AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523

BIBLIOGRAPHIC INPUT SHEET

FOR AID USE ONLY

1. SUBJECT CLASSIFICATION

A. PRIMARY
Agriculture AF25-0000-G635

B. SECONDARY
Soil fertility,fertilizers,and plant nutrition--India

2. TITLE AND SUBTITLE
Phosphate rock: elusive,valuable ore (discovered at Jhamar Kotra,Rajasthan,India)

3. AUTHOR(S)
Young,R.D.; Davis,C.H.

4. DOCUMENT DATE
1970

5. NUMBER OF PAGES
6p.

6. ARC
ARC

7. REFERENCE ORGANIZATION NAME AND ADDRESS
TVA

8. SUPPLEMENTARY NOTES *(Sponsoring Organization, Publishers, Availability)*
(In War on hunger,v.4,no.2,p.13-17)

9. ABSTRACT

10. CONTROL NUMBER
PN-RAA- 166

11. PRICE OF DOCUMENT

12. DESCRIPTORS
Phosphate deposits
India

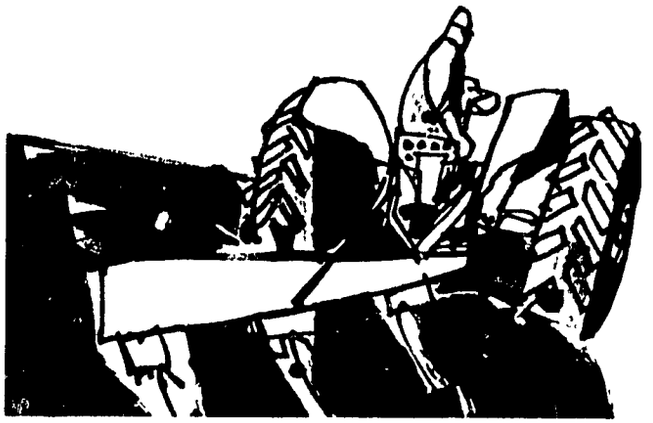
13. PROJECT NUMBER

14. CONTRACT NUMBER
PASA TA (QA) 6-69 GTS

15. TYPE OF DOCUMENT

AID 590-1 (4-74)

10



THE TECHNICAL FRONT

PHOSPHATE ROCK: *Elusive, Valuable Ore*

By Ronald D. Young and C. H. Davis

Phosphate is one of the three essential nutrients of plant growth. Along with nitrogen and potash, it is found in fertile soils throughout the world. Where it is lacking, it must be added in the form of fertilizer. Free world consumption for 1968 was about 17 million metric tons of nitrogen fertilizer, 13 million metric tons of phosphate fertilizer, and 10 million metric tons of potash fertilizer.

Nearly all fertilizer phosphorus comes from phosphate rock, which is found in a variety of geological deposits throughout the world. Several developing countries mine phosphate for fertilizer production; many more either have deposits which are being considered for exploitation or are searching for deposits of commercial value.

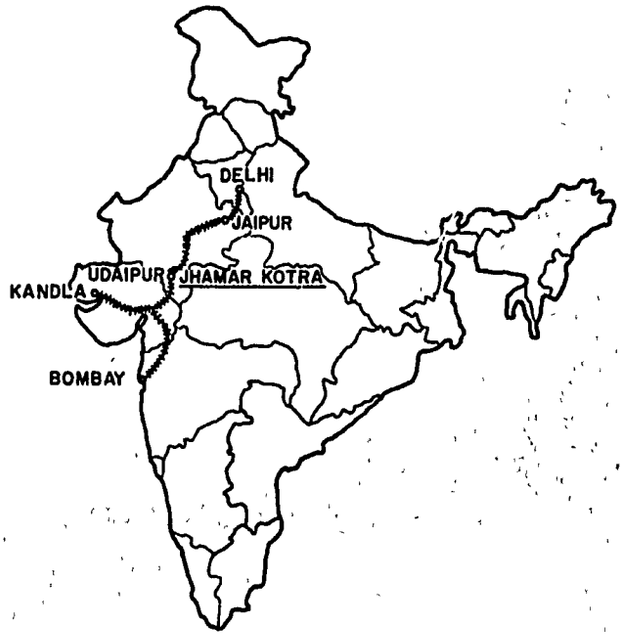
India, for one, seems to have "struck oil" in the form of an important discovery of phosphate ore at Jhamar Kotra, near the picturesque lake city of Udaipur in southwestern Rajasthan State. The absence of any appreciable phosphate minerals suitable for use in fertilizer production has been a key problem in planning and implementing India's fertilizer program. The need for importing large tonnages of phosphate ore to support the planned production of phosphate fertilizers imposes a significant cost factor and a substantial outlay of foreign exchange. With the Jhamar Kotra discovery, India might begin taking the first steps toward self-sufficiency in phosphate fertilizer production.

Mr. Young is Chief of the Processing Engineering Branch of the Tennessee Valley Authority, Muscle Shoals, Ala. Mr. Davis is a member of the International Fertilizer Development Staff there. The TVA, which is uniquely qualified in matters of fertilizer production and plant design, works closely with the Agency for International Development to help developing nations meet their constantly increasing fertilizer needs.

The use of domestic phosphate is attractive to many developing nations because it may cost less than imported rock, it reduces foreign exchange requirements, domestic production soon becomes a source of national pride, and many more jobs are added to the national economy through local mining, beneficiation and transportation.

Careful Testing Required

However, utilization of some phosphate deposits is neither technically nor economically feasible, and preliminary evaluation can save much time and money. Quick laboratory methods for characterizing phosphate rock and forecasting its potential for fertilizer processing have been worked out by the Tennessee Valley Authority researchers at its National Fertilizer Development Center in Muscle



Jhamar Kotra, site of a major phosphate discovery, is easily accessible to many large cities in India.

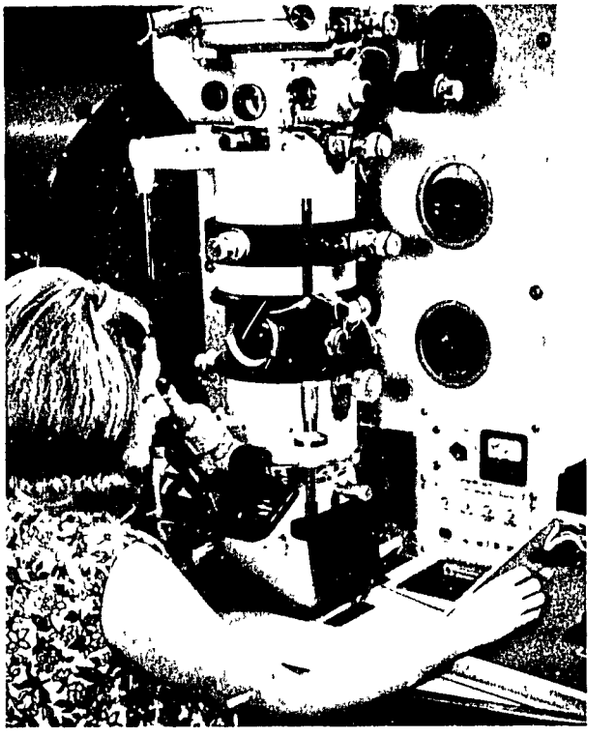
Shoals, Ala. TVA makes these services available to developing nations through the Agency for International Development.

Since 1963, TVA has furnished AID with 40 teams to help 20 developing nations. Some 30 publications report the findings and experiences of these teams. The Agency financially supports TVA's facilities and staff to maintain a world fertilizer information service and to conduct training courses in fertilizer production, marketing and use for technicians and visitors from the developing nations.

"Phosphate rock" is a general term for natural ores containing substantial amounts of phosphorus. Actually, there are many phosphate rocks. Deposits differ in physical texture, mineral form in which the phosphorus occurs, and in the nature and abundance of impurities.

In studies of more than 300 rock samples from a collection of about 500 samples from all parts of the world, TVA scientists have found no two samples identical in physical and mineralogical properties. Thus, phosphate deposits are often impossible to characterize without extensive tests.

Their wide variety of forms makes deposits difficult to find. Sporadic efforts to locate phosphate minerals in India had been essentially fruitless until the AID-sponsored visit of noted geologist Dr. R. P. Sheldon a few years ago. He suggested several specific areas for search and provided tips on types of formations to explore. As a result, the Geological Survey of India located some prospects in the Mussoorie area of the Himalayan foothills in extreme northern India and in the Jaisalmer district of Rajasthan State. These indications were mainly low-grade, marginal ores with high impurity content; and the deposits in the Himalayas were in a very remote area and would require expensive underground tunnel mining.



The electron microscope, which can be used to magnify crystals more than a million times, helps determine the structural type of phosphate minerals.

Jhamar Kotra Discovery

Following the same leads, some small deposits that appeared more promising were located near Udaipur. In September 1968, geologists discovered the deposits at Jhamar Kotra, where good high-grade and medium-grade phosphate ore appears in thick beds very near the surface. The find has been called one of the most exciting mineral discoveries of recent years.

The results of core drillings and early geological mapping indicate total quantities ranging from 60 million to 100 million tons. The ore is in thick veins, ranging from 90 to 280 feet. A large part of the deposit is easily accessible for direct surface mining. Large-scale mining by mechanical means or a combination of blasting and mechanical removal will probably be practical.

Exposed outcroppings of the ore at the surface have a rough appearance, which local people refer to as "magar machi", crocodile stone. This rather common-appearing material had been overlooked for years.

Mineralogical Properties

Once ore is located anywhere in the world, it must be analyzed. TVA researchers have found that similarities in chemical composition of phosphate rock may obscure differences in mineralogical type. For example, simple chemical analyses may show two deposits to contain the same amount of phosphorus. But to assume that they should be processed in the same manner could be disastrous. Their mineral form may be so different that they require totally different processing for efficient use. On the other hand, deposits of the same mineralogical type but substantially different in phosphorus content might be processed in a

In some phosphate deposits, impurities are present as distinct grains (left) and can be separated out by physical treatment. In others, impurities are part of the crystal structure (right) and cannot be removed physically.

similar manner.

Thus, one of the first steps in evaluating a phosphate deposit, in addition to finding out how much phosphorus it contains, is to describe its mineralogical properties. TVA does this primarily by a combination of chemical analyses, optical and electron microscopic studies, and x-ray diffraction. The results provide guidelines for upgrading and processing the ore.

For such analyses to be really useful, phosphate samples should be collected by responsible geologists. On some occasions, analysis of unrepresentative samples has proved quite misleading about the true character of the ore.

Petrographic studies by Indian and American experts have characterized the Jhamar Kotra deposit as a metasedimentary formation of the Precambrian period. This means that the material is quite old geologically—about 500 million years. The type of formation is quite unusual, and the very high grade (37 to 40 percent phosphate for a large part of the material as mined) is matched by only a very few commercial deposits.

The high-grade Jhamar Kotra ore is almost pure apatite that is essentially nonsubstituted. "Pure" apatite is that which contains only calcium, phosphorus, fluorine and oxygen in a very stable structure.

Most phosphates in commercial ores are not pure apatite; some calcium has been replaced by sodium and magnesium, some phosphate by carbonate, some oxygen by fluorine, or any one of the four basic elements by other impurities. This substitution weakens the crystal structure of the ore, lowering its chemical and thermal stability. The abundant lower grade Jhamar Kotra material (20 to 25 percent phosphate) has limestone as the main impurity. Iron, aluminum, and fluorine impurities fortunately are quite low in essentially all the material. With substantial removal of the limestone impurity, the "beneficiated" ore would have about the same composition as the high grade.

Processes for Upgrading

Phosphate ore is often upgraded at or near the mine by physical means, such as washing, screening, grinding or flotation. This is called beneficiation, and it raises phosphorus content by removing unwanted materials. Ore can also be upgraded by heating (calcination). Sometimes both methods are used.

The "best" way to upgrade a phosphate ore will depend on its mineralogical properties and can be accurately determined only through tests. Simply borrowing technology which worked well on another deposit invites trouble

and may waste valuable time and resources. A nation striving to develop a fertilizer industry can afford neither. TVA studies have turned up many examples of needless—even harmful—beneficiation steps.

Impurities Often Present

In some phosphate deposits, impurity minerals are present mainly as distinct grains separate from the phosphate mineral grains and can usually be separated by physical beneficiation. The phosphate concentrate is then reacted with sulfuric acid to produce either normal superphosphate or phosphoric acid. It can also be reacted with phosphoric acid to make triple superphosphate.

In other phosphate rocks, however, the impurities may occur largely as part of the crystal structure of the phosphate mineral and cannot be removed by any physical treatments. This may limit its usefulness for some processes; for example, it may not be well suited for treatment with sulfuric acid to make phosphoric acid because of the type and quantity of impurities that are unavoidably introduced.

Nitric acid treatment works well with some ores that are hard to beneficiate or which contain excessive amounts of impurities. In this chemical beneficiation process, the impurities can be filtered off since they dissolve more slowly than the phosphate. Nearly all of the phosphate is recovered in a form suitable for production of nitric phosphate fertilizers.

Economics Plays a Part

Economics within a particular country, or even among different locations within the same country, will be a major factor in deciding which process to use and what fertilizers will be made. Normal superphosphate will be attractive in some situations, triple superphosphate in others. Sometimes nitric phosphates will be best. Or, reduction of rock to phosphorus in electric furnaces may be desirable where low-cost electric power is available. But economics is not the whole story. The choice also must be compatible with the type of rock available.

Once laboratory evaluations have pointed to the "best" process and products, it may be desirable to run small-scale tests to fully evaluate all factors connected with the particular rock. TVA often makes such tests in "bench-scale" equipment, which produces only a few pounds of product per hour.

If needed, more precise information is obtained in pilot plants. Although fairly small, these plants resemble commercial operations. Feeding is continuous, and production rates are as high as a ton per hour. TVA has pilot plants for testing nearly all established processes that use phosphate rock as a raw material.

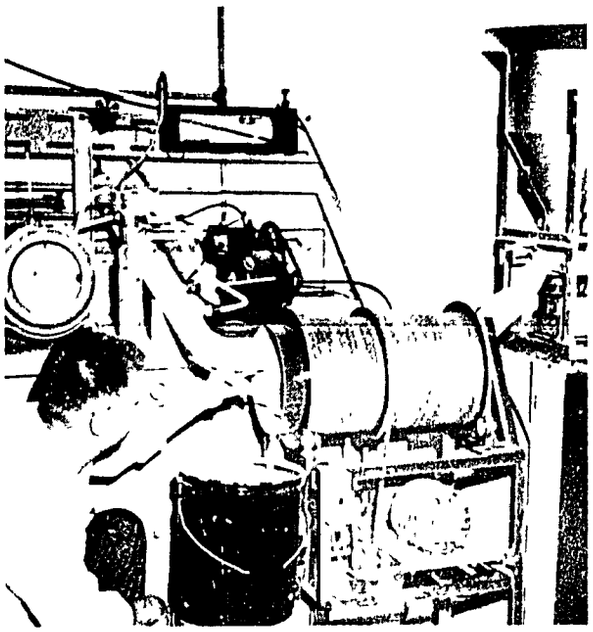
Workers mine the Jhamar Kotra phosphate deposits by hand until more modern methods can be initiated.

Direct Application

TVA mineralogical studies and related greenhouse tests have provided insight as to why some phosphate rocks produce good crop response when applied directly to the soil. The key is the extent to which the basic mineral has been altered by substitution of other chemical elements in its structure. Ores which contain an apatite mineral with a high degree of chemical substitution are sufficiently soluble to supply phosphorus to some crops. In pot tests with pine seedlings, rice, and corn, for example, rocks with the greatest substitution were shown by TVA to be almost equal to superphosphate for supplying phosphorus to these crops on some soils.

The solubility of various rocks in citrate solutions is closely related to their degree of substitution and to agronomic effectiveness. Thus, a rather simple test of dissolution of the phosphorus in ammonium citrate or in citric acid is also useful to estimate effectiveness of a rock source for crop production.

If applied directly to soil, rock phosphate should, of course, be finely ground. Application of unground rock phosphate is not recom-



Small-scale tests are useful in evaluating the merits of particular deposits for fertilizer production.

mended even for the most soluble rocks.

Results of early testing at Jhamar Kotra have indicated that about a third of the ore there can be mined and used in further fertilizer processing without any treatment other than grinding. Test quantities have also been used with good results in an ordinary superphosphate plant at nearby Udaipur, and early evaluations indicate that the material should be suitable for either acid treatment or for electric-furnace processing.

All is not entirely favorable, however. The phosphate ore is a very dense material that may be rather difficult to crush and grind finely. Also, early tests indicate that it probably will be somewhat less reactive in treatment with acids than the usual commercial Florida or North African rocks.

The problems of the search and the testing are likely to prove very worthwhile for India, as they might for many developing nations. With India's projected requirements of two to three million tons of phosphate ore in 1970-71 and increasing to about five million tons by 1973-74, the Jhamar Kotra discovery is likely to become very significant.

Potential Economic Significance

If half of the country's 1970-71 requirements for phosphate rock could be supplied by native material, a saving of about $30 million would result. If most of the requirements projected for 1973-74 could be supplied, the saving in foreign exchange would be $75 to $100 million.

Aside from these critical foreign exchange benefits, it appears likely that there will be a decrease in cost for the local phosphate ore processed near the mine site or delivered to major fertilizer plants in India. Interest already shown by a number of fertilizer producers in India seems to assure a ready market. Some have already contracted for substantial quantities for testing. Studies and evaluation of prospects for using the ore in a major fertilizer production complex constructed at the mining site will undoubtedly follow. In any event, the mining site is only seven miles from a main railroad line, and construction of a rail connection will impose no major problems. That connection will allow ore to be moved south to Bombay, north to Jaipur and New Delhi, and west to the port of Kandla in Gujarat State.

Progress made to date and support being given by the State Government of Rajasthan and the Government of India should assure adequate and rapid development of the Jhamar Kotra deposits—another encouraging step in India's struggle toward self-sufficiency in industry and agriculture.

Response of pine seedlings reflects wide range of mineralogical differences in phosphate ores from a variety of deposits.

Reprinted from

War on Hunger

A Report from The Agency for International Development

Volume IV, No. 2
February 1970