

MINERAL RESOURCES OF PORTO RICO.

By ROBERT T. HILL.

INTRODUCTION.

The island of Porto Rico consists of three geologic elements: (1) a central system of deeply ribbed and corrugated mountains, with V-shaped gorges and ridges; (2) lower hills, forming irregular bands along the north and south coast; (3) playa plains, consisting of alluvial soil, occupying old reclaimed estuaries, which extend from the foot of the central mountains across the line of foothills to the seashore.

It is roughly estimated that nine-tenths of the island is of the mountainous character and that the remaining tenth is of the foothill and playa character. The central mountains are composed of water-sorted volcanic ejecta—tuffs and conglomerates—with occasional dikes and masses of interbedded subcrystalline bluish limestone of rare or exceptional occurrence, all of which is entirely decayed at the surface, breaking down into a red clay resembling that of the southern Appalachians. The dikes are of hard, black igneous rock, with small white porphyritic crystals. In the east the substructure is said to be granites and especially syenites. In Naguabo and in Mayaguez some serpentine rocks have been observed.

The foothills are composed exclusively of rocks of sea origin, consisting of the peculiar type of tropical white limestones, of a loose-textured, chalky, marly, and shelly nature, of various degrees of induration. The rocks of the central mountain region are of Cretaceous and possibly early Eocene age; at least no evidence tending to establish other dates for their formation has been as yet discovered. The white limestones of the coastal hills are all of later Tertiary and Pleistocene age.

The playa deposits are alluvial formations, consisting usually of a rich, chocolate-colored, sandy loam.

CLAYS.

Material for construction of every kind exists upon the island and is utilized with great skill by the inhabitants. Brick and tile clays, building stone, lime, sand, cement, gypsum, and paving blocks occur. The natives, like all people of Spanish descent, are expert in masonry construction, and especially that kind which includes the manipulation of mortar, cement, and rubble. The excellence and durability of the

works of this character upon the island were everywhere noted. The cement and mortar work of old fortresses constructed two hundred years ago shows remarkable durability, and in some of the cities the mortar seams of the brick-laid pavements stand up in sharp ridges between the bricks, which have been worn thin.

Porto Rico abounds in clay suitable for the making of ordinary building brick and ordinary jug ware. This material is of two general classes: First, the residual clays of the interior mountains, resulting from the breaking down of the volcanic rocks. This is a stiff, red clay, resembling very much the red clays of the southern Appalachians. No white clays were anywhere observed, and after careful inquiry I am inclined to believe that they do not exist. This opinion is substantiated by the fact that the rocks are very free from the pure feldspars from which such clays are derived.

The second class of clays are the redeposits found in the alluvial playas. The latter are the kinds usually employed by the local brick yards, which everywhere abound. The bricks manufactured are longer, wider, and thinner than those used in this country, and are usually rather friable and sandy. The quality could no doubt be improved by more careful selection, manipulation, and firing. These bricks are used for construction and for sidewalks. Houses built of them are always superficially stuccoed. One or two notable exceptions to this rule were observed, such as the immense cavalry cuartel or barracks at Cayey, which is a very substantial brick building, void of outer protection. In Mayaguez the sidewalks are constructed of bricks laid upon the flat side. They seem to be fairly durable. The streets of San Juan are superbly paved with brick, but these are composed of vitrified slag and were manufactured in England. Formerly all the houses were roofed with heavy red tile, but of late years the corrugated iron roofs have been imported so cheaply that the tile industry has practically ceased.

Only a few potteries were observed upon the island, notably at Ponce. The ware manufactured is of the crudest kind, being a rough, red, unglazed jug ware. The quality of the output could be immensely improved by a little washing and more careful manipulation.

SAND.

Good building sand is found in nearly all the rivers, but none of sufficient purity for glass-making purposes.

STONE.

Lime of excellent character is produced from all the white limestones of the coastal formations. The blue and gray crystalline limestones of the mountainous region are also well adapted for lime making, but are not utilized.

Many of the impure limestones present every indication of a natural cement rock, but inasmuch as fuel is scarce and very expensive, it is doubtful if these can be utilized profitably.

The building stone of the island is of several kinds: Volcanic boulders, lumps of porous white limestone, massive quarry limestone, and limestone flags. The chief material used, it may appear strange to say, is of the first two classes mentioned, native masons excelling in the art of constructing walls of this lumpy material, binding it solidly together with cement. The houses constructed of the volcanic boulders are usually neatly pointed with mortar and present a picturesque and rubbed appearance. Those constructed of the softer white limestone lumps are always stuccoed. The most elaborate and satisfactory houses of the tropics are made with the latter material, resulting in thick and light walls well adapted to the climate. Of this character are nearly all the public buildings of Cuba and Porto Rico, including great fortresses, such as those at San Juan and Santiago de Cuba, upon which the shells of our navy seem to have had but little effect, no doubt owing to the sponge-like texture of the rock, which prevented shattering beyond a short radius from the point of contact—at least such shattering as would occur in material of denser nature.

Massive limestones abound along the southern slope of the central mountain range from Guayama westward to Cabo Rojo. These are of several classes. The principal kind is a gray or drab limestone of the color of commercial lithographic stone, but of intense hardness. When sawn into paving tiles this would be of great durability, and it would serve for use in all structures requiring strength. This limestone is practically a marble, being highly crystalline and of a dense and compact texture.

Near Juana Diaz there is a belt of beautiful marble of great hardness, which is quarried into large blocks. It is variegated in color, consisting of a reddish matrix mottled with numerous small white spots. At present the material is used only for structural purposes, such as piers for bridges, etc. Its ornamental properties have not been developed.

Sandstone is comparatively rare, although in the western portion of the island fairly good grindstones are made out of some of the native rocks.

A very fine flagstone is abundant on the island. It is used in San Juan for sidewalks and floor tiles, for the lining of reservoirs, and for other structural purposes. This is a very hard, black, fissile limestone, which is found in great quantities near the summit of the central range between Cayey and Aibonito, occurring in alternating layers with the volcanic tuffs. It is an excellent stone for general use. Stone material for dams, riprap, and road metal are found everywhere, convenient for local use. On the north side of the island a white coral limestone occurs in the coastal formation. This is thoroughly crystalline in places, and breaks into a firm, hard road metal. The igneous rocks of the central mountain ranges and the older limestones are also extensively used for such purposes. Inasmuch as the development of the highways of Porto Rico is a necessity which needs to be met immediately, it is gratifying to note the abundance of suitable road metal throughout the island.

Granite, of a syenitic character, is said to be quarried near Fajardo and at other places on the eastern end of the island. I saw no true granite on the island.

GYPSUM.

Gypsum occurs rather abundantly in a formation consisting of yellowish marl, which is extensively developed along the southern side of the central mountains, just north of the village of Juana Diaz. It is also reported at other localities, notably near Ponce. The deposits seen by the writer are of an impure character, being largely mixed with sand and clay, but are sufficiently valuable to be of service for the manufacture of a low grade of plaster, such as is extensively used in the country for stucco and for fertilizers. This material is extensively used for plaster in the city of Ponce, and is considered a most valuable resource by the inhabitants.

Chalk, clay, and silica for artificial cements also abound in the coastal formations.

SOILS.

The soils of the central mountain region, which, as has been noted, constitutes nine-tenths of the island, are mostly ferruginous clays, and are of such character that, while naturally forming a good matrix for retaining fertilizers, they are subject to loss of lime, phosphate, potash, etc. The cultivation of the two standard crops, coffee and tobacco, is very exhaustive of these chemical elements, and there is great need of fertilizing material. The remainder of the island is alluvial or calcareous.

FERTILIZERS.

In my travels upon the island I was struck by the occurrence in close proximity to this mountain region of great beds of greensand, gypsiferous marl, shell marl, chalk marls, and lime phosphates, of a nature apparently specially adapted for the revivification of the exhausted mountain lands. Greensand marls occur in great abundance on the road from Lares to San Sebastian, immediately adjacent to a rich and most productive coffee region, in which many abandoned acres of "ruinate"—as exhausted lands are called in the tropics—are already observable.

Lime marls abound everywhere around the coast. The gypsum marls occur near Juana Diaz, adjacent to the Rio Portugues, and near Ponce. Inasmuch as the future of this beautiful island depends entirely upon its scientific agricultural development, in my opinion these natural fertilizers, when appreciated, will constitute one of the most valuable sources of wealth. Agricultural methods have heretofore been somewhat primitive, and the products have been largely plantation crops. Within less than ten years the whole island will be devoted to growing oranges, bananas, and other export fruits for the American market, and higher and more scientific methods of agriculture will be initiated, and I venture to predict that the amelioration and improvement of the soils will be one of the first results of the island's renaissance.

A large area of the southern coast consists of rocks similar to those of Sombrero, Navassa, and other islands which abound in phosphates.

So far as I am aware, the industry has been developed only upon Mona Island, lying off the west end of Porto Rico. There is reason to believe that much of this material may be found in the rocks along the southern coast of the main island. In the vicinity of Ponce and elsewhere there are numerous caves filled with rich deposits of guano, which are now being worked and prepared for shipment to the United States.

FUELS.

It is said that near Moca there is a deposit of lignite well worthy of development. Amber has also been found in these beds.

In the western part of the island, near San Sebastian, there is an extensive formation of bituminous clay, which contains a very fair quality of lignite, although the quantity has not as yet been determined. Two specimens of this are before me, one of which is a firm, hard, fibrous lignite containing considerable pyrites, and the other, from Guatemala village, is a firm lignite of dull, glassy luster and free from impurities. The second has every aspect of a good cannel coal. The field in which this material occurs is worthy of thorough prospecting and study.

SALT.

There are many lagoons around the island, from which considerable salt is obtained by natural evaporation of the brine. The principal deposits are the salines of Coama, Guanica, and Sierra de Piñones de Cabo Rojo. The last named have made their owners wealthy. Sufficient salt for the necessities of the island can easily be obtained from these deposits.

MINERAL WATERS.

There are several thermal mineral springs upon the island, notably the Quintana at Ponce and the springs of Coamo. At these places bath houses are established and they are resorted to by invalids from all parts of the island. The waters are sulphurous and ferruginous, and are said to be of great curative value for skin diseases and rheumatic troubles.

The Licentiate Jimenez obtained in 1,000 parts of water the following components:

Analysis of mineral water from Coamo, Porto Rico.

Carbonic acid	parts in 1,000..	21.37
Hydrosulphuric acid	do.....	23.47
Hydrochloric acid	grams per gallon..	0.5444
Carbonate of lime	do.....	0.2514
Carbonate of magnesia.....	do.....	13.72
Sulphate of lime.....	do.....	0.2637
Sulphate of magnesia	do.....	0.540
Sulphate of iron	do.....	3.7
Silica.....	do.....	0.708

The temperature of this water is about 42° C., and the average temperature of the air 27.3° C.

The following analysis of the mineral water of Coamo was made by Mr. J. J. Heller in 1847:

Analysis of mineral water from Coamo, Porto Rico.

Carbonic acid.....parts in 1,000..	18.05
Hydrosulphuric acid.....do....	28.54
Carbonate of lime.....grams per gallon..	0.1304
Hydrochloric acid.....do....	0.544
Carbonate of magnesia.....do....	13.000
Sulphate of lime.....do....	0.2637
Sulphate of iron.....do....	2.9697
Sulphate of magnesia.....do....	0.544
Silica.....do....	0.705
Magnesia.....do....	Trace.

METALS.

The metallic minerals most frequently found, and which form the object of much search, are gold, carbonate and sulphide of copper, and magnetic oxide of iron. Traces of lead and indications of mercury, manganese, and bismuth have also been noted.

Gold.—Almost since the date of the discovery of the island gold has been washed in small quantities from many of its rivers, especially those of the north and east end, notably the Luquillo and Loiza. Gold also occurs in the streams near Corozal, a village on the north-central side of the island. It has never been found in great quantities, fifty cents to a dollar a day representing the average product of a hard day's labor. The gold is obtained by the natives from the river sand and gravel. The mother rock of this metal has never been determined. Lately a great many American prospectors have been seeking for quartz veins toward the heads of the streams. It is my opinion, however, that such will not be found, as there are no evidences of their existence upon the island, at least no visible quartz veins could be detected by me anywhere, although there may be small stringer veins. It is more probable that the vein material of the gold in the mother rocks is pyrite, as this is quite frequently encountered along the contacts.

While it is impossible to reach any positive conclusion as to the quantity or value of the gold of the island, experience has shown that the placer deposits are not rich or extensive. The question of its occurrence in the mother rocks is a problem which will require careful and patient exploration by scientific methods. The prospector from the United States will find that the matrix is entirely different from that with which he has been familiar, the general geologic conditions resembling those of Colombia and Panama more than those of the North American gold fields.

Copper.—Copper pyrite and the stains of carbonate of copper are frequently met with in the central mountain region, but nowhere in quantity sufficient to justify expectations of extensive occurrence. One

deposit of impure malachite, upon which the owners placed great hopes, was developed, but a single small shipment of ore exhausted the deposit.

Zinc.—Zinc sulphide (?) crystals have been found in small quantities near Malapascua, and tin has been reported, but its occurrence could not be proved.

Iron.—Nine-tenths of the rocks of the island are of a basic nature, containing a large proportion of iron. Inasmuch as these are and have long been undergoing oxidation and alteration, the conditions are theoretically favorable for the occurrence of valuable iron deposits, and in one or two instances these undoubtedly exist, notably north of Juncos. At this place there is a large deposit of magnetic iron ore of great purity, containing 66 per cent of iron and less than 0.023 of phosphorus. A French engineer has calculated that there are at least 35,000,000 tons of this ore in sight. At present it is many miles from a seaport, and its development will necessitate the construction of a railway. In my opinion this deposit is the most valuable metallic resource of the island at present in sight, and American capital will develop it as soon as allowed to do so legally. It is said that the conditions of this deposit could not be more favorable. The ore is encountered in compact masses, easy of extraction, and covered only by a light layer of earth. It constitutes a small hill, about 150 meters high, at the opening of a plain, which leads to a port by a 2 per cent grade. The construction of a railway 15 kilometers long could be done quickly and with little cost. The shipping port, Naguabo, is said to admit ships of 20 feet draft. It has been estimated that this deposit contains 10,000,000 tons of metallic iron, but I am not in a position to verify this estimate.

The following is an analysis made for Messrs. Patterson and Strad, of Middleborough, England :

Analysis of Juncos, Porto Rico, iron ore, dried at 212° F.

Constituent.	Per cent.
Peroxide of iron.....	72.500
Protoxide of iron.....	19.671
Protoxide of magnesia [manganese?].....	0.232
Alumina.....	Trace.
Lime.....	0.271
Magnesia.....	0.170
Silica.....	5.300
Sulphur.....	0.008
Phosphoric acid.....	0.056
Arsenic.....	0.000
Carbonic acid.....	Trace.
Water.....	1.790
Total.....	99.998
Total metallic iron.....	65.05

Magnetic sands, like those so abundant in the adjacent island of Martinique, occur in many of the stream beds, notably those in the western part of the island. These are worthy of further investigation. In the course of my reconnaissance I noticed many ferruginous deposits, but none of them seemed of sufficient importance to warrant development. However, all were of such nature as to indicate that the possibilities are worthy of careful study.

Pyrite.—Pyrite is frequently encountered in the igneous rocks of the central mountains. Many specimens were brought to me, but no great quantity has as yet been discovered.

CONCLUSION.

In conclusion, a few remarks concerning the striking difference, in occurrence and appearance, of the economic resources of Porto Rico from those of the United States, and of the North American continent in general, may be of interest. The geologic type of the island is Antillean in its aspects, and the sequence, arrangement, and composition of the rocks are entirely different from those of the rocks with which we are familiar in our country. The matrix and country rock of the metallic minerals are not of the quartziferous type familiar to prospectors in the United States, but are made up entirely of basic igneous rocks, such as tuffs and volcanic conglomerates, of the kind known in Central America and Colombia as "caleche," while the dike and vein material is largely of hornblende andesite-porphry. Furthermore, the bituminous material, instead of occurring in rocks of the Carboniferous period, as it largely does in the United States, is found entirely in strata of the Tertiary period. The ordinary prospector will find these conditions so foreign to those of the United States that he will be entirely lost in endeavoring to follow what are to him ordinary indications of mineral wealth.

Owing to this fact, it is necessary that the mineral resources of Porto Rico should receive thorough scientific study and exploitation. In my opinion such investigation may result in the discovery and development of many interesting resources which have escaped the observation of practical mining prospectors and my own eye in my brief reconnaissance. It is especially important that the sands and alluvial deposits of each of the 1,200 streams of the island should be carefully studied, for it is possible, if not probable, that they contain platinum and other rarer minerals. I am inclined to the latter opinion because of the resemblance of the formations, in a general way, to those of Colombia, in which these minerals occur. Furthermore, the contact phenomena are worthy of scientific investigation, and the phosphatic limestones of the coastal formations deserve systematic study.