Chapter 40

SOURCES AND CHARACTERISTICS OF QUARTZ DUST IN COAL MINES

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Abstract. Quartz dust is one of the most significant ongoing health concerns in coal mining today. Since initial verification of this health risk in coal mines by the Mine Safety and Health Administration (MSHA) during the early 1980's, the Bureau of Mines has conducted numerous studies in underground mines to identify the sources of quartz dust and its fundamental characteristics. The most significant underground quartz dust source was found to be the continuous miner excavating rock. The percentage of quartz was also found to be higher in the smaller size fractions of the dust when significant amounts of rock was mined by the continuous miner. Furthermore, the quartz content in the continuous miner return remained fairly consistent at greater distances from the face.

Another important factor speculated to affect quartz dust generation and its size characteristics is the morphology of the quartz bearing rock. The quartz content of dust between mines had notable differences with respect to the differences between kaolinite content in the dust. Low kaolinite content was associated with higher quartz content and increased size segregation of quartz into smaller dust particles, indicating that the free silica bonding matrix in the rock is most likely another factor responsible for quartz dust produced through mechanical comminution.

INTRODUCTION

The Federal Coal Mine Health and Safety Act of 1969 limits the amount of worker respirable dust exposure to a 2.0 mg/m^3 average standard for a working shift. If the respirable dust sample contains more than 5 pct quartz the dust standard is reduced. The more stringent dust standard due to quartz is determined by dividing 10 by the percentage of quartz in the dust.

Enforcement of more stringent dust standards due to quartz was difficult until the early 1980's because of insufficient analytical methods to determine the quartz percentage in individual respirable dust samples. In the late 1970's, the U.S. Bureau of Mines, the Mine Safety and Health Administration (MSHA), and the National Institute for Occupational Safety and Health (NIOSH) jointly developed the low-temperature ash-infrared procedure known as the P7 technique to analyze individual dust samples (Bureau of Mines, 1982). MSHA adopted this technique in 1981 for determination of more stringent dust standards as stipulated in the regulations (Goldberg, Tomb, and Kacsmar).

In 1981, the number of MSHA quartz analyses increased by more than 140 pct, and the number of more stringent dust standards increased by more than 200 pct (Niewiadomski, Tomb, and Parobeck, 1988). By 1984, more than 10 pct of the active coal mining sections were on a more stringent dust standard. About one-third of these entities were on a standard below 1 mg/m^3, indicating that these entities had more than 10 pct quartz in their compliance samples. Roughly 70 pct of the entities on more stringent dust standards due to quartz are in underground coal mines (Jankowski, Kissell and Nesbit, 1985). Nondesignated work positions accounted for about 50 pct of the more stringent dust standards, and were mostly roof bolter operators in underground mines.

In 1983, the Bureau of Mines initiated a quartz dust program to identify the extrinsic parameters governing the quartz exposure of coal mine workers. Several in-house and contract studies were conducted to gather a data base to identify the most significant sources, characteristics, and behavior of quartz dust in coal mines. This paper summarizes the data and results obtained since then from the various studies conducted under the Bureau's quartz dust program.

SOURCES OF QUARTZ DUST

Quartz dust measurements have been made in many locations throughout coal mines to identify the various sources of generation. Major sampling efforts were directed at roof bolter units on continuous miner sections because they represented the majority of the entities on a more stringent dust standard due to quartz. The data obtained from these sections will be examined first since it is the most significant problem. Other types of production units and areas were also sampled to identify the scope of the problem throughout coal mines. Quartz dust data from these other operations (longwall, conventional, and outby areas) will also be examined to identify less significant but other problem sources.

Respirable dust measurements were obtained with personal gravimetric samplers, and quartz analysis was conducted on these samples with the P7 method. Some instantaneous dust sampling with a Real-Time Aerosol Monitor (RAM) was also conducted to examine changes in dust levels during particular mining events. Quartz content of bulk materials (rock chip samples) was measured by x-ray analysis.

Continuous Mining Sections

Roof bolter operators were the most frequent worker occupation on more stringent dust standards due to quartz. Studies were conducted at eight continuous miner sections to identify the major source(s) of quartz (Taylor, Thakur, and Riester, 1986) (Colinet, Shirey, and Kost, 1985) (Kok, Adam, and Pimentel, 1985). These mines were selected because they were on more stringent dust standards. Dust samples were taken in the areas of production activities. Gravimetric sampling was conducted in the roof bolter return air when operated upstream of the continuous miner, at the continuous miner operator's cab, in the return air of the continuous miner, and in the roof bolter return air when operated downstream of the continuous miner. Figure 1 illustrates these locations on a typical single split return face ventilation system. Also, bulk samples of roof rock, rock partings (if any), floor rock and roof bolter cuttings were collected and analyzed for their quartz content.

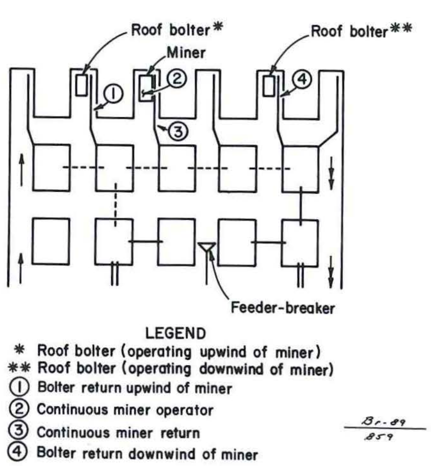

FIGURE 1. Underground dust sampling plan at continuous miner sections.

Data analysis from these continuous mining sections indicates that the roof bolting machine was not the major source of quartz dust exposure of the roof bolter operators. Figures 2 and 3 show the average dust and quartz concentrations at each sampling location for the eight mines.[1] The roof bolter return on the intake side of the continuous miner shows a significantly lower average of respirable dust and quartz dust than the other sampling locations.

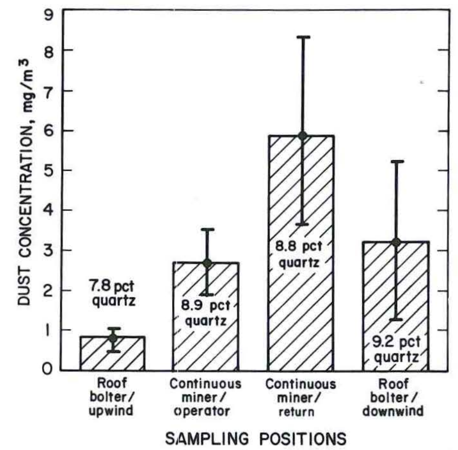

FIGURE 2. Average dust concentrations and quartz content at continuous miner sections.

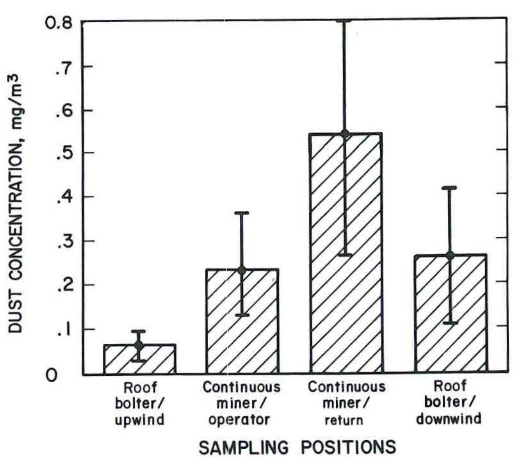

FIGURE 3. Average quartz dust concentrations at continuous miner sections.

Cuttings from the roof bolter dust collector had the highest quartz content of any of the bulk materials analyzed at these sections (see figure 4), demonstrating that the dry vacuum collection systems (used at all eight mines) on roof bolters are very efficient. However, the roof bolter collection system must be properly maintained and cleaned because notably higher levels of dust were measured when

[1]All error bars expressed in figures are at the 95 pct confidence level.

the filters were not properly seated in the collector. Dust concentrations from the bolter at one mine averaged 0.74 mg/m^3 with 8.3 pct quartz for four shifts with the collector working properly. During one shift, the cartridge-type filter was not properly seated and leaked, yielding 3.68 mg/m^3 of dust containing 13.3 pct quartz.

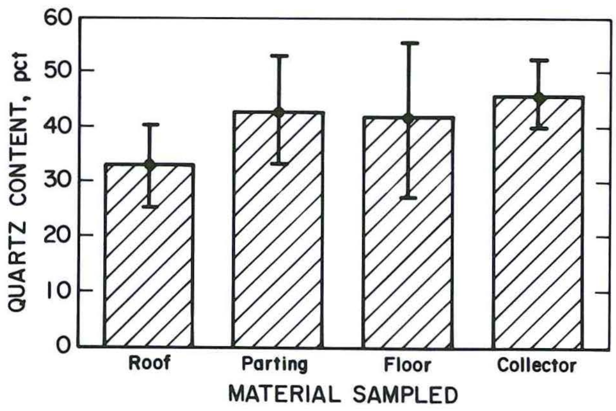

FIGURE 4. Average quartz content of rock samples and roof bolt cuttings.

The continuous miner cutting rock was the major source of quartz dust at these sections. Figures 2 and 3 reveal that both respirable dust and quartz dust concentrations are fairly high at the continuous miner operator's position and are the highest on the return side of the continuous miner. Instantaneous dust measurements with a RAM made at the continuous miner operator's cab during production indicate that the dustiest process was cutting rock. Figure 5 illustrates how dust levels notably increased at a continuous miner when cutting rock.

Roof bolter operators were exposed to high levels of quartz dust when operating on the return side of the continuous miner. Average dust levels in the bolter return when operating on the return side of the miner were significantly higher than when operating on the intake side of the miner (see figures 2 and 3). Roof bolter operators at these mines were exposed to the dust generated by the continuous miner during a portion of the shift. Their major source of quartz dust exposure was from the continuous miner cutting rock.

Longwall Mining Sections

Approximately 5 pct of designated entities on longwall mining sections have been placed on more stringent dust standards due to quartz. As previously noted, coal seams contain only a small percentage of quartz and it is the mining of top and bottom rock that contributed the greatest amount of quartz to the respirable dust. Although roof and floor rock are often mined during development of the longwall panel,

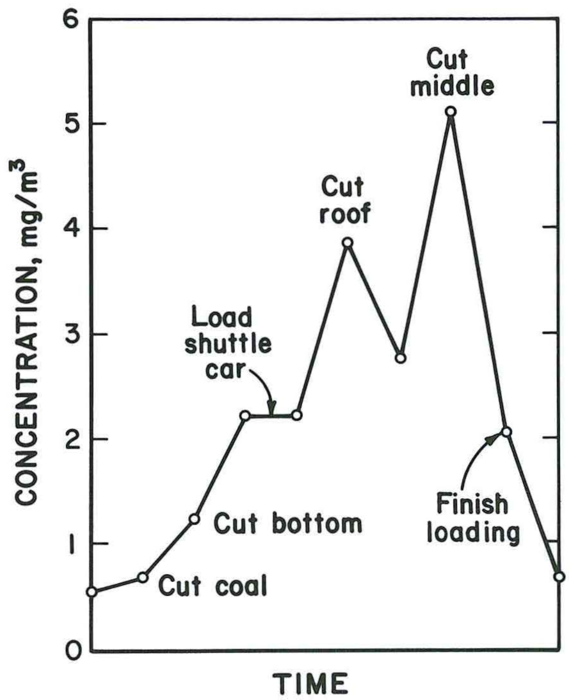

FIGURE 5. Instantaneous dust levels at the continuous miner operator's position while cutting rock.

it is seldom necessary for the longwall machine itself to extract top or bottom rock. This can be well illustrated by a situation at one particular longwall mine. During development of the longwall panel in a particular area, the continuous mining section was operating on a more stringent dust standard of 1.3 mg/m^3; MSHA sampling had determined that the average quartz content of the respirable dust was 7.5 pct. During retreat panel extraction by the longwall system, the section operated at the normal standard of 2.0 mg/m^3; MSHA sampling had determined that the average quartz content of the respirable dust was 3.5 pct. During panel development, the continuous mining machine was required to remove roof rock to provide adequate clearance for subsequently moving in the longwall face equipment. Removal of roof rock was not necessary or desired during longwall extraction.

Potential sources of airborne respirable quartz can be illustrated by the following longwalls sampled for quartz. Mine A extracted a mining height of 13 ft (4.0 m) from the middle of a 23 ft (7.0 m) coal seam, leaving 5 ft (1.5 m) of top and bottom coal. Quartz dust levels along the face are shown in figure 6. These results show only trace amounts (< 2 pct) of quartz in the airborne respirable dust and illustrate that cutting in clean coal does not contribute to the airborne respirable quartz dust levels.

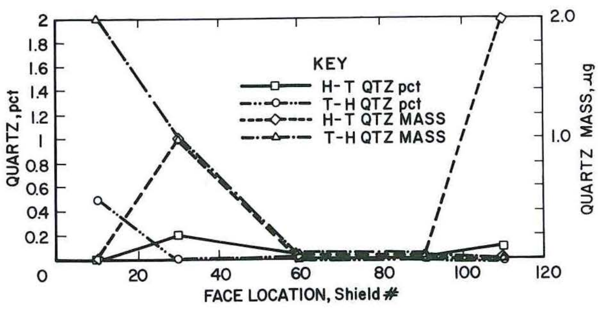

FIGURE 6. Quartz content and mass measured at longwall A.

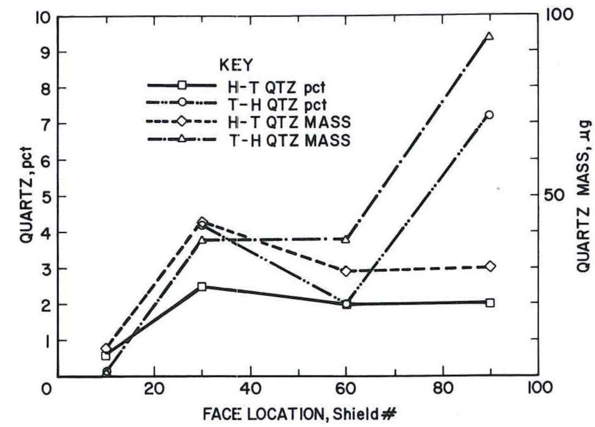

FIGURE 7. Quartz content and mass measured at longwall B.

Many coal seams contain rock intrusions or mineral partings within the seam. These represent the potential sources of airborne respirable quartz found at longwall mining operations. When rock intrusions are encountered, they must usually be mined during the longwall extraction. Rock partings must also be removed with the seam and can contribute airborne respirable quartz during extraction by the shearer or subsequent breakage in the sections crusher (located at the headgate). This feature is illustrated in figure 7. Mine B had a minor rock intrusion from the roof into the coal face between supports 25 to 35 and a major intrusion from supports 85 to 90. Average quartz dust levels along the face were approximately 3.0 pct, increasing to 4.0 at support 30 and 7.2 at support 90. However, the average quartz dust exposure of face workers was still under 3.0 pct, and the section was operating on a standard of 2.0 mg/m^3.

Mine C was a bidirectional operation with a sandstone top and numerous rock intrusions along the face. Figure 8 shows a consistent buildup of quartz dust levels along the entire face. This was due to a combination of airborne respirable quartz dust contributed from the shearer extracting the top rock and the release of quartz dust during movement of roof supports. Although quartz dust levels at the tailgate exceeded 12 pct, face workers spent little time in this area and had quartz exposure levels below 5 pct. All three longwall cases illustrate that quartz was not a significant problem, but the potential for problems exists under certain mining conditions.

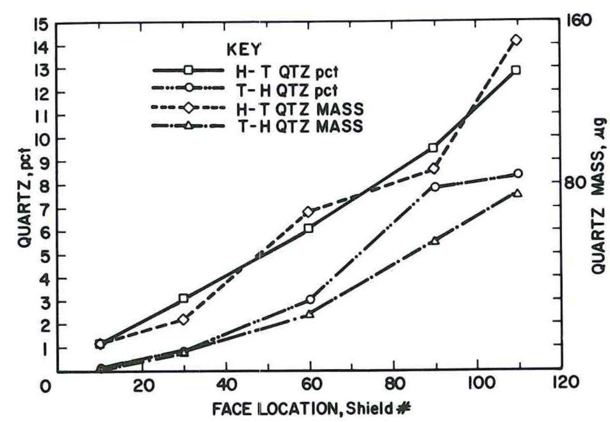

FIGURE 8. Quartz content and mass measured at longwall C.

Conventional Mining Sections

Quartz dust generation was investigated at two mines utilizing both the conventional and continuous mining methods (Organiscak, J.A., 1989). Since the most significant source of quartz dust in underground mines was the continuous miner when cutting rock, dust sampling was conducted in the immediate return of the conventional and continuous mining operations to make comparisons between the two mining methods. Both conventional and continuous sections at each mine operated in identical mining conditions so a good comparative study of the mining methods was achieved. The amount of reject in the product at both mines was greater than 40 pct and the quartz content in this reject was greater than 30 pct. Dust sampling at the conventional sections was conducted in the outer-most intake entry to eliminate any upstream contamination from other concurrent conventional mining operations in the section. Measurements were made at stationary positions in the intake and immediate return of the production face over several complete cut cycles. Dust sampling at the continuous sections was mobilized with the continuous miner. Again, measurements were made in the intake and return of the production face. Figures 9 and 10 illustrate the average return respirable and quartz dust concentrations from both mines.

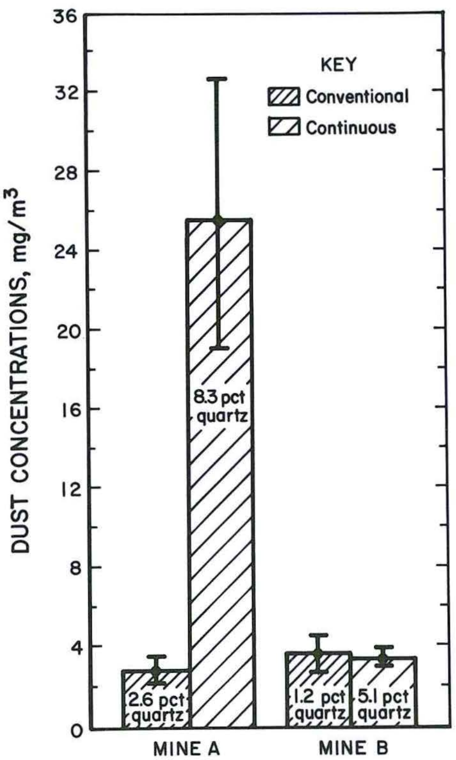

FIGURE 9. Average dust concentrations and quartz content at conventional versus continuous miner sections.

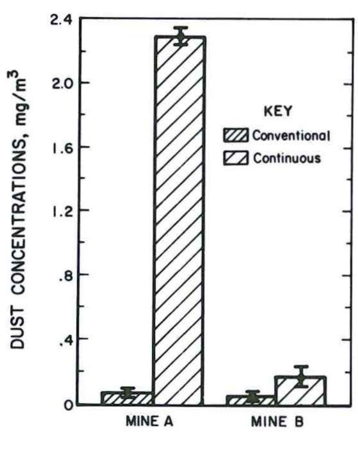

FIGURE 10. Average quartz concentrations at conventional versus continuous miner sections.

Results from the two-mine study show that conventional mining produces significantly less quartz dust than continuous mining and significantly less respirable dust in mine A (see figures 9 and 10). At the first mine studied (mine A) single-split exhaust ventilation (curtain) was used on both sections. The average respirable dust concentration in the continuous miner return was nearly eight fold higher than in the return air of the conventional operation. The average continuous miner quartz dust concentration was nearly 31 fold higher than the continuous quartz dust concentrations. At mine B, the conventional and continuous sections both employed blowing face ventilation (curtain). A fibrous-flooded bedded scrubber was used on the continuous mining machine for dust control. Respirable dust concentrations were nearly identical in both the continuous and conventional returns. However, the average quartz dust concentration for the continuous miner was 2.7 fold higher for the conventional section.

These results indicate that conventional mining produces notably less quartz dust than continuous mining and should not pose serious quartz dust problems in coal mines. The blasting of rock in conventional mining increases its product size, producing less fines and dust. The rotary cutting action of a continuous miner mills the rock into a finer product with more dust.

Outby Areas in Underground Coal Mines

Several designated outby areas on more stringent dust standards due to quartz prompted some dust sampling to evaluate the potential of quartz generation in these areas. Areas sampled included shuttle car travel entries, the area around the feeder-breaker, belt entries, and locations within a rail haulage system (belt-to-rail transfer dump, a main rail haulage entry, and several locomotives). Figures 11 and 12 show the average respirable dust and quartz dust concentrations measured in four basic outby areas.

Belt entries had the highest dust concentrations in outby areas with the lowest quartz content. These concentrations were measured between transfer points and around transfer points in main belt and section belt entries. Good perceptible air movement outby was measured in all the belt entries sampled (average for the mines surveyed ranged between 80-100 ft/min or 0.41 - 0.51 m/s). Two of the mines had low percentages of quartz in the product reject (8±7 pct), so low quartz content would be expected in the dust (0.4±0.1 pct). However, one mine had a high percentage of quartz content in the product reject (31 pct) and had low quartz content in the dust of its main belt entries (0.6±0.1 pct). This indicates that conveyor belts can be a significant source of respirable dust but may not be a significant source of quartz dust. Conveyor belts are probably not prone to generating respirable quartz dust because of the elastic properties of the belt and the durable nature of quartz materials (rock) can better weather mechanical comminution by drives, takeups, and idlers. Coal, which is more easily ground, may be readily processed into finer particles through belt abrasion and pulverization.

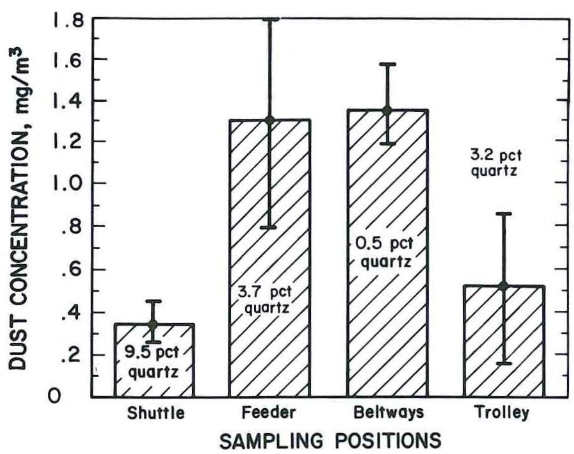

FIGURE 11. Average dust concentrations and quartz content in outby areas of underground coal mines.

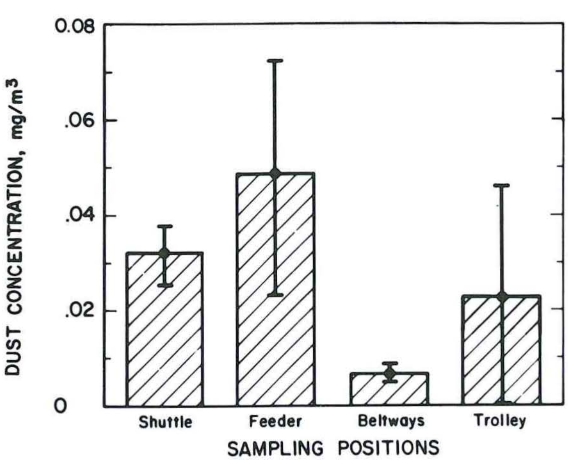

FIGURE 12. Average quartz concentrations in outby areas of underground coal mines.

The second highest dust concentrations and the highest quartz dust concentrations measured outby were around the feeder-breaker. Average quartz content of the rock feed through the feeder breaker was 30$\pm$4 pct. Although the feeder-breaker generated the largest amount of quartz dust in any of the outby areas (see figure 12), the amount generated did not pose a problem at the sections surveyed. However, there exists a potential quartz dust problem if a high quantity of large-sized rocks had to be crushed over an extended period of time. This dust could contaminate inby ventilation to the face, so this source should not be completely disregarded as a problem.

Dust measured in shuttle car entries outby the face and inby the feeder-breaker shows low dust concentrations with high quartz content. Average quartz in the rock mined and roof bolter cuttings were 44$\pm$9 pct and 54$\pm$9 pct, respectively. The dust found in the shuttle car haulage entries is a result of several sources in the section. Contaminated (dusty) air from the production face and feeder-breaker can migrate into these entries. Also, shuttle car movement through the entries can entrain the fine roof bolter cuttings dumped into these haulage entries. The amount of quartz dust found in these entries was still insignificant because dust concentrations are low.

Rail haulage had generally low concentrations of respirable dust and quartz dust associated with its operation (see figures 11 and 12). Dust concentrations were measured at the belt-to-rail dump chute, at stationary positions in the haulage entry, and on the haulage motors. The highest dust concentrations and quartz content (0.88$\pm$0.30 mg/m^3 and 6.9$\pm$2.8 pct quartz) were measured around the belt-to-rail dump chute. Airflow in the entry at this location averaged 90 ft/min (0.46 m/s). Respirable dust concentrations (0.34$\pm$0.21 mg/m^3) and quartz content (0.7$\pm$0.3 pct) were very low in the main haulage entry. Dust concentrations on the haulage motors (0.30$\pm$0.08 mg/m^3) were similar to the haulage entry, but the quartz content (2.1$\pm$0.7) was notably higher. The higher quartz content at the locomotives was likely from rail sanding to climb an outby grade leading to the mine portal. The sand contained 98 pct quartz, and instantaneous dust concentrations (from RAM sampling) nearly reached 3.0 mg/m^3 on the trailing motor when sanding took place. Also, a noticeable amount of sand was deposited along the rail, and instantaneous dust levels in the entry increased as the locomotives passed. However, the amount of quartz measured at the motors was still inconsequential to the exposure of motor operators. To avoid any potential silica problems on rail haulage systems, an amorphous silica sand or crushed slag could be used for traction media.

CHARACTERISTICS OF QUARTZ FOUND IN COAL MINES

Studies were conducted at four underground coal mines to investigate fundamental physical characteristics of quartz produced from continuous mining machines (Ramani, R.V., Mutmansky, J.M., Bhaskar, R., and Qin, J., 1987). Data was collection for 15 individual cuts at continuous miner sections in these four mines. Face channel sampling, airborne dust sampling, and run-of-mine product sampling were conducted for each individual cut. Airborne dust and quartz samples were collected with personal gravimetric samplers (respirable and total dust) and Sierra Model 298 Marple cascade impactors (personal sampler for aerodynamic size classifications operating at 2 L/min). The grease used on the impactor substrates was a mixture of toluene and 20 pct petroleum jelly instead of the silicon-based grease, so the quartz analysis would not be affected by the grease. Bulk material and dust samples were analyzed with the P7 method for their quartz content to maintain a consistency between quartz analysis of dust and bulk samples. Bulk samples were processed to obtain a -400 mesh, which were then dispersed in a fluid and deposited on a filter before P7 analysis. The P7 infrared analysis was also used to determine the amount of kaolinite mineral (clay) in the dust of the impactor samples.

Channel samples were collected and analyzed for each selected cut to identify the amount of quartz in the premined material. These channel samples were collected directly from the face before a cut was mined. Averages for each mine are summarized in figure 13. Results indicate that the main quartz sources are the roof rock (at all mines) and floor rock (at two of the mines). The rock thickness mined at all four mines averaged 25 pct of the total height extracted (mine A-32 pct, mine B-16 pct, mine C-27 pct, and mine D-23 pct).

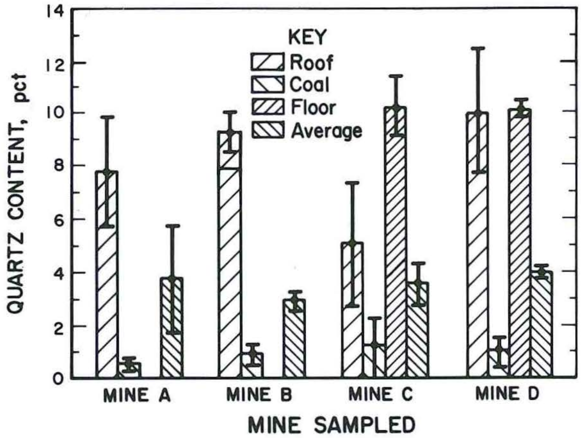

FIGURE 13. Average quartz content in seam components of mines studied for fundamental quartz characteristics.

During mining of each selected cut, respirable dust, total dust, and run-of-mine product were sampled for quartz analysis. Multiple airborne respirable and total samples were collected in the immediate return of the continuous miner for each cut. The run-of-mine product sample was obtained by collecting individual samples from all the cars at the feeder-breaker. Processing of these samples for each cut involved preliminary screening, weighing, and cone and quartering into smaller samples for transportation out of the mine. Dust and mine product quartz averages for each mine are presented in figure 14. At three of the mines (A, C, and D), quartz content was observed to be higher in smaller particle size ranges. Respirable dust had the highest quartz content, and the mine product had the lowest quartz content. Mine B did not exhibit quartz content differences between the different particle size ranges as did the other three mines. A suspected reason for this anomaly is that the roof rock (the only rock mined) was mainly comprised of draw slate that broke away easily while mining. The miner did not have to expend considerable energy to mill away the rock (from underground observation). Finally, mine B did extract the least amount of rock of the four mines.

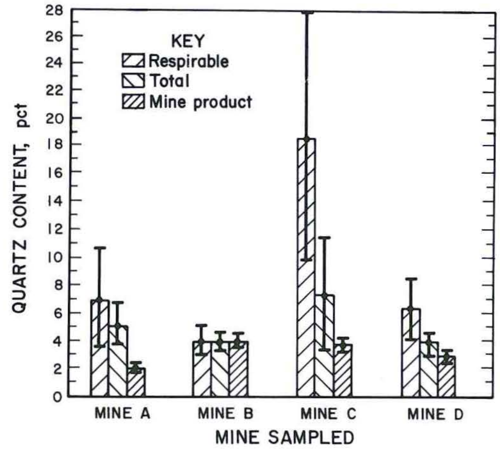

FIGURE 14. Average quartz content of dust and mine product in fundamental studies.

Impactor sampling was also conducted in the immediate return -- two crosscuts and four crosscuts outby the face in the return air to provide additional data on how quartz varies with the size of dust particles. Impactor dust samples were collected over nine cuts and analyzed for their quartz and kaolinite mineral content. The average quartz content in the return for three dust size ranges are shown in figure 15 with individual mine results shown in figures 16 and 17. The Average quartz content at various distances from the face are shown in figure 18.

Several stages of the impactor samples had to be combined for a significant amount of mass for quartz analysis. The size distribution ranges combined and analyzed for quartz included 0.6-3.5 µm, 3.5-10 µm, and 10-21 µm. The procedure of combining the various dust masses from the stages was designed to maximize the number of samples that possessed the minimum desired 25 µg of quartz mass for analysis. This procedure was successful in creating the proper quartz mass in 64 pct of the impactor samples analyzed. The P7 method has 13-22 pct measurement error for 25 to

250 µg of quartz. Some of the impactor samples (mostly the 0.6-3.5 µm range) possess a lower precision than this as a result of less weight.

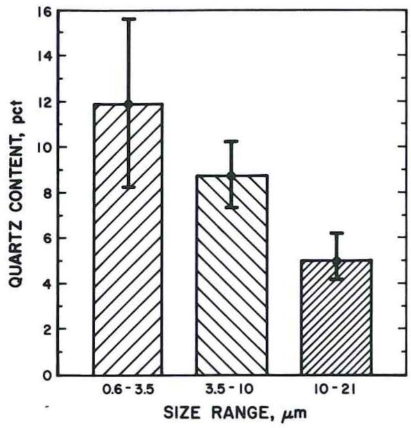

FIGURE 15. Average Quartz content of impactor samples from all mines.

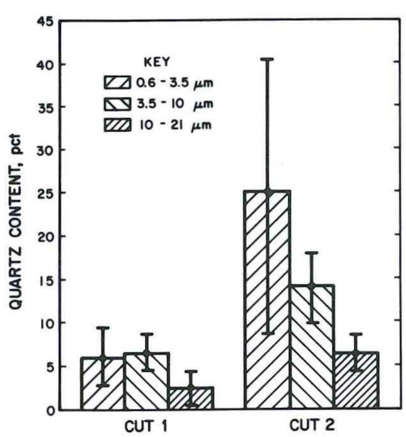

FIGURE 16. Quartz content of impactor samples from mine A.

Aerodynamically sized quartz results indicate that the quartz content tends to increase for smaller sized particles when cutting significant amounts of rock. This smaller size segregation of quartz can be observed from the average of all mines shown in figure 15. Quartz content in the 10-21 µm dust was significantly lower than the other two smaller size ranges. The 0.6-3.5 µm dust on average had a higher quartz content than the 3.5-10 µm dust, but had more variance in measurements than the two larger size ranges. This variability was most likely caused by the diminished precision of quartz analysis for the lower masses collected in this size range and the diversity in rock cut. The degree of quartz size segregation varied widely between the individual mines, indicating a high dependency on the coal seam lithology and/or rock morphology (see figures 16 and 17). Also, quartz content on average was observed to be fairly consistent at the various return locations for all size ranges (see figure 18).

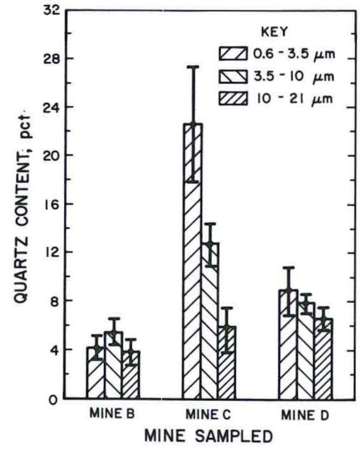

FIGURE 17. Quartz content of impactor samples from mines B, C, and D.

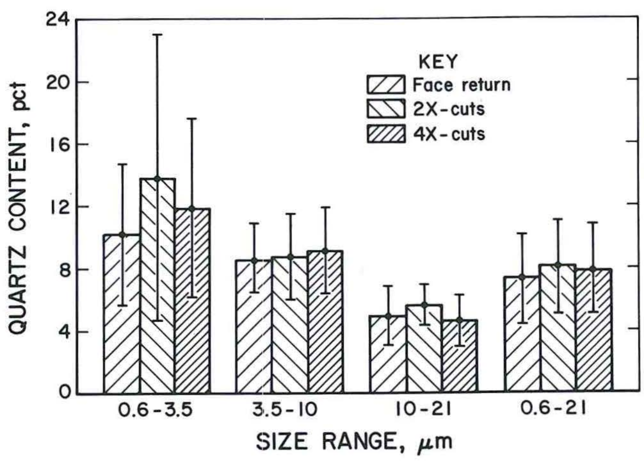

FIGURE 18. Average Quartz content of impactor samples at various distances from the mining face.

Further data examination indicates that the degree of size segregation of quartz in airborne dust may be directly related to the amount of rock mined (percentage of height mined) and the morphology of quartz bearing rock. Mine C extracted large amounts of rock (27 pct by height) and was observed to have the greatest segregation of quartz by particle size (see figure 17). Mine B and cut 1 of mine A extracted notably lower amounts of rock (16 pct and 12 pct, respectively) and quartz had the least size segregation (see figures 16 and 17). Cut 2 at mine A cut significantly more rock and the size segregation of quartz increased.

Figure 19 shows the scatter plot of the quartz content in respirable dust samples versus the portion of rock mined (percentage of seam height) for all the cuts. Examination of this plot shows that there is a moderate correlation between the amount of rock mined and quartz content in the respirable dust. However, the profound spread of some of the data points indicate that some other unexplained factors exist (especially the contrasting differences between mines A and C).

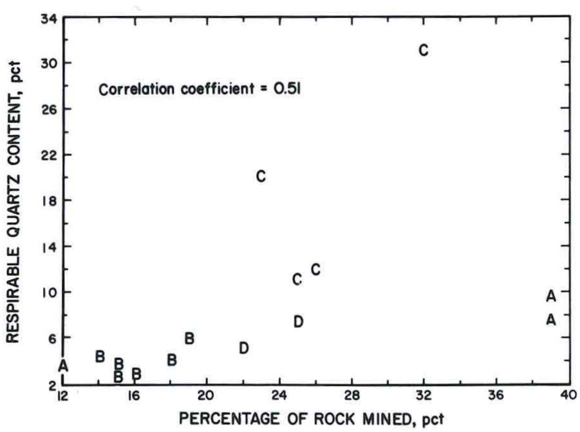

FIGURE 19. Scatter plot of quartz content in respirable dust samples and the amount of rock mined.

Further examination into the percentages of quartz and kaolinite minerals detected in the impactor dust samples indicate that the structural bonding of the quartz in the rock may be another factor responsible for the amount and size segregation of the quartz dust generated. The impactor samples collected were analyze for both quartz and kaolinite (clay) content. Figure 20 shows the average results of the mineral content in the impactor dust samples (0.6-21 µm) versus the weighted average of the quartz in the rock material mined. Both the quartz and kaolinite content in the dust for mine A notably increased from cut 1 to 2 with a significant increase in the amount of rock (sandstone) mined (12 pct to 39 pct). However, mine C mined 30 pct less rock (shale) than cut 2 of mine A and still had a notably higher quartz content in the dust than cut 2 of mine A, but discrepancies were observed between the

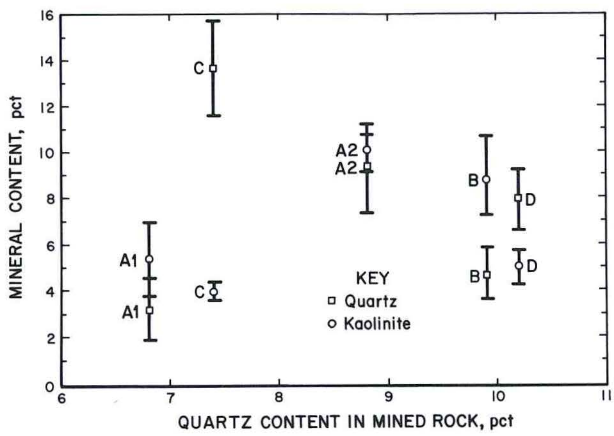

FIGURE 20. Mineral content in impactor dust samples and the quartz content in rock mined.

kaolinite and quartz portions of the dust. Kaolinite content in the dust at mine C is significantly lower than the quartz content. At mine A the quartz and kaolinite content were not significantly different. Also, note that although both mines C and D mined roughly similar amounts of shale and the quartz levels in the shale at D was higher, the quartz dust in mine D was notably lower. Kaolinite content at both of these mines was significantly lower than quartz, but the kaolinite content was higher at mine D. These results indicate that although the amount of rock mined affects the amount and size characteristics of quartz dust generated, individual differences in the rock morphology is most likely another influential factor between mines.

CONCLUSION

Quartz dust has been identified as the most important health concern in coal mines since the early 1980's. The mechanical cutting of rock by a continuous mining machine was found to be the major quartz dust in underground coal mines. Numerous non-designated occupations (roof bolters) are exposed to high levels of quartz dust because secondary support operations (roof bolting) are conducted on the return side of the mining machine.

Quartz within the dust was found to be size segregated into smaller size ranges when mining considerable amounts of rock and appears to be interrelated to rock morphology. Quartz content in the dust had a moderate correlation to the amount of rock mined. Quartz content and size distribution also showed a opposing association with kaolinite content in the dust, indicating that the silica bonding matrix in the rock is also responsible for its generation and size attributes. Finally, quartz content in the dust remained fairly uniform up to several hundred feet in the return of the dust source, demonstrating its mobility from the generation source in underground ventilation systems.

These unique quartz attributes are probably what impede existing dust control technology to adequately control quartz dust in the coal mining industry. Water spray and flooded bed scrubber systems used on continuous mining machines where found by the Bureau to exhibit diminishing collection efficiencies for smaller dust particles, therefore, making them unable to contend with the smaller quartz dust particles generated in underground mines (Jayaraman, McClelland, and Jankowski, 1988) (Colinet, McClelland, and Jankowski, 1990). Other evidence of inadequate technology can also be observed from the considerable percentage of compliance samples that contain more than 5 pct quartz. One-third of the dust samples collected in coal mines contain more than 5 pct quartz (Jankowski, Kissell, and Nesbit, 1985).

To combat this ongoing quartz dust problem, research should focus on technology to increase suppression, capture, and agglomeration of smaller sized dust particles. Secondly, advanced cutting technologies should be addressed to enhance efficiency and reliability of cutting systems in rock for reducing the amount of quartz fines from mechanical comminution. Finally, the morphology of minerals in rock types and the liberation mechanisms involved should be investigated to provide long-term direction for pioneering novel quartz dust prevention and control technology.

REFERENCES

Bureau of Mines, 1982, Standard Method P-7, Determination of Free Silica (Quartz) in Ashed Respirable Coal Mine Dust by Infrared Spectroscopy.

Colinet, J.F., et al., 1990, Laboratory Evaluation of the Quartz Dust Capture of Irrigated-Filter Collection Systems for Continuous Miners. BuMines RI 9313, 14 pp.

Colinet, J.F., Shirey, G.A., and Kost, J.A., 1985, Control of Respirable Quartz on Continuous Mining Sections (contract J0338033, BCR National Laboratory). BuMines OFR 29-86, 96 pp.; NTIS PB 86-179546.

Goldberg, S.A., Tomb, T.F., Kacsmar, P.M., MSHA's Procedure for Determining Quartz Content of Respirable Coal Mine Dust. Mine Safety and Health Administration.

Jankowski, R.A., Kissell, F.N., Nesbit, R.E., 1985, An Update of the Reduced Standards Problem and Overview of Improved Control Technology for Respirable Coal Mine Dust. 2d U.S. Mine Ventilation Symposium, Reno, NV, September 23-25.

Jayaraman, N.I., and Jankowski, R.A., 1988, Atomization of Water Sprays for Quartz Dust Control. Applied Industrial Hygiene, vol. 3, No. 12, December, pp. 327-331.

Jayaraman, N.I., McClelland, J.J., Jankowski, R.A., 1988, Reducing Quartz Dust with Flooded-Bed Scrubber Systems on Continuous Miners. VIIth International Pneumoconioses Conference. NIOSH-ILO-BOM-MSHA-OSHA, Pittsburgh, PA, August, 23-25.

Kok, E.G., Adam, R.F.J., and Pimentel, R.A., 1985, Control of Respirable Quartz on Continuous Mining Sections (contract J0338078, Ketron, Inc.). BuMines OFR 37-86, 169 pp.

Niewiadomski, G., Tomb, T. and Parobeck, P., 1988, Monitoring and Controlling Quartz Dust Exposure in U. S. Coal Mines. Current MSHA Program and Experience. VIIth International Pneumoconioses Conference, NIOSH-ILO-BOM-MSHA-OSHA, Pittsburgh, PA, August 23-25.

Organiscak, J.A., 1989, Respirable Dust Generation: Comparison of Continuous and Conventional Mining Methods When Excavating Rock in Coal Mines. BuMines RI 9233, 9 pp.

Ramani, R.V., et al., 1987, Fundamental Studies on the Relationship Between Quartz Levels in the Host Material and the Respirable Dust Generated During Mining - Volume I: Experimental Results and Analysis (contract H0358031, The Pennsylvania State University). BuMines OFR 36-88, 179 pp.; NTIS PB 88-214325/AS.

Taylor, L.D., Thakur, P.C., and Riester, J.B., 1986, Control of Respirable Quartz on Continuous Mining Sections (contract J0338077, Conoco, Inc.). BuMines OFR 18-87, 67 pp.; NTIS PB 87-181855.

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