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Survey of Nuisance and Biologically Active Dusts in Metal and Nonmetal Mines

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UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

cm^3	cubic centimeter
μm	micrometer
$\mu g/m^3$	microgram per cubic meter
mg	milligram
mg/m^3	milligram per cubic meter
mppcf	million particles per cubic foot
ppm	part per million

SURVEY OF NUISANCE AND BIOLOGICALLY ACTIVE DUSTS IN METAL AND NONMETAL MINES

By P. J. Watson,[1] D. Tallman,[2] and J. E. Pahlman[3]

ABSTRACT

The objective of this study was to prioritize the potential risks nuisance and biologically active dusts and fumes present in metal and nonmetal mines. This was accomplished by ranking numerical values derived from a matrix formula calculation that took into account dose, mine population, and sampling size. Data used in these calculations were obtained from the Mine Inspection Data Analysis System (MIDAS). The dusts determined to have the highest risk potential were quartz respirable particulates, mine dust, cristobalite respirable particulates, welding fume components, and nuisance respirable dust. Other dusts and fumes that were not ranked in this study, due to small sampling population, but which show a potential risk, include asbestos, talc, hydrogen cyanide, organic compound dusts, arsenic, metal dusts, and metal and nonmetal fumes.

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INTRODUCTION

A major mission of the Bureau of Mines is to protect miners' health and improve their safety. Asbestos, coal, and silica dusts present high potential health risks to miners and thus have been studied by both Bureau and other researchers. There are many other dusts that could produce severe, chronic, and debilitating diseases. Some of these include iron oxides (especially in combination with radon daughters or other radioactivity), taconite (which contains an asbestos-like amphibole), talc, beryllium, welding fumes, and wollastonite (a proposed asbestos substitute).

Mining of metal and nonmetal ores can produce dusts that represent a health threat to miners. There exists a significant historical perspective on the hazards of mine dust as related to health. Dusts in mines have long caused problems. Signs of pneumoconiosis in prehistoric bodies and anthracosis in Egyptian mummies have been observed. Only the lowliest Greek and Roman slaves were miners, since "condemnation to mining is almost as severe as the death penalty," according to Justinian (1).[4] Even in those ancient times, miners realized that dust was dangerous. According to Pliny, some miners tried to lessen the danger by covering their mouths with bladder skins (1).

Mine dust problems have existed since mining began, but only recently have specific health problems been linked with specific dusts. For example, in coal mining, continued exposure to respirable coal dust in excess of 2.0 mg/m^3 may lead to Black Lung or pneumoconiosis. Also, in both coal and noncoal mining operations, exposure to dusts containing silica may lead to silicosis. Because of a concern about other possibly hazardous dusts and fumes present in current mining operations, the Federal Mine Safety and Health Act of 1977 requires that the Department of Health, Education, and Welfare (HEW), now Health and Human Services (HHS) prepare reports on the toxicity levels of chemical and physical agents found in mines, through its constituent agency, the National Institute for Occupational Safety and Health (NIOSH). Pursuant to section 101 (a) (6) (b) of the Act, NIOSH prepared a document in 1979 entitled "Mining Surveillance: Potentially Toxic Occupational Exposures" (2) that reviewed existing pertinent information on toxic chemical and physical agents found in mines, gathered from sources including Government agencies (such as the Mine Safety and Health Administration (MSHA) and NIOSH), private industry, universities, associations, and labor unions.

Of the many agents identified during the 1979 review, 35 dusts, gases and fumes were identified at potentially toxic levels in mines. Dust is defined as "the loose term applied to solid particles predominantly larger than colloidal and capable of temporary suspension in air or other gases" (3). Potentially toxic dusts identified were arsenic, asbestos, benzoanthracene, benzopyrene, beryllium, chrysene, coal mine dust, ethylene glycol dinitrate, graphite, lead, perlite, silica, and talc. Benzoanthracene, benzopyrene, and chrysene were identified in diesel emissions. Fumes are "the solid particles generated by condensation from the gaseous state, generally after volatilization from melted substances, and often accompanied by a chemical reaction such as oxidation" (3). Potentially toxic gases and fumes identified were ammonia, carbon monoxide, carbon tetrachloride, hydrogen sulfide, mercury vapor, nitrogen dioxide, oxygen deficiency, nitroglycerine, perchloroethylene, trichloroethylene, and welding fumes as containing arsenic, cadmium, chromium, cobalt, lead, manganese, nickel, ozone, and vanadium. Other potentially hazardous agents identified were gamma radiation, heat, noise, and radon daughters. In general, the data base for this report was not extensive for many biologically active and nuisance dusts and fumes. Additionally, while several other dusts and fumes not mentioned in

[4] Underlined numbers in parentheses refer to items in the list of references at the end of this report.

the NIOSH report exhibit very few respiratory hazards, they are described as irritating with reactions ranging from minor skin irritations to major skin diseases. These dusts include potash, wollastonite, nepheline, salt, and trona.

The toxicity of substances present in these dusts and fumes has been assessed by NIOSH, American Conference of Governmental Industrial Hygienists (ACGIH), and others, and criteria document levels have been determined for each substance. The presence of these toxic and/or hazardous substances in mine dusts at levels above the NIOSH criteria document levels may pose a threat to the health of mine personnel. Once the levels of various dusts actually present in the mine work environment are defined and the degree of risk is assessed and prioritized, control technologies for reduction or elimination of that risk may be investigated and developed along with recommendations for future monitoring activities.

The largest body of environmental data for mine workers is kept by MSHA. Once a substance is recognized to be a potential health risk and regulatory levels are established, compliance sampling is done by mine inspectors. These data are available for computerized statistical analysis through MIDAS (4). The objective of this study was to prioritize the potential risks of biologically active and nuisance dusts and fumes present in metal and nonmetal mines. Biologically active dusts and fumes are those dusts and fumes that can react or interact with a biological system or function. Nuisance dusts are those dusts that are not presently believed to be a potential health risk, but nevertheless are an irritating nuisance in the mine environment.

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ANALYSIS OF DUST HAZARDS

PROBLEM DETERMINATION MATRIX

After reviewing the medical references on potential dust exposures, in conjunction with the published NIOSH hazards, the authors determined that development of a method for dust risk assessment ranking would be necessary. The appendix lists the medical literature surveyed in a bibliography.

In order to determine whether a given dust in a given mining commodity was a potential risk, it was necessary to develop a method for ranking. This method took the form of a critical-path flow chart (5), where each step in the process led through the path, giving a numerical value from MSHA or MIDAS data, to a final value which could then be compared with other values from different dusts and/or mining commodities. The major questions to be answered included

- Does this particular dust or fume exist in this mining commodity?

- How many miners does it affect?

- What is the dose of this dust or fume in this mining commodity and how does it compare to the threshold limit value (TLV) from the ACGIH and the critical document values from NIOSH?

- What is the duration of exposure; (hours/day, years/lifetime?)

o What is the health effect and degree of severity of the effect?

o What are the mine population characteristics; (number of persons exposed?) This critical path flow chart was also concerned with process changes and inadequate data. Only existence, mine population, and dose (the first three factors above) were included in the matrix calculations, since this information was available from MIDAS and other MSHA sources. The matrix value was calculated by the formula

$$V = (C/TLV) \times (N_i/N_t),$$

where V = matrix value,

C = dose of contaminant, mg/m^3,

TLV = threshold limit value for the contaminant, mg/m^3, from 1973 values,

N_i = number of miners in commodity,

and N_t = total number of miners; N_i and N_t both from MSHA, based on 1984 figures.

Figure 1 shows the flow chart. The average geometric dose of contaminant was then obtained by dividing the dose of C by TLV.

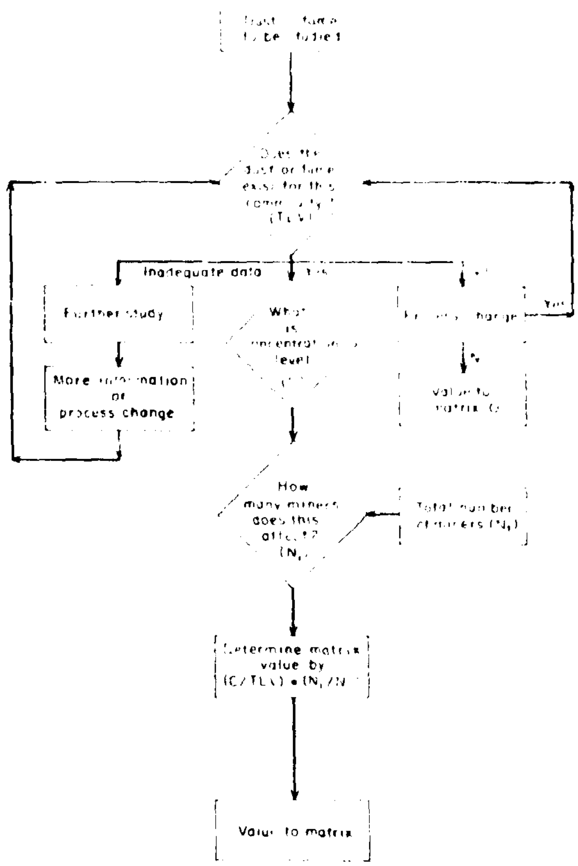

FIGURE 1.—Dust problem critical path flow chart. N is sample frequency.

To answer the questions asked in the flow chart and complete the matrix, a survey of the data contained in the MIDAS was conducted (3). As each question was answered for each commodity and/or contaminant combination using the MIDAS analysis data, the matrix could be filled in. As the matrix was completed, the variability in sampling frequency appeared to adversely affect potential hazard ranking. The contaminants recorded in MIDAS were separated into four groupings called files: Area, Dusts, Fumes, and Metals. Figure 2 illustrates the sampling frequencies for the four files surveyed, which gives an idea of where sampling was concentrated and additional sampling could be recommended. Because of this uneven sampling distribution, a concern was expressed over biasing the data by a single, anomalously large concentration value. This was a very real possibility since, often, a mine inspector will sample more frequently in areas of known potential dust hazards. This nonrandom sampling technique, along with the practice of not sampling for all contaminants in every mine, could lead to some serious biasing problems in the technique of ranking used in this report. The matrix was set up with a summing function, where the sum of commodity values considering all contaminants (S_i), the sum of contaminant values considering all commodities (S_j), and the sum of both ($S_{i,j}$) were all considered. This summing process allowed the bias of using all sample values to be demonstrated: Figure 3*A* illustrates the bias when considering the commodity totals; figure 3*B*, the bias

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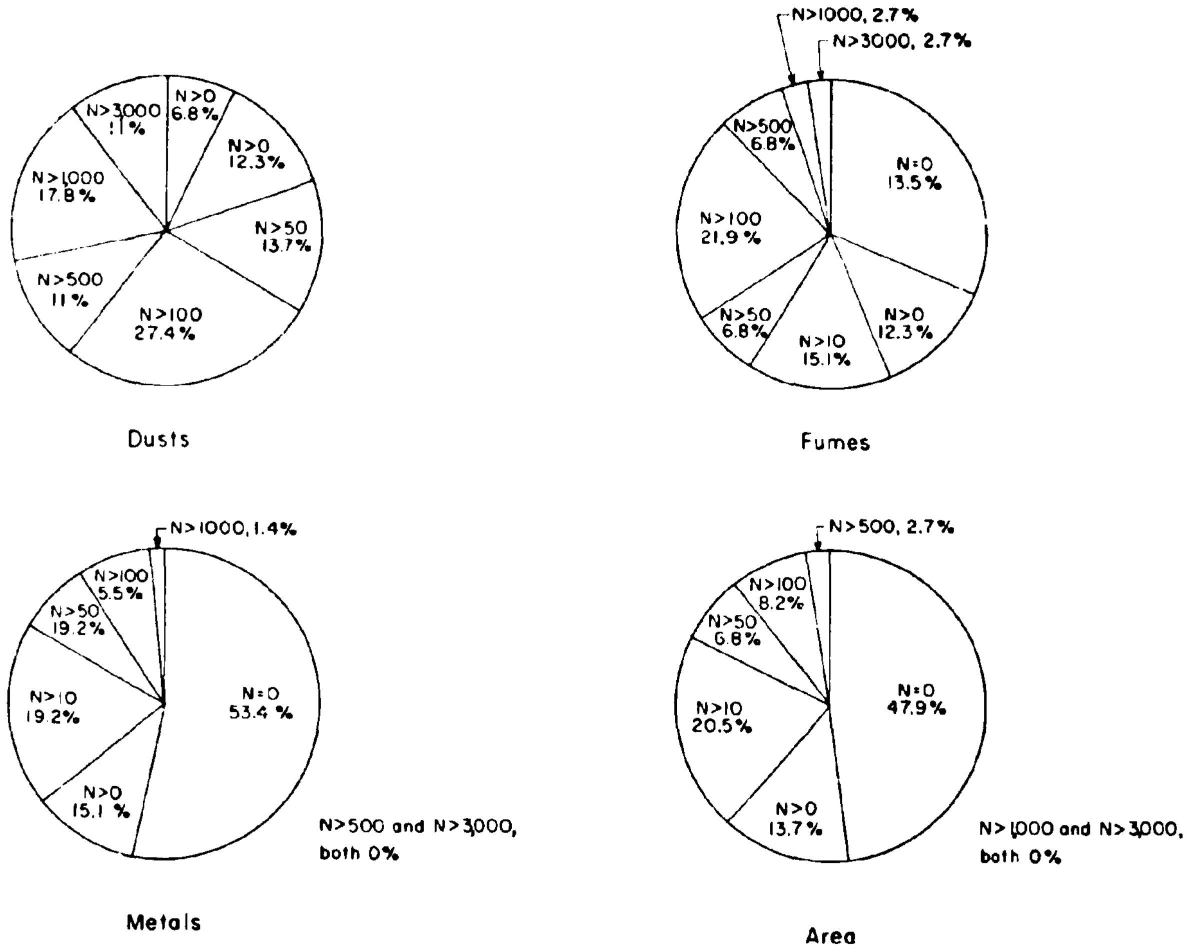

FIGURE 2.—Statistical pattern for dusts, fumes, metal dusts, and area files.

in contaminant totals; and figure 3c the bias when considering nonzero values for the total sample versus the N > 50 sample. In all, there were 88 mining commodities tracked within MIDAS, but several of these commodities were in the mineral processing area, not actually mining the materials to be processed, leaving 75 commodities to survey. Of these 75 commodities, only 53 had sampling populations greater than 50 for at least 1 contaminant. Table 1 summarizes these 53 commodities with their standard industrial classification codes. The remaining commodities were then analyzed for each of the contaminants contained within the files. Additionally, there are 134 different contaminants contained in all the files. Several of these contaminants, such as noise or oxygen content, were not considered in the matrix analysis since they do not relate to dust or fume hazards, which left 65 contaminants to survey. Of these 65 contaminants, only 24 had sampling populations greater than 50 for at least 1 commodity. Table 2 summarizes these 24 contaminants, giving MSHA code, file, and TLV information. As the matrix was completed, several interesting results became evident; these results are discussed below.

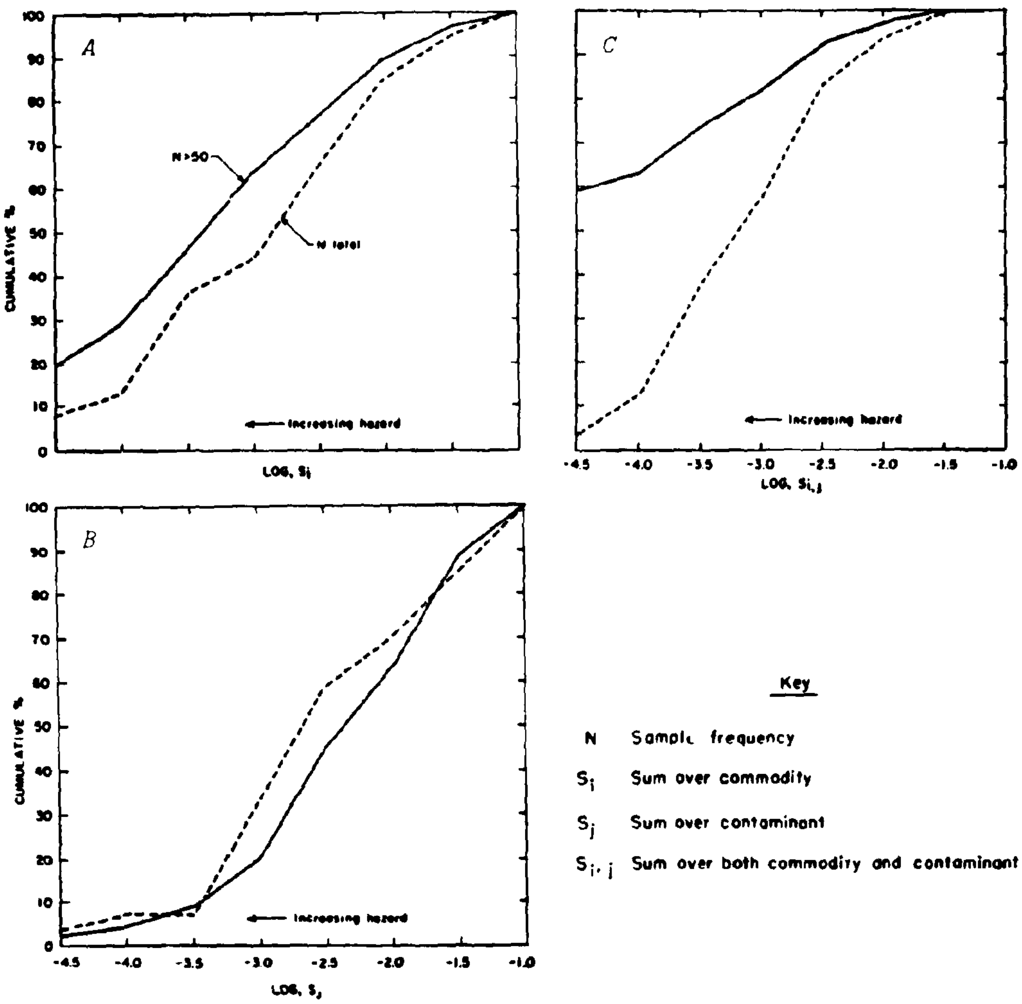

FIGURE 3.—Frequency distribution versus hazard severity for *A*, commodity totals, *B*, contaminant totals, and *C*, $N > 50$ comparing zero versus nonzero matrix values.

MATRIX RESULTS

When the matrix was completed for the four files surveyed, values for each grouping could be compared. The individual matrix values are summarized in table 3 for area files, table 4 for dusts, table 5 for fumes, and table 6 for the metal dusts. Individual contaminants within all four files as well as the separate mining commodities, could be ranked for risk potential with the result that the higher the values were, the more potential for risk. High values in the matrix could relate to high contaminant concentration, large mining population, or a combination of both. The potential risk could be considered as serious, whether it resulted from a few miners being exposed to a high contaminant concentration (such as mercury, chromium fumes, or hydrogen cyanide) or a large mining population being exposed to a somewhat lower contaminant concentration.

TABLE 1. Mining commodities surveyed

Commodity	SIC[1] code	Commodity	SIC[1] code
Iron ore	10110	Clay, common	14550
Copper ore	10210	Clay, ceramic	14590
Lead and/or zinc ore	10310	Feldspar	14593
Gold lode and/or placer	10410	Magnesite	14595
Silver ores	10440	Shale, common	14596
Molybdenum	10615	Barite	14720
Tungsten	10617	Fluorspar	14730
Uranium and/or vanadium	10940	Potash, soda, and boron	14740
Uranium	10941	Potash	14742
Beryl	10992	Trona	14743
Oil shale	13111	Sodium compounds	14744
Stone, dimension	14110	Phosphate rock	14750
Granite, dimension	14111	Salt, rock	14760
Limestone, dimension	14112	Lithium	14791
Marble, dimension	14113	Gypsum	14920
Sandstone, dimension	14114	Talc, pyrophylite	14960
Slate, dimension	14115	Nonmetal minerals	14990
Traprock, dimension	14116	Asbestos	14991
Limestone, crushed	14220	Mica	14994
Granite, crushed	14230	Pumice	14997
Stone, crushed	14290	Vermiculite	14998
Marble, crushed	14291	Alumina, mill	28191
Sandstone, crushed	14292	Salt, evaporite	28991
Slate, crushed	14293	Leonardite	29900
Traprock, crushed	14294	Cement	32410
Sand and gravel	14410	Lime	32740
Clay, fire	14530		

[1]SIC - Standard Industrial Classification.

Ranking the contaminants together produced a listing for potential risks within each mining commodity (table 7). Table 8 summarizes the survey of the individual contaminants considered throughout the mining industry.

TABLE 2. - TLV's of dusts and fumes studied

(Milligrams per cubic meter unless otherwise specified)

Dust or fume	MSHA identification		TLV
	Code	File	
Respirable mine dust	121	Dust	5
Total mine dust	123	...do...	10.0
Nitric oxide	301	Area	[1]30
Hydrogen sulfide	305	...do...	[1]20
Sulfur dioxide	421	...do...	13
Asbestos	501	Dust	[2]2
Talc, nonfibrous	511	...do...	[3]20×10^6
Quartz, respirable particulates	523	...do...	[4]10/%+2
Cristobalite, respirable particulates	525	...do...	[4]5/%+2
Beryllium dust	541	Metal	[5]2
Arsenic dust	613	...do...	[5]500
Lead dust	635	...do...	[5]150
Welding fumes	701	Fumes	10.0
Aluminum oxide fumes	703	...do...	10.0
Beryllium fumes	709	...do...	2.0
Chromic acid fumes	713	...do...	1.0
Cobalt fumes	715	...do...	0.1
Copper fumes	717	...do...	1.0
Iron oxide fumes	721	...do...	10.0
Lead fumes	723	...do...	[5]150
Manganese fumes	727	...do...	5.0
Nickel fumes	733	...do...	1.0
Vanadium fumes	743	...do...	0.05
Mixed contaminants	999	Area	

MSHA Mine Safety and Health Administration. TLV Threshold limit value.
[1]parts per million. [2]Fibers per cubic centimeter.
[3]Million particles per cubic foot.
[4]10 mg/m^3 divided by percent respirable quartz present +2 mg/m^3.
[5]Micrometers per cubic meter.

TABLE 3. - Matrix values for area file contaminants[1]

Mining commodity	N_i/N_t	MSHA code 301	MSHA code 305	MSHA code 421	MSHA code 999	Total matrix value for commodity
Copper ore	0.0609	ISP	0.0006	0.0006	ISP	0.0012
Lead and/or zinc ore	.0165	ISP	.0005	ISP	ISP	.0005
Gold lode and/or placer	.0350	0.0018	.0004	ISP	ISP	.0022
Limestone crushed	.1789	ISP	.0018	.0018	0.0251	.0287
Fluorspar	.0008	ISP	.0004	ISP	ISP	.0004
Salt, rock	.0091	ISP	.0005	ISP	ISP	.0005
Gypsum	.0060	ISP	.0001	ISP	ISP	.0001
Nonmetal minerals	.0081	ISP	.0006	ISP	ISP	.0006
Contaminant total		.0018	.0049	.0024	.0251	.0342

C/TLV Concentration/Threshold limit value.
ISP Insufficient sample population; N < 50.
MSHA Mine Safety and Health Administration.
N_i/N_t Number of miners in commodity/total number miners.

TABLE 4. - Matrix values for dusts file contaminants

Mining commodity	N_i/N_t	MSHA code 121	MSHA code 123	MSHA code 501	MSHA code 511	MSHA code 523	MSHA code 525	Total matrix value for commodity
Iron ore....................	0.0460	0.0019	0.0921	0.0017	NR	0.0138	0.0952	0.2047
Copper ore..................	.0609	.0022	.0539	ISP	NR	.0261	NR	.0822
Lead and/or zinc ore........	.0165	.0015	.0083	ISP	NR	.0070	NR	.0168
Gold lode and/or placer.....	.0350	.0012	.0247	ISP	NR	.0179	NR	.0438
Silver ores.................	.0140	.0010	ISP	ISP	NR	.0064	NR	.0074
Molybdenum..................	.0127	.0005	ISP	ISP	NR	.0088	NR	.0093
Tungsten....................	.0013	ISP	NR	NR	NR	.0010	NR	.0010
Uranium and/or vanadium.....	.0005	.0000	ISP	NR	NR	.0002	NR	.0002
Uranium.....................	.0165	.0003	.0045	ISP	NR	.0055	NR	.0103
Oil shale...................	.0015	ISP	ISP	NR	NR	.0006	NR	.0006
Stone, dimension............	.0011	ISP	ISP	NR	NR	.0004	NR	.0004
Granite, dimension..........	.0053	.0001	ISP	ISP	NR	.0032	NR	.0033
Limestone, dimension........	.0038	.0005	.0051	NR	NR	.0012	NR	.0068
Marble,dimension............	.0011	.0005	.0008	ISP	NR	ISP	NR	.0013
Sandstone, dimension........	.0017	ISP	ISP	NR	NR	.0010	NR	.0010
Slate, dimension............	.0108	ISP	NR	NR	NR	.0048	NR	.0048
Traprock, dimension.........	.0003	ISP	ISP	ISP	NR	.0001	NR	.0001
Limestone, crushed..........	.1789	.0171	.1667	.0060	NR	.0474	ISP	.2372
Granite, crushed............	.0235	.0008	.0269	ISP	NR	.0096	NR	.0373
Stone, crushed..............	.0109	.0006	.0099	ISP	NR	.0060	NR	.0165
Marble, crushed.............	.0036	ISP	.0048	ISP	NR	ISP	NR	.0048
Sandstone, crushed..........	.0130	.0003	.0147	ISP	NR	.0085	ISP	.0235
Slate, crushed..............	.0008	ISP	ISP	NR	NR	.0004	NR	.0004
Traprock, crushed...........	.0140	.0008	.0134	.0019	NR	.0056	NR	.0217
Sand and gravel.............	.2324	.0058	.1316	.0075	NR	.0845	NR	.2294
Clay, fire..................	.0051	.0002	.0044	NR	NR	.0034	ISP	.0080
Clay, common................	.0433	.0049	.0558	ISP	NR	.0258	ISP	.0865
Clay, ceramic...............	.0008	ISP	.0004	NR	NR	ISP	NR	.0004
Feldspar....................	.0020	ISP	ISP	ISP	NR	.0010	ISP	.0010
Magnesite...................	.0010	ISP	.0009	NR	NR	NR	NR	.0009
Shale, common...............	.0043	.0001	.0036	NR	NR	.0024	NR	.0061
Barite......................	.0064	.0003	.0079	ISP	ISP	.0065	NR	.0147
Fluorspar...................	.0008	.0002	.0004	ISP	NR	.0004	NR	.0010
Potash, soda, boron.........	.0017	ISP	.0019	ISP	NR	ISP	NR	.0019
Potash......................	.0073	ISP	.0067	ISP	NR	ISP	NR	.0067
Trona.......................	.0062	ISP	.0100	NR	NR	ISP	NR	.0100
Sodium compounds............	.0079	NR	.0115	NR	NR	NR	NR	.0115
Phosphate rock..............	.0274	.0015	.0280	ISP	NR	.0046	NR	.0341
Salt rock...................	.0091	ISP	.0112	ISP	NR	ISP	NR	.0112
Lithium.....................	.0011	ISP	NR	ISP	NR	.0003	NR	.0003
Gypsum......................	.0060	.0007	.0060	ISP	NR	.0014	NR	.0081
Talc, pyrophylite...........	.0345	.0044	.0818	.0057	0.0092	.0162	NR	.1173
Nonmetal minerals...........	.0081	.0006	.0079	ISP	NR	.0063	.0146	.0294
Asbestos....................	.0018	ISP	NR	.0007	NR	ISP	NR	.0007
Mica........................	.0016	ISP	ISP	ISP	NR	.0005	NR	.0005
Pumice......................	.0011	.0001	.0010	ISP	NR	ISP	NR	.0011
Vermiculite.................	.0014	ISP	ISP	.0002	NR	ISP	NR	.0002
Alumina, mill...............	.0189	ISP	.0069	ISP	ISP	ISP	NR	.0069
Salt, evaporite.............	.0017	NR	.0009	ISP	NR	NR	NR	.0009
Leonardite..................	.0002	ISP	ISP	NR	NR	.0002	NR	.0002
Cement......................	.0543	.0107	.0691	ISP	NR	.0159	ISP	.0957
Lime........................	.0146	.0022	.0109	NR	NR	.0050	NR	.0181
Contaminant total................		.0610	.8846	.0237	.0092	.3499	.1098	1.4382

NR Not reported. ISP Insufficient sample population; N < 50.

TABLE 5. - Matrix values for fumes file contaminants

Mining commododity	N_i/N_t	MSHA code 701	MSHA code 703	MSHA code 709	MSHA code 713	MSHA code 715	MSHA code 717	MSHA code 721	MSHA code 723	MSHA code 727	MSHA code 733	MSHA code 743	Total matrix value for commodity
Iron ore...........	0.0460	0.0129	0.0000	0.0000	0.0014	0.0000	0.0005	0.0028	0.0005	0.0005	0.0000	0.0005	0.0191
Copper ore.........	.0609	.0091	.0006	.0000	.0006	.0000	.0012	.0024	ISP	ISP	.0000	.0000	.0139
Lead and/or zinc ore.	.0165	.0020	.0000	ISP	.0003	ISP	.0002	.0007	.0018	.0002	ISP	.0002	.0054
Silver ores........	.0140	ISP	ISP	ISP	ISP	ISP	ISP	.0004	ISP	ISP	ISP	ISP	.0004
Limestone, crushed.	.1789	.0251	.0018	.0018	.0125	.0000	.0018	.0054	.0018	.0036	.0018	.0018	.0574
Traprock, crushed..	.0140	.0039	ISP	ISP	ISP	ISP	ISP	.0008	ISP	ISP	ISP	ISP	.0047
Sand and gravel....	.2324	.0116	.0000	ISP	ISP	ISP	ISP	.0070	ISP	ISP	ISP	ISP	.0186
Phosphate rock.....	.0274	.0030	.0003	ISP	.0008	.0022	.0003	.0008	ISP	.0003	ISP	.0000	.0077
Cement.............	.0543	.0071	.0000	ISP	.0016	ISP	.0005	.0016	ISP	ISP	.0005	ISP	.0113
Contaminant total.......		.0747	.0027	.0018	.0172	.0022	.0045	.0219	.0041	.0046	.0023	.0025	.1385

ISP Insufficient sample population; N < 50.

TABLE 6. - Matrix values for metal dusts file contaminants

Mining commodity	N_i/N_t	MSHA code 541	MSHA code 613	MSHA code 635	Total matrix value for commodity
Lead and/or zinc ore...............	0.0165	ISP	0.0002	0.0013	0.0015
Gold lode and/or placer............	.0350	ISP	ISP	.0053	.0053
Silver ore.........................	.0140	ISP	ISP	.0022	.0022
Beryl..............................	.0005	0.0001	NR	NR	.0001
Contaminant total.......................		.0001	.0002	.0088	.0091

ISP Insufficient sample population; N < 50.
NR Not reported.

TABLE 7. - Matrix values for mining commodities

Rank	Mining commodity	Value	Rank	Mining commodity	Value
1....	Limestone, crushed........	0.3233	28...	Potash....................	0.0067
2....	Sand and gravel...........	.2480	29...	Shale, common.............	.0061
3....	Iron ore..................	.2238	30...	Slate, dimension..........	.0048
4....	Talc, pyrophylite.........	.1173	31...	Marble, crushed...........	.0048
5....	Cement....................	.1070	32...	Granite, dimension........	.0033
6....	Copper ore................	.0973	33...	Potash, soda, boron.......	.0019
7....	Clay, common..............	.0865	34...	Fluorspar.................	.0014
8....	Gold lode and/or placer...	.0513	35...	Marble, dimension.........	.0013
9....	Phosphate rock............	.0418	36...	Pumice....................	.0011
10...	Granite, crushed..........	.0373	37...	Tungsten..................	.0010
11...	Nonmetal minerals.........	.0300	38...	Sandstone, dimension......	.0010
12...	Traprock, crushed.........	.0264	39...	Feldspar..................	.0010
13...	Lead and/or zinc ore......	.0242	40...	Magnesite.................	.0009
14...	Sandstone, crushed........	.0235	41...	Salt, evaporite...........	.0009
15...	Lime......................	.0181	42...	Asbestos..................	[1].0007
16...	Stone, crushed............	.0165	43...	Oil shale.................	.0006
17...	Barite....................	.0147	44...	Mica......................	.0005
18...	Salt, rock................	.0117	45...	Stone, dimension..........	.0004
19...	Molybdenum................	.0115	46...	Slate, crushed............	.0004
20...	Sodium compounds..........	.0115	47...	Clay, ceramic.............	.0004
21...	Uranium...................	.0103	48...	Lithium...................	.0003
22...	Trona.....................	.0100	49...	Uranium and/or vanadium...	.0002
23...	Gypsum....................	.0082	50...	Vermiculite...............	[1].0002
24...	Clay, fire................	.0080	51...	Leonardite................	.0002
25...	Silver ores...............	.0078	52...	Beryl.....................	.0001
26...	Alumina, mill.............	.0069	53...	Traprock, dimension.......	.0001
27...	Limestone, dimension......	.0068			

[1]Changing the threshold limit value to 0.2 fibers/cm^3 from 2 fibers/cm^3 would increase the matrix value and therefore result in a higher rank.

TABLE 8. - Matrix values for dust or fume contaminants

Rank	Dust or fume	Value
1...	Total mine dust............	0.8846
2...	Quartz, respirable particulates.	.3499
3...	Cristobalite, respirable particulates.	.1098
4...	Welding fumes..............	.0747
5...	Respirable mine dust.......	.0610
6...	Mixed contaminants.........	.0251
7...	Asbestos...................	.0237
8...	Iron oxide fumes...........	.0219
9...	Chromic acid fumes.........	.0172
10..	Talc nonfibrous............	.0092
11..	Lead dust..................	.0088
12..	Hydrogen sulfide...........	.0049
13..	Manganese fumes............	.0046
14..	Copper fumes...............	.0045
15..	Lead fumes.................	.0041
16..	Aluminum oxide fumes.......	.0027
17..	Vanadium fumes.............	.0025
18..	Sulfur dioxide.............	.0024
19..	Nickel fumes...............	.0023
20..	Cobalt fumes...............	.0022
21..	Nitric oxide...............	.0018
22..	Beryllium fumes............	.0018
23..	Arsenic dust...............	.0002
24..	Beryllium dust.............	.0001

Comparison of the matrix values presented several areas of potential risk. Mining commodities with the highest absolute matrix values are summarized in table 9. These commodities range from metals (copper, gold lode--placer, and lead--zinc), to stone products (crushed limestone and sand and gravel), to several unique mining commodities (common clay, phosphate rock, talc, and cement). The high values came from contributions from all four file areas. The area file contribution came mainly from hydrogen sulfide, which was commodity specific, e.g., phosphate and fluorspar. Dust file contributions included respirable mine dust and quartz respirable particulates. Additional values came from cristobalite respirable particulates. The highest values for the fumes files came from welding fumes and individual components

TABLE 9. - Mining commodities with highest matrix values

Commodity	Value
Limestone, crushed...............	0.3233
Sand and gravel..................	.2480
Iron ore.........................	.2238
Talc, pyrophylite................	.1173
Cement...........................	.1070
Copper ore.......................	.0973
Clay, common.....................	.0865
Gold, lode and placer............	.0513
Phosphate rock...................	.0418

TABLE 10. - Dust or fume contaminants with highest matrix values

Dust or fume	Value
Total mine dust..................	0.8846
Quartz, respirable particulates..	.3499
Cristobalite, respirable particulates....................	.1098
Welding fumes....................	.0747
Respirable mine dust.............	.0610

of welding fumes such as aluminum oxide, chromic acid, copper, iron oxide, lead, and vanadium. Lead dust, another commodity-specific dust, was the major component of the metal dust files. Table 10 summarizes the contaminants with the highest values summed throughout the entire mining industry. These contaminants are mainly dusts, with one exception. Their ranking order was quartz respirable particulates, total mine dust, cristobalite respirable particulates, welding fumes, and respirable mine dust. Cristobalite respirable particulates and welding fumes affected very few commodities, yet still ranked very high in order of potential risk and may bear closer scrutiny in future research.

Although the dusts and fumes identified in both the literature search and the NIOSH report are described as potential risks, only those dusts and fumes that are currently being regulated showed up in the matrix as potential risks, probably due to the sampling frequency bias mentioned earlier.

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Dust is a proven health risk in the mining industry. Many dusts, from less than 0.3 μm to greater than 10 μm, will have an impact on the human system ranging from surface contact to respiratory infiltration. Individual dusts are known to cause medical problems ranging from mildly irritating, through debilitating (total disability), to fatal.

The survey of the MIDAS data indicates that the proven dust risks are more thoroughly monitored as well as studied. The dusts this ranking identified as having the highest risk potential are quartz respirable particulates, total mine dust, cristobalite respirable particulates, welding fumes, and respirable mine dust. Several of the dusts and fumes for which data are available in MIDAS, which may adversely impact miners' health, appear not to have been studied as thoroughly as those with known risks. Some of these other dusts and fumes not considered in this study, due to small sampling population, may have shown a potential risk if more samples in more commodities had been taken and recorded. These include asbestos, talc, cyanide (HCN), organic compound dusts, arsenic, other metal dusts, and metal and nonmetal fumes of all varieties (mercury, etc.). The potential health risks of these dusts and fumes are discussed in the references in the Appendix. Increasing sample frequency for all dusts and fumes considered, though time consuming and expensive, is recommended to allow more logical comparisons between dusts and across commodities.

Additional areas for future considerations are cross contamination, additive effects of more than one dust present, and fugitive dusts. These are areas ripe for potential study, but which are lacking hard data.

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APPENDIX.--SUMMARY OF REVIEW OF DUST RISKS

Many dusts exist in mines, but not all are harmful to a miner's health. Although NIOSH and ACGIH analyze the potential health risks for dusts and set the allowable standards for those dusts in mines, dust control and assessment have long been Bureau concerns (1-13). References 1 through 13 demonstrate some of the history of that concern.

In order to develop a background for constructing the matrix, an extensive literature search was conducted in other areas of dust information besides historical bckground. These articles are listed in the bibliography at the end of the appendix. Health risks of some specific dusts and fumes are covered in references 14 through 72 and are identified in table A-1 with their specific reference numbers. General health effects are discussed in references 73 through 96, while dust sampling techniques and general regulatory standards for dusts and fumes are discussed in references 97 through 110 and references 111 through 126, respectively.

TABLE A-1. - Dusts and fumes with potential health risks identified from the literature survey

Dust or fume	References
Asbestos, including chrysotile	18, 20, 22, 25, 29, 31, 35, 47-49, 53, 54, 62, 66, 70
Beryllium	19-20, 26, 33-34, 41, 44-45, 65, 72
Coal	15-16, 22, 51, 59
Diatomite	24
Fluorspar	30
Gold	21, 29, 50 71
Kaolin	14, 32, 46
Iron, including taconite	17, 23, 27-28, 39, 42-43, 57-58, 64, 69
Magnetite	52
Nepheline	55
Phosphate	60
Potash	38
Salt	56, 68
Silica	20, 36, 67
Slate	37
Trona	61
Welding fumes	63
Wollastonite	40

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