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THE U.S. PHOSPHATE INDUSTRY AS A SOURCE OF U_3O_8 TO THE YEAR 2000

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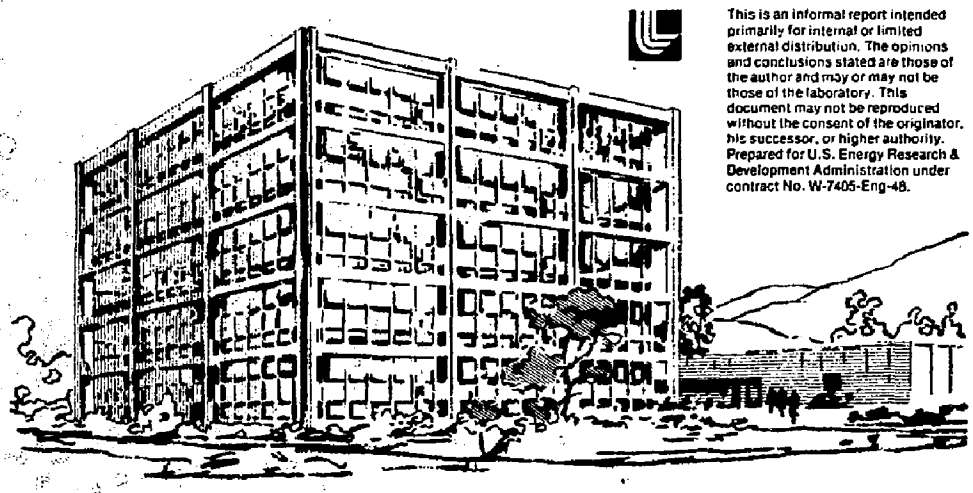


A B S T R A C T

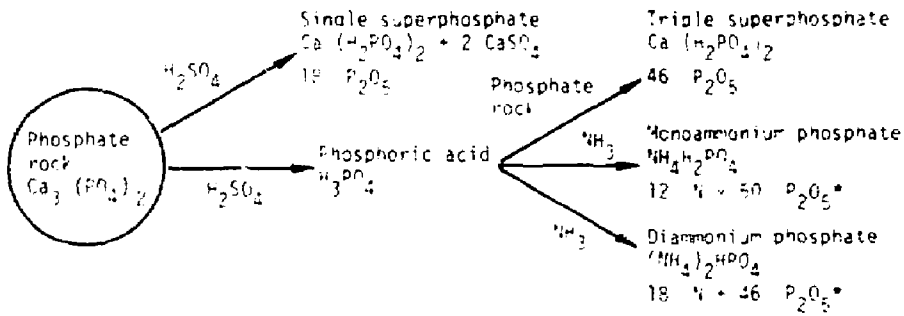
U_3O_8 recovered as a by-product of the phosphate fertilizer industry may equal 3600-5200 tons by 1985 and represent 7-10% of the anticipated annual U.S. demand. If the enormous U.S. phosphate reserves and resources are mined primarily for their uranium content they appear sufficient to fill more than twice the projected cumulative U.S. demand to the year 2000.

In the early fifties a concerted effort was made to find and develop domestic uranium supplies. Among the low grade sources of uranium that were investigated were the phosphate deposits that are exploited primarily by the fertilizer industry. They contain 100-200 ppm U_3O_8. A large number of projects were funded by the government in order to develop processes to remove the U_3O_8 either before the phosphate rock was processed by leaching techniques or from phosphoric acid during the production of the phosphate fertilizers (Figure 1). These extraction techniques were not uniformly applied by all fertilizer manufacturers. The high cost of recovery--between $10 and $30 per pound--made the by-product uncompetitive with conventionally mined U_3O_8. As late as 1971 many commercial fertilizers contained appreciable amount of U_3O_8 (Figure 2). Nevertheless, about 500 tons of U_3O_8 were recovered between 1953-1961.[8]

As increasing amounts of phosphate ores have been put through the wet phosphoric acid process and the price of U_3O_8 has increased, both industry and government have continued to survey the situation. Research has been designed to reduce costs[8] and improve the processes for recovery.[9] Part of the phosphate industry set up recovery systems in the late 50's including Blockson Chemical Company, Division of Olin Mathieson Chemical Corporation, Joliet, Illinois, International Minerals and Chemical Corporation, Bartow, Florida and U.S. Phosphoric Products Division, Tennessee Corporation, East Tampa, Florida.[10] In recent years the larger phosphate companies have been sub-contracting with such companies as Uranium Recovery Corporation, Westinghouse and Gulf R&D Corporation of Gulf Oil to install U_3O_8 recovery plants.[2,3]

Figure 1

Production of phosphate fertilizers



*Compositions given are typical compositions in the fertilizer trade, but compositions may vary over a range of about 10 % depending on the type of phosphate rock used and the process variables.

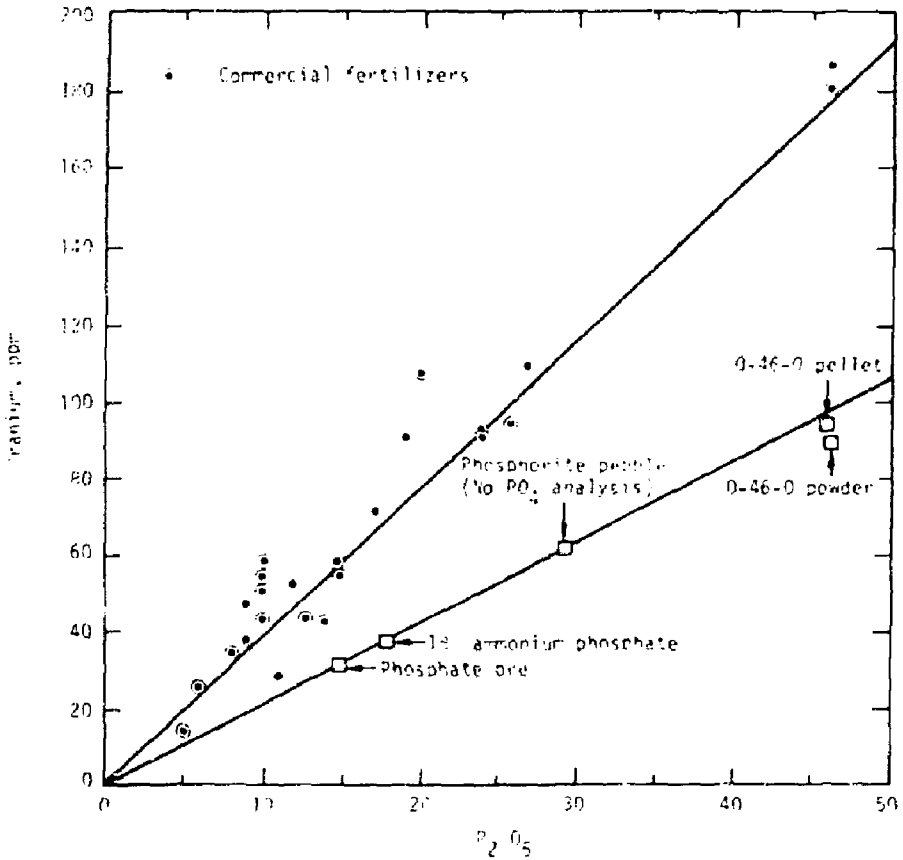


Figure 2. Uranium and P_2O_5 in commercial fertilizers (solid circles) and at various stages in a phosphate fertilizer processing plant (squares) - circa 1970.

TABLE I

U_3O_8 Contained in Phosphate Deposits

	1972	1980
U.S. Annual Domestic Phosphate Demand*	4.7[1]	6.5[1]
U.S. Production of Phosphate*	6.5[1]	8.0-11.5[1,3]
U_3O_8 Contained in Produced Phosphates**	2.95[2]	3.6-5.2

P_2O_5 - U.S. Reserves[4]*		Contained U_3O_8**
Identified	3,210	1,460
Hypothetical	6,190	2,810
Total	9,400	4,270

	1985	2000
U.S. Annual Demand for U_3O_8**	53[5]	90-150[5,6]
U.S. Cumulative Demand for U_3O_8**	372[5]	1500-2400[5,6]

* in million metric tons of P_2O_5

**in thousands of metric tons U_3O_8

One of the more attractive processes is offered by Gulf. The recovery unit is a plant mounted in truck trailers. U_3O_8 is removed by solvent extraction using organic solvents. Currently six major producers have signed contracts and four remain uncommitted until they have had a chance to evaluate all available processes and the price of uranium. The price determines the royalties which the producers can reasonably demand of the uranium extractors. Gulf officials claim the process is profitable with the price of U_3O_8 in the $6.50-$8.00 price range.[12]

Most importantly from the standpoint of appraising the impact of the by-product on the uranium industry and its resources is the fact that the uranium extractors now feel they can estimate that 1 lb. of yellowcake (U_3O_8) will be recovered per ton of P_2O_5.[2] Currently they estimate 1600-1800 tons of yellowcake can be recovered annually from the acid streams of the six large processors and a third more can be recovered if the smaller producers are added.[2] Over the long term Gulf estimates a potential of 3000 tons/year for the next 50 years.[12]

An independent estimate of U_3O_8 recovery is given in Table 1. Because of increased demand, both domestic and world-wide, for phosphates (Figure 3) by the year 1985 between 3600 and 5200 tons of U_3O_8 will potentially be salvagable. This represents 7-10% of the anticipated annual demand in 1985[5]. To recover it requires that all phosphate producers cooperate and that super phosphates rather than unprocessed phosphate rock be exported. This surely is optimistic, but none the less possible. By estimating the total P_2O_5 production in the years 1973-2000 to be 249 million tons, 112,000 tons of U_3O_8 are potentially recoverable. This is an average of 4100 tons per year for the 27 year period and probably is an upper limit to the amount that can be recovered as a by-product. This figure agrees favorably with the Gulf estimate of 3000 tons.

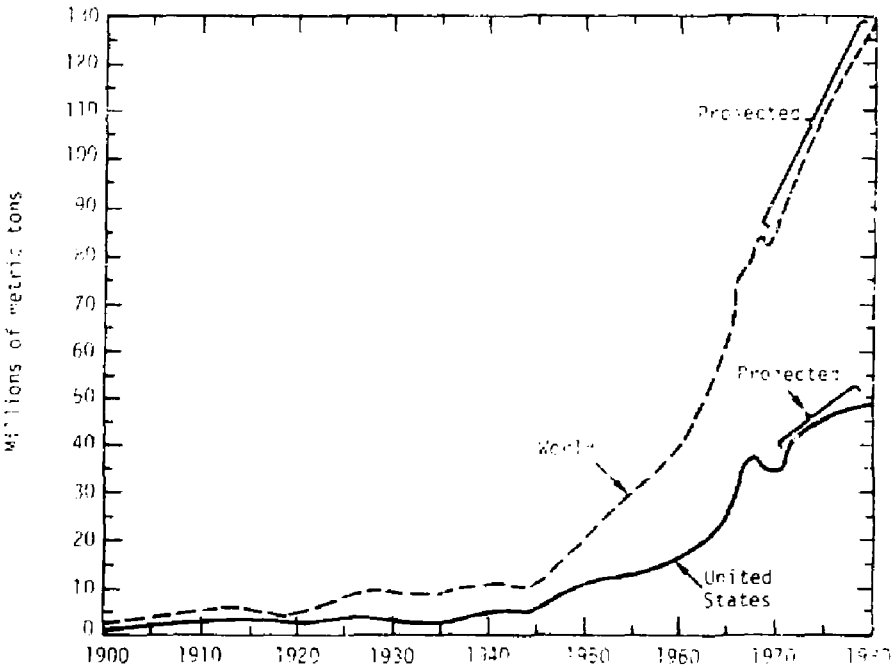


Figure 3. Phosphate rock production for the years 1900-1972 and projected to 1980. For the years 1900-1965 the curves are drawn on a yearly basis. The projections from 1973-1980 are based on estimated demand and, therefore, it is assumed that this demand will be met by increased production (Ref. 3).

If the phosphate deposits were mined for uranium, an enormous reserve could be taped. "Identified", meaning mineral deposits that may or may not be evaluated as to extent and grade, and whose contained minerals may or may not be profitably recovered, are sufficient to meet conservative demands of 1,500,000 tons[5] of U_3O_8 by the year 2000. "Hypothetical resources", meaning undiscovered deposits, whether of recoverable or subeconomic grade, that are geologically predictable as existing in known districts, contain another 2,810,000 tons (Table 1).

January 1, 1974 the export price for unground phosphate rock containing 35% P_2O_5 was $19/ton f.o.b. Florida[3]. Thus a ton of P_2O_5 and its contained one pound of U_3O_8 is sold for $54 per ton. It is likely that if phosphates were mined exclusively for their U_3O_8 content and a cheap process were developed to extract it, the cost of the uranium would be of this order, i.e. $50-60/pound.

Another potential source of U_3O_8 occurs in the Florida phosphate districts in the form of a leach zone within altered friable phosphatic sandstone. Although extensive at one time, it has systematically been removed with the overburden during normal phosphate mining. In 1971 54,600 tons of U_3O_8 were considered recoverable from the zone at a price of $67 per pound.[8] These calculations assume a 42% overall recovery. In view of the recently perfected organic solvent extraction processes, it is possible that the recovery rate could be increased and the cost of extraction lowered. Alternatively, the leach zone may be amenable to <u>in situ</u> recovery processes.

In resume then, the phosphate industry can fill about 7-10% of the annual U.S. demand for uranium by virtue of increasing fertilizer production and large reserves. U_3O_8 can be recovered as a by-product using existing technology. If the decision were to be made to mine the phosphate primarily for its uranium content, the amount of U_3O_8 contained in the phosphate deposits

is sufficient to fill more than twice the projected accumulative demand to the year 2000. It is noteworthy that the Soviet Union and Morocco have recently signed an agreement to study the possibility of extracting uranium from Morocco's phosphate deposits. Morocco has about half of the world reserves of phosphate rock.[13]

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