Testimony before the Committee on Education and Labor Subcommittee on Workforce Protections

United States House of Representatives

"Breathless and Betrayed: What is MSHA Doing to Protect Miners from a Resurgence of Black Lung Disease?"

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Good morning, Chairwoman Adams, Ranking Member Byrne, and distinguished members of the Subcommittee. My name is John Howard and I am the Director of the National Institute for Occupational Safety and Health, or NIOSH, which is part of the Centers for Disease Control and Prevention (CDC) within the U.S. Department of Health and Human Services (HHS). I am here today to provide the Subcommittee two updates. First, I will provide an update on the science supporting the contribution that inhaling respirable crystalline silica makes to developing pneumoconiosis in U.S. coal miners. Second, I will describe NIOSH's efforts to improve the technology for assessing coal miners' exposures to quartz—the form of crystalline silica found in coal mine dust (IARC, 1997).

I. Science Supporting Crystalline Silica (Quartz) as a Contributing Cause of Pneumoconiosis in U.S. Coal Miners

A. Quartz Exposure and Pneumoconiosis in Coal Miners

As mines produce coal, a variety of activities generate dust and aerosolize it. Some airborne dust particles are small enough to remain suspended in the air for long periods of time and can be inhaled deep into the lung. The term respirable coal mine dust or "RCMD" refers to the part of coal mine dust that is composed of these small particles. RCMD is most commonly comprised of micron and submicron particles of coal, quartz, pyrite, calcite, dolomite, clay minerals, and diesel particulate matter. RCMD is generated by a number of mining activities including mining coal, loading and transporting coal, applying rock dust (i.e., a dust composed mostly of finely milled limestone), and most importantly for potential quartz exposure, mining or drilling into geologic strata overlying the coal seam or interbedded with the coal seam. The mineralogy and particle size distribution of RCMD vary both within a single mine and from mine to mine depending on the local geology, rock dusting practices, mining methods, and the use of engineering controls.

Over time, inhalation of a sufficient amount of RCMD into the lungs can lead to a spectrum of potentially disabling and sometimes fatal respiratory diseases, including pneumoconiosis—a class of interstitial lung diseases where inhalation of dust leaves the lung stiff and fibrotic, interfering with the body's ability to get oxygen to the tissues (Petsonk et al., 2013). The risk of developing these pneumoconioses is related to the cumulative amount of RCMD inhaled into the lungs over time (NIOSH, 2011). These diseases predominantly include coal workers' pneumoconiosis (CWP), silicosis (another type of pneumoconiosis), and mixed dust pneumoconiosis. Except in the setting of very intense RCMD exposure, pneumoconiosis typically presents after a latency of several decades from first exposure.

Pneumoconiosis can be detected by radiographic imaging of the chest. On plain chest radiographs, CWP and silicosis can be characterized by small opacities, more severe disease with a higher density of small opacities, and especially severe disease characterized by large opacities called progressive massive fibrosis (PMF). Since the lowest point seen in the mid-1990s, NIOSH surveillance of active coal miners for pneumoconiosis using chest radiographs has identified marked increases in the prevalence of pneumoconiosis. The most recently reported prevalence of radiographic pneumoconiosis among active underground coal miners with 25 or more years' tenure is about 20 percent in the regional areas of eastern Kentucky, western Virginia, and the state of West Virginia and 5 percent in the rest of the U.S. (Blackely, Halldin, et al., 2018). Pneumoconiosis affecting younger miners has also been reported. PMF has increased, particularly in the three states of Central Appalachia mentioned above, with a particularly large number of cases (n=416) identified as receiving care at three rural clinics in western Virginia (Blackley, Reynolds, et al., 2018). There is no medical or surgical cure for pneumoconiosis. The only approach is to prevent inhalation of respirable mineral dusts that cause pneumoconiosis such as respirable coal mine dust and respirable crystalline silica.

B. Quartz Exposure and Pneumoconiosis in Contemporary Coal Miners

Coal mining activities that disturb rock containing quartz can generate dust aerosols that contain respirable crystalline silica. Inhaling excessive amounts of crystalline silica causes silicosis, a type of pneumoconiosis (NIOSH 2002). It has been known for many years that coal miners, particularly miners in certain jobs such as underground coal miners engaged in roof bolting, miners at the face, and surface miners engaged in drilling through rock overburden, can develop silicosis, or CWP mixed with silicosis (Banks et al., 1983; Vallyathan et al., 2011).

Coal Workers' Health Surveillance Program Data. In a 2010 publication, NIOSH investigators thought that crystalline silica exposures were playing an important role in the increasing burden of pneumoconiosis, and rapidly progressive pneumoconiosis, in U.S. underground coal miners (Laney et al., 2010). They described an increasing occurrence of a specific type of radiographic abnormality associated with silicosis, called "r-type opacities," among underground coal miners from eastern Kentucky, western Virginia, and West Virginia. Occurrence was higher in the 2000s relative to the 1990s and 1980s and occurrence was higher in miners from those Appalachian states relative to the rest of the U.S. The same pattern of findings was shown for PMF. Due to the nature of the data, a specific exposure mechanism to explain their findings could not be established, but the authors noted that

> "the continuous rise in the demand for coal, coupled with increasing productive mining equipment has led to the depletion of the largest, most easily accessible North American underground coal seams. These factors, and the increasing price of energy sources, have made mining thinner seams of coal more economically feasible" (Laney et al., 2010).

Luttrell and Honaker (2012) describe how this has led to mining large amounts of rock together with coal;

> "It is not uncommon for eastern operations to experience yields under 30–35%, thereby producing only 1 t of clean coal from three or more tons of mined product. An estimate complied [*sic*] from production records supplied by coal producers suggests that the average

yield is now less than 50% (i.e., 49.8% ± 3.5%) for the total USA. This situation is expected to worsen as eastern reserves become thinner and more challenging to mine…Consequently, ever increasing amounts of rock from out-of-seam dilution are being mined…".

In a follow-up to the 2010 publication, NIOSH investigators documented that the prevalence of r-type opacities continued to increase in the 2010s in coal miners working in eastern Kentucky, western Virginia, and West Virginia relative to earlier decades, and also relative to coal miners in the rest of the U.S. (Hall et al., 2019).

MSHA Inspection Data. An evaluation of respirable dust and quartz data collected in underground coal mines by Mine Safety and Health Administration (MSHA) mine inspectors confirms underground coal miners' exposure to crystalline silica (Doney et al., 2019). Between 1982 and 2017, over two hundred thousand quartz samples were collected across the U.S. The overall respirable quartz geometric mean of these samples was 0.038 mg/m^3, with 18.7 percent of samples exceeding MSHA's permissible exposure limit (PEL) that reduces allowable exposures to respirable coal mine dust to ensure exposures to no more than 0.1 mg/m^3 quartz (calculated only when the percentage of quartz in respirable coal mine dust exceeded 5 percent). The percentage of samples collected for the continuous mine operator and helper occupational group, exceeding MSHA's reduced respirable coal mine dust PEL adjusted for quartz content, was 21.9 percent, and the percentage of samples exceeding the exposure limit for the roof bolter occupational group was 19.1 percent. Mean percent quartz in respirable coal mine dust samples for Central Appalachia (MSHA Districts 4, 5, and 12) were significantly higher than in the rest of the U.S.

Black Lung Clinic Data. Evaluation of coal miners with PMF seen in Appalachian clinics also supports the role for crystalline silica (quartz) in the increase of the most severe form of pneumoconiosis. In 2018, NIOSH investigators reported a group of 416 coal miners with PMF receiving care at three Black Lung clinics in western Virginia (Blackley, Reynolds, et al., 2018). Later that year, the investigators published a summary of detailed interviews with a convenience sample of 19 miners with

PMF from these clinics (Reynolds et al., 2018). Nine were roof bolters, seven continuous miner operators, one shuttle car operator, and two worked a combination of jobs. Eighteen reported being in the vicinity when continuous mining machines were used to cut significant amounts of rock either to reach coal seams or in the process of extracting them. Fourteen reported that ventilation controls were not consistently maintained and 13 reported that RCMD was improperly sampled.

Lung Tissue Pathology Data. Further support for the contribution of crystalline silica (quartz) to pneumoconiosis in contemporary underground coal miners in eastern Kentucky, western Virginia, and West Virginia comes from evaluation of pathological findings in samples of lung tissue from miners in these areas. Silicosis can be clearly differentiated from CWP by microscopic examination of lung tissues.

In a 2016 report, a group of investigators sought lung tissue samples from coal miners with rapidly progressive pneumoconiosis (Cohen et al., 2016). They identified 13 miners with evaluable lung samples. The longest-held jobs for eight of these miners were operating continuous mining machines. Four miners were roof bolters, and one was a surface miner. Eleven were from West Virginia. Based on reviews of radiographs and pathological findings in lung tissue, twelve were identified as having PMF. On pathology examination, 11 miners were diagnosed as having silicosis and only four miners had classic lesions of simple CWP. Polarized light microscopy of the lung tissue samples showed the presence of large amounts of birefringent mineral dust particles consistent with crystalline silica and other minerals. Ongoing research by these investigators, with assistance from NIOSH, is comparing lung pathology in largely older lung samples held by NIOSH as part of the National Coal Workers' Autopsy Study to lung pathology findings in more recent lung samples obtained by biopsy or at the time of lung transplantation or autopsy. One aspect of the research is to use more sophisticated techniques to characterize the composition of particles found in the lung.

C. Conclusion

Scientific evidence to date from surveillance surveys, MSHA inspection data, clinical and radiographic examinations, and lung tissue analysis, support the conclusion that quartz, a form of crystalline silica, plays a contributing role in the current outbreak of pneumoconiosis in coal miners, particularly in eastern Kentucky, western Virginia, and in West Virginia.

II. Technology for Evaluating Coal Miners' Exposures to Respirable Coal Mine Dust

A. Continuous Personal Dust Monitor

For several decades, NIOSH has had a major ongoing research effort in the area of developing new technologies for monitoring coal miner exposure to respirable dust. This research led to the development, certification, and commercialization of the continuous personal dust monitor (CPDM) which involved close collaboration with MSHA, the mining industry, labor unions and the instrument manufacturer--Thermo Fisher Scientific.

In 2016, MSHA, under a final rule, *"Lowering Miners' Exposure to Respirable Coal Mine Dust, Including Continuous Personal Dust Monitors,"* mandated the use of a CPDM in all active U.S. underground coal mines. The Thermo Scientific PDM3700 is currently the only approved CPDM to monitor exposure to RCMD. It is jointly approved for use in coal mines by MSHA and NIOSH under criteria set forth in 30 C.F.R. part 74. The introduction of the field-based CPDM, which provides near real-time exposure data to individual miners, was a significant advancement over the traditional monitoring method, based on a gravimetric sampler whose dust collection sample must be sent to a laboratory for analysis in order to obtain results, which can take several weeks. Since its introduction into coal mines, the CPDM has significantly improved respirable coal mine dust monitoring capabilities and compliance with MSHA coal mine dust exposure regulations. The CPDM has also proven its value as a tool that enables miners and management to take proactive measures to immediately reduce exposures by quickly implementing engineering controls or modifying work tasks.

B. Current Methods for Evaluating Coal Miners' Exposures to Quartz

Although the introduction of the CPDM was a major step forward for monitoring miner exposure to RCMD, it measures all types of respirable dust expressed as mass concentration. The CPDM does not differentiate between the individual minerals and other components of respirable dust, and is therefore unable to assess miners' exposure to quartz (a form of crystalline silica) in near real time. Instead, quartz exposure is measured once a quarter from samples collected by MSHA for compliance purposes. Some coal mine operators also perform quartz monitoring for self-assessment and to evaluate the effectiveness of intervention strategies to reduce or eliminate exposure to quartz. Both MSHA and mine operators use a gravimetric dust sampler to perform compliance and self-assessment sampling. A compliance sample, once collected, is sent to an MSHA laboratory for analysis which can take several days to weeks before results are reported to the mine operator. A self-assessment sample is sent to a private sector laboratory for analysis which can also take several days to a week before results are reported to the mine operators.

C. Efforts to Improve the Technology for Measuring Coal Miners' Exposures to Crystalline Silica

Timely monitoring of quartz would provide better protection for miners. NIOSH is pursuing technologies to advance the science of rapidly assessing quartz exposures in the field through two lines of research—one involving private sector partners, and the other involving NIOSH scientists.

1. Academic and Private Sector Research Efforts

Funding academic and private sector companies to develop novel technologies for near real-time measurement of quartz is an important way to improve exposure assessment technology. To stimulate this type of research, NIOSH utilizes its external contracts and grants program to accelerate research in high-priority areas where there are critical knowledge gaps or commercialization challenges. In September 2018, NIOSH contracted with Thermo Fisher Scientific to develop a stand-alone, near real-time, quartz dust monitor for compliance sampling. In addition, a solicitation for New Technology Broad Agency Announcement (BAA) contracts (BAA 2019-Q-69532) invited proposals for new technologies that address non-regulatory personal measurement of coal dust or quartz. As stated in the BAA solicitation, while regulatory compliance currently requires mass-based measurement, NIOSH believes there is a market for non-mass-based units measuring coal dust, quartz, or both, that are low enough in cost that the units can be issued to every miner to provide near real-time results. This allows miners to identify elevated quartz levels and take immediate corrective action to prevent overexposure. NIOSH is currently evaluating three proposals received in response to the BAA solicitation.

2. NIOSH Research Efforts

At NIOSH's Pittsburgh and Spokane Mining Research Divisions, NIOSH has unique laboratory facilities and in-house research expertise that can be focused on developing a prototype for a field-based *"rapid quartz monitor"* (RQM). Starting in 2012, this NIOSH research effort has focused on developing a field-based method for rapid quartz analysis as opposed to the traditional laboratory-based, MSHA P7 method (see Table 1). The field-based, RQM prototype is based on three components: (1) a *sampler*, which is composed of a pump, cyclone and sampling cassette; (2) a Fourier Transform Infrared (FTIR) *analyzer*; and (3) a software-based quartz concentration *calculator* (See Figure 1).

Specifically, the field-based RQM prototype involves a gravimetric sample collected on a filter inside a "shoot through" cassette (which has not been mine-tested as of this writing). The "shoot through" cassette is specially designed for direct insertion into any one of four commercially available portable FTIR analyzers. Once analyzed, a NIOSH-developed software program called FAST (Field Analysis of Silica Tool) automatically calculates the quartz concentration from the FTIR spectrum and sampling information provided by the mine operator. A test version of the NIOSH-developed FAST software is currently available on the NIOSH website. The analytical method used by this field-based approach—FTIR spectroscopy—is also used to conduct the laboratory-based MSHA P7 analysis for quartz compliance sampling. Compared to the laboratory-based MSHA P7 analytical method, preliminary laboratory studies show a relative difference of less than 15 percent on average for coal dust samples analyzed in the laboratory using the field-based RQM prototype.

NIOSH Field Test Evaluations. Between 2016 and 2018, NIOSH conducted usability tests of the field-based, prototype RQM at four coal mines in West Virginia, including three underground mines operating continuous miner sections and one surface mine. The traditional sampling cassette was used because the specially designed “shoot through” sampling cassette, now available, was still in development at the time of these usability tests. The mines conducted the testing in collaboration with NIOSH, collecting more than 200 area and personal dust samples with a gravimetric sampler. While the traditional sampling cassette used for this testing limited the accuracy of the analysis, and only provided an estimate for quartz, the mines were still able to use the information output from the field-based prototype RQM approach to assess the efficacy of a control technology for a continuous miner section, and to identify occupations and tasks characterized by high concentrations of quartz.

MSHA Field Test Evaluations. At the present time, NIOSH is supporting MSHA field evaluations of the field-based prototype RQM approach to determine how well the results correlate with the analytical results provided by the standard, laboratory-based, MSHA P7 approach. MSHA’s Technical Support group will collect respirable coal mine dust samples on both the traditional and the “shoot through” cassette. The collected samples will be analyzed by MSHA using the field-based, prototype RQM and the standard laboratory-based MSHA P7 method. Sampling will be initially conducted in MSHA Districts 2 and 3, and will be expanded to include samples from each MSHA district across the USA.

D. Technological Readiness of the Field-Based, Prototype RQM for Compliance Use by MSHA

The current field-based prototype RQM monitoring approach was designed as an engineering control tool. It has the potential to be used for compliance sampling in the future, pending further validation of the prototype method in active coal mines. These technological evaluation studies are necessary to investigate whether or not specific characteristics of the dust present in the coal-mining atmosphere require further refinement of the analytical technique.

The timeline for completing the field testing will be influenced by the number of samples required to achieve a statistically representative dataset of underground coal mines in the USA. Analysis of the results and preparation of a paper that would document the performance of the prototype would then be completed, undergo peer and stakeholder review, and be published in a peer-reviewed scientific journal. Since the three components of the RQM are off-the-shelf components, no commercialization would be needed.

An important limitation that needs to be addressed before the prototype is considered for compliance sampling is that the field-based, prototype RQM was designed for self-assessment sampling. It was not originally conceived and designed as a compliance tool and therefore was not designed to include tamper-proof components. This means that the integrity of the sample cannot be guaranteed, which it would need to be if the prototype is to be used as a compliance tool. Another consideration is that the adoption of the field-based, prototype RQM as a compliance tool would require miners to wear two sampling devices—one for coal dust and one for quartz—which may hinder miner acceptance.

III. Conclusions

A. Science Supporting Respirable Crystalline Silica as a Contributing Cause for Pneumoconiosis in eastern Kentucky, western Virginia and West Virginia

The scientific evidence published to date demonstrates that the crystalline silica component of respirable coal mine dust contributes to the rising prevalence of pneumoconiosis in coal miners, particularly in eastern Kentucky, western Virginia and West Virginia.

B. Technological Readiness of the Prototype Rapid Quartz Monitor

Although showing promise as a self-assessment tool for exposure to crystalline silica in coal mines, the field-based, prototype RQM is not currently technologically ready for use as a compliance tool.

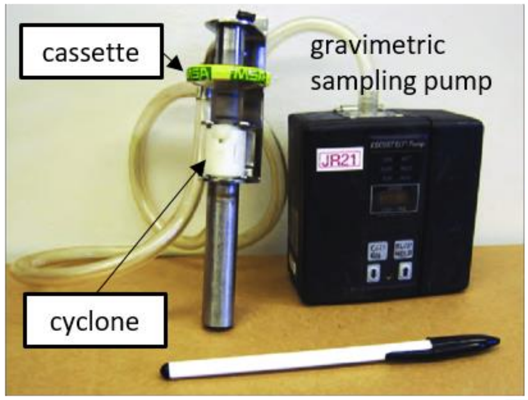
Table One

	MSHA P7 method		NIOSH Rapid Quartz Analysis	
	Step	**where**	**Step**	**where**
1	Airborne respirable dust samples are collected on pre-weighed membrane filters using MSHA/NIOSH approved personal respirable dust samplers as described in 30 CFR Part 74. After collection, the filter capsules are reweighed to one thousandth of a milligram in order to determine the net sample mass.	Mine	Airborne respirable dust samples are collected on membrane filters using MSHA/NIOSH approved personal respirable dust samplers as described in 30 CFR Part 74.	Mine
2	Transporting/mailing the sample to the analytical lab		Sample remains on-site	
3	**Removing the filter media from sampling cassette** – The filter media containing the dust sample must be removed from the sampling cassette.	Lab	**Opening the sampling cassette** – The two end caps of the sampling cassette are removed while the filter media containing the dust sample remains inside the cassette.	Mine
4	**Pre-treatment of the sample** – The sample filters are ashed in a low-temperature radio-frequency asher to destroy the organic matrix (coal dust and collection filter).	Lab		
5	**Re-deposition of the sample –** Ashed samples are deposited onto an approximately 9 mm diameter area of a vinyl acrylic copolymer(VAC) (DM450) filter.	Lab		
6	**Analysis of the sample using FTIR instrumentation –** The sample is inserted in the FTIR analyzer (PE Model2000, GX or equivalent) and analyzed. The redeposited, ashed dust samples are scanned between wave numbers of 1,000 and 700 cm·' to determine the quartz and kaolinite content.	Lab	**Analysis of the sample using FTIR instrumentation –** The cassette is inserted in the portable FTIR analyzer and analyzed. The sample is scanned by FTIR between wave numbers of 4,000 and 400 cm·' to determine the quartz and kaolinite content.	Mine
7	**Sample data analyzed** – The mass of quartz in the deposit is determined (after correcting for the interference by kaolinite) by comparison to calibration curves for standard quartz samples and standard kaolinite samples. The percentage of quartz in the sample is calculated using the quartz mass determined from the analysis and the sample's mass of dust.	Lab	**Sample data analyzed** – The data generated by the FTIR analysis are processed by NIOSH FAST software to determine respirable quartz concentration and mass (after correcting for the interference by kaolinite).	Mine
8	The results are received by the mine	Mine		

Figure One

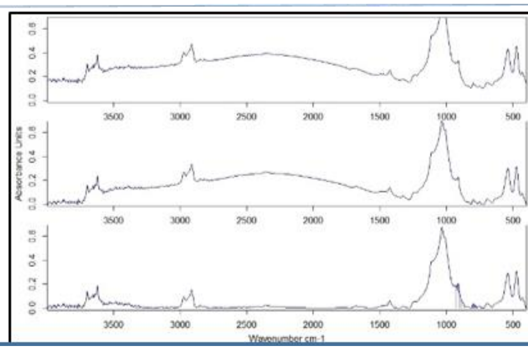
Process for measuring quartz exposure using the field-based prototype RQM approach

Step 1: Collect samples using gravimetric samplers equipped with a traditional coal dust sampling cassette (a) or a “shoot through” cassette (b)



Step 2: Analyze samples with a portable FTIR unit

Step 3: Calculate quartz concentration from the FTIR data using NIOSH FAST software



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