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MINING TECHNOLOGY IN 1972

by

Amil Dubnie*

SUMMARY

During 1971, there was a slight decrease in the tons of ore mined from surface metal mines and a slight increase in ore mined underground. As a result, the ratio of surface-mined to total showed a decrease from 0.69 to 0.66.

In surface non-metal mines during 1971, the increase in underground ore was greater than for surface-mined ore. This resulted in a decrease in the ratio of surface ore to total ore from 0.66 to 0.65.

The substantial increases in surface-mined coal continued and the ratio of surface-mined to total coal rose to 0.75.

During 1971, about 33 per cent of underground metallic ore was mined by cut-and-fill stoping or variations thereof, followed by open stoping with long-hole drilling at 26 per cent. In terms of tons mined in underground metal mines, sublevel caving accounted for about 17 per cent, making this the third most important method.

Decreases in mining costs occurred in underground mining of potash by the room-and-pillar method, and gold-quartz mining by shrinkage stoping. Other methods showed substantial increases. It is apparent that advances in underground mining technology are not keeping pace with rising costs.

An important advance during 1972 was the introduction on a production scale of slurries for underground blasting and means for bulk handling and loading them.

Key Words: Mining, Stoping, Mine Costs

*Mining Engineer, Mining Research Centre, Mines Branch, Department of Energy, Mines and Resources.

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INTRODUCTION

The Mining Research Centre, Mines Branch, Department of Energy, Mines and Resources, as well as conducting research in matters of interest to the mineral industry, gathers information on the trends in mining technology. The purpose of these activities is to assess the effects of new developments and to identify areas into which research efforts can be profitably directed.

The Mining Research Centre works closely with Statistics Canada in the gathering of production and technical information from statistical and other reports. The information received from Statistics Canada is supplemented by information obtained from technical literature surveys and personal contacts with mining company personnel and with mining associations.

The report that follows presents a series of statistical tables which outline the growth of mining, and show the trends in technology. A brief summary is given of the salient advances which occurred in 1972. The most recent year for which complete production data are available is 1971; therefore the tables cover this year. Complete data for 1972 will be available early in 1974.

Preliminary estimates released by Statistics Canada in January, 1973 show that the value of Canadian mineral production reached a new high of $6.4 billion in 1972, compared with the previous high of $5.9 billion in 1971. The largest increase was for fuels, which showed a 15 per cent increase, followed by non-metallics at 6 per cent, structural materials 4 per cent, and metals 2 per cent. Figure 1, based on Statistics Canada reports, gives a graphical presentation of the value of mineral production by classes, since 1950.

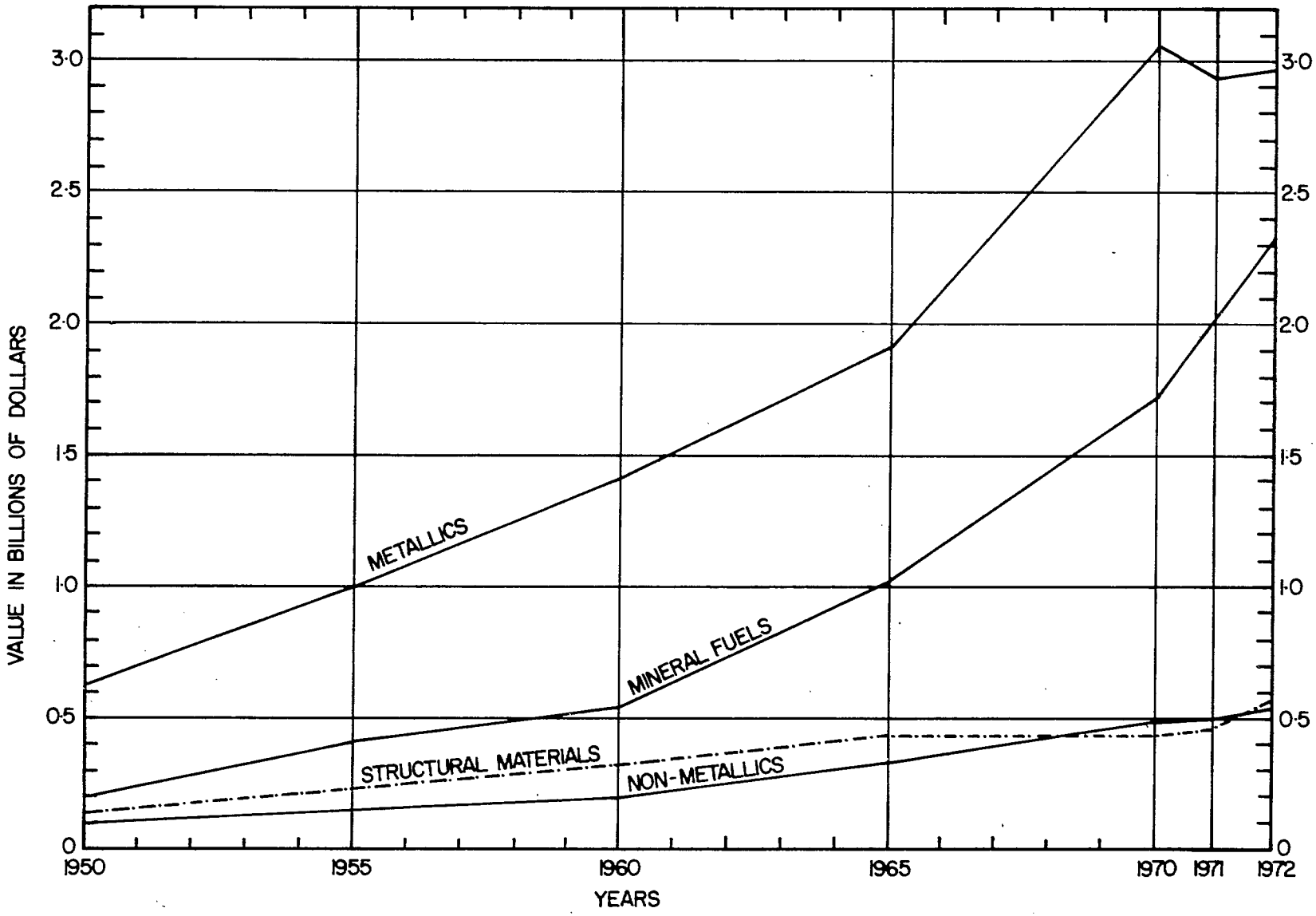

Figure 1. Value of Canadian Mineral Production by Classes, 1950-1972.

PRODUCTION ANALYSIS

Tonnage of Ore and Waste Mined

Table 1 shows the tonnages of ore mined and rock quarried in the Canadian mining industry for selected years during the 1950-1971 period. Waste material broken is not included in the totals, except in the case of asbestos mines, where waste broken in surface mines is normally included in Statistics Canada reports. In order to bring the reports for metals and non-metals to the same standard, waste was excluded by the author for non-metal mines, commencing in 1968. Table 1 shows the changes in the scale of production of metal and non-metal ores in the Canadian mineral industry. However, the strength or weakness of the market for a specific commodity may affect ore production for a given year. During 1971 there were increases in production of the ores of copper, asbestos, and potash. There were decreases in production of ores of gold-quartz and molybdenum. The production of other ores showed only slight changes, one way or the other. The production of coal showed an increase to 18.4 million tons in 1971, continuing the recent surge in production. Production of coal for 1972 was approximately 20.9 million tons. Table 1 is particularly useful for showing the longer-term increases in production of the various ores.

Underground and Surface Mining

Table 2 gives a comparison of ore produced from underground and surface mines during the period from 1950 to 1971. The changing character of Canadian mining is illustrated by the ratio of surface ore to total ore mined. The ratio for metal mining rose from 0.14 in 1950 to 0.51 in 1965. The ratio actually reached 0.50 in 1963, but this is not shown in the table. Throughout the 1960's there has been a steady increase in percentage of surface-mined ore; the ratio of surface ore to total ore in 1970 was 0.69, but this was slightly reduced at 0.66 for 1971.

TABLE 1

TONNAGE OF ORE MINED AND ROCK QUARRIED IN CANADA

Selected Years, 1950 to 1971
(millions of net tons)

Types of Mines	1950	1960	1965	1967	1968	1969	1970	1971
METAL MINES (excluding waste broken)								
Gold - Quartz	17.0	14.7	12.0	10.3	9.3	9.0	8.0	7.4
Uranium[1]	-	-	-	-	-	-	2.0	3.2
Iron Ore	4.4	33.0	89.2	90.2	100.9	90.9	103.0	100.8
Copper - Gold - Silver	8.8	14.0	20.0	31.3	34.8	33.2	42.3	48.8
Nickel - Copper	10.8	20.8	24.3	24.8	29.5	22.2	34.6	34.2
Silver - Cobalt	0.7	0.2	0.3	0.2	0.3	0.2	0.2	0.3
Silver - Lead - Zinc	4.8	5.8	10.1	11.7	12.6	13.5	14.0	14.4
Molybdenum[1]	-	-	-	-	-	-	18.1	12.3
Misc. Metal Mines	0.2	13.0	10.7	18.1	14.5	21.4	4.0[2]	4.1
Sub-total, Metal Mines[3]	46.7	101.5	166.6	186.6	205.0	190.4	226.4	225.5
NON-METAL MINES (excluding waste broken)								
Asbestos[4]	12.2	33.2	53.4	77.5	31.5	32.5	34.9	36.1
Gypsum	3.8	5.1	6.1	5.3	7.5	6.6	6.2	6.5
Talc and Soapstone	-	0.1	0.1	0.1	0.1	-	0.1	0.1
Feldspar, Quartz, Neph Syen.	1.1	1.6	2.0	1.9	1.8	1.9	1.2	2.1
Rock Salt	-	1.3	3.4	3.6	3.9	3.2	4.4	4.6
Potash[5]	-	-	-	-	-	-	13.9	15.6
Other non-metals	0.5	0.7	5.7	9.2	11.3	14.2	0.3	1.1
Sub-total, Non Metal Mines[3]	17.6	42.0	70.7	97.6	56.1	58.4	61.0	66.1
Stone, all kinds, quarried	18.1	45.4	76.8	80.6	75.9	70.1	70.7	73.5
COAL MINING (excluding waste broken)								
Coal	18.5	10.7	11.4	11.1	11.0	10.7	16.6	18.4
Grand Total, Ore and Rock[3]	100.9	199.6	305.5	375.9	348.0	329.6	374.7	383.5

(1) with miscellaneous metals prior to 1970
(2) excludes uranium and molybdenum as of 1970
(3) may not balance owing to individual rounding
(4) waste included, 1950-1967, inclusive
(5) included with "other non-metals", prior to 1970.

Source: Statistics Canada, Reports.

TABLE 2

ORE DISTRIBUTION - SURFACE AND UNDERGROUND

(millions of net tons of ore broken)

	METAL MINES				NON-METAL MINES				COAL MINES			
Year	Underground	Surface	Total	Ratio Surface/Total	Underground	Surface	Total	Ratio Surface/Total	Underground	Surface	Total	Ratio Surface/Total
1950	39.6	6.3	45.9	0.14	2.3	15.4	17.7	0.87	13.3	5.8	19.1	0.30
1960	74.8	26.8	101.6	0.26	3.5	38.5	42.0	0.92	6.7	4.3	11.0	0.39
1965	81.0	85.5	166.5	0.51	9.8	60.8	70.6	0.86	6.0	5.6	11.6	0.48
1966	67.5	94.8	162.3	0.58	11.1	67.4	78.5	0.86	6.0	5.4	11.4	0.47
1967	70.9	115.6	186.5	0.62	18.2	79.4	97.6	0.81	5.5	5.9	11.4	0.52
1968	70.0	135.0	205.0	0.66	17.9	38.2	56.1(1)	0.68	4.7	6.3	11.0	0.57
1969	62.7	127.8	190.5	0.67	20.2	38.3	58.5	0.65	4.3	6.4	10.7	0.60
1970	71.3	155.1	226.4	0.69	20.8	40.2	61.0	0.66	4.6	12.0	16.6	0.72
1971	75.5	149.9	225.4	0.66	23.0	42.9	65.9	0.65	4.6	13.8	18.4	0.75

(1) Waste not included for 1968 and later years.

Source: Statistics Canada reports and author's estimates.

Table 2 does not take into account the large amounts of waste which are mined in surface mines. In 1970 the waste-to-ore ratio for producing surface metal mines was 0.78. In 1971 the ratio was 0.94. This includes only the waste which was drilled and blasted. There was also an unknown tonnage of waste from mines in the pre-production period. An estimate of about 50 million tons from this source appears realistic. Until a mine reaches production status, no records of waste mined are gathered federally.

It is estimated that, during 1971, the amount of waste mined in underground mines was 5.3 million tons, during the mining of about 75.5 million tons of ore. However, there is also a large amount of waste from development. It is estimated that, during 1970, approximately 200 miles of lateral and decline development, and approximately 70 miles of raises and winzes were driven in Canada. The waste from each foot of these openings is becoming greater each year as cross-sections are increasing to accommodate larger-scale equipment.

In surface mining of industrial minerals, the waste-to-ore ratio for 1971 is estimated at 1.05 against 1.4 for 1970. The ratio fluctuates depending upon the opening of new mines, and implementation of short-term major stripping programs in established mines. The fewer number of industrial mineral mines, as compared with the number of metal mines, tends to accentuate the effect of major stripping programs upon the ratio for the group. Waste mined in underground industrial-mineral mines was negligible. In terms of tonnage this group of underground mines is dominated by the potash mines where virtually no waste is mined.

During 1971, the ratio of surface to total coal mined increased to 0.75. An increase is expected in this ratio for 1972. Not shown in Table 2 is the rock waste which must be drilled and blasted before coal can be removed in some western Canadian surface mines. For 1971, it is estimated that approximately 40 million tons of waste rock was stripped.

If the waste (tailings) rejected during processing is taken into account, it is readily seen that the final saleable product from mines represents only a small part of the volume actually mined. For example, during asbestos mining in 1971, about 36.1 million tons of ore were produced and 48.1 million tons of waste rock were stripped for a total of 84.2 million tons. The fibre actually shipped amounted to 1.6 million tons or 1.9 per cent of all the material mined. In metal mining, a greater percentage of all material mined is shipped as concentrates, but this varies with the grade of concentrate which can be produced. For example, it is estimated that, in nickel-copper mining in 1971, about 15 per cent of the total material mined was finally shipped as concentrates.

Mining Methods Used in Breaking Canadian Ores

Tables 3 to 5 show the mining methods used in breaking of Canadian ores during 1969, 1970 and 1971. During the compilation of these tables, underground mines presented a problem owing to the variations in recognized mining methods which may be applied. However, the tonnage mined was distributed among the headings which represent the recognized methods.

The difficulty of classifying mining methods is illustrated by, say, open stoping where the ore may be drilled off with long or short holes. The so-called sublevel caving methods sometimes do not rely on "caving" for breaking the ore, in which case it could be considered as open stoping. Again, a mining company may rely largely on caving to break the ore, yet may induce this caving by some drilling and blasting.

Since 1970, the classification of mining methods has been revised to exclude "blasthole stoping" which is not consistent with the normal method of classifying stoping methods according to the method of support. Long holes may be used during breaking in shrinkage, open, or other stoping.

TABLE 3

METHODS USED IN MINING OF CANADIAN ORES - 1969

(millions of net tons of ore broken)

Ore Mined	Total No. of Mines	Tons Broken	UNDERGROUND MINES								SURFACE MINES	
			Stoping Methods									
			Shrinkage	Cut & Fill Sg. Set. Stulls	Longholes Open Stopes Sublevel	Shortholes Open Stopes Sills	Room & Pillar Panel	Caving -block -sublevel	Number of mines	Tons Ore Broken	Number of mines	Tons Ore Broken
	METAL MINES											
Gold - Quartz	32	9.03	2.46	3.33	2.59	0.65	-	-	32	9.03	nil	-
Copper - Gold	54	33.14	2.06	4.40	5.86	1.71	1.19	1.10	43	16.32	11	16.82
Nickel - Copper	28	22.16	1.53	10.31	3.99	0.06	-	4.00	24	19.89	4	2.27
Silver - Cobalt	7	0.22	0.22	-	-	-	-	-	7	0.22	nil	-
Silver - Lead - Zinc	21	13.51	0.61	0.99	4.15	0.11	2.80	-	18	8.66	3	4.85
Uranium	4	3.06	-	0.44	-	-	2.60	-	3	3.04	n/a	n/a
Iron Ore	18	90.88	-	-	2.21	-	1.34	-	3	3.55	15	87.33
All Other Metals	13	18.43	0.38	0.12	1.28	-	0.17	-	6	1.95	7	16.48
Total Metals [1]	177	190.43	7.26	19.59	21.18	2.43	8.10	5.10	136	62.66	40	127.75
	NON-METAL MINES											
Asbestos	13	32.54	-	-	-	-	-	n/a	2	n/a	11	30.63
Gypsum	12	6.56	-	-	-	-	0.71	-	3	0.71	9	5.85
Salt	3	3.21	-	-	-	-	3.21	-	3	3.21	nil	-
Barite	2	n/a	-	n/a	-	-	-	n/a	2	n/a	nil	-
Feldspar, Qtz, Neph-syen.	12	1.73	-	-	-	-	-	-	nil	-	12	1.73
Potash	8	13.84	-	-	-	-	13.84	-	8	13.84	nil	-
Talc and Pyrophyllite	3	0.05	n/a	-	-	-	-	-	2	n/a	1	n/a
Fluorspar and Misc.	2	0.27	-	0.20	0.07	-	-	-	2	0.27	nil	-
Total Non-Metals [1]	55	58.45	n/a	0.26	0.07	-	17.76	2.06	22	20.17	33	38.28
	FUELS											
Coal	43	10.67	-	-	mined by longwall and room and pillar methods				18	4.27	25	6.40
Total, all ores [1]	275	259.55	7.28	19.85	21.25	2.43	27.44	7.16	176	87.10	99	172.45

(1) Totals may not balance due to individual rounding and to absence of data (noted n/a) which could not be published under the Statistics Act.

Source: Statistics Canada and author's estimates.

TABLE 4

METHODS USED IN MINING OF CANADIAN ORES - 1970

(millions of net tons of ore broken)

Ore Mined	Total No. of Mines	Total Tons Broken	UNDERGROUND MINES									SURFACE MINES	
			Stoping Methods										
			Shrinkage	Cut & Fill Undercut & Fill	Open Stoping	Room and Pillar	Sublevel Caving	Caving, Other	Other Methods	No. of Mines	Tons Ore Broken	No. of Mines	Tons Ore Broken
METAL MINES													
Gold - Quartz	29	8.01	2.00	2.87	1.44	0.13	0.22	1.09	0.27	29	8.01	nil	-
Uranium	4	1.96		0.33		1.63				4	1.96	1	n/a
Iron Ore	15	102.96	-	-	-	-	-	-	-	2	n/a	14	99.52
Copper - Gold - Silver	50	42.43	2.78	3.61	7.96	0.43	1.98	0.52		36	17.28	14	25.16
Nickel - Copper	29	34.64	2.96	11.59	2.52	-	8.17	5.52	0.31	24	31.07	5	3.59
Silver - Cobalt	7	0.25	0.22	-	-	-	-	-	-	6	0.22	1	n/a
Silver - Lead - Zinc	26	13.96	0.47	0.55	5.51	.23	-	.03	0.20	22	6.98	4	6.98
Molybdenum	7	18.10	0.66	-	0.68	-	-	-	-	4	1.34	3	16.76
Other Metals	6	4.05	-	0.18	0.71	0.16	-	-	-	3	1.05	3	3.00
Total Metals[1]	173	226.36	9.09	19.13	18.82	2.58	10.37	7.16	0.78	130	67.93	45	155.01
NON-METAL MINES													
Asbestos	13	34.93	-	-	-	-	-	n/a	-	2	n/a	11	33.14
Gypsum	10	6.18	-	-	-	0.34	-	-	-	3	0.34	7	5.84
Talc-Soapstone-Pyrophyllite	4	0.03	n/a	-	n/a	-	-	n/a	-	2	n/a	2	n/a
Feldspar and Quartz	9	1.16	-	-	-	-	-	-	-	nil	-	9	1.16
Salt (mined only)	3	4.37	-	-	-	4.37	-	-	-	3	4.37	nil	-
Potash	9	13.93	-	-	-	13.93	-	-	-	9	13.93	nil	-
Other non-metals	4	0.33	-	0.20	.03	-	-	0.11	-	3	0.33	1	n/a
Total, Non-Metals	52	60.93	-	0.20	0.03	18.64	-	0.11		22	18.97	30	39.14
FUELS													
Coal	29[2]	16.60	Underground coal mined by longwall and room and pillar, not included in totals below.							15	4.62	14	11.98
Total, all ores[1]	254	303.89	9.09	19.33	18.85	21.22	10.37	7.27	0.78	167	91.52	89	206.13

(1) Totals may not balance due to individual rounding and to absence of data (noted n/a) which cannot be published under the Statistics Act.

(2) Includes only mines producing 25,000 tons per year or more, but total tons produced is from all mines.

Source: Statistics Canada and author's estimates.

TABLE 5

METHODS USED IN MINING OF CANADIAN ORES, 1971

(millions of net tons of ore broken)

Ore Mines	Total No. of Mines	Total Tons Broken	UNDERGROUND MINES									SURFACE MINES	
			Stoping Methods										
			Shrinkage	Cut & Fill Undercut & Fill	Open Stoping	Room and Pillar	Sublevel Caving	Caving Other	Other Methods	No. of Mines	Tons Ore Broken	No. of Mines	Tons Ore Broken
	METAL MINES												
Gold - Quartz	27	7.38	1.89	3.29	1.57	-	.12	-	.09	27	7.38	nil	-
Uranium	4	3.17	-	.21	-	2.95	-	-	-	3	3.16	1	.01
Iron Ore	17	100.75	-	-	1.09	.08	1.54	1.5	-	3	4.21	14	96.55
Copper - Gold - Silver	52	48.73	3.00	3.04	10.00	.30	5.0	-	.30	38	21.95	14	26.78
Nickel - Copper	10	34.23	4.04	16.53	2.22	.01	6.49	1.00	.53	8	30.81	2	3.42
Silver - Cobalt	7	.26	.21	-	.05	-	-	-	-	7	.26	nil	-
Silver - Lead - Zinc	19	14.40	.44	1.70	4.01	.03	-	.01	.17	15	6.36	4	8.04
Molybdenum	8	12.32	.09	-	.58	-	-	-	-	4	.67	4	11.65
Other Metals	6	4.11	-	.12	.35	.16	-	-	.07	3	.70	3	3.41
Total Metals[1]	150	225.35	9.67	24.89	19.87	3.53	13.15	2.51	1.16	108	75.50	42	149.86
	NON-METAL MINES												
Asbestos	13	36.06	-	-	-	-	-	n/a	-	2	n/a	11	34.24
Gypsum	11	6.46	-	-	-	.81	-	-	-	3	.81	8	5.65
Talc - Soapstone - Pyrophyllite	4	.07	n/a	-	-	-	n/a	n/a	-	2	n/a	2	n/a
Feldspar & Quartz	12	2.08	-	-	-	-	-	-	-	nil	-	12	2.08
Salt	3	4.58	-	-	-	4.58	-	-	-	3	4.58	nil	-
Potash	8	15.60	-	-	-	15.60	-	-	-	8	15.60	nil	-
Other, Non-Metals	10	1.08	-	.13	.01	-	-	.04	-	2	.18	8	.90
Total Non-Metals[1]	61	65.93		.13	.01	20.99		.04		20	23.02	41	42.91
	FUELS												
Coal	26[2]	18.43	Underground coal mined by longwall, room and pillar and hydraulicking, not included in totals below.							13	4.62	13	13.81
Total, All Ores[1]	237	309.71	9.68	25.02	19.88	24.52	13.16	4.38	1.16	141	103.14	96	206.58

(1) Totals may not balance owing to individual rounding and to absence of data (noted n/a) which cannot be published under The Statistics Act

(2) Includes only mines producing 25,000 tons per year or more, but total tons produced is from all mines.

Source: Statistics Canada and author's estimates.

Where only one or two mining companies are responsible for all of the production of a commodity, data for these companies has been excluded from Tables 3 to 5 as publication would be in conflict with the Statistics Act. Examples are the two underground asbestos mines, and two companies mining talc and soapstone.

Tables 3 to 5 clearly show that the dominant Canadian underground mining methods are cut-and-fill or derivations thereof and open stoping. However, in recent years there has been a substantial growth in mining by the sublevel caving method.

Rock Breaking Analysis

Tables 6, 7 and 8 give estimates of the amount of drilling required to break rock in Canadian mines from 1968 to 1971. It is apparent from the tables that long-hole drilling produces about three times as much broken rock per foot of hole as short-hole drilling. There is also a correlation between the tons broken per foot drilled and the stoping method. Where larger-scale stoping methods are in use, the yield per foot drilled is high whereas the converse also holds. This is illustrated in Table 8 by the high yields in mining of iron ore, nickel, copper and lead zinc as compared with the lower yields for uranium, gold-quartz and silver-cobalt.

The large tonnage per foot of drilling in surface mines is to be expected owing to the large diameter of the holes drilled. During 1971, the yield in iron ore mining reached 47.25 tons per foot drilled. It might be pointed out that average hole diameters are larger in iron-ore mining than elsewhere. The average yield in surface industrial-mineral mining reached 16.14 tons per foot drilled, also an improvement over 1970. It should be pointed out that the average hole diameters are smaller in mining of non-metallics than in mining of metals.

TABLE 6

ROCK BREAKING ANALYSIS, CANADIAN MINERAL MINES

(average of years 1968 and 1969)

Type of Mining	UNDERGROUND MINES								SURFACE MINES			
	LONGHOLE DRILLING				SHORTHOLE DRILLING				LONGHOLE DRILLING			
	Tons ore & waste broken	Feet drilled	Most common bit diam.	Tons per foot drilled	Tons ore & waste broken	Feet drilled	Most common bit diam.	Tons per foot drilled	Tons ore & waste broken	Feet drilled	Most common bit diam.	Tons per foot drilled
	(millions)		(in.)		(millions)		(in.)		(millions)		(in.)	
METAL MINES												
Gold-Quartz	2.4	2.4	1 5/8	1.0	7.0	21.6	1 1/4	0.33	nil	-	-	-
Copper - Gold	7.1	6.0	1 3/4	1.2	10.2	24.9	1 1/4	0.41	49.0	2.3	9 7/8	21.2
Nickel - Copper	10.1	5.6	2 1/8	1.8	14.3	31.7	1 3/8	0.45	7.7	0.4	9 7/8	20.8
Silver - Cobalt	nil	-	-	-	0.3	1.4	1 1/4	0.20	nil	-	-	-
Lead - Zinc	4.4	4.2	2	1.1	4.8	11.3	1 1/4	0.43	8.4	0.4	9	20.5
Uranium	nil	-	-	-	3.4	9.2	1 3/8	0.36	nil	-	-	-
Iron Ore	3.9	1.7	2 1/8	2.2	nil	-	-	-	139.0	4.8	9 7/8 12 1/4	28.8
Other Metals	1.2	1.3	1 5/8	1.0	0.6	2.9	1 1/4	0.21	21.7	1.2	9	16.8
Total Metals	29.1	21.2	-	1.4	40.6	103.0	-	0.40	225.8	9.1	-	24.7
NON-METAL MINES												
Asbestos	-	-	-	-	1.9	0.8	1 3/8	2.35	81.1	7.0	4 6 1/2	11.7
Gypsum	-	-	-	-	0.7	0.9	1 3/4	0.76	8.5	1.5	2 1/8	5.8
Salt	-	-	-	-	4.3	5.3	1 7/8	0.80	nil	-	-	-
Barite	-	-	-	-	0.2	0.3	2 1/8	0.71	nil	-	-	-
Feld. Qtz., N. Syen.	-	-	-	-	nil	-	-	-	1.7	0.3	3	5.4
Potash	Boring machines mostly used - little drilling and blasting								nil	-	-	-
Pyrophyllite and Talc	-	-	-	-	0.04	0.06	1 1/4	0.67	0.2	0.01	2 1/2	20.0
Fluorspar and Misc.	0.9	0.9	1 7/8	1.0	0.18	0.25	1 1/4	0.72	nil	-	-	-
Total Non-Metals	0.9	0.9	-	1.0	7.3	7.6	-	0.96	91.5	8.8	-	10.4

Source: Statistics Canada and author's estimates.

TABLE 7

ROCK BREAKING ANALYSIS, CANADIAN MINERAL MINES, 1970

ORE MINED	UNDERGROUND MINES								SURFACE MINES			
	LONGHOLE DRILLING				SHORTHOLE DRILLING				LONGHOLE DRILLING			
	Tons ore & waste broken	Feet drilled	Common bit diameter	Tons per foot drilled	Tons ore & waste broken	Feet drilled	Common bit diameter	Tons per foot drilled	Tons ore & waste broken	Feet drilled	Common bit diameter	Tons per foot drilled
	(millions)		(inches)		(millions)		(inches)		(millions)		(inches)	
METAL MINES												
Gold - Quartz	1.2	0.9	1 5/8	1.35	7.2	18.0	1 1/4	0.40	nil	-	-	-
Uranium	n/a	n/a	n/a	n/a	2.2	10.0	1 3/8	0.22	n/a	n/a	n/a	n/a
Iron Ore	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	141.7	4.0	7 7/8 to 12 1/4	35.4
Copper - Gold - Silver	10.1	7.8	1 7/8	1.36	8.8	18.0	1 1/4	0.49	70.6	3.3	9	21.6
Nickel - Copper	11.3	5.7	2 1/8	1.99	21.5	30.7	1 3/8	0.70	10.4	0.3	9 7/8	33.9
Silver - Cobalt	-	-	-	-	0.2	1.0	1 1/4	0.20	n/a	n/a	n/a	n/a
Silver - Lead - Zinc	5.6	2.3	2 1/4	2.39	1.8	6.0	1 1/4	0.30	24.7	1.0	9	25.2
Molybdenum	0.7	0.6	-	1.28	0.7	2.5	1 1/4	0.28	21.8	1.0	9	21.6
Other Metal Mines	n/a	n/a	n/a	n/a	0.4	1.1	1 5/8	0.36	5.8	0.2	6 1/2	31.8
Total Metals	28.9	17.3		1.67	42.8	87.3		0.49	275.0	9.8		28.1
NON-METAL MINES												
Asbestos	nil	-	-	-	n/a	n/a	1 3/8	1.92	88.7	6.2	2 to 9	14.3
Gypsum	nil	-	-	-	0.3	0.5	1 1/2	0.60	7.5	1.5	4	5.1
Talc - Soapstone - Pyrophyllite	nil	-	-	-	0.03	0.01	1 1/4	2.66	n/a	n/a	2 1/2	23.2
Feldspar and Quartz	nil	-	-	-	nil		-	-	1.3	0.2	3	5.6
Salt	nil	-	-	-	5.3	5.4	1 7/8	0.99	nil	-	-	-
Potash	Cutting machines used - little drilling and blasting								-	-	-	-
Other Non-Metals	-	-	-	-	0.3	0.7	1 3/8	0.42	n/a	n/a	n/a	n/a
Total, Non-Metals					5.9	6.6		0.89	97.5	7.9		12.3

Source: Statistics Canada reports and author's estimates.

n/a - not available

TABLE 8

ROCK BREAKING ANALYSIS, CANADIAN MINERAL MINES, 1971

ORE MINED	UNDERGROUND MINES								SURFACE MINES			
	LONGHOLE DRILLING				SHORTHOLE DRILLING				LONGHOLE DRILLING			
	Tons ore & waste broken	Feet drilled	Common bit diameter	Tons per foot drilled	Tons ore & waste broken	Feet drilled	Common bit diameter	Tons per foot drilled	Tons ore & waste broken	Feet drilled	Common bit diameter	Tons per foot drilled
	(millions)		(inches)		(millions)		(inches)		(millions)		(inches)	
METAL MINES												
Gold - Quartz	0.4	0.4	2	1.00	7.2	14.0	1 1/4	0.51	nil	-	-	-
Uranium	n/a	n/a	n/a	n/a	3.42	8.0	1 3/8	0.43	n/a	n/a	n/a	n/a
Iron Ore	4.2	1.2	2 1/8	3.50	-	-	-	-	151.2	3.2	7 7/8 to 12 1/4	47.25
Copper - Gold - Silver	6.3	3.2	2	1.97	15.0	25.2	1 1/4	0.60	77.8	2.6	9 7/8	29.80
Nickel - Copper	8.7	3.5	2 1/4	2.49	25.4	43.7	1 1/4	0.58	9.7	n/a	n/a	-
Silver - Cobalt	-	-	-	-	0.3	0.4	1 1/4	0.75	n/a	n/a	n/a	-
Silver - Lead - Zinc	3.7	2.0	2	1.85	2.5	5.1	1 3/8	0.49	25.1	1.0	9	25.1
Molybdenum	n/a	n/a	n/a	n/a	0.6	0.6	1 1/4	1.00	20.7	1.0	2 3/4 & 9	20.7
Other Metal Mines	n/a	n/a	n/a	n/a	0.4	0.5	1 5/8	0.8	5.7	0.3	6 1/2 & 3 1/2	19.0
Total Metals[1]	23.0	10.7		2.15	54.82	97.5		0.56	290.2	8.1		36.0
NON-METAL MINES												
Asbestos	nil	-	-	-	n/a	n/a	1 3/8	n/a	82.4	5.1	2 1/2 to 9	16.15
Gypsum	nil	-	-	-	0.8	0.8	n/a	1.0	7.8	0.5	4	15.6
Talc - Soapstone - Pyrophylite	nil	-	-	-	0.04	0.01	1 1/4	4.0	n/a	n/a	2 to 2 1/2	-
Feldspar and Quartz	nil	-	-	-	nil	-	-	-	2.2	0.2	1 1/2 to 4 1/2	11.0
Salt	nil	-	-	-	5.3	5.6	1 7/8	0.95	nil	-	-	-
Other Non-Metals[2]	nil	-	-	-	0.2	0.2	1 3/8	1.0	1.2	n/a	n/a	-
Total, Non-Metals[1]					8.14	7.11		1.01	93.6	5.8		16.14

(1) Totals may not balance owing to absence of data (shown n/a) which could not be published.

(2) Excluding potash.

n/a - not available

Employment in Producing Mines

Tables 9, 10 and 11 show the total employment, costs of labour, and labour productivity in Canadian mines for 1969 to 1971. The final tabulation is affected by the policies of mining companies when distributing their operating costs. In the case of iron-ore mining and handling, the personnel and costs of operating, processing and materials-handling plants at ports are included.

From the data which were available, it is concluded that labour productivity was highest in the surface mines of molybdenum, copper and iron ore. Productivity per man-hour in industrial-mineral mines during 1971 was higher on the average than for previous years. The lowest productivity appeared in mines where small-scale underground operations were in effect (silver-cobalt) or where the mines are generally old (gold-quartz).

Operating Costs

Tables 12, 13 and 14 give an analysis of mine operating costs for 1969 to 1971, according to the type of ore and principal mining method. Many mining companies use several mining methods and operating costs are not usually broken down by method. The mines selected for analysis, therefore, represent only a sample for the years considered.

Individual costs are shown as a weighted average of the costs for mining ore and waste in the mines, and not on the basis of tons milled. This tends to show unusually low costs of milling in some operations. It also tends to show lower costs at surface-mining locations where large volumes of waste are drilled and blasted prior to ore mining Tons of overburden removed without drilling and blasting in surface mines are not included in the analysis.

Costs of underground mining by all methods continue to increase, except where gold-quartz ores are mined by shrinkage and potash by room and pillar. The decrease in the latter may be due to gradually increasing

TABLE 9

SUMMARY OF EMPLOYMENT - CANADIAN PRODUCING MINES, 1969

TYPE OF MINING	ORE MILLED			Total Ore & Waste Broken	EMPLOYEES				Total Paid Manhours	Total salaries & wages Paid	LABOUR COST		Tons O & W broken per Manhour
	Underground	Surface	Total		Admin.	Mine	Mill	Total			Per Ton Milled	Per Ton O & W Broken	
	(millions of short tons)				(thousands)				(millions $)		($)	($)	
METAL MINES													
Gold - Quartz	9.3	-	9.3	9.3	1.2	6.0	1.2	8.4	17.9	51.5	5.55	5.52	0.52
Copper - Gold	16.1	16.5	32.6	68.1	2.4	6.9	3.6	12.9	26.5	92.5	2.84	1.36	2.57
Nickel - Copper	19.8	2.2	22.0	27.9	2.9	11.9	1.1	15.9	31.1	127.8	5.80	4.58	0.90
Silver - Cobalt	0.3	-	0.3	0.2	0.1	0.3	0.1	0.5	1.1	3.2	9.13	12.70	0.24
Lead - Zinc	8.0	4.8	12.8	18.5	1.1	3.5	1.1	5.7	11.9	42.6	3.33	2.30	1.55
Uranium - Rock Mining	3.1	-	3.1	3.5	0.6	1.3	0.5	2.4	5.1	20.7	6.75	6.03	0.68
Iron Ore	3.6	82.3	85.9	136.5	2.7	3.7	4.1	10.5	22.3	101.3	1.18	0.75	6.12
All Other Metals	1.9	14.5	16.4	24.8	0.4	1.4	0.3	2.1	4.7	16.5	1.01	0.67	5.33
NON-METAL MINES													
Asbestos	1.9	23.1	25.0	88.0	1.4	2.3	3.6	7.3	17.1	59.1	2.36	0.67	5.14
Gypsum and Anhydrite	0.7	5.9	6.6	9.6	0.1	0.5	0.03	0.6	1.5	3.9	0.60	0.41	6.60
Salt (Rock Salt)	2.8	-	2.8	3.9	0.1	0.3	0.1	0.5	1.1	3.2	1.15	0.82	3.48
Barite	0.2	-	0.2	0.2	0.02	0.10	0.01	0.1	0.3	0.8	4.18	3.76	0.77
Feldspar, Quartz, Neph. Syenite	-	1.3	1.3	1.8	0.1	0.1	0.2	0.4	0.9	2.5	1.85	1.38	2.05
Potash	13.6	-	13.6	13.8	0.6	1.1	1.0	2.7	5.7	22.1	1.62	1.60	2.44
Pyrophyllite and Talc	0.02	0.03	0.05	0.05	0.02	0.06	0.01	0.1	0.2	0.4	7.47	8.12	0.27
Fluorspar and Misc.	0.3	-	0.3	0.3	0.1	0.3	0.1	0.5	1.1	3.2	10.20	11.18	0.27

Source: Statistics Canada and author's estimates.

TABLE 10

SUMMARY OF EMPLOYMENT - CANADIAN PRODUCING MINES, 1970

ORE MINED	ORE MILLED			Total Ore & Waste Broken	EMPLOYEES				Total Paid Manhours	Total Wages and Salaries	LABOUR COST		Tons O & W broken per Manhour
	Underground	Surface	Total		Admin.	Mine	Mill	Total			Per Ton Milled	Per Ton O & W Broken	
	(millions of net tons)				(thousands)				(millions)	(million$)	$	$	
METAL MINES													
Gold - Quartz	8.01	-	8.01	8.49	1.18	4.77	1.06	7.01	14.64	44.86	5.50	5.28	0.58
Uranium	1.96	n/a	1.96	2.28	0.51	1.09	0.57	2.18	4.46	18.80	9.50	8.35	0.51
Iron Ore, Underground	3.43	-	3.43	3.81	0.16	0.20	0.23	0.59	1.39	6.09	1.77	1.60	2.54
Surface	-	99.52	99.52	141.77	1.65	3.03	3.31	7.99	16.89	79.42	0.80	0.56	8.42
Copper - Gold - Silver, Underground	17.27	-	17.27	18.87	2.16	5.56	2.31	10.03	21.35	83.67	4.85	4.44	0.88
Surface	-	25.16	25.16	70.59	0.46	0.89	0.97	2.32	4.87	20.14	0.80	0.29	14.50
Nickel - Copper	31.05	3.59	34.64	43.19	3.26	15.27	1.42	19.95	42.42	190.20	5.49	4.41	1.02
Silver - Cobalt	0.22	-	0.22	0.24	.07	0.29	0.06	0.42	0.81	2.70	12.27	11.24	0.30
Silver - Lead - Zinc, Underground	6.98	-	6.98	7.41	0.71	2.58	0.79	4.06	7.94	31.64	4.57	4.27	0.93
Surface	6.98	-	6.98	24.71	0.20	0.60	0.35	1.24	2.46	12.91	1.85	0.52	10.40
Molybdenum, Undergound	1.34	-	1.34	1.41	0.13	0.66	0.03	0.82	1.73	5.33	3.98	3.78	0.82
Surface	-	16.76	16.76	21.78	0.17	0.41	0.22	0.80	1.74	7.01	0.42	0.32	12.52
Other Metal Mines	1.05	3.00	4.05	6.96	0.18	0.50	0.08	0.76	1.67	6.43	1.59	0.93	4.17
NON-METAL MINES													
Asbestos	1.79	33.14	34.93	90.50	1.41	2.60	3.74	7.74	18.18	65.19	1.87	0.72	4.98
Gypsum	0.34	5.84	6.18	7.81	0.11	0.50	0.02	0.64	1.42	3.99	0.65	0.51	5.50
Talc, Soapstone, Pyrophyllite	0.03	0.04	0.07	0.41	0.02	0.06	0.02	0.10	0.21	0.52	7.43	1.27	1.95
Feldspar and Quartz	-	1.16	1.16	1.29	0.04	0.08	0.12	0.24	0.57	1.53	1.32	1.19	2.27
Salt	4.37	-	4.37	5.32	0.09	0.44	0.09	0.62	1.32	4.78	1.09	0.90	4.06
Potash	13.93	-	13.93	13.93	0.75	1.06	0.95	2.75	5.70	22.46	1.97	1.97	2.44
Other Non-Metals	0.33	0.004	0.33	0.33	0.05	0.39	0.03	0.47	0.99	2.88	8.73	8.73	.33

Source: Statistics Canada and author's estimates.

TABLE 11

SUMMARY OF EMPLOYMENT - CANADIAN PRODUCING MINES, 1971

TYPE OF MINING	ORE MILLED			Total Ore & Waste Broken	EMPLOYEES				Total Paid Man-hours	Total Wages and Salaries	LABOUR COST		Tons O & W Broken per Manhour
	Under-ground	Surface	Total		Admin.	Mine	Mill	Total			Per Ton Milled	Per Ton O & W Broken	
	(millions of short tons)					(thousands)				(millions $)	($)	($)	
METAL MINES													
Gold - Quartz	7.40	-	7.40	7.60	0.97	4.46	0.72	6.15	12.28	39.98	5.40	5.26	0.62
Uranium	3.20	n/a	3.20	3.42	0.48	1.04	0.52	2.04	3.92	17.81	5.56	5.21	0.87
Iron Ore - Underground	4.20	-	4.20	4.20	0.17	0.54	0.16	0.87	1.85	8.48	2.01	2.01	2.27
Surface	-	96.55	96.55	151.20	2.32	2.53	3.88	8.73	17.68	94.40	0.97	0.62	8.55
Copper - Gold - Silver													
Underground	21.95	-	21.95	23.00	2.44	6.06	2.61	11.11	22.76	100.81	4.59	4.38	1.01
Surface	-	26.78	26.78	77.80	0.60	1.19	1.21	3.00	6.12	26.27	0.98	0.34	12.71
Nickel - Copper	30.81	3.42	34.23	43.80	4.25	15.94	1.57	21.76	38.47	214.04	6.25	4.89	1.14
Silver - Cobalt	0.26	-	0.26	0.30	0.07	0.31	0.08	0.46	1.11	4.19	16.12	13.97	0.27
Silver - Lead - Zinc -													
Underground	6.36	-	6.36	6.60	0.63	2.36	0.68	3.67	7.58	32.94	5.18	4.99	0.87
Surface	-	8.04	8.04	25.10	0.24	0.56	0.31	1.11	2.16	13.02	1.62	0.52	11.62
Molybdenum - Underground	0.67	-	0.67	0.70	0.01	0.35	0.15	0.51	0.68	2.84	4.24	4.06	1.03
Surface		11.65	11.65	20.70	0.17	0.21	0.33	0.71	1.50	6.95	0.60	0.34	13.80
Other Metal Mines	0.70	3.41	4.11	6.10	0.19	0.38	0.03	0.58	1.51	6.50	1.58	1.07	4.06
NON-METAL MINES													
Asbestos	1.82	34.24	36.06	84.20	1.43	2.52	3.89	7.84	16.13	69.19	1.92	0.82	5.22
Gypsum	0.81	5.65	6.46	8.60	0.10	0.47	0.03	0.60	1.31	4.21	0.65	0.49	6.56
Talc - Soapstone - Pyrophyllite	0.03	0.04	0.07	0.34	0.02	0.04	0.02	0.08	0.19	0.49	7.00	1.44	1.79
Feldspar & Quartz	-	2.08	2.08	2.20	0.11	0.11	0.25	0.47	0.82	3.18	1.53	1.46	2.68
Salt	4.58	-	4.58	5.50	0.21	0.44	0.43	1.08	2.25	8.71	1.90	1.58	2.44
Potash	15.60	-	15.60	15.60	0.64	0.90	0.95	2.49	5.36	22.62	1.45	1.45	2.91
Other Non-Metals	0.18	0.90	1.08	1.40	0.06	0.24	0.18	0.48	0.92	3.61	3.34	2.58	1.52

Source: Statistics Canada and author's estimates.

TABLE 12

ANALYSIS OF OPERATING COSTS OF SELECTED MINES

year 1969

Type of Mine	Number of Mines Analyzed	Tons O & W Broken Per Foot of Drilling	OPERATING COSTS PER TON OF ORE AND WASTE BROKEN								
			Expl. and Devel.	Mining	Sub-Total	Milling	Gen'l	Dep'n	Grand Total	Labour - Salaries and Wages	Labour - Percent of Total
SHRINKAGE STOPING											
Copper	5	0.41	0.60	3.50	4.10	1.70	2.80	1.20	9.80	3.95	40
Gold	6	0.48	1.10	4.10	5.20	2.00	1.20	0.30	8.70	4.05	47
Silver	6	0.20	3.20	6.00	9.20	3.60	2.00	0.40	15.20	9.10	60
CUT AND FILL STOPING											
Copper	8	0.36	1.00	5.90	6.90	1.80	2.50	1.50	12.70	5.90	47
Nickel	8	0.41	2.50	7.70	10.20	2.80	1.60	2.00	16.60	8.15	49
Lead - Zinc	4	0.34	2.10	8.30	10.40	2.50	2.50	2.50	17.90	7.55	42
Gold	12	0.30	1.50	9.50	11.00	2.50	2.20	0.40	16.10	9.40	58
OPEN STOPING (with longholes)											
Copper	6	1.06	0.45	2.50	2.95	1.20	2.20	1.50	7.85	2.85	36
Gold	6	0.49	0.40	3.00	3.40	1.30	1.15	0.65	6.50	3.05	47
Lead - Zinc	4	0.93	0.90	3.35	4.25	1.80	1.30	1.30	8.65	3.95	46
ROOM AND PILLAR MINING											
Lead - Zinc	3	0.6	0.40	3.90	4.30	1.30	0.70	0.30	6.60	3.20	48
BLOCK CAVING AND SUB-LEVEL CAVING											
This mining method is used in mining of asbestos, copper, and nickel. Data from an insufficient number of mines were available for publication.											
SURFACE MINING											
Asbestos	9	11.7	0.10	0.35	0.45	0.50	0.40	0.15	1.50	0.55	37
Molybdenum	3	18.5	0.10	0.55	0.65	0.90	0.50	0.55	2.60	0.55	21
Copper	7	21.0	0.10	0.60	0.70	0.55	0.40	0.30	1.95	0.50	26
Iron	12	29.0	0.20	0.90	1.10	0.85	0.35	0.30	2.60	0.75	29
Lead - Zinc	3	20.5	0.15	1.10	1.15	0.95	0.20	0.60	2.90	0.90	31

Source: Statistics Canada and author's estimates.

TABLE 13

ANALYSIS OF OPERATING COSTS OF SELECTED MINES

year 1970

Ore Mined	Number of Mines Analyzed	Tons O & W Broken Per Foot of Drilling	OPERATING COSTS PER TON OF ORE AND WASTE BROKEN ($)								
			Expl. and Devel.	Mining	Sub-Total	Milling	Gen'l	Dep'n	Grand Total	Labour - Salaries and Wages (million $)	Labour - Percent of Total
SHRINKAGE STOPING											
Gold - Quartz	4	0.61	1.01	3.74	4.74	2.00	1.28	0.25	8.27	4.3	45
Silver - Cobalt	3	0.22	5.21	6.82	12.03	2.80	1.54	1.54	18.01	1.3	48
Other Metal Mines	8	0.36	1.81	5.01	6.82	1.59	1.84	1.10	11.35	14.3	49
CUT AND FILL STOPING											
Gold - Quartz	7	0.32	0.94	6.95	7.89	2.02	2.43	0.42	12.76	18.1	68
Other Metals	15	0.55	2.37	6.96	9.33	2.17	2.59	1.43	15.52	57.2	43
OPEN STOPING (with longholes)											
Gold - Quartz	3	0.75	0.32	2.88	3.20	1.10	0.56	0.13	4.99	4.6	56
Copper	9	1.43	0.90	2.63	3.53	1.27	2.08	1.66	8.54	19.4	36
Lead - Zinc	4	2.71	0.64	2.89	3.53	2.26	1.01	0.96	7.76	8.0	32
Other Metals	5	1.82	0.72	4.38	5.10	1.56	0.58	0.71	7.95	13.6	52
ROOM AND PILLAR											
Metals	4	0.51	0.68	3.82	4.50	3.04	2.48	0.75	10.77	8.5	40
Potash	5	-	-	1.67	1.67	1.94	3.10	1.64	8.35	14.3	23
CAVING											
Copper	3	0.70	0.29	2.84	3.13	0.91	1.32	0.73	6.09	6.4	38
SURFACE MINES											
Asbestos	10	14.85	0.10	0.61	0.71	0.63	0.54	0.14	2.03	61.5	34
Iron Ore	10	32.70	0.19	1.31	1.50	1.02	0.37	1.36	4.25	55.3	13
Other Metals	9	34.00	0.08	0.37	0.45	0.44	0.18	0.23	1.30	33.8	26

Source: Statistics Canada and author's estimates.

TABLE 14

ANALYSIS OF OPERATING COSTS OF SELECTED MINES

year 1971

Ore Mined	Number of Mines Analyzed	Tons O & W Broken Per Foot of Drilling	OPERATING COSTS PER TON OF ORE AND WASTE BROKEN ($)							Labour - Salaries and Wages	Labour - Percent of Total
			Expl. and Devel.	Mining	Sub-Total	Milling	Gen'l	Dep'n	Grand Total[1]	(million $)	
SHRINKAGE STOPING											
Gold - Quartz	5	0.56	0.90	3.74	4.63	1 75	1. 13	0 36	7.90	6.9	53
Copper	7	0.48	0.50	2.92	3.44	1.35	3.97	1.91	10.65	7.7	36
Silver - Cobalt	4	0.34	3.83	8. 15	11.95	2.46	2.64	1. 15	18.69	1.9	54
Other Metal Mining	3	0.50	0.28	5.20	5.48	1.84	2. 15	3.39	12.83	2.5	38
CUT AND FILL STOPING											
Gold - Quartz	10	0.36	0 70	8.60	9.30	1.63	2 34	0.40	13.67	21.6	63
Other Metals	19	0.55	2. 19	6.60	8.80	2.55	3.04	1. 71	16.07	78.8	51
OPEN STOPING (with longholes)											
Gold - Quartz	3	0.58	0.29	2.93	3.22	1.38	0 66	0. 12	5.38	5.3	60
Copper	11	1. 18	0.89	3.05	3.92	1.66	2.52	1. 73	9.85	20.8	28
Lead - Zinc	3	3.20	0.62	3.78	4.40	2.43	1.26	1.07	9. 17	4. 1	35
Other Metal Mines	4	2.95	0.35	1. 46	1.81	2.04	0.56	0.62	5.04	10 6	42
ROOM AND PILLAR											
Metal Mines	5	0 54	0.63	4.31	4.94	2.97	1.31	0.88	10.09	19 8	39
Potash	7	-	-	1. 16	1. 16	1.57	1.99	1.40	6. 12	19.7	22
SUB-LEVEL CAVING											
Metal Mines	3	0.68	0. 19	3.50	3 70	1.55	0.96	1.92	8. 13	14. 1	42
CAVING											
Non-metal Mines	3	2.06	0.07	2.90	2.97	2.42	1.32	0.69	7.40	7 6	54
SURFACE MINES											
Asbestos	10	13 54	0. 12	0.72	0 83	0 76	0.60	0. 16	2.36	61.5	35
Iron Ore	13	33.80	0.22	1.26	1.48	1.43	0.34	1. 12	4.37	68. 1	13
Other Metal Mines	9	30.90	0. 10	0.44	0 54	0.39	0 20	0 22	1.34	36.5	26

(1) Totals may not balance owing to individual rounding.

Source: Statistics Canada and author's estimates.

production in the potash industry. Substantial increases in total costs are noted where cut-and-fill stoping and open stoping with long holes are in use. Surface mines show the least increase in overall costs.

Estimated total direct costs of mining and milling in the Canadian mineral industry (excluding fuels) are $1,025 million, and $595 million, respectively. If overhead and other costs are distributed between mining and processing, the total expenditures are estimated at $1,340 million for mining and $1,450 million for processing (including smelting).

MINING TECHNOLOGY

Underground Mining

Improvements have been made in a modified cut-and-fill stoping with non-recoverable pillars in the Sudbury area.

Access to mine workings by means of declines has been further extended. One source has reported that, of the last 17 mines which have come into production in Canada, 13 were developed with declines. Declines are now laid out at slopes of 25 to 30 per cent, whereas the earliest slopes selected were 10 to 15 per cent. A compilation of four papers on decline driving is underway in the Tunnelling Office of Canada in an effort to correct the dearth of published material on this important recent development.

One company is experimenting with 6.75- and 7.875-inch diameter rotary-drilled holes for ore breaking in large stopes. The main target is to eliminate some sublevels which is believed possible as the rotary holes can be drilled 200-feet deep.

Boring of 7-ft-diameter raises in hard rock is becoming commonplace as constant improvements are made to reaming cutters and other equipment. Studies are far advanced towards automation of raise-boring equipment.

During 1972, slurries have been tested out for primary and secondary blasting underground. This represents a major advance in blasting performance with improved safety. Impetus to this advance has been provided by successful development of a slurry pump which permits bulk loading.

The Mining Research Centre continued to expand its research on the properties of mine fill. This appears to be more important as the percentage of underground ore mined by cut-and-fill methods continues to increase.

In one major mine, experiments were undertaken to stabilize rock fill with cement grout. The grout was pumped in through holes drilled from development openings in the pillars.

Research relative to mining in thick coal seams is underway in the Mining Research Centre. Other research directed towards coal mining is related to spontaneous combustion and methane emission.

Surface Mining

The dominant trend in surface mining has been the increasing size of loading and hauling equipment A 60-cubic-yard dragline went into service at the Fording Coal operation in British Columbia. This is the largest operating equipment of its type in Canada.

Draglines with 120-and 130-cubic-yard buckets are being considered for mining of tar sands at a developing operation. The draglines will be used both for stripping and tar-sands mining. It is anticipated that further transport of mined sands will be by conveyor to railway cars after reclaiming with a bucket wheel.

One iron-ore mining company has evaluated surface haulage with a "trolley assist" method Maintenance of vehicle speed when, under electric power, has improved performance when climbing 10-per-cent grades.

Stability of wall slopes in surface mines is receiving concentrated attention. Teams of consultants, working with mining companies, are investigating the effects of groundwater, of joint and fault patterns and of production blasting on wall slopes.

Advances in surface mining technology are holding surface mining costs approximately constant.

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The publications listed below may be obtained from:

Publications Distribution Office, Mines Branch,
Department of Energy, Mines & Resources,
555 Booth Street,
Ottawa, Ontario. K1A OG1.

All requests should be accompanied by a cheque or money order made payable to: Receiver General of Canada.

R = Research Report
IC = Information Circular
TB = Technical Bulletin
RS = Reprint Series

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