FINAL REPORT

to

MINNESOTA ENVIRONMENTAL QUALITY BOARD
REGIONAL COPPER-NICKEL STUDY

Mineral Processing Studies

Dust Generation in Crushing and Handling

Mineral Resources Research Center
University of Minnesota
April 24, 1980

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Dust Generation in Crushing and Handling

by

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DUST GENERATION IN CRUSHING AND HANDLING

The purpose of the present investigation is to provide data that will permit reasonable extrapolation on the amount and character of dusts to be generated in the crushing and handling of copper-nickel bearing Duluth gabbro. No direct measurements of dust concentrations near a pilot-plant crusher operating on Duluth gabbro samples would simulate the real situation in a crusher plant or the air effluent from the dust collection system. It was proposed, therefore, that the following four sets of experimental data be used to estimate by extrapolation the potential dust generated not only in crushing, but also from conveyors, loading and transfer stations, and storage piles.

1. "Dust data" in crusher buildings and air effluents from operating taconite plants.

2. Size distribution of crushed products from each stage of the taconite plant crushing process, especially in the micron size range.

3. Size distribution of the taconite samples crushed in each stage of the MRRC pilot plant.

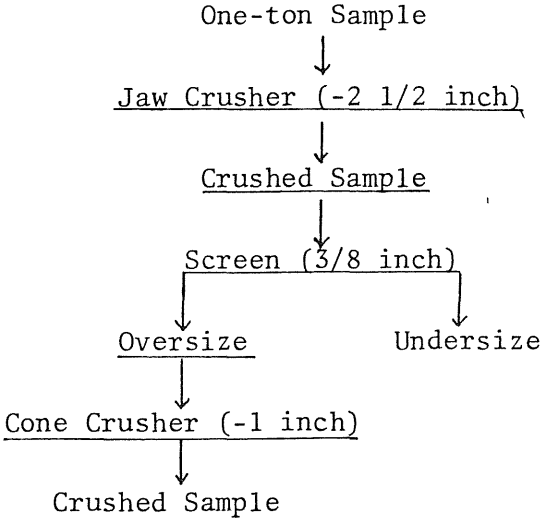
4. Size distribution of Duluth gabbro samples crushed in each stage of the MRRC pilot plant.

Although such an approach could not give precise quantitative information the data could be utilized to estimate the dust generation potential in a semi-quantitative manner.

Ideally, the "dust data" and the taconite samples should be collected simultaneously. Several different taconite plants with different degrees

of dust control facilities, including a plant meeting EPA new source performance standards should be sampled. Furthermore, about half a dozen samples of Duluth gabbro to cover a range of texture and degree of mineralization should be included. The size distribution data of both the taconite and Duluth gabbro samples in the MRRC pilot plant are necessary since the distribution characteristics of crushed products differ for different materials and for different crushers. Due to the Copper-Nickel budget constraints, however, the number of taconite and Duluth gabbro samples in the present report was limited to one sample each.

For comparative crushing studies of copper-nickel crude and taconite samples approximately a one-ton sample of 4 to 6-inch lumps of copper-nickel crude sample was hand picked from the AMAX Sample 2 pile. Three drums of taconite lumps weighing in excess of one ton were received from Erie Mining Company on November 22, 1977. The flowsheet for the crushing studies, patterned after the Erie plant flowsheet, is shown below. The crushers at MRRC were a 10-inch x 20-inch Traylor jaw crusher and a 2-foot Symons cone crusher.



The size distributions of the jaw crusher, minus 3/8-inch screen, and the cone crusher products were determined using testing screens to 200 mesh and then microscreens wet to 10 μm. Originally, the minus 200-mesh fractions were to be fractionated with an air classifier by the Donaldson Company, but sufficiently large samples of the minus 200-mesh fractions were not obtained. The results are given in Tables 1 and 2, and the size distribution data are plotted in Figures 1 and 2 in terms of cumulative percent weight passing versus particle diameter on a log-log paper. It is apparent both in the tables and figures that the jaw crusher product of the taconite sample was coarser than that of the Duluth gabbro sample, but that the size distributions of the minus 3/8-inch screen products and the cone crusher products were similar.

To investigate if the copper and nickel contents might segregate upon crushing, the size fractions were combined in regular intervals and analyzed. The analytical results are included in Table 2(a). Both the copper and nickel contents showed tendencies to increase in finer size fractions. A head sample was prepared by reconstituting the minus 3/8-inch screen product and the cone crusher products in proportion to the weights and analyzed. The head analysis is given in Table 3.

TABLE 3. HEAD ANALYSIS OF DULUTH GABBRO SAMPLE

Constituent	Percent
Copper (Cu)	0.90
Nickel (Ni)	0.20
Cobalt (Co)	0.032
Iron (Fe)	12.99
Sulfur (S)	1.74

TABLE 1. SIZE DISTRIBUTIONS OF CRUSHED PRODUCTS OF A TACONITE SAMPLE FROM ERIE MINING COMPANY

Size	Jaw Crusher Product	-3/8" Screen Product (5.07% by Weight)	Cone Crusher Product (94.93% by Weight)
+3 inch	41.12		
+2	29.74		
+1.5	9.91		
+1	6.35		3.93
+0.742	3.38		16.85
+0.525	2.87	0.04	28.53
+0.371	1.93	0.07	18.69
+3 mesh	1.27	6.24	10.20
+4	0.79	14.44	5.33
+6	0.61	14.46	3.86
+8	0.46	12.24	2.82
+10	0.34	9.76	2.11
+14	0.25	7.90	1.36
+20	0.18	6.07	1.27
+28	0.14	5.01	0.93
+35	0.09	3.41	0.65
+48	0.09	3.64	0.70
+65	0.07	2.74	0.50
+100	0.06	2.38	0.42
+150	0.07	2.29	0.38
+200	0.05	1.59	0.19
+37 μm	0.10	3.37	0.47
+20	0.05	1.85	0.30
+10	0.03	0.83	0.17
-10	0.05	1.67	0.34

TABLE 2(a). SIZE DISTRIBUTIONS OF CRUSHED PRODUCTS OF MRRC LOT 2 DULUTH GABBRO SAMPLE FROM AMAX

Size	Jaw Crusher Product			-3/8" Screen Product (5.22% by Weight)			Cone Crusher Product (94.78% by Weight)		
	% Wt	% Cu	% Ni	% Wt	% Cu	% Ni	% Wt	% Cu	% Ni
+3 inch	35.78								
+2	29.48	*	*						
+1.5	8.47								
+1	6.06						1.62		
+0.742	3.29						14.06	0.73	0.18
+0.525	3.33	0.65	0.19				32.71		
+0.371	2.36			0.10			18.82		
+3 mesh	1.67	0.72	0.26	2.54	0.89	0.19	9.48	0.80	0.18
+4	1.16			7.28			5.10		
+6	0.99	0.86	0.25	9.00	1.05	0.26	3.63	0.90	0.20
+8	0.79			8.20			2.62		
+10	0.73	1.03	0.255	7.58	1.07	0.27	2.05	0.96	0.225
+14	0.62			6.78			1.54		
+20	0.58	1.27	0.295	6.26	1.17	0.28	1.28	1.21	0.27
+28	0.56			5.67			1.11		
+35	0.45	1.20	0.26	5.64	1.16	0.26	0.79	1.28	0.275
+48	0.53			5.62			1.01		
+65	0.56	1.05	0.255	6.86	1.16	0.265	0.86	1.30	0.275
+100	0.43			5.80			0.80		
+150	0.71	1.01	0.27	6.15	1.14	0.295	0.76	1.40	0.31
+200	0.37			3.97			0.53		
-200	1.08	1.32	0.405	12.50	1.32	0.40	1.23	1.75	0.395

*Analyses not available

TABLE 2(b). SIZE DISTRIBUTIONS OF THE MINUS 200-MESH FRACTIONS OF CRUSHED PRODUCTS OF MRRC LOT 2 DULUTH GABBRO SAMPLE FROM AMAX

Size	Jaw Crusher Product			-3/8" Screen Product (5.22% by Weight)			Cone Crusher Product (94.78% by Weight)		
	% Wt	% Cu	% Ni	% Wt	% Cu	% Ni	% Wt	% Cu	% Ni
				A. Sized by Microscreening					
+37 μm	0.67	1.23	0.385	6.89	1.29	0.41	0.66	1.63	0.39
+20	0.16	1.45	0.50	2.18	1.40	0.45	0.21	1.55	0.40
+10	0.07	1.80	0.54	0.69	1.52	0.50	0.06	2.83	0.66
-10	0.18	2.16	0.39	2.74	2.17	0.31	0.30	2.29	0.38
Composite	1.08	1.45	0.41	12.50	1.52	0.40	1.23	1.84	0.40
				B. Sized by Sedimentation Sizing					
+37 μm	0.74	1.41	0.44						
+20	0.16	1.07	0.32						
+10	0.09	1.31	0.35						
-10	0.09	1.29	0.30						
Composite	1.08	1.34	0.40						

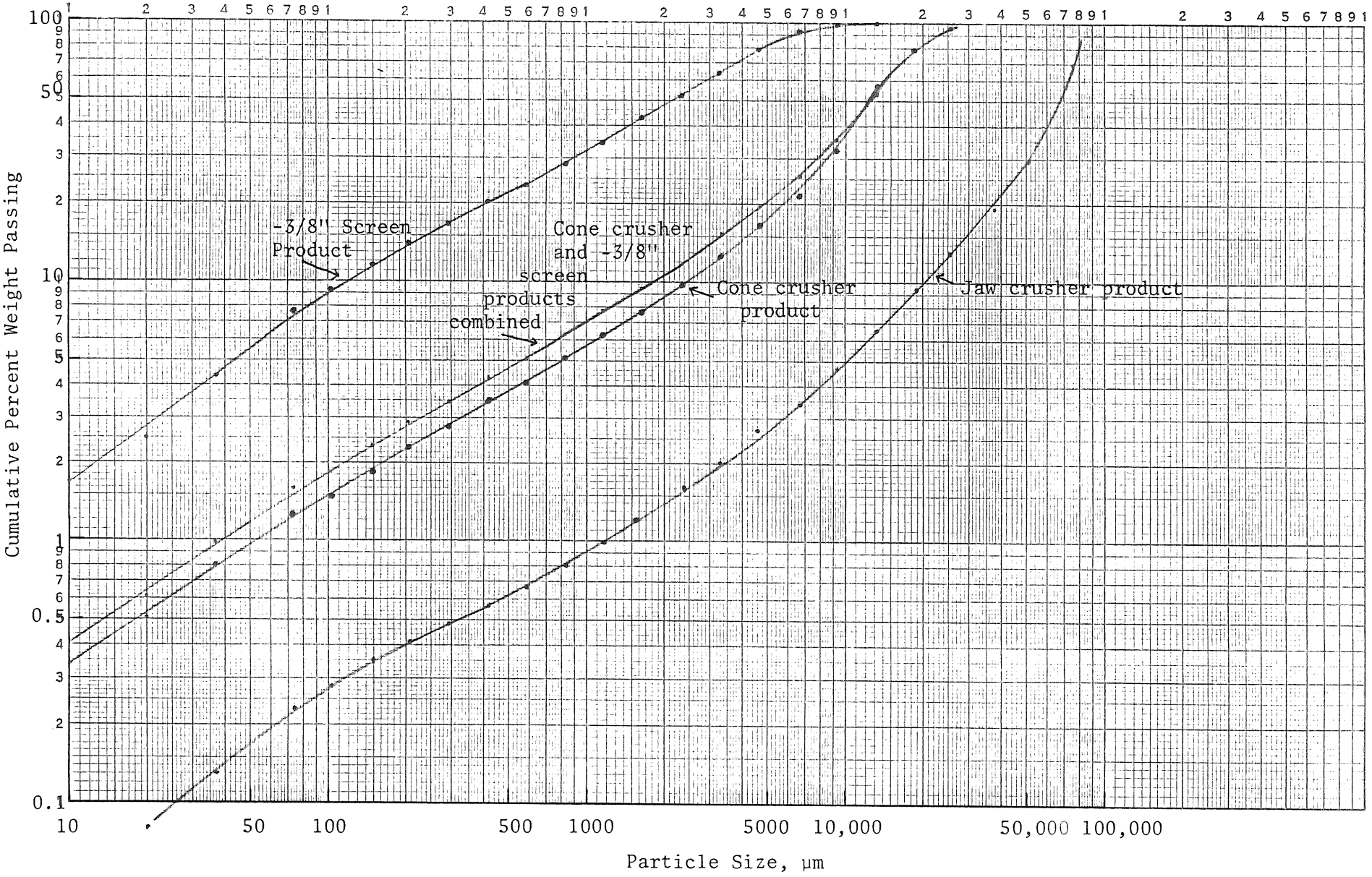


FIGURE 1. SIZE DISTRIBUTIONS OF CRUSHED PRODUCTS OF A TACONITE SAMPLE FROM ERIE MINING COMPANY

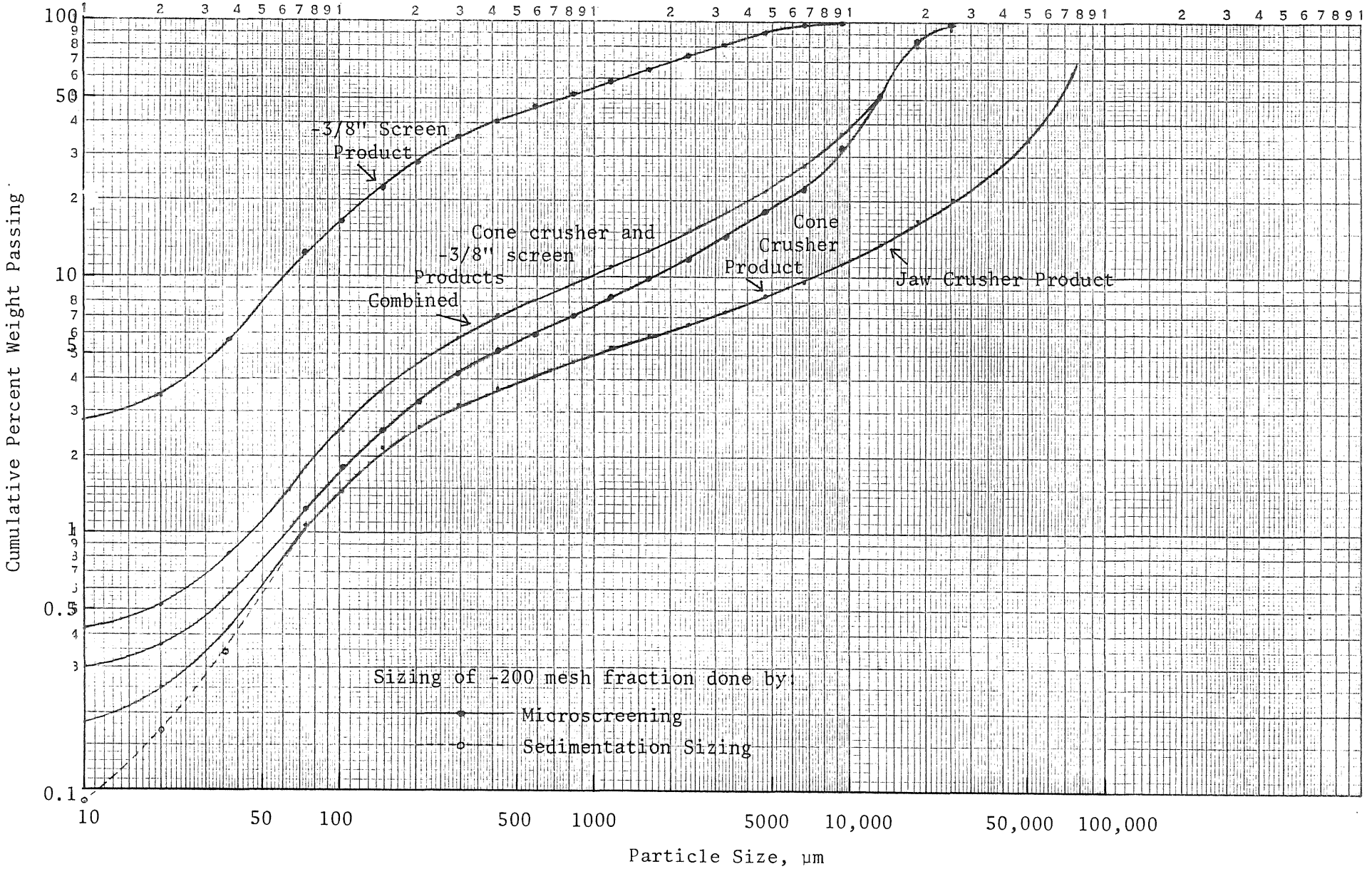


FIGURE 2. SIZE DISTRIBUTIONS OF CRUSHED PRODUCTS OF MRRC LOT 2 DULUTH GABBRO SAMPLE FROM AMAX

In a separate investigation the minus 200-mesh fractions of pilot plant flotation tailing samples were sized with microscreens and each size fraction was analyzed for copper and nickel. The copper contents of minus 10-μm fractions were noted to be unexpectedly high. Similar trends were noted in the analytical results of microscreened fractions of the present samples as shown in Table 2(b). Since all the water samples used in microscreening (amounting to approximately 3 liters) ended with minus 10-μm fractions and were removed by evaporation in order to recover all the dissolved elements, the high copper contents of minus 10-μm fractions were suspected to be due to dissolution of the brass rims of the microscreens. Hence, the minus 200-mesh product of the Jaw Crusher Product was fractionated into the same size ranges using the sedimentation sizing method. The results shown in Table 2(b) show that the copper content of the minus 10-μm fraction was appreciably less and the composite analysis of the minus 200-mesh fraction was more in line with the analytical data in Table 2(a). It is evident that the sedimentation sizing method rather than microscreens should have been used to avoid sample contamination.

The head sample and the minus 10-μm fractions of the three products of the crushed Duluth gabbro were submitted to the Regional Copper-Nickel Study for shipment to Barringer Research Ltd. for analysis of elemental composition. The results received from Barringer are given in Table 4. A comparison of the analytical results on the Jaw Crusher Product fractionated by microscreening and sedimentation sizing, particularly those of copper and zinc, suggests that the corrosion of microscreens affected the analytical results of these two elements. Since the head sample and the Jaw Crusher Product fractionated by sedimentation sizing were free from such contamination, more importance should be given to these two

TABLE 4. TRACE ELEMENT ANALYSIS RESULTS IN PERCENT ON MRRC LOT 2 DULUTH GABBRO SAMPLE FROM AMAX AND ON MINUS 10-μm FRACTIONS OF ITS CRUSHED PRODUCTS

		Minus 10-μm Fraction of Crushed Products			
		Jaw Crusher Product		-3/8" Screen Product	Cone Crusher Product
	Head	(microscreen)	(sedimentation)	(microscreen)	(microscreen)
Al	8.55	7.79	6.61	6.46	8.31
B					
Be	0.00012	0.00009	0.00005	0.0001	0.00009
Ca	5.1	4.38	3.86	4.04	5.27
Cu	0.999	2.52*	1.21	2.46*	2.63*
Fe	13.8	15.6	10.8	20.5	14.4
Mg	4.28	4.05	2.97	3.39	3.88
Mn	0.132	0.143	0.134	0.219	0.126
P	nd	nd	nd	nd	nd
Ba	0.0258	0.0129	0.0667	0.0134	0.0098
Se					
Te					
As					
Si					
Sr	0.0239	0.022	0.0205	0.0189	0.0252
Zr	0.012	0.0116	0.00783	0.00884	0.0123
Ti	1.09	0.935	0.638	0.929	0.955
V	0.0162	0.0151	0.0096	0.0233	0.0135
Zn	0.0113	0.364*	0.0579	0.41*	0.257*
Th	0.0004	0.0005	0.00049	0.0008	0.0007
K	0.767	0.655	0.596	0.61	0.593
Na	2.4	1.67	1.58	1.12	1.92
Cd	nd	nd	0.0009	nd	nd
Cr	0.0126	0.0132	0.0141	0.0017	0.014
Co	0.018	0.0263	0.0191	0.0239	0.0258
Ag	0.0002	0.0007	0.0008	0.0007	0.0008
Mo	0.0008	nd	0.002	0.0027	nd
Ni	0.17	0.346	0.21	0.284	0.326
Pb	0.005	0.024	0.012	0.0265	0.029

*Contamination through corrosion of microscreens suspected

sets of data. It is evident that copper, zinc, silver and nickel tended to increase their concentrations somewhat in the 'dust' fraction upon crushing, indicating that sulfide minerals were broken to finer sizes more readily, but all the other elements did not change their concentrations significantly.

SUMMARY

Duluth gabbro and taconite lumps crushed through a pilot plant jaw crusher and cone crusher gave similar size distributions. Therefore, it was surmised that the dust generation potential in crushing Duluth gabbro would be similar to that in the existing crushing facilities for taconite. Though sulfide minerals tend to break somewhat preferentially, there were no unusual concentrations of any trace elements in the potential dust fraction.