U. S. Geological Survey.

REPORTS-OPEN FILE SERIES, NO. 957: 1967.

[illegible] Int. 2905

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1. Preliminary materials map of the Chester quadrangle, Hampshire and Hampden Counties, Massachusetts, by G. William Holmes. 1 map, scale 1:24,000, 1 table. Massachusetts Dept. of Public Works, 100 Nashua St., Boston, Mass. 02114; and USGS, 80 Broad St., Boston, Mass. 02110. Material from which copy can be made at private expense is available at the Broad St. address.

2. Preliminary materials map of the Massachusetts portion of the Hancock quadrangle, Massachusetts-New York, by G. William Holmes. 1 map, scale 1:24,000, [illegible] tables. Massachusetts Dept. of Public Works, 100 Nashua St., Boston, Mass. 02114; and USGS, 80 Broad St., Boston, Mass. 02110. Material from which copy can be made at private expense is available at the Broad St. address.

3. Marine phosphorite deposits—economic considerations, by James B. Cathcart. 21 p., 1 table.

4. Phosphate exploration in Colombia—[illegible], by James B. Cathcart. 19 p., 1 fig., 1 table.

5. Florida type phosphorite deposits—origin and techniques for prospecting, by James B. Cathcart. 27 p., 1 fig., 2 tables.

6. Distribution and geologic habitat of [illegible] and associated potash deposits, by Robert J. Hite. 35 p., [illegible] figs.

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UNITED STATES DEPARTMENT OF THE INTERIOR

US GEOLOGICAL SURVEY [Reports - open-file series, no. 957]

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PHOSPHATE EXPLORATION IN COLOMBIA--A CASE HISTORY

By James B.achelder Cathcart 1917-

U.S. Geological Survey, Denver, Colorado, U.S.A.

Open-file report

1967

Report prepared for presentation at ECAFE Seminar on Raw Materials,

Bangkok, Thailand, December 4-11, 1967

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Phosphate exploration in Colombia--a case history

by James B. Cathcart

Abstract

Exploration for phosphate rock was successfully carried out in less than 4 months in Colombia. Exploration was based on the theory that phosphorites are deposited in a miogeosyncline, adjacent to a foreland or craton, where deposition of clastic material is at a minimum, and where upwelling currents deposit a suite of rocks characterized by chert, black shale, carbonate rock, and phosphorite.

Previous work had demonstrated that phosphate was present in Colombia, that it was found only in rocks of Cretaceous age, and that the best phosphate was in rocks of Late Cretaceous age in the Eastern Cordillera.

Field work showed that phosphorite deposits were present only in the Eastern Cordillera (in the miogeosyncline) in rocks of Late Cretaceous age. Rocks of Late Cretaceous age in the Central and Western Cordillera are in the unfavorable eugeosynclinal facies and brief reconnaissance did not disclose any phosphorite.

Emphasis during field work was toward the delineation of lithofacies within the miogeosyncline, and the field investigation pointed to the area in Norte de Santander where the best phosphorite was found. Phosphate deposits are present in both the geosynclinal and the platform facies in Upper Cretaceous rocks, and are spread through a large area in the Eastern Cordillera--from Huila in the south to Norte de Santander in the north--a distance of more than 600 kilometers.

Introduction

Exploration for phosphate rock in Colombia was successfully carried out between August and December 1966. The program was sponsored by the U. S. Agency for International Development and was undertaken in collaboration with the Inventario Minero Nacional of Republic of Colombia.

This report is a summary of the exploration technique and the results of the exploration, and is based on the more complete and detailed report by Cathcart and Zambrano (1966).

Many geologists of the U. S. Geological Survey and the Inventario Minero Nacional of the Republic of Colombia assisted in the work. Without their complete and wholehearted cooperation, it would not have been possible to accomplish the work. I would like to thank Dr. Dario Suescun Gomez, Director, and Drs. Francisco Zambrano, Marino Arce and Pedro Mojica, geologists of the Inventario Minero Nacional, and E. M. Irving, D. E. Ward, D. H. McLaughlin, Jr., and C. M. Tschanz, geologists of the U. S. Geological Survey for their assistance.

Previous work

Exploration for phosphate rock in Colombia began as early as 1942 (Hubach, 1952), but with so little success that in a summary in 1960, Wokittel pointed out that there were no known economic deposits of phosphate in the country. In 1961, Bürgl made a reconnaissance study of the Eastern Cordillera which showed that most of the phosphate is in rocks of Late Cretaceous age and that the samples which contained the highest percentages of P_2O_5 are overwhelmingly concentrated in rocks of the Senonian Stage (Bürgl and Botero, 1962). Slansky (1963) concluded that the Upper Cretaceous was the most favorable stratigraphic interval and that the western part of the Eastern Cordillera was the most favorable structural location for possibly economic phosphorite. From 1963 to 1966, work done by the U.S. Geological Survey and the Inventario Minero Nacional had shown that there were scattered outcrops of phosphorite in rocks of Late Cretaceous age from near Neiva in the Department of Huila in the southern part of the country to near Suratá in the Department of Santander in the north. Phosphorite is also known to crop out in Táchira State in Venezuela in rocks of Late Cretaceous age.

General theory of phosphorite exploration

The theory used in exploration for marine phosphorite deposits is based on the pioneer work of Kazakov (1937), who first proposed that phosphate is deposited in areas of oceanic upwelling. His concept was used by McKelvey and others (1953) to explain the deposition of the phosphorite of the Phosphoria Formation of the Northwestern United States, and was later further developed and expanded to define the lateral and vertical sequence of facies common where phosphate-rich waters upwell onto a shoaling bottom (McKelvey, 1963; McKelvey and others, 1959; Sheldon, 1964a, 1964b). The facies concept defines the unique sequence of rocks deposited by upwelling currents, from a black shale and phosphorite facies in the deeper parts of the basin to a limestone and chert facies containing some phosphate to a sandy facies on the shelf. The sandy facies also contains phosphorite beds, but they are usually not as high-grade nor as abundant or thick as the phosphorite beds in the deeper parts of the basin.

The very large amounts of phosphate in the marine phosphorite deposits indicates that the area of deposition must be open to oceanic circulation over long periods of time. Because deposition of this type of sediment is extremely slow, the site of deposition of the phosphorite must be a long distance from a source of clastic or volcanic sediment. If too much clastic material is dumped into the basin of deposition, the phosphate is so diluted that no economic concentration will occur.

The miogeosyncline is the only type of tectonic basin that meets the requirements of being open to oceanic circulation while being away from a source of clastic or volcanic sediment. The study of known economic marine phosphorites shows that most were deposited in a miogeosynclinal environment.

General geology of Colombia

The dominant physiographic features of Colombia are the Andes Mountains, which form a broad, northerly trending belt that extends the entire length of the country. In Colombia the Andes chain consists of three high ranges--the Western, Central, and Eastern Cordilleras, separated by the Cauca and Magdalena River Valleys. East of the Eastern Cordillera is the plain of the Llanos--which includes the Llanos basin and the Guyana shield.

The Western and Central Cordilleras were part of a deep eugeosynclinal basin in Cretaceous time, the Llanos basin and the Guyana shield form the Craton of foreland of the Cretaceous miogeosyncline, and only the Eastern Cordillera contains rocks of the Cretaceous miogeosyncline (Weeks, 1947; Belding, 1955; Burgl, 1961; Campbell, 1965).

Cretaceous rocks of the Eastern Cordillera

According to Bürgl (1961), the floor of the miogeosyncline of the eastern Andean province oscillated during Cretaceous time, leading to repeated marine transgressions, marked in the stratigraphic record by a variety of facies. The stratigraphy of the Cretaceous of the Eastern Cordillera is shown on the correlation chart (Table 1), modified slightly from Burgl (1961).

Table 1.--Near here

Beds of phosphorite are present only in rocks of Late Cretaceous age--in the Guadalupe and La Luna Formations, and field work indicated that they are further restricted to the Galembo Member of the La Luna Formation and the stratigraphically equivalent upper and lower chert units of the Guadalupe Formation. Phosphatic beds are also present in the Villeta Formation and in the Pujamana Member of the La Luna Formation, but the beds contain only sparse phosphate grains and are not likely to be economic.

The Guadalupe Formation consists largely of clastic material--sandstone, siltstone, and siliceous claystone, and some chert, and phosphorite. Black and gray shale and some limestone are present toward the base of the formation. The La Luna Formation consists of black shale, limestone, chert, and phosphorite.

(p. 6a follows)

(after Bürgl, 1961)

European stages			Vicinity of Bogota		Santander		Norte de Santander
Upper	Maestrichtian			Lower Guaduas		Umir	Catatumbo
			Guadalupe	Tierna sandstone			Mito Juan
				Dura sandstone			Colon Shale
	Senonian	Campanian		Upper chert			
		Santonian		Lower chert	La Luna Formation	Galembo Member	La Luna Formation
		Coniacian		La Frontera		Pujamana Member	
	Turonian					Salada Member	
	Cenomanian		Villeta	Exogyra mermeti-Chipaque Lst.			
Lower	Albian			Uno sandstone		Salto Limestone	Cogollo
				Colombiceras horizon		Simiti Shale	
	Aptian				Basal Limestone	Tablazo Limestone	
						La Paja Formation	
	Barremian					Rosa Blanca	Yuruma
	Neocomian	Hauterivian	Caqueza			Tambor Formation	
		Valanginian		Caqueza Sandstone			Rio Negro
		Berriasian		Culebra Slate			
Upper Malm	Tithonian			Sanama schists			

Rocks of Cretaceous age underlying the Guadalupe Formation are dominantly black shale, fine-grained sandstone, and a few limestone beds--the Villeta and Cáqueza Formations. Black shale in the Villeta Formation is radioactive and thin beds of sandy limestone in the formation contain some phosphate (Burgl and Botero, 1962).

Cretaceous rocks underlying the La Luna Formation in the Department of Santander consist of radioactive black shale, limestone, and a basal sandstone. In the Department of Norte de Santander, the Cogollo and Yuruma Formations that underlie the La Luna Formation consist of limestone and shale (table 1). None of the formations contain known phosphate.

The rocks of the uppermost part of the Guadalupe are sandstone. The overlying Guaduas Formation consists of claystone, minor sandstone, and some beds of coal. The Umir, Colón, Mito Juan and Catatumbo Formations, overlying the La Luna Formation in the northern part of the country consist of shale and fine grained sandstone and are not known to be phosphatic.

Paleogeography of the Late Cretaceous

One of the most important criteria in the search for phosphorite deposits is the paleogeography during that period of geologic time when phosphorite was being deposited. The evidence in Colombia was very clear--that marine phosphate was deposited in Late Cretaceous time. Accordingly, a paleogeographic map of that time was prepared. Because data are not precise, the map is at best an approximation, but it is thought to be accurate within the limits of the scale. The position of the foreland or craton is based on the work of Weeks (1947) and Campbell (1965), and the line between the eugeosyncline and the miogeosyncline is modified somewhat after Campbell (1965).

Available published information indicated the miogeosyncline in the latitude of Bogota was narrow and that it widened both to the north and to the south (fig. 1).

Figure 1.--Paleogeographic and lithofacies map of the Late Cretaceous of Colombia, showing distribution of phosphorite.

Lithofacies

The facies change in the miogeosyncline, from clastic at the foreland to black shale-chert-phosphorite in the deeper waters is an important clue to the location of a possible economic phosphate deposit. Thus, each phosphorite locality was carefully examined to determine its position in the miogeosyncline, and its facies. Preliminary field examination indicated that there were at least two facies--a clastic or sandy facies represented by the Guadalupe Formation, and a limestone-black shale-chert facies represented by the La Luna Formation. Both facies contain beds of phosphorite. A series of traverses were made across the miogeosyncline to determine, more accurately, the position of the facies.

East of Bogotá toward the foreland, the Guadalupe Formation consists of a thick section of light-colored clastic rocks that contain only a few thin beds of phosphatic sandstone. The section at Lake Tota, to the north, is similar. The phosphatic sandstone beds are about 0.2 to 0.3 meter thick, and contain a maximum of about 7 percent P_2O_5. The sandy facies, close to the foreland, is thick, and contains only minor phosphate, none of economic interest.

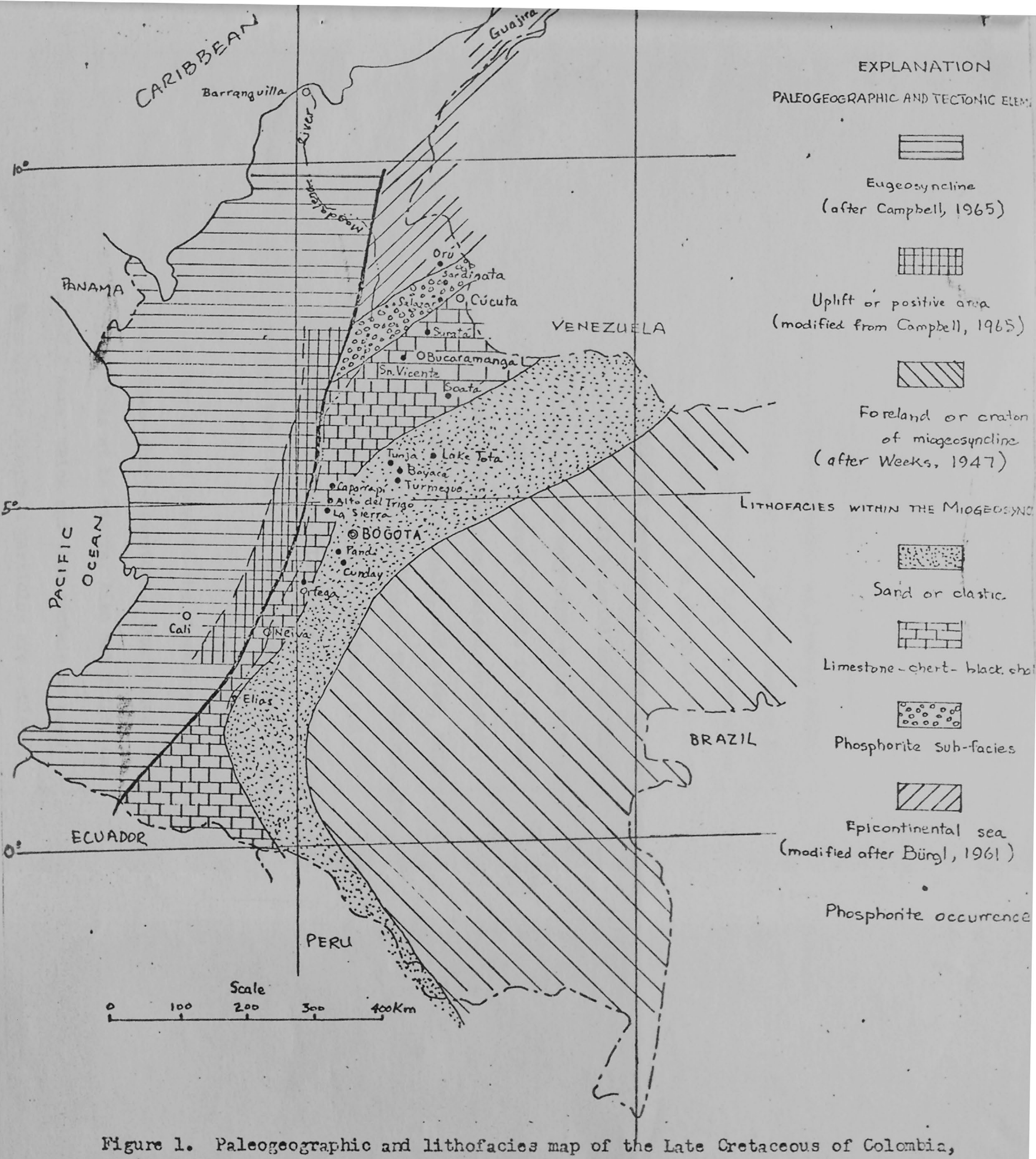

Figure 1. Paleogeographic and lithofacies map of the Late Cretaceous of Colombia, showing distribution of phosphorite.

To the west, away from the foreland, and toward the basin, the sand facies contains good phosphorite beds. At Cunday, Pandi, and Turmequé, for example, phosphorite sand beds are as much as 2 meters in thickness and contain up to 30 percent P_2O_5. Examination of thin sections shows abundant evidence that the phosphate particles were reworked--i.e., there are broken and re-rounded grains, compound grains, broken and rounded phosphatized shell material and so forth.

Fine-grained (silt size) quartz is the only other major mineral phase. Calcite is not present, except in trace amounts in a few of the samples. The associated rocks include fine grained sandstone, chert or siliceous shale, some black or gray shale, and a few, thin beds of limestone. The sequence generally is thinner than the clastic sequence close to the foreland, is ~~generally~~ mostly finer grained, and contains chert beds. The sequence could be classed as a phosphorite subfacies of the sand facies, but field work was not detailed enough to map the subfacies.

Still farther west, in the deeper part of the miogeosyncline the facies changes to black shale-chert-limestone. The facies contain calcareous phosphate beds at La Sierra, Alto del Trigo, and Caparrapí, that are 0.1-0.2 meter thick and that contain as much as 17 percent P_2O_5. Many of the phosphate particles are replaced foraminifers, and other phosphatized fossil material--including fish bones. Very fine-grained, silt-size quartz is present in varying amounts, and calcite is the cementing material.

The lateral sequence of facies in the latitude of Bogotá indicated that better deposits of phosphorite might be expected to the west--toward the Magdalena River. However, a traverse in this showed that near the Magdalena River rocks of Late Cretaceous age consist of a thick series of coarse clastic material that must have been dumped into the basin from the west, probably from the positive area (fig. 1). Thus, the miogeosynclinal basin in Late Cretaceous time was too narrow in its central part for phosphorite deposits to form.

The evidence that the miogeosyncline widened to the north and that the best area in which to look for phosphorite was north of Suratá was confirmed by field work. Phosphate beds in the limestone-chert-black shale facies increase in thickness and in grade northward and westward. Thus, beds near Soatá are about 0.2 meter thick while beds near San Vicente are as much as 1 meter thick and contain more abundant phosphate pellets than the beds near Soatá (fig. 1).

Still farther north, near Salazar and Sardinata, the phosphorite beds are as much as 2 meters in thickness and contain as much as 32 percent P_2O_5. The area is within the chert-limestone-black shale facies, and the phosphorite beds are thick and high-grade. This area has been separated as a phosphorite subfacies of the limestone-chert-black shale facies.

North of Sardinata, near Oru, phosphate beds are present in rocks of Late Cretaceous age, but the beds are thin and low in P_2O_5 content. The phosphate beds are calcareous and are associated with thin beds of limestone, calcareous silty shale, and chert. The facies here may represent deposition in shallower water toward what Bürgl (1961) calls an epicontinental sea facies. The Upper Cretaceous (La Luna Formation) of the Guajira peninsula (fig. 1) is in Bürgl's epicontinental sea facies and consists of thin bedded gray calcareous shale, limestone, and very minor chert. No phosphorite beds were found in this area, and the facies is certainly different from the facies in the deeper part of the miogeosyncline.

The miogeosyncline apparently widens to the south (fig. 1), but much of the area is covered with Tertiary sediments and little is known of the facies or their distribution. More phosphorite may remain to be discovered in this area. Much exploration remains to be done in Colombia--the paleographic and facies map (fig. 1) shows several unexplored areas and as exploration continues this map should be refined and made more complete.

Field procedures

The procedure used to locate the phosphorite deposits in Colombia has been outlined in the previous pages, but it is thought that a brief, general recapitulation, stressing the actual field procedures, will be of value.

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The first step in a prospecting program is to locate a broad, generally favorable area in which a marine phosphorite deposit might be expected. This is the miogeosyncline. Previous geologic investigation might be expected to at least outline this type of broad structural environment, and indeed, this was true in Colombia. The second step is to determine if phosphorite was deposited in the area of the miogeosyncline, or if the unique suite of rocks associated with phosphorite--i.e., black shale-chert-carbonate rock--was deposited in the miogeosyncline. In Colombia, previous work (Bürgl and Botero, 1962; Slansky, 1963; and unpublished data of the U.S. Geological Survey and the Inventario Minero Nacional of Colombia) had clearly demonstrated the presence of phosphate and the associated suite of black shale-chert-carbonate rock in the miogeosyncline, and had also demonstrated that the phosphate was restricted to the Senonian Stage of the Late Cretaceous.

Thus, a study of the literature indicated that conditions were, overall, very favorable for the presence of an economic deposit of phosphorite in the Eastern Cordillera of Colombia. The value of the search of the literature cannot be overemphasized. This search, in Colombia, limited the area that could be expected to yield potentially economic deposits and also restricted the stratigraphic interval that should be carefully examined.

Because marine phosphorites contain uranium, they are significantly higher in radioactivity than other sedimentary rocks. An examination was made of all available gamma-ray logs of oil wells in the country, and this examination showed that abnormal radioactivity was confined to black shales of the Villeta Formation, and to the black shale-chert-limestone facies of the La Luna and Guadalupe Formations. Field work showed that the high radioactivity of the Villeta Formation was caused by uranium in the black shales not by phosphorite, but showed that phosphorite caused high radioactivity in the La Luna and Guadalupe Formation. Therefore, the gamma-ray data also showed the stratigraphic interval that contained the phosphorite.

The next step was to make a lithofacies map of the area of the miogeosyncline to further restrict the area in which to look. Accordingly, the first step in the field work was to examine all of the previously discovered phosphate occurrences, and to plot these occurrences on a lithofacies map. In addition, general traverses were made across the miogeosyncline, to aid in constructing the lithofacies map. This step made it clear that the search should continue in the northern and southern parts of the country where the miogeosyncline widened, and where phosphorite might be present.

The general outcrop areas of rocks of Late Cretaceous age were known, and the actual discovery of the phosphorite was made by traversing the roads in the outcrop areas with a hand scintillation counter. Because marine phosphorites are very extensive deposits, a search of the road cuts in the area of outcrop will ordinarily show the presence of the phosphorite, even if the road net is not extensive.

Marine phosphorite beds contain enough uranium ~~so~~ that radioactivity anomalies will be detected with a portable scintillometer when the instrument is used in a car at slow speeds. Areas of anomalous radiation were carefully examined and sampled, and the samples were analyzed for P_2O_5 in the laboratory. The samples were taken on the basis of hand lens examination of the rock.

Sample localities were plotted on the map and related to a lithofacies within the miogeosyncline, and the paleogeographic and lithofacies map was continually refined during the field work. The final product is shown in this report as figure 1. Some of the favorable areas that were not examined because of lack of time have since been investigated by geologists of the U. S. Geological Survey and the Inventario Minero Nacional of the Republic of Colombia, and additional phosphorite has been located. The work is continuing.

The recognition of phosphate rock in the field may be difficult for the inexperienced geologist. The best method of learning to recognize the material is by actual experience, but failing that, there are several chemical tests that can be employed. Ammonium molybdate solution used with nitric acid produces a yellow precipitate if the rock is phosphatic. The test is delicate and qualitative. A drop of dilute hydrochloric acid, will produce a white "bloom" on the rock, if phosphate is present, and phosphorite outcrops in areas where groundwaters are acid may have a white bloom. A semiquantitative colorimetric test has been devised by Shapiro (1952). P_2O_5 content can be estimated to within about 5 percent, but the test must be used with caution, because the very small sample volume used may give results that are not representative. Laboratory analysis of representative samples is necessary to obtain accurate grade data.

Literature cited

Belding, H. F., 1955, Geological development of the Colombian Andes: in Bullard, F. M., ed., Conf. Latin-American Geology, Proc., p. 43-63, Texas University, Austin.

Burgl, Hans, 1961, Histórica geológia de Colombia: Revista de la Academia Colombiana de Ciencias Exactas, Físicasy Naturales, v. XI, no. 43.

Burgl, Hans, and Botero, G., Dario, 1962, Las capas fosfacticas de la Cordillera Oriental (Informe Preliminar): Servicio Geol. Nacional, Inf. no. 1416, 54 p.

Campbell, C. J., 1965, The Santa Marta wrench fault of Colombia and its regional setting: Fourth Caribbean Geological Conference, Trinidad, BWI.

Cathcart, J. B., and Zambrano O., Francisco, 1966, Roca fosfatica en Colombia (Informe Preliminar): Inventario Minero Nacional, Inf. no. 1516, 110 p.

Hubach, Enrique, 1952, Estado actu~~r~~al de la exploración de fosfatos en Colombia: Servicio Geol. ~~Nal~~ Nacional. Inf. no. 860, 5 p.

Kazakov, A. V., 1937, The phosphorite facies and the genesis of phosphorites, in Geological investigations of agricultural ores USSR: Leningrad Sci. Inst. Fertilizers and Insecto-fungicides Trans. (USSR) no. 142, p. 95-113 (Special issue in English published for 17th Internat. Geol. Cong.).

Literature cited--continued

McKelvey, V. E., 1963, Successful new techniques in prospecting for phosphate deposits, <u>in</u> U. S. Dept. State, Natural Resources--Minerals and Mining, mapping and Geodetic Control: United Nations Conf. Application Sci. and Technology for the Benefit of Less Developed Areas. Geneva, 1963, U. S. Papers, v. 2, p. 164-172.

McKelvey, V. E., Swanson, R. W., and Sheldon, R. P., 1953, The Permian phosphate deposits of the Western United States: Internat. Geol. Cong., 19th, Algiers, 1952, Comptes Rendus, sec. 11, pt. 11, p. 45-64.

McKelvey, V. E., Williams, J. S., Sheldon, R. P., Cressman, E. R., Cheney, T. M., and Swanson, R. W., 1959, The Phosphoria, Park City, and Shedhorn Formations in the western phosphate field: U. S. Geol. Survey Prof. Paper 313A, 41 p.

Shapiro, Leonard, 1952, Simple field test for the determination of phosphate in phosphate rocks: Am. Mineralogist, v. 37, p. 341-342.

Sheldon, R. P., 1964a, Exploration for phosphate in Turkey--a case history: Econ. Geology, v. 59, p. 1159-1175.

__________, 1964b, Paleolatitudinal and paleogeographic distribution of phosphorite: U.S. Geol. Survey Prof. Paper 501C, p. C106-C113.

U. S. GOVERNMENT PRINTING OFFICE : 1959 O - 511171
867-100

Literature cited--continued

Slansky, M., 1963, Contribution a l'etude du probleme du phosphate in Colombia: Servicio Geol. ~~Nal.~~ Nacional Inf. 1471, 92 p.

Weeks, L. G., 1947, Paleogeography of South America: Am. Assoc. Petroleum Geol. Bull., v. 31, no. 7, p. 1194-1241.

Wokittel, Roberto, 1960, Recursos minerales de Colombia: Comp. Estud. Ofic. en Colombia, X, 239 p.