


From Reserve Mining to Today: Amphibole Mineral Fibers Issues on the Mesabi Iron Range



Hillary Carpenter

Toxicologist

Minnesota Department of Health

Taconite Production

- The taconite pellet production process was developed in the 1940s to economically remove iron from low grade ore.
 - Taconite ore typically contains 20 - 25% iron
 - Through a process of grinding and pellet production the iron concentration is increased to about 60% - close to that of natural iron ore

Taconite Production

- The grinding process, which reduces large rocks to the consistency of talc, produces large amounts of waste material (tailings of various sizes) and uses large volumes of water
 - For every ton of iron produced two tons of waste material is generated

The Reserve Mining Company Legacy

- Reserve Mining Company was formed to mine and process taconite ore from the eastern end of the Mesabi Iron Range
 - Created as a joint venture by Armco and Republic Steel Corporations which at the time they were the 4th and 5th largest steel companies in the country
 - The facility at Silver Bay was the world's first taconite plant

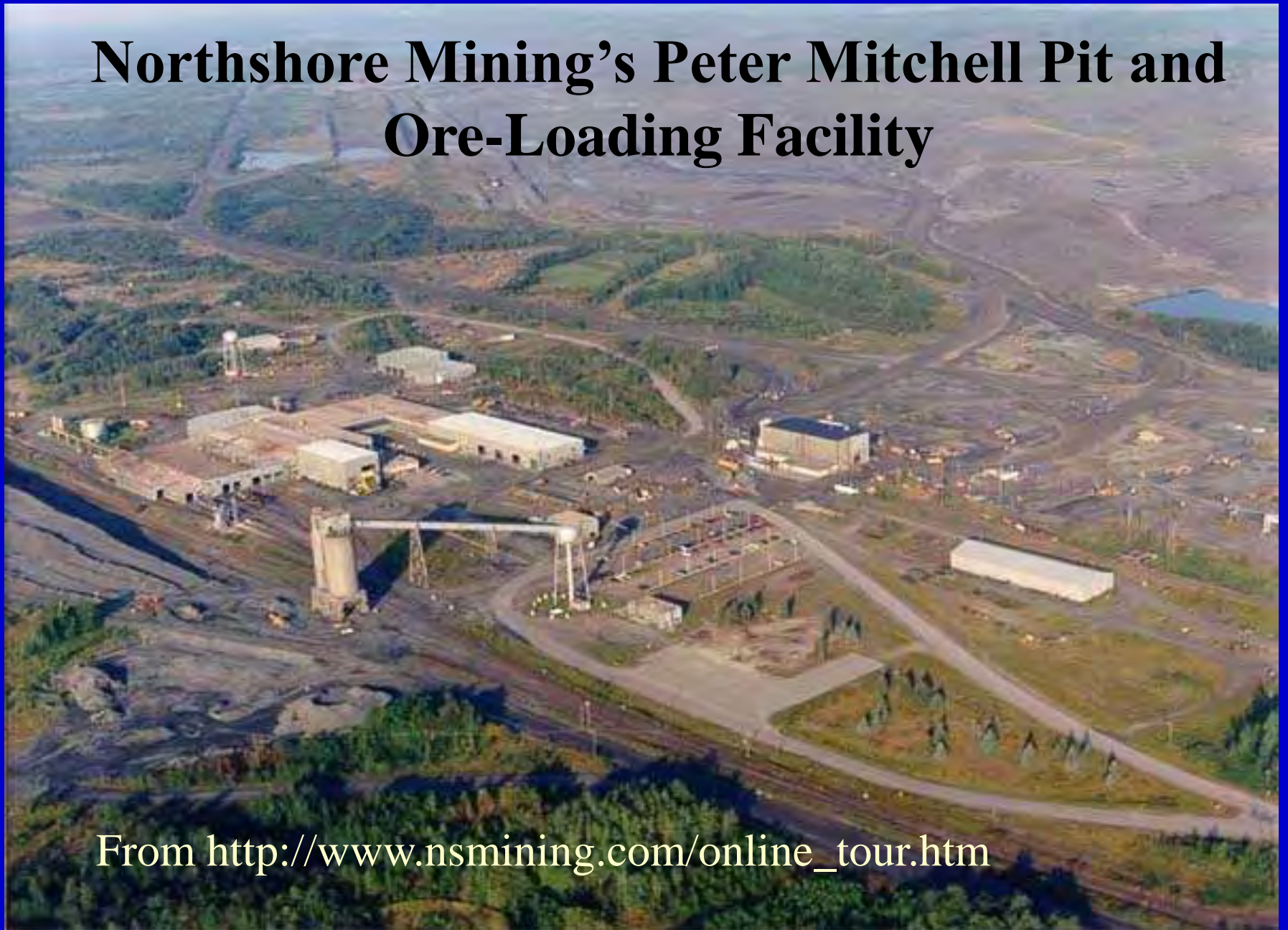
The Reserve Mining Company Legacy

- Reserve Mining Company was first permitted to produce taconite in 1947
 - State and Army Corps of Engineer permits allowed Reserve to dispose of tailings directly into Lake Superior
 - Concerns expressed about the permit were not about pollution of the lake, rather were about the compromise of drinking water supplies of downstream communities

The Reserve Mining Company Legacy

- Reserve Mining Company began its operation in 1955 and went to full scale operation in 1956
 - By 1960 production capacity was 10 million tons of taconite pellets per year
 - This amounted to about 15% of the domestic iron ore consumed by the U.S. steel at that time

Northshore Mining's Peter Mitchell Pit and Ore-Loading Facility



From http://www.nsmining.com/online_tour.htm

Northshore Mining's Processing Plant



From http://www.nsmining.com/online_tour.htm

The Reserve Mining Company Legacy

- At the time the total waste discharge was 67,000 tons of crushed taconite tailings per day. That material was suspended in about 600 million gallons of water
- Particulate air emissions averaged about 100 tons per day

The Reserve Mining Company Legacy

- By the late 1960s concerns about the amounts of materials being placed into Lake Superior and the air of Silver Bay were being expressed by environmentalists and the U.S. Department of the Interior
 - Environmentalists challenged Reserve's discharge permits in state courts



Photographed From US District Court Case Files

Reserve mining is causing an “increase of the green water phenomena both within and without the zone of discharge” Judge Eckman, 1970

The Reserve Mining Company Legacy

- In 1972 the Justice Department and the newly formed Environmental Protection Agency filed a federal civil lawsuit against Reserve to stop tailings discharges into Lake Superior
- Ultimately numerous citizen groups and the states of Minnesota, Wisconsin and Michigan were involved in litigation against the company and its parent corporations

The Reserve Mining Company Legacy

- In 1973 scientists from the regional EPA lab in Duluth reported the discovery of asbestos-like fibers in Lake Superior and Duluth drinking water.
 - These mineral fibers were traced to Reserve's tailings and determined to be Cummingtonite-Grunerite
 - Determined by the court to be identical to amosite

ASBESTOS-TYPE FIBER FOUND IN DULUTH WATER

ST. PAUL DISPATCH

Discharge Source Attributed To Reserve Mining

St. Paul Dispatch

Today's Closing N.Y. Stock Quotes

7 a.m. temperature 85 46 PAGES

ST. PAUL, MINN., FRIDAY, JUNE 15, 1973

PRICE 10 CENTS

FOR STATE CHAIRMAN

GOP Nominates Carlson

ROBERT J. O'KEEFE
Staff Writer

part of their meeting Thursday night "speaking" themselves for nominating a candidate only to find out he wouldn't run.

Other prospects considered in addition to Carlson were state Sen. Robert Brown and Robert Stassen. Carolyn Ring, announced candidate for state chairwoman, and William McFadden, a

the Democratic - Farmer-Labor party.

CARLSON is a graduate of Middlebury College, Middlebury, Conn. He and his wife have a son and daughter.

He has been active in politics on the state and Minneapolis level since 1966.

He is a former director



By D. BOCKMEYER
Staff Writer

Asbestos-type mineral fibers are being discharged from the Reserve Mining Co. taconite plant at Silver Bay, Minnesota Pollution Control Agency (PCA) Director Grant Merritt said today, both from the plant smokestack and from the taconite slurry chute into Lake Superior.

Meanwhile, Dr. Warren Lawson, executive director of the State Health Department, said asbestos-type materials have been found in Duluth's water supply.

DULUTH
miles from
on the N
lake.

asbestos-like fibers was introduced in the Reserve Mining case in Federal court in Minneapolis as evidence to strengthen the PCA's case against Reserve.

EDWARD SCHEMEL, assistant to the president of Reserve, said today that the discharge has made public without its validity. He will do everything in his power to see that the public learns the truth as quickly as possible.

Lord had a... stamped a lot of...

June 15, 1973: Reserve case shifts to concern over public health.

The Reserve Mining Company Legacy

- Following more than twelve years of legal action Reserve began disposing of tailings in a constructed basin and began placing emission controls on the facility
 - Filtration equipment to remove fibers was placed in downstream drinking water treatment facilities
 - Levels of fibers in Lake Superior rapidly decreased when the dumping of tailings ceased

Northshore Mining's processing plant and remaining tailings delta



From http://www.nsmining.com/online_tour.htm

The Reserve Mining Company Legacy

- Reserve Mining closed in 1986 and the operation reopened under new management in 1990.
- The mine and taconite production facility is currently operated by Northshore Mining Co., a subsidiary of Cleveland-Cliffs, Inc.
- More than 30 years later the subject of asbestos-like fibers associated with the taconite pellet production process remains controversial

Northshore Mining Company (NMC)

- NMC operates under permits that restrict fiber levels in the effluent from their tailings basin and control the level of ambient air fibers in Silver Bay and Beaver Bay
- Because it has not been possible to develop a health-based standard for fiber emissions, the courts recommended the use of what has been referred to as the “comparison city standard”

Northshore Mining Company (NMC)

- Basically the comparison standard states that citizens living around the NMC facility can be placed at no greater risk from breathing fibers than the citizens of a reference city such as St. Paul
- This standard, which has been included in all subsequent permits, has been an ongoing point of contention between NMC and the MPCA

Northshore Mining Company (NMC)

- NMC has suggested that the approach is unfair because it is in effect a “rolling standard”
- They have also argued that they are not emitting fibers, but are instead emitting cleavage fragments
- In addition the company argues that because most of their fibers are short (i.e. less than 5 μm in length), they are non-toxic

Mineral Fibers

- For the purpose of controlling ambient fiber concentrations the state of Minnesota defines a mineral fiber as a particle with parallel sides and an aspect ratio of 3:1
 - The state uses no minimum length cut-off in its definition
 - The state does not regulate asbestos emissions per se, rather it regulates the emission of amphibole mineral fibers

Mineral Fibers

- Asbestos (which translates to unquenchable) is a generic name given to six fibrous mineral that have been used in commercial products.
- Asbestos includes:
 - **Chrysotile** (a serpentine mineral) which is found in 90-95% of all asbestos containing products in buildings in the U.S.
 - Five types of amphibole

Mineral Fibers

- Amphibole asbestos includes:
 - **Amosite** – the fibrous form of cummingtonite-grunerite called brown asbestos
 - **Crocidolite** – the fibrous form of riebeckite called blue asbestos
 - **Tremolite** asbestos
 - **Actinolite** asbestos
 - **Anthophyllite** asbestos

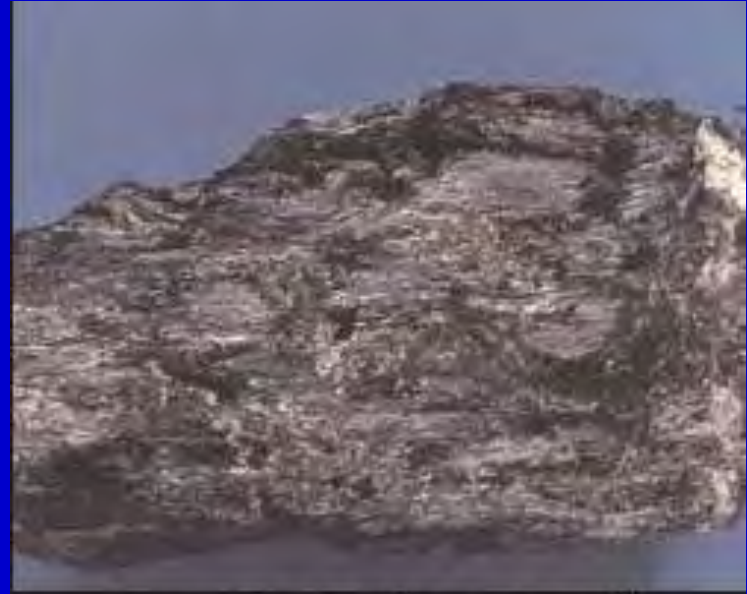
Mineral Fibers – Asbestos



Mineral Fibers - Morphology



amosite



cummingtonite-grunerite

Mineral Fibers

- For regulatory purposes (OSHA, EPA) fibers in a sample are counted if they are more than 5 μ m in length with an aspect ratio of 3:1 or greater
- Other methods such as the ISO 10312 requires that only fibers 5 μ m in length with an aspect ratio of 5:1 or greater be counted

Mineral Fibers

- Because of their structure these fibers are flexible and durable and have a high tensile strength. These properties allow them to be used commercially as fire and heat resistant materials
 - Used in over 1,000 commercial applications including clothes, insulation boards and ceiling tiles, asbestos cement sheets and pipes for construction, friction products such as brake and clutch linings

Mineral Fibers

- Asbestos Related Diseases (ARDs)
 - Mesothelioma – the hallmark disease
 - Lung Cancer – potentiated by cigarette smoking
 - Asbestosis – a severe pneumoconiosis (fibrotic disease)
 - Pleural plaques
 - Pleural Thickening
 - Asbestos Warts – benign callus-like warts

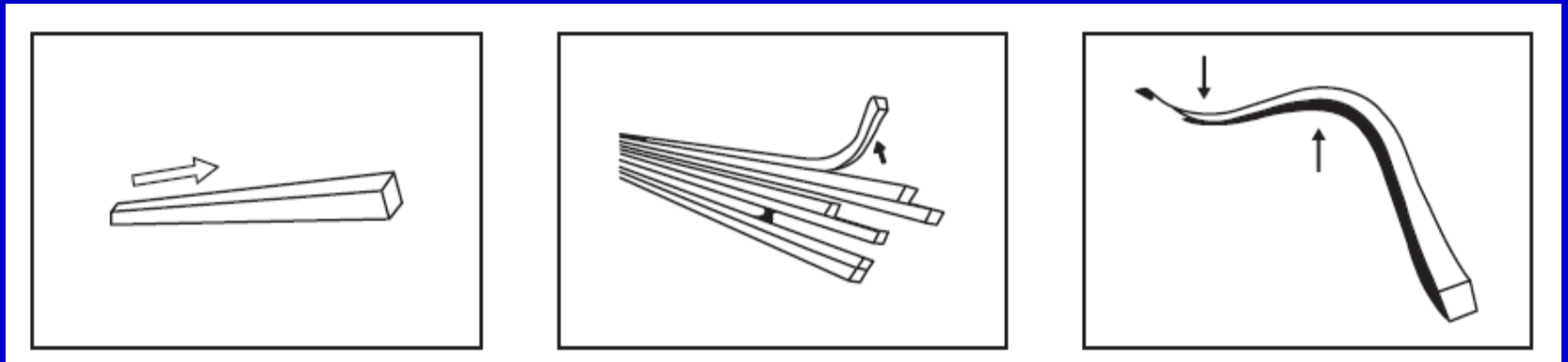
Mineral Fibers

- Amphibole – group of 40 – 50 silicate minerals that can occur in either a fibrous (asbestiform) or non-fibrous (non-asbestiform) habit
- Most amphiboles occur in a non-asbestiform habit – asbestiform amphiboles are relatively rare

Mineral Fibers

- **Asbestiform** refers to minerals in a fibrous habit; long, thread-like fibers with aspect ratios of 20:1 to 100:1 or higher.
- When in the asbestiform habit fibers are flexible – when pressure is applied fibers do not shatter but simply bend much like a wire
 - Can occur as polyfilamentous bundles

Mineral Fibers – Asbestiform



Mineral Fibers

- While all asbestos is asbestiform, not all asbestiform minerals are asbestos (e.g., winchite and richterite from Libby)
- Both asbestiform and non-asbestiform minerals have the same chemical composition and crystal structure – they are not distinguishable by electron diffraction or energy dispersive X-ray analysis



Scanning electron micrograph of asbestiform amphibole from a former vermiculite mining site near Libby, Montana.

Mineral Fibers

- **Cleavage fragments** can result when non-asbestiform minerals are crushed during milling and/or processing into fragments
 - Result from cleavage along the minerals' two or three dimensional plane of growth.
 - A portion of these fragments may fit the definition of a fiber but they don't have the properties of flexibility and strength.

Mineral Fibers

- It has been suggested that because cleavage fragments are not flexible, do not have the same tensile strength as true fibers, and may not be as durable as an amphibole fiber, they are not as toxic as fibrous amphiboles
 - This line of reasoning would suggest that exposure to cleavage fragments is benign and of little or no health significance

Mineral Fibers

- However, for the purpose of public health assessment and protection agencies such as the EPA and MDH make no distinctions between fibers and cleavage fragments of comparable composition, size and shape
- This approach is based on the following information -

Mineral Fibers

- An EPA peer consultation panel convened in 2003 that concluded that it is prudent at this time to conclude equal potency (of cleavage fragments and fibers)
- There are no routine air asbestos analytical methods, including those used by EPA, NIOSH, MSHA, ASTM and ISO that differentiate between crystalline fibers and cleavage fragments on an individual fiber basis

Mineral Fibers

- The epidemiological and health studies the U.S. EPA and Cal EPA use for cancer risk assessments of fibers were based on exposures to both cleavage fragments and fibers, and were unable to distinguish between the two
- No well designed animal or epidemiological studies have adequately tested the hypothesis that cleavage fragments with the same dimensions as a fiber are benign or that the human body makes any distinction between them

Mineral Fibers

- Studies that purport to show that cleavage fragments are benign are questioned by many asbestos health experts
- Issue of determining between fibers and cleavage fragments must be resolved on the basis of biological activity and aspect ratios of the respirable fibrous bodies

Mineral Fibers

- Part of the current dogma is that fibers shorter than 5 μm in length exhibit no toxicity in biological systems
 - Based in large measure on the idea that short fibers are cleared from tissues more quickly than longer fibers
 - Also based on the idea that macrophages, which are thought to be of primary importance to asbestos' toxic mechanism, are less able to effectively dissolve long fibers

Mineral Fibers

- When examining results from published studies, it should be remembered that techniques counting fibers longer than 5 μm in length were chosen for the convenience of optical microscopic evaluation, not because there is any sharp distinction between risk associated with fibers longer or shorter than this length

Mineral Fibers

- This means that for most epidemiological studies, and many experimental studies, fiber counts done for exposure assessments ignored or depended on microscopic results where fibers shorter than 5 μm in length could not be “seen”

Mineral Fibers

- In samples taken from Libby Montana 65% of the fibers detected were less than 5 μm in length
- Distributional analysis of fiber length showed that only 30% of the fibers fall within the regulated range
- EPA's risk assessment used only regulated fibers to calculate risks

Mineral Fibers

- Studies in animals, epidemiological studies, and examination of autopsy material from asbestos-induced cancers have indicated that it is likely that some measure of toxic potency resides in fibers shorter than 5 μm in length

Mineral Fibers

- Despite the fact that evidence collected to date indicates the presence of significant amounts of amphibole only on the eastern end of the range, controversies regarding mineral fibers and taconite production range-wide remain
- Also a source of concern with use of coarse tailings as aggregate