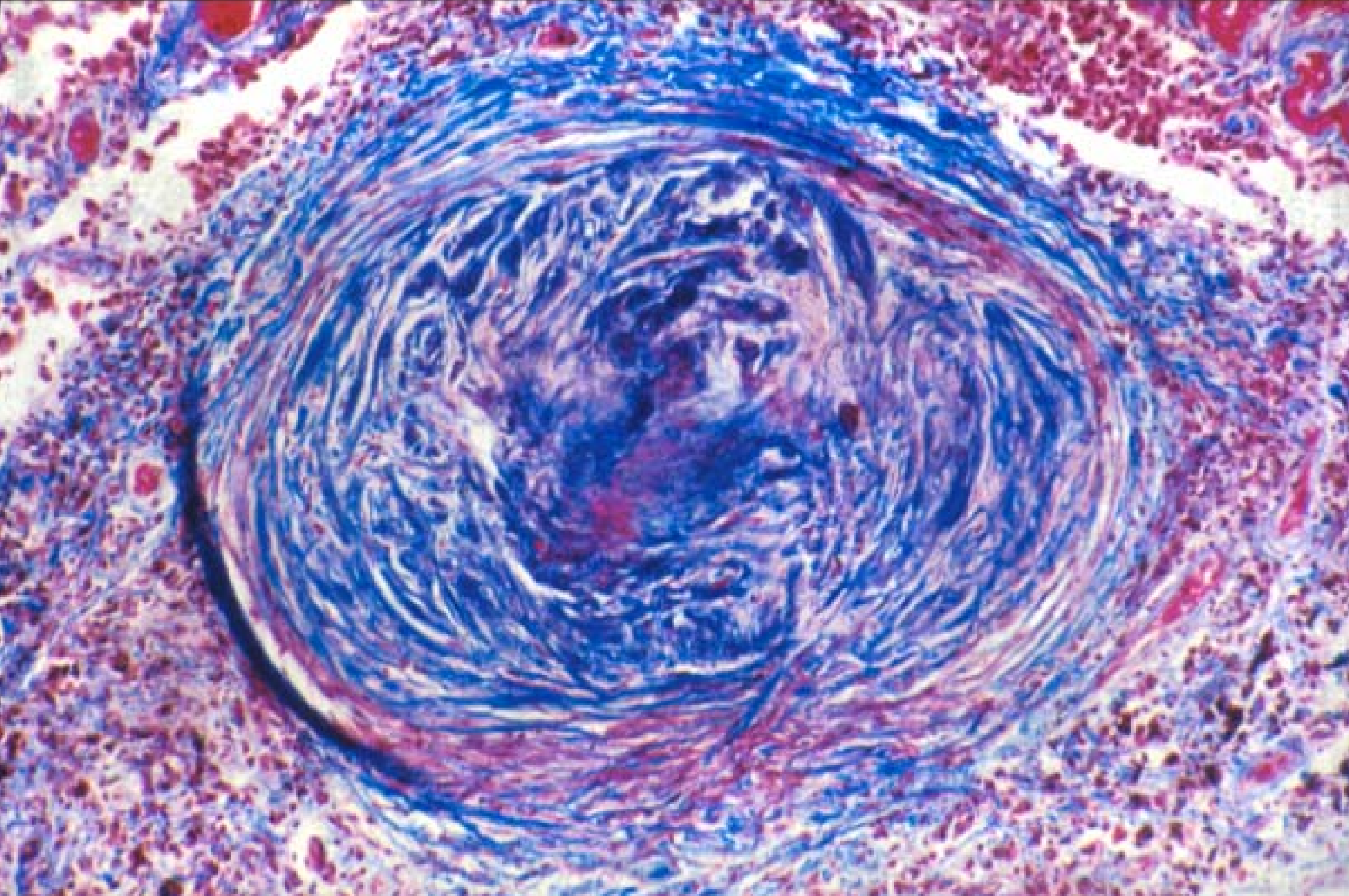

Adverse Health Effects from Silica Exposures

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Modena October 2008

Overview of Presentation

- Review the adverse health effects from silica exposures
- Radiographic Silicosis – Acute, Accelerated, Chronic
- COPD (Expiratory Airflow Obstruction)
- Cancer of the lung
- Rheumatic disorders -- possible relationship
- Renal disease – possible relationship
- Traditional chest radiography & CT HRCT
- Why is silicosis so difficult to prevent?

ATS Reference
Respirable Silica Exposures
Adverse Health Effects

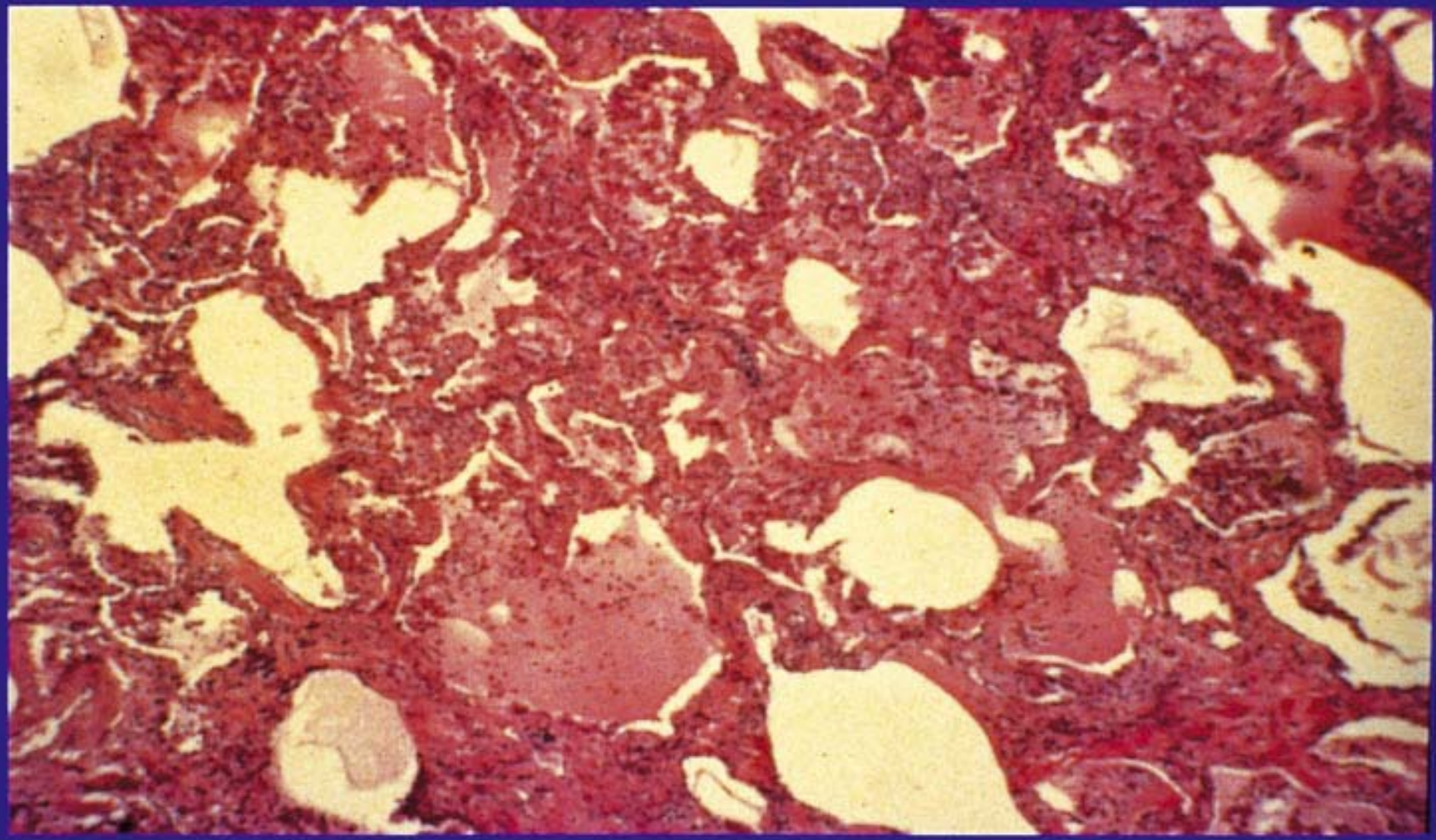
ATS. Adverse Effects of Crystalline Silica Exposure. Am J Respir Crit Care Med 1997; 155:761-768. Beckett, Abraham, Becklake, Christiani, Cowie, Davis, Jones, Kreiss, **Parker**, Wagner.

NIOSH Reference

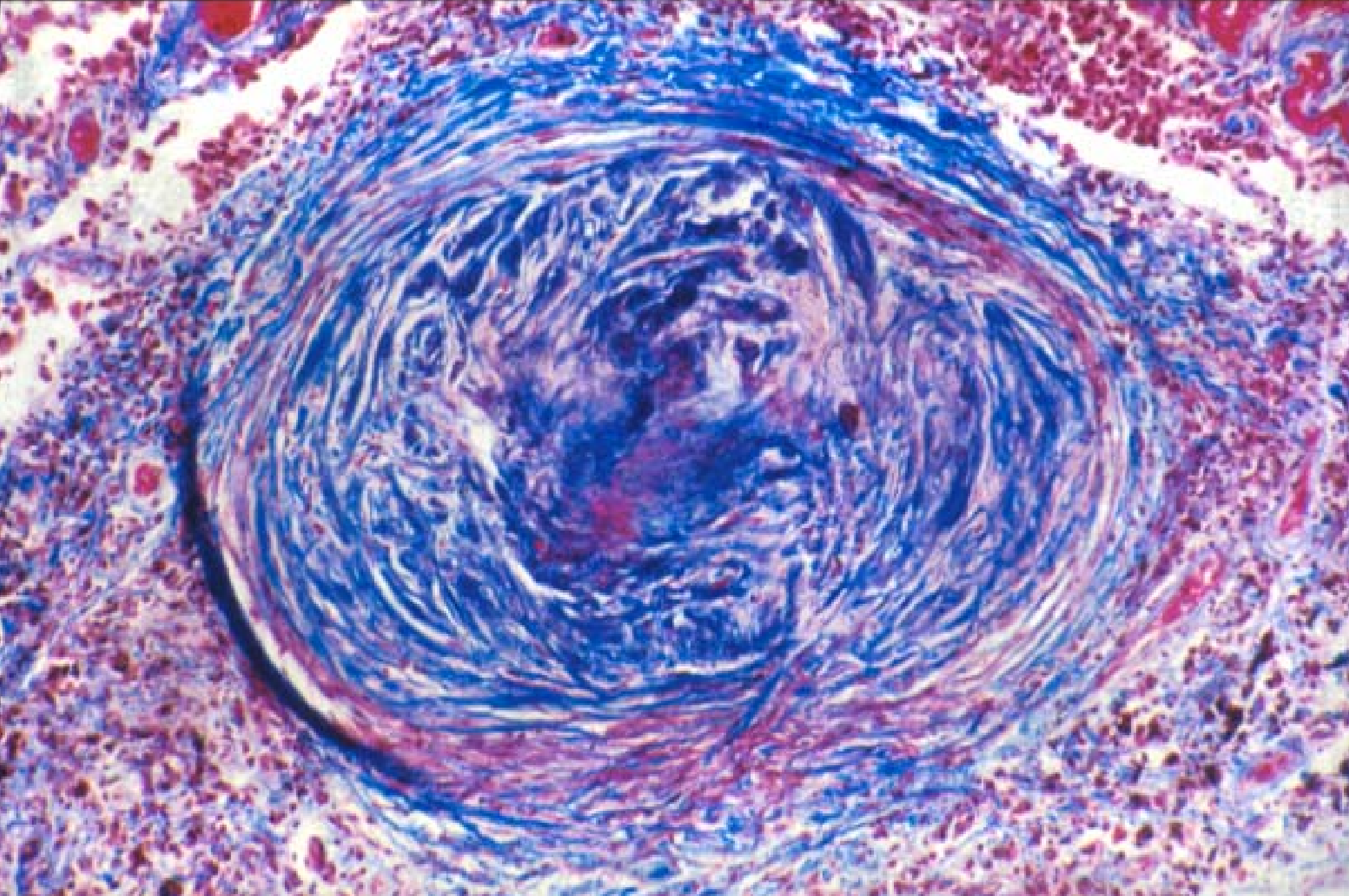
Current Intelligence Bulletin Adverse Health Effects from Cristalline Silica Exposures

What Health Effect Are We Trying to Prevent or Recognize ?

- Radiographic Silicosis ?
- Accelerated Loss of Lung Function ?
- Lung Cancer ?
- Other possible effects



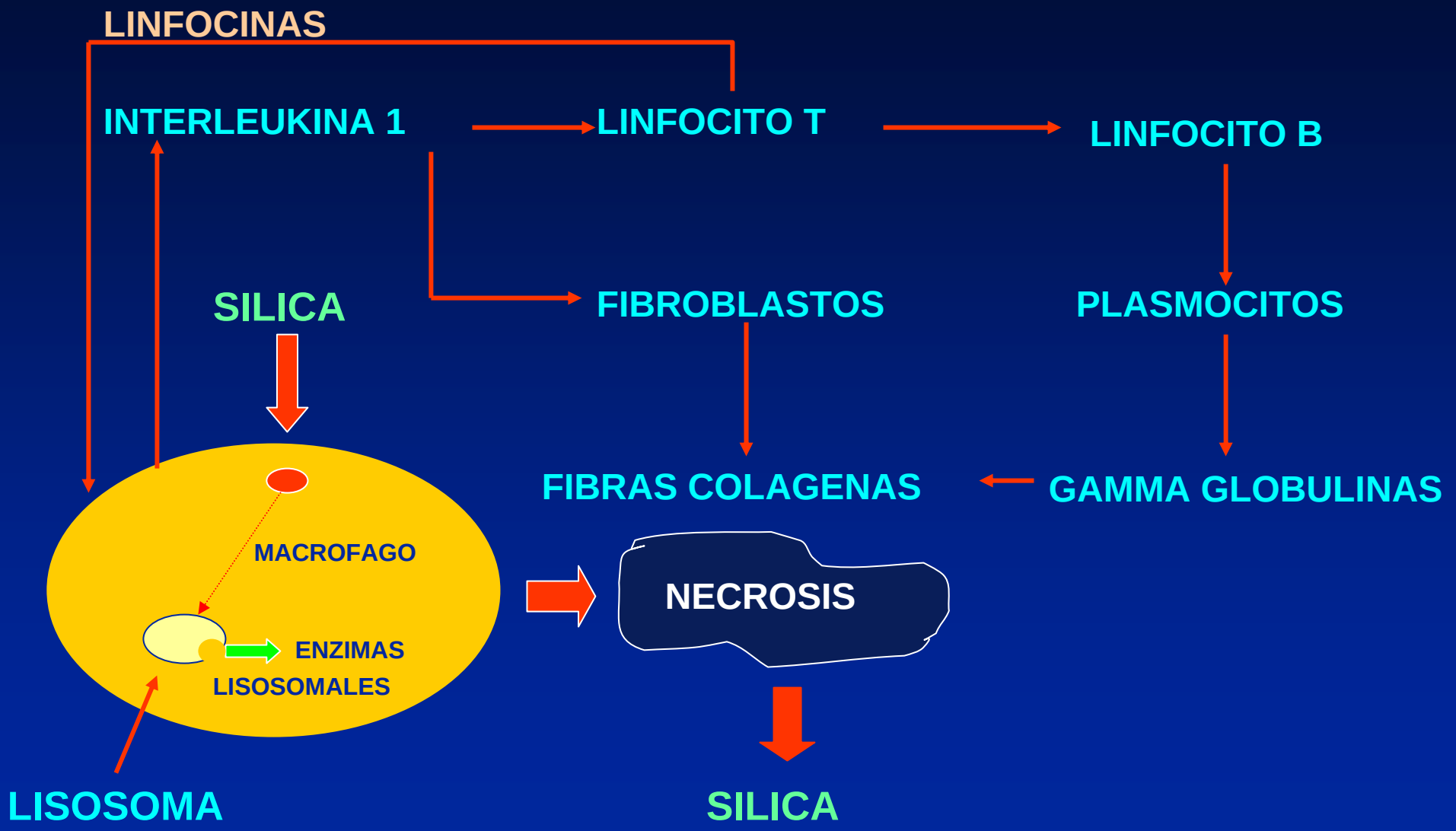
Acute silicosis (silicoproteinosis)
(Courtesy Dr. Jack Parker).



Silicosis Pathogenesis

- Inhalation of respirable silica containing dusts
- Imbalance of dust retention and dust clearance
- Toxicity of dust – old versus freshly fractured
- Macrophage and tissue injury
- Acute and chronic repair responses

LUNG INJURY FROM SILICA ESPOSIZION



Silicosis is Still With Us

- ***Silicosis prevalence*** is hard to precisely measure for many reasons - numerous occupations, transient workers, variable disease detection methods --death certificate, compensation, screening
- Delay between exposure and development of disease - Latency of many years
- ***However*** the disease is still with us

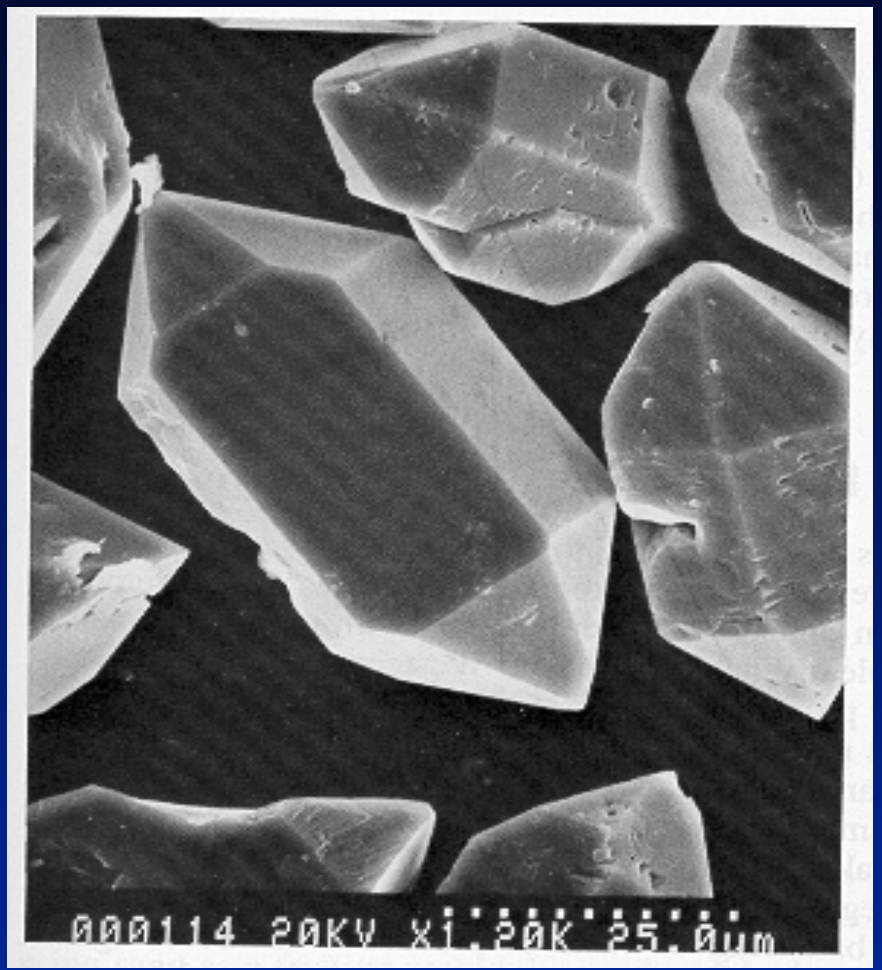
Affected sandblaster. Note cavity left upper zone. (Courtesy Dr. Jack Parker).

Dust Characteristics Affecting Biological Activity

- Particle Size: Median diameters of silica particles retained in human lung range from 0.5 to 0.7 uM, so < 1 uM believed most toxic.
- Free Crystalline Silica Content: In mixed dusts, the nature of the mixture is important.
- Freshly Crushed vs. “Aged”: Silica particles react with water to form cytotoxic hydroxyl radicals. Freshly crushed particles are more potent in this regard.

Physical Forms of Silica

- **Silicon Dioxide ("silica"):** Most abundant mineral on earth. Exists in crystalline and amorphous forms.
- **Crystalline Forms:** Based on tetrahedrons with silicon in center and oxygen atoms at corners. Examples: quartz, cristobalite, tridymite. Toxic after inhalation.
- **Amorphous forms:** Noncrystalline, relatively nontoxic. Examples: diatomite (skeletons of prehistoric marine organisms) or vitreous silica. Amorphous silica can be converted to crystalline cristobalite or tridymite by heating.



Quartz crystals extracted from limestone.
SEM photograph; marker indicates 25 □M.

Seaton A. In: ISBN 0-7216-4671-9, 1995.

U.S. Respirable Silica Exposure Limits

- OSHA Permissible Exposure Limit :

  $10\ mg/m^3 \div (\%\ SiO_2 + 2)$

  or 0.1 mg/cubic meter

- NIOSH Recommended Exposure Limit:

  $0.05\ mg/m^3$

Occupations Associated with Exposure to Silica

- Essentially any occupation that disturbs the earth's crust or involves use or processing of silica-containing rock or sand has potential risks.
- Tunneling, quarrying, stone cutting, foundry work, sandblasting, silica flour production, ceramics production.
- Unexpected new settings continue to be reported.

Surface (strip) mining. Note exposure of onlooker.
(Courtesy Dr. Jack Parker).

Sandblasting

Sandblasting. Note cloud of dust created by airborne sand particles. From: DHHS (NIOSH) Pub. No. 92-102.

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Diagnosis of Silicosis

- Three elements play a key role in diagnosis:

  1) A history of exposure sufficient to cause silicosis.

  2) Chest x-ray with opacities consistent with silicosis.

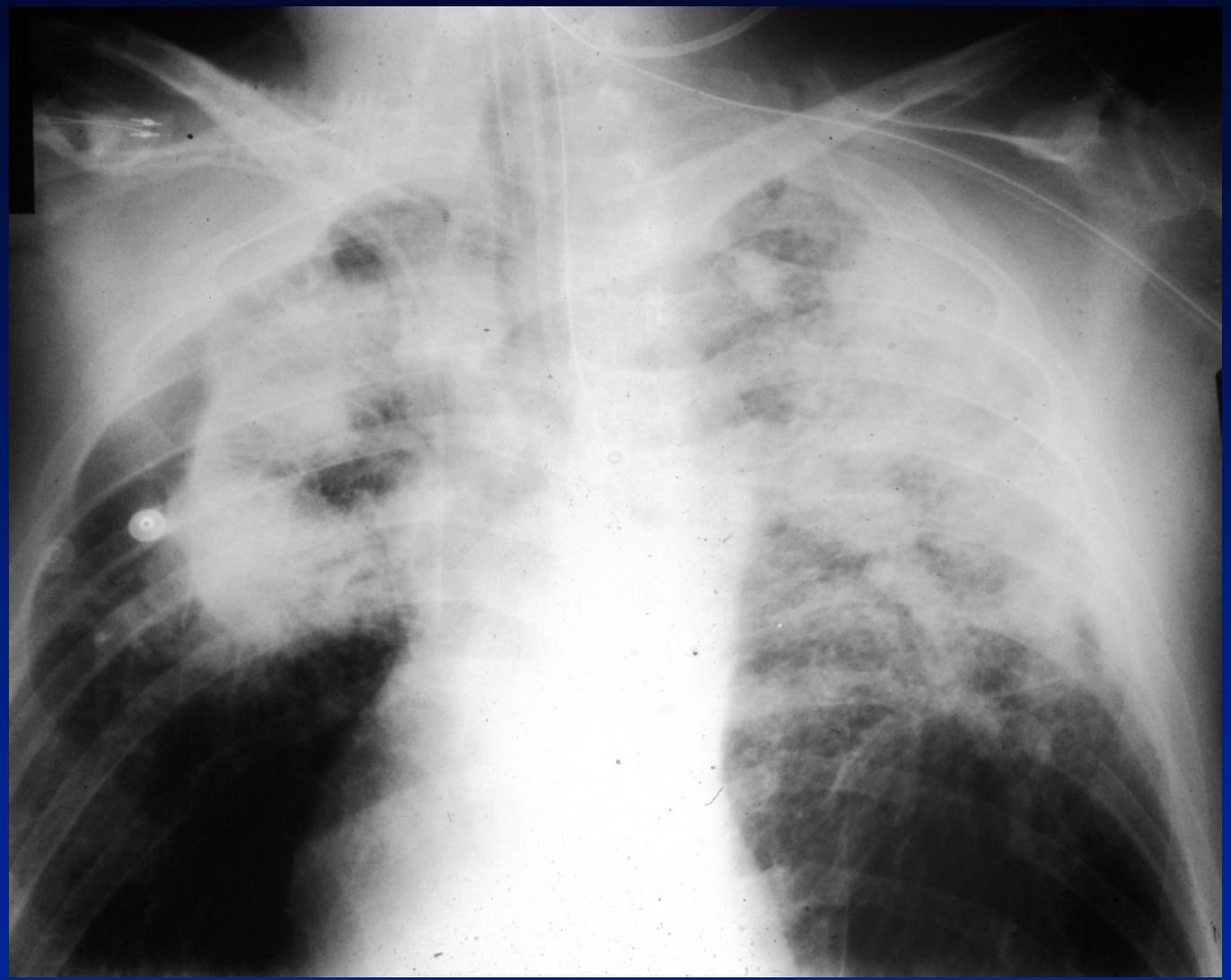
  3) No underlying diseases more likely to be causing the abnormalities (mycobacterial or fungal infection, cancer, sarcoidosis, etc).

Categories of Silicosis

I. **Patterns of Chest X-ray Involvement**
   A. Simple Silicosis
   B. Progressive Massive Fibrosis (PMF)
   C. Acute Silicosis

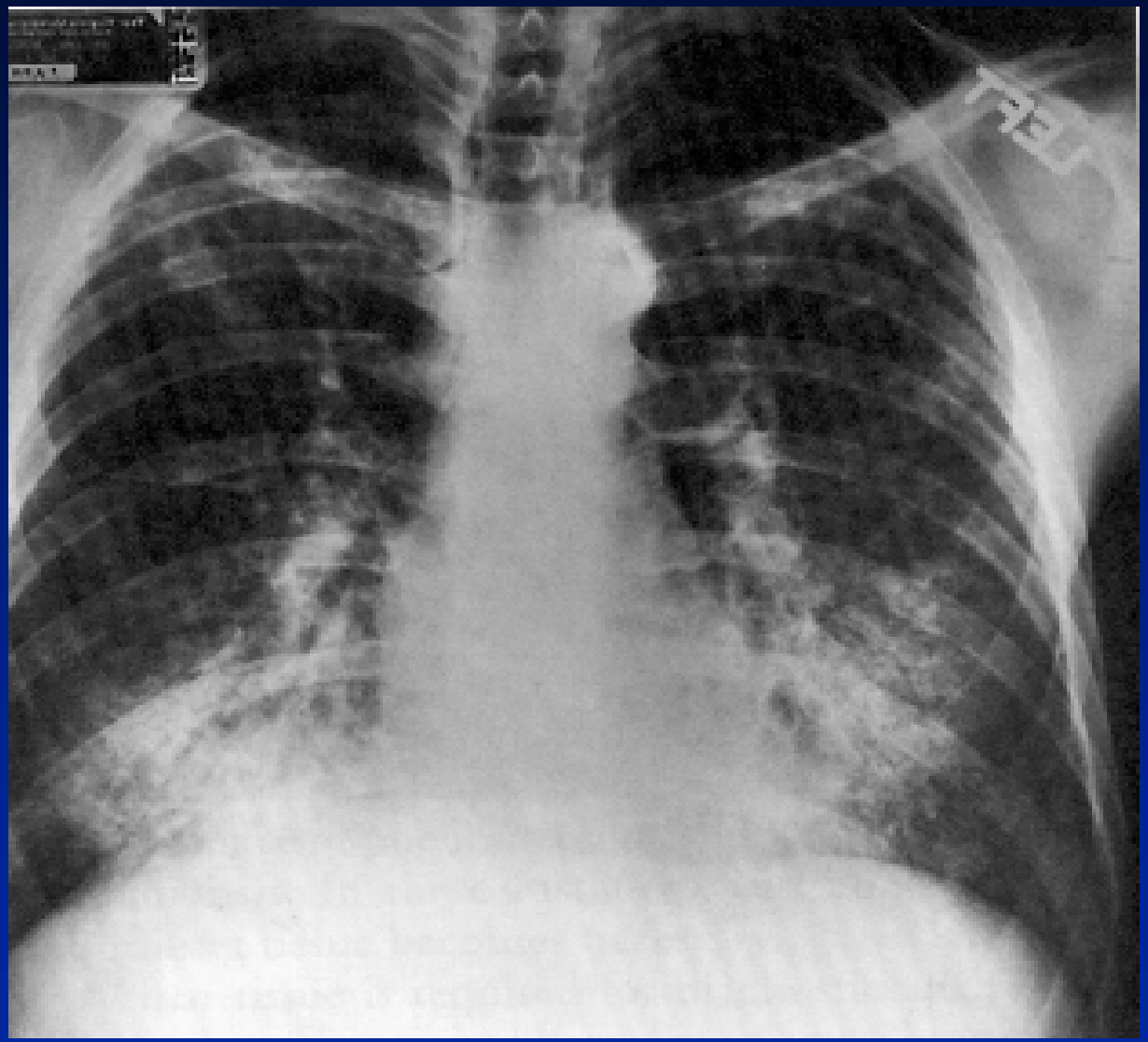
II. **Types of Silicosis**
   A. Chronic Silicosis (typically10 to 30 yrs)
   B. Accelerated Silicosis (less than10 yrs)
   C. Acute Silicosis (typically several yrs)

Simple Silicosis (courtesy Dr. J. E. Parker)



End-stage silicosis and respiratory failure
Note endotracheal tube (Courtesy Dr. Jack Parker)

Acute Silicosis in a Surface Miner



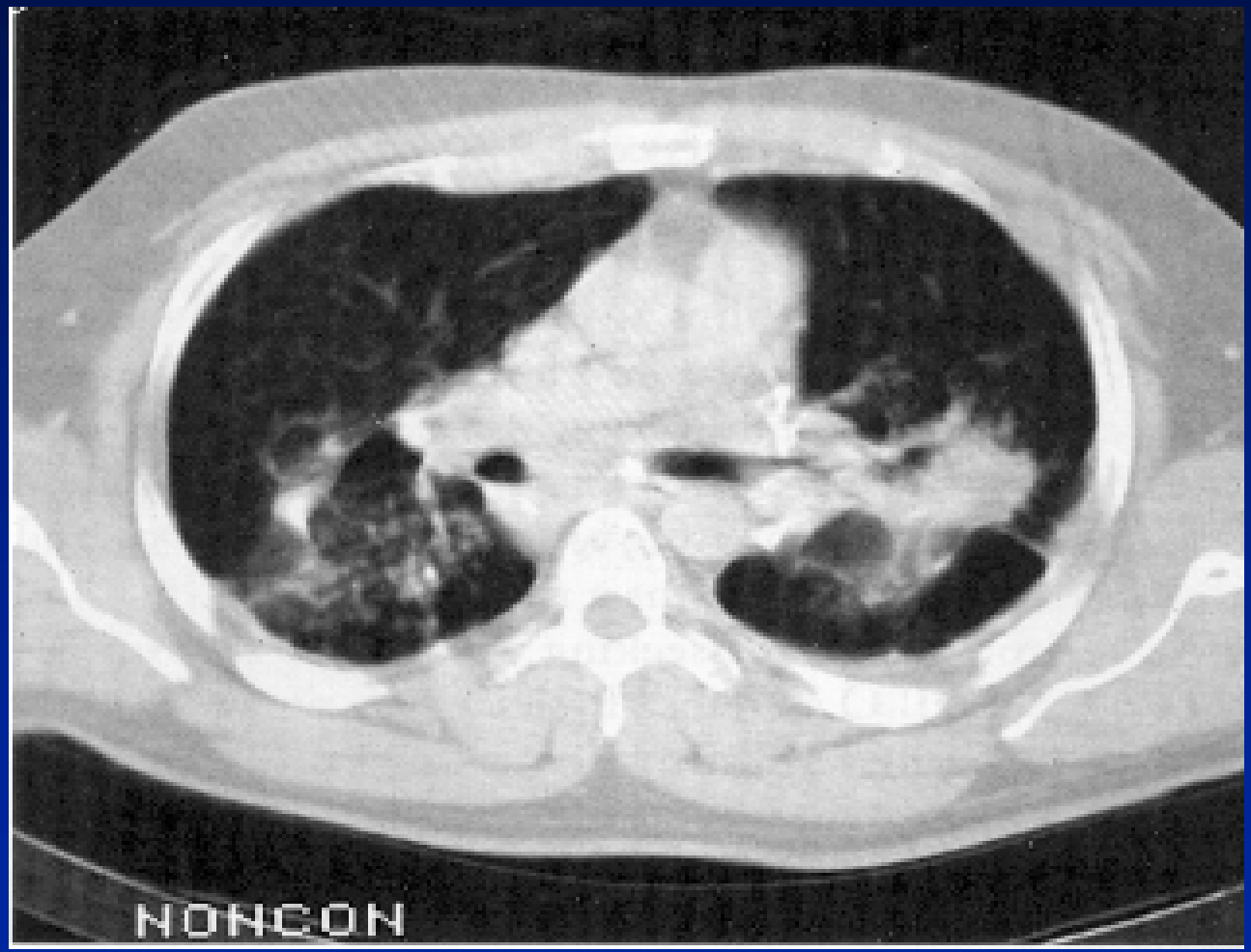
Parker & Banks. In: OLD ISBN 1-55009-060-7, 1998

Complications of Silicosis

- Mycobacterial Infections
- Chronic Bronchitis and Airflow Obstruction
- Immune-Mediated Complications
- Lung Cancer

ATS. Adverse Effects of Crystalline Silica Exposure. Am J Respir Crit Care Med 155:761-768, 1997.

Chest CT of patient with PMF. Conglomerate densities are well-demonstrated by CT. Note subpleural bullous changes.



Parker & Banks. In: OLD ISBN 1-55009-060-7, 1998

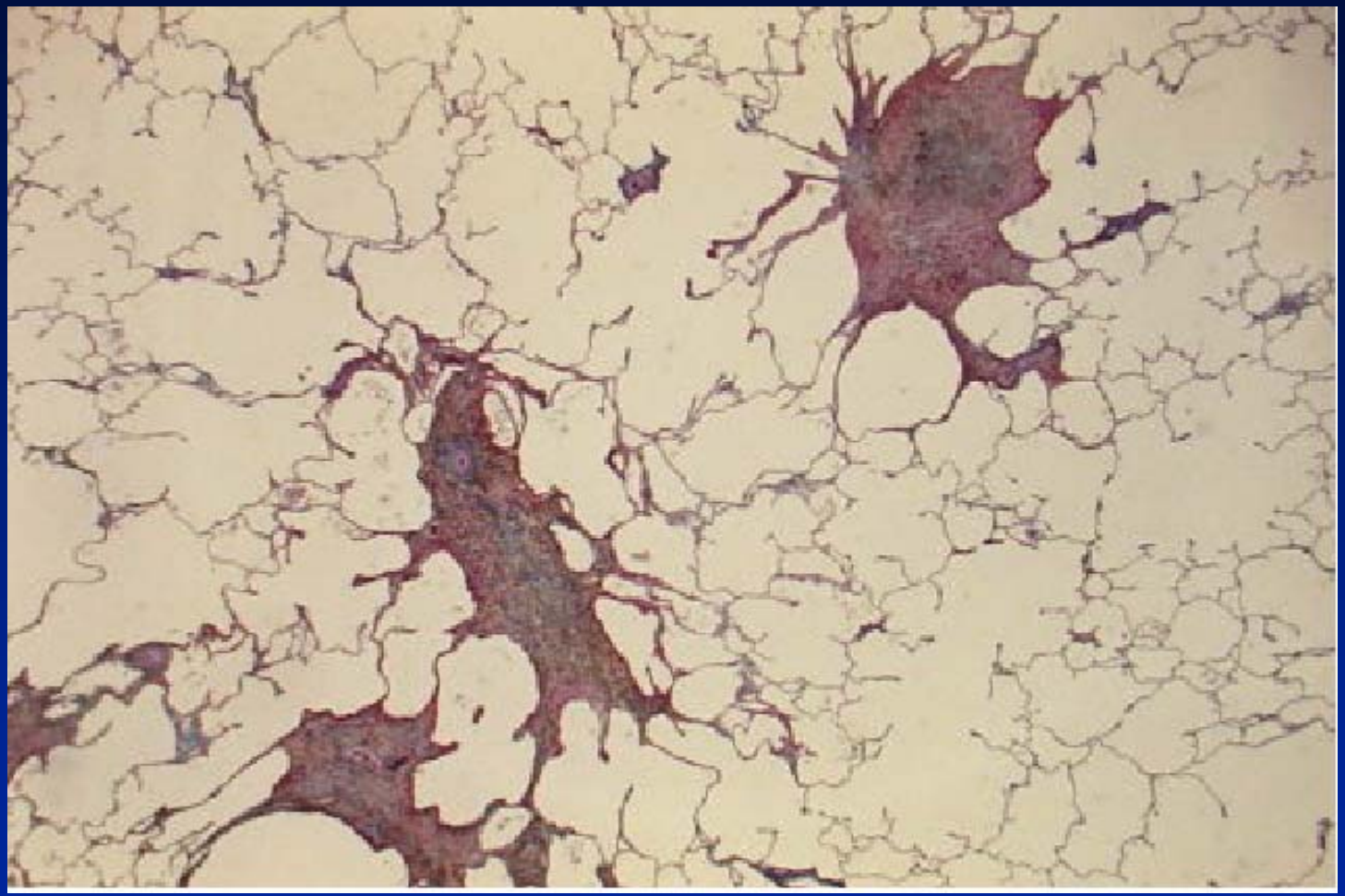
Silicosis Can Be Prevented?

- …silicosis is becoming a negligible factor, …in the future it will largely be stamped out (V. Wrabitz, 1939).

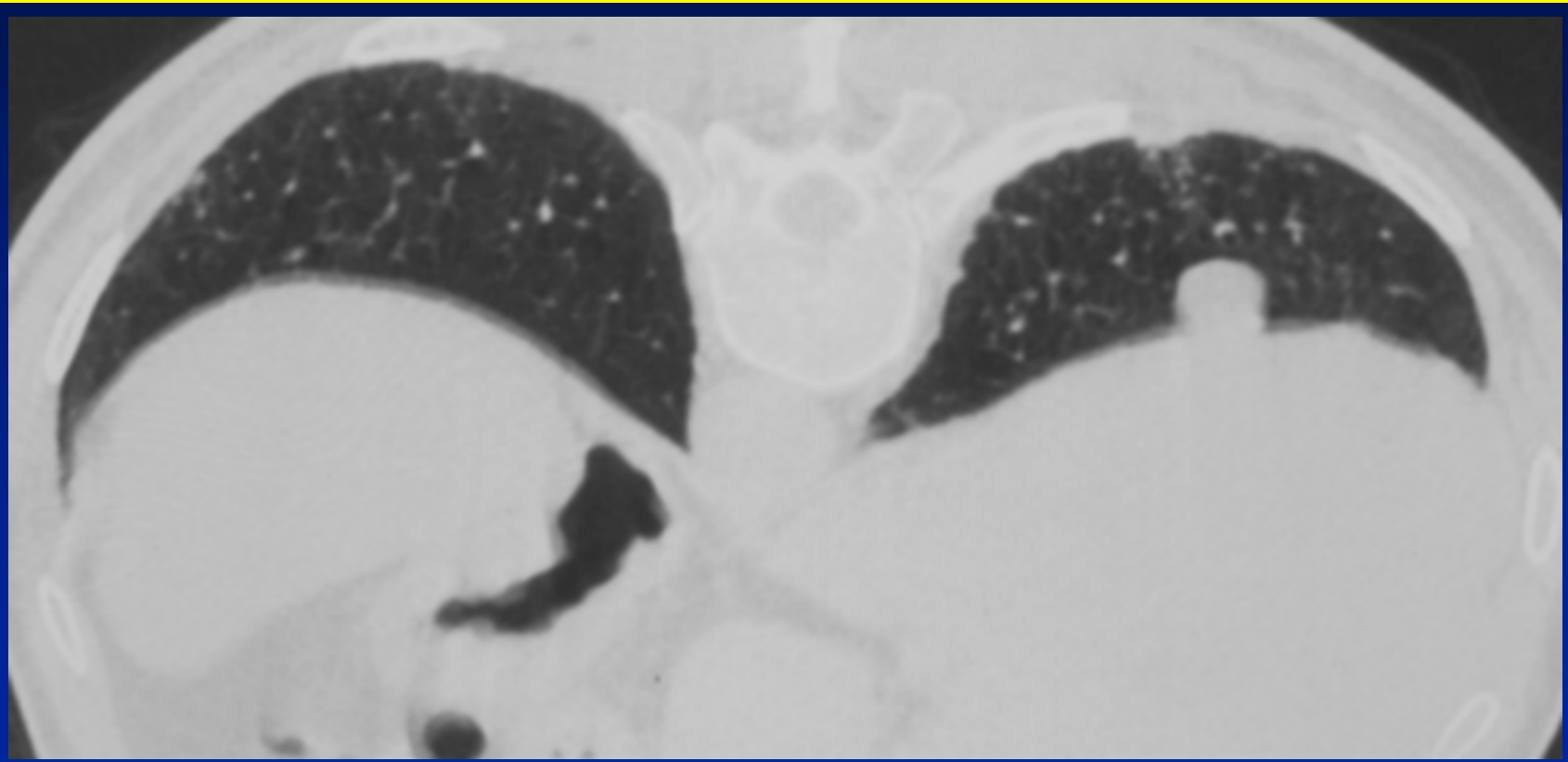
- (The) current opinion (is) that most of the cases of silicosis represent a residue of old cases (V.M. Trasko, 1956).

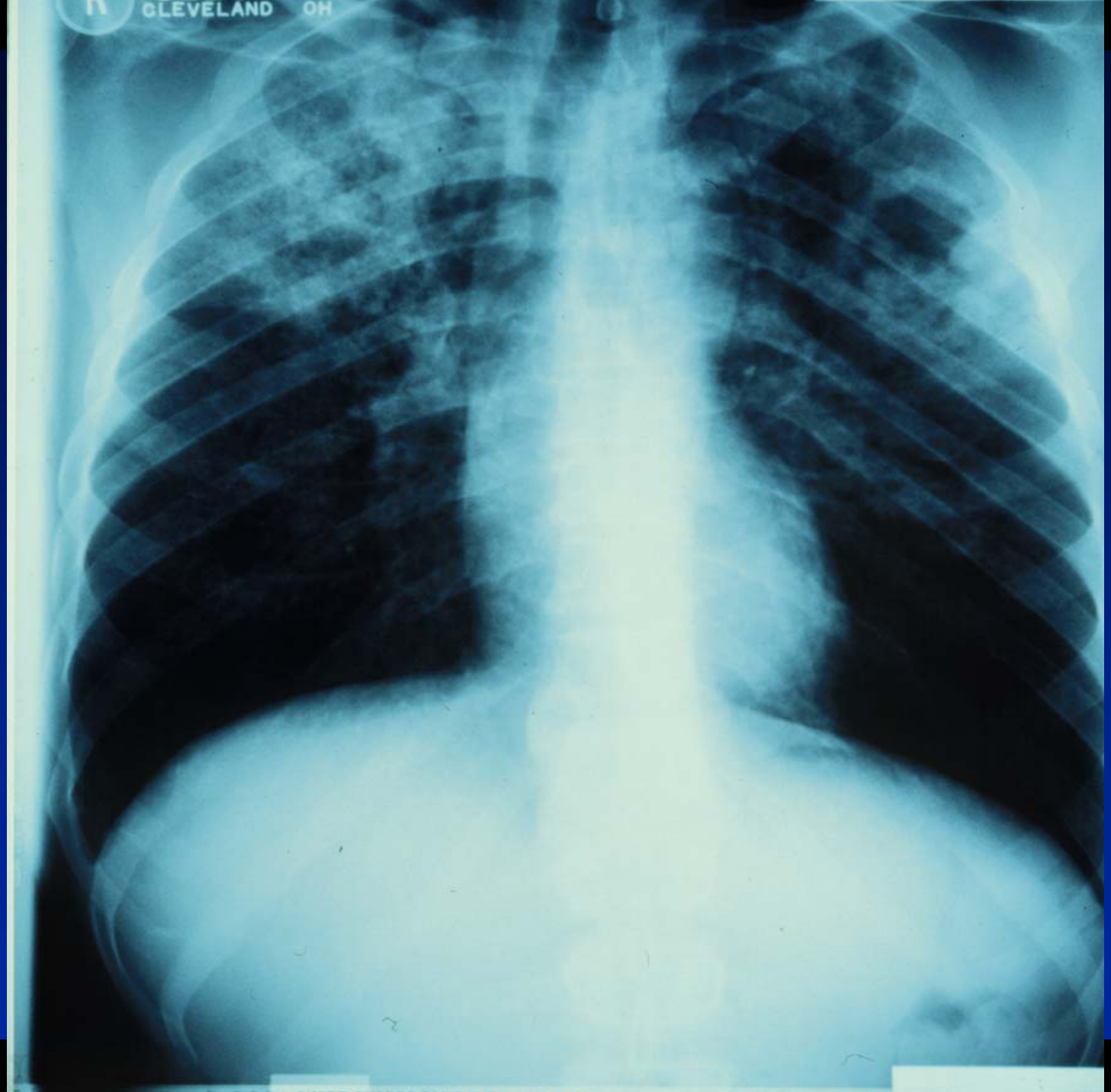
Is Silicosis Preventable? A Comprehensive Prevention Program Might Attempt To:

- Educate workers and employers about hazards of silica exposures
- Monitor airborne silica levels and respond as appropriate to minimize exposures
- Institute medical monitoring programs
- Consider TB and HIV prevention and treatment activities
- When disease is present and is recognized, evaluate where preventive efforts failed



Parker
CT-HRCT Classification of Occupational and Environmental Respiratory Disease: CANCER

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CLEVELAND OH

What Health Effect Are We Trying to Prevent or Recognize ?

- Radiographic Silicosis ?
- Accelerated Loss of Lung Function ?
- Lung Cancer ?
- Other diseases??

Chest Radiography in Dust Exposed Workers

- Chest radiography has been useful tool in screening and surveillance of dust exposed workers
- Chest radiograph has been helpful in exposure response relationships
- Although a helpful tool, improvement is possible
- Documents failures of dust control

Limitations of Radiographic Imaging

- Imperfect tool, not diagnostic gold standard
- Airway disorders not always seen
- Not a useful cancer screening tool
- Functional impairment not well evaluated or assessed
- Cannot provide certainty about the etiology of observed findings due to limited lung response patterns

Recapitulation

- Chest radiographs of good quality, classified using the ILO system, recorded, and reported with consistency and accuracy are the most important tool for health screening and surveillance of workers exposed to silica containing dusts.

Why is silicosis so difficult to prevent?

- Silica is ubiquitous
- It takes only a small chronic exposure to cause disease - football field volume
- Freshly fractured silica is even more toxic than aged silica
- Requires sustained effort in a tough social, economic, political, legal environment

Complications of Silicosis or Silica Exposures

- Mycobacterial Infections
- Chronic Bronchitis and Airflow Obstruction
- Immune-Mediated Complications
- Lung Cancer

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Conclusion

- Health Screening and Surveillance can be effective tools for prevention
  - HOWEVER
- Neither screening nor surveillance alone prevent disease
- Only control of the dust exposures prevent disease

Silica- Related Lung Disease Recognition and Prevention

Is Clearly A Complex and Challenging Problem