THE SOUTH AFRICAN PHOSPHATE ROCK INDUSTRY

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Introduction

The use of natural manures, fish and bones as fertilizer materials extends back to the beginning of recorded history, but the benefits of using such natural fertilizers were not recognized in terms of their mineral content until well into the nineteenth century. In 1804 de Saussure published his work on the mineral content of plants (de Saussure, 1890) and set the stage for the establishment of the fertilizer industry. A patent for the manufacture of mixed fertilizer was granted to H W Köhler in Austria ca. 1830. The process involved the treatment of uncalcined bones with sulphuric acid in order to liberate phosphoric acid. The latter was mixed with calcium hypochlorite, charcoal and liquid manures. By 1850, as a result of contributions by several other investigators, notably by Gotthold Escher (1835) and Justus Liebig (1840) fertilizer manufacture had become a profitable business.

The first use of phosphate rock in the manufacture of fertilizer is credited to Sir James Murray, who was granted a Scottish patent (Murray, 1842a) on 12th May, 1842, and a British patent (Murray, 1842b) a few weeks later. Thereafter the superphosphate industry developed rapidly, and gave impetus to the search for and the mining of phosphate rock deposits.

Commercial phosphate rock mining commenced in 1863 in Ontario, Canada, in 1883 in Hawthorne, Florida, in 1885 in Russia and in 1923 in Morocco, North Africa. The USA, Morocco and the USSR are still the main producing countries in the world, and are likely to remain so for a long time to come.

For many years the South African fertilizer industry was dependent upon phosphate rock imported from Morocco, and fertilizers imported mainly from Holland. The existence of a phosphate ore deposit at Phalaborwa was noted in 1904 by the late Dr Hans Merensky. On the average the ore was of such a low grade, however, that most mining experts would have concluded that it could not be worked economically for the phosphate values. Indeed, a company called South African Phosphates Limited attempted to mine small, high-grade pockets of ore from 1930 onwards. Their sales price was R5,76 per ton whereas imported phosphate rock was being landed at R3,40 per ton. After four years they abandoned the unequal struggle and closed down.

Dr Merensky was of the opinion, however, that South Africa would need to develop a phosphate mine at Phalaborwa sooner or later, and in 1945 he launched a prospecting programme in order to determine the extent of the phosphate deposit. The results astonished him. Even to this day the full extent of the orebody has not been established, but this early prospecting programme already indicated an orebody that could almost be described as unlimited.

During the second world war the importation of phosphate rock and fertilizers into South Africa ceased completely. Holland, South Africa's main supplier of fertilizers, was occupied and Morocco, the country's main supplier of phosphate rock, became technically an enemy country during the German occupation of France. Rationing of fertilizers was instituted and by 1946 the situation had become so bad that severe food rationing was being seriously considered. It became painfully clear that Phalaborwa's phosphate would have to be mined, whether the venture was economically attractive or not. In 1951 the Phosphate Development Corporation (Foskor), was formed. Financing consisted of a shareholding of R1 000 000 by the Industrial Development Corporation, and an interest-free Government loan of R1 476 470. Construction work started early in 1953, and by 1955 a mine and an ore-dressing plant with a capacity of 60 000 tons of phosphate concentrate per annum had been established. The first consignments of phosphate rock were sold at R14,69 per ton, at a loss.

Despite many trials and tribulations Foskor grew steadily until by 1969 it was able to supply the country's total demand for phosphate rock at a price that made imported rock unattractive. In 1970 a production rate of 1 million tons per annum was achieved for the first time. From very modest beginnings, Foskor has grown to an operation of respectable size, not to mention strategic value. The total capital investment has now passed the R57 million mark and will be in the region of R90 million by the end of 1976. At present Foskor saves the country an estimated R74 million to R85 million per annum in foreign exchange by rendering the importation of phosphate rock unnecessary.

Competitive position of the South African phosphate industry in the world market

Until eighteen months ago, South African phosphate rock and phosphate derivatives could not be exported at competitive prices. A few years ago Foskor was producing more than the local demand and a stockpile of almost 600 000 tons of rock was accummulated at Phalaborwa. A study of the export market showed that if the rock were to be offered in Europe at a competitive price vis-a-vis Moroccan or Florida rock, some 90 per cent of the delivered price would have been represented by railage and

ocean freight costs. The free on-rail price at Phalaborwa would not have been quite sufficient to cover marginal production cost.

The situation has changed dramatically since the end of 1973. To understand the reasons for this it is necessary to analyse the main factors in the past history of the world phosphate rock industry. An assessment of South Africa's chances of remaining competitive requires a closer look at current and future factors that will characterize the global production and marketing of phosphate rock, as well as the main characteristics of the South African Industry.

Price history of phosphate rock

For almost a century phosphate rock was regarded as a low-priced bulk commodity. Figure 1 illustrates the price history of phosphate rock.

If the gradual erosion of monetary values by inflation is taken into account, it is clear that the price of phosphate rock in real terms actually decreased over the years. The ability of the phosphate rock industry to survive at all under these conditions can be attributed to steadily increasing efficiency due to technological development and the handling of larger volumes. Due to the long history of low price levels and low profit margins phosphate rock mining ventures were never considerd to be attractive investments. This led inevitably to selective mining of the best ore, i e high in grade and with as little overburden as possible. It also led to underinvestment in the industry. During the early 1960's a number of oil companies in the USA diversified into fertilizer manufacturing operation, overestimated the growth in world demand, and steered the industry into a situation of oversupply. The low returns on investment gradually led to disillusion and most of the oil companies sold out their interests by the late 1960's. The result was that the American industry could not attract sufficient investment capital for normal growth and entered a period of stagnation.

In addition, the American phosphate rock mining industry was being subjected to increasing restrictions by the environmentalists.

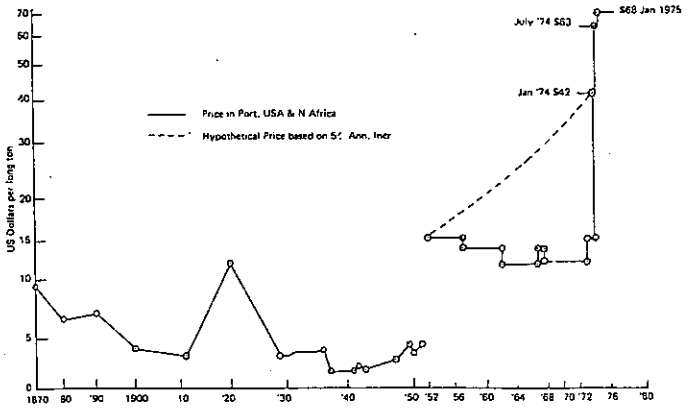

FIG 1 Price history of phosphate rock

Inevitably, a world shortage developed. It became increasingly clear that substantial increases in the price of phosphate rock were needed to stimulate investment in additional production capacity and to tender the mining of less favourable ore bodies (lower grade and/or higher overburden-to-ore ratios) economical. In 1972 and 1973 the prices of such major trading commodities as oil, agricultural products and gold increased enormously. The drastic increase in oil prices by the oil producing and exporting countries was a spectacular success and proved convincingly that a cartel of producers of essential raw materials can wield impressive power over the consumers.

Shortly after the 'oil crisis' appeared on the scene towards the last quarter of 1973, Morocco, the leading phosphate rock exporting country, seized the opportunity and announced a three-fold increase in the price of Moroccan rock, effective from January 1, 1974. The Office Cherifien des Phosphates, Morocco's state-controlled phosphate mining corporation, justified the increase mainly on three arguments (See Phosphorus and Potassium, November/December 1973):

(i) If the price had been escalated at the very reasonable rate of 5 per cent pa from 1952, in order to compensate for inflation, the 1974 price level would have been the same as their newly announced price.

(ii) The impact of the 200 per cent increase in rock prices on the cost of producing a major crop such as grain would be a negligible 1,5 per cent.

The rise in the price of agricultural products would more than compensate the farmer for the increased cost of fertilizer.

(iii) Since most producers of fertilizers sell the major part of their output in their own domestic markets where prices are generally controlled to a greater or lesser extent by the individual governments, the fertilizer industry should have little difficulty in passing the price increase on to the farmer.

Six months later, OCP announced a further price increase of 50 per cent, stating bluntly that the price rise reflected the shortage of this commodity. In January 1975 a further increase of 8 per cent was announced to compensate for inflation.

As soon as Morocco was firmly established as the price leader, the other producing countries followed suit and raised their rock prices to similar levels. Table 1 lists the recent price history for Moroccan and Florida phosphate rock.

TABLE 1 Recent price history of phosphate rock

(i) Morocco (OCP) US dollars per ton, fas

BPL%	July 1972	July 1973	Jan 1974	July 1974	Jan 1975
80	14,60	16,50	50,00	75,00	—
77/79	13,80	15,60	47,25	71,00	76,50
75/77	12,10	13,80	42,00	63,00	68,00
72	10,10	12,00	40,00	60,00	65,00
70			37,50	56,25	60,75

(ii) Florida (Phosrock) US dollars per ton fob

BPL%	July 1972	March 1973	Jan 1974	July 1974	Jan 1975
76/77	12,28	14,50	30,00	47,50	62,00
74/75	11,18	13,10	27,50	42,00	55,00
72/73	10,30	12,00	25,50	38,00	—
70/72	10,02	11,50	24,00	36,00	48,00
68/70	9,42	10,80	22,00	33,00	43,00
66/68	8,70	9,90	20,00	30,00	39,00
64/66	8,37	9,40	18,00	27,50	36,00

South Africa's current competitive position in export markets

The current price levels have made it possible for South Africa to participate in what has become a highly lucrative trade in phospatiferous products. Considering the abrupt change in price level, the South African industry has been quick to react to the opportunities presented. The country's two largest fertilizer manufacturers have entered into long-term export contracts for the supply of phosphoric acid and fertilizers, the production of which will consume 1 250 000 tons of rock per annum. Deliveries under these export contracts must commence early in 1977.

In order to support this export drive, as well as the growing domestic demand, Foskor has launched an expansion programme of more than R40 million to raise production from a nominal 950 000 tons per annum to 2 750 000 tons per annum by the end of 1976.

The South African fertilizer producers have announced the construction of two very large processing plants, one at Phalaborwa, the other at Richards Bay.

The current price of phosphate rock for domestic fertilizer requirements is R15,00 per ton for Phalaborwa and is fixed on an annual basis by the Government Price Controller. This is equivalent to approximately $35 per ton fob Morocco, taking railage, shiploading and ocean transport costs to Morocco into account, ie roughly half the Moroccan price. The contract price for phosphate rock intended for the manufacture of products for the export trade is firmly linked to production cost and not to ruling world market prices. As a result, the South African fertilizer industry is now in a strongly competitive position vis-a-vis fertilizer plants in countries that have to import rock at current prices.

The possibility of producing exportable surpluses of phosphate rock

Phalaborwa's vast reserves can best be illustrated by referring to Figure 2 and Table 2.

The Phalaborwa igneous complex has a surface area of approximately 20 square kilometres. The average head grade of the ore is about 6,7 per cent P_2O_5. Exploration holes to a depth of 1 000 metres have revealed no more than slight variations in the vertical mineralization. The orebody probably extends to more than 1 500 metres in depth. Table 2 summarises the reserves in terms of ore and merchant-grade phosphate concentrate as a function of depth.

At the present stage of the development of mining technology an opencast mine on such a large orebody could

TABLE 2 Phosphate ore reserves at Phalaborwa

Mining depth, metres	Ore reserves, Millions of tons	Merchant grade Concentrate, millions of tons
100	2 159	298
300	6 477	894
600	12 954	1 788
1 000	21 590	2 980
1 300	28 067	3 874
1 500	32 385	4 470

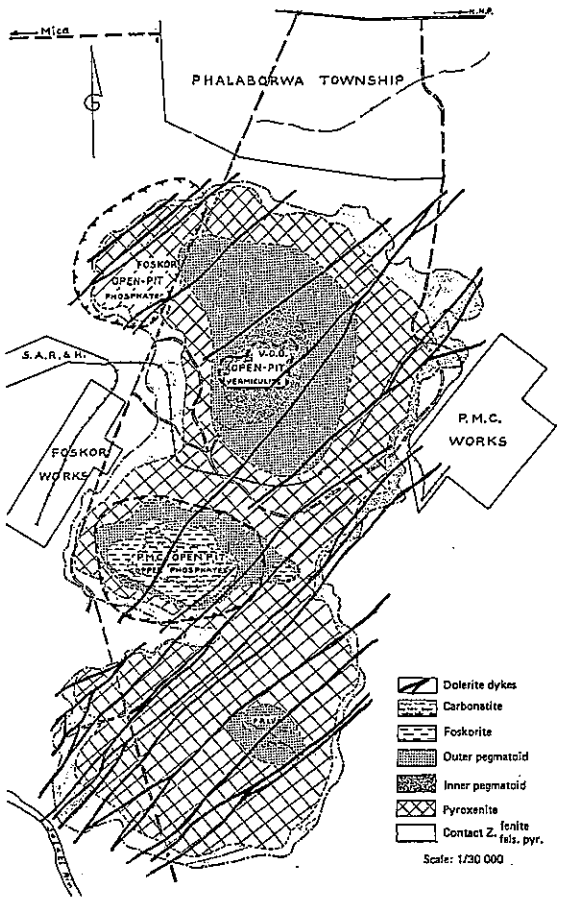

FIG 2 The Phalaborwa igneous complex

reach a depth in the region of 600 metres. Future mining methods may well make substantially greater depths feasible. Phalaborwa's economic ore reserves have increased dramatically with the improvement of mining and ore-dressing technology. When Foskor first came into production, high-grade ore was mined selectively to yield a flotation feed grade of approximately 14 per cent P_2O_5. The then economic reserves were measured in terms of a few decades. At present the average head grade of the ore is not quite 7 per cent P_2O_5 and the economic reserves, at the present consumption rate in domestic agricultural applications, are sufficient for more than a thousand years. It is quite clear that this orebody alone could supply domestic needs and support substantial exports for centuries.

Backed by the certainty of almost inexhaustible reserves and stimulated by the attractive price levels in the export trade, the possibility of further export schemes, over and above those mentioned previously, are being actively examined by the industry.

However, even the huge extensions now being made to Foskor's production capacity will not be able to satisfy both the demands of the domestic industry and the export commitments mentioned previously for more than a few years. The domestic fertilizer requirements will receive absolute priority, ie exports will have to diminish progressively as local demand increases, unless further extensions are provided at Phalaborwa. An exhaustive study on how best to provide more rock in order to maintain existing export commitments and to cater for export projects that are under consideration, was launched some time ago and is now in an advanced stage.

The preliminary indications are that a further expansion in Foskor's production capacity will have to be much larger than the presently foreseeable needs, if it is to be economical. Accordingly, the production of exportable surpluses or rock in future may well be unavoidable. The economic viability of such an expansion would depend partly on sales of the surplus rock in the export market.

The world market for phosphate rock

South Africa's future competitive position in the world market for phosphate rock and derivatives depends to a very large extent upon the future price levels for the various phosphatic products in this market. Since this is a vast and complex subject, the main emphasis here will be on phosphate rock.

Forecast of world phosphate rock supply and demand

Understandably, a number of forecasts have been published since phosphate rock became a commodity of intense interest after Morocco announced the unprecedented price increase 17 months ago. Table 3 is a summary of the most authoritative forecasts (Windrige & Isherwood, 1974; Cohen, 1974; see also Chem. Engrg News June 24 1974).

Of the major suppliers only Morocco and the Spanish Sahara are expected to play increasing roles in the phosphate rock export trade.

In the Spanish Sahara a phosphate mine is being developed at Bu Craa and present indications are that virtually its total output will be exported. Morocco now exports almost its total output as rock, but is installing phosphoric

TABLE 3 World phosphate rock supply and demand forecast 1974–1985 (millions of metric tons)

	1974	1977	1980	1985
Demand	107	132	160	204
Supply	107	140	165	190
Major suppliers:				
Morocco	19	25	30	40
Spanish Sahara	1,5	6	10	12,5
USA	40	50	60	63
USSR	23	29	34	40
China	3	4,5	7	12

acid plants and will be exporting approximately 85 per cent of its output as rock by the end of the decade. The USA currently exports about 25 per cent of its output as rock, but exports are expected to drop to below 20 per cent of output by 1980, and some authorities think that the USA may even become a net importer in the 1980's. The USSR exports approximately 25 per cent of its current output to the West as rock. Indications are that this export trade may decrease to a lower level in future or even cease altogether. Indeed, the Soviet Union recently concluded a deal with Morocco whereby a new mine would be developed at Meskalas with Soviet aid. In return, Russia would receive rock from Morocco at a rate of 3 to 5 million tpa from 1980, rising to 10 million tpa by 1990 (Hughes, 1974).

China's production is expected to be consumed within the country.

Future price indications

There is little doubt that Morocco will emerge as the world leader in the phosphate rock export trade in the years to come. As such, Morocco will have the power to influence the phosphate price level in the export trade almost at will. In a situation of undersupply Morocco's ability to set prices is unchallenged. When supply/demand balance or oversupply occurs, Morocco's ability to maintain prices will be diminished, but only to a certain extent. The following factors need to be considered:

Economic reserves of phosphate rock

Prior to 1974, when rock prices were at the $11,00 to $14,00 per ton level, phosphate rock mines in North Africa and the USA had difficulty in showing even marginal profits. Production cost amounted to approximately $8 to $10 per ton. In order to survive, the most favourable ore was mined. As a result, most of the deposits that had both high-grade ore and relatively thin overburden have been exhausted. At the new price levels less favourable orebodies have become economic.

Table 4 illustrates the sharp increase in economic reserves with permissible mining costs (Turbeville, 1974).

TABLE 4 World economic phosphate rock reserves in millions of tons

Cost per ton in 1974	$8	$12	$20
North America	1 666	4 855	14 827
South America	48	263	844
Europe	752	1 860	3 720
Africa	1 606	7 650	18 600
Asia	304	1 076	4 175
Oceania	108	680	1 180
World	4 484	16 384	43 346

That the mines are already processing lower-grade ore is evident by the fact that Morocco is not even offering 80 BPL rock any more, and their popular 75/77 BPL grade has in practice dropped to 74 BPL and is expected to drop even further to about 72 BPL. Also, a new grade of 70 BPL is now being offered. There are indications that a similar pattern is developing in the American industry.

The effects of inflation

The world economy has been reeling under the impact of unprecedented rates of inflation for the last three to four years. New mines have a much higher production cost due to rapid rises in the cost of capital equipment, labour and fuel. Available information indicates that Moroccan production costs for old mines have escalated to $14 to $15 per ton and for new mines to at least $20 per ton.

In Florida the additional cost element of complying with extremely rigorous environmental protection legislation has become evident.

North African economics

Most of the North African rock producers are developing countries and depend to a significant degree on phosphate rock exports for foreign revenue.

In the case of Morocco, the trade deficit for the first half of 1974 rose from DH 175 million to DH 456 million, despite the three-fold increase in rock prices announced on January 1, 1974. The higher rock price increased export earnings by 65,6 per cent over the corresponding period of 1973, but costs of imports rose by 73,1 per cent. After a further increase of 50 per cent in rock prices was announced on July 1, 1974, it was estimated that the country's trading account would show a small surplus for the year as a whole (see Quarterly Economic Review No 1 1975).

Although the state-owned Office Cherifien des Phosphates could still live with a rock price of $20 – $25 per ton, the country as a whole needs a price in the region of $60 per ton.

Morocco's success in raising prices in 1974 at a time when the world shortage amounted to only about 4 per cent, is significant. From Table 3, the expected world demand will be 165 million tons by 1980, and Morocco's production will be 30 million tons. The export trade in phosphate rock is forecast to amount to approximately 78 million tons by this time (see Westinform Shipping Report No 306, Jan 1975). By withdrawing 6 million tons or roughly 20 per cent of their production from the world market, the Moroccans can create at 4 per cent deficit in world supply, or an 8 per cent shortage in the export trade and maintain the high price. If co-operation with other North African producers can be arranged, a North African cartel could

maintain the high price levels for as long as they wished. It would certainly pay them far better to sell slightly less at the high price level, than to sell full output at prices close to production costs.

Buyer resistance

During the first quarter of 1975 fertilizer usage in most European countries dropped by 20 to 30 per cent. This is being attributed partly to the inclement weather which has interfered with normal agricultural practice, and partly to farmer resistance to the high cost of fertilizer. During 1974, however, fertilizer demand remained high in most countries, despite the rapid increase in fertilizer prices. Rising prices for agricultural produce more than compensated the farmers for increased production costs. On the other hand, many of the poorer developing countries are unable to pay for their fertilizer needs at current prices and may well be forced to accept a lower standard of living.

It is too early to analyse the reasons for the current slump in world fertilizer demand, but if buyer resistance to high prices is playing a significant role, it can only do so for a limited period. Apart from the fact that people gradually adjust to a shift in the relative values of various commodities, past levels of agricultural production can not be maintained for long under conditions of reduced fertilizer application.

Characteristics of the South African phosphate rock industry in relation to the world industry

By far the largest portion of the world's phosphate rock mining industry is based on sedimentary deposits which occur in layers no more than a few metres thick, but spread over very large areas, sometimes hundreds and even thousands of square kilometres in size. These deposits are generally near the coast, and more often than not consist of soft sedimentary rock or even unconsolidated phosphatic sands. They are also generally of high grade, analysing from 20 per cent P_2O_5 to 34 per cent P_2O_5, and are covered by a few metres of overburden. Accordingly, they frequently lend themselves to opencast mining in which very large draglines can be used with little or no necessity for drilling and blasting.

Table 5 lists the average thicknesses of ore and overburden for a few of the largest producing areas operating on sedimentary orebodies.

TABLE 5 Ore and overburden thickness of some sedimentary deposits

Area	Overburden metres	Ore bed metres
Florida	4,6	9
North Carolina	27,4	12,2
Morocco	9—10	2
Spanish Sahara	10—30	4

When the overburden is shallow, open-cast mining techniques are applied. Underground mining is practiced when thick overburden of sufficient strength is encountered.

Most of the existing mines are within 100 km of the coast and many of the orebodies do not require expensive and sophisticated ore-dressing techniques such as crushing, milling and flotation. In many cases, especially in North Africa, the rock as mined can be sold as merchant grade phosphate rock, whilst in some cases a simple washing and drying process is all that is needed to produce saleable material.

Phosphate rock is produced on a significant scale from igneous complexes only at Phalaborwa and at Kola in the USSR. By contrast with the sedimentary deposits, the igneous complexes are ancient volcanic pipes of relatively small surface area, but deep vertical mineralization. They also consist of hard rock which requires extensive drilling and blasting. The Russian operation is blessed with high-grade ore (18 to 22 per cent P_2O_5) and a distance of less than 200 km from the nearest port.

In contrast with the high-grade orebodies elsewhere, the average head grade of the ore at Phalaborwa is 6,7 per cent P_2O_5, making it the lowest grade of phosphate ore mined commercially in the world. From Table 5 it is seen that in most cases between 0,5 and 5 tons of overburden have to be removed for every ton of ore mined. If further processing of ore is required, eg washing, milling and in some cases flotation, only 1,5 to 2 tons of material need be treated to yield a ton of merchant grade rock. At Phalaborwa the production of a ton of merchant-grade rock requires drilling, blasing and haulage of 7 tons of ore and 1,5 tons of waste, and crushing, milling and flotation of 7 tons of ore. The low-grade, hard ore immediately puts Foskor at a sizeable disadvantage vis-a-vis most other producers.

In terms of transport to final destination South Africa also has an enormous disadvantage compared to North Africa. Phalaborwa is more than 1 000 km by rail from Richards Bay, and so much further from Europe than the North African producers that the ocean freight disadvantage amounts to as much as $10—$15 per ton.

The only advantages that we do have are that we have 20 years experience in mining low-grade ore and making a success of it, and that we produce a high-grade phosphate rock. Phalaborwa rock has a grade of 80/81 BPL while the average grade of rock in the export market is 72/74 BPL. In times of scarcity high-grade rock commands premium prices and in times of surplus production the sales of high-grade rock are the last to suffer.

In this paper it has been shown that South Africa has the ore reserves and the technology to produce exportable surpluses of phosphate rock. We also have the wherewithal to produce exportable surpluses of phosphatic products such as phosphoric acid, fertilizers and industrial phosphates. The

economics of such exports depend entirely on the prices that these commodities can command in the export market.

The North African phosphate rock producers have compelling reasons for maintaining high price levels for phosphate rock, which should of course mean high price levels for all phosphatic products.

However, world markets are notoriously unpredictable, and we should never lose sight of the fact that our long distances to port and to European user markets leave us with an inherent cost disadvantage vis-a-vis the North African states. The latter have a larger cushion between current production costs and sales prices than we have.

One question remains to be answered. Would it be desirable to export phosphate rock as such or should we always convert our total rock output to processed products of higher sales value? I believe the answer to be affirmative. In the first place, expansion of output, whether it be of rock, phosphoric acid or fertilizer, simply does not follow a smoothly rising curve. An expansion to a mine cum ore-dressing plant, to a phosphoric acid plant, or to a fertilizer factory takes place in steps of economic size. For this reason alone there will inevitably be times when surplus rock is being produced.

Secondly, the production of phosphoric acid for export is tempting because the fact that it is a liquid greatly simplifies shiploading and unloading in comparison with solid products such as rock or fertilizer. Also, as an intermediate, it is very acceptable to countries that wish to produce fertilizers but lack the capital and technology to build phosphoric acid plants. However, it would be a mistake to install sufficient phosphoric acid capacity to process the total output of surplus rock over and above domestic needs. The production of single and double superphosphate both require phosphate rock. It could easily happen that the growth in domestic fertilizer requirements will dictate that surplus rock be diverted from phosphoric acid manufacture to fertilizer manufacture at a time when world market conditions do not warrant further additions to the country's phosphate rock production capacity. The result would be under-utilization of installed phosphoric acid capacity and concomitant adverse effects on the economics of phosphoric acid production.

The third reason is the most important one. The world supply/demand patterns for phosphate rock and its derivative products are seldom in phase. At the moment Morocco, the USA, South Africa, Tunisia, Spain, Iran, the Levant, Israel, Algeria and Jordan are gearing up for massive phosphoric acid exports. Together, it is expected that they will be responsible for an increase in the world phosphoric acid trade from 925 000 tons in 1974 to 6 300 000 tons by 1980 (see Westinform shipping Report No 306). Forecasts indicate a world oversupply of phosphoric acid by 1976, while the world phosphate rock supply is expected to be tight until at least 1978. (Windridge & Isherwood; see also Westinform Shipping Report No 306).

Some countries that produce both rock and phosphoric acid have already indicated that they would supply rock to foreign customers only if specified quantities of phosphoric acid were also purchased.

Clearly, South Africa as a whole would be in a far stronger marketing position if we could offer rock, phosphoric acid and fertilizer at any given instant. Together, South Africa's phosphate rock industry and its fertilizer manufacturers have a golden opportunity to turn the country's phosphate industry into a very substantial earner of foreign revenue. This is a highly worthwhile goal, but to achieve it excellent co-operation between the rock producing industry, the fertilizer manufacturers, the South African Railways and the Government will be needed.

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