

Occupational Health Hazards in Mining & Metallurgical Work

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Mining and Occupational Health: The Beginnings – Ancient Times

The history of occupational health can be traced into antiquity.

Observations of increased rates of illnesses and mortality among miners date back to Greek and Roman times. In the 4th century BC, Hippocrates noted lead toxicity in the mining industry. In the second century AD, the Greek physician, Galen, recognized the hazardous exposures of copper miners to acid mists.





Occupational Health: George Bauer

1556

Georg Bauer (Agricola) publishes *De re metallica* (On the Nature of Metals), a discussion of the methods of mining, and the dangers and diseases of miners. The book included suggestions for mine ventilation and worker protection, discussed mining accidents, and described diseases associated with mining occupations such as silicosis.



Occupational Health: Ramazzini and Ellenborg



1700

Bernardini Ramazzini publishes
first edition of *Diseases of
Workers*

1743

Ulrich Ellenborg publishes a
pamphlet on occupational
diseases and injuries among
gold miners



What is an occupational disease?

1. “occupational illness” means a condition that results from exposure in a workplace to a physical, chemical or biological agent to the extent that the normal physiological mechanisms are affected and the health of the worker is impaired thereby and includes an occupational disease for which a worker is entitled to benefits under the *Workplace Safety and Insurance Act, 1997*



Occupational Disease (continued)

2. Work-related illnesses are those caused by physical, chemical, or biological hazards in the workplace. They can also include acute psychological trauma resulting from work.



Which workplaces hazards may cause occupational illness?

- dust, gases, or fumes
- noise
- chemical agents (solvents, metals, etc.)
- vibration
- radiation (ionizing and non-ionizing)
- infectious bacteria or viruses (biologic agents)
- extreme hot or cold temperatures
- extremely high or low air pressure



How does the body react to workplace hazards?

- Three kinds of reactions in the body:
 - Immediate or acute reactions – example: shortness of breath, nausea from chemical spill
 - Gradual reactions – asthma or dermatitis
 - Delayed reactions – long term exposure with hearing loss, cancer
 - May develop after exposure or job is finished



What should the family doctor ask workers?

- A standardized set of key screening questions asked of every patient is the single most important method of recognizing the link between illness and occupation



What are the doctor's key screening questions?


- What type of work do you do?
- Do you think your health problems might be related to your work?
- Are your symptoms different at work and at home?
- Are you currently exposed to chemicals, dusts, metals, radiation, noise or repetitive work? Have you been exposed to chemicals, dusts, metals, radiation, noise or repetitive work in the past?
- Are any of your co-workers experiencing similar symptoms?



How does a doctor decide a worker may have an occupational disease?

The decision-making process should address the following six questions:

- Is the clinical illness, including the history, physical examination, and laboratory findings, consistent with other case descriptions?
- Is the timing between exposure and clinical onset compatible with the known biologic facts about the hazard?
- Is the exposure dose within the range of doses believed to cause such effects?

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- Are there special attributes of the particular patient that make it more or less likely that he or she would be so affected?
 - Are there alternative ways of constructing the case that better fit the available facts?
 - Where there remains significant uncertainty about the cause, how important is it to be certain?




Health Hazards of Mining

- Airborne Hazards:
 - Particulates, naturally occurring gases, engine exhaust, chemical vapours
- Physical Hazards:
 - Noise, vibration, heat and humidity, air pressure changes, ionizing radiation, EMF
 - Trauma
- Biological Hazards:
 - Tuberculosis, hepatitis, Legionella



Airborne Particulates

- Free crystalline silica is the most abundant compound in the earth's crust
- **Mainly Quartz**, plus tridymite, cristobalite
- Respirable particles formed when rock is drilled, blasted, crushed or pulverized
- Dispersed by wind, vehicle traffic, earth-moving machinery
- Rock may contain 30% silica or more

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- Silica exposure may occur in any mining operation, surface or underground
 - Found in overburden of surface mine or ceiling, floor or ore deposit of an underground mine
 - Respirable silica commonly produced by drilling, blasting and cutting
 - Ontario Regulation respecting Silica



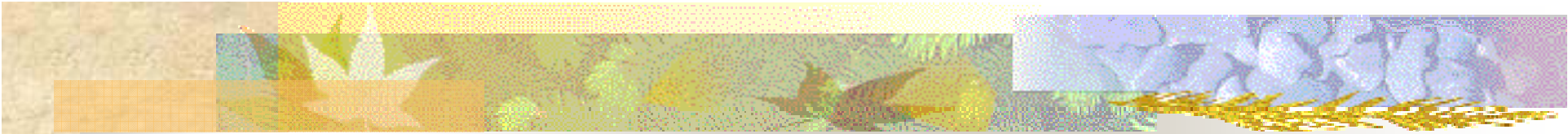
Silica-related Diseases

- Silicosis
- Tuberculosis
- Lung cancer
- Connective tissue and kidney diseases
- Emphysema and chronic bronchitis



Silicosis

- Scarring disease of the lung from inhalation of free crystalline silica
- Chronic silicosis can be simple or complicated
- Chronic simple silicosis may cause no symptoms, may slowly progress or even start after exposure ends, and consists of small round X-ray opacities
- Diagnosed on screening or incidental X-ray (for MI), or at autopsy
- Chronic complicated silicosis has progressively worsening symptoms and enlarging lung opacities, even after exposure ends.

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- Subacute silicosis develops after 3-6 years of high exposure, and resembles chronic complicated silicosis
 - Acute silicosis develops within a couple years of massive exposure and is clinically distinct from the other forms



Symptoms of Silicosis

- Chronic Simple Silicosis (10 – 12 years exposure)
 - No symptoms; X-ray changes only
- Chronic Complicated (>20 yrs) and subacute (2 to 5 years heavy exposure)
 - Chest tightness, cough
 - Shortness of breath
 - Expectoration
 - Signs and symptoms of right heart failure
- Acute silicosis (several months intense exposure)
 - Dry cough
 - Fever
 - Severe dyspnea
 - May be fatal



Tests for Silicosis

- Pulmonary function tests (screening & diagnosis)
 - Normal in simple silicosis
- Chest X-ray (screening & diagnosis)
 - Egg shell calcification in lung lymph nodes
 - Small round opacities, initially in upper lobes
- Blood tests for oxygen capacity (diagnostic)
- TB skin test (yearly if silicosis)
- Bronchoscopy, lung biopsy (for difficult to diagnose cases)



Treatment of Silicosis

- No cure for silicosis
 - Prevention is key
- No specific treatment
- Smoking cessation
- Supplemental oxygen
- Treat infections, TB
- Breathing exercises
- May be fatal, from right heart failure





Silica and Tuberculosis

- Silica exposure slightly increases the risk of developing tuberculosis
- Silicosis increases the risk of developing tuberculosis by three times
- Silicosis and HIV positive = 15 X increase in TB risk



Silica and Lung Cancer

- Association between silicosis and lung cancer
- Risk increases with smoking and exposure to other carcinogens such as diesel emissions and radon
- Silica exposure without silicosis does not have increased risk of lung cancer



Silica and connective tissue and kidney diseases

- Silica exposure associated with scleroderma, rheumatoid arthritis and kidney disease



Emphysema and chronic bronchitis

- Long-term silica exposure increases the risk for developing emphysema and chronic bronchitis
- Risk increases with smoking



Other particulates

- Coal and coal workers pneumoconiosis
- Asbestos and asbestosis
- Diesel engine exhaust
 - Mixture of gases, vapours and particulate
 - CO, nitrogen oxide, SO₂, VOCs (formaldehyde, etc.), PAHs
 - Particulate < 1 um diameter & respirable
 - Eye, nose, throat and chest irritation
 - Headache and nausea
 - Lung cancer - IARC Group 2A probable human carcinogen
 - Controls: low sulfur diesel fuel, engine maintenance, ventilation



Metals and other chemicals

■ Arsenic:

- Metal ore contaminant
- Commercially extracted during copper smelting
- nerve damage in arms and legs: weakness; “pins and needles” sensation
- Increased skin pigmentation and thickening; anemia
- Lung cancer



■ Beryllium:

- In Ontario, sometimes found in re-processed scrap received from other locations
- Chronic beryllium disease
- Chronic cough, wheezing, shortness of breath
- Allergic reaction: BeLPT blood test available
- Scarring of the lungs
- PFT and Chest X-ray changes
- Treatment: remove from exposure, Oxygen, prednisone, anti-cancer drugs
- Lung cancer



Cadmium

- By-product of zinc, lead & copper ore smelting and refining
- Acute effects: chemical pneumonia, kidney failure
- Chronic effects: emphysema, lung cancer, kidney disease, bone wasting



Cyanide

- Used to extract copper and gold in hydrometallurgical processes
- Acute effects: shortness of breath, headache, gastrointestinal upset, dizziness, loss of consciousness
- Chronic effects: nerve damage



■ Lead

- Exposure risk greatest during metallurgical processing (also true for Cd, Mn, Pt and Co)
- Acute poisoning:
 - abdominal pain, nausea and vomiting
 - anemia; kidney failure
 - Headache, confusion, coma
- Chronic poisoning
 - Fatigue, muscle and joint pain
 - Anemia; chronic kidney disease
 - Nerve damage with weakness in arms and legs and “pins and needles” sensation
 - Personality and memory changes
 - Infertility
 - gout



■ Mercury

- Chronic mercury poisoning
- Personality changes, tremor, kidney disease
- Gingivitis and dental erosion

■ Nickel

- Allergic contact dermatitis; asthma
- Nasal and lung cancer

■ Nickel carbonyl

- Volatile, colourless liquid
- Very toxic
- Headache, nausea, vomiting
- Fever, chills, chest pain
- Lung irritation, fluid in lungs, death



■ Solvents

- Dermatitis
- Acute impairment
- Chronic brain damage
- Liver damage

■ Welding fumes

- Photokeratitis
- Metal fume fever
- Lung irritation



Gases and Vapours (1)

- **Methane:** simple asphyxiant, explosive
- **Hydrogen sulfide:** eye, nose, throat irritation; acute respiratory depression, rapid loss of consciousness and death
- **Radon gas** (uranium mines)
 - Source of ionizing radiation



Gases and Vapours (2)

- **Carbon monoxide:** chemical asphyxiant
 - Engine exhaust, blasting
 - Fires
 - Acute: headache, malaise, myocardial infarction, coma, death
 - Chronic effects: neurologic damage after acute exposure; heart disease



Hollinger Mine in Timmins

- Gave birth to Ontario's mine rescue program
- February 10 1928: Thirty-nine miners died in the fire from CO asphyxiation; some found still sitting at lunch table
- Common practice to throw used timber, dynamite boxes and other refuse in unused shrinkage stopes
- Spontaneous combustion caused one of these dumps to catch fire, filling the mine with carbon monoxide gas
- As gold mining did not release gas and fire was considered unlikely because of damp mine conditions, no rescue teams or emergency equipment were on site
- Rescue team arrived from Pittsburgh 21 hours later
- Commission investigating the fire recommended a service to ensure that trained and equipped crews would be available to respond to such emergencies in the future.
- The mine rescue program was up and running by the next year
- Initially, program stocked emergency gear and operated special smoke rooms for training rescuers
- Extended to deal with rockbursts, floods, bulkhead failures and other mining hazards



- Oxygen deficiency

- displacement by methane or from combustion
- Rapid loss of consciousness, coma, brain injury, death

- Blasting by-products

- Nitrogen oxides
 - Also from diesel exhaust
 - Lung irritation
- Carbon monoxide production



Physical Agents

■ Noise

- Ubiquitous in mines: machines, fans, blasting, ore transportation
- Noise-induced hearing loss: disability starts at 25dB hearing loss
- No treatment; preventable
 - Education; Noise reduction at source, path or worker; Audiometry
- Hearing Loss and Fitness for Duty
 - Signal detection and localization: signal must exceed background noise + hearing loss by 15dB
 - Impact on person-to-person speech intelligibility and safe coordination of tasks

Table 1. Estimates of noise exposure from plant and equipment

Noise source	Range (dB)	Mid point
Cutting machines	83–93	88
Locomotives (electrical)	85–95	90
Haulage truck	90–100	95
Loaders	95–100	98
Long-wall shearers	96–101	99
Chain conveyors	97–100	99
Continuous miners	97–103	100
Loader-dumper	97–102	100
Fans	90–110	100
Pneumatic percussion tools	114–120	117



■ Ionizing radiation

- Radon gas decay products emit ionizing radiation
- Uranium mines
- Lung cancer
- Control with ventilation



■ Heat stress:

- Underground: Heat from rock itself
- Geothermal gradient: rock temperature increases 1°C every 100 m in depth
- Auto-compression of air column
- Heat from machinery
- Humidity
- Physical activity

■ Vibration

- Hand-Arm Vibration
 - Air-powered rock drills
- Whole Body Vibration
 - Exposure while operating mobile equipment



- Outdoor UV

- Surface mines
- Skin cancers

- Infra-red radiation exposures

- Pyrometallurgical processes
- Heat stress
- Cataracts

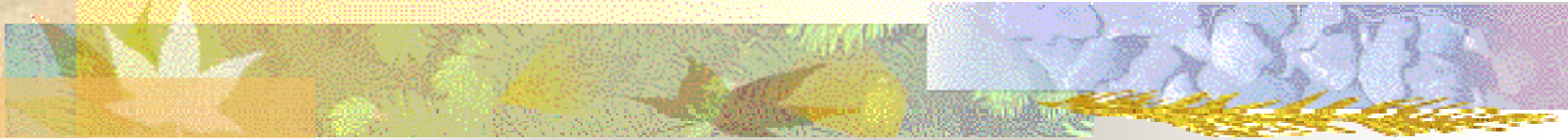
- Electromagnetic fields

- Electrolytic smelting and refining processes



Other health concerns

- Ergonomic issues
 - MSDs from manual handling
 - Overhead work and shoulder injury
 - Broken ground and ankle & knee injuries
 - Equipment control design
 - Vehicle cab design
 - Shiftwork &/or prolonged shifts and fatigue

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- Electrical contact - electrocution
 - Infectious diseases from poor hygiene and over-crowded living conditions
 - Sanitation: Water and food quality
 - Insects (mosquitoes and West Nile virus)
 - Wild animals
 - Psychosocial hazards
 - Substance abuse
 - Isolation
 - Traumatic injuries and Post-Traumatic Stress



Thank you!

- Questions?