

***Exposure to quartz, pulmonary functions  
and biological effects among rock  
drillers***

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# Background

- **Rock drillers operate drilling rigs**
- **The process generates airborne particulate matter containing crystalline silica that can be inhaled**
- **Granite, which is a common rock in Norway, may contain up to 20-40 % quartz.**
- **Silicosis caused by inhalation of crystalline silica containing dust is one of the most important occupational diseases worldwide.**
- **Chronic obstructive pulmonary disease (COPD) has also been associated with exposure to crystalline silica.**



# Aims

- **Assess exposure to crystalline silica and particulate matter**
- **Determine effects of such exposure on pulmonary function**
- **Examine silicosis using high-resolution computed tomography among the highest exposed workers.**
- **Study blood biomarkers to increase biological knowledge of crystalline silica and particulate matter effects**

# Material and methods

- **Cross-sectional design**
- **Participants recruited from three contractors**
- **136 rock drillers were examined, of whom 13 were no longer exposed**
- **48 referents (non-exposed heavy construction workers and administrative staff)**
- **Approved by the South East Norwegian Regional Ethics Committee for Medical Research**
- **Air sampling**
- **Pulmonary function, Spirare SPS330 spirometer**
- **High resolution computer tomography**
- **Biomarkers of**
  - **Inflammation**
  - **Pneumoproteins**
  - **Fibrosis**
- **Proteomics of microvesicles in blood**

# Demographics and exposure data

	<b>Exposed (N=136)</b>	<b>Referents (N=48)</b>
	<b>AM (min-max)</b>	<b>AM (min-max)</b>
<b>Age, years</b>	<b>39.5 (18-72)</b>	<b>37.3 (22-65)</b>
<b>Body mass index, kg m<sup>-2</sup></b>	<b>27.2 (19.8-41.7)</b>	<b>26.2 (21.0-41.4)</b>
<b>Current smokers (%)</b>	<b>19.1</b>	<b>25.0</b>
<b>Former smokers (%)</b>	<b>21.3</b>	<b>14.6</b>
<b>Years exposed</b>	<b>10.7 (1-42)</b>	<b>-</b>
<b>Current respirable exposure to <math>\alpha</math>-quartz (<math>\mu\text{g m}^{-3}</math>)</b>	<b>40 (0-440)</b>	<b>-</b>
<b>Current respirable exposure to PM (<math>\mu\text{g m}^{-3}</math>)</b>	<b>244 (0-1360)</b>	<b>-</b>
<b>Cumulative exposure to <math>\alpha</math>-quartz (years * <math>\mu\text{g m}^{-3}</math>)</b>	<b>69 (10-5890)</b>	<b>-</b>
<b>Cumulative exposure/year (<math>\mu\text{g m}^{-3}</math> * years<sup>-1</sup>)</b>	<b>50 (4-190)</b>	<b>-</b>

# Pulmonary function measures among rock drillers and referents

	Exposed (N=136)	Referents (N=48)
	AM (SD)	AM (SD)
<b>FVC (L)</b>	<b>5.1 (0.9)</b>	<b>5.3 (0.8)</b>
<b>FVC % *</b>	<b>99.4 (12.4)</b>	<b>104.7 (10.3)</b>
<b>FEV<sub>1</sub> (L/s)</b>	<b>4.0 (0.7)</b>	<b>4.3 (0.6)</b>
<b>FEV<sub>1</sub> % *</b>	<b>96.2 (12.0)</b>	<b>103.1 (10.8)</b>
<b>FEV<sub>1</sub>/FVC x 100 *</b>	<b>79.4 (6.2)</b>	<b>81.4 (4.7)</b>
<b>FEF<sub>25</sub> % *</b>	<b>95.8 (20.2)</b>	<b>101.9 (22.9)</b>
<b>FEF<sub>50</sub> % *</b>	<b>89.7 (23.6)</b>	<b>98.8 (22.5)</b>
<b>FEF<sub>75</sub> % *</b>	<b>71.6 (25.1)</b>	<b>82.3 (26.0)</b>
<b>MMEF % *</b>	<b>85.6 (22.3)</b>	<b>93.8 (21.9)</b>

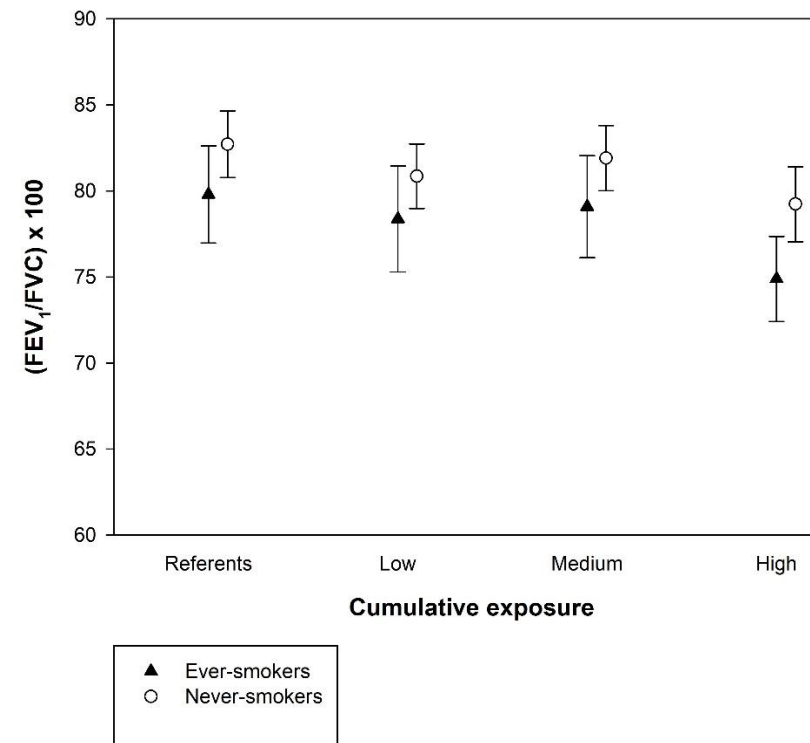
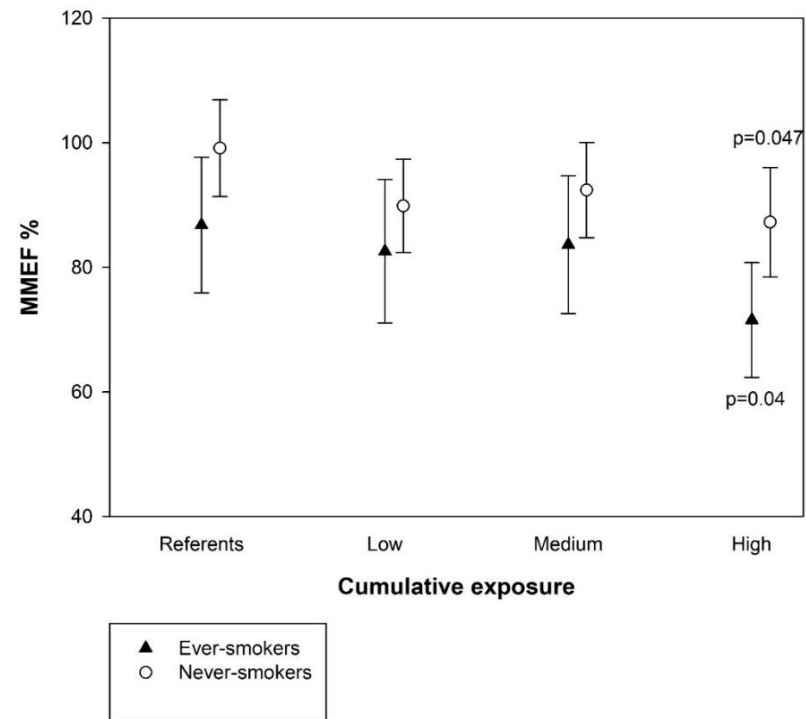
- p<0.05; AM = arithmetic mean; SD = standard deviation
- Forced vital capacity; Forced expiratory volume in one second;
- Forced expiratory flow at 25 % of FVC (and 50 and 75%);
- Maximal mid-expiratory flow (MMEF).

# Results from multiple linear regression analysis

	Panel A				Panel B			
	Including all 136 crystalline silica exposed rock drillers and 48 referents				Including only 136 crystalline silica exposed rock drillers			
	Ever exposed	Ever smoking	BMI	Asthma	Cumulative $\alpha$ -quartz exposure	Ever smoking	BMI	Asthma
	$\beta$	$\beta$	$\beta$	$\beta$	$\beta$	$\beta$	$\beta$	$\beta$
FVC %	-4.6*	—	-0.77***	—	—	—	-0.92***	—
FEV <sub>1</sub> %	-6.5**	—	-0.47*	—	—	—	-0.52*	—
FEV <sub>1</sub> /FVC x 100	-2.0*	-3.5***	—	—	-1.9*	-3.0**	—	-4.4*
FEF <sub>25</sub> %	No model				No model			
FEF <sub>50</sub> %	-8.9*	-11.7**	—	—	—	-10.1*	—	—
FEF <sub>75</sub> %	-10.4*	-15.5***	—	—	-7.8*	-11.7**	—	-18.8*
MMEF %	-8.0*	-12.0***	—	—	-6.1*	-9.4*	—	-16.6*

\*\*\*p<0.001; \*\*p<0.01; \*p<0.05

**Based on regression analysis, the rock drillers with the highest cumulative exposure had significantly lower Tiffeneau index and MMEF%, indicating obstruction of the small airways. Ever-smokers performed poorer than never-smokers. No silicosis was detected when the highly exposed workers were examined with HRCT.**



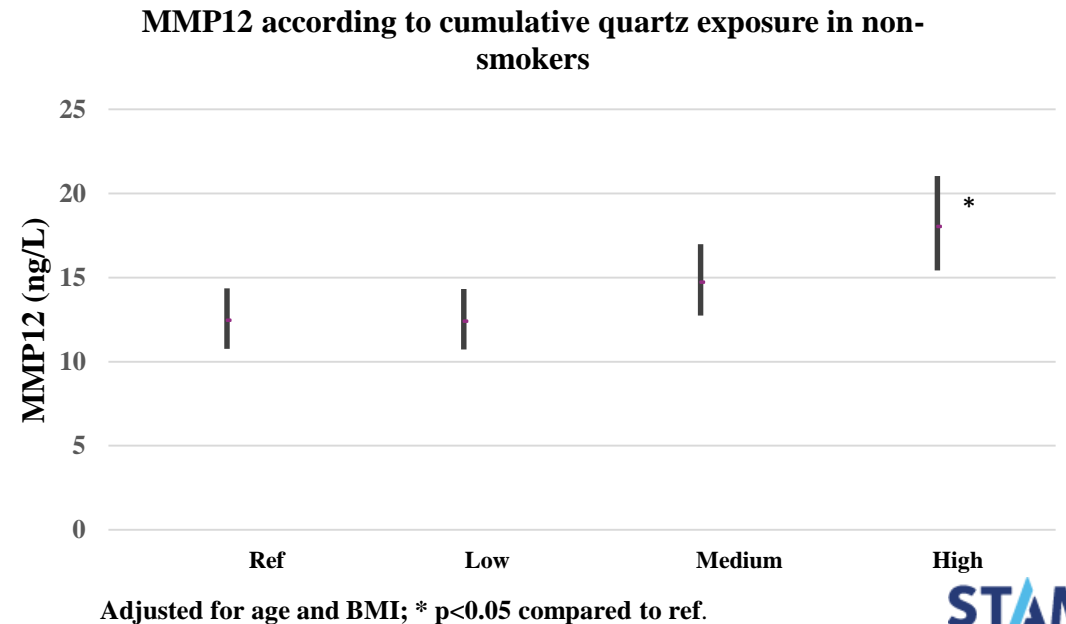
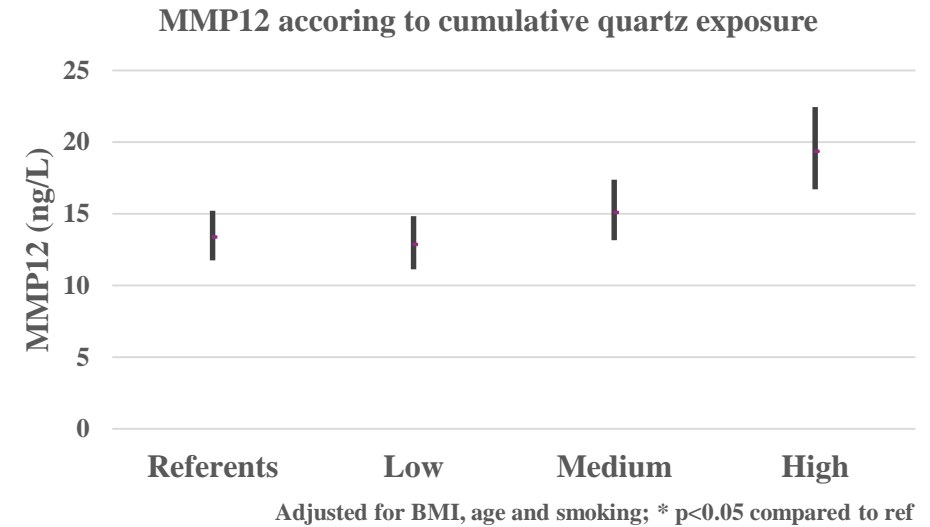


# Matrix metalloproteinases

- **MMP-1 (interstitial collagenase/fibroblast collagenase)** breaks down the interstitial collagen types I, II, and III, tissue remodeling
- **MMP-9 (gelatinase B)** breaks down extracellular matrix in normal physiological processes
- **MMP-12 (macrophage metalloelastase)** degrades soluble and insoluble elastin

# Matrix metalloproteinases

	Exposed		Referents		p
	Mean	Min-Max	Mean	Min-Max	
MMP-1 (ng/L)	66	1-2950	98	5-893	0.15
MMP-9 (ng/L)	680	191-2093	658	202-2119	0.74
MMP-12 (ng/L)	16	6-73	13	7-61	0.04

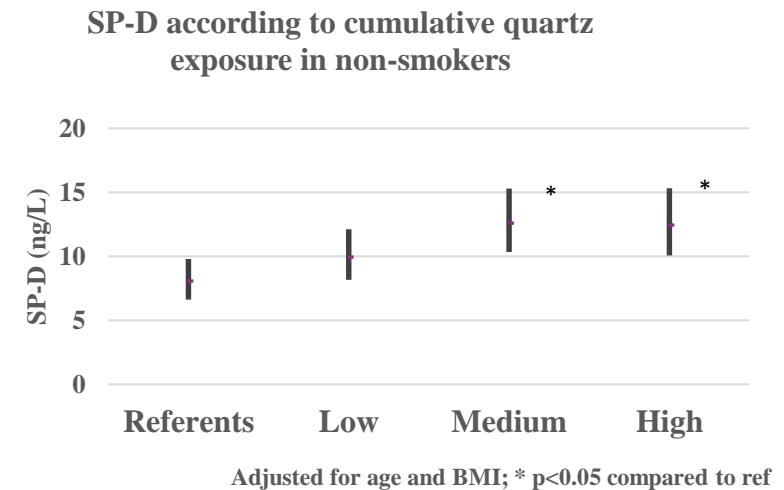
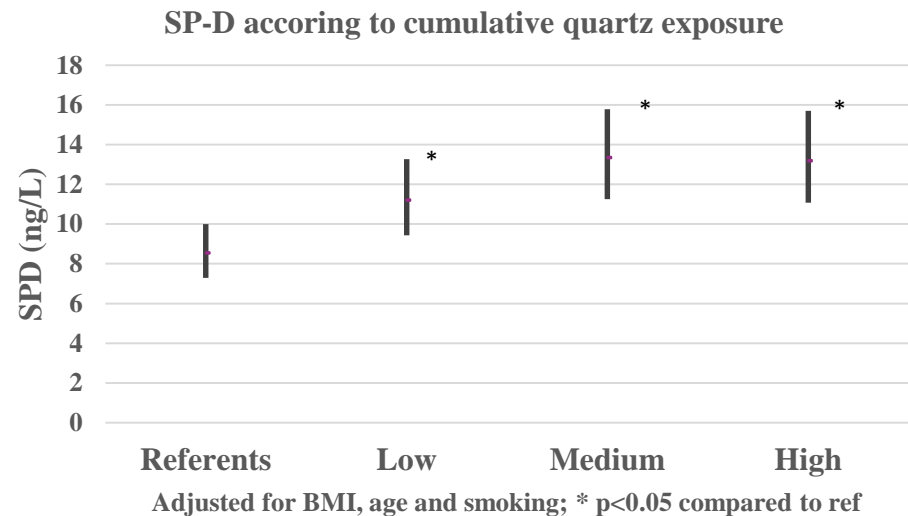


# Pneumoproteins

- **CC-16 (Club cell protein 16)** is regarded as an anti-inflammatory protein secreted by the pulmonary club cells
- **SP-A (Surfactant protein A)** is used to opsonize bacterial cells in the alveoli marking them for phagocytosis by alveolar macrophages
- **SP-D (Surfactant protein D)** primary task is to act as a defence protein against any pathogen invading the lung

# Pneumoproteins

	Exposed		Referents		
	Mean	Min-Max	Mean	Min-Max	p
CC-16 (ng/L)	12	2.4-31	12	3.3-34	0.89
SP-A (ng/L)	1248	43-3934	766	1-3912	0.02
SP-D (ng/L)	13	4-100	8.8	3.6-17	<0.001



# **In summary**

- **Rock drillers exposed for 21.7 years at  $80 \mu\text{g m}^{-3}$  of quartz have pulmonary obstruction in the small airways without signs of silicosis. The obstruction is larger for ever smokers than never smokers.**
- **They also have increased serum levels of MMP12, which is regarded as an important enzyme for the breakdown of elastin and development of emphysema**
- **There are, most likely, substantial alterations in the surfactant of the alveoli among the most highly exposed workers**

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