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ECONOMIC EFFECTS OF MINERAL RESOURCE DEVELOPMENT

IN NORTHEAST MINNESOTA

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The economic effects of mineral resource development addressed in this paper are the changes in employment, population and income in the State of Minnesota and in Northeast Minnesota which are associated with mining and related activities in Northeast Minnesota (Figure 1). These include the present mining, processing and shipping of natural ores and taconite pellets and the potential copper-nickel development.

The findings reported here are based on a study recently completed for the U.S. Bureau of Mines on the economic importance of the mineral industry in Minnesota. The main study report was prepared by Patrick D. Meagher while a related report on an econometric model of the Minnesota and U.S. iron mining industry was prepared by Harald L. Lyche (4,8). I am indepted to both colleagues for much of the content of this paper.

Industry Turning Points

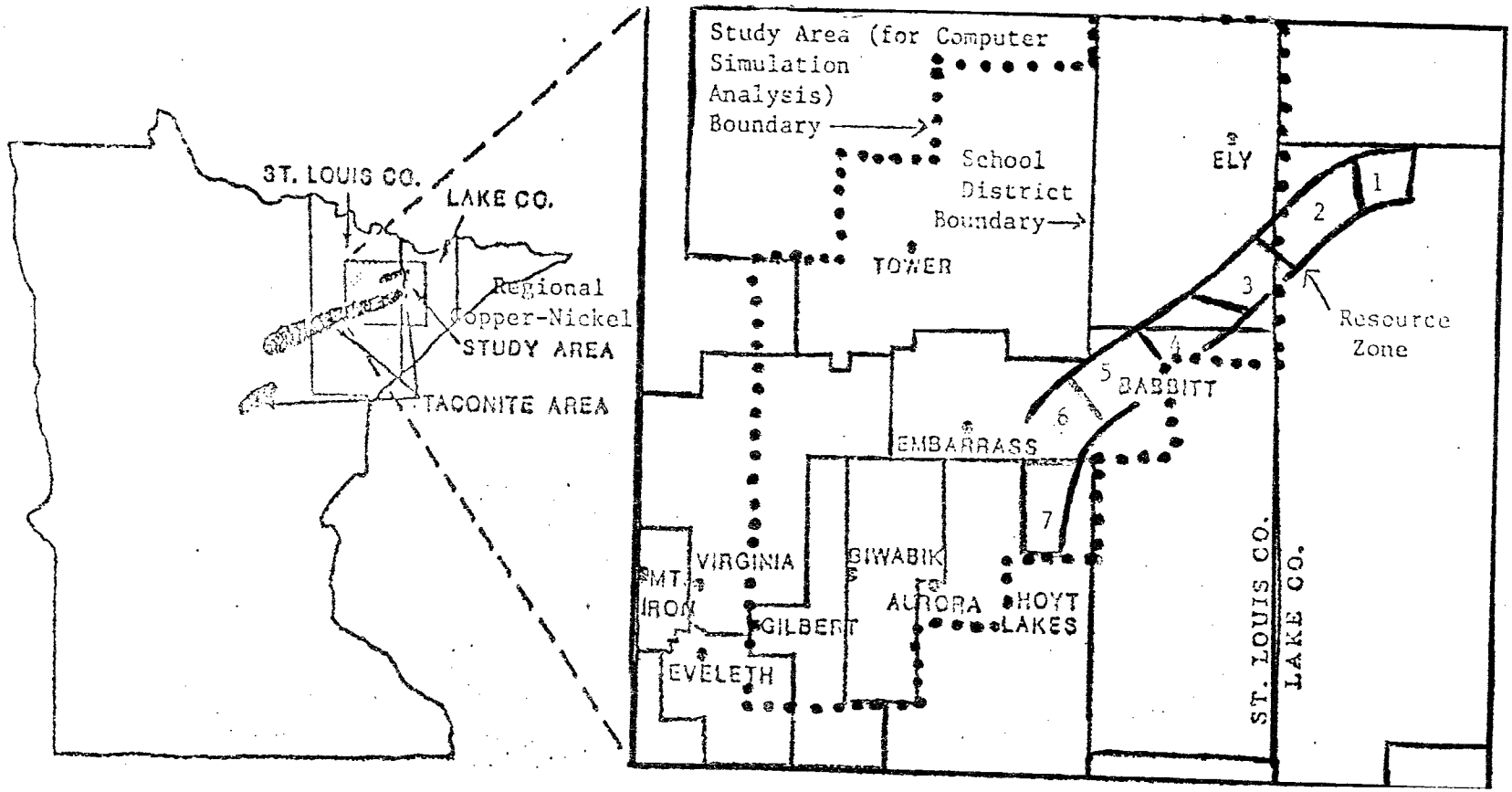
Before assessing the statewide economic effects of regional mineral resource development, I wish to review briefly some turning points in the recent history of the mining industry in this region. Each of these turning points marks an important shift in the economic climate of mineral resources development and related population, employment and income growth.

First, the shift from natural ores to taconite production gradually turned around the decline in total iron ore production. By 1960, an upward trend had emerged, which has continued to the present. Minnesota is now the leading state in the value of metals production. This shift in production also reduced its seasonality, which meant a more seasonally stable industry workforce. Meanwhile, periodic construction booms were triggered as taconite production capacity increased from near-zero in 1955 to nearly 70 million long tons in 1980.

Second, the import dependency of the U.S. iron and steel industry increased through the 1960's. Net iron ore imports nearly doubled -- from 20.9 million long tons in 1961 to 39.4 million long tons in 1970 -- while Minnesota production increased by less than one third -- from 43.2 million long tons to 56.7 million longs tons. For the 1980's, iron ore imports are projected to decline in the one scenario listed in this study which calls for rising import prices and expanding domestic production capacity.

Figure 1

Location of Taconite Areas and Incorporated Places, School Districts, and Copper-Nickel Resource Zones in Copper-Nickel Study Area in Northeast Minnesota.



Third, the sharp climb in the industry price index for taconite, which coincided with the devaluation of the U.S. dollar in February 1973, marked a shift in the pricing environment for the iron and steel industry. Taconite actually dropped in price through the 1950's and 1960's and the early 1970's when measured in constant dollars.

Fourth, the energy crisis of the early 1970's heralded a new set of obstacles for the regional mining industry. While taconite production was increasing in Minnesota, the manufacturing sector was reducing its share of total energy requirements by shifting them to the mining sector of the extended iron and steel industry (3). High energy prices were translating also into high transportation costs. These are likely to increase more rapidly than iron ore prices in the 1980's.

Fifth, a new state tax system for the mining industry was established by the 1977 Minnesota legislature. The new system provides for a certain set of tax levies and receipts and a certain pattern of revenue disbursements to local and state agencies. Because the basic tax levy is adjusted to the industry price index for taconite, which has increased sharply since 1973, the taconite tax revenues also have increased sharply. Regional and local agencies are prime beneficiaries of the increased revenues.

Sixth, the iron and steel manufacturing sector of the extended iron and steel industry is under severe economic presure from the competition of a technologically advanced and efficient manufacturing plants in Asia and Europe. Replacement of old, inefficient facilities with new ones probably requires some industry relocation, which would have important implications for the regional mining industry. Geographic relocation would seriously affect the competitive position of Minnesota mining operations. If the new facilities were built here, significant energy cost savings could be incurred. However, total transportation costs, including the shipment of finished steel products, could increase, thus counter-balancing the energy-cost savings. If the new facilities were built on the Atlantic seaboard, they would have low-cost access to the iron ore resources in South America and Africa, but high-cost access to the Minnesota supplies. Either direction in iron and steel industry relocation points to growing economic uncertainties facing industry decision makers in the 1980's.

Industry and Community Vulnerability to Economic Change

Unlike the 1960's and even the 1970's, the 1980's already portend growing uncertainties in an increasingly turbulent age. Turning points abound in all sectors of our economy. Not being prophets, our predictions are likely wrong, usually on the conservative side. We anticipate less change than actually occurs.

Both the mining industry and the mining-based community have survived repeated cycles of rapid economic change. The last quarter-century, however, has been marked by the reduction of seasonality in

output, payroll, and employment. Until the 1970's, even the business cycle had tempered its impact. Only the short-lived construction booms persisted as reminders of the potential volatility of economic conditions in this industry and region.

Industry Comparisons

The economic importance of the mining industry in Northeast Minnesota is represented, first, by its value of production and purchases in the State. Using constant 1970 dollars, we compare the estimated 1970 and projected 2000 production of the mining and other mineral-related industry in Table 1. Projected output levels in this table are based on the high taconite development option (of slightly more than 100 million long tons gross output in 2000). The copper-nickel development is represented in Sector No. 5. Also shown are the related work force and earnings estimates and projections.

The data in Table 1 show that the iron mining industry directly accounts for 1.4 percent of the industry gross output in the State, 0.8 percent of the total employed work force, and 1 percent of the earnings of this work force. The direct impact of this industry on the Minnesota economy may be small. It is, however, the largest industry in the economic base of Northeast Minnesota.

In 1970, total iron ore production was 57.1 million long tons. This production, which was valued at $571 million, required a total work force of 15,153. Average output per worker for the employed work force of 15,153 was 43,450 tons per year. Average earnings per worker was $13,200. This compares with earnings of $12,950 per worker in the stone and clay mining industry and with earnings of $11,030 per worker in petroleum refining. Investment per worker is smaller in these two groups than in iron ore mining.

In the high taconite gross output option for 2000, total iron ore production (entirely taconite) is projected at 1,052.5 million -- an increase of 84.2 percent above the 1970 level. Output per worker is projected at 86.3 tons, which is twice the 1970 level. This compares with projected increases of 223 percent and 257 percent, respectively, in the stone and clay mining and petroleum refining industries. The annual increase in output per worker is projected at 2.3 percent in iron mining as compared with 4 percent adn 4.3 percent, respectively, in stone and clay mining and petroleum refining. The lower rate for the iron mining industry reflects a higher base-year level, a shorter work week, and added effort in environment-related activities.

Input Requirements and Output Disbursements

Another measure of economic vulnerability is the internal structure of an industry and a community -- their inputs and outputs. Inputs are the raw materials, intermediate goods, and services used in a

Estimated and Projected High Taconite Gross Output (in 1970 dollars), Employment and Earnings (in 1970 dollars) in Specified Producing Sector in Minnesota, 1970 and 2000.

No.	Title	Gross Output		Employment		Earnings	
		Estimated 1970 (thou.dol.)	Projected 2000 (thou.dol.)	Estimated 1970 (no.)	Projected 2000 (no)	Estimated 1970 (thou.dol.)	Projected 2000 (thou.dol.)
Total		42,008,140	96,366,264	1,599,952	2,180,933	11,546,720	21,921,792
Mining:							
4.	Iron and ferro	571,488	1,052,459	13,153	12,193	120,324	225,789
5.	Non ferrous me.	7,932	735,474	146	2,692	1,336	49,869
6.	Copper ore min.	0	0	0	0	0	0
7.	Stone and clay	67,264	127,641	2,197	1,290	28,451	30,778
Manufacturing:							
20.	Petroleum indus.	273,300	529,048	2,032	1,101	22,417	28,142
22.	Stone, clay gl.	230,800	429,417	7,956	9,106	67,403	149,202
23.	Primary iron a.	156,720	357,860	4,598	3,855	42,614	55,468
24.	Primary copper	0	0	0	0	0	0
25.	Other primary	131,180	266,661	2,558	2,759	23,708	39,697
Services:							
34.	Transportation	79,673	185,408	3,248	3,298	28,638	48,822
40.	Electric serv.	335,550	629,665	5,403	4,403	58,693	63,200
41.	Gas service ex.	282,425	515,833	2,367	3,620	46,352	56,582

production process. Outputs are the results of this process. The inputs and outputs of four of the 12 mining-related industries in Minnesota are examined next.

Iron Ore

The industry comparisons show the taconite industry to be a particularly intensive user of electric power and natural gas. Electricity is used for electromagnetic separation of iron-bearing material from waste rock. Natural gas is extensively used to fire kilns which harden taconite pellets. Maintenance and repairs results in large purchases from the construction industry. There are also large purchases of machinery and transportation. Most of the transportation exepnditure is for taconite pellet storage, docks, and harbor facilities needed for shipping pellets on the Great Lakes. There are also significant purchases from the petroleum industry, the primary iron and steel industry and from wholesalers. Petroleum purchases are primarily diesel fuel and lubricants for equipment. Primary iron purchases are chiefly grinding balls.

Purchases from the eight principal industry groups -- Electricity, Gas, Construction, Machinery, Transportation, Petroleum Refining, Primary Iron and Steel -- constitute 79 percent of taconite industry purchases from Minnesota suppliers, which were estimated at $125 million in 1970. This amounts to approximately $2.20 per ton of pellets produced. Wages and salaries paid to taconite workers amounted to an additional $2.15 per ton of pellets produced.

The taconite industry is Minnesota's eight ranking export-producing industry in terms of the dollar volume of sales outside the State. It accounts for approximately six percent of the total exports.

Copper Ore

Copper-Nickel mining appears as a hypothetical, not yet existing, mineral industry in this study. The input data are for a single open pit mining operation producing 20 million metric tons of ore annually. This operation is integrated with a concentrating mill.

Copper-nickel mining and concentrating would purchase inputs primarily from Construction, Chemicals, Petroleum, Primary Iron and Steel, Machinery and Electric Service. Purchases from these industry groups would account for 81 percent of total purchases from industries located in Minnesota.

Primary Iron and Steel

There is a Primary Iron and Steel industry in Minnesota. It consists of a steel maker who melts scrap in an electric furnace; and a

number of gray iron foundries. Inputs are purchased primarily from Construction, Other Primary Metals, Fabricated Metals, Machinery, Electric Machinery, Railroads, Motor Freight, Electric Service, Gas Service, Wholesale Trade, Finance and Insurance, Business Services, and Other Industry. Purchases from the 13 industry groups constitute 71 percent of industry purchases from Minnesota industry.

Primary Copper

The Primary Copper industry would produce refined copper and nickel from ore concentrate produced by the copper mining industry. This industry does not now exist in Minnesota. It is included in the study in order to show how this potential industry would be integrated into the Minnesota economy and to give an indication of its relative magnitude.

This industry would have a very simple input structure. Apart from concentrate from copper mining, it would have purchases from Other Primary Metals, Transportation, and Electric Service. These inputs would constitute 97 percent of purchases from other Minnesota industry.

The input of refined copper (from Sector 24) is required because of refining technology. Transportation inputs would be significant because of the need to import slag-forming compounds which are not produced in Minnesota. It is assumed that these would come by water transportation to Duluth and other Lake Superior harbors. Utilization of Electric Service would be heavy because refining technology is electrolytic. The copper-nickel industry would require slightly more electricity per dollar of finished copper than the taconite industry requires per dollar of pellets.

The potential primary copper industry would probably not have extensive ready markets within Minnesota. For example, Other Primary Metals includes about 12 small establishments engaged in the drawing of non-ferrous metals and copper alloy castings. Most of these are primarily involved in producing aluminum castings. None engage in rolling, drawing, and extruding of copper as their principal business, if at all. And most of these firms appear to work on a job basis. Similarly, Fabricated Metal Products includes only one firm producing plumbing faucets and fittings which may be made from copper alloys.

Projected Industry Development

Projected mineral development was represented, first, by the high taconite option. The baseline option provides for a 37.5 percent increase in taconite production -- approximately one-half of the high output option. This compares with an overall 131 percent increase in total output value.

The three economic indicators for the two taconite development options are represented as differences from the 1970 estimated levels in Table 2. The baseline option represents the level of industry activity associated with the alternate taconite development option (of 78.6 million long tons of output). The projected mining impact is represented by the industry differences between the high taconite development option and the alternative taconite development option. The sum of the projected mining baseline and the projected taconite mining impact is equal to the projected 2000 level of each industry indicator in the high taconite output option.

Anticipated industry expansion from the baseline to the high taconite output option would involve increases in the three economic indicators for the taconite industry (Sector 4) as follows:

	Taconite	Total
Gross Output (mil. 1970 dol.)	$266.6	$1,095.2
Employment (thousand)	3.1	21.3
Earnings (mil. 1970 dol.)	$57.2	$835.8

All of the anticipated mineral expansion is taconite. Most of the increase in total economic activity associated with the expanded taconite industry production would occur in Northeast Minnesota.

Industry Multipliers

Short-Term Effects

Another important measure of industry and community vulnerability to economic change is the industry multiplier. An industry demand multiplier, for example, shows the total effects -- direct and indirect -- of demand changes on the input-supplying industries. These effects are derived from inter-industry transactions on current account and hence, they show year-to-year industry output changes associated with a $1 change in a given industry final demand.

The industry incidence of the total effect of a $1 increase in the final demand for the gross output of the iron mining industry is shown, in part, in Table 3. For example, the total effect -- direct and indirect -- of a $1 increase in the exports of iron ore on the iron mining industry itself is also $1 (because of the lack of intra-industry transactions). Total effect on all industries of the $1 increase in iron ore exports is $1.33. Thus, in this example, the indirect effect on other industry output totals to $0.33.

Because differences in the proportions of total outlays for primary inputs and imports, corresponding differences occur in industry demand multipliers. However, the demand multiplier for any

Table 2

Projected Effects of Iron Mining Industry Expansion on Gross Output (in 1970 dollars), Employment and Earnings (in 1970 dollars) in Specified Producing Sector in Minnesota, 1970-2000.

No.	Title	Gross Output		Employment		Earnings	
		Mining Baseline (thou.dol.)	Taconite Impact (thou.dol.)	Mining Baseline (no.)	Taconite Impact (no.)	Mining Baseline (thou.dol.)	Taconite Impact (thou.dol.)
Total		95,271,014	1,095,250	2,159,628	21,305	21,086,040	835,752
Mining:							
4.	Iron and ferro	785,825	266,634	9,104	3,089	168,587	57,202
5.	Non ferrous me.	735,386	88	2,692	0	49,863	6
6.	Copper ore min.	0	0	0	0	0	0
7.	Stone and clay	126,140	1,231	1,274	16	30,416	362
Manufacturing:							
20.	Petroleum indus.	521,354	7,694	1,085	16	27,732	410
22.	Stone, clay gl.	424,249	5,168	8,997	109	147,406	1,796
23.	Primary iron a.	351,997	5,863	3,792	63	54,559	909
24.	Primary copper	0	0	0	0	0	0
25.	Other primary	364,334	2,327	2,742	17	39,445	252
Services:							
34.	Trans., exc.	177,745	7,663	3,151	137	46,804	2,018
40.	Electric serv.	606,878	22,787	3,987	146	60,913	2,287
41.	Gas service ex.	503,084	12,749	3,531	89	55,184	1,398

Table 3

Demand and Supply Multipliers for Selected Industry in U.S. and Minnesota.

Industry No.	Title	United States Demand	United States Supply	Minnesota Demand	Minnesota Supply
Mining:					
4.	Iron and ferro	1.691	3.127	1.333	1.000
5.	Nonferrous metals	1.828	4.146	1.331	2.316
7.	Stone and clay	1.788	3.133	1.420	2.896
Construction:					
pt. 8	New construction	2.243	1.000	1.619	1.357
pt. 8	Maint. & repair const.	1.855	2.562		
Manufacturing:					
pt. 20.	Petroleum refining	2.244	2.143	1.354	1.968
pt. 20.	Petro. related prod.	2.241	2.748		
pt. 22.	Glass, glass prod.	1.846	2.545	1.621	2.501
pt. 22.	Stone, clay prod.	2.068	2.523		
22.	Primary iron	2.124	3.211	1.451	2.823
25.	Primary non ferrous	2.449	3.445	1.619	2.269
Transportation:					
34.	Trans., exc.	1.688	2.382	1.452	2.267
35.	Railroad	1.662	2.635	1.392	1.916
36.	Local, suburban	1.723	1.856	1.409	1.448
37.	Motor freight	1.710	2.503	1.372	2.304
38.	Air trans.	1.755	2.389	1.410	1.285
Utilities:					
40.	Electric service	1.784	2.137	1.650	2.036
41.	Gas service	2.192	2.612	1.174	1.875
42.	Water & sani. service	2.429	1.907	2.197	1.301

industry in the Nation is larger than the corresponding demand multiplier for a Region, such as Minnesota. This difference is due to the generally greater industry dependence on imports in the Region than in the Nation. For the Minnesota mineral-related industries, the differences are large because of the near complete lack of energy resources in the State and the large capital requirements of these industries, which are financed by out-of-state private financing. Thus, imports are large for the energy-producing industries while out-of-state value added is large for the taconite industry.

The supply multipliers differ greatly from the demand multiplier among mineral-related industries. These industries are "basic" to the total economy in the Nation and, in most cases, the Region. The supply multipliers are low, of course, for those industries which disburse their gross outputs to only a few purchasing industries (e.g., petroleum refining) or largely to final demand sectors, including exports.

Demand and supply multipliers differ in their application as well as definition and computation. Demand multipliers show the industry-wide effects -- direct and indirect -- of a short-term change in the final demand for a specified industry output. Supply multipliers show the industry-wide effects -- direct and indirect -- of a short-term change in the supply, or gross output, of a specified industry. Thus, for the mineral industries, the industry-wide effects of changes in supply are larger than the corresponding changes in final demand because of the occurrence of greater inter-industry linkages in output disbursements than input purchases. Access to both multipliers is desirable, therefore, in assessing the short-term industry-wide effects of projected changes in both output demand and output supply, especially for the mineral-industries, which include several of the basic industries of the U.S. economy. The economic effects of curtailment of iron and steel and iron ore impacts, for example, would be as large, and even larger, than curtailment of petroleum impacts.

Long-Term Effects

While the short-term output multipliers are generally low for the mineral-related industries, the long-term output multipliers are higher because of the large induced effects resulting from the large value added component. Much of the value added is retained in the State, particularly as wage and salary payments to employees and tax payments to state and local governments. Both forms of income payments are recirculated within the Minnesota economy.

The long-term taconite mining impact on the Minnesota economy is represented by changes in all industry gross output which are due to changes in the demand for taconite pellets. To show this impact, the gross output difference (of $266.6 million) between the baseline and

high taconite output option is adjusted, first, for the short-term effect by adding the equivalent short-term indirect gross output change (of $89 million) associated with the increase in taconite industry output. The taconite industry and its input-supplying industries in the State are now viewed as a single industry complex, which represents an expanding sector of the Minnesota economy against which overall State economic growth is measured. The derived long-term demand multiplier for industry output is 3.08 (i.e., 1,095.2 ÷ 355.6) rather than 1.33, as in the short-term case. The long-term multiplier thus incorporates the long-term induced effects of the recycling of the "new" dollars derived from the taconite exports.

The multiplier analysis illustrates the importance of viewing the taconite industry, not in isolation, but as a part of a growing taconite industry cluster. This cluster as a whole has an overall long-term economic impact which is 2 to 3 times its corresponding short-term level. This is simply another way of describing what has long been observed, namely, that the full importance of the taconite industry is greatly underestimated if only the direct, or even short-term, impacts are considered.

Market Outlook and Anticipated Investment

In this section, we review the market outlook and anticipated industry capacity which supports the projected taconite output levels. First, U.S. consumption of iron ores is forecast to increase at a 1.6 percent compound annual rate for the period 1977-2000 in the high Minnesota taconite output option (Table 4). Should this forecast be correct, then at all times during this period consumption of ore will exceed planned production capacity in Minnesota. The difference will be made up by production elsewhere in the country and by imported ore. Minnesota production of iron ores has hovered around 65 percent of domestic production since 1970 (25).

Historical production data combine taconite and natural ores. Minnesota natural ores production declined rapidly during the period 1970 to 1978. By 1980, natural ores production will be negligible. For that reason, the projected future production discussed here is for taconite only.

Imports of ore are expected to peak at about 45 million tons in 1978 or 1979 and then begin a slow decline to about 30 million tons annually by the end of the century in the high taconite output option (3). United States imports of iron ore would come primarily from Canada, with much of the rest coming from Venezuela and, perhaps, also, Brazil and Africa.

The market outlook for the Minnesota taconite industry is affected by the rapidly increasing value of its production. The steel industry price index increased 7.1 percent per year in the 1976-1980

Table 4

Projected Consumption, Imports and Production of Iron Ores in the U.S. and Taconite Production and Capacity in Minnesota for High Taconite Output Option, 1980-2000

	United States			Minnesota	
Year	Consumption	Imports	Domestic Production	Production	Capacity
			(mil. long tons)		
1980	134.8	43.4	91.4	59.4	67.7
1981	136.9	42.7	94.2	61.2	68.8
1982	139.1	42.0	97.1	63.1	68.8
1983	141.3	41.3	100.0	65.0	71.7
1984	143.6	40.5	103.1	67.0	75.9
1985	145.9	38.7	106.2	69.0	78.8
1986	148.2	38.8	109.4	71.1	84.1
1987	150.6	37.9	112.7	73.3	87.1
1988	153.0	37.0	116.0	75.4	87.1
1989	155.5	36.1	119.4	77.6	87.1
1990	157.9	35.0	122.9	79.9	91.2
1991	160.5	34.0	126.5	82.2	91.2
1992	163.0	32.9	130.1	84.6	91.2
1993	165.7	31.8	133.9	87.0	91.2
1994	168.3	30.6	137.7	89.5	91.2
1995	171.0	30.6	140.4	91.3	101.2
1996	173.7	30.6	143.1	93.0	101.2
1997	176.5	30.6	145.9	94.8	101.2
1998	179.3	30.6	148.7	96.7	101.2
1999	182.2	30.6	151.6	98.5	101.2
2000	185.1	30.6	154.5	100.4	101.2

period. Because of more rapidly increasing transportation charges, the mine value of Minnesota taconite production increased by 5.3 percent per year. Post-1980 price increases are projected at a 5-percent annual rate in the assessment of the tax impact of the taconite industry. In the industry comparisons and multiplier analysis, however, a constant 1970 price is used.

Finally, because of the cyclical fluctuations in U.S. consumption, the Minnesota industry would produce both above and below the long-run trend levels. Between 1970 and 1971, for example, production declined from 56.1 million tons to 51.3 million tons, or 8.6 percent. By the end of 1972, annual production had declined another 4.5 percent. Then, in 1973, production increased by 22.5 percent. This was followed by a 2.5 percent decline in 1974 and a further 12.5 percent decline in 1975. The fluctuations averaged at 10.1 percent, exclusive of the effects of the strike in 1977. If future cyclic fluctuations in Minnesota taconite production were to average 10.1 percent above and below the long-run trend, then in 1987, for example, production could be as much as 80.7 million tons, or as little as 65.9 million tons.

Impact of Taconite and Copper-Nickel Development in Northeast Minnesota

This section presents forecasts of the impact of the taconite industry and, also, the potential copper-nickel industry on the Northeast Minnesota economy (including Douglas County, Wisconsin). The impact forecasts include induced effects as well as the direct and indirect effects of traditional impact analysis based on input-output methods. All impact forecasts are in terms of the employed work force and population relative to a baseline projection for the period 1970-2000. The forecast model yields gross output, value added and earnings, among other variables, for the industry, with 53 sectors if industry detail.

The forecast model is calibrated to the actual data for 1977 and to the high taconite production option for the period from 1980 to 2000. In this option, the Minnesota taconite industry expands production from about 57 million long tons in 1980 to about 100 million long tons in 2000. Employment in the taconite industry does not increase over this period because of increases in worker productivity. Output per worker in taconite and all other industries is assumed to increase at the long-term historical rate during the 1980's and at 80 percent of the long-term rate after 1990.

The high taconite option provides for no copper-nickel development. Computer runs under different assumptions concerning taconite industry growth and copper-nickel development yield the projections of employment and population which differ from the high taconite option. Since all other assumptions are held to be the same, deviations from the high taconite option are measures of the impacts of taconite industry and copper-nickel development.

Taconite industry and potential copper-nickel development impacts are presented as differences between the baseline and the high taconite output, and then between the high taconite option and the copper-nickel development. Impact estimates are generated in two separate simulation runs, one in which a special assumption is made concerning the taconite industry and another in which copper-nickel development is assumed (Tables 5 and 6).

In the simulation run for copper-nickel development, it is assumed that construction of a single open pit mine capable of producing 20 million metric tons of ore annually commences in 1983. In addition, the mine is assumed to be fully integrated with a smelter-refinery capable of producing 100,000 metric tons of primary copper and nickel annually, starting in 1986. Some impacts would be felt in 1986, of course, but 1986 is a transition year in which the negative impacts of the winddown in construction activity would be mixed with the positive impacts of mining operations. At the point where operations start, a new data base is introduced. In this way, any direct repercussions from the construction period are eliminated in the mining, concentrating, smelting and refining operations as they begin to generate their own impacts.

Lingering effects from the massive construction project required for copper-nickel development are responsible for anomalies in the impact forecasts. For example, rapid expansion of facilities to meet demand during the construction period results in a slump in construction, once copper-nickel operations commence. Thus, copper-nickel development has negative forecast impacts on employment in construction. These negative impacts gradually diminish but do not entirely disappear by the year 2000. Similarly, a boom-bust cycle is induced in capital goods industries like Logging, Wood Products, Paper Products, Primary Iron, and Machinery. The bust in Primary Iron, Sector 24, which includes steel shapes and forms, is followed by an apparent boom by the year 2000. Employment in copper-nickel ore mining, Sector 7, and smelting and refining, Sector 25, would fluctuate because of changes in output per worker. By the 1980's, when mine and related facilities would be constructed, output per worker would be only slightly greater than in 1977, but shortly thereafter it would increase more rapidly. Thus, the copper-nickel development has positive population impacts, except for the decline in the number of elderly persons, which is due to the lingering effects of earlier construction activity.

Community Economic Effects of Mineral Industry Development

Community economic effects of mineral industry development are viewed, finally, from local and regional perspectives, namely, employee commuting, industry suppliers and tax revenue disbursements. Employee commuting from place of residence to place of work establishes the

Table 5

Industry Employment Impacts of Taconite Industry Expansion and Copper-Nickel Development in Northeast Minnesota and Douglas County, Wisconsin, 1980-2000.

No.	Title	1980 Deviation from Baseline		1987 Deviation from Baseline		1990 Deviation from Basline		2000 Deviation from Baseline	
		Fe	Cu-Ni	Fe	Cu-Ni	Fe	Cu-Ni	Fe	Cu-Ni
					(number)				
1.	Livestock	0	0	0	0	18	0	46	0
2.	Other agricul.	0	0	0	13	19	0	34	0
3.	Peatland ag.	0	0	0	0	0	0	0	0
4.	Ag., for., fish.	0	0	8	5	12	0	33	1
5.	Iron ores (taconite)	0	0	1,054	0	1,549	0	3,053	0
6.	Other metal ores	0	0	0	0	0	22	0	13
7.	Copper ore	0	0	0	1,584	0	1,561	0	1,488
8.	Empty	0	0	0	0	0	0	0	0
9.	Empty	0	0	0	0	0	0	0	0
10.	Non-metal mining	0	0	2	15	2	39	4	26
11.	Peat mining	0	0	0	0	0	0	0	0
12.	Construction	0	0	342	30	174	-120	385	-99
13.	Food & kindred prod.	0	0	15	99	24	87	62	78
14.	Apparel	0	0	20	124	29	109	73	101
15.	Logging	0	0	7	19	8	-6	14	-6
16.	Wood products	0	0	16	33	17	8	30	-3
17.	Paper products	0	0	13	43	19	-4	44	5
18.	Printing	0	0	19	104	30	26	76	21
19.	Chemicals	0	0	4	5	5	37	10	23
20.	Peat chemicals	0	0	0	0	0	0	0	0
21.	Petroleum refining	0	0	9	7	12	6	25	4
22.	Rubber & plastic	0	0	1	4	1	30	3	19
23.	Stone & clay	0	0	25	76	29	80	55	-1,094
24.	Primary iron	0	0	17	-45	24	-5	44	1,109
25.	Primary copper	0	0	0	578	0	566	0	528
26.	Copper,roll.,draw.	0	0	0	0	0	0	0	0
27.	Other metal roll.,	0	0	1	1	2	47	2	33
28.	Metal fabricating	0	0	47	23	57	14	109	-14
29.	Machinery	0	0	72	-31	74	60	156	35
30.	Electric mach.	0	0	10	10	11	25	17	14
31.	Misc. manufacturing	0	0	11	6	14	33	24	20
32.	Transportation,exc.	0	0	28	10	37	65	63	54
33.	Rail transport	0	0	22	16	30	37	117	20
34.	Local transport	0	0	3	0	5	1	17	0
35.	Truck transport	0	0	22	34	32	24	77	20
36.	Air transport	0	0	0	1	0	0	1	1
37.	Communication	0	0	24	37	33	24	70	16
38.	Electric service	0	0	50	17	72	26	143	16
39.	Gas service	0	0	9	1	14	3	27	2
40,	Water utilities	0	0	0	0	0	0	0	0
41.	Wholesale trade	0	0	172	275	228	227	519	221
42.	Retail trade	0	0	793	1,557	1,299	1,723	3,337	1,576
43.	Finance, ins.	0	0	93	9	129	8	128	7
44.	Real estate	0	0	51	68	63	74	116	70
45.	Hotels,per.serv.	0	0	86	392	143	484	438	464
46.	Business services	0	0	38	0	55	1	139	0
47.	Auto repair		0	8	0	12	0	31	0
48.	Amusements	0	0	5	0	8	0	24	0
49.	Medica, educ.	0	0	88	1,171	151	1,672	465	1,832
50.	Fed. govt. enter.	0	0	23	0	37	0	104	0
51.	State,local govt. ent.	0	0	0	0	0	0	0	0
52.	Other industry	0	0	27	0	41	0	117	0
53.	Government	0	0	626	475	959	1,379	3,030	1,286
	Total	0	0	3,861	6,767	5,478	8,363	13,262	7,887

Table 6

Population Impacts of Taconite Industry Expansion and Copper-Nickel Development in Northeast Minnesota, 1980-2000

Age	1980 Deviation from Baseline		1987 Deviation from Baseline		1990 Deviation from Baseline		2000 Deviation from Baseline	
	Fe	Cu-Ni	Fe	Cu-Ni	Fe	Cu-Ni	Fe	Cu-Ni
1-5	0	0	204	275	631	1,153	2,799	1,635
6-17	0	0	610	4,638	978	3,265	3,549	1,548
18-24	0	0	736	1,610	1,124	1,876	2,674	1,082
25-34	0	0	822	4,810	1,806	2,639	5,852	2,178
35-59	0	0	545	4,653	1,022	5,780	4,670	6,561
60-64	0	0	69	421	127	372	423	335
65+	0	0	170	-368	308	-227	974	166
Total	0	0	2,147	16,039	5,997	14,858	20,941	13,455

primary industry economic impact area while the location of industry suppliers establishes the secondary area. The four counties, the 20 cities and townships, and the 21 school districts which reveive taconite tax revenues are generally within the primary impact area.

Employee Commuting

Most taconite industry workers live within 10 to 15 miles of the mining operation. Very few -- less than 10 percent of the total-- commute more than 20 miles.

Within the commuting areas of Northeast Minnesota taconite plants total employment is projected to decline in the late 1980's. If copper-nickel development were to start in 1983, the increase in jobs in this industry would delay the regional employment decline until the late 1990's. If neither taconite industry expansion (beyond the baseline level of 78 million tons) nor copper-nickel development were to occur by 1990, the projected employment decline would mean an even sharper population decline within the primary taconite industry commuting areas.

Industry Suppliers

Of the 2,431 individual taconite industry suppliers who were located in Minnesota in 1977, 60 percent were in Notheast Minnesota while 33 percent were in the Minneapolis-St. Paul Metropolitan Area. The Northeast Minnesota suppliers represented 44 of the 54 Minnesota industry groups listed earlier. Thus, the taconite industry here is linked, in varying degree, with almost every segment of the Minnesota, and especially the Northeast Minnesota, economy. Much of this infrastructure is available for copper-nickel development.

Expansion of mining into manufacturing operations would introduce additional forward (i.e., product market) and backward (i.e., input supplier) linkages. Such expansion would increase substantially the secondary impact area of potential future Northeast Minnesota mineral industries.

Tax Revenue Disbursements

Community economic effects of mineral industry development are demonstrated, also, by the sharply increasing levels of industry tax revenues. The 1977 legislative revisions in the taconite production tax marked a sharp upward shift from $58 million to $98 million in total taxes collected,specifically from the Northeast Minnesota mining industry. Total occupation, production and royalty taxes collected exceeded $500 million for the 10-year period starting in 1970.

Except for the regional allocation, the total mineral tax revenues were split evenly between the state, school districts, and other local

governments in the 1970-1979 period. For the 1980-89 period, however, the projected tax revenue total of $1.7 billion, which assumes a five-percent growth rate for taconite pellet prices, shifts in increasingly larger proportions to the regional protection funds. The largest recipient of projected tax revenues is the Taconite Area Environmental Protection and Economic Development Fund (which is administered by the Iron Range Resources and Rehabilitation Board). This fund was established for purposes of minelands reclamation, local economic development and related projects. The smaller of the two regional funds is the Northeast Minnesota Economic Protection Fund. This fund was created to aid in economic rehabilitation and diversification of industrial enterprises in the region.

The distribution of the total tax revenues among the various agencies is thus projected to shift between the two 10-year periods as follows:

Revenue Receiving Unit	Proportion of Total 1970-79 (pct.)	1980-89 (pct.)
Cities and Towns	8	6
School Districts	28	19
Counties (incl. prop. tax relief)	22	18
Regional (incl. environ. & econ. protection funds)	14	40
State	28	17
Total	100	100

Total monies received by each tax revenue recipient would increase over the two 10-year periods because of the very large projected increase in total taxes collected from the iron mining industry. The two protection funds, however, would receive nearly $660 million of the projected revenues.

Summary and Conclusions

The findings reported here are based on a study recently completed for the U.S. Bureau of Mines on the economic importance of the mineral industry in Minnesota. They show the many economic dimensions of the mineral industry and its linkages with the economy of the State and Region. The economic interdependence is greater now than ever before, not only directly in mining industry jobs and payroll, but even more so, indirectly in spin-off jobs and payroll in residentiary activities -- those that serve the resident industry and population,

especially local government. While the short-term statewide impacts of mining industry are small, the long-term impacts are two to three times as large.

Economic effects of mineral industrial development are assessed in terms of output, employment and population changes in Minnesota and Northeast Minnesota. Three development scenarios are presented -- a baseline option, a high taconite option, and a copper-nickel development option.

Expansion of taconite production from the baseline to the high taconite option is associated with an increase of $266.6 million in taconite output value and $1,095.2 in total Minnesota output. Mining-related industry output would increase by $89 million. The taconite-related industry cluster multiplier is represented by the $1.1 billion increase in total industry output resulting from the $255.6 million increase in taconite-related industry output.

Northeast Minnesota impacts of mineral resources development are shown by the increases in employment associated with the taconite and copper-nickel development as follows:

	Taconite		Total	
Year	Employment	Population	Employment	Population
1987	3.9	2.1	6.8	16.0
1990	5.5	6.0	8.4	14.9
2000	13.3	20.9	7.9	13.5

Thus, the Northeast Minnesota impact is somewhat smaller than the Minnesota impact and the impact of copper-nickel development (1 mine of 20 million tons ore and 1 smelter-refinery of 100 thousand tons copper) is less than the impact of taconite development.

Future profitability of mineral development depends on market prices, production costs and economic access to both markets and supplies. Much uncertainty surrounds future mineral development in this Region because of the economic conditions which are outside our control. Among these conditions are increasing market competition and temporarily decreasing per capita requirements for the products of the mineral industries -- present and potential. While short-term industry prospects may improve, long-term prospects of iron and steel industry relocation remain. More and more, the location and viability of the metal mining industry are of national, and not only state and regional, importance.

Of particular importance to the Northeast Minnesota mining industry are the level and location of future investment in the U.S. iron and steel industry. Increased import dependency in iron and steel products would reduce the demand for Minnesota taconite. Replacement of existing iron and steel plants with new facilities

closer to foreign sources of iron ore also is likely to reduce the demand for Minnesota taconite. Need for further study of future industry location and investment is strongly indicated by these trends and prospects.

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