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BUREAU OF MINES

1989

UNITED STATES DEPARTMENT OF THE INTERIOR • Manuel Lujan, Jr., Secretary

BUREAU OF MINES • T S Ary, Director

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Territories under U.S. administration.

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PHOSPHATE ROCK

By William F. Stowasser

Mr. Stowasser, a physical scientist with 19 years Bureau of Mines experience, has been the commodity specialist for phosphate rock since 1974. Domestic survey data were prepared by William Fields, mineral data assistant, and the international data table were prepared by Peter Roetzel, international data assistant.

Phosphate rock production in the United States increased almost 10% in 1989 over that of 1988. The production of 49,817,000 tons[1] was consumed in several markets. The estimated U.S. demand pattern was 19,180,000 tons used in domestically consumed fertilizer, 20,803,000 tons was converted to fertilizer and exported, 1,647,000 tons was used domestically in other than fertilizer applications, and 512,000 tons was exported as other than fertilizer chemicals.

The United States exported 7,842,000 tons of phosphate rock and imported 704,000 tons preserving the general trends of declining phosphate rock exports and increasing imports.

World production of phosphate rock was similar to that of 1988. Production remained at a plateau of about 162 million tons.

DOMESTIC DATA COVERAGE

Domestic production data for phosphate rock are developed by the Bureau of Mines from two separate voluntary surveys of U.S. operations. Typical of these surveys is the semiannual Phosphate Rock Survey. Of the 19 operations to which a survey request was sent, all responded, representing 100% of the U.S. production data shown in table 1.

LEGISLATION AND GOVERNMENT PROGRAMS

Section 3001(b)(3)(A)(ii) of the Resources Conservation and Recovery Act (RCRA), known as the Bevill Exclusion, excludes "solid waste from the extraction, beneficiation, and processing of ores and minerals" from regulation as hazardous waste under subtitle C of RCRA, pending completion of certain studies by the Environmental Protection Agency (EPA). In 1980, the EPA interpreted this exclusion on a temporary basis to encompass "solid waste from the exploration, mining, milling, smelting, and refining of ores and minerals." On September 1, 1989, EPA published the final criteria and took final action on all but 20 mineral processing waste streams. The wastes proposed for removal from the Bevill Exclusion were furnace offgas solids from elemental phosphorus production, phosphogypsum from phosphoric acid production, and furnace slag from elemental phosphorus production.

As of September 1, 1989, the status of previously proposed Bevill mineral processing wastes in the phosphoric

TABLE 1

SALIENT PHOSPHATE ROCK STATISTICS[1]

(Thousand metric tons and thousand dollars unless otherwise specified)

	1985	1986	1987	1988	1989
United States:					
Mine production (crude ore)	175,227	135,683	148,426	162,299	170,268
Marketable production	50,835	40,320	40,954	45,389	49,817
P_2O_5 content	15,634	12,248	12,470	13,833	15,116
Value	[2]$1,235,800	[2]$897,131	[2]$793,280	$887,809	$1,084,022
Average per metric ton[3]	$24.31	$22.25	$19.37	$19.56	$21.76
Sold or used by producers[4]	46,634	41,776	43,673	48,441	49,280
P_2O_5 content	14,363	12,750	13,286	14,760	14,935
Value	[2]$1,133,675	[2]$929,621	[2]$845,812	$947,721	$1,072,454
Average per metric ton[3 5]	$24.31	$22.25	$19.37	$19.56	$21.76
Exports[6]	9,136	7,848	8,454	8,092	7,842
P_2O_5 content	2,931	2,521	2,737	2,608	2,522
Value[2]	$263,631	$211,701	$194,691	$206,984	$227,272
Average per metric ton[3]	$28.86	$26.97	$23.03	$25.58	$28.98
Imports for consumption	[7]34	528	464	[r]676	705
C.i.f. value	$1,747	$25,435	$22,134	[r]$26,310	$29,878
Average per metric ton	[8]$51.54	[8]$48.18	$47.70	[r]$38.92	$42.44
Consumption[9]	37,532	34,456	35,683	41,022	42,143
Stocks, Dec. 31: Producers	15,534	13,277	10,884	9,323	11,027
World: Production	148,842	138,870	144,228	[p]163,673	[e]162,000

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Data for the same items appearing in this and other tables may not reconcile because of manual or computer rounding.
[2]The total value is based on a weighted value.
[3]Computer-calculated average value based on the weighted sold or used values.
[4]Includes domestic sales and exports.
[5]Weighted average of sold or used values.
[6]Exports reported to the Bureau of Mines by companies.
[7]Bureau of the Census data, excluding reported Canadian and Israeli imports.
[8]Average unit value obtained from unrounded data.
[9]Expressed as sold or used plus imports minus exports.

acid and elemental phosphorus sectors was as follows:

1. Furnace off-gas solids was conditionally retained because it passed high-volume criteria.

2. Furnace scrubber blowdown was removed because of low volume.

3. Process wastewater was removed because of low volume.

4. Slag was retained because it passed all criteria.

5. Phosphogypsum was retained because of high volume.

6. Process wastewater was conditionally retained because of high volume.

As of September 25, 1989, the proposed status of each of the phosphate commodity wastes and the basis for each were as follows:

1. Elemental furnace off-gas solids from 5 operations was not retained within the Bevill Exclusion.

2. Phosphoric acid process wastewater from 28 operations was retained within the Bevill Exclusion.

The Office of Radiation Programs, EPA, ruled that conditionally and pending further studies, a reduction of radon emissions from phosphogypsum stacks would not be required. The emissions were within the acceptable risk of 1 cancer death per year for every 10,000 people from radon–222 gas from an active phosphogypsum stack. The maximum mortality risk from radioactive particulates was estimated at about 2 in 1,000,000.

STRATEGIC CONSIDERATIONS

Phosphate rock is not strategically stockpiled. The United States is a net exporter of both phosphate rock and phosphate chemicals. There is concern, however, over the adequacy of domestic supply in future years when the deposits of phosphate rock in Florida that have sustained domestic and export markets for many decades are mined out. Phosphate rock deposits in Florida, after 100 years of production, have a limited supply of high-quality reserves remaining. (The subject of phosphate rock reserves is discussed in this publication under reserves.) A review of mine production plans of Florida mines shows that as years progress, the supply of phosphate rock from remaining mines will decline. The rate of decline will depend on future mining rates, if environmentally sensitive wetlands and hardwood stands will be permitted and mined, if technology to improve the quality of phosphate rock can be developed, and if the economics of mining and processing phosphate rock become sufficiently attractive to develop new mines in Florida and expand the capacity of the mine in North Carolina.

Raw material demand for phosphate rock is closely associated with production levels in the world's fertilizer industries. The demand for agricultural products is tied to population. A world population over 5 billion in 1989 is forecasted to reach 6.2 billion in the year 2000.

The increase in population and an anticipated increase in per capita income will increase the demand for food, feed, and fiber, increasing the pressure on world agriculture to produce the necessary quantities of these products. Programs and policies are needed to promote growth in fertilizer application and food production so that people, particularly in developing countries, can have higher nutritional levels in the year 2000.

ISSUES

The demand for U.S. phosphate rock in 1989 was more than expected when India discontinued receiving Moroccan phosphoric acid and purchased an additional 1.5 to 2 million metric tons of diammonium phosphate (DAP). The tonnage was supplied for the most part by U.S. producers, and with this windfall, prices were sustained during the main shipping period of the year. As shipments to India declined, prices for DAP fell, indicating overcapacity of the U.S. DAP industry. The decline in prices forced high-cost plants to close or reduce production. Overcapacity in the U.S. DAP industry was the reason, and it was forecasted that India's imports of DAP will be less in 1990. Low DAP prices will probably encourage sales into some areas; however, the quantities sold were not expected to increase in 1990 over that of 1989. Closing DAP plants in the United States may not resolve the issue as Morocco plans to double its DAP capacity at Jorf Lasfar in the next few years.

After 100 years of production from Florida's Bone Valley Formation, it is difficult to accept the prognosis of a decline in the supply of phosphate rock from the region. This decline was particularly difficult to accept in 1989 when efforts were made to replenish domestic grain stocks, depleted by the drought in 1988, and supply an exceptionally strong export market for phosphate fertilizers. At issue is the development of replacement mines to offset production losses as phosphate rock deposits are mined out in Florida. There are a limited number of remaining deposits from which acceptable products could be produced in Florida. Investors have been reluctant to develop new mines in Florida without assurance of a profitable return. Current selling prices and estimated production costs from a potential new mine do not encourage investments.

The future supply of phosphate rock could be increased by investment in North Carolina, where large reserves are available, to accommodate a mine expansion. Expansion of existing mines in Florida does not appear at this time to be economically feasible, and quality reserves are limited.

PRODUCTION

Compared with 1988, domestic production of marketable phosphate rock increased 10% in 1989 to 49.8 million tons. Production was 2 million tons higher than planned by producers as they responded to improved demand in the domestic and export sectors for phosphate fertilizers and elemental phosphorus derivatives. Most of the increased supply originated in Florida. Of the total U.S. production, Florida and North Carolina supplied 88%, and the balance was produced in Idaho, Montana, Tennessee, and Utah.

Florida and North Carolina

Phosphate rock was produced in Florida by Agrico Mining Co., a division of Agrico Chemical Co., owned by Freeport-McMoRan Resource Partners L.P.; CF Industries Inc.; Estech Inc., owned by C&G Holdings Inc.; Gardinier Inc., 80% ownership by Cargill, Inc.; IMC Fertilizer Inc. (IMC); Mobil Mining and Minerals Co.; U.S. Agri-Chemicals Corp.; Seminole Fertilizer Corp., owned by Tosco Corp.; and Occidental Chemical Agricultural Products Inc. in northern Florida. Nu-Gulf Industries Inc., a subsidiary of Nu-West Industries Inc., shipped phosphate rock from inventory but did not produce it in 1989.

Low-fluorine soft phosphate rock was recovered from hard phosphate rock tailing ponds in north-central Florida by Manko Co., Howard Phosphate Co., and Loncala Phosphate Co.

Texasgulf Inc., a subsidiary of Elf Aquitaine Inc., was the only producer of phosphate rock in North Carolina. Studies to deepen the harbor and channel at Morehead City, NC, for navigation by deeper draft vessels were in progress. Texasgulf produced phosphate rock from the Lee Creek Mine adjacent to the Pamlico River.

Western States

Phosphate rock was mined in Idaho, Montana, and Utah. Nu-West produced phosphate rock from a number of deposits in Idaho. The phosphate rock was beneficiated and calcined at Conda, ID. J. R. Simplot Co. produced phosphate rock from the Gay Mine, Fort Hall Indian Reservation, and the Smoky Canyon Mine, Caribou National Forest. The Gay Mine's main bed phosphate rock was used by Simplot, and the lower-grade shale was used in FMC Corp.'s electric furnaces. Monsanto Co. supplied its Soda Spring, ID, electric furnaces from the Enoch Valley Mine. Rhône-Poulenc Basic Chemicals Co. operated the Wooley Valley Mine, ID, to supply phosphate rock to its Silver Bow, MT, electric furnaces. Cominco American Inc. operated an underground mine, beneficiation, and drying plant near Garrison, MT. The dried product was exported to Canada. Chevron Resources Co. produced phosphate rock from the Vernal Mine, UT. It was transported by pipeline to Rock Springs, WY.

CONSUMPTION AND USES

The demand pattern for phosphate rock in the United States was stable during the past decade. Between 85% and 90% of phosphate rock consumed was used to produce phosphate fertilizer for domestic or export markets. Frequently, over 50% of the manufactured fertilizer was consumed domestically; however, there were several years during the past decade that fertilizer exports exceeded domestic consumption.

Phosphate rock exports have declined from a 14 million ton-per-year level in 1979 to about 8 million tons-per-year in recent years as the industry

TABLE 2

PRODUCTION OF PHOSPHATE ROCK IN THE UNITED STATES, BY REGION[1]

(Thousand metric tons and thousand dollars)

Region	Mine production		Marketable production: Used directly		Marketable production: Beneficiated		Marketable production: Totals[2]			Ending stocks
	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content	Value[3 4]	
1988:	162,299	[r]20,951	3,832	1,045	41,557	12,787	45,389	13,833	887,809	9,323
1989:										
January-June										
Florida and North Carolina	[r]92,616	[r]16,279	266	81	[r]22,993	[r]7,029	[r]23,259	[r]7,111	[r]500,958	[r]9,954
Idaho, Montana, Tennessee, and Utah	4,912	1,225	1,555	416	1,412	431	2,967	847	[r]64,702	1,757
Total[2]	[r]97,527	[r]17,505	1,821	497	[r]24,405	[r]7,461	[r]26,226	[r]7,958	[r]565,660	[r]11,711
July-December										
Florida and North Carolina	68,115	8,840	292	88	20,088	6,155	20,380	6,242	458,657	9,541
Idaho, Montana, Tennessee, and Utah	4,626	1,145	1,785	473	1,426	442	3,211	916	58,479	1,486
Total[2]	72,740	9,986	2,078	561	21,514	6,597	23,591	7,158	517,137	11,027
Grand total[2]	170,268	27,490	3,899	1,058	45,919	14,058	49,817	15,116	1,084,022	XX

[r] Revised. XX Not applicable.

[1] Data for the same items appearing in this and other tables may not reconcile because of manual/computer rounding.

[2] Data may not add to totals shown because of independent rounding.

[3] Computer-calculated value based on the weighted sold or used value.

[4] The total value is based on a weighted value. The total value does not equal the sum of the regional or 1/2-year totals because weighted regional or overall 1/2-year unit values were used in the calculations. The regional and 1/2-year values are approximate.

converted more phosphate rock to higher value intermediates or finished fertilizer. The emergence of phosphate fertilizer industries in developing countries with domestic phosphate rock deposits caused major changes in trade patterns. Countries with indigenous phosphate rock deposits like Jordan, Morocco, Senegal, and Tunisia established fertilizer plants that competed in markets throughout the world. Phosphate rock imports, particularly shipments from Morocco and Togo, to plants on the Mississippi River increased in the last years of the decade to similar levels that existed at the beginning of the decade. The resumption of substantial imports was prompted by a need for higher quality phosphate rock than was available domestically to produce high purity fertilizers.

The balance of phosphate rock was consumed with silica and coke in electric furnaces to produce elemental phosphorus. Elemental phosphorus was used to produce high-purity phosphoric acid, salts, and phosphorus chemicals for industry and home consumption. These included detergents and cleaners, chemicals for food and beverages, and metal-treating chemicals.

The detergent builder, sodium tripolyphosphate, was the principal derivative of elemental phosphorus. The manufacture of thermal or furnace phosphoric acid accounted for 80% to 85% of U.S. elemental phosphorus production. About 10% of the elemental phosphorus production was used to produce phosphorus pentasulfide, phosphorus pentoxide, and phosphorus trichloride. About 50% of the elemental phosphorus produced was used to manufacture sodium tripolyphosphate.

The gradual decline in elemental phosphorus production and the quantity of phosphate rock consumed in electric furnaces during the past decade was caused by banning phosphates from home laundry products in some areas of the country. Several companies decided to construct plants to produce higher quality, lower cost, wet-process phosphorus acid purification plants that would produce a purified acid to replace thermal acid in food and detergent grade products. Thermal acid will continue to be used by semiconductor manufacturers and in other ultrahigh-purity markets. Where thermal acid competes with purified wet-process acid, lower cost wet-process acid will probably be the choice selected in the future.

TABLE 3

U.S. PHOSPHATE ROCK SOLD OR USED GRADE DISTRIBUTION PATTERN

Distribution (percentage)

Grade (percent BPL[1] content)	Distribution (percentage)				
	1985[2]	1986	1987	1988	1989[2]
74 or more	2.9	4.5	3.4	2.0	0.8
72 to less than 74	4.2	4.0	5.4	5.6	7.4
70 to less than 72	12.0	7.8	7.1	8.8	6.2
66 to less than 70	62.9	57.5	61.6	59.7	61.7
60 to less than 66	13.1	20.3	17.5	14.9	19.3
Less than 60	4.8	5.9	5.0	9.0	4.7

[1] 1.0% BPL (bone phosphate of lime or tricalcium phosphate) = 0.458% P_2O_5.
[2] Data do not add to 100% because of independent rounding.

TABLE 4

FLORIDA AND NORTH CAROLINA PHOSPHATE ROCK SOLD OR USED GRADE DISTRIBUTION PATTERN

Grade (percent BPL[1] content)	Distribution (percentage)				
	1985[2]	1986	1987	1988	1989
74 or more	3.4	5.1	3.8	2.3	0.9
72 to less than 74	4.8	4.6	6.0	6.4	7.6
70 to less than 72	12.6	9.0	7.6	8.2	6.2
66 to less than 70	65.9	60.7	65.3	64.0	66.4
60 to less than 66	12.8	20.6	17.3	14.4	18.9
Less than 60	.6	—	(3)	4.7	—

[1] 1.0% BPL (bone phosphate of lime or tricalcium phosphate) = 0.458% P_2O_5.
[2] Data do not add to 100% because of independent rounding.
[3] Less than 0.1 of 1%.

STOCKS

Phosphate rock was inventoried in wet rock piles adjacent to the beneficiation plants in Florida and North Carolina. The stocks were reclaimed for drying or calcining for export or for wet-grinding before wet-process phosphoric acid manufacture. Industry stocks peaked in 1981 when about 20 million tons was reported at yearend. Since 1981, the phosphate rock inventory tonnage declined each year, reaching 9.3 million tons in 1988. In the Western States, where the climate made it diffi-

TABLE 5

TENNESSEE AND WESTERN STATES PHOSPHATE ROCK SOLD OR USED GRADE DISTRIBUTION PATTERN

Grade (percent BPL[1] content)	Distribution (percentage)		
	1987	1988	1989
72 to less than 74	—	—	5.6
70 to less than 72	3.5	12.5	6.1
66 to less than 70	33.9	29.8	28.6
60 to less than 66	19.3	18.2	21.8
Less than 60	43.3	39.5	37.9

[1] 1.0% BPL (bone phosphate of lime or tricalcium phosphate) = 0.458% P_2O_5.

TABLE 6

PHOSPHATE ROCK SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY GRADE AND REGION[1]

(Thousand metric tons and thousand dollars)

Grade (percent BPL[2] content)	Florida and North Carolina			Tennessee and Western States[3]			Total		
	Rock	P_2O_5 content	Value[4 5]	Rock	P_2O_5 content	Value[4 5]	Rock	P_2O_5 content	Value[4 5]
January-June 1988	20,472	6,275	369,224	2,850	817	53,973	23,322	7,092	423,197
July-December 1988	21,922	6,762	460,738	3,197	907	63,786	25,119	7,669	524,524
January-June 1989:									
74 or more	r205	r70	r6,440	—	—	—	r205	r70	r6,440
72 to less than 74	r2,385	r796	r67,575	—	—	—	r2,385	r796	r67,575
70 to less than 72	1,059	345	29,654	376	122	13,690	1,435	467	43,344
66 to less than 70	13,635	4,194	270,008	889	275	26,831	14,524	4,469	296,839
60 to less than 66	r4,790	r1,358	r106,283	582	166	6,314	r5,372	r1,524	r112,597
Below 60	—	—	—	871	221	13,974	871	221	13,974
Total[6]	r22,074	r6,763	r479,960	2,718	784	60,809	r24,792	r7,547	r540,769
July-December 1989:									
74 or more	189	66	5,332	—	—	—	189	66	5,332
72 to less than 74	894	300	28,489	346	116	12,776	1,240	416	41,265
70 to less than 72	1,611	522	47,503	—	—	—	1,611	522	47,503
66 to less than 70	15,005	4,600	311,557	869	269	21,631	15,874	4,869	333,188
60 to less than 66	3,357	934	79,153	757	213	9,237	4,114	1,147	88,390
Below 60	—	—	—	1,459	370	16,006	1,459	370	16,006
Total[6]	21,056	6,422	472,034	3,431	968	59,650	24,487	7,390	531,684

r Revised.
[1] Data for the same items appearing in this and other tables may not reconcile because of manual or computer rounding.
[2] 1.0% BPL(bone phosphate of lime or tricalcium phosphate) = 0.458% P_2O_5.
[3] Includes Idaho, Montana, and Utah.
[4] F.o.b. mine.
[5] The total value is based on a weighted value. The total value does not equal the sum of the regional totals because weighted regional unit values were used in the calculations. The regional values are approximate.
[6] Data may not add to totals shown because of independent rounding.

TABLE 7

PHOSPHATE ROCK SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY USE[1]

(Thousand metric tons)

Use	1988 total		1989 January-June		1989 July-December		1989 Total[2]	
	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content
Domestic:[3]								
Wet-process phosphoric acid	36,721	11,083	r19,017	r5,732	18,914	5,662	37,931	11,394
Normal superphosphate	r840	r325	r384	r125	553	172	937	297
Triple superphosphate	r641	r159	r234	r77	176	60	410	137
Defluorinated rock	66	22	—	—	—	—	—	—
Direct applications	1	([4])	2	1	1	—	3	1
Elemental phosphorus	2,044	553	917	250	1,205	325	2,122	575
Ferrophosphorus	36	9	18	4	19	5	37	9
Total[2]	40,349	12,152	r20,571	r6,189	20,866	6,225	41,437	12,413
Exports[5]	8,092	2,608	4,222	1,358	3,620	1,164	7,842	2,522
Grand total[2]	48,441	14,760	r24,793	r7,546	24,487	7,389	49,280	14,935

r Revised.
[1] Data for the same items appearing in this and other tables may not reconcile because of manual or computer rounding.
[2] Data may not add to totals shown because of independent rounding.
[3] Includes rock converted to products and exported.
[4] Less than 1/2 unit.
[5] Exports reported to the Bureau of Mines by companies.

TABLE 8

PHOSPHATE ROCK SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY USE AND REGION[1]

(Thousand metric tons)

Use	Florida and North Carolina		Tennessee and Western States[2]		Total[3]	
	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content
1988:	42,395	13,036	6,047	1,723	48,441	14,760
1989:						
January-June:						
Domestic:[4]						
Agricultural	r17,943	r5,434	1,693	501	r19,636	r5,934
Industrial	11	3	924	252	935	255
Subtotal	r17,954	r5,437	2,617	753	r20,571	r6,189
Exports[5]	4,120	1,326	102	32	4,222	1,358
Total[3]	r22,074	r6,763	2,719	785	r24,793	r7,547
July-December:						
Domestic:[4]						
Agricultural	17,473	5,269	2,171	626	19,643	5,894
Industrial	34	10	1,190	320	1,223	330
Subtotal	17,507	5,279	3,361	946	20,866	6,224
Exports[5]	3,549	1,143	71	21	3,620	1,164
Total[3]	21,056	6,422	3,432	967	24,486	7,388
Grand total[3]	43,130	13,185	6,151	1,752	49,279	14,935

r Revised.
[1] Data for the same items appearing in this and other tables may not reconcile because of manual or computer rounding.
[2] Includes Idaho, Montana, and Utah.
[3] Data may not add to totals shown because of independent rounding.
[4] Includes rock converted to products and exported.
[5] Exports reported to the Bureau of Mines by companies.

TABLE 9

FLORIDA AND NORTH CAROLINA PHOSPHATE ROCK SOLD OR USED BY PRODUCERS[1]

Year	Rock (thousand metric tons)	P_2O_5 content (thousand metric tons)	Value: Total[2] (thousands)	Value: Average per ton f.o.b mine
1985	40,857	12,702	$972,748	$23.81
1986	36,333	11,236	810,429	22.31
1987	38,692	11,891	765,061	19.77
1988	42,395	13,036	829,963	19.58
1989	43,129	13,184	951,995	22.07

[1] Data for the same items appearing in this or other tables may not reconcile because of manual or computer rounding.
[2] The total value is based on a weighted value.

cult to unload frozen ore from trucks or rail cars, ore was stockpiled near the electric furnaces and chemical plants to permit year-round production.

During 1989, stock levels were about 9.5 million tons in January, 10.9 million tons in June, and stabilized at about 11 million tons for the balance of the year.

TRANSPORTATION

Phosphate rock was moved by rail from production centers in central and north Florida to terminals on Hillsborough Bay, FL and in Jacksonville, FL. The CSX Transportation Railroad moved phosphate rock from central Florida to Eastern Associated Terminals Co., Rockport Phosphate Terminal, International Minerals & Chemical Phosphate Terminal Co., and Agrico's Big Bend Terminal. Phosphate rock was shipped in bulk carriers to ports around the world and barged from Hillsborough Bay to chemical fertilizer plants on the Mississippi River. Freight, loading, and weighing charges were components of the cost of transporting phosphate rock from mine to vessel in central Florida. In 1974, the cumulative cost was $2.20 per ton. By 1990, the total cost increased to $6.98 per ton plus a Rockport Phosphate Terminal improvement charge of $0.36 per ton. Weighing charges were available at the shipper's request that reduced the cost from $0.22 per ton to about $0.02 per ton for a 20,000 ton cargo.

In north Florida, the Norfolk Southern Railroad transported phosphate rock from mine to vessel at Jacksonville, FL at a total cost of $9.08 per ton.

Specially designed barges with a capacity of 2,431 tons moved phosphate rock from the Lee Creek Mine to the Morehead City Port Terminal. The barge's capacity can move more than 15,400 tons every 3 days over the 93-kilometer section of the intercoastal waterway. Self-unloading barges discharged to conveyors for either direct delivery to a traveling shiploader or to a storage building. In Tennessee and the Western States, phosphate rock was moved by rail or truck from mine to beneficiation plant. Recently, two companies have installed slurry pipelines to convey concentrates to chemical fertilizer plants.