MINERAL MINING

SECTOR REPORT

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I. Quantity Produced

The publication *Alaska's Mineral Industry*, from 1981 through 1988, published jointly by the Alaska Department of Natural Resources, Division of Geological and Geophysical Surveys and Division of Mining, and the Alaska Department of Commerce and Economic Development, Division of Business Development, summarizes various primary data sources on an annual basis.[1] An annual history of the quantity of minerals produced in Alaska since 1900 is provided in the appendixes of the most recent edition of the *Alaska's Mineral Industry* reports.[2]

Most of the minerals produced in Alaska are exported to markets outside of Alaska. The notable exceptions are coal and gravel. A little over half of all of the coal and almost all the sand and gravel produced in the state are used within Alaska. Alaska produces about 5 percent of the gold mined annually in the U.S. and less than 0.5 percent of the annual world gold production. Other minerals from Alaska have historically contributed little of total U.S. and world production, but the Greens Creek Mine in Southeast and the Red Dog Mine near Kotzebue are changing that. In 1989 the Greens Creek Mine produced close to 5.2 million ounces of silver, making it currently the largest silver producing mine in the United States. The Red Dog Mine is projected to produce about 550,000 tons of zinc concentrate a year.[3] This level of production is almost twice the current level of zinc production in the U.S., and would make up about 17 percent of total world production.[4]

II. Value of Production

The value of production (price times quantity) is useful when comparing the production of different minerals. The value of production is an elusive measure since the price used in the calculation is often an average price for all producers of a variety of different grades of minerals at various times of the year. The value of production changes

due to a combination of price and quantity changes. Even if the value of production does not change, prices may be increasing while output is decreasing. Also, in order to compare values of production in different years, they must be adjusted by the gross national product deflator in order to adjust for the effects of inflation.

A value of production estimate is reported in the *Alaska's Mineral Industry* publications and, given the limitations discussed above, is useful to compare the production of collections of minerals and the mineral industry as a whole. The *Alaska's Mineral Industry* publications calculate value of mineral production using "weighted and rounded averages of unit prices over the period studied."[5] The values of production for the past eight years are presented in Table A in constant dollars (after using the GNP deflator to adjust for the effects of inflation). The value of production in constant dollars from 1980 through 1988 increased on average 11.7 percent annually in metal mining, decreased annually 8.3 percent on average in industrial mineral mining, and increased on average 8.8 percent annually in coal and peat production. Overall, from 1980 through 1988, the total value of production in constant dollars in Alaskan mineral mining increased at an average annual rate of 0.9 percent. The value of production jumped 47 percent between 1988 and 1989, because the Greens Creek Mine began producing large amounts of silver. When the Red Dog mine begins production in 1990, the total value of exports from this mine is projected to add over $600 million to the value of production of Alaska mineral mining.[6]

TABLE A. ESTIMATED VALUE OF PRODUCTION IN MINERAL MINING IN ALASKA

(in millions of constant 1982 dollars)

	Metals	Industrial Minerals	Coal and Peat	Total
1980	38.6	120.8	18.7*	178.1
1981	59.9	122.1	18.7*	200.6
1982	71.7	106.6	18.2	196.4
1983	66.6	120.3	17.5	204.4
1984	59.2	103.1	22.8	185.1
1985	55.8	111.7	36.2	203.8
1986	54.3	84.2	35.5	173.9
1987	89.5	46.2	36.3	174.5
1988	94.1	60.5	36.9	191.5

* Does not include value of peat production

Source: *Mineral Mining Sector Report.*

Gold, sand and gravel, and coal have historically been the largest mineral industries in Alaska, comprising about 89 percent of the total value of all minerals produced--but that has changed with very substantial silver production at Greens Creek and zinc production at Red Dog. Compared to other sectors in the Alaskan economy, metal mining, coal mining, and other mining contributed less than one percent to total gross state product throughout most of the 1980s. This low overall contribution to the output of the state is in part due to the dominance of the oil and gas industry, which dwarfs most other sectors of the economy.

III. Employment

The total estimated numbers of people engaged in mineral mining activities in the past eight years are reported in *Alaska's Mineral Industry, 1988.* [7] These estimates of employment are classified as jobs based on a five-month year or a twelve-month year. The five-month jobs occur primarily during the warm months from mid-May through mid-October. In particular, placer mining, recreational mining, and sand and gravel mining, which require extensive labor activity outdoors, operate on a much smaller scale during the winter. The total employment during the five-month period from mid-May to mid-October was estimated at 4353 in 1988 while the total employment during the remainder of the year was estimated at 1835. These estimates imply that employment in the summer months may be as much as 2.3 times larger than employment in other months of the year. Notably, employment in twelve-month jobs expanded, on average, 3.4 percent annually from 1981 through 1988, while seasonal five-month jobs contracted, on average, 2.8 percent annually from 1981 through 1988. [8]

In order to compare the seasonal and twelve-month jobs in different industries, the jobs in each industry are scaled to year-round equivalent jobs by multiplying the number of jobs by the fraction of the year (12/12 or 5/12) for which the job is actually filled by a worker. These estimates of full-time equivalent jobs are presented in Table B. These estimates include both self-employed (proprietary) workers and wage and salaried employees.

Separate estimates of wage and salary employment in the mineral mining industry are available from the Department of Labor, as presented in the *Statistical Quarterly*, and are listed near the bottom of Table B. The Department of Labor wage and salary employment estimates do not include proprietary (self-employed) workers and are, therefore, much smaller than the estimates from the Department of Natural Resources and Department of Commerce and Economic Development. The difference between the Department of Labor wage and salary employment and total employment estimates from the Department of Natural Resources serves as a rough estimate of the percentage of self-employment in the mining industry. No attempt has yet been made to reconcile the total employment and wage and salary employment estimates, or to directly estimate the number of self-employed mineral mining workers.

TABLE B: YEAR-ROUND EQUIVALENT JOBS IN MINERAL MINING IN ALASKA

	1981	1982	1983	1984	1985	1986	1987	1988
Mineral Production	1,482	1,654	1,469	1,642	1,518	1,336	1,274	1,310
Mineral Development	200	210	145	185	245	171	427	1,294
Mineral Exploration	1,057	179	232	120	55	62	91	280
Total	2,739	2,043	1,846	1,947	1,818	1,569	1,792	2,884

Average Annual Wage and Salary Employment reported to Department of Labor

Total	793	755	738	654	634	571	725
Self-Employment or unreported	1,946	1,288	1,108	1,293	1,184	998	1,067

(difference between Department of Natural Resources and Department of Labor totals)

Source: Calculations described in *Mineral Mining Sector Report.*

SECTOR REPORT

MINERAL MINING

I. All Mineral Mining

Several basic economic measures of mineral industry activity in Alaska can be used to describe the economic trends of each industry over the past fifteen years. These economic measures include quantities produced, prices of minerals, value of production, employment, factor input costs, and regulatory costs. Before the trends in individual industries can be described, the relevance and reliability of each of these measures must be assessed.

Mineral mining in this report includes all metal mining, industrial mineral mining, and fossil fuel mineral mining (coal). The exploration, development, and production of each of these minerals are part of these industries. The oil and gas mining industry is analyzed in a separate sector report.

A. Quantity Produced

The publication *Alaska's Mineral Industry*, from 1981 through 1988, published jointly by the Alaska Department of Natural Resources Division of Geological and Geophysical Surveys and Division of Mining and the Alaska Department of Commerce and Economic Development, Division of Business Development, summarizes various primary data sources on an annual basis.[9] Production estimates for these publications are based on data compiled from Department of Natural Resources and Department of Commerce and Economic Development questionnaires distributed to private companies and individuals, responses to telephone surveys, and information provided by the U.S. Bureau of Mines, the U.S. Geological Survey, University of Alaska, precious metal refiners, and consultants. The State Annual minerals report reconciles these various sources and notes in the data when different sources provide data which cannot be reconciled. The methods of surveying and measuring quantities are continually refined each year to make estimates more accurate. An annual history of the quantity of minerals produced in Alaska since 1900 is provided in the appendixes of the most recent edition of the *Alaska's Mineral Industry* reports.[10]

Most of the minerals produced in Alaska are exported to markets outside of Alaska. The notable exceptions are coal and gravel. A little over half of all of the coal produced in Alaska is used within the state. Almost all of the sand and gravel produced in the state is used within the state. As listed in Table 1, Alaska in 1987 produced about 5 percent of the gold mined annually in the U.S. and less than 0.5 percent of the annual world gold production. Other minerals from Alaska contributed small fractions of total U.S. and world production in 1987. In 1989, the Greens Creek Mine began production, multiplying the

amount of silver produced in Alaska: nearly 5.2 million ounces came from Greens Creek in its first year--making it currently the largest producing silver mine in the U.S. Greens Creek also produces gold (23, 530 ounces in 1989) and some lead and zinc. The Red Dog Mine is projected to produce about 550,000 tons of zinc concentrate a year.[11] This level of production is almost twice the current level of zinc production in the U.S. as a whole. When compared to total world zinc production from all sources, Red Dog Mine will comprise about 17 percent of total world production when it is at full production in the early 1990s.[12]

TABLE 1. COMPARISON OF ALASKA PRODUCTION IN 1987 TO U.S. AND WORLD PRODUCTION

Mineral	Alaska Production	Percent of World Production	Percent of U.S. Production
Gold	229,707 ounces	0.5%	5.7%
Silver	54,300 ounces	<0.1%	<0.1%
Tin	288,000 pounds	<0.1%	61.0%

Sources: *Commodity Yearbook*, Commodity Research Bureau, (N.Y.) and Alaska Department of Natural Resources and Department of Commerce and Economic Development, *Alaska's Mineral Industry, 1988*. Estimate of domestic (U.S.) tin production and percent from Alaska from Thomas Bundtzen, personal communication, July 31, 1989.

B. Prices of Minerals

Secondary sources for data on prices of minerals are the 1988 and earlier editions of the *Commodity Yearbook*, (Commodity Research Bureau, N.Y.) and various Bureau of Mines publications. In particular the Bureau of Mines *Minerals Yearbook* and *Mineral Facts and Problems*, are more comprehensive information sources. However, there is a two to three year time lag in their publication. Current price information is available for most of the metals (copper, lead, zinc, tin, gold, silver, platinum) from the *Wall Street Journal* or *Anchorage Daily News*. *Metals Week* is also a standard reference for mineral price information. The price series used in this report comes from the *Commodity Yearbook*, which provides a consistent time series of prices for a particular grade of mineral sold at a particular location from 1964 through 1987. Since prices vary by location and quality of the mineral, prices of minerals are used only as an index for relative changes in the prices actually received by mining industries in Alaska. The actual price received in Alaska may differ, depending on the level of refinement of the ore and the location at which it is sold. However, these differentials between world market prices and Alaska prices are constant over time; changes in world prices are directly reflected in changes in prices received in Alaska.

The unit price of individual minerals which are easily transported is determined primarily by the lowest marginal costs of producing the mineral in the world. Prices of individual minerals play a vital role in determining the quantity of a mineral to be produced in a particular area. If the world price is below the marginal, or additional cost of production in an area with mineral reserves, then production of the mineral will likely occur. As the world price rises, reserves with higher average costs of production can feasibly begin production. As a result, rising world prices are often followed by rising levels of production for mineral industries.

Most mineral producers in Alaska are "price takers" which means that as they change the level of production, the price which they receive for the minerals does not change directly as a result of their supply of minerals to the market. Because of these competitive world market conditions, business decisions in Alaska regarding the level of mineral development expenditures, the level of production, and the rate of return on investments will depend primarily on economic conditions outside Alaska, rather than local economic conditions.

Furthermore, if a mineral producer significantly changes the total world quantity of a mineral produced, then the price for the mineral on the world market may change; the producer is said to have price power or monopoly power. The Red Dog Project will be the largest producing zinc mine in the world and may have some "price power" which means that the level of production at Red Dog may affect the world price of zinc.

Several conditions may alter the competitive market conditions which exist for most Alaska mineral producers. For minerals which are relatively costly to transport, markets in different areas of the world may be segmented. The prices of minerals in the segmented markets may differ substantially and will be determined by production costs in

the immediate market area. Also, the average total costs of production are often incurred over long periods of time, and the prices of minerals are difficult to forecast. These sources of uncertainty may make the comparison of prices and average total costs very complex.

In order to compare prices of minerals in different years, the prices must be expressed in constant dollars. In other words, the effect of changes in the overall level of prices (i.e., the rate of aggregate inflation) must be removed from the mineral price series. One way to measure the rate of aggregate inflation for the United States is with the gross national product (GNP) deflator for the United States. In order to express the mineral prices in constant dollars, the price in each year is divided by the GNP deflator for that year. The deflated prices or "prices in constant dollars" are also referred to as "real prices" to distinguish them from prices expressed in nominal or current dollars.

C. Value of Production

The value of production (price times quantity) is useful when comparing the production of different minerals. The value of production is an elusive measure since the price used in the calculation is often an average price for all producers of a variety of different grades of minerals at various times of the year. The actual price at which individual producers sold their individual products at different times of the year may vary, thereby making the estimate of the value of production and the actual number of total dollars received from the sale of the minerals different.

Further, comparing the value of production in different years is difficult if the price used to calculate the value of production is not clearly documented for each mineral. The value of production changes due to a combination of price and quantity changes. Even if the value of production does not change, prices may be increasing while output is decreasing. Also, in order to compare values of production in different years, they must be deflated by the GNP deflator in order to express all values in constant dollars.

To avoid misinterpretation, the average price used in the calculations of value of production should be reported separately from quantity and value numbers to detail how the value was calculated. A more revealing dollar measure of output might be gross revenues or gross receipts. This information is, however, proprietary and unavailable for our purposes.

A value of production estimate is reported in the *Alaska's Mineral Industry* publications and, given the limitations discussed above, is useful to compare the production of collections of minerals and the mineral industry as a whole. The *Alaska's Mineral Industry* publications calculate value of mineral production using "weighted and rounded averages of unit prices over the period studied."[13] The nominal values of production reported in *Alaska's Mineral Industry* are deflated by the GNP deflator to express all value in constant dollars. The values of production for each year from 1980 through 1988 are presented in Table 2 in current and constant dollars. The value of production in constant dollars from 1980 through 1988 increased on average 11.7 percent annually in metal mining,

decreased annually 8.3 percent on average in industrial mineral mining, and increased on average 8.8 percent annually in coal and peat production. Overall, from 1980 through 1988, the total value of production in constant dollars in Alaskan mineral mining increased at an average annual rate of 0.9 percent. Table 3 summarizes some basic shares in total value of production as of 1988. Remember that Tables 2 and 3 go only through 1988 and therefore don't include the very large increases in value of production as a result of the new Greens Creek and Red Dog mines. Gold, sand and gravel, and coal were historically the largest mineral industries in Alaska, comprising about 89 percent of the total value of all minerals produced. Compared to other sectors in the Alaskan economy, metal mining, coal mining, and other mining contributed less than one percent to total gross state product throughout most of the 1980s. This low overall contribution to the output of the state is in part due to the dominance of the oil and gas industry, which dwarfs most other sectors of the economy.

TABLE 2. ESTIMATED VALUE OF PRODUCTION
IN MINERAL MINING IN ALASKA
(in millions of current dollars)

	Metals	Industrial Minerals	Coal and Peat	Total
1980	33.1	103.5	16.0*	152.6
1981	56.3	114.8	17.6*	188.6
1982	71.7	106.6	18.2	196.4
1983	69.2	125.0	18.2	212.4
1984	63.8	111.0	24.6	199.4
1985	62.1	124.2	40.3	226.6
1986	61.9	96.1	40.5	198.5
1987	105.4	54.4	42.7	202.4
1988	114.1	73.4	44.7	232.2

VALUE OF PRODUCTION IN MINERAL MINING IN ALASKA
(in millions of constant 1982 dollars)

	Metals	Industrial Minerals	Coal and Peat	Total
1980	38.6	120.8	18.7*	178.1
1981	59.9	122.1	18.7*	200.6
1982	71.7	106.6	18.2	196.4
1983	66.6	120.3	17.5	204.4
1984	59.2	103.1	22.8	185.1
1985	55.8	111.7	36.2	203.8
1986	54.3	84.2	35.5	173.9
1987	89.5	46.2	36.3	174.5
1988	94.1	60.5	36.9	191.5

* Does not include value of peat production

Source: *Alaska's Mineral Industry, 1988*, Alaska Department of Natural Resources, Division of Geological and Geophysical Surveys and Division of Mining and Alaska Department of Commerce and Economic Development, Division of Business Development.

GNP deflator for United States used to deflate to constant dollars, deflator in 1982 = 1.00
Source: *Statistical Abstract of the United States, 1989*, U.S. Department of Commerce, Government Printing Office, Washington, D.C.

TABLE 3. SHARES IN 1988 OF VALUE OF PRODUCTION IN CONSTANT DOLLARS

	Percent of Total Value of Production of Mineral Mining in Alaska	Percent of Major Sub-Industry Value of Production in Alaska	
Gold	49%	Gold Value of Production as Percent of Total Metal Mineral Value of Production	99%
Sand and Gravel	21%	Sand and Gravel Value of Production as Percent of Total Industrial Mineral Value of Production	66%
Coal	19%	Coal Value of Production as Percent of Total Coal and Peat Value of Production	99%
Gold, Sand, Gravel, and Coal combined	89%		

Source: *Alaska's Mineral Industry, 1988*, Alaska Department of Natural Resources, Division of Geological and Geophysical Surveys and Division of Mining and Alaska Department of Commerce and Economic Development, Division of Business Development.

D. Operating Costs

Operating costs at mineral mines in Alaska include the cost of factor inputs such as labor and materials, environmental regulations, government taxation, and transporting mined materials to processing plants or shipping facilities.

1. Labor

The total cost of employing workers can be analyzed in two components: the number and types of workers employed to work at mining operations and the wage paid to each of these employees.

Employment. The total estimated numbers of people engaged in mineral mining activities for each year from 1980 through 1988 are listed in Table 4. [14] These estimates are classified as jobs based on a five-month year or a twelve-month year. The five-month jobs occur primarily during the warm months from mid-May through mid-October. In particular, placer mining, recreational mining, and sand and gravel mining, which require extensive labor activity outdoors, operate on a much smaller scale during the winter. The total employment during the five-month period from mid-May to mid-October in 1988 was estimated at 4353 while the total employment during the remainder of the year was estimated at 1835. These estimates imply that employment in the summer months may be as much as 2.3 times larger than employment in other months of the year. Notably, employment in twelve-month jobs expanded, on average, 3.4 percent annually from 1981 through 1988, while seasonal five-month jobs contracted, on average, 2.8 percent annually from 1981 through 1988.

In order to compare the seasonal and twelve-month jobs in different industries, the jobs in each industry are scaled to year-round equivalent jobs by multiplying the number of jobs by the fraction of the year (12/12 or 5/12) for which the job is actually filled by a worker. These estimates of year-round equivalent jobs from 1980 through 1988 are presented in Table 5. These estimates include both self-employed (proprietary) workers and wage and salaried employees.

These estimates of year-round equivalent jobs likely understate the total due to the additional weekly hours worked by workers in the seasonal (summer) mining industries (primarily gold and silver placer mining, recreational mining, and sand and gravel mining). Long hours of daylight and the short summer season encourage mine operators in these summer mining industries to extend their working hours to more hours per week than found in industries which can operate year-round (such as lode operators and coal mining). Due to these extended hours in summer mining industries, the number of year-round equivalent jobs created in industries which employ only during the summer may actually be larger than estimated in Table 5. If workers in summer mining industries work 50 percent longer per week (60 hours instead of 40 hours per week) than workers in year-round industries, then the total year round equivalent employment in mineral mining estimated in Table 5 could be as much as 30 percent higher.

Separate estimates of wage and salary employment in the mineral mining industry, available from the Department of Labor in the *Statistical Quarterly*, are listed near the bottom of Table 5 and in Table 6. The Department of Labor wage and salary employment estimates do not include proprietary (self-employed) workers and are, therefore, much smaller than the estimates from the Department of Natural Resources and Department of Commerce and Economic Development. The difference between the Department of Labor wage and salary employment and total employment estimates from the Department of Natural Resources serves as a rough estimate of the percentage of self-employment in the mining industry. No attempt has yet been made to reconcile the total employment and wage and salary employment estimates or to directly estimate the number of self-employed mineral mining workers.

The Department of Labor estimates of wage and salary employment are available for each month of the year; the values for each month in 1987 are reported in Table 7. Since most of the summer seasonal employment is self-employment and most of the non-summer employment is wage and salary employment, the Department of Labor monthly wage and salary employment totals likely understate total mineral mining employment to the greatest extent during the summer months. Despite this bias toward greater understatement of total employment in the summer, wage and salary employment during the summer months is still as much as 48 percent higher than the annual average. Compared to the coldest winter months, summer wage and salary employment is as much as 2.7 times larger.

According to the estimates presented in Table 5 and Table 6, from 1981 to 1988, total full-time year-round equivalent employment in mineral mining grew on average 0.7 percent annually. Wage and salary employment declined on average 1.5 percent annually from 1981 to 1987. In contrast, during the period from 1975 to 1981, wage and salary employment in mineral mining grew on average 13 percent annually. Most of this rapid growth was in metal mining, which grew on average 17 percent annually from 1975 to 1981.

TABLE 4. MINERAL MINING EMPLOYMENT

	Months of Employment	1981	1982	1983	1984	1985	1986	1987	1988
Mineral Production	mixed	3276	3725	3336	3675	3350	2952	2729	2779
Gold/Silver	mixed	1335	2001	2006	1700	1540	1157	1249	1305
Placer	5	1250	1950	2000	1700	1505	1155	1197	1206
Lode	12	85	51	6	0	35	2	52	99
Recreational	5	1500	700				230	245	350
Sand & Gravel	5	271	900	1200	1600	1435	1100	868	752
Building Stone	5	40			185	200	225	185	210
Coal	12	85	90	95	115	115	125	127	122
Peat	5	15					60		
Tin,Jade,Soap Stone	12	30	34	35	75	60	55	55	40
Mineral Development	12	200	210	145	185	245	171	427	1294
Mineral Exploration	12	1057	179	232	120	55	62	91	280
Total	mixed	4533	4114	3713	3980	3650	3185	3247	4353

Source: *Alaska's Mineral Industry, 1988* and Thomas K. Bundtzen, Senior Economic Geologist, Alaska Department of Natural Resources, Division of Geological and Geophysical Surveys, Letter dated May 16, 1989.

TABLE 5. YEAR-ROUND EQUIVALENT JOBS IN MINERAL MINING IN ALASKA

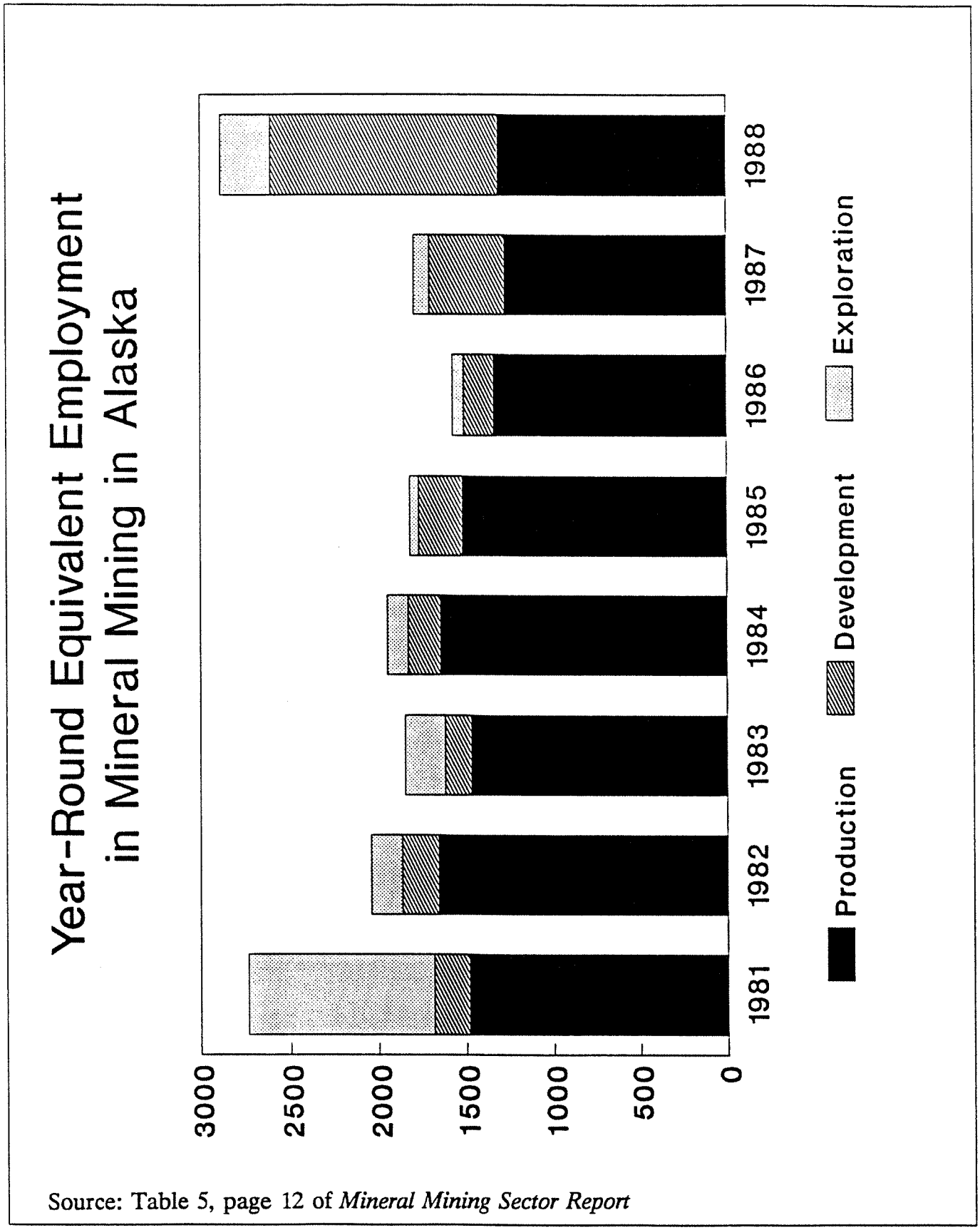
	1981	1982	1983	1984	1985	1986	1987	1988
Mineral Production	1482	1654	1469	1642	1518	1336	1274	1310
Gold/Silver	606	864	839	708	662	483	551	602
Placer	521	813	833	708	627	481	499	503
Lode	85	51	6	0	35	2	52	99
Recreational	625	292				96	102	146
Sand & Gravel	113	375	500	667	598	458	362	313
Building Stone	17			77	83	94	77	88
Coal	85	90	95	115	115	125	127	122
Peat	6	0	0	0	0	25	0	0
Tin, Jade, Soap Stone	30	34	35	75	60	55	55	40
Mineral Development	200	210	145	185	245	171	427	1294
Mineral Exploration	1057	179	232	120	55	62	91	280
Total	2739	2043	1846	1947	1818	1569	1792	2884
Average Annual Wage and Salary Employment reported to Department of Labor								
Metal Mining (SIC 10)	546	570	559	461	386	361	493	
Other Mining (SIC 12 and 14)	247	185	179	193	248	210	232	
Total (SIC 10, 12, and 14)	793	755	738	654	634	571	725	
Self-Employment or unreported (difference between Department of Natural Resources and Department of Labor totals)	1946	1288	1108	1293	1184	998	1067	

Source: Calculations from Table 4 of this report:

Year-round equivalent employment = (employment from Table 4) * (months of employment/12)

Wage and salary employment from Alaska Department of Labor, Statistical Quarterly, various years

FIGURE 1. YEAR-ROUND EQUIVALENT EMPLOYMENT
IN MINERAL MINING IN ALASKA



Source: Table 5, page 12 of *Mineral Mining Sector Report*

TABLE 6. TOTAL WAGE AND SALARY EMPLOYMENT
ANNUAL AVERAGES

	Metal Mining (SIC 10)	Other Mining (SIC 12 and 14)	Total Mineral Mining (SIC 10, 12, and 14)
1975	212	172	384
1976	228	172	400
1977	W	W	W
1978	188	W	W
1979	234	184	418
1980	319	207	526
1981	546	247	793
1982	570	185	755
1983	559	179	738
1984	461	193	654
1985	386	248	634
1986	361	210	571
1987	493	232	725

Source: Alaska Department of Labor, Statistical Quarterly, various years and quarters.

W: withheld due to small sample size.

TABLE 7. SEASONAL VARIATION IN MINING EMPLOYMENT IN ALASKA

		Metal Mining	Other Mining	Total Metal and Other Mining	Monthly Index
1987	Jan	236	171	407	56.1
	Feb	260	167	427	58.9
	Mar	246	141	387	53.3
	Apr	405	218	623	85.9
	May	505	254	759	104.7
	Jun	638	272	910	125.5
	Jul	708	293	1001	138.1
	Aug	749	325	1074	148.1
	Sept	697	288	985	135.9
	Oct	609	231	840	115.9
	Nov	473	216	689	95.0
	Dec	393	203	596	82.2
1987 Annual Avg.		493	232	725	100.0

Source: Alaska Department of Labor, Statistical Quarterly, 1987.

Monthly Index = 100 * (Total Monthly Employment in Metal mining and Other mining divided by 1987 annual average employment in metal mining and other employment)

Wages. Wages in mining industries in Alaska are driven by two major economic conditions: the value of output per worker and relative wages. In the short run, the wage received by mining workers is affected by wages received by workers in industries other than mineral mining. In order to retain workers at mining jobs, mine owners must offer wages comparable to what workers can receive in jobs requiring similar skills in other industries. If comparable wages are not offered, then the workers will move to the industries with the higher wages. Over time, as workers are able to relocate and are able to acquire skills to move to other industries, the effect of the wages in other industries becomes even more powerful on mining wages. The wage in one industry relative to the wage in another industry is called a relative wage. These relative wages remain constant over time in the absence of dramatic changes in demand conditions or technological change.

The level of wages in the long run is determined predominantly by the value of the additional output produced by an individual worker. If the value of this additional or marginal output increases because of an increase in the price of the output, a technological change, a change in available equipment, or a change in the total number of workers, then in the long run, the wage received by the workers will move to reflect the change in the value of output they produce. If the price of a mineral in constant dollars and the technology used to extract the mineral are relatively constant over time, then wages will also be relatively constant over time. Falling or rising prices of minerals accompanied by stable technology will usually be associated with falling and rising wages respectively in mineral industries. This connection between prices and wages is more powerful in the mining industry than in other industries due to the relatively direct connection between labor input and output produced.

Wages in mining industries in Alaska are likely affected by both the value of a worker's marginal output and the relative wages in industries with similar occupations and jobs. In the Lower 48, mining jobs are often compared to steel industries and automobile industries since these industries share similar high capital investments and highly unionized workforces. In Alaska, the industries most comparable to the mineral mining industries are construction and oil and gas mining industries which use similar capital intensive production and require workers with similar skills to operate heavy machinery. The real wages (nominal wages deflated to constant dollars) in mineral mining industries were a nearly constant proportion of real wages in construction and oil and gas mining prior to the 1972 oil pipeline construction boom, as seen in Figure 2. The relative wages between pairs of these industries were nearly constant prior to 1972.

The average wage in construction, oil and gas extraction and mineral mining diverged during pipeline and early oil production years (1972-1978). Wages in other mining (including coal and sand and gravel) during the same period increased as did wages in the construction industry. As the demand for the construction of the pipeline, buildings, roads, and drilling platforms expanded in the construction industry, wages for the available construction employees were bid up. The demand for construction activity generated demand for sand and gravel to complete the construction projects. In order to attract workers to operate sand and gravel mining equipment, trucks, and loaders, the sand and

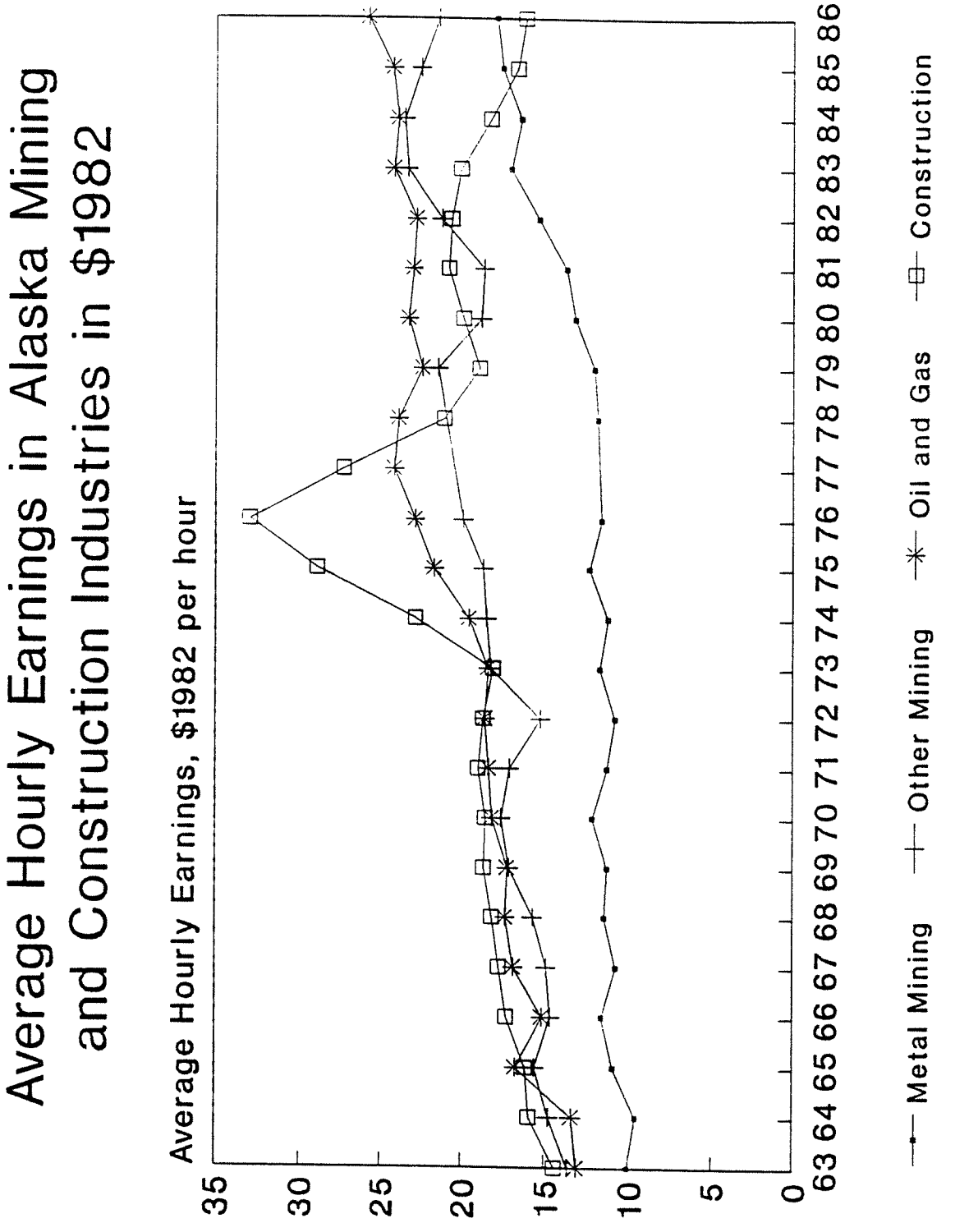
gravel mining industry offered wages comparable to wages in the construction industry to workers operating similar equipment. As a result, wages in other mining were bid up and the relative wage between construction and other mining (in particular sand and gravel mining) remained nearly constant over the period.

Metal mining wages, however, were largely unaffected by the escalation of construction and oil and gas wages in the rest of the state during the pipeline construction boom: metal mining wages continued to grow slowly while oil and gas, construction, and other mining wages grew rapidly from 1972 through 1977. In other words, the relative wage in metal mining declined in relation to oil and gas, construction, and other mining. During this period, the level of production in gold mining fell dramatically from 34,000 ounces in 1971 to 8639 ounces in 1972. Part of the reason for this fall in production was likely the diversion of workers from gold mining (and other metal mining) to construction, sand and gravel, and oil and gas jobs which offered higher relative wages.

A comparison of metal mining wages in Alaska, Colorado, and California suggests that real wages in metal mining in Alaska escalated relative to wages in these other states from 1979 through 1986, as displayed in Figure 3. In the early 1980s, when per capita income for the entire state increased relative to the rest of the U.S., nearly all industry wages, including metal mining, increased to maintain relative wages.

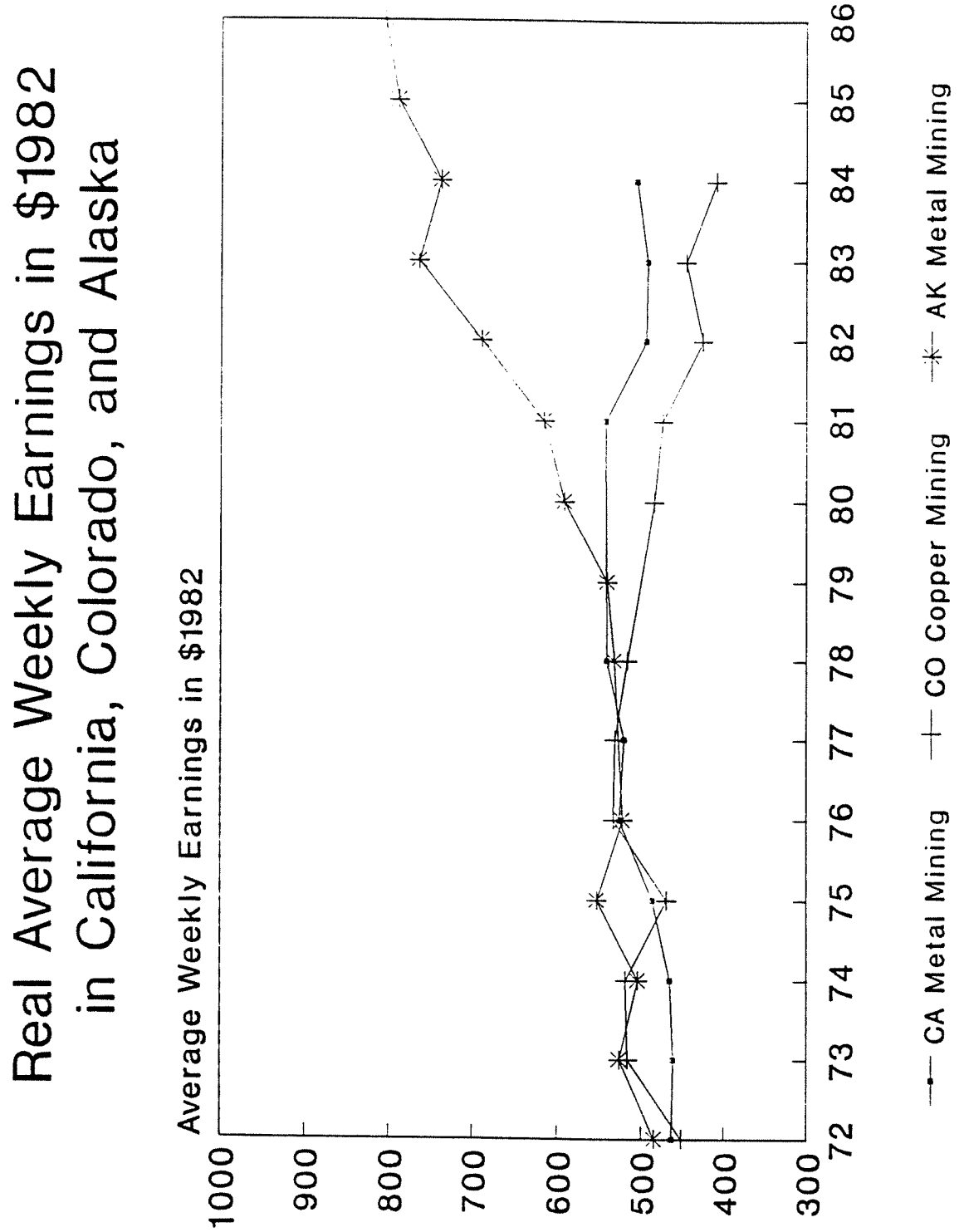
Wages comprise a major portion of mineral mining costs. While industry-wide data describing the wage share of receipts in Alaska are unavailable, we can compare the payroll share of total value of shipments in mineral mining states with comparable mining conditions. This is not a foolproof procedure since the share of payroll in total value of shipments varies from state to state due to variations in production techniques determined by geological conditions. In addition, the labor share of value of shipments likely varies considerably from mine site to mine site within Alaska due to the availability of different machinery and different site characteristics. Keeping these limitations in mind, the labor shares of total value of shipments for various minerals and states as of 1982 are listed in Table 8. For this sample of locations and minerals, the labor share of total value of shipments averaged around 30 percent of the total, with a range from 10 percent up to 80 percent.[15]

FIGURE 2. WAGES IN CONSTRUCTION, OIL & GAS, METAL MINING, OTHER MINING IN ALASKA.



Source: Alaska Department of Labor, *Statistical Quarterly*, various years.

FIGURE 3. WAGES IN DIFFERENT STATES IN METAL MINING



Source: U.S. Dept. of Labor, *Supplement to Employment, Hours, and Earnings, States and Areas Data for 1980-1984.*

TABLE 8. PAYROLL SHARES OF VALUE OF SHIPMENTS
IN WESTERN STATES OF THE U.S. IN 1982

(Payroll/Value of Shipments)

	Mean	High	Low	N
Metal Mining	36.5%	60.8%	25.9%	7
Gold and Silver	43.1%	70.3%	16.4%	5
Bituminous Coal	25.0%	50.9%	8.1%	4
Sand and Gravel	30.6%	34.0%	24.5%	3

Includes Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, and Wyoming

N=number of states for which payroll and value of shipments are reported for each mineral

Industry	State	Payroll/Value of Shipments
Metal Mining	Arizona	33.8%
	Colorado	60.8%
	Idaho	40.7%
	Montana	29.3%
	Nevada	25.9%
	New Mexico	38.4%
	Wyoming	26.9%
Gold and Silver	Idaho	36.9%
	Nevada	22.3%
	New Mexico	16.4%
	Utah	70.3%
	Arizona	69.5%
Gold	Utah	95.0%
Silver	Arizona	38.5%
Copper	Arizona	33.5%
	New Mexico	32.7%
Bituminous Coal	Colorado	50.9%
	New Mexico	17.0%
	Wyoming	13.3%
	Montana	8.1%
	Utah	27.8%
Sand and Gravel	Idaho	34.0%
	Nevada	24.5%
	New Mexico	33.3%

2. Regulatory Costs and Government Costs

A second, smaller component of operating costs is the collection of taxes, royalties, and rental payments made by mine operators to the State of Alaska. The State of Alaska levies a mining license tax on all mining operations in Alaska. The tax is assessed on federal taxable income on a progressive tax scale as listed in Table 9. New mining operations are exempt from this tax during the first three and a half years of operation. The mining license tax is the largest source of state revenue from the mineral mining industry and totals on the order of one million dollars a year.

TABLE 9. ALASKA STATE MINING LICENSE TAX

Federal Taxable Income	Tax
under $40,000	zero
$40,000 to $50,000	3%
$50,000 to $100,000	$1500 plus 5% on excess over $50,000
over $100,000	$4000 plus 7% on excess over $100,000

Source: Jean Mell, Department of Revenue, telephone conversation, May, 1989.

In addition, all mining operations in Alaska which operate on state land are assessed rent on mining properties whether or not they are in production. Coal mining operations are assessed lease payments of three dollars an acre on all leased state land. All other mining operations on state land are assessed rental fees which depend on the number of years since claims were first located, as follows:

Number of Years First Located	Rental Amount per Acre for Mining Leases	Rental Amount for Each Mining Claim or Leasehold Location
0 – 5	$ 0.50	$ 20
6 – 10	$ 1.00	$ 40
11 or more	$ 2.50	$ 100

These payments are from bill CSSB 129 which amended Section 2. AS 38.05.210(a).[16]

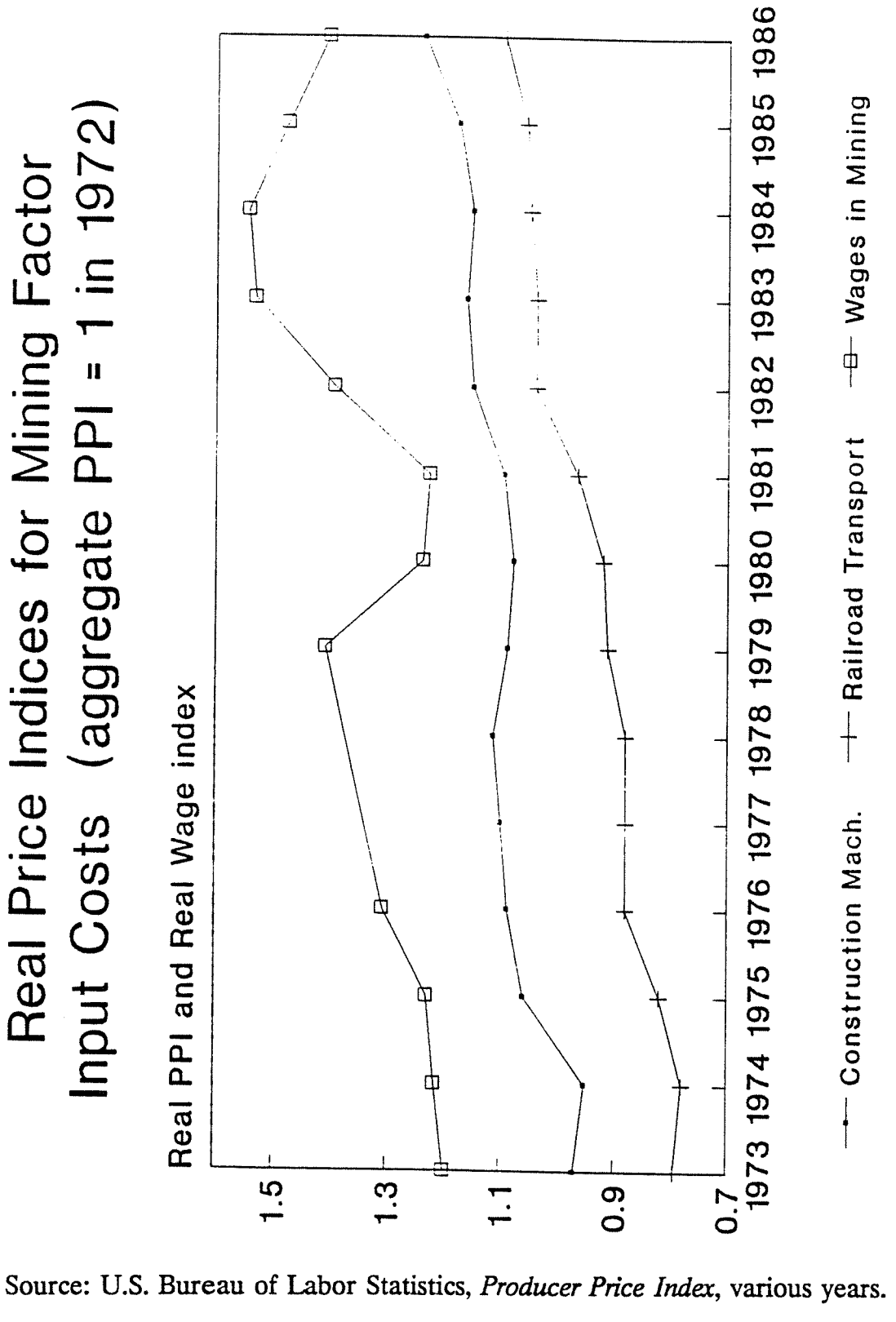
When mining production is begun on state lands, the state assesses a royalty on net profits. Roughly, net profits are the residual between gross receipts from the sale of the mined minerals and the costs of production, including payroll, materials, depreciation, maintenance, and other operations expenses. Coal mining operations are assessed a five percent royalty. Currently the Usibelli operation near Healy is on a temporary royalty reduction and is assessed approximately a 3 percent royalty which will be increased to 5 percent gradually. Idemitsu-Kosan will be levied a 5 percent royalty at the Wishbone Hill site near Sutton when production begins, as planned, in 1991. All other mineral mining operations on state land are assessed a 3 percent royalty on net profits when they are producing. This royalty was established by legislation enacted in 1989. [17]

For mining operations which are classified as corporations, as defined in federal statutes, the State of Alaska assesses a 3 percent corporate income tax on federal taxable income. Various deductions related to specific mining operations may reduce this rate to as low as 2 percent.

3. Equipment Costs and Transportation Costs

Two other major factor inputs to the mining operation are mining equipment and railroad transportation. The cost of construction machinery such as trucks, loaders, and bulldozers give an indication of the cost of mining equipment in Alaska. As displayed in Figure 4, in recent years the costs of construction machinery and railroad transportation (as measured by the U.S. producer price index for these items) have increased relative to the aggregate producer price index for the United States. From 1973 to 1986, the price of construction machinery increased in constant dollars on average 1.9 percent annually.[18]

FIGURE 4. TRANSPORTATION AND CONSTRUCTION MACHINERY COSTS



Source: U.S. Bureau of Labor Statistics, *Producer Price Index*, various years.

4. Capital Costs

The total value of capital factor inputs in the mining industry is difficult to measure. Annual additions to the capital stock--or investments--are more readily available, and are called either exploration expenditures or development expenditures.

Exploration Expenditures. Exploration expenditures are general capital investments. The information gathered through various exploration activities can be applied to a variety of mine sites and a variety of minerals. Exploration expenditures may be made with no specific plans to begin mining. The level of exploration expenditures can be interpreted as an indicator of long-term expectations about mineral prices and an indicator of mining operators' confidence in growth in the mineral industry. Exploration expenditures are highly sensitive to changes in the price of minerals. The levels of exploration expenditures from 1979 through 1988 are listed in Table 10. Exploration expenditures (primarily for precious metals) grew on average 40 percent annually each year from 1975 through 1980 while prices for gold and silver grew at almost 15 percent annually over the same period.[19]

Development Expenditures. Development expenditures are specific capital investments. Development capital expenditures involve mine site capital expenditures intended to create infrastructure needed to conduct mining for specific minerals. Usually, development expenditures are made only when actual mining operations are expected to be feasible. Total mineral mining development expenditures increased on average 11 percent annually from 1979 through 1986, prior to the development of the Greens Creek and Red Dog mines. Total Greens Creek development expenditures were about $114 million. Development expenditures at the Red Dog Mine Project were approximately $55 million in 1987 and $200 million in 1988. Expenditures on this project are expected to total $420 million (in current dollars) between 1987 and 1991. After that, development expenditures for the entire mineral mining sector will likely return to levels less than $100 million (in constant 1982 dollars) per year. Development expenditures in current and constant dollars for years 1979 through 1988 are listed in Table 11 and graphed in Figure 5.

TABLE 10. MINERAL MINING EXPLORATION EXPENDITURES

Nominal Mineral Mining Exploration Expenditures
(in millions of current dollars)

Year	Base Metals	Precious Metals	Industrial Materials	Coal and Peat	Other	Total
1979	10.28	4.61	0.15	0.20	61.25	76.49
1980	6.78	5.09	1.25	0.13	52.00	65.24
1981	28.26	35.27	10.30	2.34	0.13	76.30
1982	31.76	10.94	0.00	2.90	0.02	45.62
1983	9.76	20.90	2.07	1.34	0.07	34.13
1984	4.72	14.95	0.27	2.07	0.28	22.28
1985	2.40	6.48	0.00	0.27		9.15
1986	1.85	6.11	0.17	0.79		8.91
1987	2.52	11.74	0.29	1.15	0.03	15.73
1988	1.21	41.4	0.16	2.73		45.5

Real Mineral Mining Exploration Expenditures
(in millions of 1982 constant dollars)

Year	Base Metals	Precious Metals	Industrial Materials	Coal and Peat	Other	Total
1979	13.08	5.87	0.19	0.25	77.93	97.32
1980	7.91	5.94	1.46	0.15	60.68	76.12
1981	30.07	37.52	10.96	2.49	0.14	81.17
1982	31.76	10.94	0.00	2.90	0.02	45.62
1983	9.39	20.11	1.99	1.29	0.07	32.85
1984	4.38	13.88	0.25	1.92	0.26	20.69
1985	2.16	5.83	0.00	0.24	0.00	8.23
1986	1.62	5.35	0.15	0.69	0.00	7.81
1987	2.14	9.97	0.25	0.98	0.03	13.36
1988	1.00	34.15	0.13	2.25	0.00	37.53

Source: Department of Natural Resources and Department of Commerce and Economic Development, *Alaska's Mineral Industry*, various years. Current dollar values are deflated to constant dollar values using U.S. GNP deflator, from U.S. Department of Commerce, *Statistical Abstract of the U.S.*, 1989.

TABLE 11. MINERAL MINING DEVELOPMENT EXPENDITURES

Nominal Mineral Mining Development Expenditures
(in millions of current dollars)

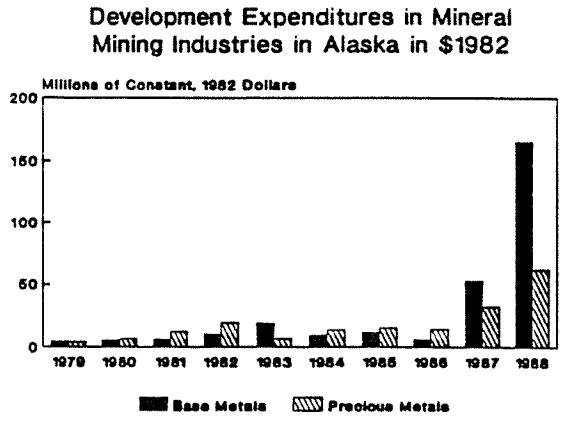
Year	Base Metals	Precious Metals	Industrial Materials	Coal and Peat	Total
1979	3.60	3.14	1.00	0.00	7.74
1980	5.00	5.75	1.20	0.00	11.95
1981	5.95	11.40	7.00	0.35	24.69
1982	10.27	19.32	4.25	7.75	41.59
1983	19.50	7.11	1.00	0.25	27.86
1984	10.71	15.06	0.58	27.00	53.35
1985	13.00	16.89	1.83	2.40	34.12
1986	7.26	16.42	0.12	0.53	24.33
1987	62.08	37.64	0.19	0.34	100.25
1988	200.00	74.95	0.00	0.00	274.95

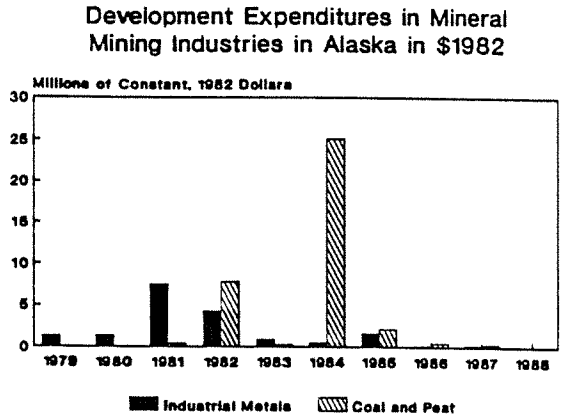
Real Mineral Mining Development Expenditures in 1982 Dollars

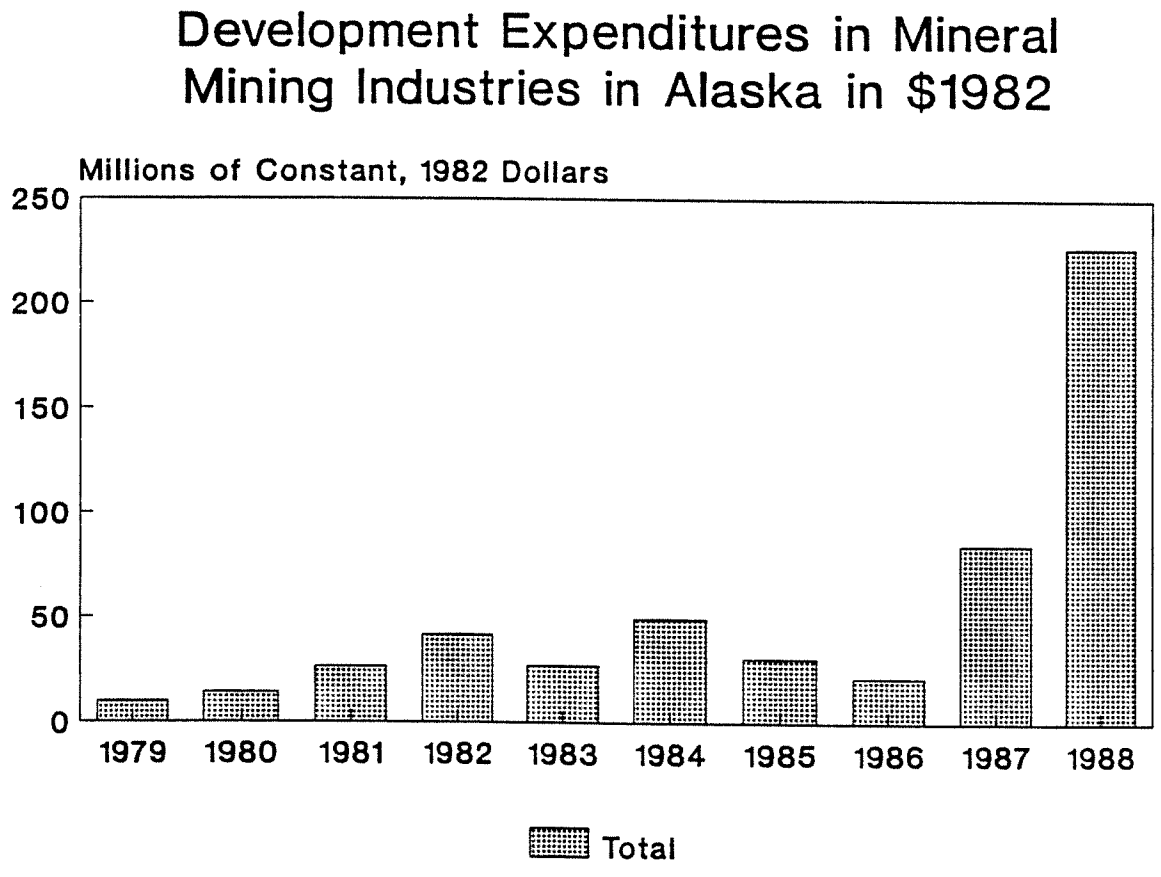
Year	Base Metals	Precious Metals	Industrial Materials	Coal and Peat	Total
1979	4.58	3.99	1.27	0.00	9.85
1980	5.83	6.71	1.40	0.00	13.94
1981	6.32	12.13	7.45	0.37	26.27
1982	10.27	19.32	4.25	7.75	41.59
1983	18.77	6.85	0.96	0.24	26.82
1984	9.94	13.98	0.54	25.07	49.53
1985	11.69	15.19	1.65	2.16	30.68
1986	6.36	14.39	0.11	0.46	21.33
1987	52.74	31.98	0.16	0.29	85.17
1988	164.97	61.82	0.00	0.00	226.80

Source: Department of Natural Resources and Department of Commerce and Economic Development, *Alaska's Mineral Industry*, various years. Current dollar values are deflated to constant dollar values using U.S. GNP deflator, from U.S. Department of Commerce, *Statistical Abstract of the U.S.*, 1989.

FIGURE 5. DEVELOPMENT EXPENDITURES







Source: *Alaska's Mineral Industry*

II. Individual Mineral Industries

Using the basic economic measures described in the previous section, the economic trends in individual (three and four digit SIC) industries can be described in more detail. In particular, the interaction between prices and quantities, production and employment, and the impacts of particular development projects on these economic variables can be described.

A. Metals

Metals that are currently being produced in Alaska or were produced in the past include gold, silver, tin, zinc, platinum, lead, copper, mercury, and chromium.

1. Gold

Quantity. Estimates of gold production in *Alaska's Mineral Industry, 1988* are based on completed questionnaires from mine operators, precious metal refiners, stockholder reports, and informal surveys from mining districts. In 1988, 208 completed questionnaires were returned to the Departments of Natural Resources and Commerce and Economic Development. These departments continually refine the survey methods and try to ensure comparability of data across different years.[20]

The first historically measured gold production began in 1880 in Juneau. Production increased steadily to a peak in 1906 of over one million ounces in that year. During both World War I and World War II, production was drastically reduced due to the diversion of workers to war-related activities. Between the world wars, in the 1920s and 1930s, production fluctuated above 300,000 ounces per year. After World War II, production remained under 300,000 ounces per year and declined steadily until 1972. Production levels for years 1946 through 1988 are depicted in Figure 6.[21]

Prices. Historical gold prices are made complex by use of gold as a standard of value in international trade. Prior to 1944 gold served as a standard of value for most major world currencies which were defined in quantities of gold, and a fixed relationship was maintained between a country's gold stock and money supply. This gold standard effectively created fixed exchange rates -- forcing the flow of gold between countries to maintain the balance of payments among countries. Under the adjustable peg system, or Bretton Woods system, established in 1944, the price of gold was allowed to vary for most currencies, while an ounce of gold was pegged to a set value in U.S. dollars ($35.00/ounce). Starting in August 1971, under the managed floating exchange rates, the United States government ended its promise to exchange gold for dollars at the rate of $35/ounce which had existed for 37 years -- severing the link between gold and the international value of the dollar.

The world price of gold is now determined largely by supply and demand conditions in the world market for gold. If the world supply of gold increases considerably, the world price of gold will likely decline. Since the level of gold production in Alaska is small

relative to world production, any variations in Alaska production will have imperceivable effects on the overall world supply of gold. Since Alaska production has only a minute effect on world production, Alaska can have only a small effect on world prices for gold. Alaska producers are said to be "price takers," meaning they take the world price of gold as given and cannot affect the price if they produce more or less.

The level of production in Alaska is determined by the cost of producing in Alaska. Several important factors affect the costs of production. For individual mining operations or individual gold reserves, the cost of mining different quantities of gold may be relatively constant for different levels of production. Price variations may not affect the level of mining in a particular mine. However, for the gold mining industry as a whole, average costs of production rise for less accessible gold reserves which lie in areas which require more machinery, labor, or other factor inputs to mine the gold. Marginal reserves of gold have average costs of production which are just above the world price of gold. As world prices rise above the average cost of production in these marginal reserves, mining will likely begin in the marginal reserves. As a result, average cost of production for the gold industry as a whole will be higher and total Alaska gold production will increase as world prices increase.

This industry supply response to price changes can be summarized by an elasticity. On average from 1968 to 1987, for every one percent increase in world gold prices, the level of production in Alaska increased by 1.1 percent. This response implies the supply price elasticity is about 1.1 for this time period. A supply price elasticity of 1.1 is relatively large, and suggests many marginal reserves (with marginal costs of production just above the world price of gold) exist in Alaska.

The most recent variations in gold prices are depicted in Figure 6.[22] On average, the price of gold increased at an annual rate of 13 percent from 1968 to 1987. This includes anomalous speculative price increases in the early 1980s. If gold prices continue to rise, production in Alaska will also continue to grow. Because the supply price elasticity is near or above one, production in Alaska can be expected to grow at about the same rate of growth as world prices if supply conditions similar to those in the 1968 to 1987 period hold in the future.

Employment. Employment has been reported separately for gold mining only in recent years. Employment in gold and silver mining combined from 1981 through 1988 is listed in Table 12. In 1988 these estimates include reported employment from 208 mechanized placer mines and three small lode operations statewide. Small recreational-assessment projects that recover gold bullion from panning, pick and shovel prospecting, long-tom sluicing, and suction dredging are not included.[23]

Two major technological alternatives exist for gold mining in Alaska: there were roughly 202 placer miners and three lode operators in 1987. Currently, and probably for the next two to three years, placer mining will dominate the industry.[24]

Compared to the U.S. as a whole, Alaska produces about 6 percent of the gold and employs about 16 percent of all the gold mining employees in the U.S., suggesting that Alaska uses more labor intensive techniques than in other areas of the U.S. This labor intensity is likely due to the unique climatic and wilderness conditions in Alaska which preclude the use of large machinery; also, Alaska has many small operations.

TABLE 12: EMPLOYMENT AND PRODUCTIVITY
IN GOLD AND SILVER MINING IN ALASKA

Year	Employment (year-round equivalent jobs)	Output per Employee-Year (ounces of gold per employee-year) All Operations	All Placer Operations*
1981	606	221	
1982	864	203	
1983	839	201	
1984	708	247	
1985	662	287	297
1986	483	331	333
1987	551	417	453
1988	602	441	

Source: Employment from Table 5 of this report, Production from *Alaska's Mineral Industry, 1987.*

* Productivity of placer mines is the ratio of total placer production divided by total year-round equivalent employment for placer mines as reported in Table 5. Total production for all placer mines is not reported separately from lode mines in the 1988 report. Data for small family-operated mines are not available.

Capital Expenditures. Exploration expenditures for gold are not completely separable from exploration expenditures for all precious metals. However, gold is often the primary precious metal for which exploration is conducted. In Alaska, exploration expenditures for precious metals usually reveal gold and silver. Exploration expenditures respond very sensitively to expectations of future prices. As gold prices increased four-fold in the late 1970s and early 1980s exploration expenditures for precious metals increased eight-fold. Stabilizing gold prices have led to stabilized precious metal exploration expenditures. The high sensitivity to price reflects the dependence of exploration expenditures on future market conditions.

Development expenditures used to invest in capital at particular mine sites increased in real (constant dollars) at an average annual rate of 20 percent from 1981 through 1986. In the most recent years, most capital expenditures for the Greens Creek Mine and some for the Red Dog Mine have been investments for silver mining. [25]

2. Silver

Quantity. Historically, production of silver in Alaska grew steadily to over 1 million ounces in 1915-1916 and declined steadily thereafter but remained at levels above 100,000 ounces per year until World War II. As depicted in Figure 7, production after World War II and up to 1960 averaged around 30,000 ounces per year. From 1963 to 1980 production remained below 10,000 ounces with the exception of 1973. In that year rising silver prices encouraged higher levels of silver production. After the speculative price bubble for silver, silver production in the 1980s rose dramatically relative to the 1961-1980 calm.[26] Silver production is linked closely to gold production in Alaska since many of the gold mines in Alaska also produce quantities of silver, especially after the gold ore has been refined. The Greens Creek Mine, which opened in 1989 and produced nearly 5.2 million ounces of silver that year, has pushed Alaska silver production above the historic highs. The Red Dog Mine is also expected to produce some silver.

Prices. The prices of silver in 1979 and 1980 stand out in Figure 7 as unique outliers in the historical trend of silver prices. During these two years the Hunt brothers attempted to corner the market on silver and to drive the price of silver above levels sustainable by mining extraction costs. Real prices increased on average 3.9 percent annually from 1964 to 1987, but that growth contained speculative components which did not reflect rising production costs.[27] The real costs of production are likely to grow slowly during the 1990s.

Capital Expenditures. Development expenditures at Red Dog Mine, Greens Creek Project, and Heap Leach Gold-Silver Developments include silver development.[28] These projects will add to the growing silver production.

3. Copper

Quantity Produced. Between 1900 and 1946 copper production remained above one million pounds per year with the exception of some years during World War II and early years of the depression (1930 and 1931). Peak production of over 100 million pounds occurred in 1915. As seen in Figure 8, after World War II production was sporadic, but generally remained below 100,000 pounds per year until the production of copper ended in 1970.[29]

Prices. As depicted in Figure 8, real world copper prices fell on average 2.4 percent annually from 1964 to 1987.[30] Prices did increase substantially in 1989, but production in Alaska is unlikely to begin again unless copper prices remain up over the longer term. The exhaustion of copper mines elsewhere in the U.S., which can be mined more cheaply than Alaska copper mines, and long-term rising copper prices cannot be expected to occur in the next twenty years.

4. Platinum

Quantity. Most Alaskan production of platinum occurred between 1915 and 1949. Since that time the data has been withheld due to the limited number of reporting establishments. Based on total cumulative production for the years 1950 through 1987, the average annual production of these few establishments is approximately 500 ounces per year (approximately 17,000 ounces were mined between 1950 and 1987).[31] Historical platinum production is graphed in Figure 9.

Price. The real world price of platinum increased, on average, 1.7 percent annually from 1964 through 1987, as shown in Figure 9.[32] If the price continues to rise, higher levels of production in Alaska may be observed.

5. Zinc

Quantity. No major amounts of zinc were produced in Alaska through the 1980s. Some small amounts from exploration activity were extracted but not produced commercially. The Red Dog Mine will produce zinc, lead, silver, and barite. The reserves at the mine are estimated at 85 million tons of ore containing mostly zinc (17.1 percent) with lesser amounts of lead (5.0 percent) and silver (2.4 ounces per ton of ore). During years of full operation, Red Dog Mine is expected to produce 550,000 tons per year of zinc concentrate, 100,000 tons per year of lead concentrate, and 50,000 tons per year of polymetallic concentrate suitable for processing in an Imperial smelter-type furnace (which would yield a variety of metals).[33] This level of production would almost triple total U.S. mine production of zinc. [34]

Prices. As displayed in Figure 10, real world prices for zinc grew 0.2 percent annually from 1964 to 1986 and declined at about 1 percent annually since prices peaked

in 1974 and 1975.[35] At presently planned production levels, Red Dog mine would be the second largest mined zinc reserve in the world after the original Broken Hill deposit in New South Wales, Australia and the largest producing zinc mine in the world. U.S. mine production of recoverable zinc in 1986 was 203,000 metric tons, and has declined steadily on average 4 percent annually over the past decade.

Because of the large contribution of zinc the Red Dog Mine will make to total U.S. production, the producers of zinc will likely have some price power or monopoly power. When production begins at Red Dog and substantially larger amounts of zinc are available on the world market, the world price of zinc will likely fall; buyers of zinc won't be willing to pay as much as they previously did for the more abundant mineral. After this initial decline in prices, the Red Dog Mine producers will be able to adjust the level of output at the mine in order to influence the world price of zinc up or down. The degree of influence or monopoly power which Red Dog mine producers have on world zinc prices will depend on the reactions of other zinc producers and buyers of zinc.

Capital Expenditures. The total capital cost of the Red Dog Mine is estimated at $420 million in 1988 dollars. Construction began in 1987. About $140 million of the capital costs were expended in 1987 and $200 million in 1988. These expenditures amounted to 90 percent of the total mining development expenditures in Alaska in 1987 and 72 percent in 1988. During 1987, 400 workers were employed in construction activity at the site. In 1989 an estimated 900 persons were employed by contractors working on the road, port facilities, and mine site.[36] Operation of the mine is expected to begin in 1990.[37]

6. Tin

Quantity. Tin was produced in Alaska from 1902 to 1955, with a break during World War II. As shown in Figure 11, production restarted sporadically in the 1970s and grew relatively steadily from 1979 through 1988. Much of the production in the past ten years has been on the Seward Peninsula, mostly at Cape Creek.[38]

Price. As seen in Figure 11, the price of tin in constant dollars rose on average 0.69 percent annually between 1964 and 1987.[39] If real prices continue to increase at this slow rate, production of tin in Alaska is not expected to expand in the near future.

7. Lead

Quantity. Most of the Alaska production of lead occurred between 1914 and 1943. As seen in Figure 12, production since World War II has been small and sporadic. The Red Dog Mine is expected to produce 100,000 tons per year of lead concentrate, and the Greens Creek mine about one-tenth of that amount.[40] This level of lead production is 100 times larger than highest previous levels of lead production in Alaska earlier this century.

Price. The price of lead in constant dollars fell, on average, 2.3 percent annually between 1964 and 1987 (see Figure 12).[41] Due to these falling prices, lead production will likely occur only as a byproduct of other mining operations.

8. Mercury

Production of mercury in Alaska was concentrated between 1921 and 1974. Currently about 50, 76-lb flasks are being produced each year.[42] The exact level of production is withheld since it is being produced by a single establishment.

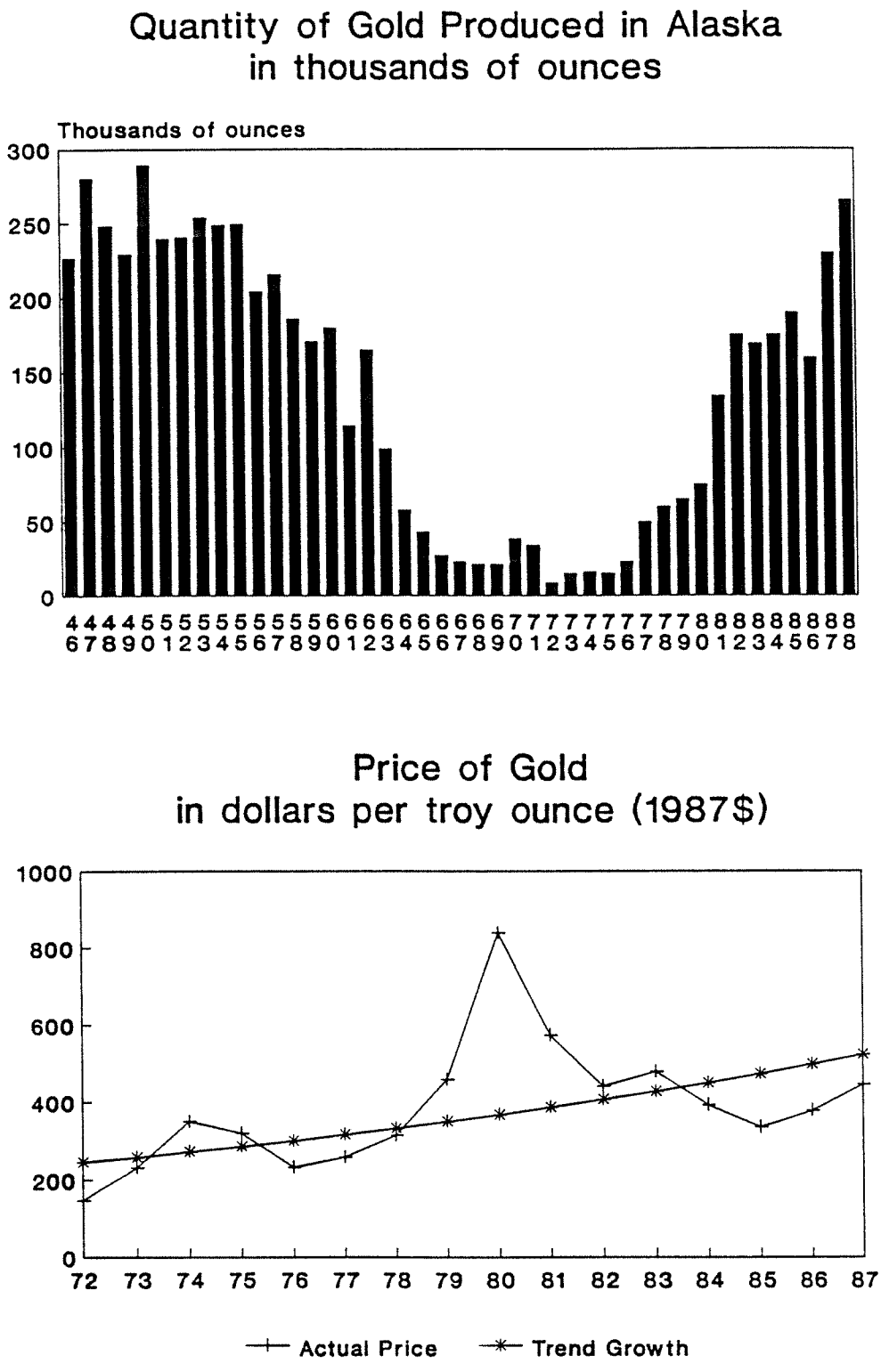
9. Antimony

Production of antimony has been sporadic from 1937 to the present, with many years of no production. In the late 1980s production was less than 100,000 pounds. No production was reported in 1987.[43]

10. Chromium

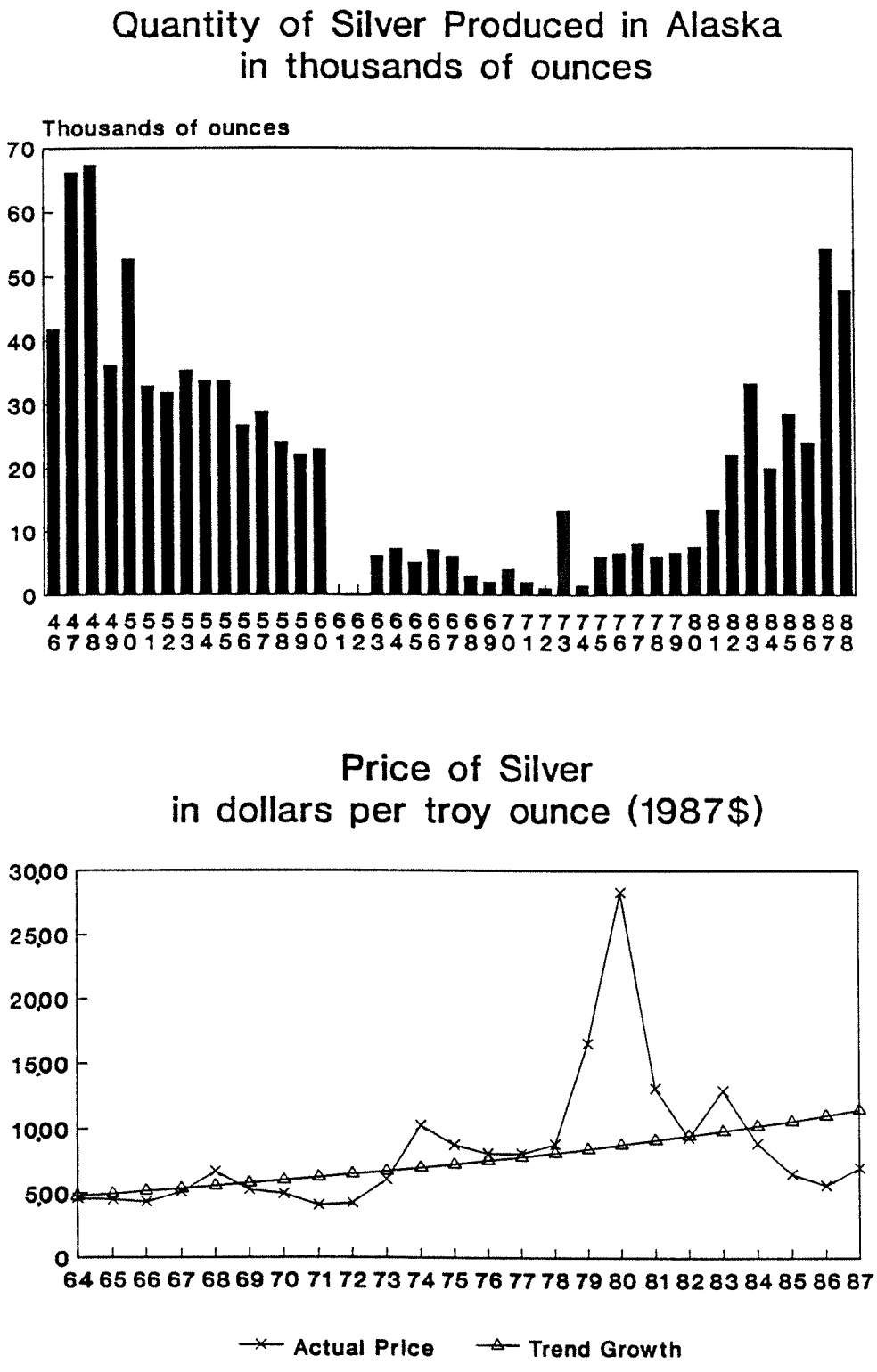
Chromium has been produced sporadically in Alaska. Currently the metal is not being produced.[44]

FIGURE 6. GOLD QUANTITIES AND PRICES



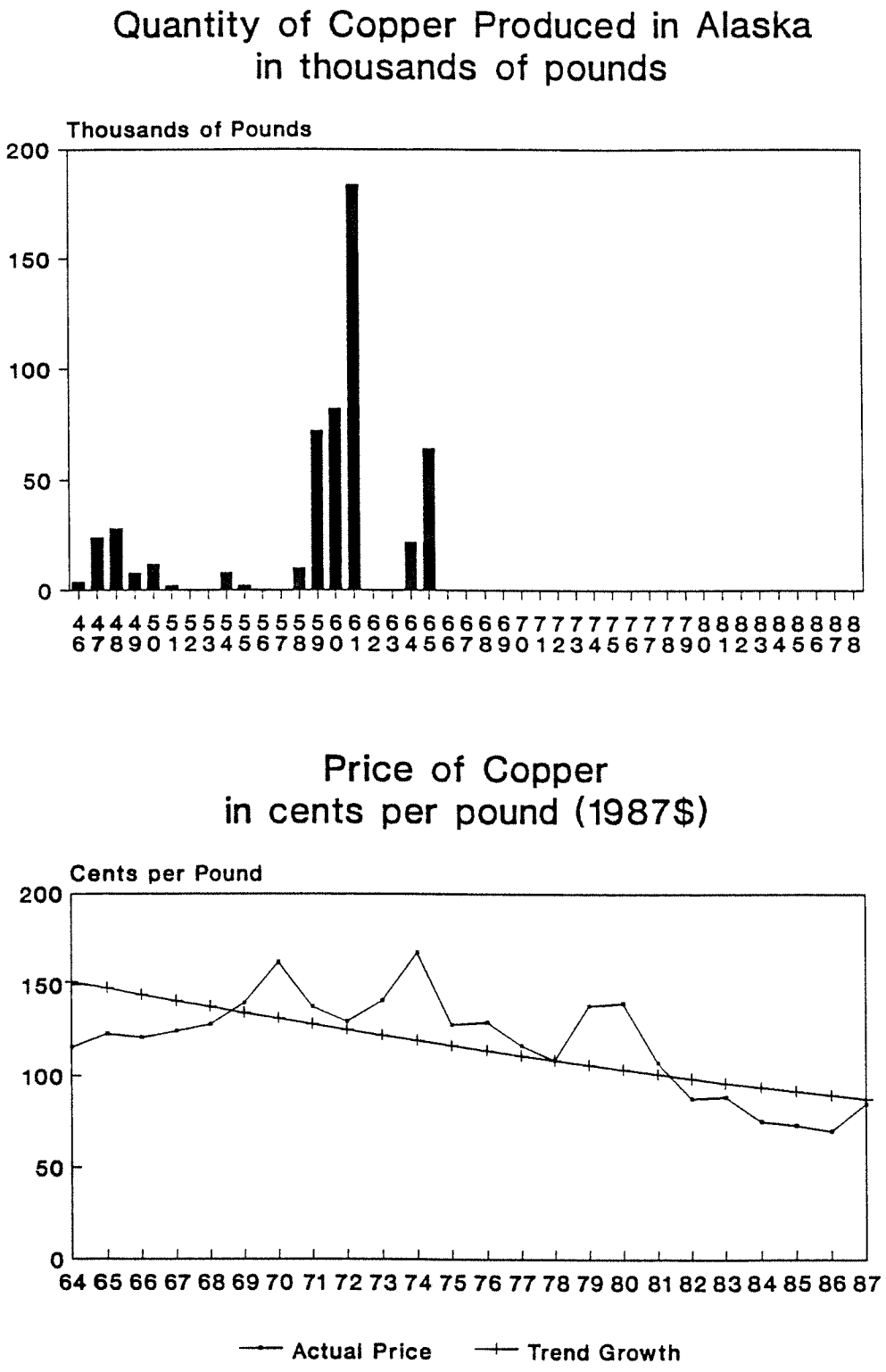
Sources: Prices from *Commodity Yearbook*, Quantities from *Alaska's Mineral Industry*

FIGURE 7. SILVER QUANTITIES AND PRICES



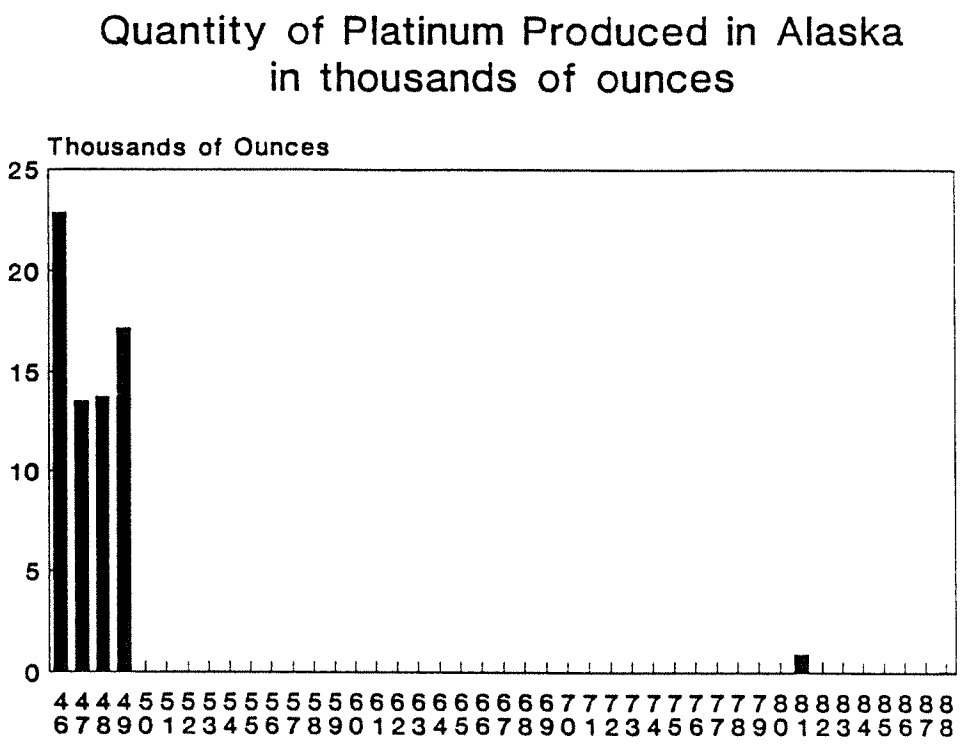
Sources: Prices from *Commodity Yearbook*, Quantities from *Alaska's Mineral Industry*

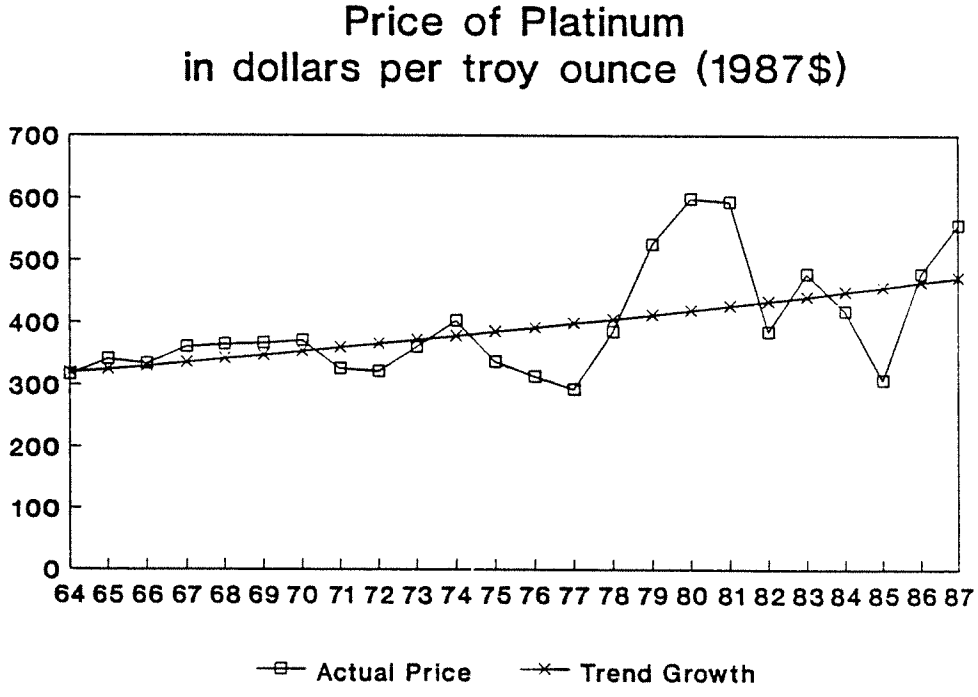
FIGURE 8. COPPER QUANTITIES AND PRICES



Sources: Prices from *Commodity Yearbook*, Quantities from *Alaska's Mineral Industry*

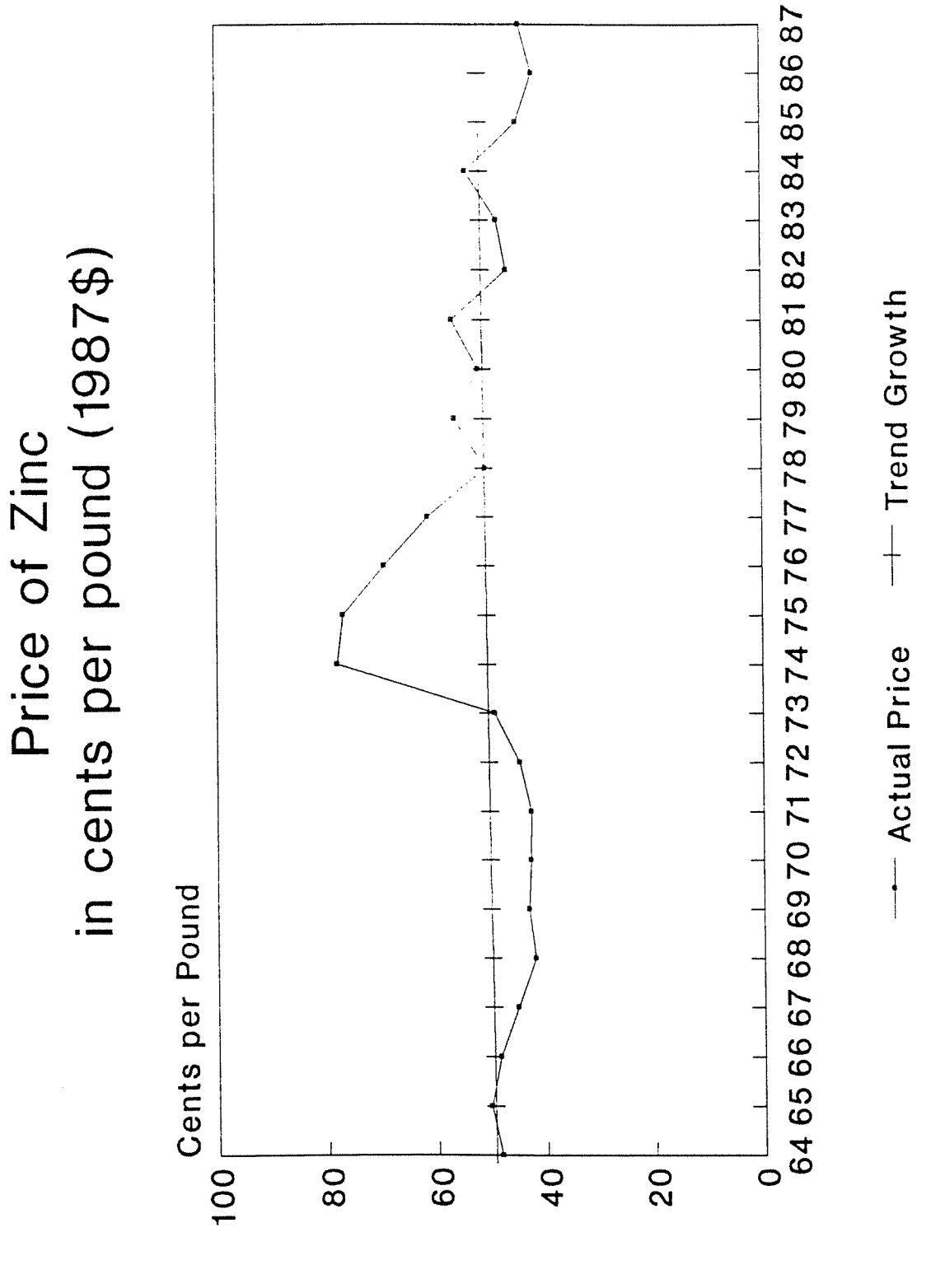
FIGURE 9. PLATINUM QUANTITIES AND PRICES





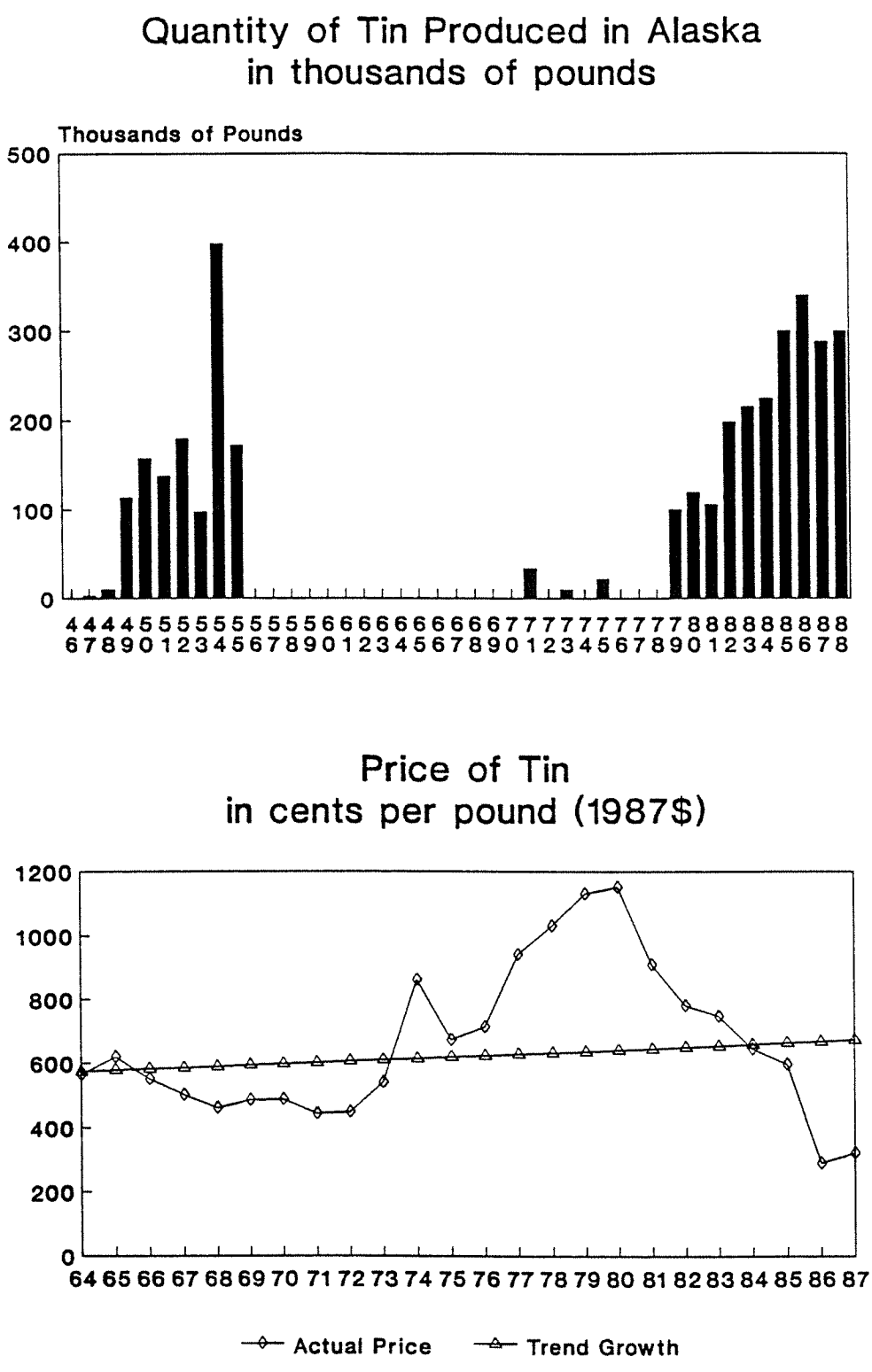
Sources: Prices from *Commodity Yearbook*, Quantities from *Alaska's Mineral Industry*

FIGURE 10. ZINC PRICES



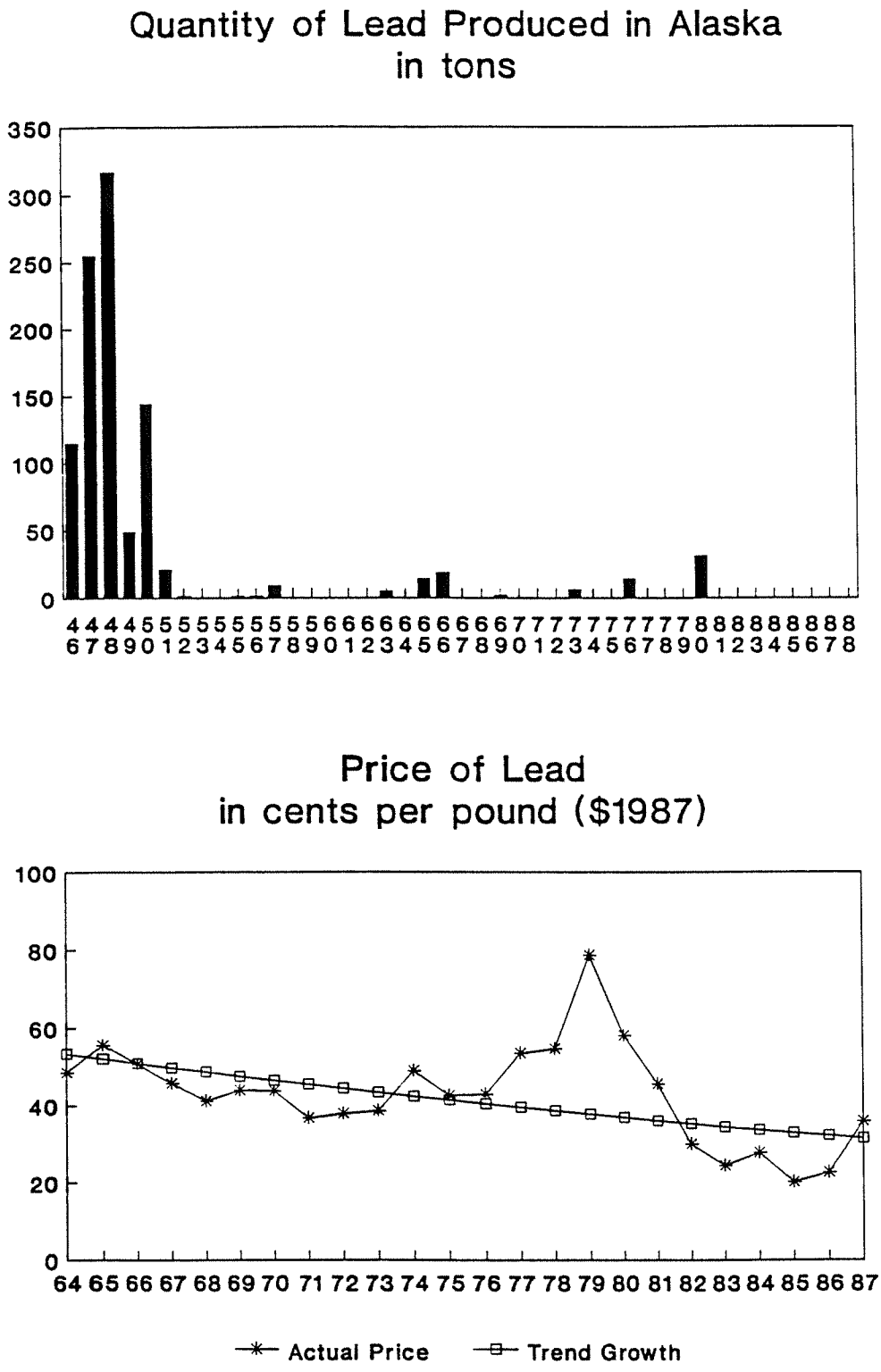
Sources: Prices from *Commodity Yearbook*

FIGURE 11. TIN QUANTITIES AND PRICES



Sources: Prices from *Commodity Yearbook*, Quantities from *Alaska's Mineral Industry*

FIGURE 12. LEAD QUANTITIES AND PRICES



Sources: Prices from *Commodity Yearbook*, Quantities from *Alaska's Mineral Industry*

B. Industrial Minerals

1. Sand and Gravel

Quantity. Unlike other mining industries in Alaska, the sand and gravel produced in Alaska is primarily for local markets. Gravel production in Alaska has been driven primarily by the demand for construction projects in basic industries such as the construction of the trans-Alaska oil pipeline and haul road, North Slope Oil production, and construction in the Anchorage urban area. Construction for oil production and housing will continue to be the primary determinant of the level of gravel production. Special construction projects such as road construction may increase gravel production temporarily.

Prices. The price of sand and gravel varies regionally within Alaska due to variations in transport and mining costs. Prices range from $1.40 per ton on the Alaska Peninsula to $10.50 per ton in Southwestern Alaska. In other areas of Alaska, prices fall in a more narrow range from $2 to $5 per ton.[45]

Employment. Employment in sand and gravel is determined primarily by the level of production. As listed in Table 13, the ratio of output per employee was stable for the period 1984 through 1987, when the measurements of employment and production are comparable across years. This stability in output suggests that the technology and modes of production used are stable.

TABLE 13. EMPLOYMENT IN SAND AND GRAVEL MINING

	Employment		
	Five-Month Jobs	Year-Round Equivalent Jobs	Output per Employee (tons per employee-year)
1981	271	113	
1982	900	375	
1983	1,200	500	
1984	1,600	667	40,480
1985	1,435	598	47,528
1986	1,100	458	45,574
1987	868	362	46,123
1988	752	313	55,158

Source: Employment from Table 5 of this report and Production from *Alaska's Mineral Industry*, 1988. Output per employee is the ratio of production and total employment.

2. Building Stone

Quantity. The production of building stone is similar to the production of sand and gravel since these industrial minerals provide construction materials to the local Alaskan markets. Building stone needs for pipeline construction, North Slope oil production, and building construction have determined the quantity of building stone produced in the past and will continue to determine the growth and contraction of this industry.

Prices. The price of building stone likely follows regional variations similar to price variations for sand and gravel. The price of these building materials depends critically on the cost of extracting the minerals in local area quarries.

Employment. Employment in rock quarries was reported at 185 in 1987 and 210 in 1988.[46] The level of employment likely depends directly on the level of production; the technology used appears stable.

3. Barite

Quantity. Barite was produced in Alaska only between 1963 and 1980.[47] It was used primarily in oil drilling mud.

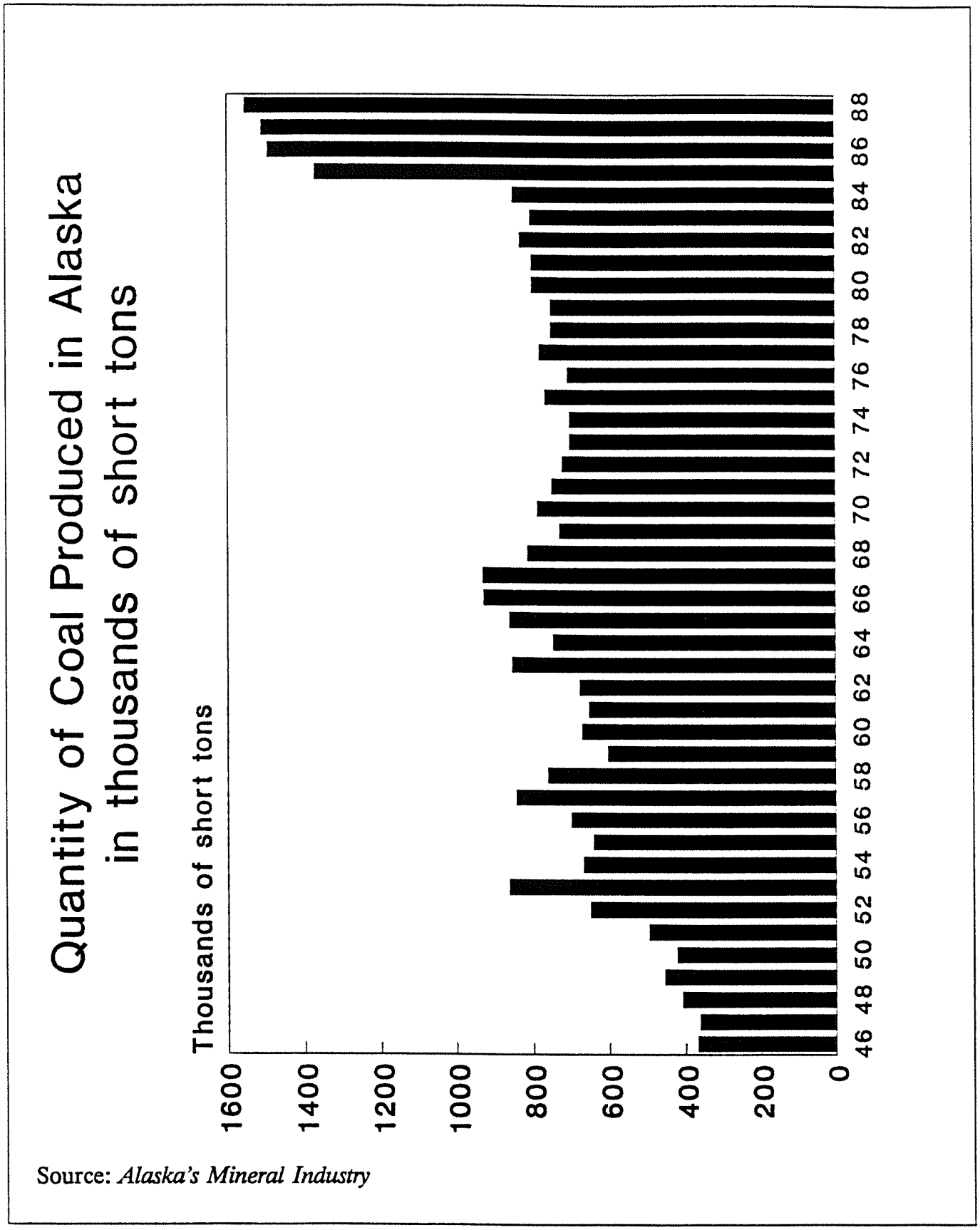
C. Coal

Commercial coal mining in Alaska dates back to 1855, when coal was extracted by a Russian-American Company in Coal Cove on the Kenai Peninsula. From that time to World War II, coal production grew gradually with increasing demand for energy in the state. In 1943, the Usibelli Coal Mine, Inc. was the first to begin strip mining in the state. Underground mining continued until 1968, when Fort Richardson and Elmendorf Air Force bases in Anchorage converted coal-fired steam power plants to natural gas. [48]

Production was relatively stable from 1970 through 1985, with Usibelli Coal Mine, Inc. supplying less than one million tons per year to local power generators including Golden Valley Electric Authority (GVEA), Fairbanks Municipal Utility System (FMUS), and military bases. After 1985 production almost doubled when the first shipment of 800,000 tons of coal annually was begun to Korea. The continued and expansion of export of Nenana Field coal depends on drying the coal in order to reduce water content by 27 percent so it can be used in existing burners in Japan and Korea. Historical coal production is graphed in Figure 13.

Idemitsu-Kosan (a Japanese company) plans to begin production from the Premier coal seam in the Wishbone Hill area in 1991. Production is planned at 1,000,000 tons per year for about 15 years, and all the coal is planned for export to Japan. The coal which may be extracted from the Wishbone Hill Coal district is of higher Btu and lower moisture content than coal from the Nenana field. [49]

FIGURE 13. QUANTITY OF COAL PRODUCED IN ALASKA



Source: *Alaska's Mineral Industry*

The local and export markets for coal are segmented due to high transport costs separating the two markets. The price of coal in Japan, Korea, or the Pacific Rim is determined primarily by the production costs of coal in Pacific Rim countries and the cost of transporting the coal. The price of coal sold in the railbelt of Alaska is determined primarily by the costs of production in Alaska. The observed contract price will vary among customers based upon a number of factors such as location of delivery, quality, length of contract, and quantity of purchase. The local price is also influenced by the competitive position of the buyer, because there is a single producer and a small number of purchasers. Buyers who have access to alternatives to coal are in a relatively stronger negotiating position than buyers without access to alternatives. The local price is potentially influenced by the world coal price, if the world price exceeds the cost of production in Alaska plus the cost of transporting the coal from Alaska to the Pacific Rim market.

Prices contracted by local buyers, as seen in Table 14, escalated in real terms from 1.6 percent to 3.6 percent between 1973 and 1988, depending on the exact period and buyer considered. These escalations were primarily due to renegotiation of the contracts to reflect unforeseen real cost increases.

TABLE 14. CONTRACT PRICE HISTORIES FOR USIBELLI COAL

Golden Valley Electric Authority

Year	1973	1985	1988
Contracted Price Mine mouth $/MMBtu	$0.47	$1.30	$1.33
US GNP deflator (1982$ = 1)	49.5	111.2	118.0

Fairbanks Municipal Utility System

Year	1976	1985	1988
Contracted Price Mine mouth $/MMBtu	$0.72	$1.56	$2.02
US GNP deflator (1982$ = 1)	63.1	111.2	118.0

Implied annual average real price increases:

GVEA	1973 to 1985:	1.9%	1973 to 1988:	1.6%
FMUS	1976 to 1985:	2.5%	1976 to 1988:	3.6%

Source: Eric Larson and Scott Goldsmith, "Alaska Railbelt Coal Price Projection Memorandum," April, 1989, ISER, UAA, prepared for the Alaska Power Authority.

Currently Usibelli Coal Mine, Inc. employs about 120 full-time workers. Approximately 25 to 30 new employees were hired in 1984, just prior to the production increase of 800,000 tons to fill the Korean export contract. As in other mining operations, the level of employment is directly tied to the level of output and the amount of available equipment, so further increases or decreases in production would lead to corresponding changes in employment. Based on the changes observed in 1985, if the Usibelli coal mine doubled production again by the mid-1990s--to about four million tons total each year--the level of employment at the mine could reach 200 to 250 employees, depending on whether new equipment were added to perform the mining.[50]

Idemitsu-Kosan estimates that a total of 184 employees will be hired full-time to extract about 1 million tons per year at the Premier Coal group in the Wishbone Hill Coal District. The mining operation in Wishbone Hill is planned to be more labor intensive than the Usibelli mine. Idemitsu-Kosan will rely on loaders and trucks rather than a single large dragline, as Usibelli does.[51] Because of these differences in technology, the output per employee will be much lower at the Idemitsu-Kosan site.

TABLE 15. EMPLOYMENT IN COAL MINING IN ALASKA

	Employment (year-round equivalent jobs)	Output per Employee Year (tons per employee year)
1981	85	9,412
1982	90	9,222
1983	95	8,453
1984	115	7,384
1985	115	11,913
1986	125	11,941
1987	127	11,881
1988	122	12,705

Source: Employment estimates from Table 5 of this report and production from *Alaska's Mineral Industry, 1988.* Output per employee is the ratio of production and employment in each year.

Factor inputs other than labor comprise about 60 percent of total costs over the life of the mine. The breakdown of costs is presented in Table 16.

TABLE 16. COMPOSITION OF COAL MINING COSTS

Cost Component	Percent of Total Cost
Labor	37%
Capital	30%
Materials	28%
Royalties	4%
Income and License Tax	2%

Source: Eric Larson and Scott Goldsmith, "Alaska's Railbelt Coal Price Projection Memorandum," April, 1989, ISER, UAA, prepared for Alaska Power Authority.

Most of these mining factor input costs have escalated in real terms over the past decade. The cost of construction machinery is often used as a reference in coal contracts to specify contracted price escalation of capital equipment. The producer price index (PPI) for construction machinery increased 1.9 percent relative to the aggregate PPI from 1973 to 1986. Roughly 20 percent of the capital equipment in a coal mining operation is replaced every one or two years. The remainder of the capital is purchased for the life of the mine, so that the costs of this fixed capital are sunk and not affected by real increases. The major material in coal production is fuel oil, the cost of which the Alaska Energy Authority (formerly the Alaska Power Authority) projects will increase by 2.6 percent annually in real terms. Transport costs for coal in the U.S. increased 2.5 percent annually in real terms from 1970 to 1986. About 70 percent of this real escalation was attributable to rising labor costs (47.2 percent of railroad transport costs) and rising fuel costs (about 12.2 percent of total railroad transport costs).[52]

Endnotes

1. T.K. Bundtzen, C.B. Green, R.J. Peterson, and A.F. Seward, *Alaska's Mineral Industry, 1982, 1983, 1984, 1985, 1986, 1987.* Division of Geological and Geophysical Surveys, Special Report 41, prepared in cooperation with Alaska Department of Commerce and Economic Development, Division of Business Development, and Alaska Department of Natural Resources, Division of Geological and Geophysical Surveys and Division of Mining.

2. Appendixes F and G in *Alaska's Mineral Industry, 1987.*

3. *Alaska's Mineral Industry, 1987*, page 18.

4. Includes all sources of zinc: smelters, primary, and secondary sources, from *Commodity Yearbook*, Commodity Research Bureau, N.Y. 1988.

5. *Alaska's Mineral Industry, 1987*, footnote in Table 7 on page 23.

6. ISER calculation.

7. Thomas K. Bundtzen, Senior Economic Geologist, Division of Geological and Geophysical Surveys, Department of Natural Resources, Letter dated May 16, 1989.

8. Thomas K. Bundtzen, Senior Economic Geologist, Division of Geological and Geophysical Surveys, Department of Natural Resources, Letter dated May 16, 1989.

9. T.K. Bundtzen, C.B. Green, R.J. Peterson, and A.F. Seward, *Alaska's Mineral Industry, 1982, 1983, 1984, 1985, 1986, 1987.* Division of Geological and Geophysical Surveys, Special Report 41, prepared in cooperation with Alaska Department of Commerce and Economic Development, Division of Business Development, and Alaska Department of Natural Resources, Division of Geological and Geophysical Surveys and Division of Mining.

10. Appendices F and G in *Alaska's Mineral Industry, 1987.*

11. *Alaska's Mineral Industry, 1987*, page 18.

12. Includes all sources of zinc: smelters, primary, and secondary sources, from *Commodity Yearbook*, Commodity Research Bureau, N.Y. 1988.

13. *Alaska's Mineral Industry, 1987*, footnote in Table 7 on page 23.

14. Thomas K. Bundtzen, Senior Economic Geologist, Division of Geological and Geophysical Surveys, Department of Natural Resources, Letter dated May 16, 1989.

15. Bureau of the Census, U.S. Department of Commerce, *Census of Mineral Industries, 1977, 1982*, Government Printing Office, Washington, D.C.

16. Jean Mell, Alaska Department of Revenue, telephone conversation, May, 1989.

17. Jean Mell, Department of Revenue, telephone conversation, May 1989, and Kirwin Kraus, Division of Mining, Department of Natural Resources, telephone conversation, May, 1989.

18. Bureau of Labor Statistics, Department of Labor, *Producer Price Indexes*, various years, Government Printing Office, Washington, D.C.

19. Department of Natural Resources and Department of Commerce, *Alaska's Mineral Industry*, 1987, Figure 2, page 5. and *Commodity Yearbook*, Commodity Research Bureau, N.Y., 1987.

20. *Alaska's Mineral Industry, 1987.*

21. *Alaska's Mineral Industry, 1987.*

22. Commodity Research Bureau, *Commodity Yearbook*, N.Y.

23. *Alaska's Mineral Industry, 1987.*

24. T.K. Bundtzen, telephone conversation, May, 1989.

25. *Alaska's Mineral Industry, 1987.*

26. *Alaska's Mineral Industry, 1987.*

27. Commodity Research Bureau, *Commodity Yearbook*, New York.

28. *Alaska's Mineral Industry, 1987.*

29. *Alaska's Mineral Industry, 1987.*

30. *Commodity Yearbook.*

31. *Alaska's Mineral Industry, 1987.*

32. *Commodity Yearbook.*

33. *Alaska's Mineral Industry, 1987.*

34. If zinc concentrate contains about 70% recoverable zinc, then the mine could be expected to produce 385,000 tons of recoverable zinc each year. This amount of zinc is three times larger than the current production of recoverable zinc in the U.S.

The estimate of the content of the fraction of zinc ore which is recoverable zinc is from T.K. Bundtzen, telephone conversation, May, 1989.

35. *Commodity Yearbook.*

36. *Alaska's Mineral Industry, 1988*, pages 20-21.

37. *Alaska's Mineral Industry, 1988.*

38. *Alaska's Mineral Industry, 1987.*

39. *Commodity Yearbook.*

40. *Alaska's Mineral Industry, 1987.*

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42. *Alaska's Mineral Industry, 1987.*

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44. *Alaska's Mineral Industry, 1987.*

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46. *Alaska's Mineral Industry, 1987.*

47. *Alaska's Mineral Industry, 1987.*

48. Coal Operators and Alaska Leaseholders Association, *Alaska Coal: Executive Briefing Book*, 1989.

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50. *Alaska's Mineral Industry, 1987.*

51. Eric Larson and Scott Goldsmith, "Alaska's Railbelt Coal Price Projection Memorandum," ISER, UAA, April, 1989, prepared for Alaska Power Authority.

52. Eric Larson and Scott Goldsmith, "Alaska Railbelt Coal Price Projection Memorandum." April, 1989, ISER, UAA, prepared for Alaska Power Authority.

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