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Trends in the Phosphate Industry of Idaho and the Western Phosphate Field

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TRENDS IN THE PHOSPHATE INDUSTRY OF IDAHO AND THE WESTERN PHOSPHATE FIELD

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ABSTRACT

Since 1945, Idaho's phosphate industry has progressed from a single underground mine producing somewhat over 100,000 tons of phosphate rock a year, all of which was shipped out of the state for processing, to four large surface mines yielding about 4,000,000 tons of rock a year, 90% of which is converted into fertilizer and elemental phosphorus within the state. The estimated annual value of these products of the phosphate industry considerably exceeds the combined value of lead, zinc, silver, and other metals producted in the famous Coeur d'Alene mining District of northern Idaho.

Rapid growth of the phosphate industry was made possible principally by (1) the largest reserves of the required grades of phosphate rock available by low-cost surface mining in any state outside of Florida; (2) the success of the state's principal fertilizer manufacturer in penetrating the West North Central States phosphate fertilizer market during the period of its most rapid growth; (3) establishment of the elemental phosphorus industry just as the market for phosphate detergents began its explosive growth; and (4) electric power rates which have remained among the lowest of the nation, a fact of critical importance in the elemental phosphorus industry where 13,000 kilowatt hours of electric power are required for each ton of phosphorus produced.

Growth in the fertilizer segment of Idaho's phosphate industry ceased in the late 1960's as a result of less favorable market conditions which apparently were associated mainly with the great increase in fertilizer production in the southern and midwestern states. However fertilizer production again turned upward in 1972 as consumption again began to increase rapidly. Growth of the elemental phosphorus industry may taper off during the 1970's if phosphate-based detergents should become less acceptable.

PREFACE

The need has been indicated for a comprehensive, but rather concise summary of the development of, and recent trends in, Idaho's phosphate industry, probable influences bringing about these trends, and a statement as to the significance of the industry to Idaho's economy. Developments in the phosphate industry in the other three states of the Western Phosphate Field, namely Montana, Wyoming and Utah, have been included in this study in order to provide the necessary perspective for, and understanding of, events in Idaho. The strength of Idaho's phosphate industry can be much better appreciated when one is aware of trends in the other three states.

The author has been repeatedly handicapped in this study by non-availability of such data as actual annual output of fertilizer and elemental phosphorus by the several plants producing these commodities; by many inconsistencies in the data which have been available; by the disclosure rule which has resulted in the U.S. Bureau of Mines lumping data on the phosphate industry with a dozen other mineral commodities as well as combining data for several states of the West and Arkansas; and by the lack of direct information as to what forces have brought about certain key events. As a result, many data estimates have had to be made upon the basis of diverse and sometimes extremely tenuous clues. Explanations for events have had to be reasoned out, in many cases, on the basis of information gleaned from a variety of sources, including personal conversations. Documentation not always has been possible, because in most cases the author was requested not to give the source of his information, while in other instances he was cautioned not to associate certain statistics or events with a particular industrial concern.

It is hoped that those informed on the subject will promptly advise the author of any corrections he should make in this manuscript.

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I wish to thank the several companies which comprise the phosphate industry of Idaho and the Western Phosphate Field for their assistance in my research. Anonymity has been requested, however, and the documentation therefore has been limited to "information obtained by interview".

Mr. A.L. Service of the U.S. Bureau of Mines was especially helpful during my period of research in the field. Dr. Morton W. Scripter, Head of the Department of Geography, College of Mines, University of Idaho, read the preliminary draft of this paper and made many valuable suggestions. Clifford H. Wood has contributed valuable ideas on cartographic techniques and drafted the basic map 1.

I. INTRODUCTION

The most rapidly developing segment of Idaho's mining and mineral products industries since World War II has been the mining and processing of phosphate rock in the southeastern corner of the state (Map 1.) Employment rose from an estimated 100 in mining and beneficiation in 1945 to approximately 600 in mining and an estimated 1500 in the manufacturing of fertilizer and elemental phosphorus in the peak year of 1966. Since 1966, however, employment in phosphate rock mining has dropped back to about 400 and manufacturing employment has declined to an estimated 1250. These figures represent about 13% of Idaho's mining employment and 3% of its manufacturing employment (1).

By way of comparison, more than 2700 persons are employed in mining and about 1200 in related milling, smelting, and refining in the lead-zinc-silver industry in Idaho's principal mining area, the Coeur d'Alene District. Value of marketable phosphate rock output in southeastern Idaho averages about $23,000,000 annually, compared with more than $75,000,000 for all smelted and refined metals produced in the Coeur d'Alene District (2). However, if one were to calculate the value of output in the phosphate industry on a truly comparable basis, that is, in terms of the value of fertilizers and elemental phosphorus produced, a total of some $96,500,000 would be obtained, of which all but approximately $4,000,000 value is produced in southeastern Idaho (3). Thus, in southeastern Idaho, there exists a mineral-based industry which actually surpasses, by nearly 30%, the metallic mineral industry of the Coeur d'Alene District of northern Idaho in value of output, although not approaching it in terms of the actual number of mining employees (4).

The development, locational aspects, and recent trends in the mining and processing of phosphate rock in Idaho form the subject of the present study.

II. PHOSPHATE ROCK IN THE WESTERN FIELD

Distribution

Southeastern Idaho contains the largest and most accessible commercial grade phosphate rock deposits in the Western Phosphate Field. Although the field encompasses considerable portions of four states, as outlined on Map 1, well over half of the field's presently usable reserves of rock are located within a rectangle only about 60 miles long and 20 miles wide in southeastern Idaho (Bottom Inset, Map 1). By far the greatest concentration of phosphate rock exposures is found in the southeastern half of this rectangle, within about 25 miles of Soda Springs. The reserves within this rectangle constitute about one-third of the U.S. total (5). By way of comparison, the entire Western Phosphate Field contains about 44% of the U.S. reserves (6). Tonnage estimates of Idaho's phosphate rock reserves of various grades, 90% of which are concentrated within the rectangle, are provided in Table 1.

Within the rectangle referred to above are found Idaho's four active phosphate rock mines, as well as five additional inactive mines that were operated during the 1960's, mostly for short periods of time. Actually three of the active, and all five of the inactive, mines are located within the southeastern half of the rectangle. Production from the four operating mines was estimated at about 80% of the total for the Western Phosphate Field in 1970 (Table 2).

Not only does southeastern Idaho possess the most extensive reserves in the Western Phosphate Field, but the commercial grade rock members are generally thicker and more easily mined than in other states of the Field. For example, Montana's principal producing mine is a very deep one, extending 1,000 feet beneath the surface. Morever, the mining sections are relatively thin, being about 3.5 to 4 feet in thickness, and they are steeply dipping and cross-faulted (7). By contrast, the deposits at Idaho's largest producer the Gay Mine, are covered by only a few feet of overburden and are, therefore, mined from the surface. The commercial beds are almost flat-lying and are 20 to 30 feet thick (8). The phosphate beds in Idaho's other three active mines are steeply dipping, and in some cases faulted; nevertheless, they are amenable to surface mining in large scale operations.

Table 1. Idaho Phosphate Rock Reserves

	Grade	Tons
Available by Surface Mining Methods	+31% P_2O_5	176,000,000
	24 - 31%	322,000,000
	18 - 24%	358,000,000
	10 - 18%	339,000,000
Within 100 Feet Below Entry Level (Underground Mining Methods Required)	+31% P_2O_5	870,000,000
	24 - 31%	1,150,000,000
	18 - 24%	1,148,000,000
	10 - 18%	1,638,000,000
	Total	5,988,000,000*

*Total differs slightly from that of figures given above because of rounding.

Source: A.L. Service, An Evaluation of the Western Phosphate Industry and its Resources, Part 3, Idaho, U.S. Bureau of Mines Report of Investigations No. 6801, 1966, p. 10.

Characteristics

The Western Phosphate Field consists of the marine Phosphoria formation of Permian Age, except in northeastern Utah, where it is represented by the stratigraphically equilvalent Park City formation (9). Although originally deposited as mud in flat-lying beds on the sea bottom, the strata subsequently have been extensively folded and faulted, primarily during the Laramide Revolution. From the latter time to the present, the area has been repeatedly uplifted and subjected to a long period of erosion. As a result, in southeastern Idaho, the phosphate strata are exposed in narrow strips along the flanks of ridges and mountains where surface mining can be carried on. In most other areas, however, the strata are not as well exposed at the surface, and underground mining often is necessary.

Predominant rocks are phosphatic shales, mudstone, limestone, and chert. Most of the rocks have a high carbonaceous content and are therefore generally brown, gray, or black in color (10). The carbonaceous material must be removed by calcining before the rock can be processed for fertilizer.

The Meade Peak member of the Phosphoria formation contains most of Idaho's economic reserves of phosphate rock, and all of it within the key rectangle described earlier. Only small quantities of phosphate rock are found in the Retort member of the Phosphoria formation north, northeast, and south of the rectangle in southeastern Idaho (11), although it is the principal source of phosphate rock in Montana.

Thickness of the Meade Peak member varies from 125 to 225 feet in southeastern Idaho and thins out in the direction of Montana, Wyoming, and Utah. High grade beds (+31% P_2O_5) within the Meade Peak member are usually two to six feet in thickness. Lower grade beds are often more than 10 feet, and sometimes over 20 feet, thick. Several beds of acid and furnace grade phosphate rock are usually worked in surface mines. Minimum workable thickness is usually three feet, except where two or more thinner beds are separated by low grade beds only a few inches thick.

Table 2. Grade Classification of Western Phosphate Rock (12)

Designation	P_2O_5 Content	Use
#1 - Acid, fertilizer or high grade.	over 31%	Can be used without beneficiation for the manufacture of phosphoric acid and phosphate fertilizer.
#2 - Furnace grade.	24 to 31%	Can be used directly in electric furnaces for the manufacture of elemental phosphorus.
#3 - Beneficiation grade (submarginal).	18 to 24%	Must be beneficiated for use in the manufacture of either elemental phosphorus or phosphate fertilizer.
#4 - Low grade shales (submarginal).	10 to 18%	Cannot normally be economically processed at the present time.

All phosphate rock now being mined in Idaho is either acid or furnace grade (Table 2), because preparation costs are thereby kept at a minimum. However, it is usually necessary to calcine the rock in order to remove carbonaceous matter. In some cases, as at the Conda Mine, furnace grade rock is beneficiated to acid grade so that it can be used in fertilizer manufacture (13). Stockpiling of beneficiation grade ore is taking place at the Gay Mine, in anticipation of the time when it can be economically beneficiated to furnace or acid grade (14).

III. MINING OF PHOSPHATE ROCK

Idaho Phosphate Rock Mines of the Present and Recent Past

Operating Mines

J. R. Simplot Company's Conda Mine, located near Soda Springs (Bottom inset Map 1), is the oldest operating phosphate mine in Idaho, having been in continuous production since 1921. It was developed and operated as an underground mine by the Anaconda Company for the purpose of supplying phosphate rock to that company's fertilizer plant at Anaconda, Montana, until both the mine and fertilizer plant were sold to the J.R. Simplot Company in 1959. However, the Simplot Company purchased rock from the mine beginning in 1955, utilizing surface mining methods, and since 1959 all production has been from open pits (15). From the start of open pit mining, the ore has been beneficiated in order to bring it to acid grade as required for fertilizer manufacture (16). Production capacity greatly increased with the shift from underground to surface mining, reaching about 600,000 tons per year in the mid-1960's, compared with about 100,000 tons annually up until 1946.

In 1946, the J.R. Simplot Company opened the Gay Mine east of For Hall for the purpose of supplying phosphate rock to its Pocatello fertilizer plant. Although constructed in 1944, the plant did not go into production until rock could be obtained from this mine (17). In 1947, production soared to well over 500,000 tons. Much of this output was, however, shipped abroad in 1947 and 1948 as part of the U.S. foreign aid program (18). Production dropped sharply in 1948 when mining for this purpose ended, but in 1949, the first of the elemental phosphorus furnaces of the F.M.C. Corporation near Pocatello went on line using ore from the Gay Mine. Thereafter rock output gradually increased at the mine, but apparently it was five to ten years before 1947 production level was again reached. Annual output is estimated to have reached nearly one million tons by 1960 as the J.R. Simplot Company doubled fertilizer production. It then reached nearly two million tons

Table 3. Estimated Annual Production of Marketable Phosphate Rock at Active Mines in Western Phosphate Field - 1971

Mine	Operator	Type	Production Tons
Idaho			
Gay Mine	J.R. Simplot Co.	Surface	1,900,000*
Henry Mine	Monsanto Chemical Company	Surface	1,000,000
Wooley Valley	J.A. Tertling (for Stauffer Chemical Company)	Surface	400,000
Conda Mine	J.R. Simplot Co.	Surface	600,000**
		Idaho Total	3,900,000
Montana			
Brock Mine	Cominco-American, Inc.	Underground	200,000
Relyea Mine	Dorothy Relyea	Underground	50,000
		Montana Total	250,000
Wyoming			
Leefe Mine	Stauffer Chemical Company	Surface	720,000
Utah			
Vernal Mine	Stauffer Chemical Company	Surface	300,000**
		Grand Total, Western Field	5,180,000

*600,000 tons used by the J.R. Simplot Co., and 1,300,000 tons by the F.M.C. Corporation.

**After beneficiation.

Sources: Estimates made by the author.

by 1970, following a decade in which the F.M.C. Corporation doubled its elemental phosphorus production and the J.R. Simplot Co. further expanded fertilizer output (19).

The Henry Mine, 16 miles north of Soda Springs (Bottom Inset, Map 1), is the most recently opened mine in the Western Phosphate Field, having gone into production at the beginning of 1970 (20). It replaces the Ballard Mine several miles nearer town, as the source of phosphate rock for the Monsanto Chemical Company's expanded elemental phosphate plant at Soda Springs. An estimated one million tons of ore is mined annually to make the Henry Mine the second largest producer in the Western Phosphate Field. The predecessor Ballard Mine had been in existence since the Monsanto Chemical Company's elemental phosphorus plant went into operation in 1952. Until a large scale plant expansion program was started in 1965, about 400,000 tons of phosphate rock was mined annually at the Ballard Mine. Thereafter, production increased steeply until nearly one million tons must have been mined annually in the last years of operation (21).

The next most recently opened mine in the Western Phosphate Field is the Wooley Valley Mine of J.A. Tertling, about eight miles southeast of the Henry Mine, which dates only from 1967. All output from the Wooley Valley Mine is sold to the Stauffer Chemical Company for use in their elemental phosphorus plant at Silver Bow, Montana, replacing three underground mines near Melrose, Montana, which were closed because of their high cost of operation (22). Estimated annual rock production at the Wooley Valley Mine is 400,000 tons.

Recently Closed Mines

From 1967 to 1969, the Mountain Fuel Supply Company mined phosphate rock from their Upper Dry Valley Mine. This rock was transported some 30 miles by a devious road and rail route to a new beneficiation and calcining plant the company constructed at Conda. The processed rock was sold to fertilizer manufacturers elsewhere in the western United States (23). Lowered prices in the fertilizer market apparently caused the early demise of this operation.

From late 1965 to late 1967, the El Paso Natural Gas Products Corporation obtained phosphate rock from their Mabie Canyon Mine on Dry Ridge

via a 21-mile long rail line they constructed especially for the purpose. The rock was used for the manufacture of triple superphosphate and ammonium phosphate fertilizers at their new fertilizer plant at Conda (24).

Between 1959 and 1963, the Central Farmers Fertilizer Company mined phosphate rock from a ridge overlooking Georgetown Canyon, northeast of the town of the same name. Mining conditions appear to have been more difficult than at other surface mines in southeastern Idaho. The beds which were mined dipped 65° to 75° and were broken by several transverse faults with displacements of up to 80 feet. For every ton of phosphate rock mined, it was necessary to remove nearly five tons of waste shales, overburden, and chert (25).

In 1960 the Waterloo Mine near Montpelier was finally closed permanently due to the depletion of acid-grade ore after being operated intermittently since 1907. An underground mine from 1907 to 1929, it was reopened as the first surface mine in the Western Phosphate Field in 1945 (26). Ore from this mine was sold to fertilizer companies elsewhere in western United States, with the leading market probably being in California. Annual rock production always was small compared with the other mines described, averaging only several thousand tons a year. After closing the Waterloo Mine, the San Francisco Chemical Company mined about 100,000 tons of rock from the Diamond Gulch Mine, north of Montpelier, during 1960 and 1961 (27).

The Centennial Mine, on the Idaho-Montana state boundary 35 miles east of U.S. Highway 93, was operated by the J.R. Simplot Company in 1956 and 1957. Two hundred thousand tons of acid-grade ore were shipped to the Northwest Nitro Chemical Company fertilizer plant at Medicine Hat, Alberta, in Canada (28).

Several small mining operations were carried on at various times between 1907 and 1943 south and west of Montpelier. The most important of these were in Paris Canyon between 1907 and 1930 (29). None approached the magnitude of modern day operations which have been described.

In reviewing the trends in the mining of phosphate rock in Idaho, as graphically depicted in Chart 1, several eras may be noted:

1907 - 1919 = Spasmodic production of phosphate rock in lots of a few thousand tons for shipment to consumers far beyond the boundaries of Idaho.

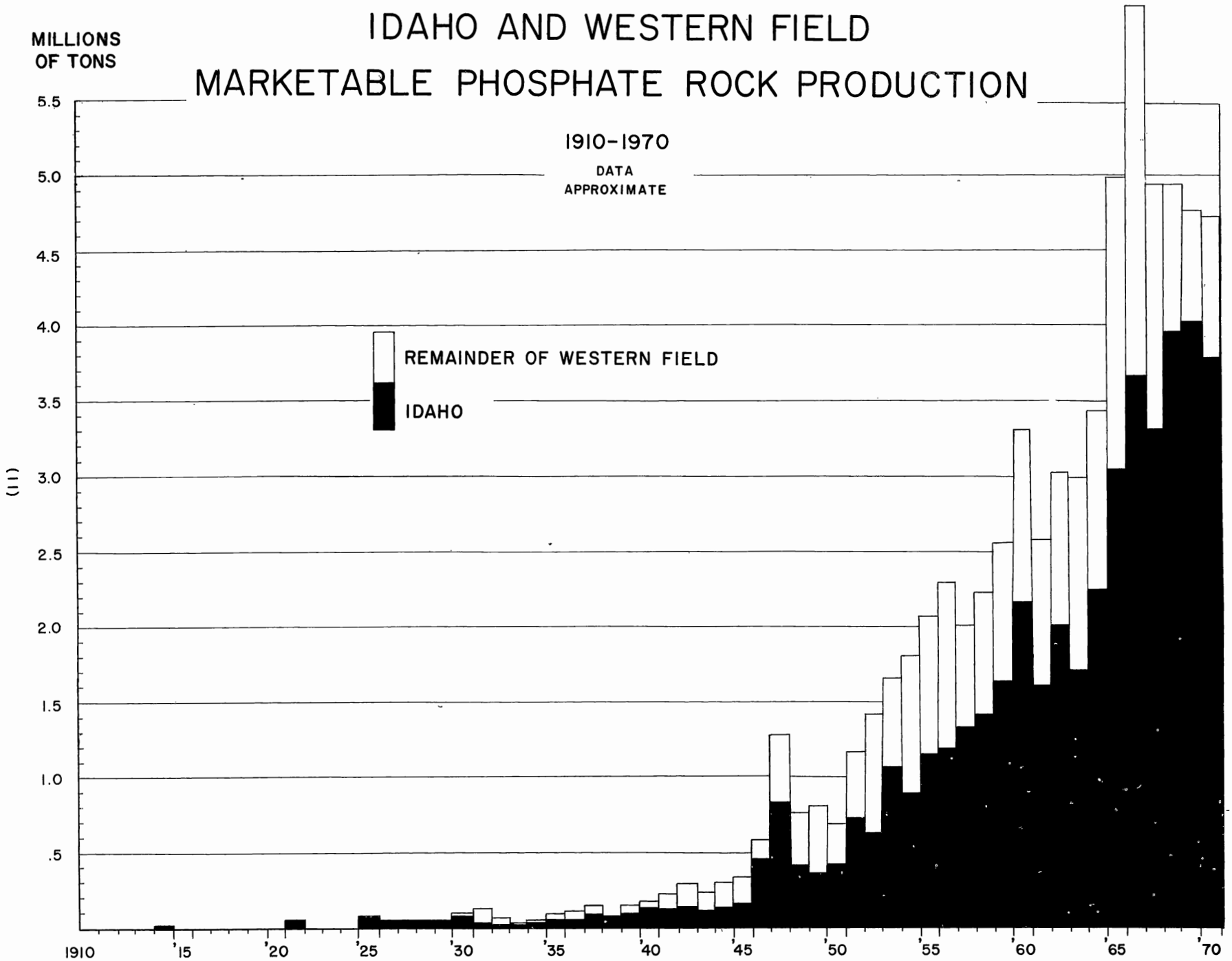

IDAHO AND WESTERN FIELD
MARKETABLE PHOSPHATE ROCK PRODUCTION
1910-1970
DATA APPROXIMATE
MILLIONS OF TONS
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
.5
REMAINDER OF WESTERN FIELD
IDAHO
1910
'15
'20
'25
'30
'35
'40
'45
'50
'55
'60
'65
'70

CHART I

1920 - 1945=	Shipment of several tens of thousands of phosphate rock annually from the Conda Mine to the Anaconda Company fertilizer plant at Anaconda, Montana, and smaller quantities of rock from the Waterloo Mine to distant fertilizer companies, principally in California. Production peaked at about 66,000 tons per year in 1925 and 123,000 tons in 1945, and dropped to only 20,000 tons in 1933, during the depths of the economic depression.
1946 - 1963=	Idaho's phosphate fertilizer and elemental phosphorus manufacturing industries became firmly established. Annual production of phosphate rock rose from about 400,000 tons per year in 1946 and 1950 to 2,000,000 tons in 1960, followed by a temporary decline during the economic recession of the early 1960's. Shipment of unprocessed phosphate rock to consumers outside of Idaho ceased after 1961.
1964 - 1966=	Rapid expansion of both fertilizer and elemental phosphorus production capacity, accompanied by a doubling of phosphate rock output in the Western Phosphate Field during these three years.
1967 - 1970=	Loss of over 25% in active fertilizer producing capacity due to closing of the El Paso Natural Gas Products Corp. fertilizer plant at Conda, and at a slower growth rate than formerly in elemental phosphorus productive capacity. Resumption of phosphate rock shipments to Montana, this time to an elemental phosphorus plant at Silver Bow. Annual production of marketable phosphate rock was stabilized at just under 4,000,000 tons per year by 1970.

Mining in the Western Phosphate Field Outside of Idaho

Idaho's share of the total tonnage of phosphate rock mined in the Western Phosphate Field declined from a high of nearly 100% in most years before 1930 to less than 50% during several years of the World War II era (Chart 1). Idaho's percentage share of the rock production started to drop when the Montana Phosphate Products Co, now Cominco American, Inc., began to ship phosphate rock from the underground Anderson-Brook Mine near Garrison, Montana, (Top Inset, Map 1) to the new Consolidated Mining and Smelting Co., Ltd., fertilizer plant at Trail, B.C., Canada, in 1929 (30). This was the only sizeable phosphate mine in the Western Phosphate

Field outside of Idaho until the Graveley Mine was opened within a few miles of the Anderson-Brock Mine in 1940, followed by the Luke Mine in 1943 (31). It was these underground mines that resulted in Montana's becoming the leading phosphate rock producing state in the Western Field during the 1941-1945 period, although the total annual production of 100,000 to 180,000 tons from the two or three mines mentioned was small by present day standards.

Idaho regained first place in 1946 with the opening of the Gay Mine. By 1947, Idaho's production reached 74% of the Western Phosphate Field, but this was immediately followed by a sharp decline in output at the Gay Mine, resulting in Idaho's share returning to less than 50% by 1949. The opening of Wyoming's first significant phosphate mine, an open pit operation at Leefe in 1947 by the San Francisco Chemical Company (32), also contributed to Idaho's lower percentage standing after 1947. As was the case in Montana, all of Wyoming's rock was shipped to fertilizer plants elsewhere. Destinations of these rock shipments were widely dispersed over western United States and Canada.

During most of the 1950's, there was a rather steady rise in phosphate rock output both in Idaho and in the other states of the Western Phosphate Field (Chart 1). This was followed by a brief decline in output in both areas during the early 1960's. Idaho's share averaged a little over 60% of the Field's during this time period. New developments outside of Idaho began with the opening of the underground Maiden Rock and Canyon Creek Mines near Melrose, Montana, by the Stauffer Chemical Company in 1952 to supply rock for the company's new elemental phosphorus plant at Silver Bow, 24 miles to the north (33) (top inset Map 1). Then, in 1954, the mining of phosphate rock was initiated in Utah, with the opening of five small underground mines by the San Francisco Chemical Company at the northern end of the Crawford Mountains, only a few miles southwest of the surface mine at Leefe, Wyoming (34). Three more small mines were opened the next year, including one by the J.R. Simplot Company at Rex Peak. However, none of these small mines was operated for more than a few years, and Utah's two major mines were opened in 1957 and 1961. These were, respectively, the Cherokee underground mine

in the Crawford Mountains and the Vernal surface mine near the town of the same name (35). Cherokee Mine ore was beneficiated together with rock from the Leefe surface mine in Wyoming. The resulting acid-grade ore was then sold widely in western United States and Canada. The Vernal rock also was beneficiated and shipped to Western Phosphates (Stauffer Chemical Company) fertilizer plant at Garfield, Utah. The Vernal Mine tapped the largest single body of phosphate rock in the Western Field, with the San Francisco Chemical Company (later Stauffer Chemical Company) controlling some 500,000,000 tons of phosphate rock averaging about 20% P_2O_5 (36).

Montana Phosphate Products Co., which subsequently became Cominco American, Inc., closed its Graveley Mine in 1956, but operated the Anderson Opencut Mine from 1955 to 1961, and the opened the underground Gimlet Mine in 1961 (37). All of these mines were located near Garrison, Montana, and the rock from all of them was exported to Cominco's fertilizer plants at Trail and Kimberley, B.C., in Canada, along with the output from Cominco American's other two mines in the area, the Anderson-Brock and Luke Mines.

The last new phosphate mine to open in the Western Phosphate Field outside of Idaho was the underground Douglas Creek Mine south of Hall, Montana, in 1963, by Cominco American, Inc. The rock was beneficiated at the mine and shipped to the parent company's phosphate fertilizer plants at Trail and Kimberley, B.C., Canada.

Phosphate rock production doubled in the Western Field outside of Idaho in only two years, between 1964 and 1966, thus paralleling the trend in Idaho as depicted in Chart 1. However, in the late 1960's, while rock production held at peak levels in Idaho, there was a sharp decline in the remainder of the Western Field. By 1969, production outside of Idaho was about a quarter of what it had been in 1966.

The abrupt rise in output during the middle 1960's was associated mainly with an explosive expansion of the phosphate fertilizer industry. Exports of Montana rock to Cominco's fertilizer plants at Trail and Kimberley, B.C., are estimated to have doubled during this period. In Utah, the San Francisco Chemical Company doubled the capacity of its Cherokee Mine and also operated its Vernal Mine to capacity. The Cherokee and Leefe Mines provided

rock for the new Bunker Hill Company ammonium phosphate fertilizer plant at Kellogg, Idaho (38), while the Vernal Mine served the Stauffer Chemical Company's Garfield, Utah, plant which doubled its fertilizer producing manufacturing capacity (39).

After 1966 a series of adverse developments occurred for producers in the Western Phosphate Field outside of Idaho. A weakening of the fertilizer market has been commented upon in reports by the U.S. Bureau of Mines (40). The San Francisco Chemical Company lost important markets in California and Canada for the rock from its Leefe and Cherokee Mines. A reduction of ship rates beginning in 1964 made it possible for Florida producers to deliver phosphate rock to California at prices below those for the Western Field phosphate rock after payment of rail freight charges between Leefe and California. Special reduced "backhaul" rates of $4.50 per ton, $1.14 less than the rail rate, were established for phosphate rock shipped via the "Rice Queen", a vessel which was, and continues to be, engaged in the rice export trade from California to the West Indies (41). Without the phosphate rock, this ship would have to return to California empty. In Canada, Florida phosphate rock has received the benefit of low backhaul rates on potash trains returning to the mines in Saskatchewan from the Port of North Vancover, B.C., since 1965 (42).

The Stauffer Chemical Company in 1967 closed its high cost underground phosphate rock mines near Melrose, Montana, in favor of Idaho's higher quality, lower cost, surface-mined rock, even though this rock had to be transported 345 miles by rail. Difficulty in recruiting men for work in the underground mines may also have been a factor (43). Cominco American, Inc., closed four underground mines, including all but the Brock Mine, proper, in Montana during 1967 and 1968 (44). Stauffer Chemical Company, which absorbed the San Francisco Chemical Company, also was forced to close its Vernal Mine in Utah for more than a year in 1968 and 1969. This action was an indirect result of an extended strike in the copper industry which caused a prolonged cutoff in the supply of sulphuric acid obtained by the Stauffer Chemical Company from the Kennecott Copper Company for use in the former's fertilizer plant at Garfield, Utah. By 1969, only about 20% of the Western Phosphate Field rock production was coming from outside of Idaho, in contrast to nearly 40% in the early 1960's.

After the Vernal surface mine reopened in 1969, the largest part of its production was exported to Cominco of Canada for use in that company's fertilizer plants at Trail and Kimberley, B.C., apparently replacing rock previously obtained at greater cost from the less distant underground mines in Montana. The Leefe surface mine then became the principal source of rock for the Stauffer Chemical Company's fertilizer plant at Garfield, Utah. The most recent development on the Stauffer properties was the closure of the underground Cherokee Mine on June 15, 1971 (45).

IV. PHOSPHATE PROCESSING INDUSTRIES IN IDAHO

Almost 90%, or 3,500,000 tons annually, of the phosphate rock mined in Idaho is manufactured into elemental phosphorus, phosphoric acid, and phosphate fertilizer within the state, with production of elemental phosphorus estimated to account for at least 60% of the rock consumption. Processing of most of the rock within the state contributes much more to the economy of Idaho than would be the case if the unprocessed rock were shipped to out-of-state manufacturers. An indication of the economic value of having the phosphate-processing industries in the state is to be found in the fact that for the year 1970 more than three times as many persons were employed in these industries as in the actual mining of the rock. Employment figures were approximately 1250 and 400 persons, respectively. With average annual wages in the order of $9400 for mining and $9500 in manufacturing in the counties where the phosphate industry was concentrated, total wage income was about $3,760,000 from the mining phase, and $11,875,000 from the manufacturing phase of Idaho's phosphate industry. Putting it another way, about 1.6% of all wages received by workers in Idaho were paid by the phosphate industry (46).

The J.R. Simplot Company Fertilizer Plant

In 1946, the J.R. Simplot Company began production, on a small scale, of superphosphate fertilizers in a plant which was purchased from the Federal Government. Mr. Simplot's original objective was to manufacture fertilizer needed for his extensive potato farms. By the end of World War II, he was the largest single supplier of dehydrated potatoes to the armed forces; hence the Federal Government's interest in assuring an adequate fertilizer supply for raising the potatoes (47). His plant was located a short distance west of Pocatello adjacent to Union Pacific Railroad's main line (Figure 4). The site near Pocatello was chosen because of access to the Pocatello labor supply (48).

In 1945, the J.R. Simplot Company began exploration and development for the Gay Mine on the Fort Hall Indian Reservation about 35 miles distant. This was done after the Anaconda Company advised that it could not supply

Table 4. Operating Phosphate Processing Plants in the Western Phosphate Field - 1970

Location	Company	Product	Annual Capacity - Tons
Idaho			
Pocatello	J.R. Simplot Company	Triple Superphosphate	360,000
		Ammonium Phosphate	200,000
		Phosphoric Acid	270,000
Pocatello	F.M.C. Corporation	Elemental Phosphorus (4 Furnaces)	145,000
Soda Springs	Monsanto Chemical Co.	Elemental Phosphorus (3 Furnaces)	110,000
Conda	J.R. Simplot Company (Beneficiation plant)	Acid Grade Concentrate	600,000
Kellogg	Bunker Hill	Phosphoric Acid	33,000
		Ammonium Phosphate	70,000
Montana			
Silver Bow	Stauffer Chemical Co. (Victor Chemical Works)	Elemental Phosphorus (2 Furnaces)	42,000
Wyoming			
Leefe	Stauffer Chemical Co. (San Francisco Chemical Co.) (Beneficiation Plant)	Acid Grade Concentrate	750,000
Utah			
Garfield	Stauffer Chemical Co. (Western Phosphates)	Triple Superphosphate	75,000
		Ammonium Phosphate	-
		Phosphoric Acie	50,000
Vernal	Stauffer Chemical Co. (San Francisco Chemical Co.) (Beneficiation Plant)	Acid Grade Concentrate	300,000

Sources: E.C. Houston, The Phosphate Industry in the United States, July 1970 (Office of Agricultrual and Chemical Development, Division of Chemical Development, Tennessee Valley Authority, 1970) and U.S. Bureau of Mines publications.

phosphate rock from the Conda Mine, the source Simplot had been counting on. In the early years the sulphuric acid required in the manufacture of superphosphate fertilizer apparently was obtained from the Kennecott Copper Company in Utah (47), but later it was purchased from the Anaconda Company in Montana (49), and still later from the Bunker Hill Company in Kellogg, Idaho (50).

The chemical reaction occurring in the manufacture of superphosphate fertilizer is represented by Expression 1 (51).

$$(1)\quad Ca_{10}(PO_4)_6F_2 + 7H_2SO_4 \longrightarrow 3Ca(H_2PO_4)_2 + 7Ca\ SO_4 + 2HF$$

Phosphate rock	Sulphuric acid	Superphosphate	Calcium sulphate	Hydrogen fluoride

The F.M.C. Corporation Elemental Phosphorus Plant

In developing the Gay Mine, the J.R. Simplot Company discovered that large quantities of furnace grade phosphate ore would have to be removed in order to reach the acid grade deposits beneath. To render this economically feasible, an agreement was made with the Food Machinery Chemical Corporation, then referred to as the Westvaco Chemical Corp., to supply the latter with furnace-grade ore for the manufacture of elemental phosphorus (52). As a result of this event, the F.M.C. Corporation opened its first electric furnace for the production of elemental phosphorus at a site within a half mile of the J.R. Simplot fertilizer plant in 1949. Three additional furnaces were put on line during the next three years, bringing production capacity to 75,000 tons of elemental phosphorus per year by 1952.

Besides the low cost of furnace grade ore, the F.M.C. Corporation found the electric power rates quite favorable in southeastern Idaho. Rates were comparable to those in the T.V.A. power area, and little more than half those in Florida, the only other area with large reserves of ore mineable by surface methods which was known at that time.

Monsanto Chemical Company Elemental Phosphorus Plant

In 1952 the Monsanto Chemical Company completed the first electric furnace of its new elemental phosphorus plant just north of Soda Springs, Idaho. The second electric furnace became operational in 1954, bringing annual capacity to 40,000 tons (53). Monsanto was attracted to Soda Springs by the same advantages that induced the F.M.C. Corporation to locate in Idaho, namely, the abundant reserves of furnace-grade phosphate ore which could be mined by low cost surface methods and the relatively low power rates. In fact, the Ballard Mine, source of the ore, was company-owned and only 15 miles from the plant.

Central Farmers Fertilizer Company Complex

From 1959 to 1963, the Central Farmers Fertilizer Company operated a complex in Georgetown Canyon, northeast of Georgetown, Idaho, that included an open pit phosphate rock mine on a ridge above the canyon, an elemental phosphorus electric furnace of 21,000 tons per year capacity, a phosphoric acid plant, and a triple superphosphate fertilizer plant of 120,000 tons annual capacity. A railroad spur was constructed up the canyon to connect the complex with the main line of the Union Pacific Railroad at Georgetown.

There are two basic approaches employed in the production of phosphoric acid which is used in the manufacture of triple superphosphate and ammonium phosphate fertilizers. One is referred to as the sulphuric acid or "wet process", and the other is known as the electric furnace or "thermal reduction" method. The wet process requires considerably less capital investment in plant, utilizes a simpler procedure, and is therefore much more widely used. It is the method employed so successfully by the J.R. Simplot Company at Pocatello, as well as by the Bunker Hill Company at Kellogg, Idaho. In the wet process, phosphoric acid is obtained by digesting phosphate rock with sulphuric acid, a chemical reaction represented by Expression 2 (54).

$$(2)\quad Ca_{10}(PO_4)_6F_2 + 10H_2SO_4 + 20H_2O \longrightarrow 10\,CaSO_4 + 2H_2O + 6H_3PO_4 + 2HF$$

Phosphate rock	Sulphuric acid	Water	Gypsum	Phosphoric acid	Hydrogen fluoride

Triple superphosphate is then obtained by mixing the phosphoric acid with phosphate rock as depicted in Expression 3 (55).

$$(3)\quad Ca_{10}(PO_4)_6F_2 + 14H_3PO_4 \longrightarrow 10Ca(H_2PO_4)_2 + 2HF$$

Phosphate rock	Phosphoric acid	Triple superphosphate	Hydrogen fluoride

By contrast, the thermal reduction method which was used by the Central Farmers Fertilizer Company began with the production of elemental phosphorus in an electric furnace. The phosphorus was then burned, or oxidized, to phosphorus pentoxide (P_2O_5), which was then absorbed in water to produce highly concentrated phosphoric acid (56). The phosphoric acid obtained by this method is exceptionally pure, as required in the manufacture of chemicals but far more pure than is necessary in the production of fertilizer.

According to Waggaman and Bell (57), the cost per ton of phosphorus pentoxide in triple superphosphate fertilizer is about 20% greater when the electric furnace process is used. Therefore, the use of this method is justified only when a sufficiently large saving can be obtained in transportation costs, by shipping elemental phosphorus rather than phosphoric acid to a distant fertilizer plant, thereby offsetting the higher production costs. For example, some of the elemental phosphorus produced by the Monsanto Chemical Company at its Soda Springs plant is sent to California for use in the manufacturing of fertilizer. However, if the elemental phosphorus is converted into phosphoric acid, and thence to fertilizer, at the site of the electric furnace, as was the case at the Central Farmers Fertilizer Company's Georgetown Canyon plant, not only are the savings in transportation lost, but the cost of manufacturing the fertilizer is significantly greater than would be the case if the wet process were used. This was one of several technical problems resulting in the failure of the Central Farmers Fertilizer enterprise.

Other contributing factors to the Central Farmers Fertilizer Company's decision to terminate operations at their Georgetown Canyon plant in 1963 reputedly included the following (58): (1) the cost of producing the elemental phosphorus was about 40% higher than at another nearby successful plant; (2) mining costs were relatively high; (3) there were serious air pollution problems which resulted in fluorine poisoning of rangeland; (4) the cost of pumping the necessary water supply up the canyon via pipeline from the vicinity of Georgetown was high; and (5) snowslides impeded transportation in the canyon in the winter.

El Paso Natural Gas Products Corporation Fertilizer Plant

In 1964 the El Paso Natural Gas Products Corporation purchased the entire Georgetown Canyon plant of the Central Farmers Fertilizer Company, and dismantled and moved a portion of it to Conda where El Paso was constructing a new 200,000 tons per year triple superphosphate and ammonium phosphate fertilizer plant (59). Included among the facilities was a 310-ton per day phosphoric acid plant and an 800-ton per day sulphuric acid plant. Sulphur was brought in the molten state in railroad cars for the manufacture of sulphuric acid (60). Phosphate ore was delivered on a newly constructed rail line which extended to the company's Mabie Canyon Mine 21 miles distant in the Dry Valley. This elaborate fertilizer plant opened in late 1965 and operated for only two years, until late 1967. Technological problems were primarily responsible for the closure of this plant, although slowed growth in the demand for fertilizer apparently was a factor as well.

The Bunker Hill Company Fertilizer Plant

In 1961, the Bunker Hill Company started manufacturing phosphoric acid in a 23,000-ton per year plant adjacent to their zinc smelter near Kellogg in northern Idaho (62). Capacity was increased to 33,000 tons in 1965 when an ammonium phosphate fertilizer plant of 70,000 tons annual capacity was installed. An agreement was reached with the Stauffer Chemical Company whereby the latter handled the marketing and distribution of the fertilizer products (63). These fertilizer-manufacturing facilities were established in order to profitably utilize the sulphuric acid produced as a by-product while eliminating sulphur dioxide emissions into the atmosphere from the zinc smelter. The phosphate rock was obtained from

the San Francisco Chemical Company (later Stauffer) beneficiation plant at Leefe, Wyoming (64). Some was also purchased in Montana for a time (65).

Much of the phosphoric acid manufactured by the Bunker Hill Company was sold to the California Spray Corporation for use in their nitric fertilizer plant at Kennewick, Washington (66), at least until large quantities were required in the production of ammonium phosphate fertilizer at Kellogg beginning in 1965. Some phosphoric acid also has been sold directly to farmers for use on the land.

The Anaconda Company Beneficiation Plant

The Anaconda Company operated a mill at Conda to crush and dry acid grade phosphate rock obtained from the Conda Mine. A washing plant was added in 1950 to beneficiate the slightly lower grade ore then being mined. Modifications were made in 1955 when surface mining of furnace grade ore started and more intensive beneficiation became necessary, because all of the rock was destined for the manufacture of fertilizer (67). In 1965, a new beneficiation plant was installed by J.R. Simplot Company, new owner of both the mill and mine, for the purpose of doubling previous capacity (68).

The Mountain Fuel Supply Company Beneficiation Plant

From 1967 to 1969 the Mountain Fuel Supply Co. operated a beneficiating and calcining plant adjacent to the El Paso Natural Gas Products Corporation's fertilizer plant at Conda. Rock was obtained from the Upper Dry Valley Mine (69). The treated rock was sold to fertilizer manufacturers elsewhere in the West. A highly competitive market as well as technical problems in processing apparently brought about the closure of this facility.

The Kerr-McGee Corporation Vanadium Recovery Plant

Since 1964, the Kerr-McGee Corporation has operated a facility near the Monsanto Chemical Company's Soda Springs elemental phosphorus plant for the purpose of recovering vanadium pentoxide from the by-product ferrophosphorus slag produced at the latter plant (70). Ferrophosphorus slag is also sent to the Vitro Minerals and Chemical Company plant in Salt Lake City, Utah, for the same purpose from both of Idaho's elemental phosphorus plants as well as the one at Silver Bow, Montana (71).

V. RECENT EXPANSION OF IDAHO'S SURVIVING PHOSPHATE PRODUCTS INDUSTRIES

The long-established fertilizer and elemental phosphorus manufacturers in Idaho greatly expanded their plants during the decade of the 1960's (Chart 2). Fertilizer capacity increased from 380,000 tons per year in 1959 to 830,000 tons by 1965, but dropped back to 630,000 tons after the El Paso Natural Gas Products Company plant closed in 1967. During the decade, phosphoric acid producing capacity increased from 93,000 tons of P_2O_5 per year to 303,000 tons. Elemental phosphorus capacity rose from 136,000 tons in 1960 to 255,000 tons in 1970.

J. R. Simplot Company Expansion

First to expand was the J. R. Simplot Company which completed its ambitious expansion and modernization program during the seven-year period from 1959 to 1966. Previously, in 1953, the company had converted from superphosphate to the much more concentrated triple superphosphate fertilizer (72). Annual productive capacity was increased from 200,000 to 360,000 tons by 1963 (73). A phosphoric acid plant of 70,000 tons P_2O_5 capacity was installed at the beginning of the expansion program in order to supply the necessary phosphoric acid for manufacturing the triple superphosphate. Between 1963 and 1966, phosphoric acid capacity was nearly quadrupled to 270,000 tons per year (74). Beginning in October 1966, part of the greatly expanded output of this product was exported to Simplot's new fertilizer plant at Brandon, Manitoba, Canada (75). Some of the acid also was sold for direct application as fertilizer.

In 1960 the J. R. Simplot Company purchased and moved to Pocatello the Anaconda Company's 100,000-ton per year ammonium phosphate fertilizer plant (76). A second ammonium phosphate plant of equal capacity was added in 1964 (77). Then, in the following year, a 100-ton per day ammonium sulphate plant was put into operation (78). The anhydrous ammonia required for the manufacture of these fertilizers had been purchased from the United States Steel Corporation at Geneva, Utah (79), but in 1963 a 150-ton a day anhydrous ammonia plant was installed at Simplot's Pocatello works, using natural gas as a raw material (80).

All sulphuric acid required for the manufacture of phosphoric acid and fertilizer was purchased by the Simplot Company until 1959 when a 400-ton a day sulphuric acid plant was constructed at Pocatello (81). Capacity was increased to 700 tons a day in 1963 (82), and a 1200-ton per day plant was added two years later. The 1963 expansion eliminated the need to purchase any further supplies of sulphuric acid from the outside (83). Elemental sulphur recovered from sour natural gas and by-product sulfide gas in Wyoming and Montana is used in the manufacture of the sulphuric acid (84). Since the 1963 and 1965 expansions, additional supplies of sulphur have been imported from Canada (85).

Monsanto Chemical Company Expansion

The Monsanto Chemical Company announced in 1964 that it would triple its elemental phosphorus producing capacity (86). Initially, the two original electric furnaces were modified to raise their capacity. This project, which resulted in only a 5,000-ton per year increase in capacity, was completed in 1965 (87), whereupon work on the third electric furnace was begun. The third furnace was finished in 1966,

IDAHO-Phosphate Processing Capacity

1950 – 1970

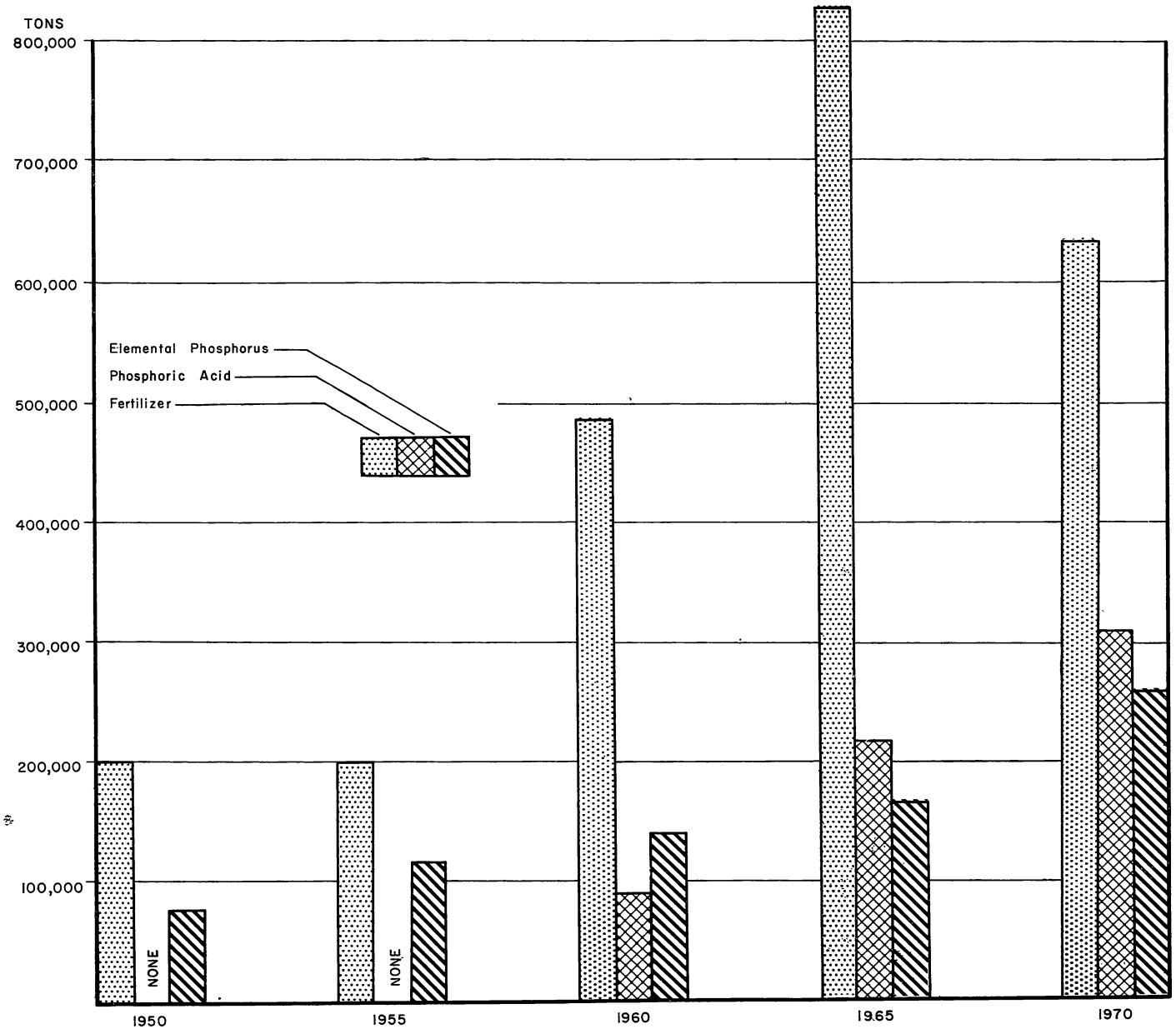


CHART 2

doubling capacity of the plant to 90,000 tons of elemental phosphorus per year (88). Construction of a fourth furnace had been planned by about 1968, but there still were only three furnaces in 1970. However, by the last named year, modifications had been made to the three existing furnaces which brought total capacity of the plant to 110,000 tons annually (89). Thus by 1970, the Monsanto Chemical Company was within 10,000 tons of the goal announced in 1963 to triple capacity.

F.M.C. Corporation Expansion

The F.M.C. Corporation started work on replacing two of its four old furnaces at the Pocatello plant in 1966. Information is not available as to whether the remaining two furnaces were later modified or replaced, but during the period from 1964 to 1970, elemental phosphorus producing capacity of the plant was nearly doubled, being raised from 75,000 to 145,000 tons per year (90).

VI. LOCATIONAL ASPECTS OF IDAHO'S PHOSPHATE PROCESSING PLANTS

In this section, locational influences which have favored the success and large scale expansion of the four surviving phosphate fertilizer and elemental phosphorus plants in Idaho will be examined.

Phosphate Fertilizer Plant Location Patterns

Raw Material Access

A study of the location of phosphate fertilizer plants in the United States reveals that about one-half of the phosphate fertilizer and phosphoric acid manufacturing capacity is located in central Florida's phosphate mining area, while another 40% is found along either the Mississippi Waterway System, or the Gulf Coast portion of the Intracoastal Waterway.

Most of the remaining capacity is located in Idaho, California, Utah , and North Carolina (91). In each of these locations except California, a general pattern can be identified in which the plants are situated either close to the phosphate rock mines or along waterways where the rock can be delivered by low-cost barge transportation. Even in California some of the phosphate rock is now being delivered by ship from Florida. Along the waterways, barge transportation also can be used to bring in the elemental sulphur required for manufacturing sulphuric acid, or the sulphuric acid itself can be so delivered. Finally, the waterways can be used as a means of moving fertilizer to market, or where this is not done, the mere availability of barge transportation is sufficient to force a reduction of rail freight rates.

The J. R. Simplot Company's fertilizer plant location, which is within a short and inexpensive rail haul of the company's two phosphate rock mines, is, therefore, consistent with the normal plant location pattern found in the phosphate fertilizer industry.

The tendency for phosphate fertilizer plants to locate near, or within low-cost shipping distance of a phosphate rock source, is a result of the considerable weight reduction which occurs when phosphate rock is converted into phosphoric acid and fertilizer. About 1.5 tons of acid-grade phosphate rock are required to manufacture one ton of triple superphosphate (92). This estimate takes into consideration the intermediate step of manufacturing phosphoric acid as well as the phosphate rock that is used directly, i.e., reacted with the phosphoric acid, in the production of triple superphosphate.

The smaller phosphoric acid and ammonium phosphate fertilizer plants near Kellogg, Idaho, are about 850 rail miles from the principal source

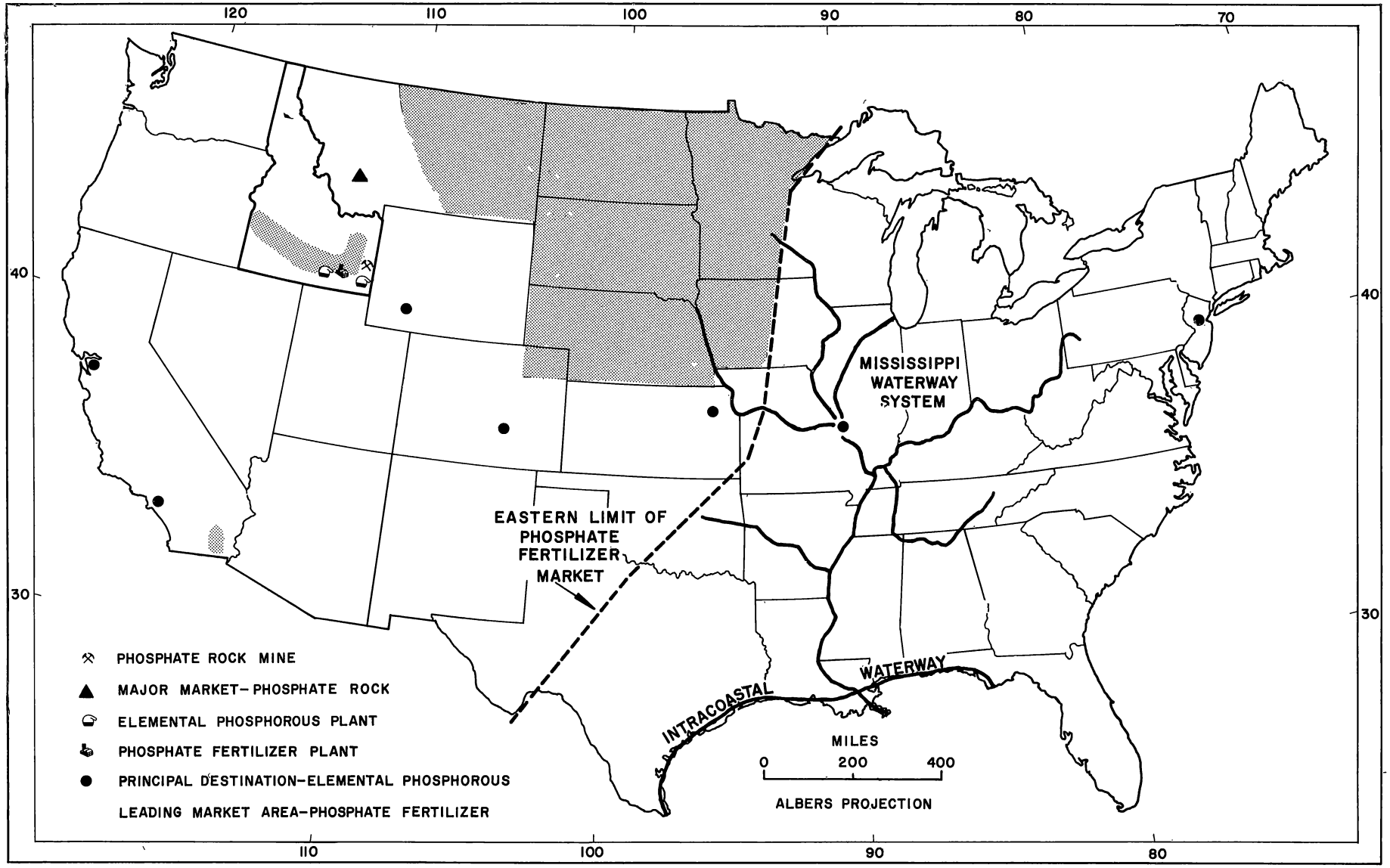
of phosphate rock at Leefe, Wyoming. Rail transportation charges are $7.88 per ton (93), which is estimated to be about 90% of the selling price of the rock. It is further estimated that roughly 100,000 tons of phosphate rock and 45,000 tons of sulphuric acid are required annually to operate the Kellogg plant at a rate approaching capacity. Transportation charges on this quantity of phosphate rock brought in by rail from Leefe, Wyoming, would total $788,000 per year. If, on the other hand, the plant were located at Leefe, transportation charges on the sulphuric acid would be slightly greater, about $855,000, assuming a transportation charge of $19.00 per ton. Waggaman and Bell (94) confirm the fact that it is more economic to locate near the source of sulphuric acid. Furthermore, the major portion of the phosphoric acid and ammonium phosphate fertilizer market is in the Pacific Northwest (95).

Inadequate water supply could be a serious barrier to operating a phosphoric acid plant in the arid southwestern corner of Wyoming. Nearly fifteen tons of water are required for for steam and cooling while manufacturing one ton of P_2O_5 equivalent phosphorc acid (96).

Market Access

Much of the J. R. Simplot Company's success in fertilizer was a result of the company's ability to penetrate the nation's most rapidly growing new market for phosphate fertilizer during the 1944-1969 period, the West North Central States (Map 2). During these 25 years, phosphate fertilizer consumption increased by fifteen times in the region mentioned, finally reaching 26% of the United States total (97). Eastern limit of Simplot's fertilizer market extends from the western tip of Lake Superior southwestward to the Big Bend of the Rio Grande River in Texas. Thus most of Minnesota and two-thirds of Iowa are within the market area

PRINCIPAL MARKETS: IDAHO PHOSPHATE INDUSTRY PRODUCTS



MAP 2

(98). Beyond this eastern limit, which is plotted on Map 2, Florida phosphate rock and fertilizers monopolize the market because of the low cost barge transportation on the Mississippi River - Intracoastal Waterway System. Other important markets for J. R. Simplot include southern Idaho, Washington, and the Imperial Valley of California, although sales are made throughout the West. The only foreign market which has been penetrated is northwestern Mexico.

In order to offset the relatively high transportation costs to the distant markets J. R. Simplot was seeking to penetrate, the company converted from superphosphate (20 to 22% available P_2O_5) to the much more concentrated triple superphoshate (45 to 48% available P_2O_5) in 1953. In this way, transportation costs per unit of plant food were reduced by more than one-half, freight rates being the same of both superphosphate and triple superphosphate fertilizers.

Idaho as a Location for Elemental Phosphorus Plants

Locational Advantages

The elemental phosphorus industry has been increasingly attracted to Idaho since the late 1940's because the best existing combination of abundant furnace grade phosphate rock reserves mineable by low cost surface methods, and relatively low electric power rates, is to be found in the southeastern portion of that state (99). Power rates in 1964 were reported to be 4.5 and 5.0 mills per kilowatt hour at the two elemental phosphorus plants in that area (100). The Tennessee Valley Authority formerly offered comparable rates. However, during 1969 and 1970 the T.V.A. rate for firm power was raised from 4.51 to 6.28 mills, while the rate for interruptible power increased from 4.32 to 6.03 mills (101). Furthermore, the Tennessee Valley area has an even more serious disadvantage, namely inadequate phosphate rock reserves. Only about 1% of

of the nation's reserves are found in the T.V.A. area, compared with 36% in southeastern Idaho (102).

Florida has reserves nearly as extensive as those in Idaho, also mineable by low cost surface methods, but electric power rates are among the highest in the nation and averaged about 7.5 mills in 1964 (103). With power consumption being in the order of 13,000 kilowatt hours for each ton of elemental phosphorus produced, a power rate of 4.5 mills per kilowatt hour would result in a saving of $39.00 when compared with a rate of 7.5 mills. Assuming other costs to be similar in both places, the $39.00 power saving would amount to approximately 15% of the total cost of manufacturing elemental phosphorus (Tables 5 and 6).

As of 1969, about 36% of the U.S. elemental phosphorus manufacturing capacity existed in Idaho, compared with only 26% during the period from 1952 to 1963 (104). In 1969, the Tennessee Valley Authority power area possessed 44% of U.S. Capacity, a decline from 56% in 1963 (105).

Table 5. Estimated Cost of Producing Elemental Phosphorus by the Electric Furnace Process - Early 1960's.

Total plant cost.....$7,500,000
Annual capacity (phosphorus...short tons.....20,000

Item	Amount required per ton of phosphorus produced	Unit Cost	Cost per ton of phosphorus
Phosphate rock	10.5 tons	$4.00 - $7.00	$42.00 - $73.50
Coke	1.5	20.00 - 25.00	30.00 - 37.50
Silica	1.4 "	2.00	2.80
Electrodes	40 pounds	.17	6.80
Labor (wages, salaries)	-	-	57.00
Maintenance (materials)	-	-	10.00
Electric power	13,000 kwh	.003 - .005	30.00 - 65.00
Utilities	-	-	5.00
Fuel	-	-	6.50
Laboratory services	-	-	2.50
Depreciation (5%)	-	-	18.75
Miscellaneous	-	-	10.00
Total (rounded)			$230.00 - $295.00

Source: Petersen, Norman S.,
The Phosphate Rock Industry of the Pacific Northwest - Preliminary

Bonneville Power Administration, Portland, Oregon, 1964

Table 6. Estimated Cost of Producing Elemental Phosphorus by the Electric Furnace Process at a Plant in Southeastern Idaho - 1970

Item	Quantity	Unit Cost	Cost per ton of phosphorus
Phosphate Rock	10+ tons	$6.00 per ton	$60.00
Coke	1.5 "	30.00 " "	45.00
Silica	1.4	2.15 " "	3.00
Electrodes	40 pounds	0.20 per pound	8.00
Labor (allowing 30% increase over 1964)	-	-	75.00
Maintenance	—	—	10.00
Electric power	13,000 kwh.	.005/kwh	65.00
Other (utilities, lab services, depreciation, and miscellaneous)			50.00
		Total	$316.00

Based on estimates made by the author, using data in Table 5 as a guide.

Locational Disadvantages

Idaho's two principal locational disadvantages for elemental phosphorus production are the lack of a nearby source of coke and the large distance from the principal markets for the product. One and one-half tons of coke are required for each ton of elemental phosphorus produced (106). Although in the 1950's most of the necessary supply of coke could be obtained from steel mills in California, Colorado, and Utah, during the 1960's most had to be secured from West Virginia and Virginia (107). Transportation costs on coke obtained from such great distances approximate the cost of the coke itself. In 1963 these transportation charges added about 6% to the cost of manufacturing elemental phosphorus in Idaho. Experimental plants for producing coke from low-grade western coals were conducted at Midvale, Utah, and Kemmerer, Wyoming, in the early 1960's.

The burden of distance is not as serious for elemental phosphorus as it is for the phosphate fertilizers because of the concentrated nature of the product. Freight tariffs on Idaho phosphate fertilizers shipped to points near the eastern limits of the market area in Minnesota, central Iowa, and Oklahoma, for example, amounted to between 25% and 30% of the cost of manufacturing the product in the early 1960's (108). By contrast, the freight charges on elemental phosphorus shipped from Soda Springs, Idaho, to St. Louis came to between 15% and 20% of the cost of manufacturing the product (109). Furthermore, elemental phosphorus is not competing on the open market to the extent that fertilizer is. Most elemental phosphorus produced in Idaho is destined for other chemical plants of the parent companies, where it is converted into a variety of chemicals. Much of the Monsanto Chemical Company's elemental phosphorus is shipped to

East St. Louis, Ill., and Long Beach, Calif., while most of the F.M.C. Corporation's production is utilized at Green River, Wyo., Newark, Calif., and, at least formerly, at plants in Lawrence, Kansas, and New Jersey. Monsanto Chemical Company also supplies phosphorus in lesser quantities to the Colorado Fuel and Iron Co., in Pueblo, Colo, where it is utilized in the manufacture of ammonium phosphate fertilizer (110).

VII. PHOSPHATE PROCESSING PLANTS ELSEWHERE IN THE WESTERN PHOSPHATE FIELD

The Anaconda Company

To Montana belongs the distinction of attracting the first phosphate processing plant in the Western Phosphate Field, namely the Anaconda Company's phosphate fertilizer plant which operated from 1920 to 1959. The plant was established to make profitable use of the sulphuric acid obtained from the company's copper smelter (111). Phosphate rock from Conda, Idaho, was used. The scale of operation was small, however, as indicated by the fact that only a few tens of thousands of tons of phosphate rock were used each year until World War II when more than 100,000 tons were consumed annually. These figures compare with an estimated one million or more tons which have been required annually since the mid-1960's at the J. R. Simplot Company's fertilizer works near Pocatello.

The Stauffer Chemical Company

In the Western Phosphate Field outside of Idaho there now exist two major manufacturing plants utilizing phosphate rock. At Silver Bow, Montana, is the Stauffer Chemical Company's elemental phosphorus plant. Recently the capacity of this plant has been increased from 30,000 to 42,000 tons per year (112). Bonneville Power Administration electric power rates are the lowest in the nation by a large margin, being only 2.2 mills as late as 1964 (113). Apparently the very low power rates, plus the shift in 1967 to lower cost, better quality phosphate rock from Idaho made possible this recent expansion. The elemental phosphorus is sent to the parent company's chemical plants at Chicago, Illinois and South Gate and Richmond, California (114).

At Garfield, Utah, the Stauffer Chemical Company operates a 50,000-ton phosphoric acid plant and associated 75,000-ton triple superphosphate

and ammonium phosphate fertilizer plant (115). Phosphate rock is obtained from the Company's open pit mines at Leefe, Wyoming, and Vernal, Utah (116). Markets for the fertilizer are reported to be mainly in the Intermountain West.

The Stauffer Chemical Company also operates a beneficiation and calcining plant of 750,000 tons annual capacity at Leefe, Wyoming and 300,000-ton beneficiation plant near Vernal, Utah. The Leefe plant treats phosphate rock from the Leefe open pit mine (117) Until June 1971, ore from the Cherokee underground mine in the nearby Crawford Mountains of Utah also was concentrated there. Principal destinations for the processed rock shipped from the Leefe plant include the Bunker Hill Company's phosphoric acid and ammonium phosphate fertilizer plant at Kellogg, Idaho; the California Spray Corporation's nitric phosphate fertilizer plant at Kennewick, Washington; the Stauffer Chemical Company's fertilizer plants at Tacoma, Washington (118), and Garfield, Utah; and, at least formerly, the Northwest Nitro Company's fertilizer plant at Medicene Hat, Alberta, and several fertilizer manufacturers in California (119). Florida phosphate rock has taken over most of Stauffer's Canadian and California markets for reasons explained previously (p. 13).

All phosphate rock beneficiated at the plant near Vernal, Utah, went to Stauffer Chemical Company's Garfield, Utah, fertilizer plant until 1968. Since 1969 most of the rock from Vernal has been shipped to Cominco's fertilizer plants at Trail and Kimberley, B.C., in Canada (120).

Cominco American, Inc.

From 1963 to 1968 Cominco American, Inc., operated a flotation beneficiation plant adjacent to its Douglas Creek Mine in Montana for the purpose of concentrating ore to acid grade prior to shipment to the Cominco fertilizer plants at Trail and Kimberley, B.C. (121, 122). A weakening of Cominco's fertilizer market brought the end to this operation.

VIII. MEANS OF TRANSPORTATION USED AND FREIGHT TARIFFS

Railroads

The phosphate industry of Idaho and adjacent states is highly dependent upon the railroads for transportation. All elemental phosphorus and much of the fertilizer move to market by rail. A large share of the phosphate rock also is transported from the mines, or from beneficiation plants near the mines, to the elemental phosphorus and fertilizer plants by rail (123). Other raw materials, such as liquid elemental sulphur used in the manufacture of sulphuric acid at fertilizer plants, or coke for the elemental phosphorus plants, are brought in by rail.

Trucks

Trucks are normally used to move phosphate ore from mine to processing plant when distances are less than about 20 miles. For example, the Monsanto Chemical Company operates a fleet of especially large capacity trucks over its own private haulage road between the Henry Mine and its elemental phosphorus plant near Soda Springs, a distance of about 15 miles (124). The trucks are too large and carry loads much too heavy to be permitted on public county roads. On the other hand, the El Paso Natural Gas Products Corporation constructed a railroad between its Mabie Canyon Mine in the Dry Valley and its fertilizer plant at Conada, a distance of 21 miles (125).

Trucks were used to haul phosphate rock from the Gay Mine to the A. R. Simplot fertilizer plant near Pocatello, a distance of 35 miles, during the first few years the mine was operated. However, a rail line was completed before the F.M.C. Corporation elemental phosphorus plant went on line in 1949 with its much larger rock requirements (126).

The longest truck haul by far is found in Utah. Until recently trucks carried as much as 300,000 tons of beneficiated ore a year 206 miles west from the Vernal Mine to Garfield fertilizer plant. Since 1969 the ore has been trucked to Phoston, Utah, on the Union Pacific Railroad, thereby reducing the road haul to 155 miles (127). Dependence upon truck transportation is unavoidable at the Vernal Mine because the nearest railhead is 100 miles north, in Wyoming.

Conveyor Belts

A two-stage conveyor belt moves phosphate rock about a mile down a steep slope from the truck unloading point on top of a ridge to waiting railroad cars nearly 1,000 feet below at the J.A. Tertling Wooley Valley Mine, Idaho. A similar two-stage conveyor 5,000 feet long carried ore 800 feet down a steep slope from the truck unloading platform to the Central Farmers Fertilizer Company complex in Georgetown Canyon, Idaho, when it was in operation (128).

Shipping Distances

The greatest distance phosphate rock has been shipped from the Western Phosphate Field was about 1,000 miles from Leefe, Wyoming, to several destinations in central California and to Tacoma, Washington, over a period of many years (129). Phosphate fertilizers long have been shipped from Pocatello to customers 1,000 to 1,500 miles distance in Minnesota, the Imperial Valley of California, northwestern Mexico, and elsewhere (130). Elemental phosphorus is transported 1575 miles from Soda Springs to St. Louis; 1,000 miles from Soda Springs to California; and formerly, 2,500 miles from Pocatello to New Jersey (131). Rail

transportation is characteristically more economical to use than trucks when bulk commodities are being shipped over such great distances.

Freight Charges

Phosphate Rock

A special rate of $5.64 per ton of phosphate rock shipped by rail from Leefe, Wyoming, to California points was in effect for the San Francisco Chemical Company in 1964. At that time, the price of beneficiated acid grade rock, F.O.B. Leefe, was $8.53 (132). Thus the freight tariffs added about two-thirds to the cost of the rock in California. At about the same time freight charges were $5.07 per ton for moving rock by rail from Garrison, Montana, to Kimberley, B.C., and $5.60 from Garrison to Tadanack (Trail), B.C. (133).

Rail tariffs from the Gay Mine to the J. R. Simplot Company fertilizer plant near Pocatello were about 75 cents per ton, and from the Conda Mine to the same destination in the range of $1.25 to $1.50 per ton, also in about 1964 (134). Average value of Idaho rock was $5.76 per ton at the time.

It already has been observed that rail transportation charges of $7.88 per ton are 90% of the estimated selling price of rock shipped from Wyoming to the Bunker Hill Company fertilizer plant at Kellogg, Idaho.

Fertilizer

In 1963, rail charges on triple superphosphate fertilizer shipped from Pocatello, Idaho to Des Moines, Iowa, near the eastern limit of J.R. Simplot Company's market area, were $13.00 per ton on a minimum shipment of 100,000 pounds (135), a little over one-fourth the cost of

manufacturing the fertilizer. Cost of shipping acid-grade phosphate rock, which has about 35% less P_2O_5 content, would have been about 20% less. Rail freight rates were about 40% higher in 1970 than in 1963 (136), while prices on phosphate rock and fertilizer had risen much less. Thus the competitive position of Idaho phosphate fertilizers in the Midwestern market presumably has been impaired.

Elemental Phosphorus

Cost of shipping elemental phosphorus from Pocatello to St. Louis was $39.20 per ton in 1962, about 18% of the cost of producing the product (137). Charges to Newark, California, were $28.60 or $25.80 per ton, depending upon the size of shipment (100,000 or 180,000 pounds, respectively). Later figures were about 13% and 12%, respectively, of the cost of manufacturing the elemental phosphorus.

IX. SUMMARY AND PROSPECTS

A Quarter Century of Rapid Growth

Until 1946, Idaho's phosphate industry was limited to the mining and beneficiation of up to slightly over 100,000 tons of phosphate rock per year from a single major mine. All rock was shipped out of state for further processing. In 1946, the J. R. Simplot Company commenced operation of a superphosphate fertilizer plant near Pocatello. Three years later, the F.M.C. Corporation began production of elemental phosphorus in the first of its electric furnaces near the Simplot plant. Finally, in 1952, the Monsanto Chemical Company initiated the manufacture of elemental phosphorus near Soda Springs. As of 1970, these three companies remained the principal producers and consumers of phosphate rock in Idaho. Each of the companies started production at the right time to take advantage of rapidly growing markets for its product.

The J. R. Simplot Company began fertilizer production just as what was to be a fifteen-fold increase in phosphate fertilizer consumption within a twenty-five year period was getting underway in the West North Central States. Previously, this region had consumed less than 5% of the U.S. phosphate fertilizer production, but by 1969 its share had increased to 26%. During the same time span, the Pacific States' share increased from 2% to 5%, and the Mountain States' share advanced from 1% to 5% of the total national consumption. All of these regions were within Simplot's market area.

Idaho's elemental phosphorus plants initiated production in time to take advantage of the rapid growth in the market for phosphate detergents which began in the late 1940's. Since the middle 1950's, detergents

have accounted for more than 40% of the market for elemental phosphorus (138). In 1966, 49% of elemental phosphorus produced in the U.S. was manufactured into tripolyphosphate and other sodium phosphates for use in synthetic detergents, soaps, and sanitizers. Other major uses were in phosphate fertilizers, animal feed supplements, and chemical additives for foods and beverages. Together these uses accounted for another 40% of elemental phosphorus consumption (139).

Advantages of Idaho for the Phosphate Industry

Fertilizer

Southeastern Idaho holds two major attractions for the phosphate fertilizer industry. First, there are the large reserves of phosphate rock of required quality which can be mined by low cost surface methods. It is important to be close to the supply of phosphate rock because of substantial weight reduction takes place during phosphate fertilizer manufacture. Second, although the major portion of the fertilizer market is distant, southeastern Idaho is centrally located with respect to several widely dispersed markets: the large North Central State market to the northeast and east; the surrounding southern Idaho market; the Washington state market to the northwest; and the California and Southwestern market to the southwest. Freight tariffs have been negotiated with the railroads which permit penetration of each of these far-flung markets and some others as well.

A much smaller fertilizer plant in northern Idaho has excellent access to the Pacific Northwest's phosphoric acid and fertilizer market. In all, about 4% of the nation's phosphate fertilizers are manufactured in Idaho.

Elemental Phosphorus

The advantage of being located as close as possible to the nation's largest reserves of furnace-grade phosphate rock which can be inexpensively mined by surface methods is even more compelling for the elemental phosphorus industry. This is true because of the more than ten to one reduction in weight which takes place during the extraction of the elemental phosphorus from phosphate rock. This great weight reduction prevents the shipment of phosphate rock to distant consuming centers in the Midwest and California for processing. Furthermore, electric power rates are substantially less than those in Florida, the only other place in the U.S. where comparable resources of phosphate rock mineable by surface methods are to be found. As a result of these factors, 36% of the nation's elemental phosphorus is produced in southeastern Idaho.

Constraints on Future Growth of Idaho's Phosphate Industry

It seems probable that growth of Idaho's phosphate industry will be greatly slowed during the decade of the 1970's. Insofar as the fertilizer industry is concerned, national consumption of phosphate fertilizers has continued to increase at the rate of about 4% per annum (140). However, many very large phosphoric acid, triple superphosphate, and ammonium phosphate fertilizer plants have been constructed in Florida and along the Gulf Intracoastal and Mississippi Waterway Systems in recent years. In fact, the nation's wet phosphoric acid productive capacity doubled between 1963 and 1970, while ammonium phosphate capacity tripled, and triple superphosphate capacity expanded by about two-thirds (141). Meanwhile, national consumption of phosphate fertilizers increased by only about 55%. Thus it is inevitable that the fertilizer manufactured at the many new plants provides increased competition for the J.R. Simplot Company's product.

The competition is particularly intense in the eastern portion of the marketing area for Idaho fertilizers, not only because of the greater proximity of the Midwestern and Southern producers, but also because of the constant improvements being made by the Federal Goverment in the Mississippi Waterway System (Map 2). Barges with their lower freight rates have been favored by these improvements while rail freight rates on Idaho fertilizer moving eastward have advanced 40% since the series of rate increases began in 1967. Not only is fertilizer moving from the South into the Midwest, but Florida phosphate rock is shipped by barge to fertilizer plants as far northwest as Minnesota (142).

Very recently a degree of uncertainty has developed with respect to the foremost market for elemental phosphorus, Idaho's other major phosphate product. Since the middle 1950's, nearly half the output of elemental phosphorus has been utilized in the manufacture of phosphate-based detergents. Obviously, if concern about water pollution should cause a significant shift away from the use of such detergents, growth of Idaho's elemental phosphorus industry could be greatly slowed during the decade of the 1970's. Under existing circumstances, Idaho's phosphate fertilizer and elemental phosphorus industries will do well to maintain their present degree of prosperity during the next several years.

Developments During the Year Following Completion of this Report

The period of slowed growth which characterized the phosphate fertilizer industry during the late 1960's and the beginning of the decade of the 1970's came to an end during 1972. Demand for fertilizer increased significantly, and the pressure was on for capacity production from both phosphate rock mines and processing facilities.

In line with this trend, the idle El Paso Natural Gas Products fertilizer plant at Conda (p. 23) was purchased by the Agricultural Products Corporation. Mining of phosphate rock was resumed at the Mabie Canyon Mine (p. 8) in July 1972 after a lapse of five years (143), and in August the fertilizer plant was reopened. Also reopened under lease was the adjacent Mountain Fuel Supply Co., where rock from the mine is washed and calcined before being utilized by the fertilizer plant.

Approximately 850,000 tons of rock was excavated from the Mabie Canyon Mine during the active season from July through October 1972 by the Agricultural Products Corp. It is expected that during the period from June to October 1973 about 1,500,000 tons will be mined making this the Western Phosphate Field's second largest producer. After washing and calcining, about 900,000 tons of concentrate will remain, of which about 500,000 tons is expected to be used in the manufacture of phosphate fertilizer at Conda, and 400,000 tons will be sold to other fertilizer manufacturers. The principal market for the concentrate is in British Columbia, Canada, but lesser quantities will be sent to California and Utah.

Technological problems have been overcome and capacity of the Conda fertilizer plant is being expanded. It is anticipated that well over 300,000 tons of diammonium phosphate (18-46-0) fertilizer will be manufactured there by the Agricultural Products Corp. in 1973. Largest market is expected to be in the Great Plains, particularly the West North Central States, with other important markets being in Washington and California.

DOCUMENTATION

1. Estimates made from Idaho Department of Employment data sheets entitled "Employment in Idaho."

2. Estimates made from U.S. Dept. of the Interior, Bureau of Mines, Mineral Industry Surveys, "Mineral Industry of Idaho", Preliminary Annual Reports for 1969 and 1970. Average value of Idaho's phosphate rock in 1968 was $5.89 per short ton. A round figure of $6.00 per ton is used in calculating approximate total value of rock production for 1970.

3. Total product output value of Idaho's phosphate industry is estimated on the basis of the following assumptions, which have been developed from interviews and data provided in publications documented elsewhere: manufacturing cost of elemental phosphorus = $315 per ton; triple superphosphate = $50; ammonium phosphate = $55; and phosphoric acid = $45, with all these estimates except that for elemental phosphorus being possibly on the low side.

   It is then assumed that the state's 245,000-ton per year elemental phosphorus, 360,000-ton triple superphosphate, and 270,000-ton ammonium phosphate capacity are used to about 85% of those capacities, and that 60,000 tons of phosphoric acid are sold instead of being consumed in the manufacture of fertilizer already accounted for.

   The above assumptions would indicate actual production of nearly 210,000 tons of elemental phosphorus, 310,000 tons of triple superphosphate, and 230,000 tons of ammonium phosphate, plus the 60,000 tons of phosphoric acid believed to be shipped directly. Manufacturing values would then be about $66,000,000; $15,500,000; $13,000,000; and $3,000,000 for the respective products, or a grand total of $96,500,000.

4. The statistics reported by the U.S. Bureau of Mines show that the value of mineral products from the Coeur d'Alene District is more than three times as great as the value of marketable phosphate rock produced in southeastern Idaho. This comparison is, however, misleading. The value of lead, zinc, silver, copper, and antimony produced in the Coeur d'Alene includes the value added by smelting and refining after mining. By contrast the value credited to the phosphate industry includes only the value of the mined rock, enhanced, in some cases, by a limited amount of beneficiation. To be truly comparable, the values of phosphate fertilizers and elemental phosphorus produced in Idaho should be given. The only phosphate rock per se given in the final tabulation should be that which is shipped unprocessed, from the state. This amounts to only about 10% of the state's phosphate rock production, the other 90% being converted into phosphate fertilizers and elemental phosphorus as discussed in reference (3).

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WESTERN PHOSPHATE INDUSTRY

1970

BRITISH COLUMBIA

ALBERTA

WASHINGTON

OREGON

IDAHO

WYOMING

UTAH

Kimberley
Cominco Phosphate Fertilizer Plant

Cominco Phosphate Fertilizer Plant
Trail

C.P.R.R.

Spokane
U.P.R.R.

Kellogg
Bunker Hill Company Phosphate Fertilizer Plant

B.N.R.R.

Butte

Centennial Mine (ab)

U.P.R.R.

Pocatello

U.P.R.R.

Stauffer Chemical Company Mine and Beneficiation Plant
Leefe

Cherokee Mine
8 (ab)
Rex Mine

U.P.R.R.

Stauffer Chemical Company Phosphate Fertilizer Plant
Garfield

Phoston

Stauffer Chemical Company Mine and Beneficiation Plant
Vernal

Truck Route
U.S. Highway 40

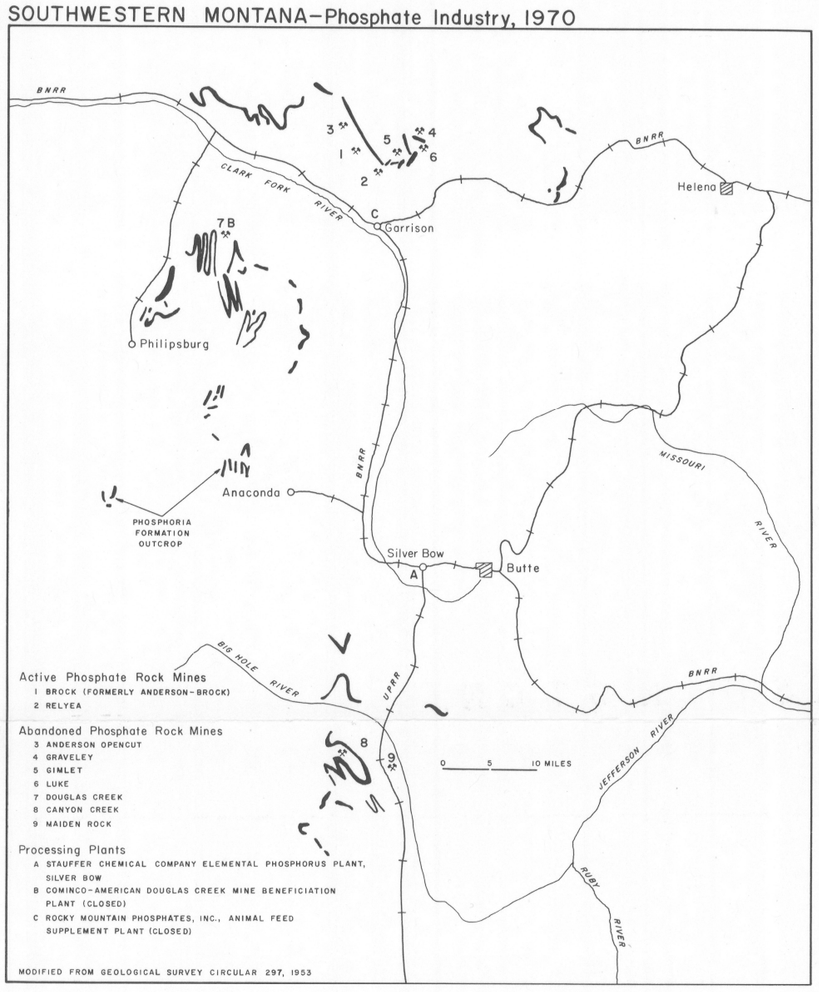
Limits of Western Phosphate Field

0 Miles 100

48
46
44

116 114 112 110

SOUTHWESTERN MONTANA–Phosphate Industry, 1970



SOUTHEASTERN IDAHO – Phosphate Industry, 1970