Program for geological research on phosphate deposits of Turkey

by

Richard P. Sheldon

United States Geological Survey

NOTE: Distribution limited to US AID/Turkey and appropriate offices AID/W.

Program for geological research on phosphate deposits of Turkey

by

Richard P. Sheldon
United States Geological Survey

In deciding on a geological program for phosphate rock research, several basic premises must be made at the outset. The first and most important is that the program will be of optimum size and structure, and sufficient money appropriated to achieve this goal.

The second premise is that this program is aimed at supplying the scientific background that is necessary for intelligent exploitation but is not intended to supply or duplicate the geologic work that properly is the responsibility of the exploitation companies themselves. This point needs amplification. There is a basic difference in the interests of governmental geologic research and the geologic work of exploitation companies, either private or public. The government geologic research is aimed at stimulating and increasing the productivity of the total mining effort of the country, whereas exploitation geologic work is aimed at increasing the productivity and the competitive position of the company doing the work. The government geologic agency should have the goal of disseminating geologic data and ideas, whereas the exploitation company of competitive necessity usually keeps its results secret.

This difference of interests means that in order to achieve the necessary cooperation between industry and the governmental research agency, there should be little or no overlap in work and the research should be of the type required and asked for by industry. That is, it should consist of research that is beyond the scope of any individual company but still necessary to intelligent exploitation. Such research studies include among other things regional stratigraphic analysis, mineralogic and petrographic studies, and quadrangle mapping.

A third premise is that Turkish geologists will carry this work out. Insofar as special knowledge and experience are required and requested to expedite the program, American scientific help should be supplied. The reason for this is purely practical. The study of the Turkish phosphate deposits is likely to continue for a number of years, and the experience to be gained in the study should accrue to Turkey. American scientists take their Turkish experience back to America when they leave, and this represents a great loss to Turkey, which is already relatively poor in numbers of geologists and geologic experience.

Fields of research.--Three main fields of research need to be undertaken. They are stratigraphic field work, laboratory and office studies, and detailed field mapping. Each of these fields is described below in general terms. It is impractical to attempt to present any detailed program, as the finer points of such a program need to be evolved as the program progresses. For this reason, it seems wise to begin the program on more or less of a pilot basis and expand it as it becomes practical.

Stratigraphic field work.--This work involves: 1) the measuring, describing, and sampling of the phosphate bearing formation and, 2) collecting of fossils from the phosphate bearing formation and their study.

To date no definite minable phosphate deposit that is competitive on the world market has been discovered, so that much hard geologic work must be done to capitalize fully on this discovery. Today we know that phosphate rock occurs in Turkey but we don't know if and where minable deposits occur. The first chemical analyses to be received of the rock so far discovered are somewhat discouraging in that they show lower P_2O_5 values than field chemical tests indicated. Also the thicknesses of the phosphatic zones are not as great as one would wish. However, preliminary field studies also indicate fairly large variation of thickness and probably P_2O_5 grade across facies strike, that is going from shallow to deeper water rocks. Thus there is a good chance that good deposits competitive on the world market will be found even if the so-far-discovered deposits prove to be less than competitive.

The principal job for the present, then, is to begin exploring outcrops. So far only three small areas of outcrops have been studied and extensive outcrop is yet to be examined.

Trenching, sampling, measuring and description of the rocks by the geologists of M.A.C. have been started in the Kilis, Karababa Dag, and Mardin areas. This work is described in the previous geologic section of my report. This work is only a bare beginning but illustrates the type of work to be done. Reference to reports of the U.S. Geological Survey on the northwestern phosphate field of the United States will serve as additional illustrations. This type of work is somewhat specialized, and some previous knowledge of phosphate deposits is desirable. Also, a paleontologist is essential to the success of the stratigraphic study.

At least one field assistant should be assigned to the project for each geologist, and, depending on the work, perhaps more. These assistants should have geologic training and either be students or recent graduates. In view of the fact that geology students from Turkish universities get little or no field work, I would strongly recommend students be hired in any event, if no more than to give these young men some field experience. However, in view of the spring and fall field season of southeastern Turkey, it probably will be necessary to hire recent graduates as assistants. As these assistants gain experience they can be given such work as supervision of laborers in the trenching operation.

At first it would be desirable to assemble one field team consisting of 3 or 4 geologists and their assistants. The team should probably begin in the Mardin area and should measure and sample the phosphate-bearing formation (and its facies equivalents) about every 3-5 kilometers along outcrop. Also a diamond-drilling program should be started as soon as possible in the Mardin area. If a bulldozer is necessary for trenching it also should be obtained. Several field teams could be formed by hiring several more men or advancing field assistants. Thus, the experienced men can train the new men. By such slow, but geometric, expansion the geologists necessary to do this job can be hired and trained.

It is impossible to say now what the optimum size of the stratigraphic research team should be. Perhaps two field crews of about three geologists and their assistants would be sufficient. Perhaps 3 or 4 such teams may be required. I would estimate between 30 and 100 geologist-years would be required. A large part of these geologist-years of course would be spent in laboratory and office work, as described below.

The success of this program will depend largely on the competence in the geology of phosphorite attained by the men carrying the program out. Such competence is acquired only by experience and study, and special effort should be made to help the senior men assigned to the project. I recommend that several geologists be sent to the United States for training and field experience in American phosphorites. Several field studies on marine phosphorite are currently being carried out by the U.S. Geological Survey in Idaho, California, and North Carolina so that in-service training with the U.S. Geological Survey might be arranged. An alternative to training of Turkish geologists in the United States is to send a phosphorite specialist to Turkey to train Turkish geologists. There are advantages to both approaches, but it seems to me that the experience to be gained in working with an American exploration project and associating with a number of American phosphate specialists rather than just one, outweighs the advantages to be gained by sending an American geologist to Turkey.

Laboratory and office studies.--This work, which must be done mainly by the stratigraphic geologists when they are not in the field, has five objectives: (1) collection and organization of data, (2) laboratory study of rocks, (3) analysis of data, (4) study of geologic literature on other phosphate deposits, and (5) publication of results.

The collection of data consists of literature research for published data on the phosphate-bearing formation; collection of oil-company data including cuttings, cores, and mechanical logs; and collection of mining-company data including P_2O_5 and other chemical analyses. These

data along with the field data should then be organized and catalogued so as to be readily available. The chemical analytical data particularly need careful organization to avoid mixups in the samples and analyses.

The laboratory study of the rocks includes petrographic, mineralogic, physical properties, chemical and paleontologic studies. The petrographic studies, or microscopic examination of rock thin sections, is important both to collect new data on the rocks and to help the field man interpret what he sees in the field with his hand lens. Perhaps the most important economic application of the petrographic work is the information it gives for beneficiation of the phosphate rock. Mineralogic work gives basic data necessary for most of the other studies. For example, the accurate determination of the gangue mineral in the ore is also necessary for beneficiation work. The physical properties of the rocks, such as bulk and powder specific gravities, and porosity, need to be determined for such purposes as reserve calculations, oil company mechanical log interpretations, and beneficiation studies. Chemical studies are of course vital to evaluation of the deposits in terms of both the phosphate content and the content of undesirable elements such as iron and aluminum. The carbonate content of the ore is important to know as it wastes sulfuric acid in the manufacture of fertilizer. Analysis of trace elements in the phosphate rock may lead to recovery of important byproducts. Paleontologic studies are necessary for the stratigraphic study.

Analysis of all these data will yield maps and detailed rock correlation charts showing the extent of rock units, the areas where they change into other rock units, and their variation in thickness throughout the area. Maps showing the areal extent, thickness, and grade of the phosphate rock can then be constructed and reserve estimates can be made. Finally, after the modes of deposition of the phosphorite and other rocks have been studied and understood, clues to the occurrence of the less obvious phosphate deposits will emerge. This possibly could set off a second wave of phosphate exploration.

The literature of other phosphate deposits in the world should be carefully studied. In particular the American, Russian, and Israeli literature should be helpful. The Bibliography of Geologic Literature Exclusive of North America, published by the Geological Society of America, and the Bibliography of Geologic Literature of North America, published by the United States Geological Survey, should prove extremely helpful in locating this literature. Such a study will undoubtedly not only save duplication of effort but will furnish many ideas to be tested on the Turkish deposits.

Publications describing the results of this program are its main product. First, raw data, particularly measured sections and chemical analyses should be published immediately on completion. Then as work in areas such as the Mardin uplift is completed, a preliminary report giving correlation charts, maps, and ideas of origin should be published. Finally, regional monographs should be compiled towards the end of the project. Many topical papers on subjects such as paleontology, mineralogy, and petrography should be published as the studies progress.

Not only are the mining companies that are active at the time furnished new ideas and information, but companies entering the field can be given the encouragement and technical data necessary to get them started.

Most of the laboratory and office studies will be carried out by the field personnel. However, some specialists may need to be hired. A chemist should be hired if the organization does its own analyses. A petrographer and mineralogist are needed, but it is to be hoped that one or two of the field men will have these qualifications. Undoubtedly, some permanent clerical help will be needed for sample and chemical analysis bookkeeping.

Detailed geologic field mapping.--When minable phosphate deposits are located, either by industry or the government research agency, detailed mapping should be done. The mining companies will probably not map the total area of potential, but only the area they are interested in mining. Thus, in order to both delineate the total potential area and to encourage mining, the area should be mapped by the research agency. Also, potential areas that are not being mined should be mapped.

Present geologic mapping in Turkey to my knowledge does not meet rigorous standards required for adequate resource evaluation. In order to properly evaluate a phosphate deposit not only the thickness and grade of the rock but also the extent, depth, and structure of the beds need to be known. The latter can be learned from precise geologic mapping on a sufficiently large scale. Reference to the U. S. Geological Survey quadrangle map series will give examples of this type mapping.

The first requirement for an accurate geologic map is an accurate base map. Apparently the 1:25,000 army topographic maps are sufficiently accurate for this purpose but they should be checked. Their scale is large enough for this work. Next, aerial photographs are necessary to aid the geologist in tracing of rock units and in locating himself on the ground. However, the actual job of mapping should be done in the field and not from aerial photographs in the office. In other words, photo-geologic maps are not satisfactory for this type of resource evaluation, except under special circumstances.

The units to be mapped are rock units or formations which are lithologic entities such as chert, limestone, and shale. Much of the geologic mapping of Turkey has been of time-rock units, that is, rocks of Late Cretaceous, Early Cretaceous, etc., age. This type of unit is not lithologic but depends on the fossils found in the rocks. However, the age of the fossils is subject to change with increased knowledge. The rock unit is not subject to change. Thus, a hard chert unit which would make a good hanging wall in a mine or a soft marl that could be stripped would be mapped, regardless of age.

When these rock units are accurately located and their surface attitudes or dip and strike determined, and if their stratigraphic thicknesses are measured, the subsurface configuration of any unit can be estimated fairly accurately. Thus, the depth and attitude of the phosphatic zones--critical information for resource evaluation--can be calculated. These same maps can then be used to give geologic information necessary for road construction, plant foundation studies, ground-water exploration, pipeline construction, and many other things.

To properly do such geologic mapping requires some years of experience. I recommend that such a specialist be sent to Turkey from the U. S. Geological Survey for two years to map an appropriate phosphate area, perhaps in the Mardin uplift region. Several Turkish geologists would be assigned to work with the specialist in order to learn the mapping techniques. The first year would perhaps be spent with the Turkish geologists assisting the specialist and during the second year the Turkish geologists would each start mapping their own quadrangle under the supervision of the specialist.

This training would be valuable to Turkey over and above the phosphate program. Many of Turkey's geologic problems can be solved by such detailed mapping and the technique should be introduced to the country.

Conclusion

Several countries including Peru and Israel have had phosphate rock discovered within their borders. The first wave of exploration produced no minable phosphate deposits, so the discoveries remained for some time as interesting mineral occurrences. It was only by intense imaginative geologic research that these mineral occurrences were turned into valuable phosphate deposits competitive on the world market. There is a very good chance that the same history will apply to Turkey. But even if phosphorite that is competitive on the world market is not found, there seems to be a good chance that phosphorite deposits that are economic with respect to the domestic market will be found.

Outline of program
for geologic research on
phosphate deposits of Turkey

Immediately Should last about 1 year	Reconnaissance of Upper Cretaceous outcrops for phosphate rock.
As soon as possible	In-service training of several Turkish geologists in phosphorite geology.
Present time to end of program	Formation of one field crew to study phosphate stratigraphy in detail. Formation of other crews as necessary. American technical assistance as required and requested.

Laboratory and office studies

Undertaken concurrently with stratigraphic studies largely by same personnel as in stratigraphic studies. An additional chemist and petrographer if necessary.

Geologic field mapping

To begin as soon as possible. Two-year assignment for one U. S. Geological Survey mapping specialist. Two to four well-trained Turkish geologists to learn techniques. Mapping to be done in one of the phosphate areas in southeast Turkey.