Worker Exposure to Silica Dust in the Non-mining sectors: Literature Review

Norman Khoza
Tanya Grové
Tebogo Moraba
Schu Schutte

27 August 2009

our future through science

Content of the presentation

- Project/Study overview
- Aim of the literature review
- Silica overview
- Silicosis overview
- Global silicosis elimination programme
- National silicosis elimination programme
- Non-mining industries and exposure: globally
- Non-mining industries and exposure: South Africa
- Silica exposure: Global trends and effects
- Silica exposure: South African trends and effects
- Major silica deposits in South Africa
- Main consumers of silica in South Africa

Phase 1: Identify industries with potential of silica exposure

1	*Literature review on non-mining industries and activities in which silica exposure has been reported*	*07/2009*
2	Identification of types and number of non-mining industries in South Africa where there is a potential risk of exposure to silica dust	09/2009
3	Statistics on the prevalence of silicosis in the non-mining industry in South Africa, including a breakdown by industries.	10/2009
4	Statistics on the incidence of silicosis in the non-mining industry in South Africa, with a breakdown by industries.	10/2009
5	Statistics on the annual number of deaths from silica-related diseases in the non-mining industry in South Africa	10/2009
6	Statistics on the total number of workers eligible for compensation for silicosis (per year) and the number of individuals compensated yearly	10/2009
7	Description of programmes that are in place in industry as an effort to eliminate exposure to silicosis	11/2009
8	Phase 1 final project report	12/2009

Phase 2: Assess personal exposure to silica dust in selected non-mining industries

9	Conduct dust sampling at selected sites in non-mining industries where there is a potential risk of exposure to silica dust.	To be determined after completion of Phase 1.
10	Develop auditing tool for the DOL inspectors to be used for auditing industries for compliance with requirements.	To be determined after completion of Phase 1.
11	Compile Phase 2 final project report.	

Aim of the literature review

To present the major literature review findings on occupational silica dust exposure of workers in the non-mining industries/sectors in South Africa

Silica overview

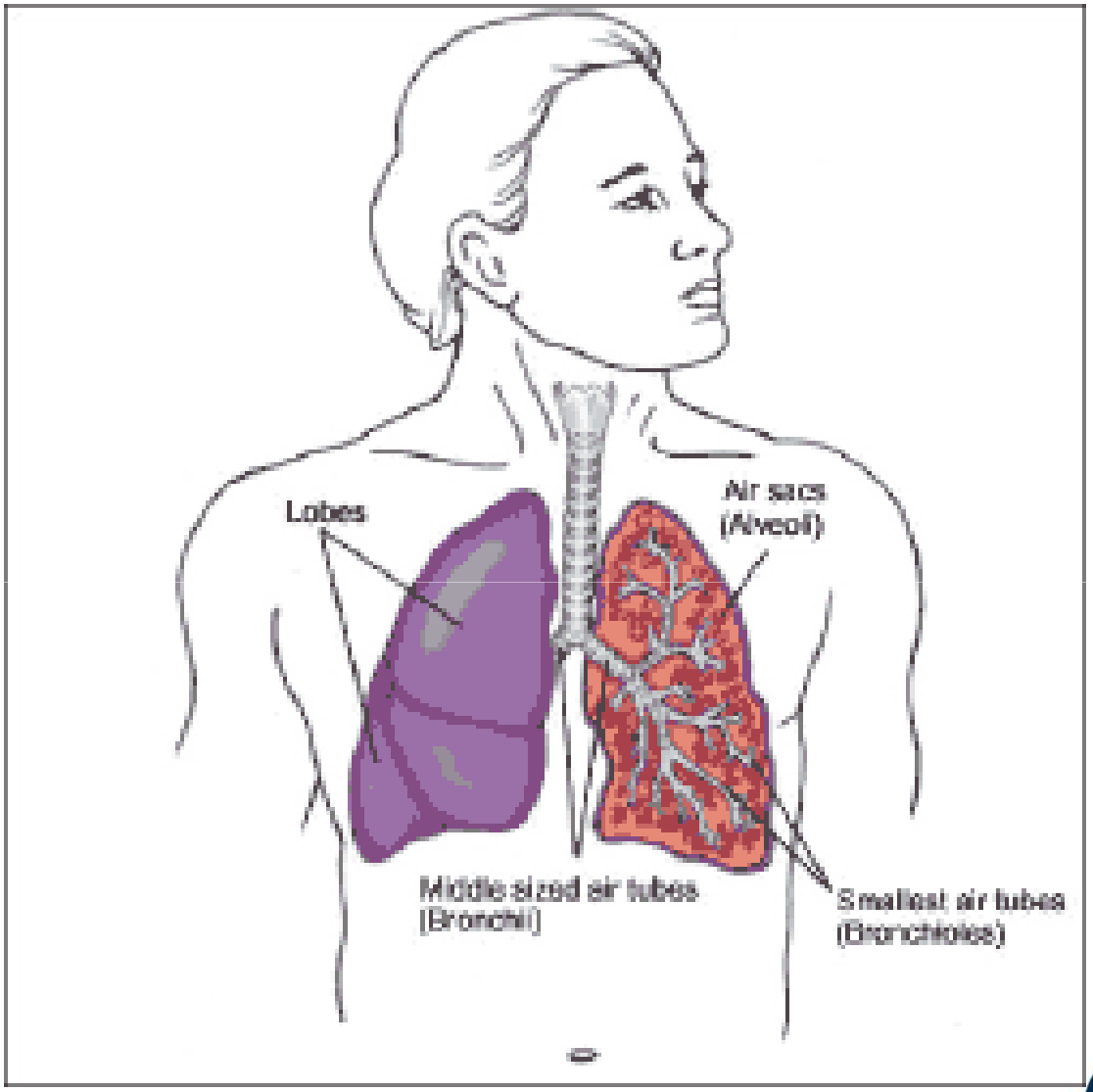
- Crystalline silica has the potential and toxicity to induce pulmonary fibrosis when inhaled
- Factors:
  - Biological activity of type
  - Particle size
  - Freshly cut or ‘aged’

Silica overview

- Silica (SiO_2)
  - Major natural component of sand, quartz, granite and mineral ores
  - Compound (silicon and oxygen)
  - (SiO_2): 75% of earth's crust

Silica overview

- Crystalline and cryptocrystalline forms
- Particle sizes:
  - Inhalable (<50 microns, >10 microns)
  - Respirable (<10 microns)



Silica overview

- Most common forms of crystalline silica (industry and naturally occurring)
  - **Quartz** (mining, blasting & construction)
  - **Tridymite** (ceramic and refractory)
  - **Cristobalite** (ceramic, refractory and diatomaceous industries)

Silica overview

- Diseases associated with silica exposure
  - Silicosis
  - Pneumoconiosis
  - Silico-tuberculosis
  - Pulmonary TB
  - Cancer (lung)
  - Interstitial fibrosis
  - Industrial bronchitis
  - Small airway diseases
  - Emphysema
  - Rheumatoid complications
  - Vascular diseases
  - Glomerulonephritis
  - Immunologic reactions

Silicosis overview

- Serious type of pneumoconiosis
- Inhalation of dust containing free crystalline silica
- Incurable & irreversible, but PREVENTABLE
- Occur 10-20 years after exposure to silica dust has stopped
- Occupational and public health problem
- Disease: Fibrotic pneumoconiosis
- Lung disease: Silicosis

Silicosis overview

- The extend of the disease depends on:
  - Concentration and nature of the dust
  - Duration of exposure
  - Individual susceptibility

Silicosis overview

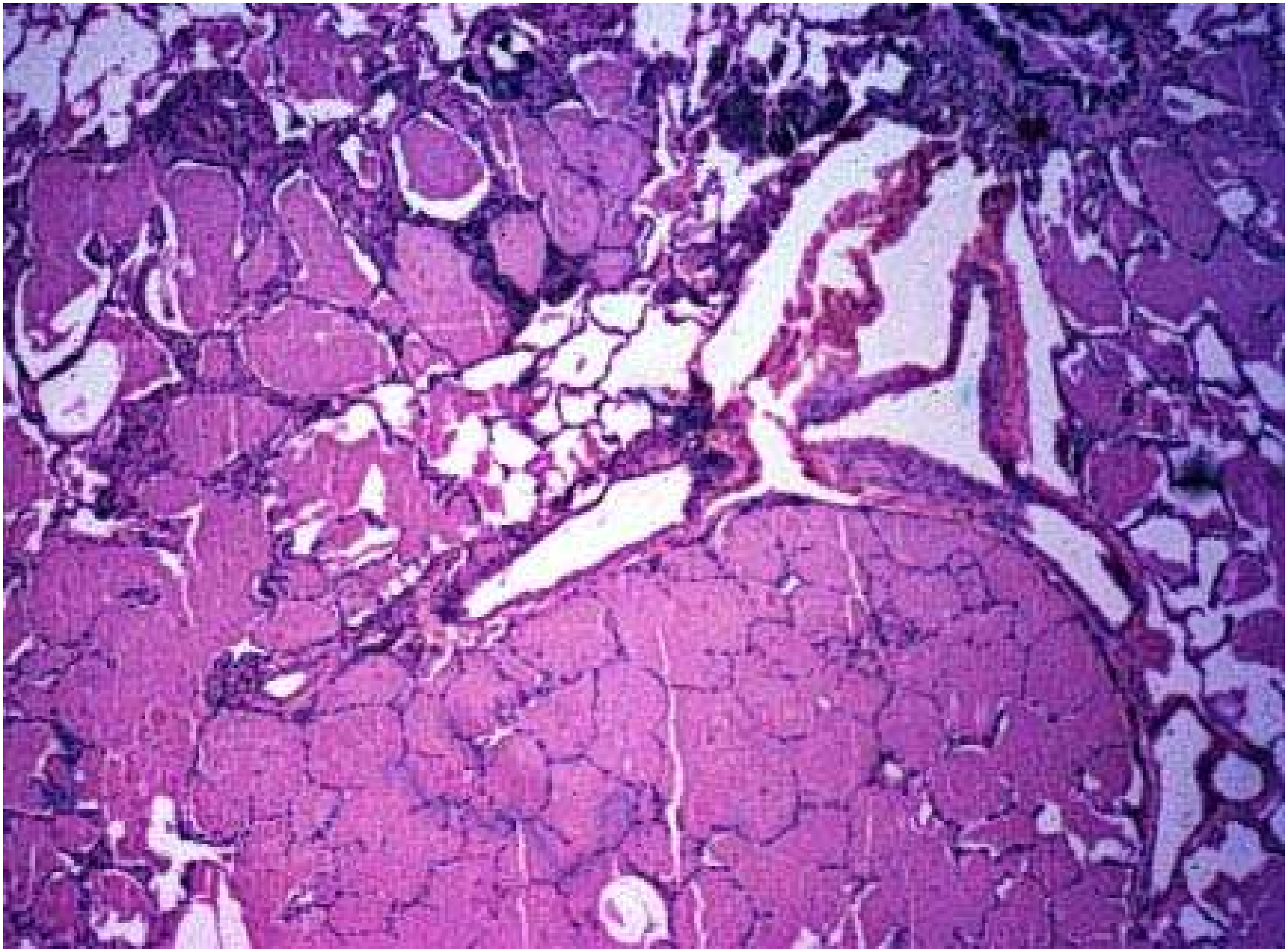
- High exposure: Very short latency period and rapid disease progression
- Clinical features: Increased susceptibility for tuberculosis (TB)
- Association with TB and HIV/AIDS: Major Occupational and Public Health concern in South Africa

Silicosis overview

- Three types of silicosis
  - Acute
  - Accelerated
  - Chronic
    - Simple
    - Complicated

Silicosis overview

- Acute Silicosis (Silicoproteinosis)
  - Intra-alveolar deposits
  - Exceptionally high concentrations of crystalline silica
  - Reactions: Weeks to two to five years after initial exposure

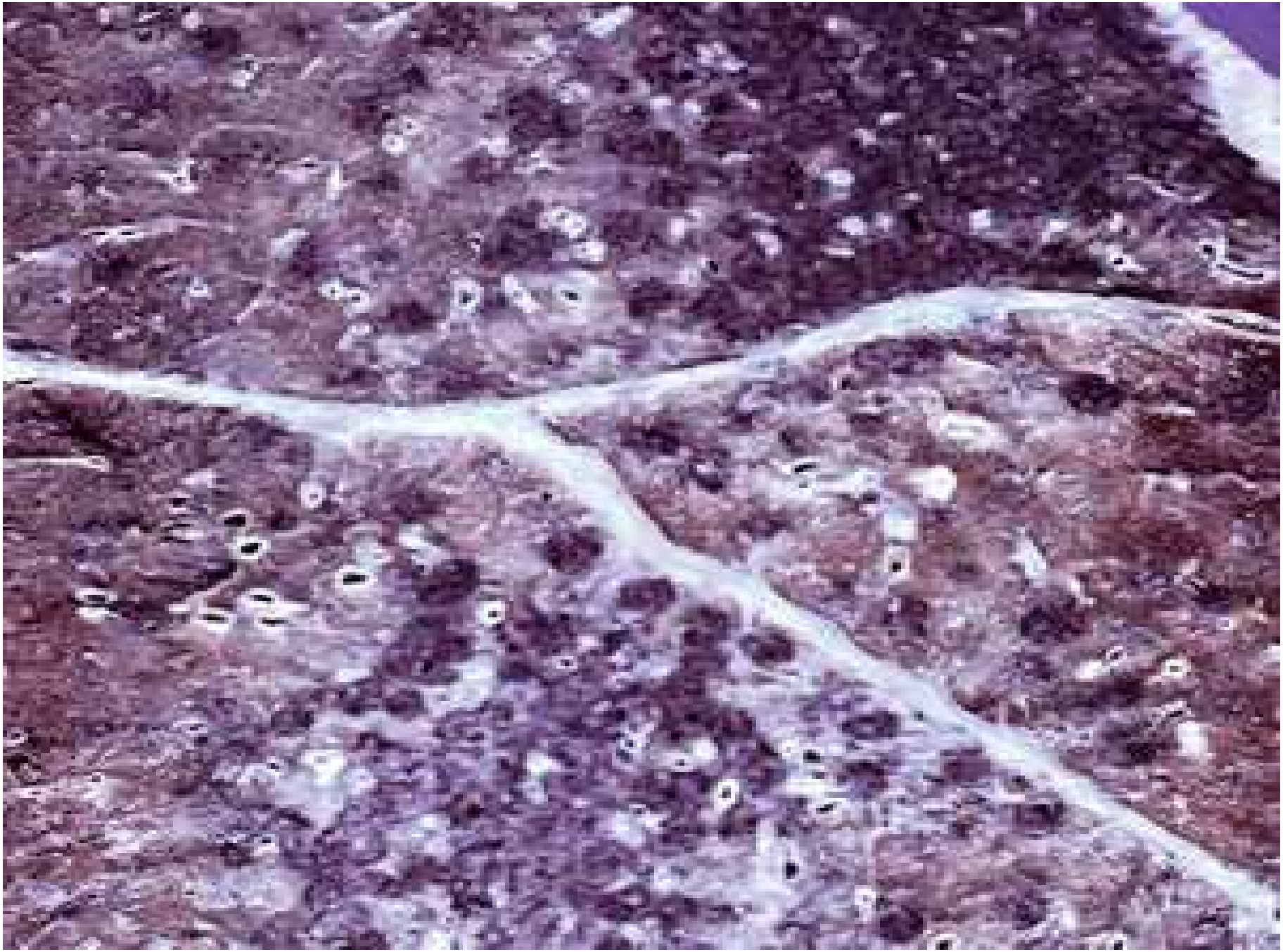


Silicosis overview

- Accelerated Silicosis
  - Rounded nodular lesions
  - Very high concentration of silica dust over short period
  - Progression faster than other types

Silicosis overview

- Chronic Silicosis
  - Most common form
  - Low and frequent exposures to dusts with 18-30% crystalline silica
  - Accumulation of silica dust
  - Structural changes in lungs, usually in upper lobes
  - Occurs after 10-30 years of exposure
  - Simple (nodules 1cm or less) and complicated (nodules exceed 1cm)



Silicosis overview

Acute	Accelerated	Chronic
➢ Sandblasting	➢ Silica flour milling	➢ Sandblasting
➢ Rock surface drillers	➢ Blasting	➢ Stone dressing
➢ Silica flour milling		➢ Refractory
➢ Ceramic making		➢ Foundry
➢ Grinding		

Silicosis Elimination: A Global Action

- Joint ILO/WHO Committee on Occupational Health proposed a joint Programme on Global Elimination of Silicosis in 1995

Silicosis Elimination: A Global Action

- **Immediate Objective**:

  Promote the development of a National Programme on Elimination of Silicosis in countries to significantly and globally reduce the incidence rates of silicosis by 2015

- **Development Objective**:

  To establish international cooperation on global elimination of silicosis in order to eliminate it as an occupational health problem by 2030

Silicosis Elimination in South Africa

- Two activities:
  - **The National Programme for the Elimination of Silicosis by the DOL, initiated in 2004**
  - Regional Work and Health in Southern Africa initiative (Sida-sponsored) 2004

Silicosis Elimination in South Africa

- The National Programme for the Elimination of Silicosis (NPES)
  - Outlines government commitment to reduce the prevalence of silicosis by 2015
  - Totally eliminate silicosis in workplaces by 2030

Silicosis Elimination in South Africa

- As part of the NPES a National Working Group (NWG) has been established to:
  - Develop and manage the programme
  - Monitor the implementation of the programme
  - Develop criteria to evaluate the success of the programme
  - Review the programme
  - Update the programme
- Will also establish Provincial Working Groups (PWG): Three already formed for KZN, EC and WC

Silicosis Elimination in South Africa

- Two activities:
  - The National Programme for the Elimination of Silicosis by the DOL, initiated in 2004
  - **Regional Work and Health in Southern Africa initiative (Sida-sponsored) 2004**

Silicosis Elimination in South Africa

- Regional Work and Health Southern Africa (WAHSA)
  - Major objectives are:
    - Reduction of dust exposure in key industries
    - Improved prevention of tuberculosis in silica exposed workers (Rees, 2005)

Non-mining industries and silica exposure: Globally

- Building, highway, bridge construction
- Sand blasting
- Masonry work
- Concrete finishing
- Drywall finishing
- Rock drilling
- Sand and gravel screening
- Rock crushing
- Ceramics, including pottery, sanitary ware and tiles
- Foundries
- Stone working or –cutting
- Glassmaking

Non-mining industries and silica exposure: Globally

- Jewellery manufacturing, especially in the agate industry
- Agriculture
- Ship building
- Railways
- Paint abrasive and chemical manufacturing

Non-mining Industries and silica exposure: South Africa

- Construction: tunnelling, rock drilling
- Power tool grinding of surfaces that contain silica
- Sandblasting
- Foundries
- Ceramic, brick, clay and pottery
- Jewellery manufacturing
- Glass manufacturing
- Agricultural sector
- Railways
- Manufacturing of soaps and detergents
- Stone or granite cutting

Silica exposure: Global trends and effects

- U.S.A.: From 1985-90 & 1990-99 silicosis caused 11% & 13%, workplace deaths in construction, respectively (Alazab, 2004; NIOSH, 2003)
- U.S.A.: Exposure level to silica is sometimes 10-50 times OSHA PEL (Park *et al.,* 2002)
- Japan: 41% of foundry workers' exposure level exceeded OSHA PEL (Koo *et al.,* 2000)
- Total number of potentially silica exposed workers in non-mining are more than twice the amount of mining industry (de la Hoz *et al.,* 2004)

Silica exposure: South African trends and effects

- Foundries
  - Estimated 21 652 exposed workers in SA (Excluding admin staff) (Rees & Weiner, 1994)
  - 83% of reported cases of silicosis were from non-mining industries, including ferrous foundries (50%), refractories (11%), ceramic factories (13%) and stone and ore crushing (9%) (Ehrlich *et al.,* 1988)
  - 10. % of workers had pneumoconiosis and prevalence increased with years of service (Meyer *et al.,* 1987)

Silica exposure: South African trends and effects

- Construction
  - About 543 686 employed (Stats SA, 2007)
  - Western Cape: 94% of workers reported exposure to dust in their working history (Deacon *et al.*, 2005)

Silica exposure: South African trends and effects

- Agriculture
  - About 614 962 permanent and seasonal employees (Stats SA, 2006)
  - Three RSA farms studied - Typical sandy soil and sandy loam soil farms in the Freestate (2) and North West Provinces (1)
  - TWA results of respirable crystalline silica (RCS) were:
    - 13% > DOL OEL
    - 22% > NIOSH REL
    - 46% > ACGIH TLV-TWA (Swanepoel *et al.*, 2009)

Silica exposure: South African trends and effects

- Ceramics and Pottery
  - Highest exposure to crystalline silica in the dust: 6.6 mg/m^3
  - Higher than reported in England (Rees *et al.*, 1992)

- Sandstone
  - Occupational Hygiene report of three sandstone companies in RSA revealed that exposure to RCS was 5-48 times the DOL OEL

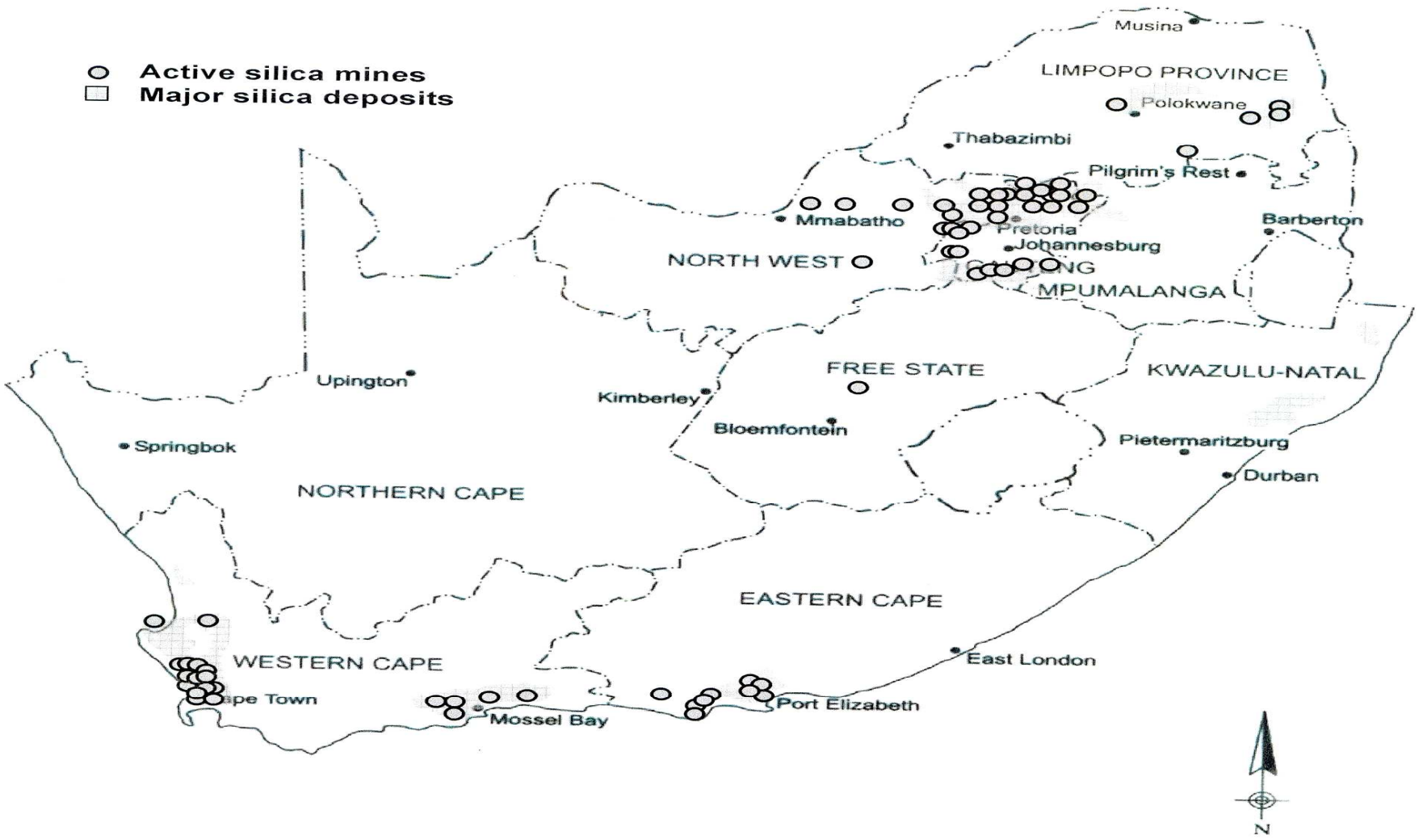
Major silica deposits in South Africa

- RSA clay deposits have high quartz concentration
- Quartz percentage of 30%-60% can be found in Grahamstown (Rees, 2005)
- Rocks with large quartz content:
  - Igneous Rock (Granite, Rhyolite & Pregmatite)
  - Metamorphic Rock (Quartz)
  - Pure Deposits (Sand) (DOL, 2007)

Major silica deposits in South Africa

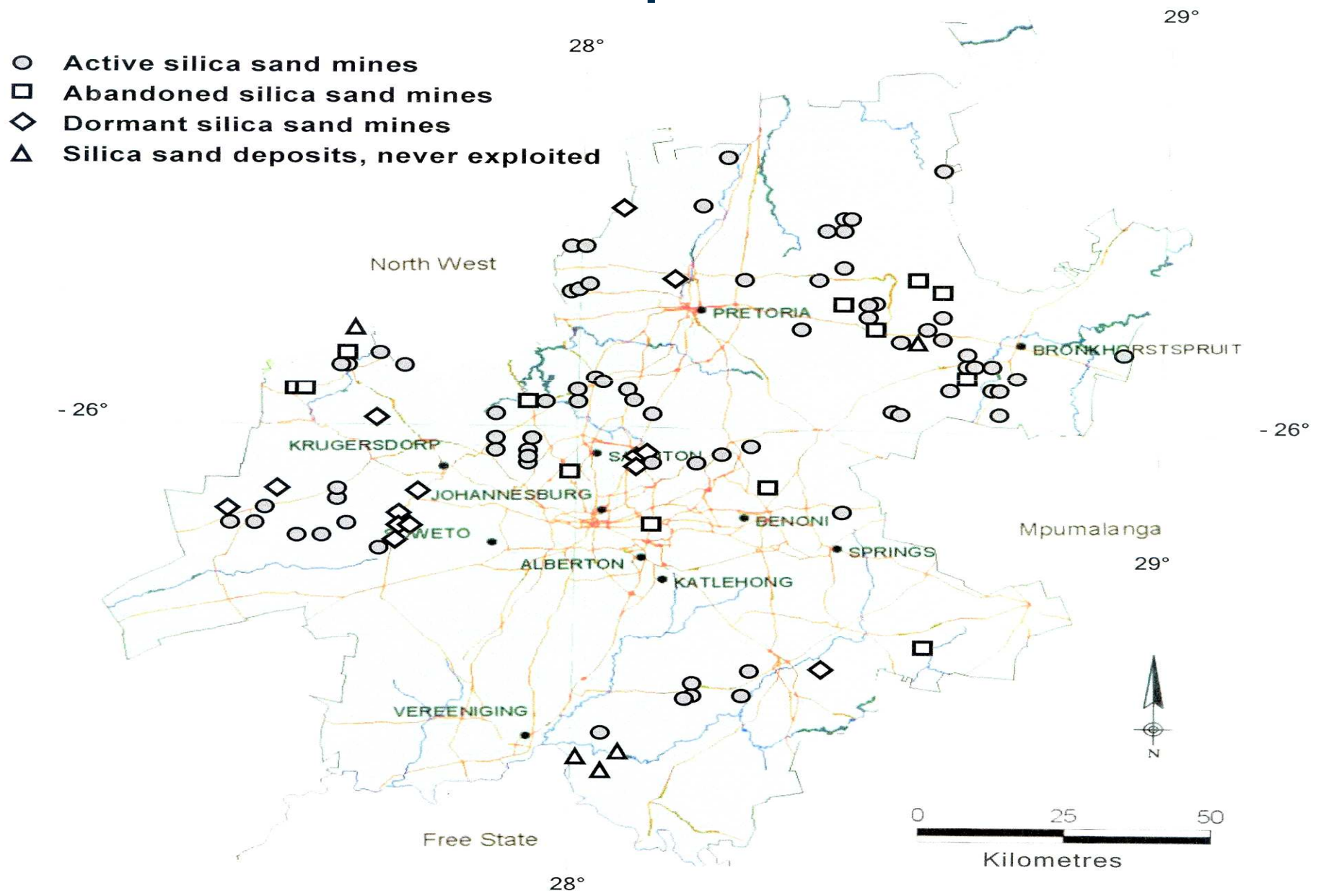
- Silica is mostly mined in:
  - Gauteng
  - Western Cape
  - Mpumalanga
  - Eastern Cape (see Diagram 1 & 2)

Simplified map of South Africa's major silica mines and deposits



Adapted, Council for Geoscience map

Simplified map of Gauteng's silica sand mines and deposits



Consumers of silica in South Africa

- Main consumers:
  - Metallurgical industry (54%)
    - Foundry sands and steel manufacture (30%)
    - Silicon and ferrosilicon production (12%)
    - Non-ferrous fluxing applications (9%)
    - Refractories (3%)
  - Glass (20%)
  - Construction (19%)

Consumers of silica in South Africa

- Two smaller users of silica:
  - Applications for filter media (4%)
  - Recreational sands (3%)

References

- DEPARTMENT OF LABOUR (DOL): Republic of South Africa. 2007. Silica exposure and its effects on the physiology of workers. [Web:]
- DEPARTMENT OF LABOUR (DOL): Republic of South Africa. 2004. Towards a national silicosis elimination programme in South Africa. Working paper 1 of the Inter-departmental Silicosis Working Group. Feb.
- DING, M., CHEN, F., SHI, X., YUCESOY, B., MOSSMAN, B. and VALLYATHAN, V. 2002. Diseases caused by silica: mechanisms of injury and disease development. *International immunopharmacology*, 2:173-182.
- FEDOTOV, I.A. 1997. Global elimination of silicosis: the ILO/WHO international programme. *Asian-Pacific Newsletter on Occupational Health and Safety*, 4(2).
- DE LA HOZ, R.R., ROSENMAN, K., AND BORCZUK, A.2004. Silicosis in dental supply factory workers. *Respi Med* 98; 791 - 794.
- KOO, K.W., CHUNG, C.K., PARK, C.Y., LEE, S., ROH, Y., AND YIM, H.W. 2000. The Effect of Silica Dust on Ventilation Function of Foundry Workers. *J occup health 2000; 42; 251 – 157.*

References

- FINKELSTEIN, M.M. 2000. Silica, silicosis and lung cancer: a risk assessment. *American Journal of Industrial medicine*, 38:8-18.
- SWANEPOEL, A., REES, D., RENTON, K. and KROMHOUT, H., 2009. Exposure to respirable crystalline silica in South African farm workers, *Journal of Physics: Conference Series,* 2009, Institute of Physics Publishing pp012005.
- PARK, R., RICE, F., STAYNER, L,. SMITH, R., GILBBERT, S., AND CHECKOWAY, H. 2002. Exposure to Crystalline Silica, Silicosis and Lung Diseases other than Cancer in Diatomaceous Earth Industry Workers: A qualitative Risk Assessment. *Occup. Environ. Med.* 2002; 59;36-43.
- KOO, K.W., CHUNG, C.K., PARK, C.Y., LEE, S., ROH, Y., AND YIM, H.W. 2000. The Effect of Silica Dust on Ventilation Function of Foundry Workers. *J occup health 2000; 42; 251 – 157.*
- *DEACON, C., SMALLWOOD, J., and HAUPT, T. 2005. Health and Well-being of older construction workers. International Congress Series 1280(2005); 172 - 177.*

Thank You!

our future through science