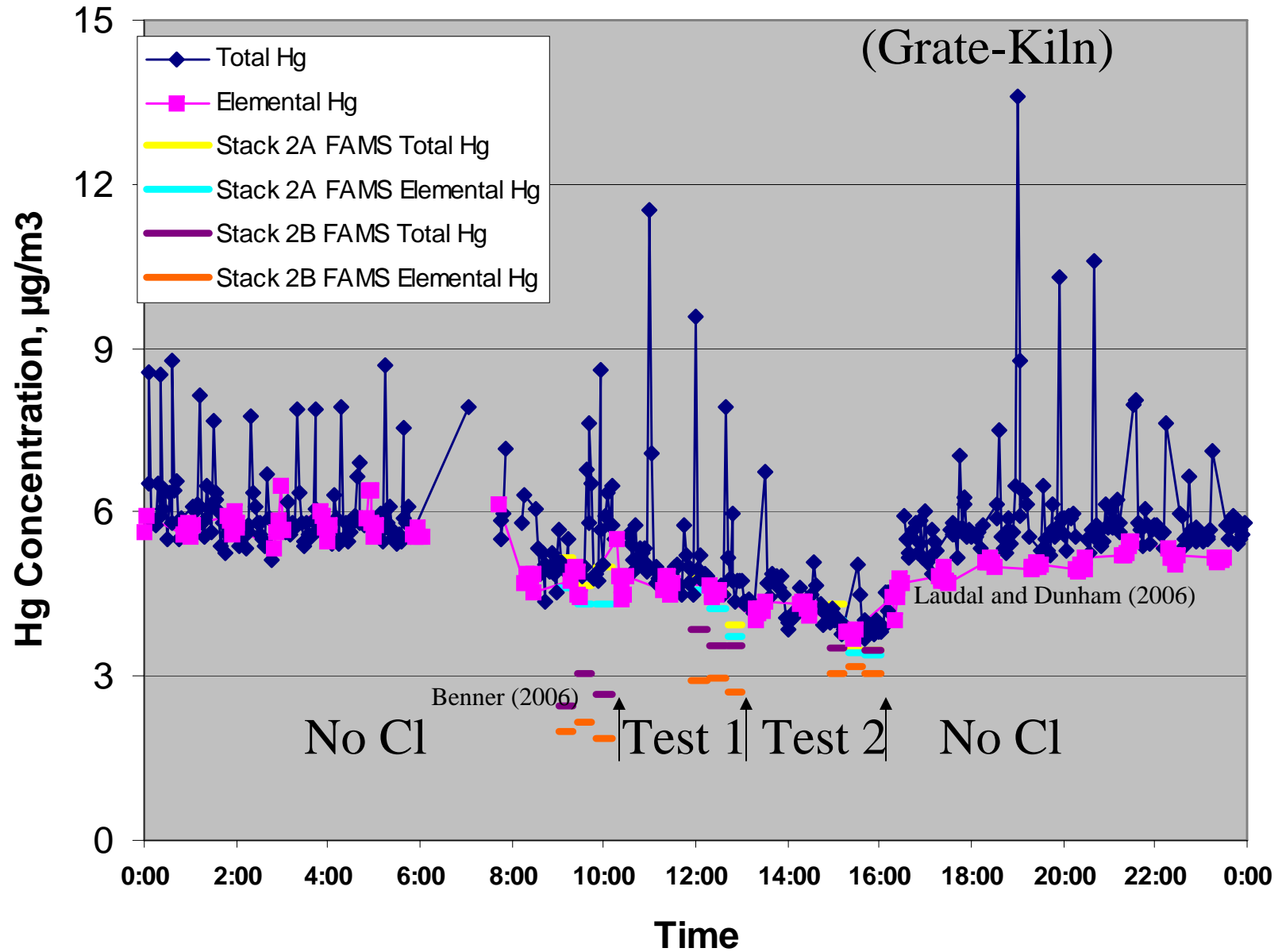
NaCl



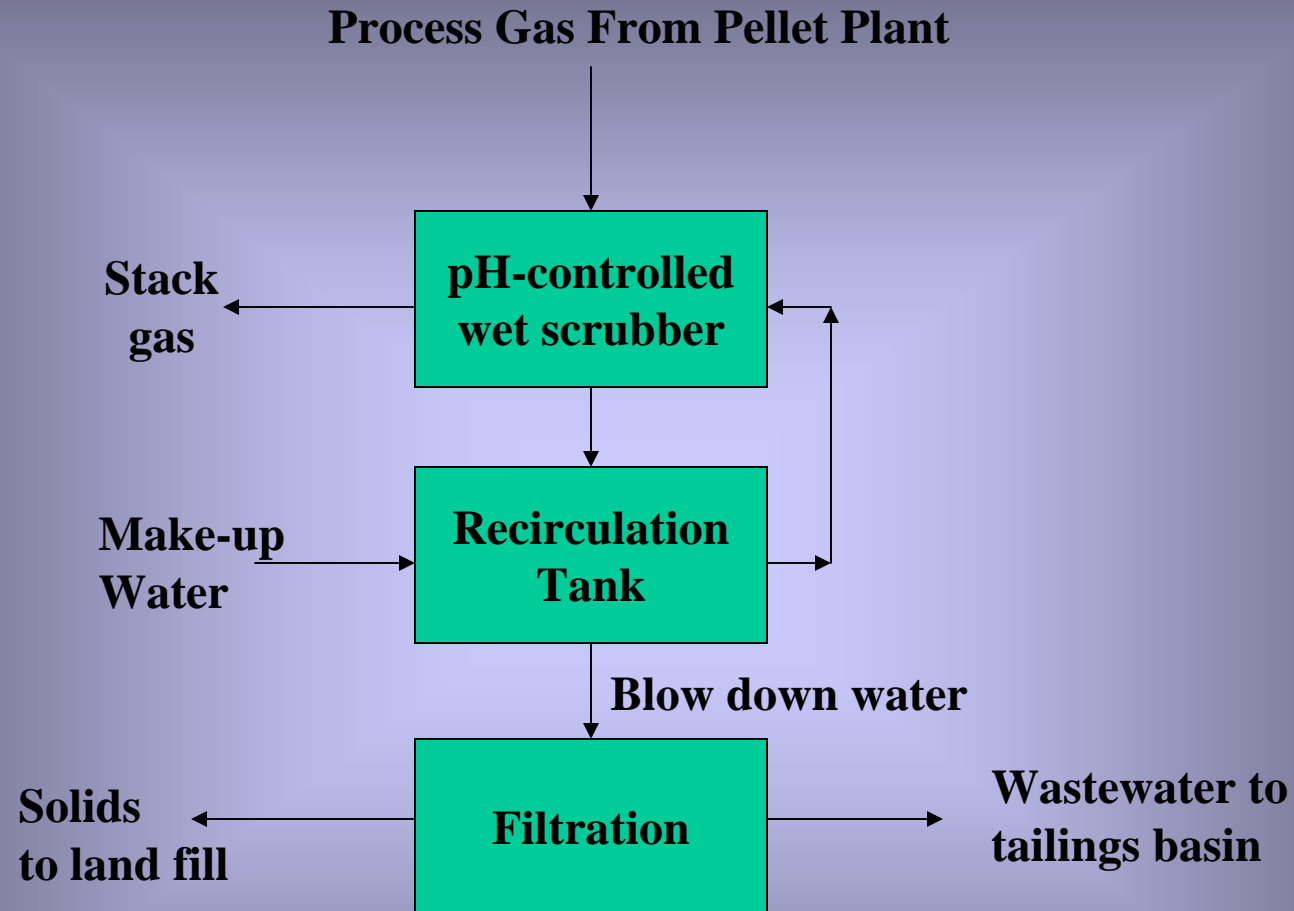
\*Pre-heat burners at Minntac for flux pellet production. United does not have pre-heat burners.

September 12, 2006

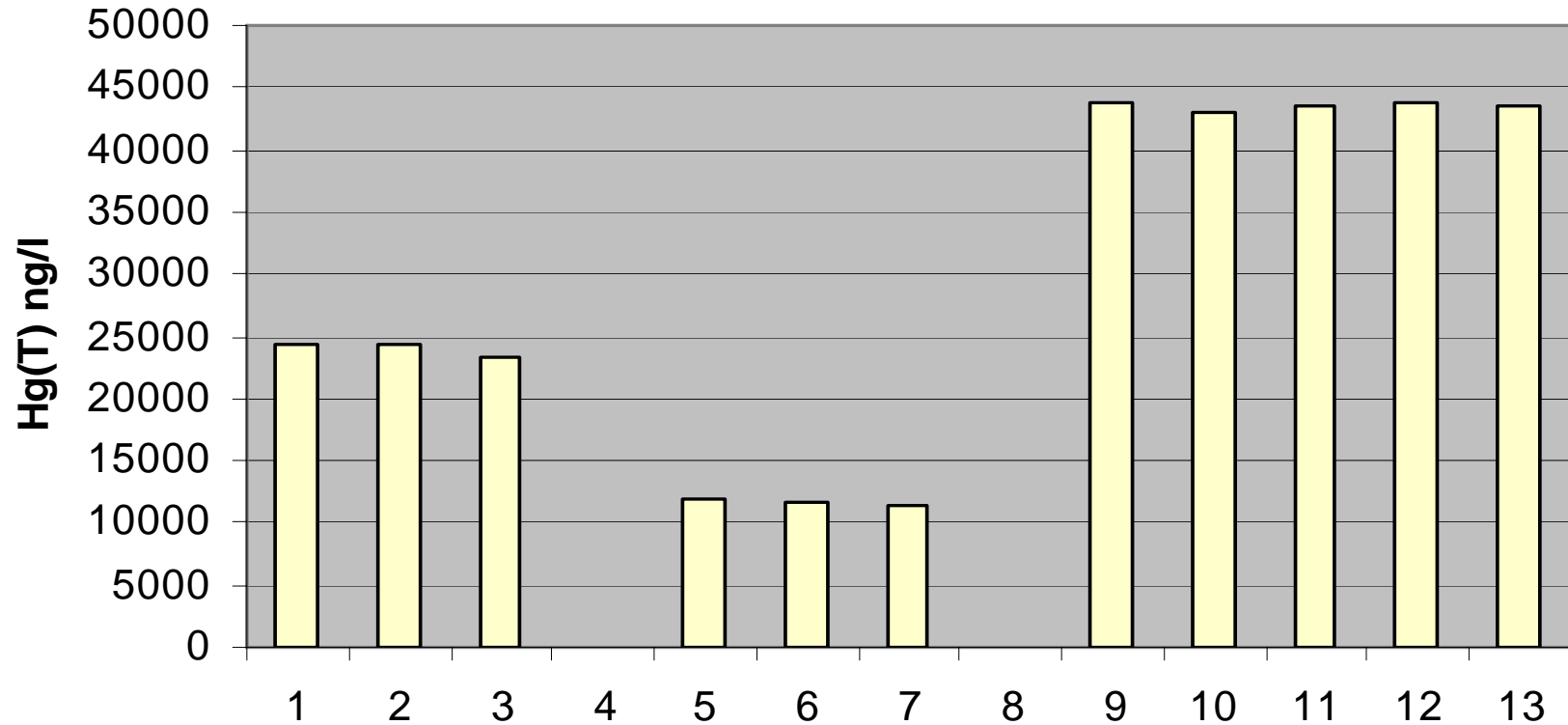
# NaCl Injection Test- United Taconite



# Keewatin Taconite's new wet scrubber



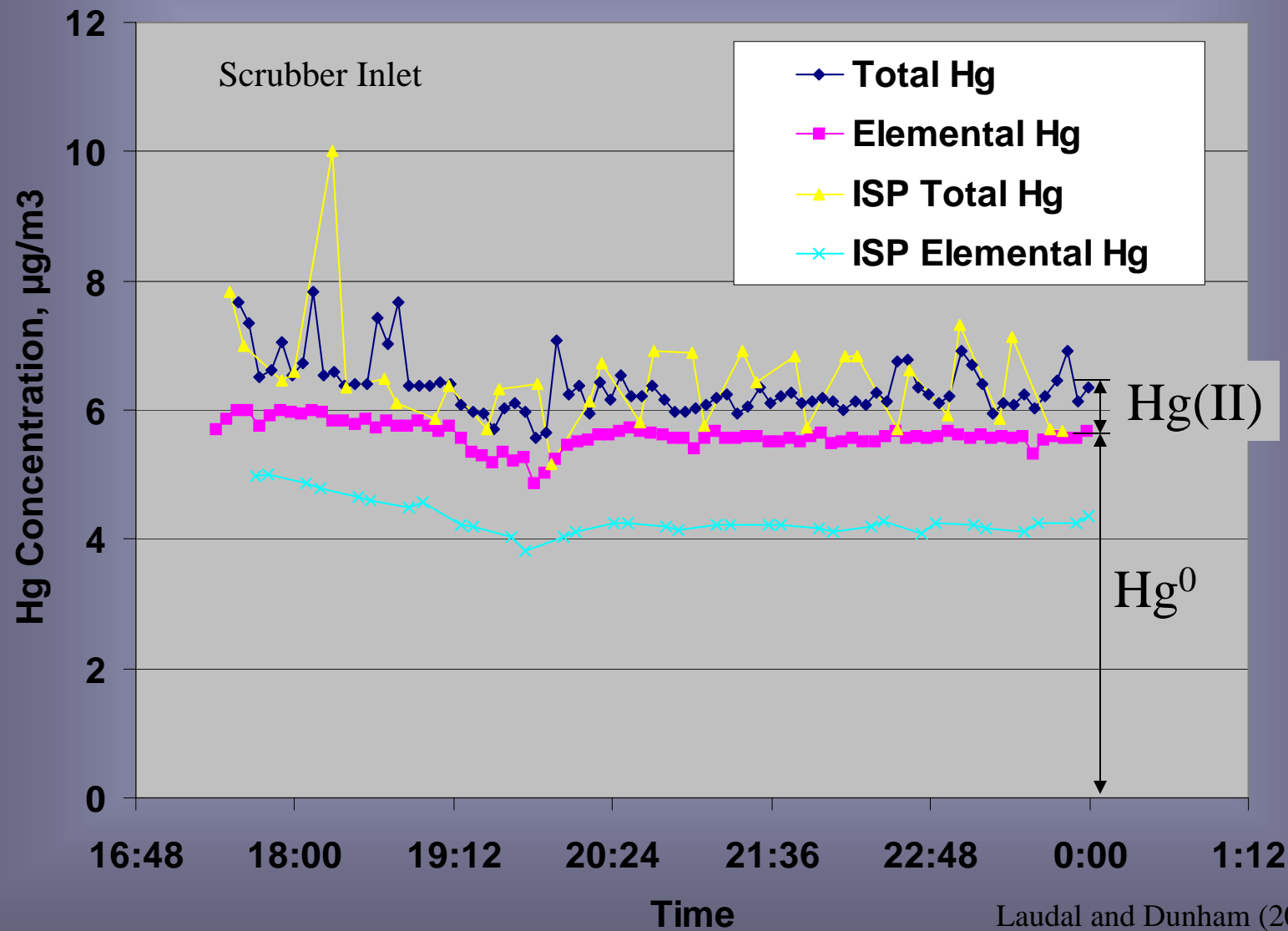
## Hg(T) Concentration in Keewatin Taconite Scrubber Water



Date:	2/2/2006	3/28/2006	8/22/2006
Blow down rate:	375 GPM	660 GPM	330 GPM
Hg captured:	28% Capture	21% Capture	43% Capture



# Keewatin Taconite Hg Monitoring Test (10/29/06) Preliminary Results



## Keewatin Taconite Scrubber Tests (10/25 to 10/29/06) Preliminary Results

Test #	Blowdown Rate (gpm)	Set pH	% Hg(II) in process gas	% Hg Captured
KT1	216	7.5	22	23
KT2	222	6.5	25	23
KT3	508	6.5	28	38
KT4	222	7.5	12	21
KT5	504	6.5	13	34

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- Mossbauer spectroscopy (completed)

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## *Carnegie Inst.:*

- H<sub>2</sub>O<sub>2</sub> generation in wet scrubbers (contracting)

## SUMMARY

- 1) Taconite plant  $\neq$  Coal-fired power plant
- 2) Hg released from ore (greenball) at low temperature
- 3) Fe-oxides react with Hg
- 4) Straight-grate  $\neq$  Grate-kiln