

The Mineral Industry of Minnesota

This chapter has been prepared under a cooperative agreement between the Bureau of Mines, U.S. Department of the Interior, and the Minnesota Geological Survey for collecting information on all minerals except fuels.

By Keith S. Olson ¹

Value of Minnesota mineral production increased 8 percent to \$550.3 million. The State continued to lead the Nation in production of iron ore, contributing 61 percent of the total usable ore shipped from mines in the United States. Ironbearing ores (including manganiferous ores) represented 91 percent of the total value of the State mineral production.

Shipments of taconite concentrates increased by 14 percent, establishing a new

record of 21.4 million long tons. Quantity and value increases were recorded for the production of portland cement, miscellaneous clay, iron ore, peat, sand and gravel, stone, and tube-mill liners. Production of masonry cement, fire clay, grinding pebbles, lime, and manganiferous ore decreased both in quantity and value.

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Table 1.—Mineral production in Minnesota ¹

Mineral	1965		1956	
	Quantity	Value (thousands)	Quantity	Value (thousands)
Clays ²thousand short tons..	207	\$311	224	\$336
Iron ore (usable).....thousand long tons, gross weight..	50,873	459,290	55,133	499,388
Manganiferous ore (5 to 35 percent Mn).....				
short tons, gross weight..	280,705	W	275,581	W
Peat.....short tons..	7,346	123	11,366	197
Sand and gravel.....thousand short tons..	37,545	27,296	39,331	28,972
Stone.....do.....	4,371	11,680	4,901	11,688
Value of items that cannot be disclosed: Abrasive stones, cement, fire clay, gem stones, lime, and values indicated by symbol W.....	XX	9,060	XX	9,696
Total.....	XX	507,760	XX	550,277

W Withheld to avoid disclosing individual company confidential data; included with "Value of items that cannot be disclosed."

XX Not applicable.

¹ Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

² Excludes fire clay included with "Value of items that cannot be disclosed."

Table 2.—Value of mineral production in constant 1957-59 dollars (Millions)

Year	Value ¹	Year	Value ¹
1957.....	\$594	1962.....	\$410
1958.....	395	1963.....	420
1959.....	340	1964.....	448
1960.....	502	1965.....	452
1961.....	428	1966.....	485

^p Preliminary.

¹ Data for 1957-64 revised.

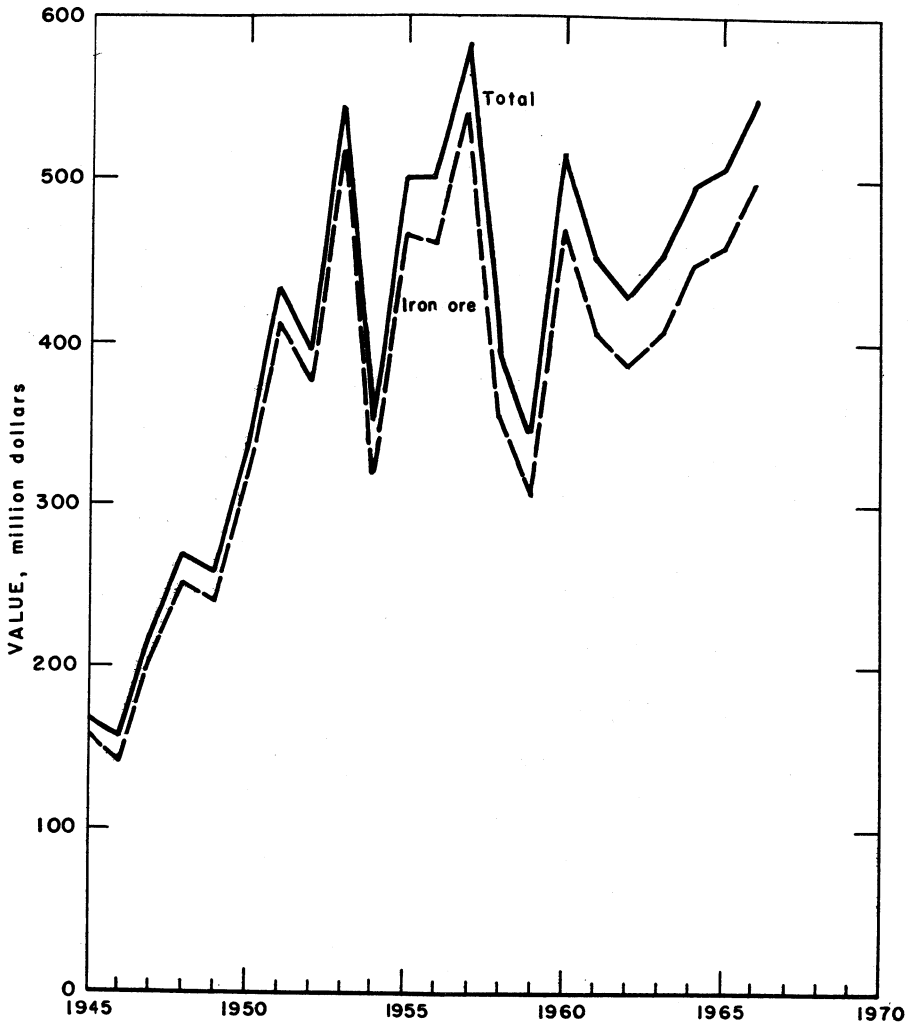


Figure 1.—Value of iron-ore shipments and total value of mineral production in Minnesota.

Table 3.—Employment and injury experience in the mineral industries

Year and industry	Average men working daily	Days active	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rates per million man-hours	
					Fatal	Non-fatal	Frequency	Severity
1965:								
Metal.....	9,801	285	2,798	22,382	—	92	4.11	253
Nonmetal.....	225	269	60	484	1	33	70.27	13,876
Sand and gravel.....	2,334	160	374	3,187	—	57	17.89	416
Stone.....	1,601	240	384	3,170	—	57	17.98	376
Peat.....	38	60	2	16	—	—	—	—
Total.....	13,999	258	3,613	29,239	1	239	8.21	509
1966: ^p								
Metal.....	10,065	293	2,944	23,575	4	99	4.37	1,283
Nonmetal.....	220	269	60	482	1	29	62.24	14,822
Sand and gravel.....	2,330	167	390	3,367	2	60	18.41	4,021
Stone.....	1,615	240	387	3,203	—	73	22.79	599
Peat.....	25	112	3	19	—	—	—	—
Total.....	14,255	265	3,784	30,646	7	261	8.75	1,725

^p Preliminary.

REVIEW BY MINERAL COMMODITIES

METALS

Copper-Nickel.—Stimulated by high demand, extensive exploration activities for copper-nickel were conducted along the Duluth Gabbro in Cook, Lake, and St. Louis Counties. Indications are that the low-grade sulfide ores contain about one percent combined copper-nickel in the ratio of three parts copper to one of nickel. It was estimated that nearly all mining would be by underground methods. Major mining companies holding leases in the area and/or conducting exploration activities included: American Metal Climax, Inc., Bear Creek Mining Co. (the exploration arm of Kennecott Copper Corp.), Cleveland-Cliffs Iron Co., Duval Corp., The International Nickel Co., Inc. (Inco), Newmont Exploration Ltd., New Jersey Zinc Co., United States Steel Corp., Phelps Dodge Corp., and The Hanna Mining Co.

In June, Inco acquired leases on approximately 5,000 acres of Federal lands in the South Kawishiwi River area near Ely. A 1,300-ton bulk sample was transported to Inco's Copper Cliff laboratory near Sudbury, Ontario, Canada, for metallurgical testing. Inco also announced tentative plans for a mining and milling operation capable of producing 125 million pounds of copper and nickel per year. After revising rules and regulations covering mining permits and leases for copper, nickel, and associated minerals on State-owned lands,

the State of Minnesota granted 50-year leases totaling about 86,500 acres to 11 companies.

The University of Minnesota Mines Experiment Station conducted tests on copper-nickel ores from northeastern Minnesota utilizing bacterial leaching and sulfide flotation methods.

Iron Ore.—Shipments of usable iron ore from Minnesota mines (excluding ore containing 5 percent or more manganese) were 55.1 million long tons, 8 percent greater than in 1965. Mine value of shipments totaled \$499.4 million, an increase of \$40.1 million. About 77 percent of the ore shipped during the year was beneficiated.

Greater demand by the Nation's blast furnace operators for a high quality fuel was evidenced by shipments of taconite concentrates increasing to 21.4 million long tons, compared with 18.9 million tons in 1965. Taconite concentrates comprised nearly 39 percent of all iron-ore shipments in 1966. Average natural iron content of usable iron ore produced was 56.4 percent. Fourteen companies operated mines in four counties. Nearly 95 percent of the ore produced was from the Mesabi Range in Itasca and St. Louis Counties. Mines on the Cuyuna Range in Crow Wing County, the Vermilion Range in St. Louis County, and the Spring Valley district in Fillmore County produced the remainder. No production was recorded in Olmsted County.

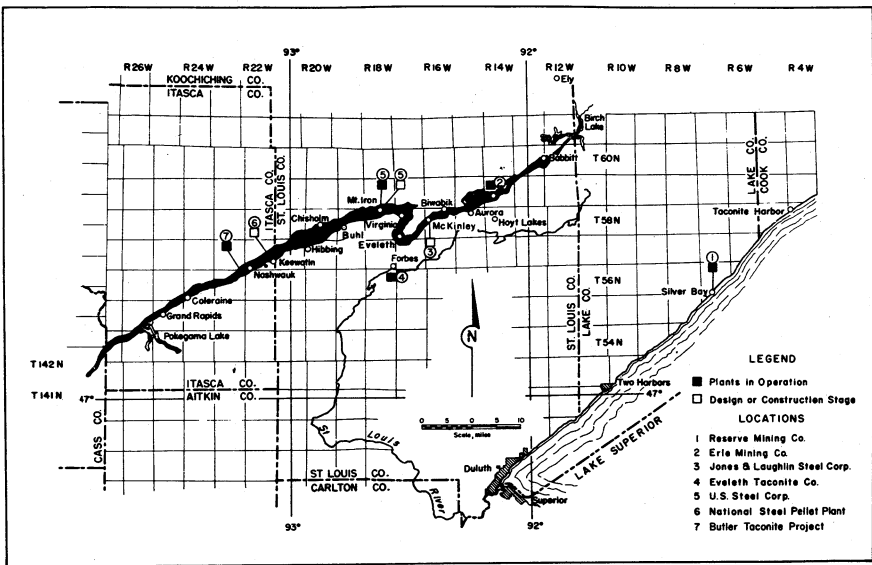


Figure 2.—Locations of currently operating and proposed Mesabi Range taconite-processing plants.

Growth of Minnesota's taconite industry continued during 1966 with three plants under construction and a fourth in design stage. In addition, expansion programs were taking place at two existing plants. The Hanna Mining Co. was nearing completion of two new pellet plants with a combined capacity of 4.4 million tons per year. At yearend, the company was conducting preoperational testing at the Butler Taconite Project near Nashauk. The company was also slated to begin production in 1967 at the National Steel Pellet Plant near Keewatin. Development work was conducted at the Kevin pit, which will supply crude taconite to the Butler Project. Crude material for the National Steel Plant will be mined from the Section 18 pit, an exhausted natural ore mine.

Near Mountain Iron, United States Steel Corp. was building the largest of the new pelletizing plants, the 4.5 million-ton-per-year Minntac operation. Production was scheduled to begin in 1967. Jones & Laughlin Steel Corp.'s proposed 2-million-ton-per-year pellet plant near Biwabik was in preliminary design stage. Reserve Mining Co. completed an expansion program at its Silver Bay pellet plant, increasing annual

capacity to 10.7 million tons. At Hoyt Lakes, Erie Mining Co. was engaged in a \$50 million expansion project designed to increase its annual pellet-making capacity to 10.3 million tons.

Combining existing plants with facilities under construction, Minnesota will have an annual taconite concentrate capacity of 32 million tons in 1967.

The two remaining underground iron mines in the State were scheduled to be closed in 1967. Inland Steel Co. announced plans to cease mining operations at its Armour No. 2 mine on the Cuyuna Range, Crow Wing County. United States Steel Corp. plans to close its Pioneer mine, at Ely, the sole producer on the Vermilion Range, St. Louis County.

The navigation season for ports shipping Minnesota iron ores began at Duluth on March 30, the earliest opening for a Lake Superior port since 1953. On December 13 the final shipment left Silver Bay. The Duluth, Missabe & Iron Range Railroad reopened its Two Harbors ore docks which had been inactive since 1962.

Lake Erie base prices for iron ore were unchanged from 1965. Increasing shipments of taconite concentrates resulted in a gain

Table 4.—Crude iron ore¹ data, in 1966, by counties and ranges
(Thousand long tons)

County and range	Stocks Jan. 1	Production		Shipments		Stocks Dec. 31
		Under- ground	Open pit	Direct to consumers	To con- centrators	
County:						
Crow Wing.....	73	438	1,217	443	1,209	76
Fillmore.....	---	---	1,404	---	1,404	---
Itasca.....	---	---	23,056	51	23,005	---
St. Louis.....	983	789	89,173	12,369	78,176	401
Total².....	1,056	1,227	114,851	12,863	103,794	477
Range:						
Cuyuna.....	73	438	1,217	443	1,209	76
Mesabi.....	983	---	112,229	12,420	100,391	401
Vermilion.....	---	789	---	---	789	---
Spring Valley district.....	---	---	1,404	---	1,404	---
Total².....	1,056	1,227	114,851	12,863	103,794	477

¹ Exclusive of ore containing 5 percent or more manganese.² Data may not add to some totals shown because of rounding.**Table 5.—Usable iron ore¹ data, in 1966, by counties and ranges**
(Thousand long tons)

County and range	Stocks Jan. 1	Production	Iron content of production	Shipments	Stocks Dec. 31
County:					
Crow Wing.....	73	1,299	657	1,296	76
Fillmore.....	98	772	361	575	295
Itasca.....	2,722	8,084	4,488	9,247	1,560
St. Louis.....	2,619	44,125	25,118	44,015	2,729
Total².....	5,512	54,280	30,625	55,133	4,659
Range:					
Cuyuna.....	73	1,299	657	1,296	76
Mesabi.....	5,245	51,506	29,186	52,549	4,202
Vermilion.....	96	704	421	713	87
Spring Valley district.....	98	772	361	575	295
Total².....	5,512	54,280	30,625	55,133	4,659

¹ Exclusive of ore containing 5 percent or more manganese.² Data may not add to some totals shown because of rounding.**Table 6.—Usable iron ore¹ produced (direct-shipping and all forms of concentrate), by ranges**
(Thousand long tons)

Year	Cuyuna	Mesabi	Vermilion	Spring Valley district	Total ²
1884-1956.....	58,842	2,095,500	93,566	3,142	2,251,050
1957.....	2,018	64,537	1,349	382	68,286
1958.....	1,119	39,833	1,027	241	42,221
1959.....	745	33,747	809	576	35,877
1960.....	1,166	54,442	1,361	473	57,442
1961.....	1,095	41,199	930	491	43,714
1962.....	655	43,041	1,158	362	45,216
1963.....	515	43,570	774	524	45,383
1964.....	513	47,256	865	420	49,054
1965.....	367	50,279	782	625	52,053
1966.....	1,299	51,506	704	772	54,280
Total².....	68,334	2,564,909	103,325	8,008	2,744,576

¹ Exclusive, after 1905, of iron ore containing 5 percent or more manganese.² Data may not add to some totals shown because of rounding.

in the average weighted mine value of Minnesota iron ore to \$9.06 per ton, compared with \$9.03 in 1965.

Nearly all iron ore shipped from Minnesota was for use in manufacturing pig iron and steel. Small quantities were sold for cement manufacture and foundry purposes.

Research on the beneficiation of non-magnetic taconites and semitaconites was continued by the Federal Bureau of Mines at its Twin Cities Research Center. The Bureau of Mines \$4.5 million plant designed to demonstrate commercial feasibility of magnetically roasting nonmagnetic taconites, semitaconites, and off-grade iron

Table 7.—Production of usable iron ore
(Thousand long tons)

Year	Gross weight		Iron content (percent)
	Ore	Iron content	
1957	68,286	35,842	52.49
1958	42,221	22,793	53.99
1959	35,877	19,412	54.11
1960	57,442	31,147	54.22
1961	43,714	24,215	55.39
1962	45,216	25,242	55.83
1963	45,333	25,576	56.36
1964	49,054	27,660	56.39
1965	52,053	29,510	56.69
1966	54,280	30,625	56.42

Table 8.—Iron ore¹ shipped from mines
(Thousand long tons)

Year	Direct shipping ore ²	Concentrates			Total usable ore ³	Proportion of concentrates to total usable ore (percent)
		Agglomerates	Other	Total		
1957-61 (average)	21,373	9,984	17,781	27,765	49,138	56.50
1962	11,466	14,085	18,744	32,829	44,295	74.11
1963	7,468	16,857	21,110	37,967	45,435	83.56
1964	10,441	19,267	19,917	39,184	49,626	78.96
1965	11,579	19,039	20,255	39,294	50,873	77.24
1966	12,863	21,580	20,690	42,270	55,133	76.67

¹ Exclusive of ore containing 5 percent or more manganese.

² Includes crushed, screened, and sized ore not further treated.

³ Data may not add to some totals shown because of rounding.

Table 9.—Dates of first and final cargoes of iron ore at U.S. upper Great Lakes ports

Port and dock	1965		1966	
	First	Final	First	Final
Ashland, Wis.:				
C&NW	May 3	¹ Oct. 30	---	---
Soo Line	May 3	¹ Oct. 30	---	---
Duluth, Minn.: DM&IR	Apr. 19	Nov. 20	Mar. 30	Nov. 27
Escanaba, Mich.: C&NW	Apr. 7	Dec. 19	Mar. 31	Dec. 23
Marquette, Mich.:				
Soo Line	Apr. 26	Dec. 5	Apr. 26	Nov. 20
LS&I	Apr. 17	Dec. 12	Apr. 4	Dec. 13
Silver Bay, Minn.: Reserve	Apr. 23	Dec. 14	Apr. 8	Dec. 13
Superior, Wis.:				
GN	Apr. 24	Dec. 9	Apr. 11	Dec. 1
NP-Soo Line	Apr. 29	Oct. 25	Apr. 22	Oct. 24
Taconite Harbor, Minn.: Erie	Apr. 21	Dec. 9	Apr. 8	Dec. 10
Two Harbors, Minn.: DM&IR	---	---	May 20	Nov. 20

¹ Dock closed August 16 but reopened for October shipment making October 30 shipment figure final for 1965 season. Docks not utilized in 1966.

Source: Skillings' Mining Review.

ores using scrap iron as a reductant, was in design stage. Construction was to begin in 1967, and the plant was slated to be in production in 1968. Approximately 250,000 tons of crude ore and 25,000 tons of automobile and other ferrous scrap will be consumed annually to produce 100,000 tons of prereduced pellets containing about 82 percent iron.

The University of Minnesota Mines Experiment Station, the University's School of Mineral & Metallurgical Engineering, and the Minnesota Geological Survey began a drilling project south of the Mesabi Range to investigate and explore the deep-lying taconite formation. Plans were to drill 10 holes on State-owned lands in the area, at intervals of about 10 miles. Drilling began

December 21 at a site about 1½ miles south of Keewatin in Itasca County. The initial phase of the project was financed by a \$100,000 grant from the Iron Range Resources & Rehabilitation Commission.

Manganiferous Ore.—Manganiferous ore shipments (containing 5 to 35 percent manganese, natural) decreased 2 percent from those of 1965. Shipments totaled 246,055 long tons consisting of 39,202 tons of direct-shipping ore and 206,853 tons of concentrates. Ninety-eight percent of the shipments were classified as ferruginous manganese ore (containing 10 to 35 percent manganese, natural), compared with 87 percent in 1965. Average natural iron and manganese contents of shipments were 34 and 13 percent, respectively.

Manganiferous ore was shipped from seven Cuyuna Range mines in Crow Wing County. Operating companies were The Hanna Mining Co. and Pittsburgh Pacific Co.

A method for recovering a high-grade manganese product from Cuyuna Range tailings by the R-N direct reduction process was developed by the University of Minnesota, Mines Experiment Station in a 2-year project sponsored by the Economic Development Administration and the Iron Range Resources & Rehabilitation Commission. The Mines Experiment Station also continued testing programs involving high intensity wet magnetic separation and flotation recovery processes.

At its Twin City Research Center, the Federal Bureau of Mines continued research in developing methods of utilizing Cuyuna Range low-grade manganese ores.

NONMETALS

Abrasive Stone.—Grinding pebbles and tube-mill liners were produced by Jasper Stone Co. from a quartzite deposit in Rock County. Quantity and value of grinding pebbles decreased from that of 1965. The quantity of tube-mill liners sold during the year increased significantly.

Cement.—Portland and masonry cements were manufactured at Duluth by Universal Atlas Cement Division of United States Steel Corp., the sole producer in the State. Production of portland cement increased over that of 1965 chiefly because of increased sales for highway construction. Sales of masonry cement reflected the decrease in residential construction with a decline in both quantity and value. Output of portland cement consisted of types I and II (general use and moderate heat) and portland-slag cement. Raw materials used in the manufacturing process were limestone from Michigan, sand, slag from the nearby blast-furnace operations, bauxite, gypsum, grinding aids, and air-entraining compounds. One 100-foot and two 200-foot rotary kilns were operated, using bituminous coal and natural gas for fuel. Shipments of portland and masonry cement were primarily to Minnesota consumers with lesser amounts shipped to Michigan, North Dakota, South Dakota, and Wisconsin.

Dundee Cement Co. began construction of a \$1 million service and distribution center on the Upper Harbor of the Mississippi River at Minneapolis.

Clays.—Production of miscellaneous clay and shale was reported from Brown, Carlton, Goodhue, Hennepin, Ramsey, and

Table 10.—Shipments of usable¹ manganiferous iron ore and ferruginous manganese ore from mines in the Cuyuna Range

Year	Manganiferous iron ore (5 to 10 percent Mn, natural)			Ferruginous manganese ore (10 to 35 percent Mn, natural)			Total shipments (long tons)
	Shipments (long tons)	Contents (natural)		Shipments (long tons)	Contents (natural)		
		Fe (percent)	Mn (percent)		Fe (percent)	Mn (percent)	
1957-61 (average) . . .	284,877	39.34	6.66	92,777	34.52	12.19	377,654
1962	129,979	40.40	6.19	131,431	33.28	12.60	261,410
1963	—	—	—	310,121	33.39	12.18	310,121
1964	27,725	36.59	9.68	140,562	32.61	12.38	168,287
1965	32,935	33.99	7.27	217,695	35.47	12.75	250,630
1966	4,035	33.55	8.61	242,020	33.87	14.12	246,055

¹ Direct-shipping and beneficiated ore.

Redwood Counties. Output increased 8 percent in both quantity and value over that of 1965. Chief reason for the increase was greater demand for raw material used in the manufacture of building brick and lightweight aggregate. A small quantity was also used in producing floor and wall tile.

Fire clay production, all of which was used in the manufacture of vitrified sewer pipe, decreased substantially from that of 1965. Red Wing Potteries, Inc., produced dinnerware and art pottery at Red Wing, chiefly from raw materials produced in other States.

The Minnesota Geological Survey continued investigating kaolin and other clay resources at numerous locations throughout the State to obtain information useful to individuals and industries interested in developing the State's clay potential.

The Federal Bureau of Mines conducted a sampling program near Cook, St. Louis County, to test the suitability of local clays as a binding agent for iron-ore pellets. Pelletizing tests were run at the Bureau's Twin Cities Metallurgical Research Center.

Gem Stones.—Minor quantities of semi-precious gem stones, principally agates, were collected by hobbyists. Gem materials were found chiefly along the north shore of Lake Superior, along the Mississippi River, and in gravel pits in the southeastern part of the State.

Lime.—Total shipments of quicklime and hydrated lime decreased about 4 percent in quantity and 1 percent in value from 1965.

American Crystal Sugar Co. produced quicklime for sugar refining at its plants at Chaska, Carver County; at Moorhead, Clay County; and at Crookston and East Grand Forks, Polk County, Minnesota's only commercial producer, Cutler-Magner Co., manufactured both quicklime and hydrated lime at its Duluth plant, using limestone transported by lake vessel from Michigan. Approximately 92 percent of the company's output was sold for chemical and industrial purposes, including paper manufacture, water purification, and metallurgical uses. Construction and agricultural uses made up the remainder. Most of the commercial production was consumed within the State, with lesser amounts shipped to Iowa, Michigan, North Dakota, and Wisconsin.

Perlite.—Crude perlite mined outside the

State was expanded by Minnesota Perlite Corp. at Bloomington and by Zonolite Division, W. R. Grace & Co. (formerly Western Mineral Products Co.) at Minneapolis. Expanded perlite was used for lightweight aggregate in concrete and building plaster, filler, and soil conditioning. Production was less, both in quantity and value, than in 1965.

Sand and Gravel.—A record high was established for sand and gravel production. The 1966 output, 39.3 million tons, exceeded the previous record established in 1965 by 5 percent. Chief reason for the gain was a 3.7-million-ton increase in production of paving material. Sales of industrial sands increased 19 percent in quantity and 16 percent in value. Sand and gravel used for building declined 12 percent in quantity and 5 percent in value. Average value of all sand and gravel produced in Minnesota was \$0.74 per ton, compared with \$0.73 per ton in 1965. Production was reported from each of the 87 counties in the State. Counties producing over 1 million tons in descending order of production were Hennepin, Washington, Dakota, St. Louis, Carlton, and Clay. Collectively, these six counties comprised 38 percent of the State total. Ninety-two percent of the total commercial production was hauled by truck, 5 percent by river barge, and 3 percent by rail.

Stone.—Total stone output increased to a record 4.9 million tons, exceeding the previous record set in 1965 by 12 percent. A 16-percent increase in the value of crushed and broken stone production and a decrease of 15 percent in the value of dimension stone output resulted in an increase of less than 1 percent in total value. Greater demand for material used as roadstone and concrete aggregate was the major reason for the increase in crushed stone production.

Limestone was quarried from deposits in 15 southcentral and southeastern counties. Major producing counties in descending order of value were Blue Earth, Scott, Dakota, Washington, and Winona, collectively representing 60 percent of the State limestone value. Crushed and broken limestone production increased more than 20 percent in both quantity and value. The largest increases occurred in limestone used for concrete aggregate and roadstone, agricultural limestone, and railroad ballast. Eighty-seven percent of the commercial

Table 11.—Sand and gravel sold or used by producers, by classes of operations and uses
(Thousand short tons and thousand dollars)

Class of operation and use	1965		1966	
	Quantity	Value	Quantity	Value
Commercial operations:				
Sand:				
Building.....	4,454	\$3,461	3,702	\$3,131
Paving.....	1,670	1,111	2,431	1,406
Fill.....	855	317	846	319
Railroad ballast.....	5	5	W	W
Other ¹	380	1,027	461	1,185
Total.....	7,364	5,921	7,490	6,041
Gravel:				
Building.....	3,319	4,896	3,123	4,342
Paving.....	13,736	8,962	15,920	10,562
Railroad ballast.....	357	165	405	249
Fill.....	1,951	951	1,010	382
Other.....	39	24	29	33
Total.....	19,452	14,998	20,487	16,068
Total sand and gravel.....	26,816	20,919	27,977	22,109
Government-and-contractor operations:				
Sand:				
Building.....	7	4	1	(²)
Paving.....	2,036	1,083	2,310	1,247
Fill.....	123	42	118	56
Other.....	36	12	14	6
Total.....	2,202	1,141	2,443	1,309
Gravel:				
Building.....	7	4	3	2
Paving.....	8,202	5,165	8,703	5,482
Fill.....	298	60	165	57
Other.....	20	7	40	13
Total.....	8,527	5,236	8,911	5,554
Total sand and gravel.....	10,729	6,377	11,354	6,863
All operations:				
Sand.....	9,566	7,062	9,933	7,350
Gravel.....	27,979	20,234	29,398	21,622
Total.....	37,545	27,296	39,331	28,972

W Withheld to avoid disclosing individual company confidential data; included with "Other."

¹ Includes blast, engine, filler, foundry, glass, molding, oil (hydrafrac), pottery, porcelain, tile, and other construction and industrial sand (1965-66), and railroad ballast (1966).

² Less than 1/2 unit.

crushed and broken limestone production was trucked, 12 percent was transported by water, and the remainder was shipped by rail. Dimension limestone production declined due to a decrease of more than 50 percent in the sales of house stone veneer. Cut stone represented 82 percent, in value, of all dimension limestone produced in the State.

Granite was produced in seven west-central and central counties. The three largest producing counties in descending order of value were Stearns, Big Stone, and Lac qui Parle. Finishing plants were operated at Delano, Cold Spring, and St. Cloud. Operations of the North Star Granite Corp. were acquired by Cold Spring Granite Co. Sales

of both crushed and broken and dimension granite declined substantially from that of 1965. Dimension granite production declined due to a lesser output of rough and dressed monumental stone. Crushed and broken granite production declined 44 percent in quantity and 20 percent in value. Decreases were reported in virtually all use patterns.

New Ulm Quartzite Quarries, Inc., produced crushed and broken quartzite from a deposit in Nicollet County for concrete aggregate and roadstone, filter uses, furnace and converter linings, poultry grit, railroad ballast, and riprap.

Crushed and broken basalt for use in concrete aggregate and roadstone was pro-

Table 12.—Granite sold or used by producers, by uses

Use	1965		1966	
	Quantity	Value (thousands)	Quantity	Value (thousands)
Dimension:				
Rough monumental..... thousand cubic feet..	W	W	21	\$73
Dressed architectural..... do.....	W	W	150	2,102
Dressed monumental..... do.....	84	\$1,217	74	1,089
Other..... do.....	1,226	12,837	---	---
Total..... approximate thousand short tons ² ..	26	4,054	20	3,264
Crushed and broken:				
Concrete aggregate and roadstone thousand short tons..	W	W	86	166
Railroad ballast..... do.....	W	W	233	346
Other ³ do.....	617	857	26	170
Total..... do.....	617	857	345	682
Grand total..... do.....	643	4,911	365	3,946

W Withheld to avoid disclosing individual company confidential data; included with "Other."

¹ Includes granite for dressed architectural and rough monumental use.

² Average weight of 166 pounds per cubic foot used to convert cubic feet to short tons.

³ Includes granite for concrete aggregate and roadstone, railroad ballast, and fill (1965); and grit, stone sand, and riprap.

Table 13.—Limestone sold or used by producers, by uses

Use	1965		1966	
	Quantity	Value (thousands)	Quantity	Value (thousands)
Dimension:				
Rough construction..... thousand short tons..	W	W	(¹)	\$3
Rubble..... do.....	W	W	---	---
Rough architectural..... thousand cubic feet..	W	W	9	40
Sawed..... do.....	21	\$96	32	157
House stone veneer..... do.....	95	254	45	114
Cut..... do.....	134	1,416	97	1,425
Flagging..... do.....	W	W	13	1
Total..... approximate thousand short tons ² ..	24	1,847	16	1,740
Crushed and broken:				
Riprap..... thousand short tons..	159	100	151	198
Concrete aggregate and roadstone..... do.....	3,043	3,713	3,706	4,377
Agriculture..... do.....	293	466	324	518
Railroad ballast..... do.....	7	10	44	60
Other ³ do.....	57	343	99	433
Total ⁴ do.....	3,560	4,631	4,323	5,585
Grand total ⁴ do.....	3,583	6,478	4,339	7,324

W Withheld to avoid disclosing individual company confidential data; included with "Total."

¹ Less than 1/2 unit.

² Average weight of 160 pounds per cubic foot used to convert cubic feet to short tons.

³ Includes limestone for fertilizer and other uses (1965), asphalt, flux, poultry grit (1965-66), and filter beds (1966).

⁴ Data may not add to total shown because of rounding.

duced in St. Louis County by Arrowhead Blacktop Co. (formerly Zenith Dredge Co.).

A small quantity of marl was produced in Wadena County for agricultural purposes.

Sulfur.—At its Pine Bend refinery in Dakota County, Great Northern Oil Co. recovered elemental sulfur, as a byproduct, utilizing the Claus process. Shipments in-

creased both in quantity and value compared with those of 1965.

Vermiculite.—Crude vermiculite mined outside the State was exfoliated by three firms in Minneapolis and St. Paul. Sales increased both in quantity and value, with the latter showing a larger increase. Material sold for lightweight concrete and plaster aggregate increased significantly, whereas that sold for insulation decreased. Sales

of exfoliated vermiculite for other uses, including masonry fill, litter, and acoustical purposes, remained approximately the same as in 1965.

MINERAL FUELS

Peat.—Seven companies in Aitkin, Carlton, Itasca, Otter Tail, Pine, and St. Louis Counties reported production. Moss and

reed-sedge comprised over 99 percent of the State total with humus peat representing the remainder. Sales increased 55 percent in quantity and 60 percent in value, chiefly because of more favorable weather conditions than in 1965. Material was sold in bulk and packaged form for soil improvement and other horticultural purposes.

REVIEW BY COUNTIES

Mineral production was recorded from every county in the State. Due to its large-scale iron-ore operations, St. Louis County produced 77 percent of the State total mineral value. Itasca County ranked second, contributing 13 percent of the State total. Mineral values in 13 counties exceeded \$1 million. Mineral value increased in 47 counties, decreased in 39, and in 1 county remained the same, compared with 1965. Nearly all increases and decreases, excluding the three major iron ore producing counties, were attributed to changes in demand for road construction materials.

Sand and gravel production was recorded in each of the 87 counties. In all but 3 (Goodhue, Ramsey, and Scott) of the 35 counties discussed in this section there was some sand and gravel production by and/or contracted for the State, county, and municipal highway departments. References to this output is not included in the individual county sections; discussion being limited to commercial operations only.

Aitkin.—Sand and gravel production for highway purposes totaled 145,000 tons, a 25-percent decrease from the previous year. Portable plants were operated by Dropps Bros. Construction, Inc., near Hill City; Megarry Bros., Inc., near Aitkin; and Ulland Bros., Inc., near McGrath.

Colby Pioneer Peat Co. and Jake McKondski produced peat from bogs near Wawina and Hill City, respectively. Approximately 1,500 tons were produced, all of which was used for soil improvement. The peat operation of Kimball & Sons Co. near Hill City was inactive in 1966.

Big Stone.—Decreased output of dimension granite was the chief reason for the 15-percent drop in value of mineral production from 1965. Granite was quarried by Cold Spring Granite Co. at the Agate

quarry near Ortonville, and by Delano Granite, Inc., at the Odessa quarry near Odessa. Processing plants were operated by the former at Cold Spring and St. Cloud and by the latter at Delano, producing finished stone for architectural and monumental purposes.

Approximately 311,000 tons of sand and gravel was produced for building and road construction. Hallett Construction Co. and Mark Sand & Gravel Co. operated pits near Odessa.

Blue Earth.—Value of mineral production increased 8 percent over that of 1965, chiefly because of greater output of sand and gravel. Dimension limestone was quarried near Mankato by Mankato Stone Co. and Vetter Stone Co., principally for architectural purposes. The latter company also produced broken limestone for riprap. Lundin Construction Co. and Mankato Ag Lime & Rock Co. produced crushed and broken limestone near Mankato for concrete aggregate and roadstone, agricultural limestone (aglime), and riprap.

About 673,000 tons of sand and gravel was produced for building and road construction purposes. Stationary plants were operated near Mankato by Guaranteed Gravel & Sand Co., Hiniker Sand & Gravel Co., and North Star Concrete Co. H. R. Loveall produced paving gravel at a portable plant near Beauford.

Brown.—Approximately 163,000 tons of sand and gravel was produced for building and road construction, less than half the 1965 output. As a result, value of mineral production decreased 35 percent compared with 1965. Fixed sand and gravel plants were operated by Roberts Bros. and Wallner Sand & Gravel near Sleepy Eye and New Ulm, respectively. Portable plants were operated by Carlson Bros., Inc., near Essig and New Ulm.

Table 14.—Value of mineral production in Minnesota, by counties

County	1965	1966	Minerals produced in 1966 in order of value
Aitkin	\$170,800	\$89,500	Sand and gravel, peat.
Anoka	W	251,000	Sand and gravel.
Becker	468,000	W	Do.
Beltrami	157,000	370,000	Do.
Benton	64,000	172,000	Do.
Big Stone	W	744,992	Stone, sand and gravel.
Blue Earth	1,528,448	1,654,522	Do.
Brown	319,593	206,306	Sand and gravel, clays.
Carlton	292,000	656,500	Sand and gravel, peat, clays.
Carver	419,926	505,690	Sand and gravel, lime.
Cass	169,331	94,000	Sand and gravel.
Chippewa	191,000	227,000	Do.
Chisago	115,000	W	Do.
Clay	1,540,827	1,764,093	Sand and gravel, lime.
Clearwater	129,000	64,000	Sand and gravel.
Cook	270,000	302,000	Do.
Cottonwood	117,000	155,000	Do.
Crow Wing	4,460,550	11,022,327	Iron ore, manganese ore, sand and gravel.
Dakota	2,145,585	2,941,187	Sand and gravel, stone.
Dodge	W	W	Stone, sand and gravel.
Douglas	74,000	551,000	Sand and gravel.
Faribault	410,000	205,000	Do.
Fillmore	W	W	Iron ore, stone, sand and gravel.
Freeborn	314,000	W	Sand and gravel.
Goodhue	385,781	476,206	Stone, sand and gravel, clays.
Grant	137,000	W	Sand and gravel.
Hennepin	4,299,500	3,707,000	Sand and gravel, clays.
Houston	96,696	W	Stone, sand and gravel.
Hubbard	35,000	13,000	Sand and gravel.
Isanti	41,000	35,000	Do.
Itasca	71,644,513	72,242,887	Iron ore, sand and gravel, peat.
Jackson	107,000	60,000	Sand and gravel.
Kanabec	619,700	136,000	Do.
Kandiyohi	369,000	438,000	Do.
Kittson	49,000	31,000	Do.
Koochiching	87,000	74,000	Do.
Lac qui Parle	520,852	539,878	Stone, sand and gravel.
Lake	115,000	115,000	Sand and gravel.
Lake of the Woods	108,000	89,000	Do.
Le Sueur	1,868,972	1,703,979	Sand and gravel, stone.
Lincoln	173,000	118,000	Sand and gravel.
Lyon	213,000	273,000	Do.
McLeod	143,000	177,000	Do.
Mahnomen	W	W	Do.
Marshall	195,000	W	Do.
Martin	254,000	158,000	Do.
Meeker	W	146,000	Do.
Mille Lacs	283,100	305,500	Stone, sand and gravel.
Morrison	193,000	224,000	Sand and gravel.
Mower	577,683	511,217	Stone, sand and gravel.
Murray	79,000	82,000	Sand and gravel.
Nicollet	569,095	606,434	Sand and gravel, stone.
Nobles	119,000	173,000	Sand and gravel.
Norman	146,000	123,000	Do.
Olmsted	646,635	743,573	Stone, sand and gravel.
Otter Tail	752,000	479,500	Sand and gravel, peat.
Pennington	183,000	W	Sand and gravel.
Pine	79,975	281,543	Sand and gravel, peat.
Pipestone	W	212,000	Sand and gravel.
Polk	1,002,014	874,264	Lime, sand and gravel.
Pope	88,000	119,000	Sand and gravel.
Ramsey	706,500	W	Sand and gravel, clays.
Red Lake	61,000	44,000	Sand and gravel.
Redwood	373,350	532,472	Sand and gravel, stone, clays.
Renville	531,600	524,300	Stone, sand and gravel.
Rice	344,154	406,512	Sand and gravel, stone.
Rock	588,410	452,163	Sand and gravel, abrasives.
Roseau	129,000	85,000	Sand and gravel.
St. Louis	389,850,510	423,257,480	Iron ore, cement, sand and gravel, lime, stone, peat.
Scott	1,270,998	1,255,058	Stone, sand and gravel.
Sherburne	143,000	377,000	Sand and gravel.
Sibley	157,000	W	Do.
Stearns	3,049,741	2,689,587	Stone, sand and gravel.
Steele	436,414	494,158	Sand and gravel, stone.
Stevens	W	W	Sand and gravel.
Swift	113,000	139,000	Do.
Todd	119,000	W	Do.
Traverse	21,000	36,000	Do.
Wabash	160,646	310,315	Sand and gravel, stone.
Wadena	61,280	66,040	Do.

See footnotes at end of table.

Table 14.—Value of mineral production in Minnesota, by counties—Continued

County	1965	1966	Minerals produced in 1966 in order of value
Waseca	\$20,000	\$49,000	Sand and gravel.
Washington	2,506,529	3,380,736	Sand and gravel, stone.
Watsonwan	W	75,000	Sand and gravel.
Wilkin	42,000	29,000	Do.
Winona	896,943	1,104,197	Stone, sand and gravel.
Wright	33,000	207,000	Sand and gravel.
Yellow Medicine	399,000	314,886	Stone, sand and gravel.
Undistributed ¹	6,209,299	7,203,998	
Total	507,760,000	550,277,000	

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."
¹ Includes some sand and gravel and stone that cannot be assigned to specific counties, and values indicated by symbol W.

Ochs Brick & Tile Co. produced shale from a pit near Springfield. Material was used in the manufacture of building brick and lightweight aggregate.

Carlton.—Due to a greater demand for road construction materials, sand and gravel production increased to 1,076,000 tons. Seven companies operated pits near Barnum, Carlton, Cloquet, Cromwell, Moose Lake, and Scanlon and produced sand and gravel for road construction, building, fill, and railroad ballast.

At Moose Lake, Nemadji Tile & Pottery Co. produced clay used in manufacturing floor and wall tile. Moss (sphagnum) peat for soil improvement was produced by Red Wing Peat Corp. from a bog near Cromwell. All sales were in packaged form.

Carver.—About 460,000 tons of sand and gravel was produced, an increase of 29 percent over that of 1965. Production was used for road construction, building, and fill. Stationary plants were operated by Wm. Mueller & Sons near Hamburg and Rosenwinkel Sand & Gravel Co. near Chaska. Fairway Construction Co. operated a portable plant near New Germany. Hallett Aggregates, Inc., produced pit-run material near Chaska. American Crystal Sugar Co. produced quicklime for use in its sugar refining plant at Chaska.

Clay.—About 1,074,000 tons of sand and gravel was produced for building, highway purposes, and fill. Rollo & George Lewis operated a dredge near Sabin, producing 60,000 tons of paving gravel. Other producers were Ames Sand & Gravel, Inc., near Glyndon; Clay County Sand & Gravel Co., near Felton; Kost Bros., Inc., and Hubert Oye Construction Co., near Moorhead; Northern Improvement Co., near Felton and Sabin; and Ulven Gravel Co., near Hawley.

At Moorhead, American Crystal Sugar Co. produced quicklime for sugar refining.

Cook.—Approximately 8.6 million tons of taconite pellets were shipped by Eric Mining Co. from Taconite Harbor. Pellets were produced at the company's Hoyt Lakes plant, St. Louis County. The 1966 shipping season began at Taconite Harbor on April 8 and concluded on December 10.

Sand and gravel production increased to about 512,000 tons, a 13-percent increase from 1965. Edwin E. Thoreson, Inc., produced building sand and gravel near Taconite Harbor. Ulland Bros., Inc., produced material for road construction near Brule River, Grand Portage, and Hovland. The State and county highway departments produced and/or contracted for paving and fill material.

Crow Wing.—Value of mineral production in the county was more than 2½ times that of 1965. Iron-ore shipments were at the highest level since 1957, although shipments of manganiferous ore decreased 2 percent in both quantity and value.

Operating companies and mines from which iron and/or manganiferous ores were shipped were as follows:

Company:	Mines
The Hanna Mining Co	Algoma, Merritt No. 2, Rabbit Lake, and Robert.
Inland Steel Co.—Pittsburgh	Armour No. 2.
Pacific Co	Hopkins, Mangan No. 1, Mangan East, Sagamore, Sultana, Trojan, and Virginia Extension.

The Hanna Mining Co. constructed a washing plant at its Rabbit Lake mine near Cuyuna and dismantled the washing and sintering plant near its Portsmouth open-pit mine. Pittsburgh Pacific Co. be-

gan production from the Virginia Extension mine and reopened the Trojan Mine. Ores from these two operations were beneficiated at the Virginia plant, a central ore-treating facility for Cuyuna Range mines operated by Pittsburgh Pacific Co.

Inland Steel Co. announced plans to close the Armour No. 2 mine near Crosby, the remaining underground producer on the Cuyuna Range.

Approximately 309,000 tons of sand and gravel was produced for building, paving, fill, and other purposes. Commercial plants were operated near Garrison by Jay W. Craig Co., near Fort Ripley by Ripley Sand & Gravel, Inc., and near Brainerd by C. L. Stodolka Co., Inc., and Les Roberts Sand & Gravel.

Dakota.—Sand and gravel production increased to 2.9 million tons, a 28-percent increase over 1965. Output was used for building, road construction, fill, and other uses. Portable plants were operated by Alexander Construction Co., Inc., near Rosemount and South St. Paul; B-Tu-Mix Co., near Inver Grove Heights; Fischer Construction Co., Inc., near Rosemount; Kimmes Bartelma Construction Co., Inc., near Burnsville, Hastings, and Lakeville; Edward Kraemer & Sons, Inc., near Savage; and Solberg Construction Co. near South St. Paul. Fixed plants were operated by Fischer Sand & Aggregate, Inc., near Rosemount; Northwestern Gravel Co., Inc., near Savage; and Standard Building Material Co. near South St. Paul.

Crushed and broken limestone was produced by Chicago, Milwaukee, St. Paul & Pacific Railroad Co. and Mann Construction Co., both near Hastings, and Edward Kraemer & Sons, Inc., at its Burnsville quarry. Sulfur was recovered as a byproduct at the Great Northern Oil Co. Pine Bend refinery.

Fillmore.—Iron-ore shipments from Fillmore County mines totaled 575,223 long tons, an increase of 3 percent from 1965. Virtually the entire output was shipped all-rail to consuming furnaces at Granite City, Ill. Shipments totaling 524,758 tons were made by The Hanna Mining Co. from its Spring Valley mine group. The remainder was shipped by Schroeder Mining Co. from the Mathison mine.

Seven companies, operating stationary and portable plants near Chatfield, Fountain, Hamony, Lanesboro, Ostrander, Pres-

ton, and Spring Valley, produced approximately 381,000 tons of crushed and broken limestone for concrete aggregate and roadstone, aglime, and riprap.

About 49,000 tons of sand and gravel was produced by Bothun & Tongerson Sand & Gravel near Lanesboro; Thompson Sand & Gravel near Rushford, and by the State highway department. Output was used for building, highway construction, and fill.

Goodhue.—Output of crushed and broken limestone increased 64 percent to approximately 349,000 tons, resulting in a 23-percent increase in value of county mineral production over 1965. The material was used for concrete aggregate and roadstone, aglime, and riprap. Portable plants were operated by Kielmeyer Construction Co. near Kenyon; Mann Construction Co. near Cannon Falls, Goodhue, Red Wing, Wamamingo, and Zumbrota; and Quarve & Anderson Co. near Aspelund, Cannon Falls, Roscoe, Wamamingo, and Zumbrota. Valley Limestone Co. operated a stationary plant near Zumbrota.

Sand and gravel production, about 79,000 tons, was approximately half the 1965 output. Material was used for building, road construction, and fill. Stationary plants were operated by six companies near Cannon Falls, Frontenac, Lake City, Pine Island, Red Wing, and Zumbrota. Mann Construction Co. produced paving gravel with a portable plant near Red Wing.

Plastic fire clay was produced near Goodhue by Red Wing Sewer Pipe Corp. at its Bellchester and North Star pits. Material was used in the manufacture of vitrified sewer pipe at the company's Red Wing plant.

Hennepin.—Despite an 11-percent decrease in quantity, the county continued to rank first in production of sand and gravel with 4.5 million tons. Decreases in production were recorded for building, road construction, fill, and other purposes. Nearly all production was centered in Minneapolis suburban areas. Commercial producers included Alexander Construction Co., Inc.; Anderson Aggregate Inc., Commercial Aggregate, Inc.; Consolidated Materials Co. (Hedberg & Sons Co.); J. A. Danens & Son, Inc.; Dunkley Surfacing Co.; Chas. M. Friedheim Co.; Glacier Sand & Gravel Co.; J. V. Gleason Co., Inc.; F. W. Hedberg & Sons Co.; Mapco Sand & Gravel Co.; and R. J. Potter Inc.

North Central Lightweight Aggregate Co., Inc., produced clay for lightweight aggregate at its Minneapolis plant.

Minnesota Perlite Corp. and Zonolite Division, W. R. Grace & Co. (formerly Western Mineral Products Co.) operated plants at Bloomington and Minneapolis, respectively, and expanded perlite from crude material mined outside the State. The expanded product was used for building plaster, concrete aggregate, soil conditioning, and filler. B. F. Nelson Manufacturing Co. and Zonolite Division, W. R. Grace & Co. produced exfoliated vermiculite from crude material mined outside the State. Sales of the exfoliated product were for aggregate in concrete and plaster, loose-fill insulation, fireproofing, pet litter, acoustical purposes, and miscellaneous uses.

Dundee Cement Co. began construction of a \$1 million distribution center on the Upper Harbor in Minneapolis. The center will be one of several supplied by the company's plant now under construction at Clarksville, Mo.

Itasca.—Itasca County ranked second in total value of mineral production, comprising 13 percent of the State total. Iron-ore shipments, representing 17 percent of the State total tonnage, increased 2 percent over 1965. Approximately 99 percent of the iron-ore shipments were concentrates. All operating mines were open pits. Operating companies and mines from which iron ore was shipped were as follows:

Company:	Mines
Cleveland-Cliffs Iron Co	Canisteo, Hill-Trumbull, Holman-Cliffs, and Sally.
The Hanna Mining Co	Harrison group, Hunner, Mississippi group, and Patrick group.
Jessie H. Mining Co	Jessie No. 2.
Jones & Laughlin Steel Corp	Hill Annex and Lind-Greenway.
Pickands Mather & Co	Danube and West Hill.
United States Steel Corp. Minnesota Ore Operations	Plummer group.

The two taconite plants of The Hanna Mining Co. near Nashwauk and Keewatin with a combined initial capacity of 4.4 million tons of pellets neared completion. At the yearend, preoperational equipment testing was being conducted at Butler Taconite Project near Nashwauk. Participating in the project with The Hanna

Mining Co. were Inland Steel Corp. and Wheeling Steel Corp. Production was to be shared on a percentage basis. The plant will produce oxide pellets using the Allis-Chalmers grate-kiln process. Construction continued at the National Steel Pellet Plant near Keewatin. This plant, with an annual capacity of 2.4 million tons of pellets, was scheduled for operation in 1967. National Steel Corp. has an 85-percent interest and The Hanna Mining Co. has a 15-percent interest in the venture. The plant will be capable of producing either oxide or prereduced pellets using a Midland-Ross designed rotary hearth furnace. Autogenous grinding methods will be employed at both operations. Stripping operations were conducted by the company at the Kevin mine which will supply crude ore to the Butler Taconite Project. Crude taconite will be mined at the Section 18 mine, a depleted natural ore operation, to supply the National Steel Taconite Plant. The company has installed 60-inch gyratory primary crushers at each of the above mines. The Hanna Mining Co. made stockpile shipments of concentrates from the Harrison, Mississippi, and Patrick groups.

Cleveland-Cliffs Iron Co. reopened the Morrison mine—last operated in 1953 by Oliver Iron Mining Division of United States Steel Corp. The Morrison was operated in conjunction with the adjacent Canisteo mine near Coleraine. Jones & Laughlin Steel Corp. reactivated its Hill-Annex semitaconite plant at Calumet, which had been closed in 1964. Mining operations were discontinued by Jessie H. Mining Co. at its Jessie No. 2 mine. Stocks of concentrate remain at the property. United States Steel Corp. conducted only stripping operations at its Arcturus mine near Taconite.

A total of 607,000 tons of sand and gravel was produced for building, highway construction, and fill. Plants were operated by Brink Sand & Gravel Co., and Megarry Bros., Inc., both near Grand Rapids; and Hawkinson Construction Co., Inc., near Cohasset, Coleraine, Grand Rapids, Marble, and Taconite.

Arrowhead Peat Co. produced moss peat for horticultural purposes from a bog near Wawina.

Lac qui Parle.—Bellingham Granite Co. and Northern Quarry Corp. quarried granite for monument use near Bellingham and

Louisburg, respectively. Near Odessa, Cold Spring Granite Co. produced granite at its Red quarry. The company operated finishing plants at Cold Spring and St. Cloud, both in Stearns County, producing stone for architectural and monumental purposes. The Cold Spring Granite Co. acquired the North Star Granite Corp. and operated the former North Star Medallion Quarry No. 9. Production from this quarry was placed in stockpile. Dakota Granite Corp. quarried granite from a quarry near Bellingham and shipped the rough stone to its Milbank, S. Dak. plant for finishing.

Due to an increase in contract production for the county highway department, sand and gravel output was about 285,000 tons, more than double that of 1965. Johnson Road Co., Inc., and Mahnomen Construction Co. operated portable plants and produced paving gravel. W. J. Stolpman produced 15,000 tons of sand and gravel near Rosen, for building, paving, and fill.

Lake.—Reserve Mining Co. completed an expansion program at its Silver Bay pellet plant, increasing annual capacity to 10.7 million tons. The company shipped 31 million tons of crude taconite from the Peter Mitchell mine near Babbitt, St. Louis County, to its Silver Bay plant and produced a record 10.8 million tons of iron ore pellets. Output exceeded the previous record set in 1965 by 8 percent. The Duluth, Missabe, & Iron Range Railroad Co. reactivated its Two Harbors iron ore docks which were idle since 1962.

Sand and gravel production totaled 186,000 tons, about the same as in 1965. Paving gravel was produced by Ulland Bros., Inc., who operated portable plants near Finland, Isabella, and Little Marais. Two Harbors Aggregate Co. (North Shore Investment Co.) operated a stationary plant near Two Harbors and produced sand and gravel for building purposes and fill.

Extensive exploration activity for copper-nickel was conducted in the Duluth gabbro area by several major mining companies. The International Nickel Co., Inc., announced that it was studying the feasibility of constructing a mining and milling operation, about 8 miles southeast of Ely, capable of producing 125 million pounds of copper-nickel each year. The company shipped a 1,300-ton bulk ore sample to its Copper Cliff Laboratory, near Sudbury,

Ontario, Canada, for metallurgical research.

Le Sueur.—Value of mineral output declined 9 percent from that of 1965. Near Kasota, The Babcock Co. quarried dimension limestone for architectural purposes. Some of the output was marketed as marble for interior trim and facings. Ed Swartout, Inc., produced roadstone and riprap at a limestone quarry near Kasota.

Approximately 776,000 tons of sand and gravel was produced. Silica sand was produced by Gopher State Silica, Inc., from the Jordan Sandstone formation. Material was used for glass manufacture, molding, engine sand, oil-field fracturing, filler, foundry uses, and other purposes. Glander Washed Sand & Gravel Co. operated a fixed plant near Le Sueur and produced material for building, paving, fill, and other purposes. Portable plants were operated by Ed Swartout, Inc., near Kasota; H. R. Loveall, near Waterville; and Lundin Construction Co., Inc., near Kasota. Material produced was used for building, paving, and fill.

Mille Lacs.—Cold Spring Granite Co. operated the Diamond Grey quarry near Isle. The company operated finishing plants at Cold Spring and St. Cloud, both in Stearns County, producing finished stone for architectural and monumental purposes.

Production of sand and gravel was approximately 186,000 tons. Carlson Bros., Inc., produced paving gravel, operating portable plants at four pits near Milaca and Princeton. Mille Lacs Sand & Gravel Co. operated a stationary plant near Milaca and produced building and road construction material. Paving material was produced and/or contracted for by the State and county highway departments.

Mower.—Value of mineral output decreased 12 percent, mainly because of a decline in production of crushed and broken limestone. Hickok Calcium White Rock Co. produced limestone for flux and poultry grit with a stationary plant near Le Roy. Martin Bustad & Son operated a stationary plant near Austin, and Osmundson Bros. operated a portable plant near Grand Meadow. Both companies produced crushed limestone for road use and aglime.

About 255,000 tons of sand and gravel was produced for road construction, fill, and other uses. Producers included Os-

mundson Bros. near Adams; and Martin Bustad & Son, Lea Sand & Gravel, and Uland Bros., Inc., all near Austin.

Nicollet.—About 549,000 tons of sand and gravel was produced for building, paving, and fill. Portable plants were operated near St. Peter by Duininck Bros. & Gilchrist, and near Cambria and Courtland by H. R. Loveall. Courtland Ready Mix, Hallett Construction Co., and North Star Concrete Co. operated fixed plants near Courtland, St. Peter, and Judson, respectively.

Crushed and broken quartzite was produced near New Ulm by New Ulm Quartzite Quarries, Inc., for refractory purposes, concrete aggregate and roadstone, railroad ballast, filter use, riprap, and other purposes.

Olmsted.—Value of mineral production increased 15 percent over 1965, mainly because of a greater demand for crushed and broken limestone. Quarve & Anderson Co. operated eight quarries near Byron, Rochester, and Rockdell. Patterson Quarries, Inc., operated its quarry near Eyota. Both companies operated portable plants producing crushed and broken limestone for roadstone and aglime.

Sand and gravel production totaled 355,000 tons, a 3-percent decrease compared with 1965. Stationary plants were operated by Quarve & Anderson Co., Riverside Sand & Gravel Co., and Rochester Sand & Gravel Co., all near Rochester. Output was used for building, road construction, fill, and other uses.

The Baker property, from which Schroeder Mining Co. produced iron ore in 1965, was inactive.

Otter Tail.—Sand and gravel production decreased 50 percent to about 666,000 tons. Major reason for the decrease was a smaller output of road construction material. Plants were operated near Battle Lake, Bluffton, Dalton, Fergus Falls, Foxhome, Henning, New York Mills, Pelican Rapids, Underwood, and Vergas. Producers included J. D. Nelson Excavating Co.; John Dieseth Co.; Thomas Leo Horstman; K. & G Aggregates, Inc.; Mark Sand & Gravel Co.; the Soo Line Railroad Co.; and the State and county highway departments. Output was for building and road construction, railroad ballast, fill, and other uses.

Northland Products Co., Inc., produced

moss peat for soil improvement from a bog near Underwood.

Polk.—Sand and gravel production decreased 43 percent to 431,000 tons, and resulted in a 13-percent decline in value of mineral output in the county. Plants were operated by five companies near Crookston, Euclid, Fertile, and Trail, and by the county highway department. Output was for building, road construction, railroad ballast, fill, and other uses.

American Crystal Sugar Co. produced quicklime at Crookston and East Grand Forks for use in supar refining. All production was from shaft kilns, utilizing coke as fuel.

Ramsey.—Value of county mineral production declined substantially from that of 1965, chiefly because of a 24-percent decrease in value of sand and gravel output. Arsenal Sand & Gravel Co. operated a fixed plant at New Brighton. Portable plants were operated by Alexander Construction Co., Inc., near North St. Paul and St. Paul; and Duininck Bros. & Gilchrist near Little Canada. Output was used for building, road construction, and fill.

Twin City Brick Co. produced 25,000 tons of shale for the manufacture of building brick. Exfoliated vermiculite was produced by MacArthur Co. in St. Paul from crude material mined outside the State. Output was used for aggregate in concrete and plaster, building insulation, and steam pipe insulation.

Redwood.—Due primarily to an increased output of sand and gravel, value of mineral production increased substantially from that of 1965. About 776,000 tons of sand and gravel was produced for building, road construction, fill, and other purposes. Chapman Sand & Gravel Co. and Walnut Washed Sand & Gravel operated fixed plants near Belview and Walnut Grove, respectively. Portable plants were operated by Carlson Bros., Inc., near Vesta and Delhi; Duininck Bros. & Gilchrist, near Redwood Falls; and Werner & Unzeitig near Lambertton.

Johnson Quarry Co. and View Quarry Co. produced granite near Belview for monument purposes. Miscellaneous clay was produced near Redwood Falls by Ochs Brick & Tile Co. for manufacturing building brick at its Springfield plant.

Renville.—Cold Spring Granite Co. quarried granite from its Rainbow quarry near Morton. The company operated finishing plants at Cold Spring and St. Cloud, both in Stearns County, producing finished stone for architectural and monument purposes.

Approximately 408,000 tons of sand and gravel was produced in the county, a 5-percent increase over 1965 output. The material was used for building and road construction. Commercial producers included Danube Washed Sand & Gravel Co., near Danube; Duinick Bros. & Gilchrist, near Renville; John Enestvedt, near Sacred Heart; Fairway Construction Co., near Hector and North Redwood; and Morton Aggregates, Inc., near Morton.

Rice.—Sand and gravel production was approximately 421,000 tons and was used principally for building, road construction, and fill. Owatonna Aggregate Corp. operated a fixed plant, whereas Charles W. Bickel and Kilmeyer Construction Co. operated portable plants. Pit run material was produced by Condon Sand & Gravel and Hallett Construction Co. Operations were located near Dundas, Faribault, and Northfield.

Nearly 102,000 tons of crushed and broken limestone was produced for roadstone, aglime, and riprap. Producers were Bryan Rock Products, Inc., B. H. Heselton Co., and Kilmeyer Construction Co. Material was produced at portable plants located near Faribault, Nerstrand, and Northfield.

Rock.—Jasper Stone Co. produced grinding pebbles and tube-mill liners from a quartzite deposit near Jasper. Finished products were sold for industrial grinding of feldspar, silica sand, paint, ceramics, and other materials that would be affected by iron contamination.

Sand and gravel production was about 413,000 tons and was used for building, road construction, and fill. Production was reported by three commercial producers with pits near Luverne and Leota.

St. Louis.—Value of mineral output in St. Louis County increased \$33.4 million to \$423.3 million. Iron-ore shipments—representing 98 percent of the total mineral value in the county—increased 9 percent in value over 1965. Eighty percent of the total iron-ore shipments in the State were from mines in St. Louis County. Companies shipping iron ore in 1966 were as follows:

Mesabi Range:

	<i>Mines</i>
The Hanna Mining Co	-----Agnew No. 2-South Agnew, Douglas group, Morton-South Eddy, and Pierce group.
Inland Steel Co	-----Dean.
Jones & Laughlin Steel Corp	-----Schley group.
Oglebay Norton Co. (Eveleth Taconite Co.)	-----Thunderbird.
Pacific Isle Mining Co	-----Higgins No. 2.
Pickands Mather & Co	-----Erie Commercial, Mahoning, and Remer Stockpile.
Pittsburgh Pacific Co	-----Arne, Corsica Lean-ore Stockpile, Corsica-Douglas Lean-ore Stockpile, Embarrass Lean-ore Stockpile, Leonidas, Lincoln, Minnewas, Nelson, Stevenson Reserve, Syracuse, and Wyoming Annex.
Reserve Mining Co	-----Peter Mitchell.
Rhude & Fryberger	-----Hull-Rust and Wade.
Snyder Mining Co.	-----Kosmerl Lease Area, Wanless, Whiteside, and Woodbridge.
United States Steel Corp. Minnesota Ore Operations	-----Kosmerl, Pilotac, Rouchleau group, Sherman group, and Stephens.

Vermillion Range:

United States Steel Corp. Minnesota Ore Operations	-----Pioneer.
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Erie Mining Co. (Pickands Mather & Co., operating agents) mined over 24 million tons of crude taconite near Hoyt Lakes. Development work was conducted on the company's area No. 9 about 6 miles west of Hoyt Lakes, which originally was used to supply Erie Mining Co.'s preliminary plant. At the Hoyt Lakes plant, the firm produced 8.6 million tons of taconite pellets, exceeding the record set in 1965 by 7 percent. The pellets were shipped 73 miles on the company-owned railroad to the company's shipping port at Taconite Harbor. Work continued on a \$50 million expansion program designed to increase annual pellet production capacity to 10.3 million tons in 1967.

At its Peter Mitchell mine near Babbitt, Reserve Mining Co. mined about 31 million tons of crude taconite, increasing its accumulative total to more than 200 million tons since initial production in 1952. Ore was crushed to about 3-inch size at the mine and transported on the 47-mile company-owned railroad to the Silver Bay

plant for further crushing, concentrating, and pelletizing.

Eveleth Taconite Co., owned by Ford Motor Co. (85 percent) and Oglebay Norton Co. (15 percent), completed the first year of operations at its Fairlane pellet plant near Forbes. Capacity of the plant was 1.6 million tons of pellets per year. Crude taconite was shipped to the plant by rail from the company's Thunderbird mine located 10 miles to the north.

United States Steel Corp. continued to operate its Pilotac mine and plant near Mountain Iron. Concentrates were shipped to the company's Extaca plant near Virginia for agglomeration. Construction continued at United States Steel Corp.'s 4.5-million-ton-per-year pellet plant on the Continental Divide north of Mountain Iron. Completion was scheduled for 1967.

Jones & Laughlin Steel Corp.'s proposed 2-million-ton-per-year pellet plant near Biwabik was in design stage.

Rhude & Fryberger leased the Gross-Nelson property from United States Steel Corp. The company conducted stripping operations at the site and began construction of a 500-ton-per-hour washing plant. At McKinley, Jones & Laughlin Steel Corp. also leased a natural ore deposit from United States Steel Corp. Plans were to develop an open-pit mine to be in operation in 1968.

Pittsburgh Pacific Co. reported cancellation of the following leases: Corsica Lean-ore Stockpile, Nelson, Stevenson Reserve, Embarrass Lean-ore Stockpile, Minnewas, Syracuse, South Stevenson, and Susquehanna Lean-ore Stockpile.

Natural ore mines producing and shipping more than 1 million long tons in decreasing order of shipments were the Sherman group, Stephens, and Rouchleau group, all operated by United States Steel Corp.; the Mahoning, operated by Pickands Mather & Co.; and the Schley group, operated by Jones & Laughlin Steel Corp.

United States Steel Corp. announced plans to close its Pioneer mine near Ely early in 1967. The Pioneer was the only operating underground mine in the county in 1966 and the sole producer on the Vermilion Range.

Hallett Minerals Co. began construction of a plant at Burnett to process crude bentonite from Montana for use as a binder for taconite pellets. Estimated initial capac-

ity of the plant was 25 tons per hour, with provision for future expansion.

At yearend, the 175-ton-per-day oxygen plant at Babbitt of Union Carbide Corp.'s Linde Division was nearing completion. Scheduled to go on stream in January, 1967, the plant will be a central oxygen supplier for jet-piercing drills operating at various taconite operations on the Mesabi Range.

American Steel & Wire Division of United States Steel Corp. produced basic pig iron and steel at Duluth. During periods of maximum production, two blast furnaces were operated. Nine open hearths were available for steel production.

Universal Atlas Cement Division of United States Steel Corp. produced portland and masonry cements at its Duluth plant. Raw materials used included limestone shipped from Michigan and slag from the nearby blast furnaces. The company was the only producer of cement in the State.

Quicklime and hydrated lime were produced by Cutler-Magner Co., from Michigan limestone at its Duluth plant. The company operated a rotary kiln, utilizing bituminous coal as fuel. Output was used for paper manufacture, agricultural purposes, mason's lime, soil stabilization, paint, petroleum refining, steel manufacturing, and water purification and softening.

Reed-sedge peat was produced by Power-O-Peat Co. (formerly Mesabi Grow Co., Inc.) near Central Lakes. Output was sold in packaged form for general soil improvement and ingredient for potting soils.

Production of sand and gravel was 2.1 million tons, a marked decrease from that of 1965. Material was used for building, paving, railroad ballast, fill, and other purposes. Seventeen companies operated stationary and portable plants at various locations.

Arrowhead Blacktop Co. (formerly Zenith Dredge Co.) produced crushed and broken basalt for concrete aggregate and roadstone at a quarry near Duluth.

Scott.—More than 397,000 tons of crushed and broken limestone was produced for concrete aggregate and roadstone, aglime, railroad ballast, asphalt filler, and riprap. Producers were B & R Rock Products, Bryan Rock Products, Inc., both near Shakopee, and J. L. Shiely Co. near Savage.

Sand and gravel production declined to 280,000 tons. Output was used for building, road construction, sandblasting, and fill. Fixed plants were operated by Belle Plaine Sand & Gravel Co., near Belle Plaine; Haferman & Stark, Inc., and Shakopee Sand & Gravel Co., near Shakopee; and Minnesota Quartz Co., near Jordan. Wissota Sand & Gravel Co. operated a portable plant near New Market.

Stearns.—Value of mineral production decreased 12 percent, chiefly because of declines in output of both crushed and broken and dimension granite. Cold Spring Granite Co. operated five quarries near Cold Spring, Rockville, St. Cloud, and St. Joseph. The company operated finishing plants at Cold Spring and St. Cloud where rough stone was processed for architectural and monument purposes. Poultry grit, traction sand, and bituminous aggregate were produced as byproducts from stone finishing wastes. North Star Granite Corp. was acquired by Cold Spring Granite Co., who continued operations at the former company's St. Cloud finishing plant but did not operate the Minnesota Pink and Pioneer Gray quarries. Delano Granite, Inc., quarried granite at its Rockville quarry and processed the rough blocks at its Delano plant. Output was sold for architectural purposes. Crushed and broken granite was produced near Waite Park by Shiely-Petters Crushed Stone Co., Inc., for concrete aggregate and roadstone, railroad ballast, and stone sand.

About 451,000 tons of sand and gravel was produced, chiefly for building and road construction. A. C. Petters Co., Inc., and Richmond Sand & Gravel Co. produced sand and gravel near St. Cloud and Richmond, respectively.

Washington.—The county ranked second in the State in sand and gravel production, with output of nearly 3.5 million tons. Material was used for building, road construction, railroad ballast, and fill. Commercial producers included Alexander Construction Co., Inc.; Kimmes Bartelma Construction Co., Inc.; Cemstone Products Co.; Commercial Aggregates, Inc.; Jay W. Craig Co.; R. J. Jager Gravel Co.; Carl Olinger; and J. L. Shiely Co. Plants were operated near Forest Lake, Hugo, Lake Elmo, Lakeland, Newport, Scandia, St. Paul Park, Stillwater, and White Bear Lake.

Bryan Rock Products, Inc., Schumann Contracting Co. (who purchased the quarry formerly operated by Nienaber Contracting Co.), and J. L. Shiely Co. produced crushed and broken limestone near Marine-on-St. Croix, Lake Elmo, and St. Paul Park, respectively. Output was used for concrete aggregate and roadstone, aglime, railroad ballast, and filter beds.

Winona.—Value of mineral production increased 23 percent to \$1.1 million, chiefly because of greater demand for road building materials. Biesanz Stone Co., Inc., produced dimension limestone for architectural purposes at its Winona quarry. Lloyd Debold, Fakler Road Construction, Inc., Hector Construction Co., Inc., and Patterson Quarries, Inc., produced crushed and broken limestone for road construction and aglime. Portable plants were operated near Dresbach, La Crescent, Lewiston, Rollingstone, St. Charles, Wilson, and Witoka. The Spitzer quarry, operated by Patterson Quarries, Inc., was depleted in 1966.

Biesanz Sand & Gravel Co. and Winona Aggregate Co. (Wissota Sand & Gravel Co.) operated stationary plants near Winona and produced sand and gravel for building, road construction, and fill.

Wright.—Delano Granite, Inc., operated its sawing and finishing plant at Delano, producing architectural and monument granite from rough blocks quarried in Big Stone and Stearns Counties. Approximately 356,000 tons of sand and gravel was produced for building and road construction. Rockite Gravel Co. operated a fixed plant near South Haven. Portable plants were operated by Jay W. Craig Co. near Rockford and Duinick Bros. & Gilchrist near Delano. Victor Johnson produced pit-run material near South Haven.

Yellow Medicine.—Crushed and broken granite for riprap and railroad ballast was produced near Granite Falls by The Green Co., Inc., contractor for the Great Northern Railway Co. Delano Granite, Inc., did not operate its Signet quarry in 1966. About 203,000 tons of sand and gravel was produced for building, road construction, and fill. Deutz & Crow Co., Inc., operated its fixed plant near Canby. Portable plants were operated near Clarkfield and Granite Falls by Johnson Road Co., Inc., and Duinick Bros. & Gilchrist.