Minnesota Taconite Workers Health Study

Minnesota Taconite Workers
Lung Health Partnership

April 12, 2013

Mountain Iron, MN

What Brings Us Here?

The Minnesota Cancer Registry showed that there were more cases of mesothelioma on the Iron Range than would be expected in an average community. (“Excess Cases”)

What is the relationship?

What can we do about it?

Key Facts

- Mesothelioma is a form of lung cancer caused primarily by exposure to asbestos particles
- The disease takes decades to develop in a person (often 30 years+)
- There is no cure

Key Facts

- Previous research shows that people in certain occupations are at greater risk of asbestos exposure and mesothelioma:
  - Shipyards, construction, demolition trades
  - Insulators, cement workers where asbestos added
  - Electrical workers (motors)
  - Some textile, tile manufacturing where asbestos is used in products

Key Facts

- Previous work showed mesothelioma on the Iron Range likely concentrated among iron mining workers
- Last major study of occupational health among Iron Range taconite workers was in the early 1990s

Key Questions

- What is the relationship of working in the taconite industry to the excess number of cases of mesothelioma?
- Are other diseases, respiratory and non-respiratory, associated with work in the taconite industry?
- Are spouses at risk for lung diseases as a result of their partners working in the taconite industry?

Key Questions

- What is the air quality of communities on the Iron Range today in the presence of taconite mining and processing operations?

Minnesota Taconite Workers Lung Health Partnership

- Brings together all the stakeholders:
  - Iron Range Legislative Delegation
  - Unions, Contractors, Industry
  - Federal, State, County, Local Agencies
  - Iron Range Health Sector
  - Retirees, Families, the Public

Co-chairs: Ron Dicklich, John Finnegan

Minnesota Taconite Workers Health Study Partnership

- Research Team
  - University of Minnesota – Twin Cities and Duluth
    - School of Public Health
      - Division of Environmental Health Sciences
    - Medical School
      - Center for Lung Health & Science
    - Natural Resources Research Institute (NRRI)
  - Minnesota Department of Health

Minnesota Taconite Workers Health Study Partnership

- 2 Science Advisory Boards (SAB)
  - Guiding UMN-Twin Cites Researchers
  - Guiding UM-Duluth Researchers
- Ongoing peer review of study questions, methods and results by independent experts

Minnesota Taconite Workers Health Study

Principal Investigator: Jeff Mandel, M.D.

Investigator and SAB biographies available on the website:

www.taconiteworkers.umn.edu

Today's Presentation

- First summary of results across all five principal studies with the focus on the main issue of mesothelioma
- Based *Report to the Legislature*
- Legislature Reports and today's slides available on website

Today's Presentation

- Investigators will summarize results of the five studies relating to mesothelioma
- Please hold your questions, write them down as we go for use in the discussion
- Other presentations and reports will be forthcoming; this is the first summary overall, not the last…

Today's Presentation

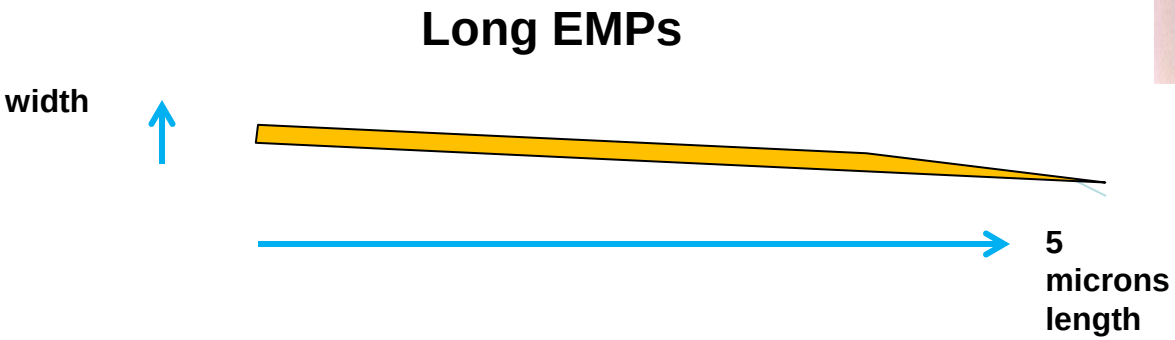
- Introduction - Jeff Mandel, M.D.
- Mortality and Mesothelioma Study - Bruce Alexander, Ph.D.
- Respiratory Health Survey - David Perlman, M.D.
- Occupational Exposure Assessment - G. Ramachandran, Ph.D.
- Environmental Study - Larry Zanko, M.S.
- Discussion

Introduction

- Give an update on all five studies
- Key findings summary
- In depth written report planned for later this year on all studies
- An additional Stakeholder meeting at end of year

Elongate Mineral Particles (EMPs)

Hair diameter=20-150 microns



Length > 5microns;
Length : width> 3:1
Different definitions
We used the NIOSH definition

Exposures In Taconite Processing

- Long EMPs*
- Short EMPs
- Silica
- Remaining dust (without silica and EMPs)
- Commercial asbestos (a type of long EMPs)

* Today's report will focus on long EMPs

Key Findings
Mesothelioma Study

- Mesothelioma is associated with working longer in the taconite industry
- Long EMPs potentially related to mesothelioma - needs further clarification

Key Findings
Mortality (cause of death) Study

- Important causes of death were evaluated and workers were found to be at higher risk for:
  - Mesothelioma
  - Lung Cancer
  - Heart Disease

- Deaths from mesothelioma are elevated <u>across the Range</u>

Key Findings
Respiratory Health Survey

- Spouses are not at risk
- Therefore, community not likely at risk
- There is some dust related lung disease in workers, probably from silica

Key Findings
Occupational Exposures

- Currently occupational exposure levels are safe
- Historical exposures were likely higher
- Historical measurements get sparse as we go back in time

Key Findings
Occupational Exposures

Because the potential for exposure to unsafe levels exists, it is essential for companies and for workers to follow appropriate safety measures.

Key Findings
Community Exposure

- Iron Range communities air is safe to breathe (lower particulates than MSP)
- Iron Range communities meet air quality standards
- Plants can be dusty but controls appear adequate

Mortality Study

Bruce Alexander, Ph.D.
School of Public Health

Purpose

- Compare rates of death in iron mining workers to the general population of Minnesota
- Evaluate all causes of death combined and deaths from specific causes
- Characterize overall health of population

Approach

- Workers born after 1920
  - Focus on people with majority of work in taconite
- Nationwide follow-up through 2007
- Determine who is still alive and the cause of death for those who died
- Compare mortality rates in workers to rates in Minnesota for people of similar age, sex, and year of birth
- Calculate Standardized Mortality Ratios (SMR)
  - SMR = Observed Deaths/Expected Deaths

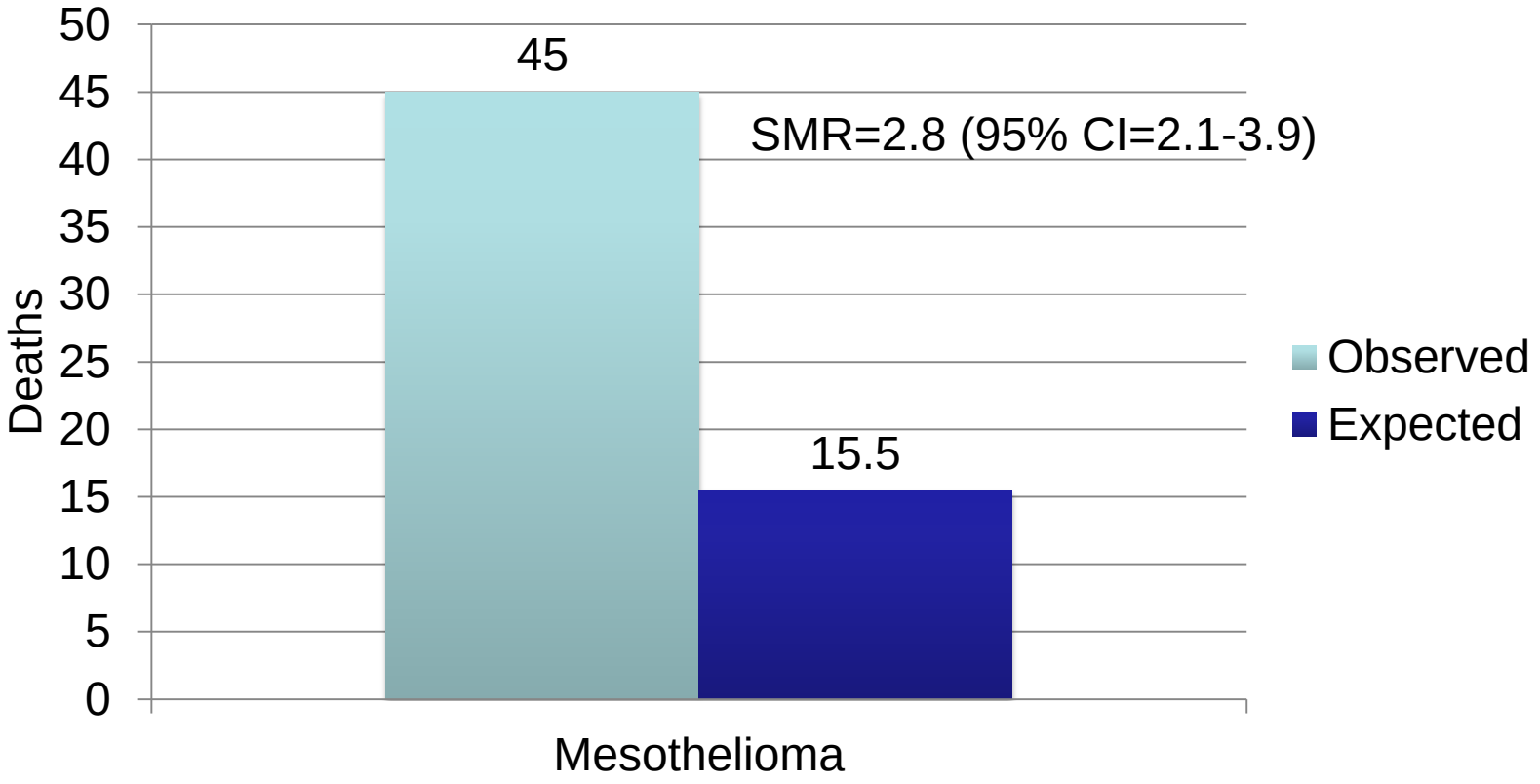
Study Population and All Causes of Death of Iron Mining Workers Born 1920 or Later

Total	44,161
Deaths Identified	13,318
Expected Deaths	12,720

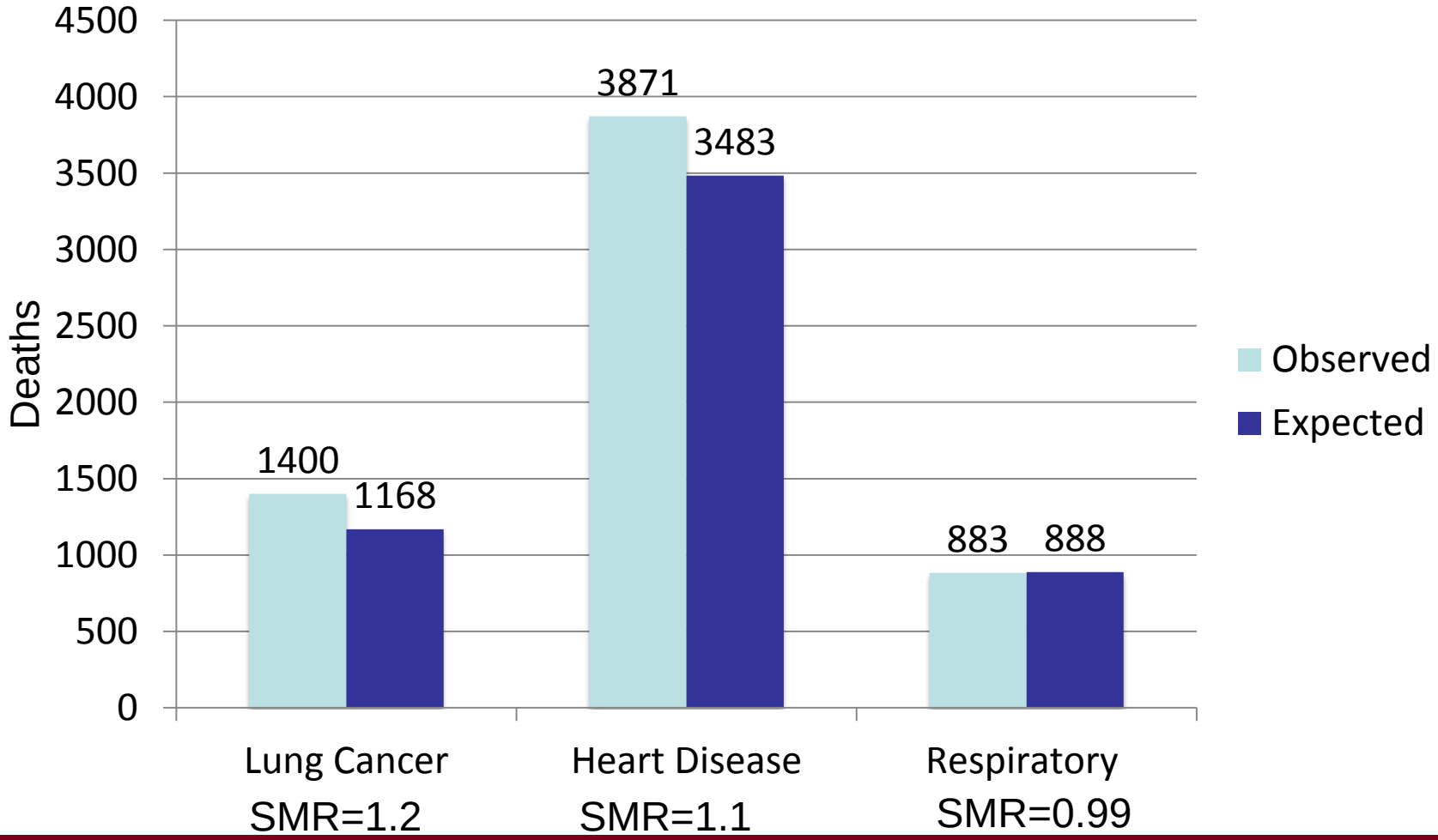
Standardized Mortality Ratio = 1.05

(95% Confidence Interval=1.03-1.06)

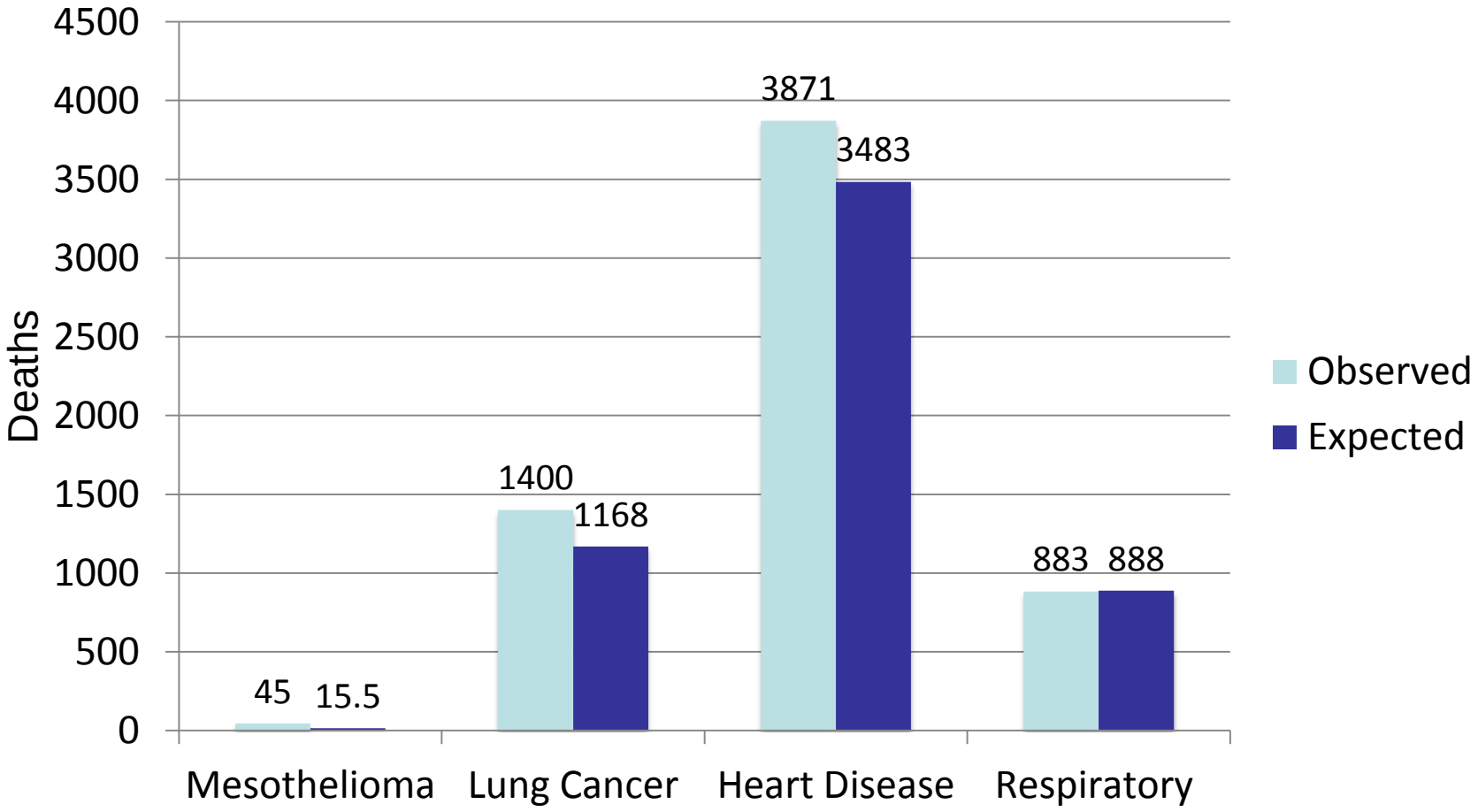
Observed and Expected Mesothelioma Deaths



Observed and Expected Deaths from Lung Cancer, Heart Disease and Other Respiratory Diseases



Observed and Expected Deaths from Mesothelioma, Lung Cancer, Heart Disease and Other Respiratory Diseases



Conclusions

- Taconite workers have higher rates of death for
  - All causes combined
  - All cancers combined
  - Mesothelioma
  - Lung cancer
  - Heart disease
  - Other causes generally at or below rates of Minnesota
- Lifestyle as well as occupational factors likely important
- Mesothelioma is an indicator of an occupational exposure to asbestos

Possible Reasons for Higher Death Rates

Mesothelioma	Lung Cancer	Heart Disease
Commercial Asbestos	Smoking	Smoking
In taconite work	Commercial asbestos	Obesity (diet)
In other jobs	Silica	Family history
	Occupational exposures	Physical activity
Taconite long EMPs exposures??	**Taconite long EMPs exposures??**	Air pollution
		Occupational exposures?

Mesothelioma Study

Bruce Alexander, Ph.D.
School of Public Health

Purpose

To determine if the risk of mesothelioma in iron mining workers is related to:

- Length of employment in taconite industry
- Exposure to the long EMPs generated by taconite operations

Study Population

- Cases of mesothelioma identified through
  - Minnesota Cancer Surveillance System: 63
  - Death certificates (non-Minnesota): 17
- Control population
  - Random sample from worker population
  - Up to 4 controls/case of mesothelioma
  - Similar age
  - Did not have mesothelioma at time of case's diagnosis or death

Exposure Assessment

- Based on work history in iron mining
- All available work histories abstracted
  - Job titles and length in each job
  - Separate hematite mining from taconite
  - Estimate probability of exposure to commercial asbestos for each job: Expert judgment
- Create job groups with similar exposure

Exposure Assessment

- Historical exposure reconstruction by job group
  - Current data
  - MSHA data
  - Company data
  - Previous research
- Yearly estimates of average exposure to EMPs
- Cumulative exposure=EMP/cc x years
  - Example: 1 EMP/cc x year = 10 years worked at average exposure of 0.1 EMP/cc

Relative Risk of Mesothelioma from Working in Taconite Industry (All Exposures)

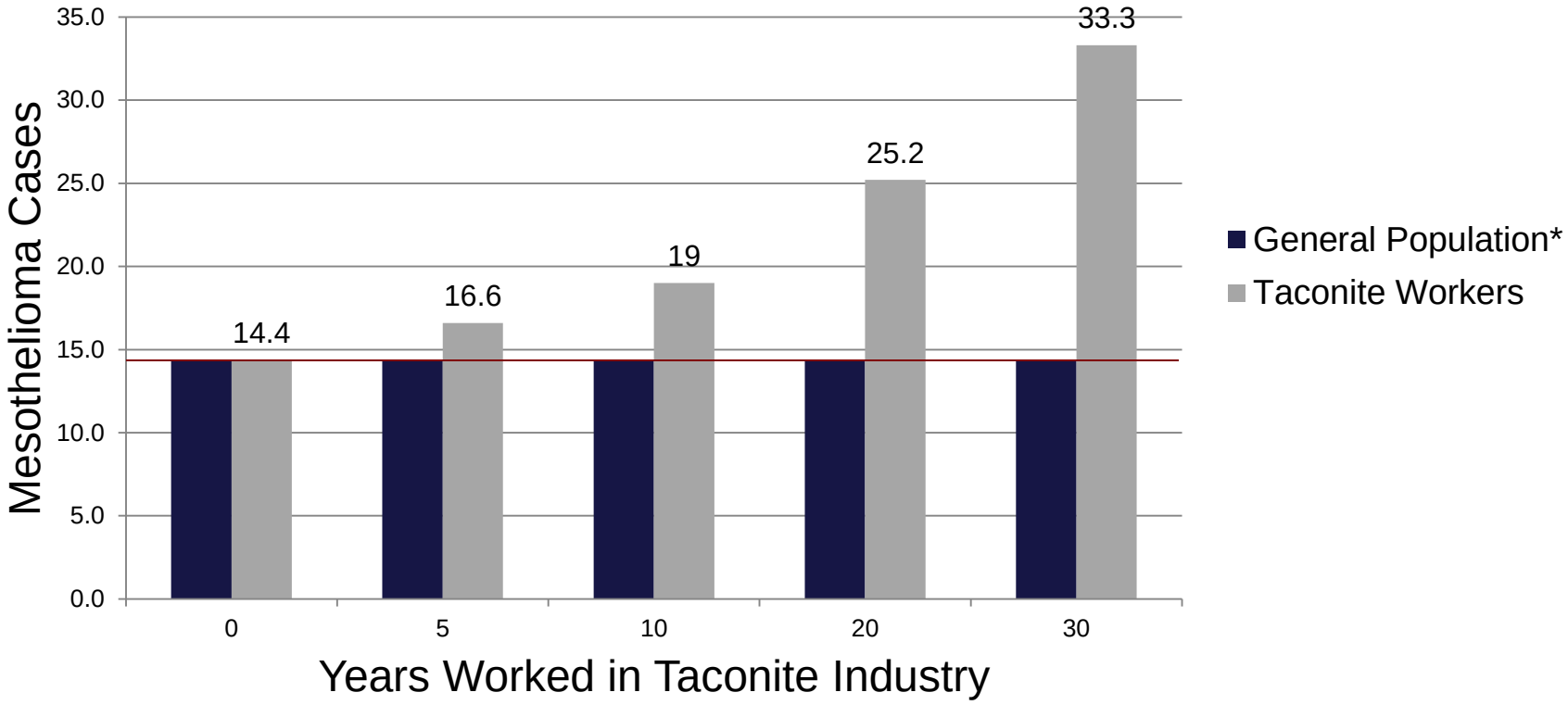
Years of Employment in Taconite Industry

- RR=1.03 (95% CI=1.00-1.06)

- Averaged across the population a 3% increase per year of employment

Control for the effects of age and employment in hematite mining

Estimated Cases of Mesothelioma in 10,000 Men Living to Age 80 Working in Taconite up to 30 Years and the Expected Cases in 10,000 Men in the General Population



*Lifetime risk for white males at age 80 is 0.144 percent.
Surveillance Epidemiology and End Results Program of the National Cancer Institute.

Relative Risk of Mesothelioma from Exposure to Long EMPs in Taconite Industry

Cumulative EMP exposure: EMP/cc x year

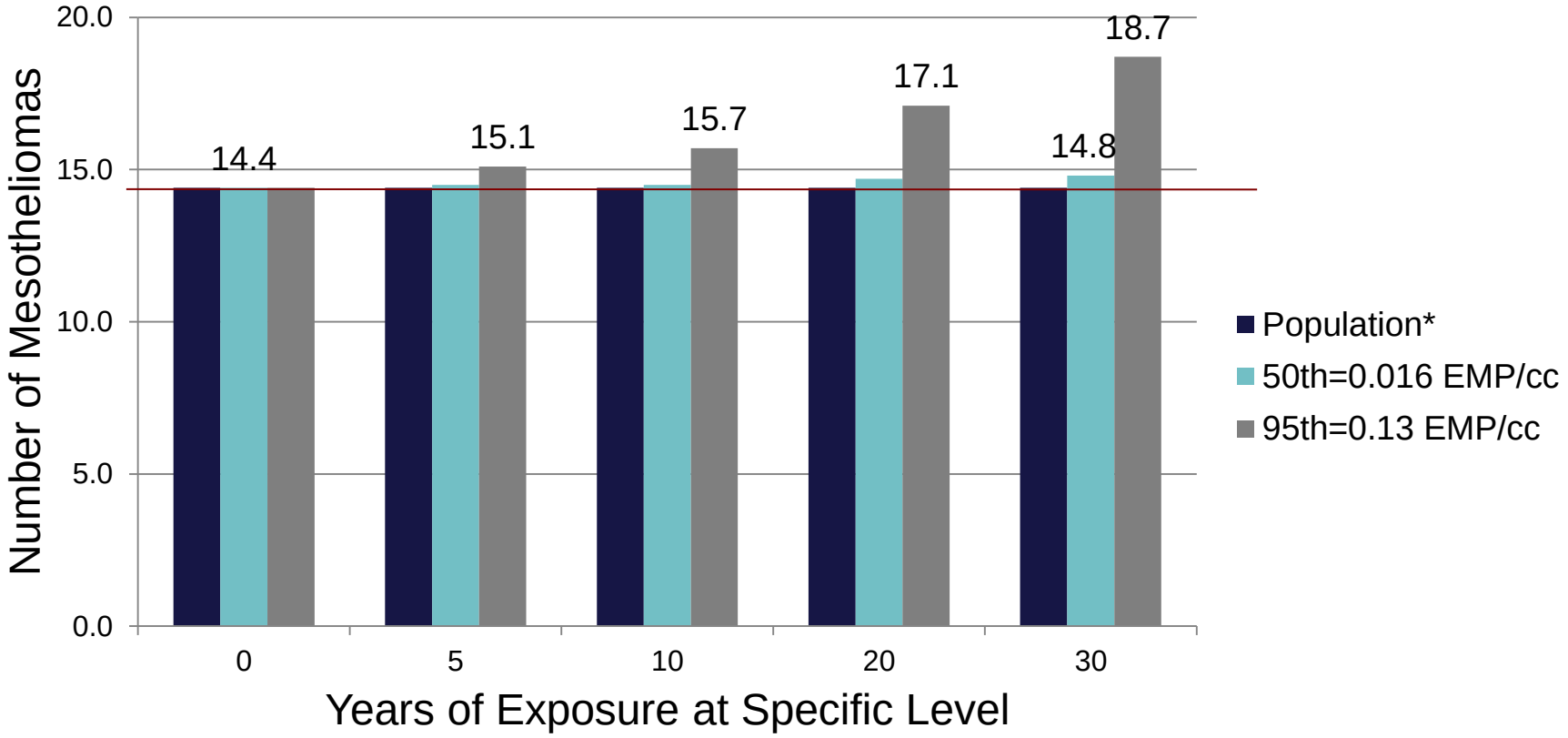
- RR=1.07 (95% CI=0.97-1.18)
- Averaged across the population, a 7% increased risk of mesothelioma per 1 EMP/cc x year

High vs. Low Exposure (above and below median)

- RR = 2.12 (95% CI=1.11-4.04)

Control for any effects of age, hematite mining, and potential for exposure to commercial asbestos

Estimated Cases of Mesothelioma in 10,000 Men Living to Age 80, Working in Taconite up to 30 Years at 50th and 95th Percentiles § of Long EMP Exposure



*Lifetime risk for white males at age 80 is 0.144 percent.
Surveillance Epidemiology and End Results Program of the National Cancer Institute.
§ Based on current range of exposure

Conclusions and Limitations

- Mesothelioma cases were more likely to work for a longer time in the taconite industry than non-cases
- Mesothelioma cases had slightly higher estimated cumulative exposure to long EMPs
  - Risk is increased, but estimate is imprecise
- Can't entirely rule out impact of commercial asbestos exposure used in taconite industry or exposure from other jobs
- Other exposures from taconite dust will be investigated

Respiratory Health Survey

David Perlman, M.D.

Medical School

Respiratory Health Survey

- Purpose was to identify non-cancerous respiratory diseases
  - Silicosis
  - Dust related lung disease
  - Benign pleural changes (lining of the lung)
- Randomly selected workers from company employment rosters were asked to participate

Respiratory Health Survey

Types of abnormalities assessed on chest X-rays

- **Parenchymal** – changes in the lung, can represent:
  - silicosis
  - asbestosis
  - fibrosis
- **Pleural** – changes in the lining of the lung, can represent:
  - Long EMPs exposure
  - silica exposure

Respiratory Health Survey

	Parenchymal (Silicosis?)	Pleural (EMPs?)
Workers	6%	17%
Spouses	1%	5%

- Other studies of open pit mining have reported rates of 4-11% for parenchymal abnormalities
- Pleural changes may have several causes:
  - Exposure to long EMPs
  - Exposure to Silica
  - Obesity

Respiratory Health Survey

- Low prevalence of abnormal X-rays in spouses suggests lack of significant community exposure
- X-ray testing suggests some dust related lung disease similar to what is seen in other open-pit mining operations
- X-ray changes among workers do show an increased amount of pleural abnormalities that likely reflect some low-level EMPs exposure to the worker population

Occupational Exposure Assessment

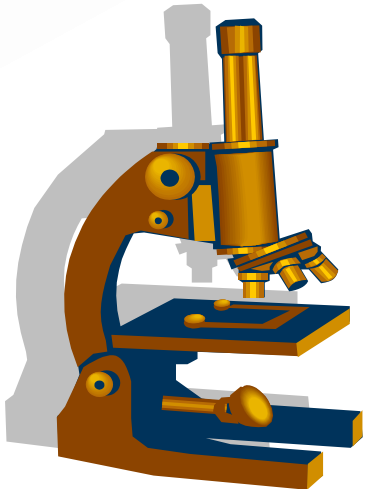
Gurumurthy Ramachandran, Ph.D.
School of Public Health

Occupational Exposure Assessment

- Assessed current and past exposures to long EMPs in the taconite industry
- Evaluated existing practices and methods to reduce workers exposures

Measuring Long EMPs

- NIOSH 7400 (PCM) method
  - Most often used
  - Easiest
  - Used for MSHA sampling
  - Good estimate
  - Doesn't look at mineralogy



EMP : Elongate Mineral Particles
PCM : Phase Contrast Microscopy
MSHA : Mine Safety and Health Administration

Sampling Method for Current EMPs Exposures

Personal

↓

Poly carbonate cassettes

↓

NIOSH Method 7400 PCM [a] & 7402 TEM [b]

PCM [a] : Phase Contrast Microscopy

TEM [b] : Transmission Electron Microscopy – identification of amphibole EMPs

Elongate Mineral Particles (EMPs)[a]

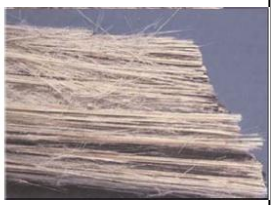
Amphibole EMPs

- Amosite (Cummingtonite-grunerite)
- Actinolite
- Anthophyllite
- Tremolite
- Crocidolite (Riebeckite)

Non-amphibole EMPs

Asbestiform EMPs

Amosite



Actinolite asbestiform

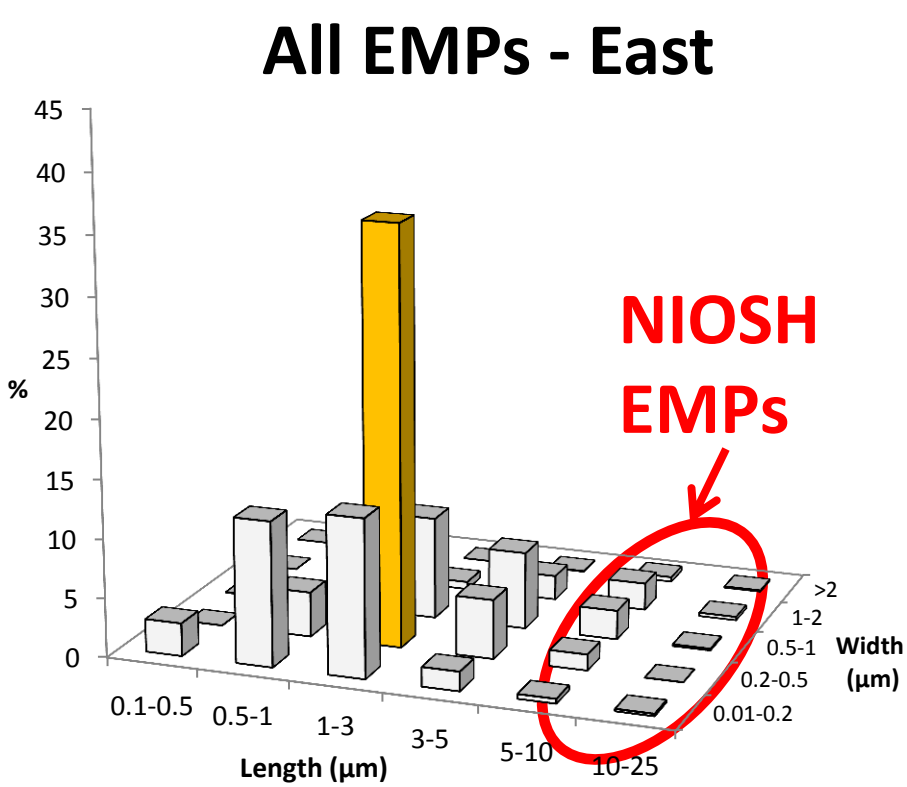
Non-asbestiform EMPs

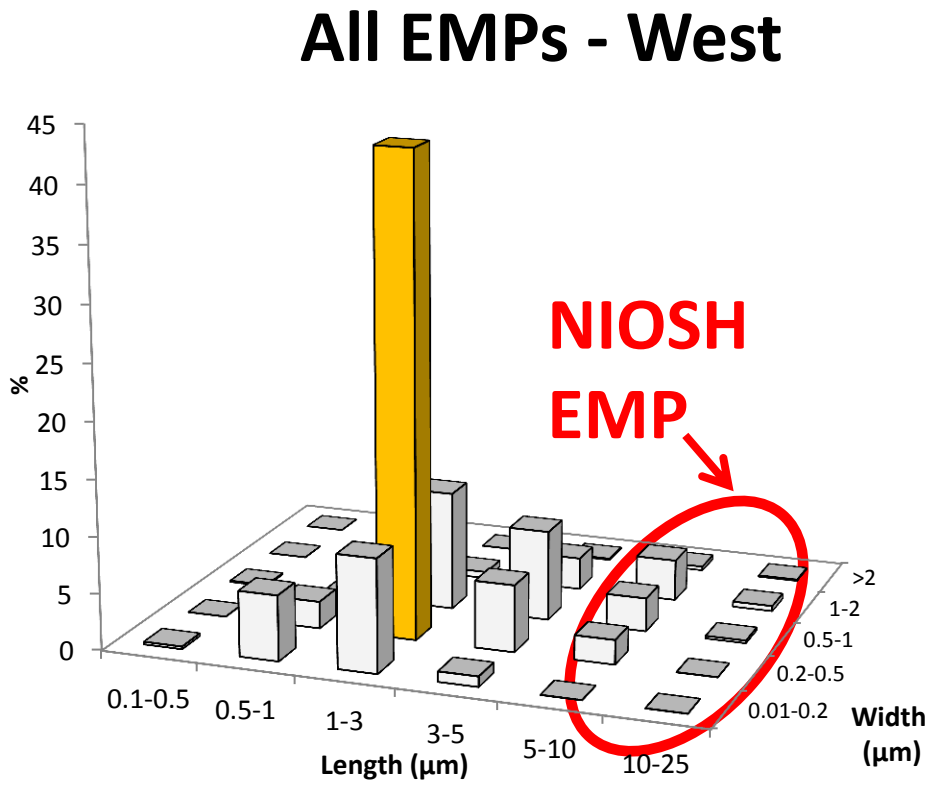
Cummingtonite -grunerite

Actinolite

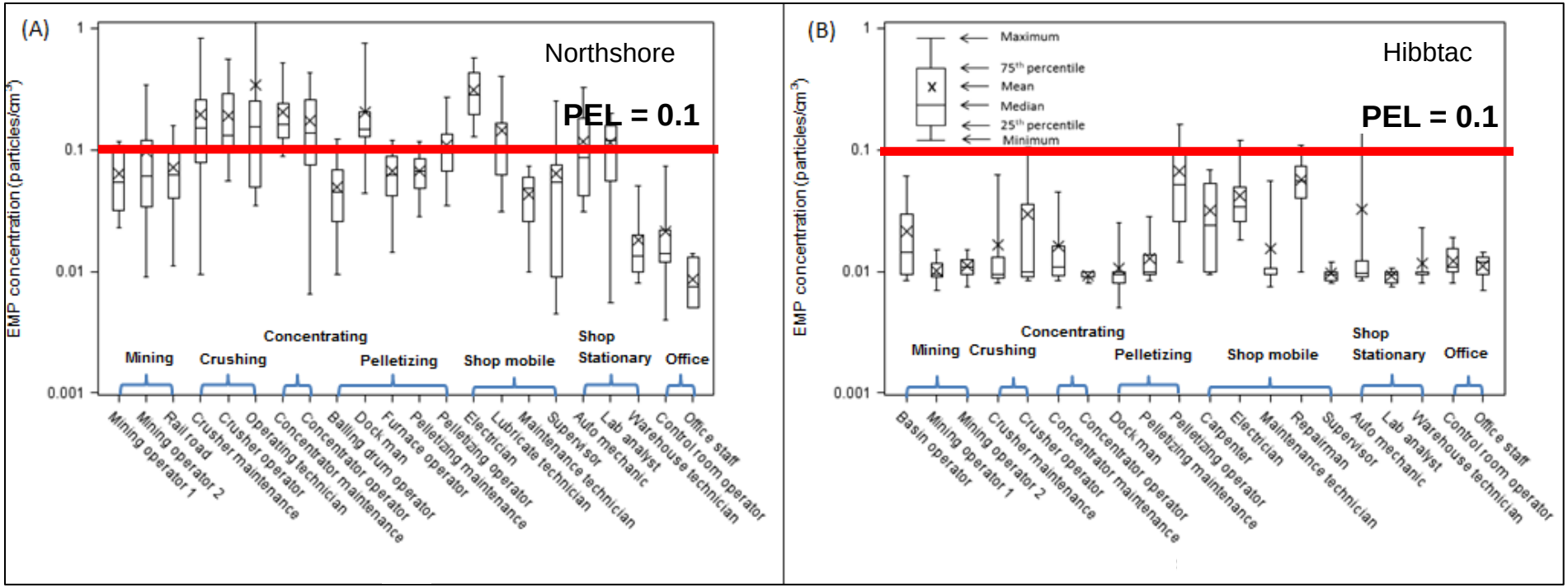
Cleavage Fragments

NIOSH 7400 Does Not Measure Short EMPs That Are More Numerous

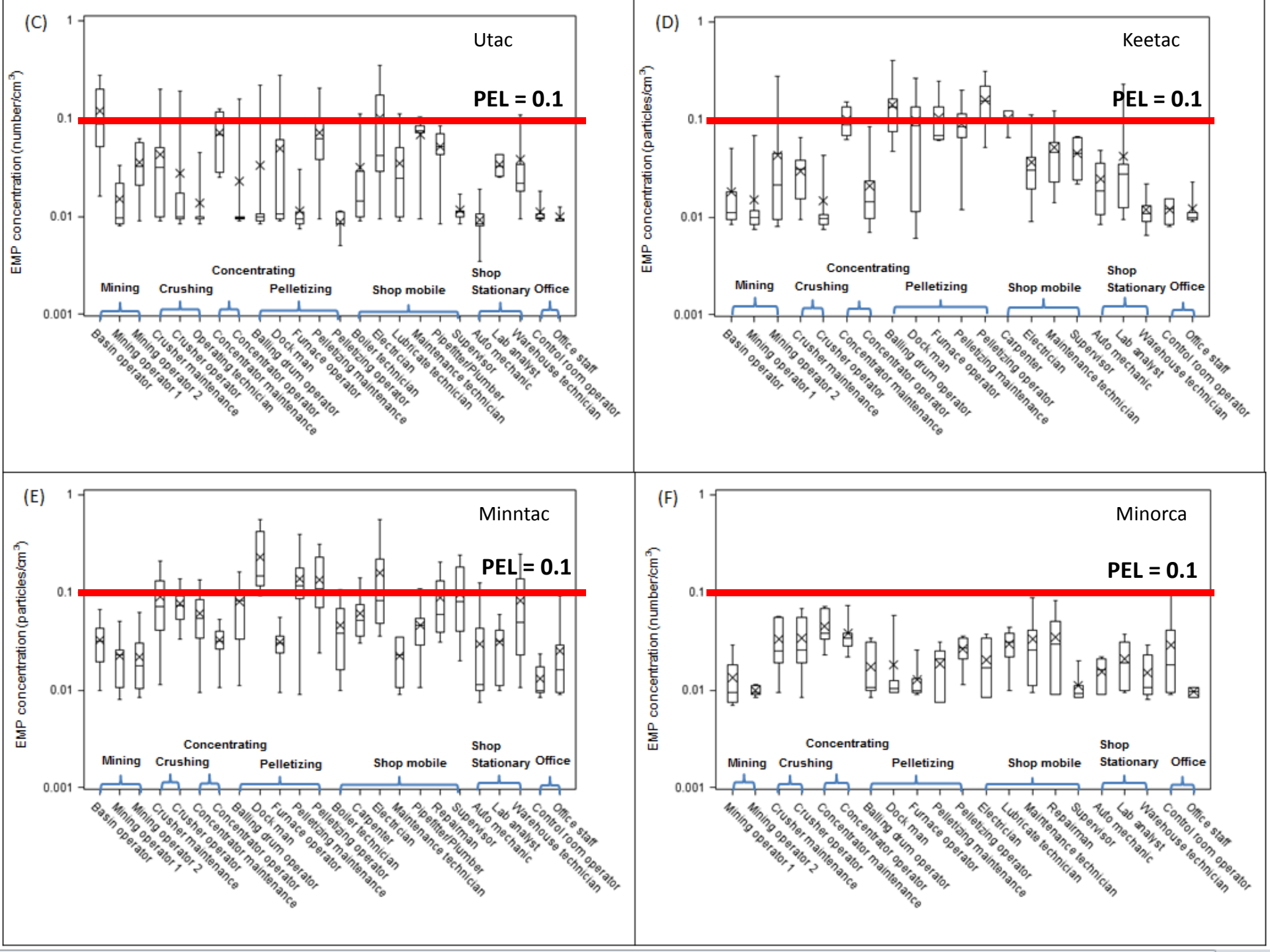




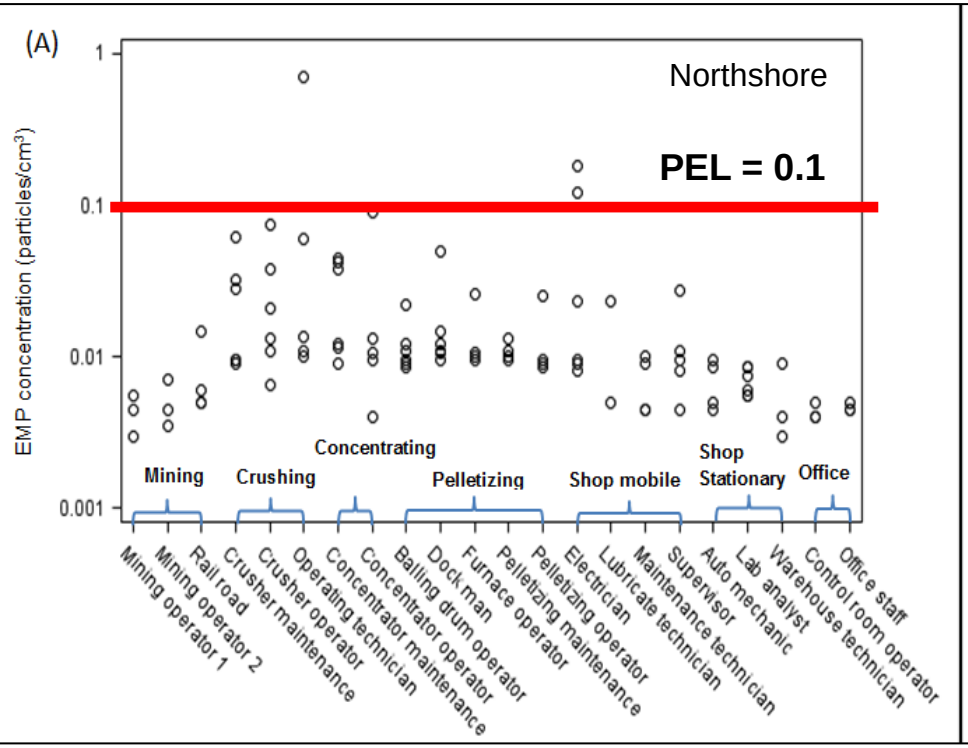
- Exposures in some job groups in some mines are above the MSHA exposure limit of 0.1 particles/cm^{3*}
- Most job groups have exposures below this limit

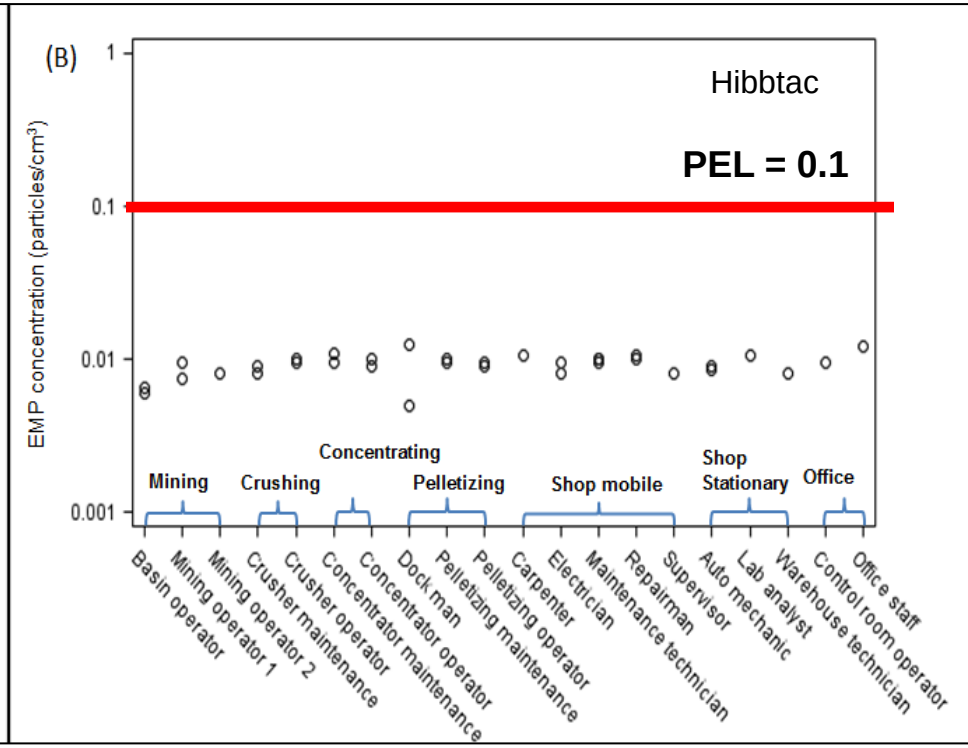


*Mine Safety and Health Administration (MSHA) Permissible Exposure Limit (PEL)


(C)
Utac
PEL = 0.1
EMP concentration (number/cm3)
1
0.1
0.01
0.001
Concentrating
Shop
Mining
Crushing
Pelletizing
Shop mobile
Stationary
Office
Basin operator
Mining operator 1
Mining operator 2
Crusher maintenance
Crusher operator
Operating technician
Concentrator maintenance
Concentrator operator
Balling drum operator
Dock man
Furnace operator
Pelletizing maintenance
Pelletizing operator
Boiler technician
Electrician
Lubricate technician
Maintenance technician
Pipefitter/Plumber
Supervisor
Auto mechanic
Lab analyst
Warehouse technician
Control room operator
Office staff
(D)
Keetac
PEL = 0.1
EMP concentration (particles/cm3)
Carpenter
Repairman
(E)
Minntac
PEL = 0.1
EMP concentration (particles/cm3)
(F)
Minorca
PEL = 0.1
EMP concentration (number/cm3)

- Almost all amphibole EMPs exposures are below the MSHA exposure limit of 0.1 particles/cm^{3*}
- Amphibole EMPs exposures are an order of magnitude lower than 0.1 particles/cm^3





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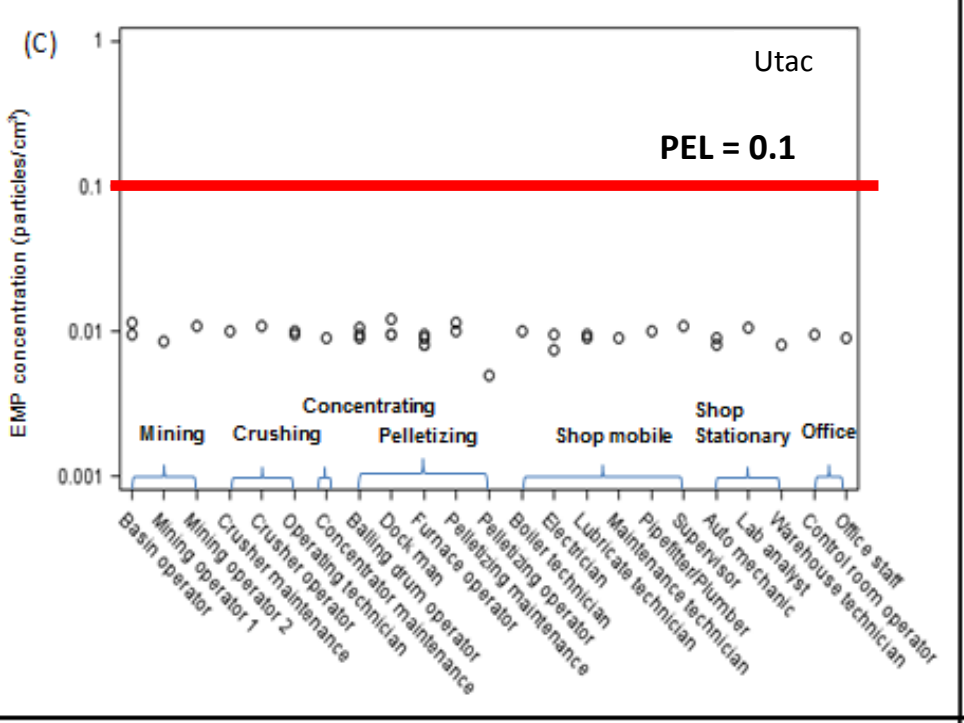
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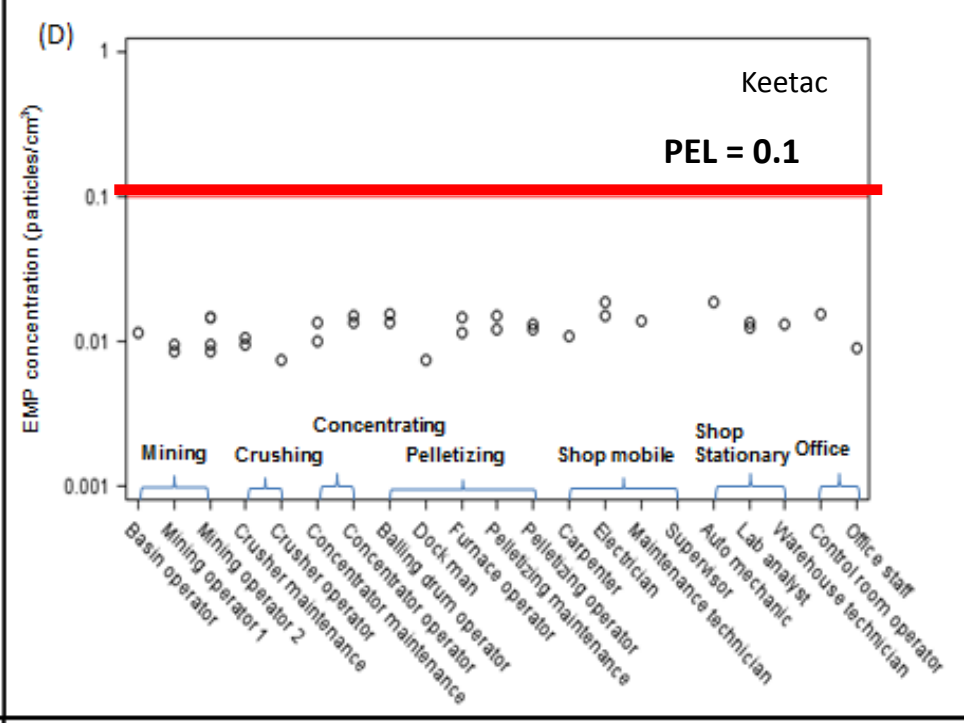
Auto mechanic
Lab analyst
Warehouse technician
Control room operator
Office staff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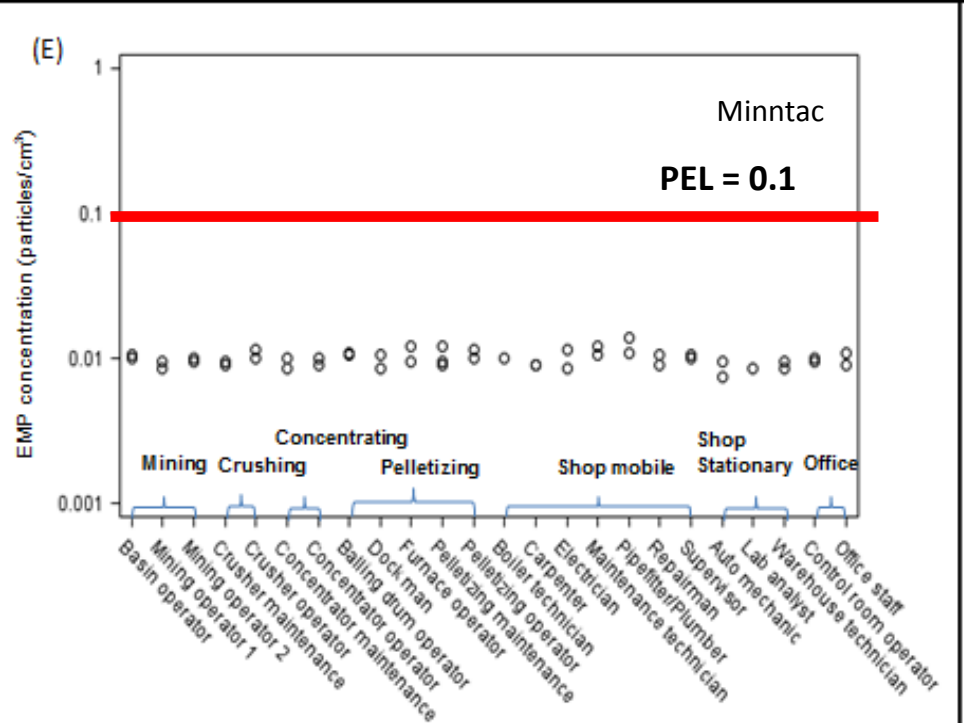
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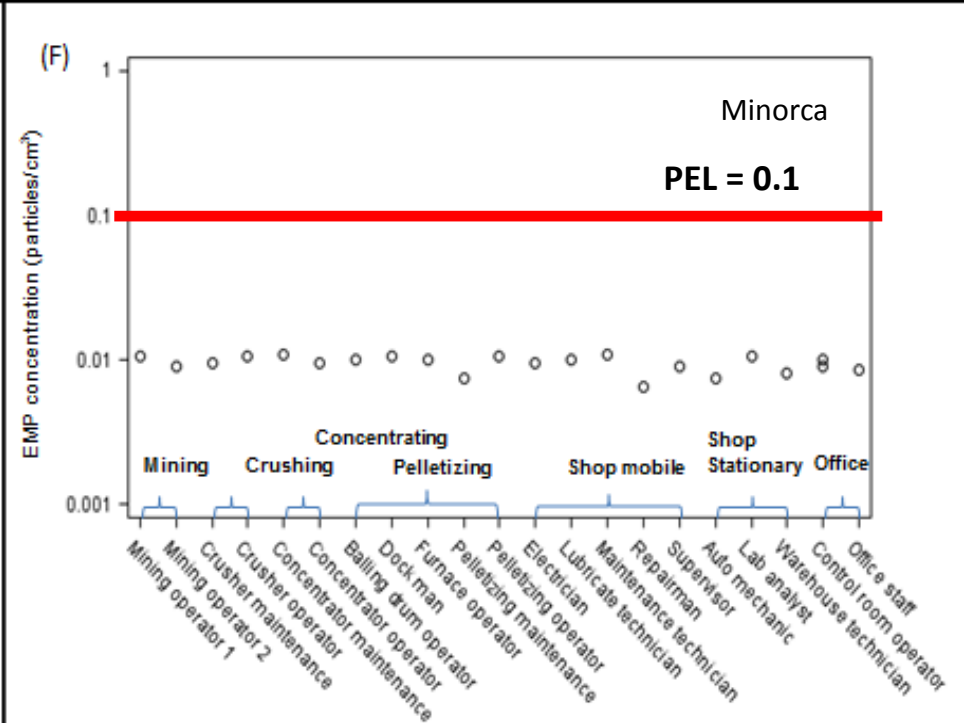
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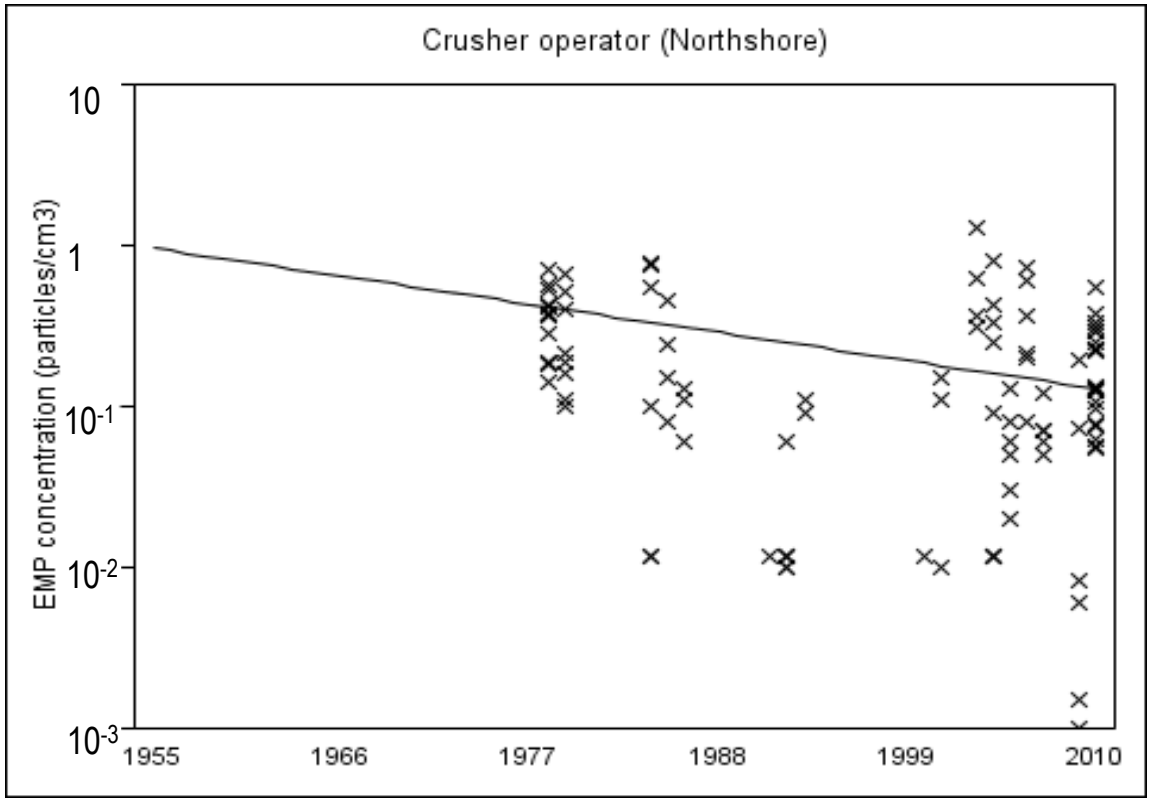
Reconstruction of Past Exposures

- Historical data were obtained from three sources:
  - MSHA – Mine data retrieval system
  - Three companies' internal industrial hygiene databases
  - Previous UMN study from the mid 1980s

Example of exposure history for one job code – *Crusher Operator in Northshore*.



EMPs Conclusions

- Exposures to total EMPs are low but are above 0.1 EMP/cm^{3*} for some jobs
- Almost all the amphibole EMPs are below the PEL
- Total EMPs measures have been decreasing through time

*Mine Safety and Health Administration (MSHA) Permissible Exposure Limit (PEL)

Assessment of Exposure Controls

- Engineering controls are appropriate for normal operations
- Miners may be exposed to elevated dust levels when making repairs or performing maintenance
- Atypical conditions may lead to significant exposures
- Plants should continue efforts to minimize exposures

Environmental Study of Airborne Particles

Larry Zanko, M.S.

Natural Resource Research Institute

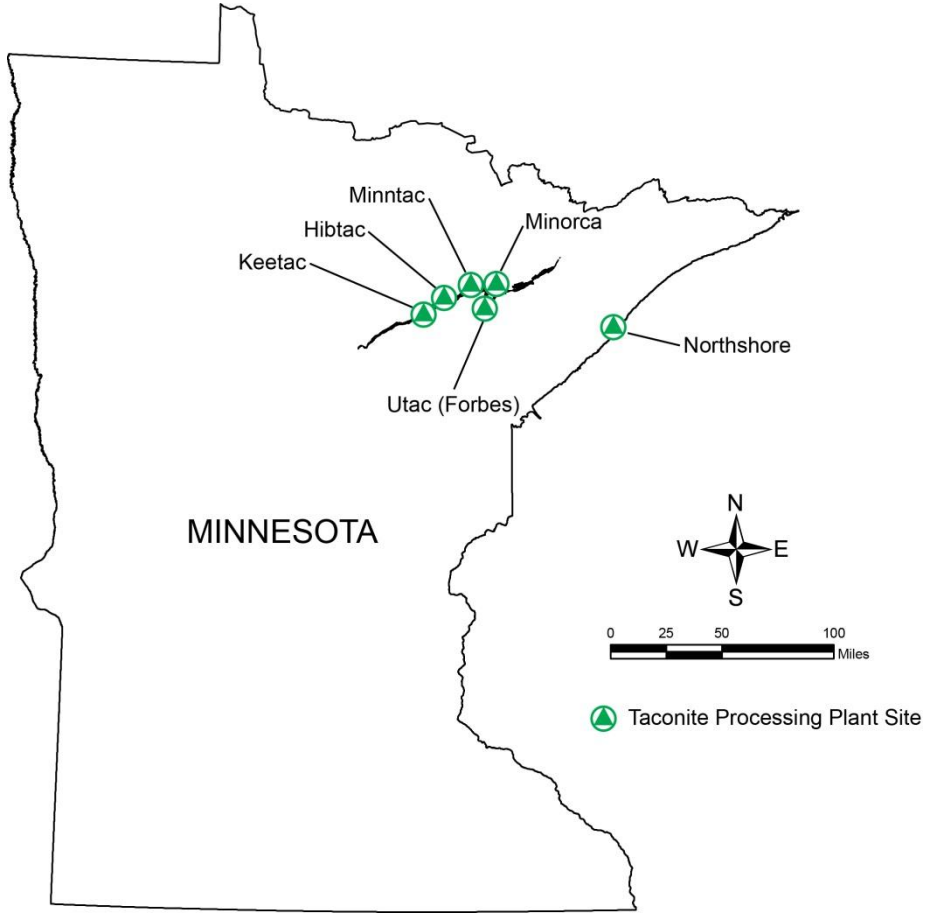
Environmental Study of Airborne Particulate Matter:

Results for Mesabi Iron Range Communities, Background Locations, and Taconite Operations

- NRRI's work represents the community/environmental component of this study
- The purpose of this work is to physically, chemically, and mineralogically characterize mineral dust in five Mesabi Iron Range (MIR) communities, three background sites, and the six taconite plants

What is in the air?

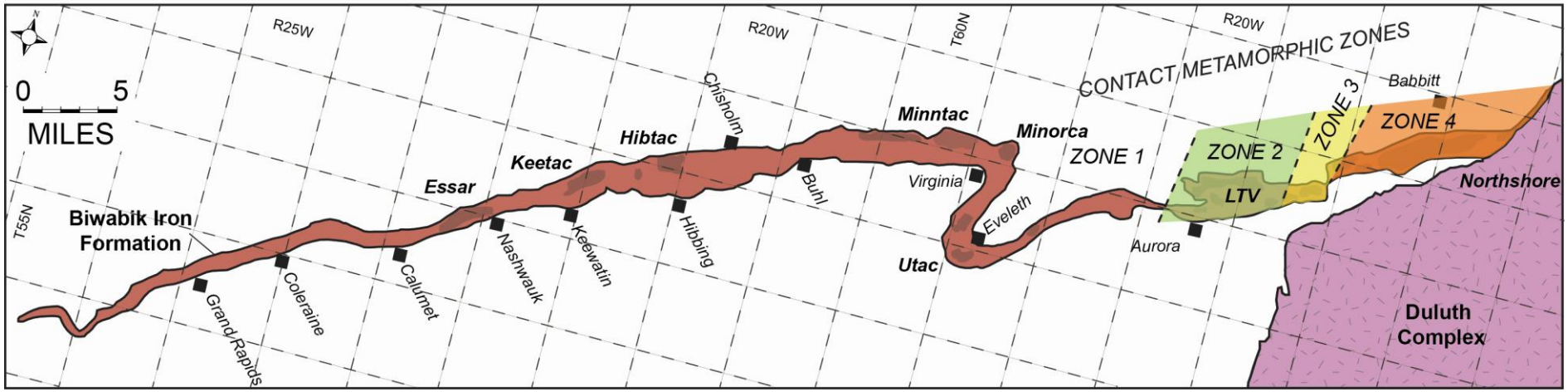
Sampling Locations



- Collect and characterize airborne particulates:
  - Keewatin, Hibbing, Virginia, Babbitt, Silver Bay --- Ely, Duluth, Minneapolis
  - Keetac, Hibtac, Minntac, Utac, Minorca, Northshore

Biwabik Iron Formation Mineralogy

West to East



Zones 1 and 2: quartz, magnetite, hematite, carbonates, talc, chamosite, greenalite, minnesotaite and stilpnomelane

Zones 3 and 4: quartz, magnetite, grunerite, hornblende, hedenbergite, ferrohypersthene (ferrosilite), and fayalite

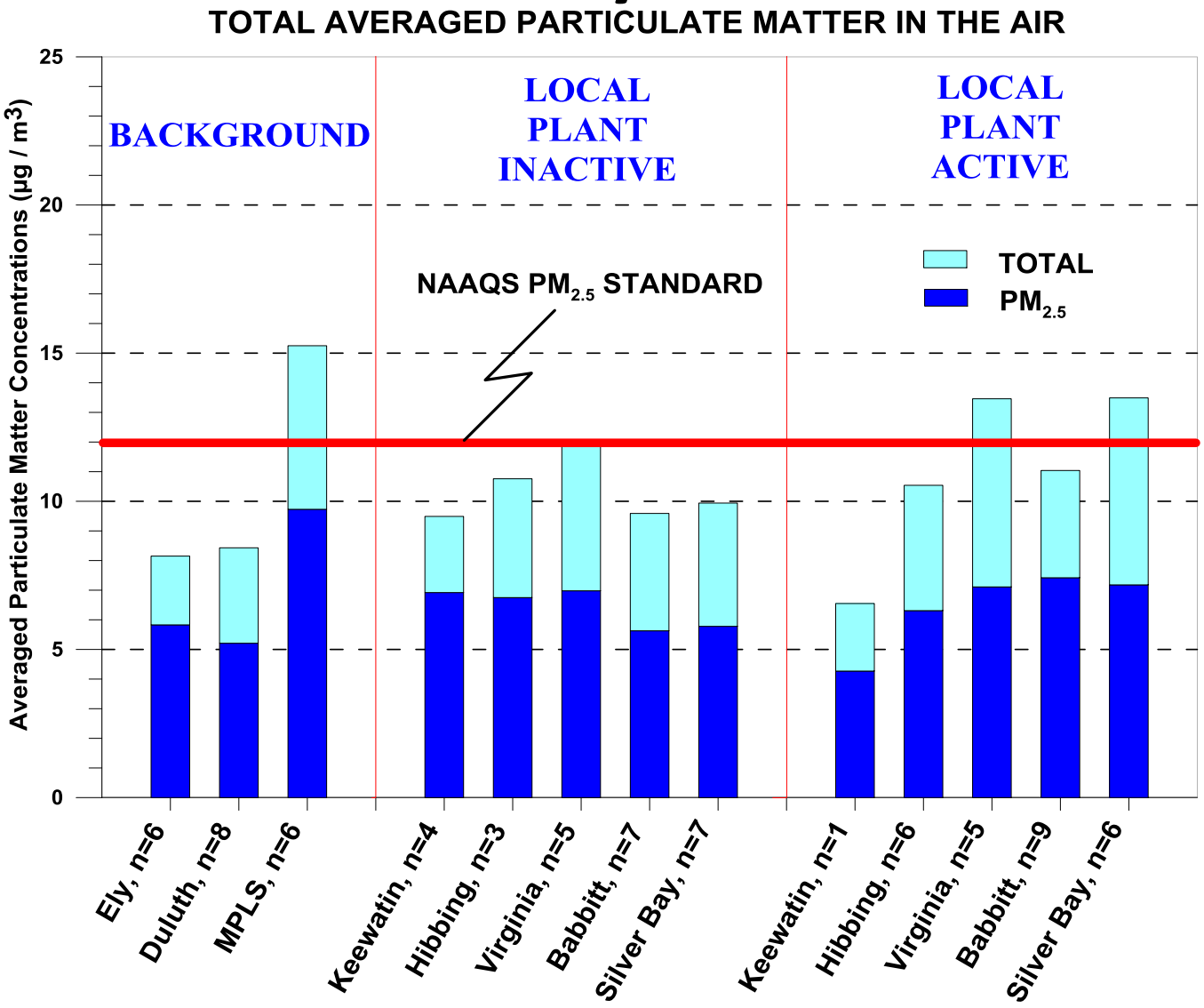
Modified from: OVERVIEW OF THE MINERALOGY OF THE BIWABIK IRON FORMATION, MESABI IRON RANGE, NORTHERN MINNESOTA Peter L. McSwiggen and G.B. Morey (2008).

Community Findings

- **Particulate matter concentrations in all MIR communities are below NAAQS Standards**
- **Particulate matter concentrations on the MIR are similar to those in the two NE Minnesota background sites, and lower than Minneapolis**
- **Mineral particulate matter in community air samples can reflect the mineralogy of the Biwabik Iron Formation and other northern Minnesota rock types and geological materials**
  - **EMP are present in air in eastern MIR communities**
  - **No asbestiform amphibole EMP have been identified to date**

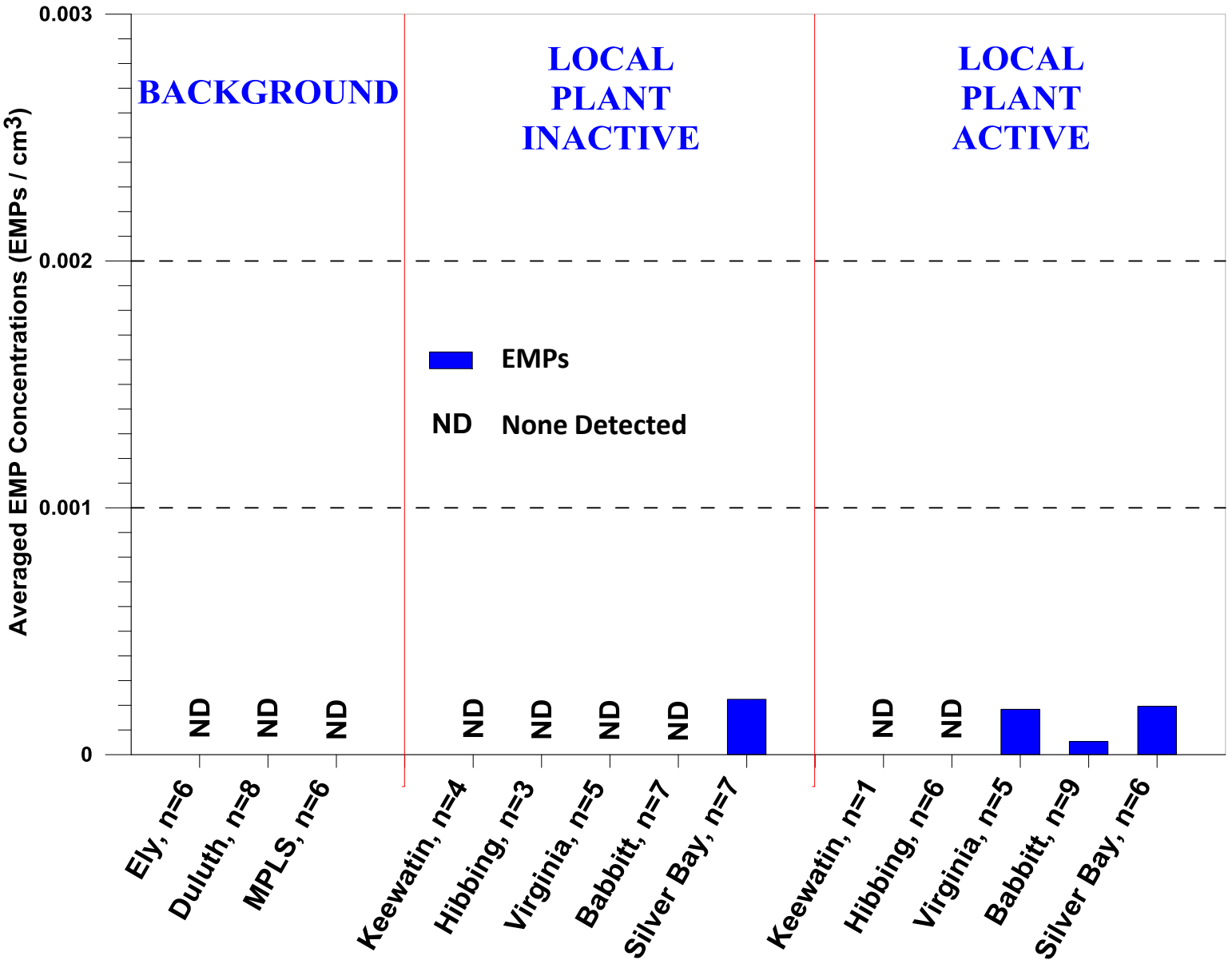
***NAAQS = US EPA National Ambient Air Quality Standard**

Community Results



- ***All MIR Communities meet the NAAQS $PM_{2.5}$ 12µg/m^3 standard***
- ***All MIR Communities meet the NAAQS PM_{10} 150µg/m^3 standard***

Community Results



Community EMP Concentrations

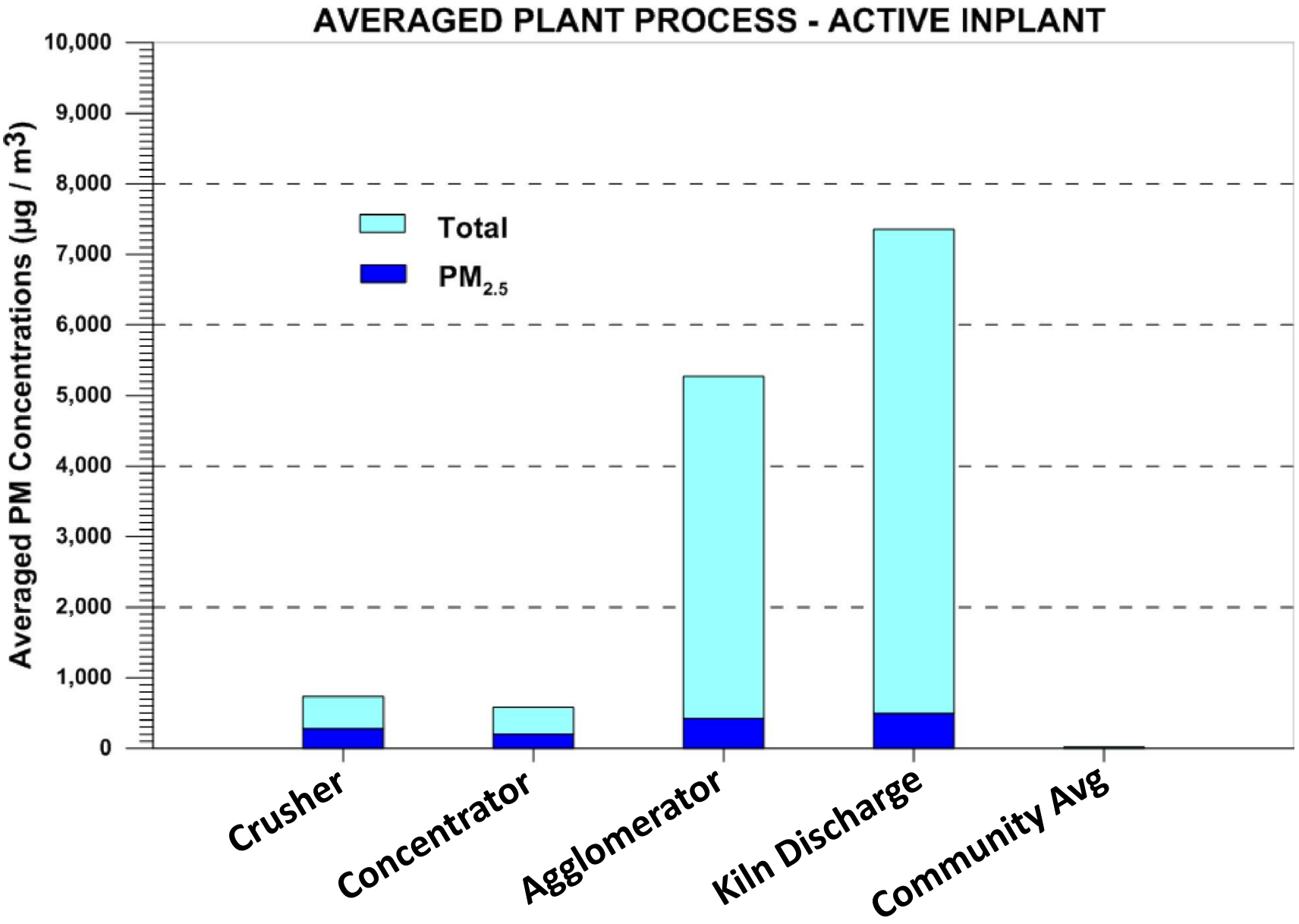
COMMUNITY	LOCAL PLANT ACTIVITY	AVERAGE EMP CONCENTRATION (EMP/cm^3)
Keewatin	Inactive	None Detected
	Active	None Detected
Hibbing	Inactive	None Detected
	Active	None Detected
Virginia	Inactive	None Detected
	Active	0.00018
Babbitt	Inactive	None Detected
	Active	0.00005
Silver Bay	Inactive	0.00022
	Active	0.00020

EMP = ≥5µm, ≥3:1 aspect ratio, covered minerals

In-Plant Findings

- Plant environments can be very dusty, with the agglomerator and kiln discharge being the most dusty
- Particulate levels (PM_1, $PM_{2.5}$, PM_{10}, and total PM) show a slight increase in the five Mesabi Iron Range communities during plant/mine activity, but this is not statistically significant compared to when the plants were not operating
- The low levels of total PM measured in the MIR communities suggest the taconite plants are isolating the dusty conditions
  - Control devices seem to be working to prevent excessive dust release to the community environments

In-Plant Findings



In-Plant EMP Concentrations*

PROCESS AREA	EMP NOT DETECTED	EMP DETECTED (AVERAGE, EMP/cm^3)
Secondary Crusher	5 Plants	Northshore (0.2)
Concentrator	4 Plants	Northshore (0.1) Minntac (0.03)
Agglomerator	6 Plants	No Plants
Kiln Discharge	6 Plants	No Plants

*Point source samples not to be confused with exposure measurements

EMP = ≥5µm, ≥3:1 aspect ratio, covered minerals

Discussion

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