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# NOTES ON THE GEOLOGY OF PANAY

By Warren D. Smith

(*From the Division of Mines, Bureau of Science, Manila, P. I.*)

Separate from

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# NOTES ON THE GEOLOGY OF PANAY[1]

By WARREN D. SMITH
(*From the Division of Mines, Bureau of Science, Manila, P. I.*)

ONE PLATE AND 3 TEXT FIGURES

CONTENTS



## INTRODUCTION

Between the years 1886 and 1890 Enrique Abella y Casariego[2] carried on geologic investigations in the Island of Panay assisted by d'Almonte. The report of his work embraces detailed descriptions of the general geologic features of the country, including orography, hydrography, with the altitude of all the principal points, followed by chapters dealing with the volcanic formations and their "tufas." There are also chapters dealing with the sedimentary formations, particularly the Tertiary series, and the work closes with a part devoted to the economic geology. It is very complete as far as it goes, but omits many important points, which is to be expected when the geology of an unknown country is treated for the first time.

Mr. Maurice Goodman, formerly of the Bureau of Science, touched at a few places on Panay in the latter part of 1905, about fifteen years after Abella. The purpose of his trip was to discover workable deposits of sulphur, gypsum, limestone, building stone, and placer gold. His stay in Panay was less than ten days. He found no deposits of either sulphur or gypsum, but the time was all too short properly to pass upon the mineral resources of any district. Mr. Goodman obtained several specimens of limestone from various points in the eastern part of Panay, the

[1] Received for publication November 27, 1914.

[2] Descripcion fisica, geol. y min. de la Isla de Panay. Chofré, Manila (1890).

analyses of which are given in his manuscript report. These show fairly pure limestone, usually with less than 1 per cent of magnesium oxide.

In the summer of 1912 Mr. Wallace E. Pratt, a geologist of the Bureau of Science, was detailed to make a rapid reconnaissance of the region about the town of Janiuay at the edge of the foothills on the eastern side of the cordillera in order to ascertain the possibilities of finding petroleum in the sedimentary formations. During his work on Suague River, which flows past the town of Janiuay, it occurred to him that there were artesian-water possibilities in that region, and he reported this to the Director of the Bureau of Science.

In the latter part of December, 1912, I was detailed to follow up the suggestions made by Mr. Pratt in regard to artesian-water possibilities, in an effort to aid the Director of Public Works in the important project of providing the city of Iloilo with an adequate supply of pure water. During the course of this work, which was confined rather closely to that section of the country immediately northwest of the city of Iloilo, the following notes regarding the general and economic geology of that part of the island were made. I was assisted in the field by Mr. Percy Kincaid, formerly of the Bureau of Science, and was furnished survey notes by Mr. R. L. Moore, of the Bureau of Lands.

## GENERAL STATEMENT

A description of the general geographic features of the Island of Panay based on Abella's work [3] follows. Panay, which because of its size, richness, and population is the most important island of the Philippines after Luzon, is situated among the Visayans precisely in the center of the Archipelago and is found comprehended between the latitudes 10° 24′ 37″ and 11° 55′ 57″ north and between the longitudes 125° 30′ 16″ and 126° 50′ 24″ east of Madrid (121° 50′ and 123° 20′ east of Greenwich).

Panay has roughly a triangular shape. The greatest lengths which can be taken from north to south and from east to west, respectively, are 168 and 119 kilometers. The total area of the island is 11,580 square kilometers, of which 4,547 apply to the district of Capiz, 2,472 to that of Antique, and 4,561 to that of Iloilo. The population of Panay consists almost entirely of Visa-

[3] An unpublished translation of this important Spanish document was made by Mr. McCaskey, formerly chief of the division of mines of the Bureau of Science. This translation is on file in the library of the Bureau of Science, Manila.

yans, and their number amounted to 775,202 according to the census of 1903. The temperature, rainfall, and vegetation conditions of Panay are very much like those of the Island of Cebu.

One cordillera runs almost from north to south separating the Province of Antique from the Provinces of Capiz and Iloilo. This cordillera lies much nearer to the western coast than to the eastern and follows a sinuous course starting in the extreme northwest corner of the island, winding eastward, and then swinging back to the southwest corner. In the northeastern part of the island there is a mountainous cluster, but no true cordillera exists. Between these two is considerable flat country, but a little north of the center of the island is a highland tract connecting the western cordillera and the eastern mountains. Owing to the necessary vertical exaggeration in the relief map (Plate I), the true physiography of the central plain does not appear in the photograph. North and south of this divide there is low country. The largest tract of plain country is comprised of what is called the Iloilo plain, the lower part of which is chiefly a delta. The largest streams of the island start on the eastern slope of the cordillera and run east or north of this and then turn to the south and meander across the Iloilo plain. The slopes on the western side of the cordillera are much more precipitous, and the streams there are short and swift. Abella's report gives detailed descriptions of the various mountain passes, the drainage in Panay, and profiles showing the general character of the skyline in various parts of the island.

## PHYSIOGRAPHY

In Abella's report there is little mention made of the physiographic and geologic factors underlying the principal characteristics of the country. The relation of topography to geology and the human response to these material factors have been shown in many parts of the world, but very little has been written on this subject in its relation to the Philippine Islands. First, I wish to draw attention to the effect of the geology upon the topography. The dominant rocks in Panay—that is, in the habitable portion—are Tertiary sedimentaries—clays, sandstones, shales, limestones, and conglomerates. We find these lying blanketlike over parts of the Iloilo plain and extending up the sides of the cordillera. In the lower part of the streams rising in the cordillera we find the course of the streams at right angles to the strike of the formation—that is, in the direction of the dip. As we go up these streams, we find tributaries

coming in on both sides or joining the main stream along lines corresponding to the strike of the formation. For some distances the main streams themselves follow the strike, but as a rule they cut nearly at right angles to it. The geologic structure is reflected in the topographic aspect of the country and is characteristic of block mountains. As we look upstream from the lower courses, we see long gentle slopes; but when we ascend and look backward, we are confronted by abrupt slopes due to the upturned edges of the formation. The conditions may be represented by the diagram as seen in fig. 1.

FIG. 1. Character of topography in tilted sedimentaries.

Where the rocks are hard, the streams cut through in narrow gorges, but where the formations are soft, as in the shales and some of the soft limestone, the country is open and the streams run in wide valleys. There are many places in Panay where one encounters box cañons, which at the time of high water are very difficult to pass through. These are usually in the hard resistant conglomerate. Many of these would afford excellent dam sites. Where the streams have cut back into the harder rock, such as volcanic agglomerates and diorite, there is no system to their course. They seem to follow no particular lines, save possibly here and there the jointing has exerted a local influence. When the low country is reached, the streams take their own courses again and meander irregularly over the broad plains.

## DISTRIBUTION OF THE PEOPLE

In the report of the Philippine Census of 1903 there is a general map showing the distribution of the various tribes of the Islands, and the map of Panay, as shown in fig. 2, is reproduced from this. Following the cordillera and the tongue of highland, cut-

ting across the north-central part of the island, and thence into the mountain cluster to the northeast, there is an area occupied by Bukidnons (people of the mountains). They occupy the same relative position to the people of the low country as do the mountaineers of eastern Tennessee and North Carolina to the people of the Piedmont Plateau. They comprise, for the most part, Visayans who have been pushed back into the mountains for

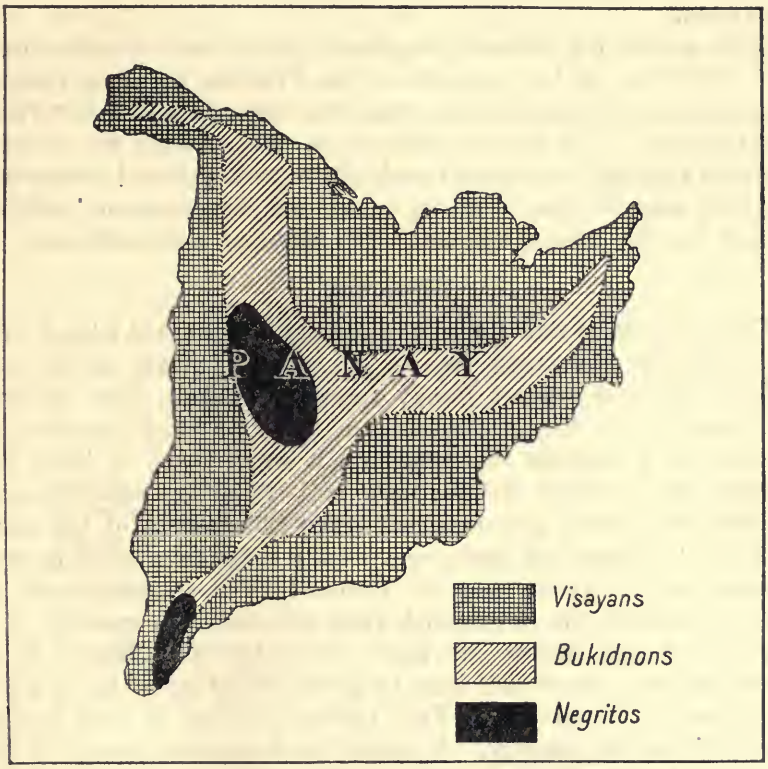


FIG. 2. Distribution of tribes in Panay.

one cause or another, their language becoming somewhat modified. At two points along the crest of the cordillera, the one in the extreme south and the other in the center of the cordillera, in the almost inaccessible region of Mount Baloy, there are two small areas said to be occupied by Negritos, the original inhabitants of the Philippines.

We have here then an excellent example of the influence of topography and geology upon the distribution of the peoples. These three groups, Negritos, Bukidnons, and Visayans, are

sharply defined, and their distribution is controlled strictly by geologic and topographical factors. Where the rocks are hardest and most denuded of soil, where the topography is the most rugged, where existence is the most difficult, there one finds the most primitive peoples. Now that there is a railroad running from north to south connecting the cities of the Provinces of Capiz and Iloilo, we shall see the territory of the Bukidnon people penetrated, and gradually their range will be more and more restricted.

Even among the lowland peoples of Panay there is a considerable variation in the dialects. The Filipino is, as a rule, a home-loving individual, who does not care to travel far from his friends. It is always difficult to get packers to go with one into the high mountains and into territory that is unknown to them, and all this tends to retard the dispersion of isolated groups and the free interchange of ideas and commodities.

## VEGETATION

There is remarkably little forest anywhere on this island with the exception of a small area in the central portion of the cordillera. In this respect Panay resembles Cebu. The extreme deforestation is due to the *caiñgin* system, which consists in clearing and burning the forest on a small tract of land, the raising of one crop on the hilly soil, then the abandonment of this tract for a new location. The inhabitants of the high country, in Panay, at least, very rarely raise two crops in succession on the same piece of ground. The encroachment of cogon grass on the deforested area prevents the growth of a new forest and makes the land unsuitable for tillage. It is easier to clear a new spot than to prepare and open the field for crops on the old ground. This ruthless system is now having its effects on the country. Without the retaining powers of the forest and undergrowth the rainfall rapidly runs off, eroding the country and carrying enormous volumes of gravel and silt into the bottom land. This is the chief cause of the great devastation wrought by the streams in this and other parts of the Philippines. The sudden rising of these mountain streams and their pouring out onto the plain cause great floods, ruin crops, and destroy bridges, resulting in the rapid silting up of river beds and filling up of navigable streams, and the formations of bars where once existed open channels. China to-day pays a terrible annual toll in lives and money as a result of the practice of the same system in the past. There is scarcely a stick of

wood left on her mountains, and the Philippines would soon be in the same plight but for the Government's timely forest conservation policy.

## GENERAL GEOLOGY

As already pointed out by Abella, the general classes of rocks found on Panay are: The recent formations of the plains; the Tertiary limestone, shales, and sandstone in the foothills; the core of igneous rocks in the cordillera; and some doubtful rocks, approaching slates, which come between the igneous formations and the Tertiary series.

The best development of sedimentaries I have yet seen in the Philippines exists on Panay, and the best sections for studying them are perhaps to be found there. On Suague River Mr. Pratt estimated that the total thickness of the Tertiary series amounts to more than 9,000 meters, and if we include the older series of "slaty" rocks at the headwaters of Ulion River the total will be about 10,000 meters. I found very much the same series on Tigum River, the two streams being roughly parallel and only a few miles apart. A short distance above the barrio of Tinayoc Tigum River has cut into the hillside, affording an excellent section, which is typical, as follows:

| | Meters. |
|---|---|
| Thin-bedded sandy shale | 15–20 |
| Heavy-bedded sandstone | 5 |
| Sandstone | ½ |
| Carbonaceous shale | ¾ |
| Sandstone | ½ |
| Carbonaceous shale, less than | ⅓ |
| Heavy-bedded sandstone | 5 |
| Thin-bedded sandstone and shale | 16 |
| Heavy-bedded sandstone at base | |

The dip at this point is 30° to the southeast, and the strike is north 10° east. Descriptions of three different samples of the sandstone follow:

*Sample 2312.*—Buff to gray, very coarse, and apparently made up of triturated particles from various kinds of igneous rocks occurring in the cordillera. There is little quartz in the specimen, but fragments of ferromagnesian minerals predominate. The buff color is largely due to fragments of olivine washed out of the decomposing picrites known to occur in the cordillera. This rock has a porosity of only 5.5 per cent, the voids being filled largely with iron oxide and calcium carbonate as a cementing material.

*Sample 2313.*—This sample is a much finer and more even-grained grayish rock with much the same mineral composition as sample 2312. The porosity of this specimen is greater.

*Sample 2314.*—This sample is a still finer grained rock with more of the characters of a shale than of a sandstone.

In the same series of sediments with these sandstone beds are several layers of conglomerate, conformable and of varying thickness. These conglomerates consist of many kinds of pebbles in a firmly cemented, sandy matrix. At one place I noted pebbles and fragments of the following kinds of rocks:

1. Limestone with coral remains.
2. Andesite—3 or 4 varieties.
3. Amygdaloid.
4. Shale.
5. Rock resembling jasper, but which is probably rhyolite, as it appears to have quartz phenocrysts.
6. Diorite—coarse-grained.
7. Diorite—fine-grained.
8. Picrite—a rock rich in olivine.
9. Quartz.

Occasionally fossil shells are found, one of which is presumably *Vicarya callosa* Jenk. Hence the age of these beds is that of the Lower Miocene, or the same age as the Cebu coal measures. Fuller descriptions of these sedimentaries are given by Abella.

*The shales.*—The shales exposed in the lower reaches of the streams flowing from the cordillera are thin-bedded and grayish to bluish, and resemble other Tertiary shales in many parts of the Philippines, the type example of which is the Vigo series on Bondoc Peninsula, Tayabas, Luzon.[4] These shales have practically the same mineral composition as the sandstone, the chief difference being in grain size. In the upper part of Tigum River the shales are yellowish, but lower down, where we first discovered them, they are bluish. In the survey of Tigum River we found that there are at least 5,000 meters of these shales exposed from the point where the survey began to the first considerable thickness of sandstone. Of course, there are occasional thin beds of sandstone in this series, but they are negligible. Several wells have been drilled by the Bureau of Public Works in these shales in the hope of obtaining artesian water, but they have been generally unsuccessful.

[4] Cf. Pratt, W. E., and Smith, W. D., *This Journal, Sec. A* (1913), 8, 331.

*Log of Well No. 161, Iloilo, Iloilo.*

| Depth in feet. | Strata. | |
|---|---|---|
| | Drillers' classification. | Remarks. |
| 0- 80 | Shale with numerous shale fragments and small gravel. | |
| 80- 90 | Finer shale, slightly calcareous | |
| 90- 100 | Dark shale, not calcareous | Fine quartz fragments; resembles loam. |
| 100- 110 | Adobe—heavy clay material | Result of disintegration of basic rock. |
| 110- 130 | Gray calcareous shale | |
| 130- 150 | Same as 90 to 100 feet | Finer grained. |
| 150- 170 | ----do | Do. |
| 170- 190 | Adobe | |
| 190- 210 | Gray shale, not calcareous | |
| 210- 300 | Shale, slightly calcareous | |
| 300- 400 | Shale, strongly calcareous | |
| 400- 500 | Fine-grained shale | Similar to previous strata. |
| 500- 600 | Shale | |
| 600- 650 | Shale, strongly calcareous | |
| 650- 675 | Sand, very fine but fairly clean | |
| 675- 710 | Adobe | |
| 710- 800 | Sand, but not so good as from 650 to 675 feet | |
| 800- 910 | Adobe | |
| 910- 920 | Shale, slightly calcareous | |
| 920- 975 | ----do | Much the same as from 910 to 920 feet. |
| 975-1,100 | Marl | |
| 1,100-2,285 | Fine-grained marl | |

A discussion of the ground-water resources will be found on page 226. A noteworthy point in connection with the wells sunk in these shales is that the water obtained was salty. Mr. Pratt in his manuscript report has given the following satisfactory explanation of the brackishness of the water:

> If one accepts the most probable explanation of the presence of salt and other minerals in the upper clay and shale, i. e., that they came from the sea water in which the beds formed and are, consequently, original constituents of the series, it is clear that the effect of ground waters, active since the elevation of the land above sea level, would be a leaching out of the soluble salts.

I see no reason for thinking that the salt water has come from the sea. Any flow of water depends upon head, and the flow normally is from the land into the sea rather than vice versa.

Rapidly changing conditions of sedimentation must have existed throughout the formation of these beds. The thinness of certain beds, the repeated alternation in character of the

*Well No. 308, Janiuay, Iloilo.*

| Depth in meters. | Strata. | |
|---|---|---|
| | Drillers' classification. | Remarks. |
| 0- 5 | Gravel and clay | |
| 5- 10 | Bowlders and clay | |
| 10- 15 | Gumbo clay | Gumbo clay is probably a stiff dark-colored clay. |
| 15- 20 | Black sticky clay | |
| 20- 35 | Joint clay | Joint clay is applied to the blue clay of the upper clay and shale series of this record. |
| 35- 37 | Blue sticky clay | |
| 37- 41 | Blue sandy clay and gravel | |
| 41- 43 | Clay and gravel | |
| 43- 55 | Blue sandy clay and joint clay | Alluvial to 43 meters. Upper clay and shale below 55 meters. |
| 55-124 | Joint clay | |
| 124-147 | Clay and loose stone | "Loose stone" is probably applied to calcareous concretions which are known to occur in the blue clay. |
| 147-169 | Joint clay | |
| 169-175 | Joint clay and loose stone | |
| 175-187 | Joint clay | |
| 187-199 | Volcanic | "Volcanic"—possibly a silt which was mistaken for volcanic tuff. The drill penetrated it 12 meters in 9 hours. |
| 199-207 | Quick clay | |
| 207-247 | Joint clay and loose stone | |
| 247-266 | Joint clay | |
| 266-273 | Joint clay and loose stone | |
| 273-315 | Joint clay | |
| 315-320 | Joint clay and loose stone | |
| 320-348 | Fine sand and gravel | |
| 348-360 | Joint clay and loose stone | |
| 360-428 | Joint clay | |
| 428-468 | Brown sand and clay | |
| 468-490 | Joint clay | |
| 490-493 | Shale | |
| 493-506 | Rock | Rock, calcareous shale. |
| 506-527 | Clay bowlders and quicksand | Clay bowlders. |
| 527-531 | Shale mixed with fine black sand | Sand from strata above mixed with shale. |
| 531-537 | Sand, gas, and salt water | |

sediments, cross-bedding, and other factors all indicate that there were either repeated oscillations of level or rapidly succeeding freshets, or both. It is important to note that the conditions are unfavorable for the formation of coal deposits of economic size. The only coal seams seen by me were not over 5 centimeters thick.

## STRUCTURE

The Tertiary series of shales and sandstones described above overlap the igneous core of the cordillera and constitute a great monocline dipping eastward toward the Iloilo plain. Near the

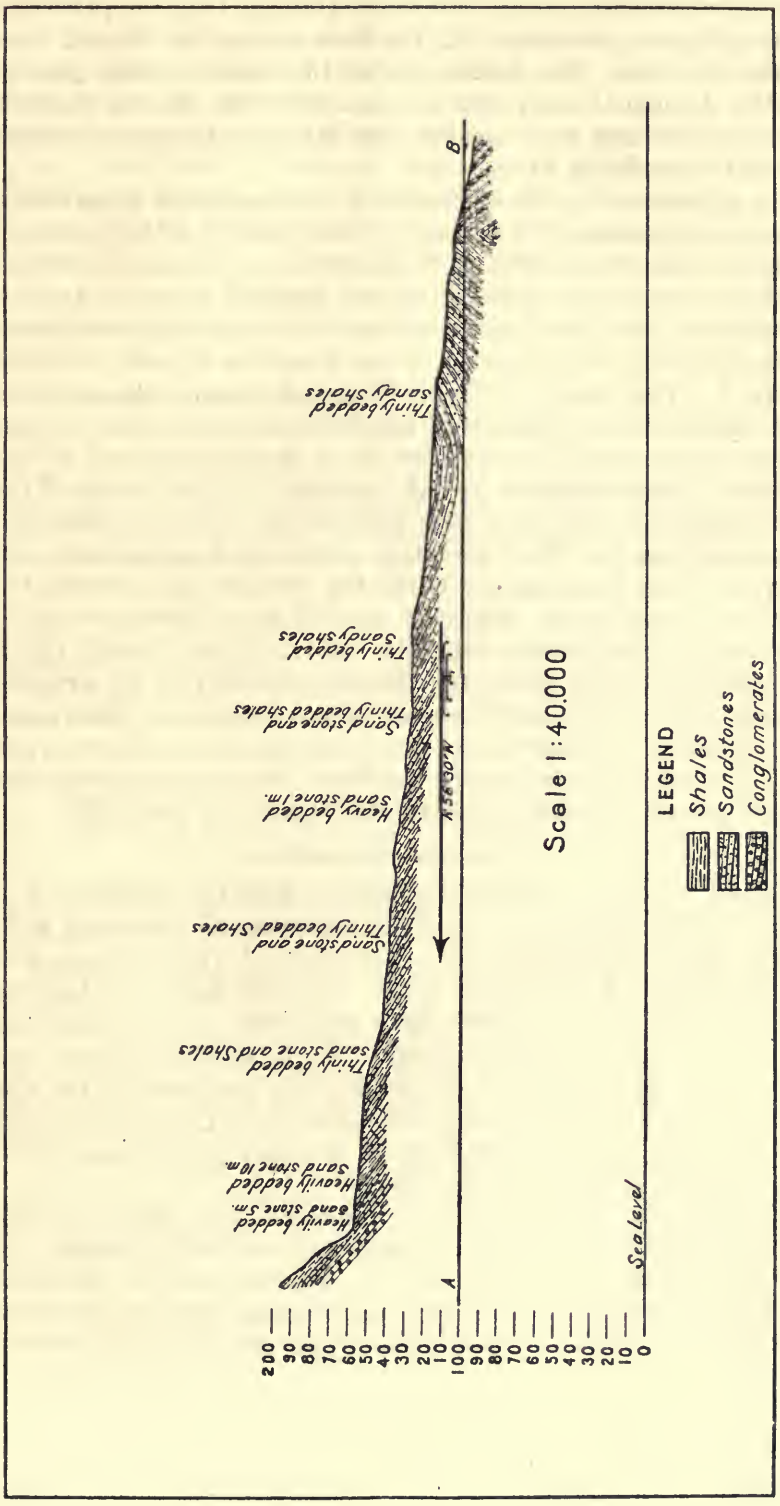


Fig. 3. Geologic section across Iloilo Province, Panay. After Abella.

cordillera the dip of the beds is as high as 70°, but gradually this inclination decreases till the beds assume an almost horizontal position. The inclination of the beds is much greater on the Antique (west) side of the cordillera. In the foothills local undulations with reverse dips attended by some faulting are to be noted (fig. 3).

As pointed out in the discussion of the control of topography, these strata assume the attitude of tilted blocks with the abrupt slope up- and the gentler slope downstream, this slope in most cases corresponding exactly to the bedding planes. Abella's profiles are very good representations of the general conditions. A somewhat modified section, using Abella as a basis, is shown in fig. 3. The survey of Tigum River has revealed the existence of a small anticline just east of Maasin, and perhaps many others exist which would be revealed by a detailed survey of the region. These anticlines are all important in the matter of the accumulation of oil. Complete folds in the strata are, however, the exception, and the dominating structure is monoclinal. Of course, where there are anticlines the reverse type of fold, the syncline, must exist. There is one of these shown in fig. 3 just west of the Maasin anticline. As anticlines usually afford the most favorable places for the accumulation of oil, artesian waters are most favorably tapped in the synclines. The reason for this marked difference between two mobile substances is due to their difference in specific gravity. For further discussion of the petroleum possibilities in this region see page 225.

### PRE-TERTIARY FORMATIONS

At an elevation of about 400 meters near the headwaters of Ulion River there is an excellent exposure of indurated sediments closely resembling slate. Intercalated with these are sills of diorite from 3 to 5 meters thick. The sills follow the bedding planes. The strike of these slaty sediments is northwest, and the dip is 30° to the northeast. No marked difference was noted between that part of the sedimentary beds nearest the sills and the interior; so it is improbable that the hard slaty character of these beds can be due entirely to the heat or pressure resulting from the intrusion of the sills.

*Specimen 2322.*—The rock is blue-black, very dense, exceedingly fine-grained, and has a hackly to conchoidal fracture. It shows on certain surfaces a very fine banding which is distinctly that of sedimentation. The cleavage in these beds is not typical of slates, and hence they might more properly be termed pseudo-slates.

*Microscopic.*—The thin section of this rock is difficult to study owing to the flakes of iron oxide and numerous dark fragments which cannot be easily identified because of their amorphous condition. Fragments of quartz, feldspar, and ferromagnesian minerals are abundant. The whole aspect of the section is that of a clastic rock. Numerous fragments of globigerines and of radiolarian tests are to be seen, but neither the species nor the genera can be distinguished. This rock probably corresponds to the "clay slates" mentioned by Molengraaff [5] in his descriptions of certain rocks collected in central Borneo. He gives the following description of certain rocks encountered on Poelau Lolong River:

> The country at this point and higher upstream consists of a system of highly folded strata. The strike may be averaged at about E.-W. and E. N. E., but both strike and dip vary considerably. The strata as a rule are highly inclined and not seldom stand vertical. The oldest group in this complex is composed of clay-slate, chert, hornstone, sandstone, diabase, diabase-tuff, and diabase-tuff-breccia, also gabbro and serpentine, the latter being derived partly from a variety of olivine-norite * * * partly from picrite or from hartzburgite. * * * Some of the diabases * * * form intrusive masses, sheets, or dikes in the sedimentary formations and are therefore younger than these. * * * The cherts are sometimes full of biotite and then resemble silicified micaceous clay-slate, at other times they turn to pure jasper and hornstone. The hornstone is sometimes of a milky white colour, often marbled and alternating with bright red jasper. The chert, and particularly the jasper and pure hornstone, contain Radiolaria and are often almost entirely composed of the tests of these organisms. In the jasper, the Radiolaria can be detected with an ordinary pocket lens, and they look like so many round specks, or little grease spots the size of a pin's head. This greasy lustre is caused by the tests of the Radiolaria being filled with an aggregate of quartz which is coarser than the cryptocrystalline composition of the jasper itself. As mentioned before (page 92) these cherts with Radiolaria are of pre-Cretaceous age.

This also describes fairly accurately what we found on the headwaters of Ulion River. Just what the exact relationships are in this rather confused group of rocks has not yet been determined, but the fact that we have rocks practically identical with those of central Borneo and that they are considered to be older than the Tertiary is very important.[6]

Near the source of Ulion River I found an outcrop of jasper, the position of which was not very clear. In thin sections this proved to be similar to the rock I had described from Ilocos Norte in 1906.[7]

[5] Geolog. Explorations in Central Borneo. Amsterdam (1902), 174.
[6] Molengraaff, op. cit., 174.
[7] *This Journal, Sec. A* (1907), 2, 145.

*Sample 2323, macroscopic.*—The rock is pinkish with occasional fine black streaks in it, rather fine-grained, and fissile, so that it breaks into more or less thin slabs.

*Microscopic.*—The groundmass consists of cryptocrystalline silica, dotted with small roundish and oval areas filled with small irregular grains of silica but little larger than those constituting the groundmass. These roundish areas undoubtedly represent tests of Radiolaria, but nothing now remains save the cast.

In another sample tests of Radiolaria belonging to the following three genera were identified: *Stylosphæra, Dictyomitra,* and *Cenosphæra.* The species of the first-named could not be told, but under the second, the species *affinis* was distinguished without difficulty, and of the third genus, which is by far the commonest, the species *minuta* and *disseminata* were recognized.

We have now found this radiolarian chert in Ilocos Norte and Bulacan, Luzon, in Panay Island, and in Balabac Island—from the northernmost to the southernmost part of the Archipelago. Outside the Philippines the same rocks are known to occur in the Moluccas,[8] in the Federated Malay States,[9] and in California,[10] and everywhere they are referred to the Jurassic. We have every reason then to believe that this formation, or group of strata, in the Philippines is distinctly older than the Tertiary.

Associated with these red rocks are some green rocks, which in a thin section are shown to be serpentine, and these, we have seen, accompany the cherts of central Borneo.

### IGNEOUS ROCKS

As Abella has devoted no little space to the igneous rocks which he found in the cordillera, I shall not discuss them at length. His list includes the following:

1. Andesite.
2. Basalt.
3. Diabase.
4. Diorite.
5. Diorite (quartz).
6. Gabbro.
7. Picrite.
8. Serpentine.
9. Tonalite.
10. Trachyte.

Of these the different varieties of andesite constitute the dominant rocks of the cordillera, and similar rocks have been described in Philippine literature. Of the rest we need call attention only to the tonalite and the picrite. We have found

[8] Martin, R., Reisen in den Molukken. Geolog. Theil. 2te Lief., 171.
[9] Scrivenor, J. B., Geol. Mag. (1912), 9, 241–48.
[10] Fairbanks, H. W., *Journ. Geol.* (1895), 3, 418.

these quartz-mica-hornblende-diorites in various parts of the Philippines, but they are not common.

As the picrites are still more uncommon, I shall give Abella's own description of them:

> The *picrites* have a beautiful emerald green color with bronze metallic reflections of a crystalline texture, and in them is seen olivine, augite, and bronze hypersthene, a white mass being distinguished among these crystals, semigranular, almost pulverulent, which at some time might have originated from a preëxisting feldspar or nepheline, which cannot now be classified as such, nor give, therefore, character to the rock. Under the microscope this white mass resolves itself into a whitish magma, amorphous and decomposed, which in the polarized light emits, notwithstanding, certain pale gray bluish and yellowish colorizations, all of which confirms the supposition attributing to it the feldspathic and nephelinic origin, * * *.
>
> Based on these characters and on the almost holocrystalline texture which the three elements of this rock display, we shall classify it as peridotic, and designate it as picrite.

The western cordillera certainly affords an interesting field for the petrographer, and its thorough exploration may some day reveal deposits of great commercial value. For instance, the "picrites" which Abella mentions are about the most basic rocks known, and in their vicinity it is reasonable to expect that valuable deposits of metals will be found.

## ECONOMIC GEOLOGY

In the third part of his report Abella discusses the occurrences of various nonmetals and metals. Since Abella's time a slight amount of prospecting has been carried on in Antique Province by Americans, with the result that promising deposits of chromic iron and copper have been reported, but nothing of value has been found on the eastern side of the cordillera. The presence of petroleum and coal has also been reported. Specimens of wolframite have been sent to the Bureau of Science by two persons from Antique Province, who, however, gave no definite information with regard to them. If there is any considerable quantity, it will be valuable. Serpentine containing asbestiform minerals has also been noted in the same province.

The presence of petroleum at Janiuay, Iloilo Province, was reported many years ago, but during a recent reconnaissance of the province, I failed to see any oil. However, at Janiuay I visited a well 537 meters in depth, which was bored nearly two years before by the Bureau of Public Works for artesian water, and which was emitting gas and salt water intermittently. This may be an indication of the presence of petroleum at a lower

horizon. That this is not simply marsh gas is, I believe, shown by the analysis.

*Analysis of the gas collected by Wallace E. Pratt*[a] *from the Janiuay well in 1912.*[b]

| | Per cent. |
|---|---|
| Hydrogen | 5.2 |
| Methane | 89.4 |
| Ethane | 0.0 |
| Carbon dioxide | 0.6 |
| Nitrogen | 4.3 |
| Oxygen | 0.0 |
| Carbon monoxide | 0.5 |

[a] *Mineral Resources P. I. for 1912* (1913), 47.
[b] Analysis by Forrest B. Beyer, chemist, Bureau of Science.

It is known, of course, that methane is the chief constituent of natural gas and that ethane is usually found in it, but examples are known where the latter is absent. The presence of hydrogen and of nitrogen particularly seems to argue in favor of the supposition that this gas is not merely a product of vegetable decay. It is not impossible, of course, to have a marsh deposit at almost any depth in sedimentary formations. The facts, however, that we have some considerable depth, presence of salt water, and these extra constituents seem to make it highly probable that this is natural gas and is associated with a deposit of petroleum. As to the amount of oil likely to be present in these formations we can only conjecture.

As traverses were made along the streams in this part of the island, close watch was kept for any oil seeps, but nothing was seen even suggestive of the presence of oil. It is possible, of course, that the oil is of so light a grade that on evaporation it leaves no residue easily detected on the rocks and thus would easily be overlooked.

The sedimentary formations are so folded that what oil may be present would be collected into natural reservoirs. There are indications also that sandy beds exist which would afford sufficient pore space for the retention of any oil that may be present. For these reasons we can say that it is not at all unlikely that petroleum does exist in this island.

## GROUND-WATER RESOURCES

The importance of an adequate supply of pure water in tropical countries no longer needs any argument. The need for a supply of uncontaminated water for the growing city of Iloilo has become pressing. Several unsuccessful deep wells have been

bored at Iloilo and in the neighboring towns. One well at Iloilo penetrated to a depth of about 800 meters in clays, sands, and shales and struck no potable water. The well at Janiuay already mentioned did not get through the thin-bedded shales and resulted only in striking salt water and gas. A number of comparatively shallow wells near Iloilo which did not go below the alluvium obtained water which in some cases proved to be brackish and in others to have a taste of iron. After these unsuccessful attempts were made, a scheme for diverting water from Tigum River into a reservoir from which it was to be piped a long distance to Iloilo was projected. This, however, would entail the expenditure of at least a million pesos, and naturally there was some hesitation about undertaking it. Finally I was detailed to visit the region with instructions to look into the artesian-well possibilities. After three weeks on the ground I submitted a report giving the following conclusions:

1. The artesian conditions of the sandstones and conglomerates are not sufficiently favorable for us to recommend any further expenditure of money in this direction.

2. It is deemed probable that an adequate water supply can be obtained from the deep gravels in the alluvial deposits in the lower end of the Iloilo plain.

3. More detailed study of this region should be made along the lines adopted by the hydrographic branch of the United States Geological Survey.

4. Geologic investigation should precede all artesian-well projects.

The first conclusion was arrived at after due consideration of the depth, inclination, thickness, and porosity of the possible water-bearing strata, all of which appeared as pointing to very unfavorable conditions, and in view of the past experience in this district in well-boring, other and simpler means of getting water should be tried first.

Since this investigation was made, reports from that locality state that in some of the wells near Iloilo, particularly the one at Molo, the water has improved and is losing some of its brackish taste. In one of these wells I noted a slight taste of iron, which would not be harmful and even might be beneficial. It is my expectation that the water from these wells will in time become entirely potable, and that sufficient water for the supply of the city of Iloilo will be obtained from numerous comparatively shallow (75 to 300 meters) wells in the ancient gravels of this plain.

## SEISMIC GEOLOGY

The seismic disturbances in this island have been discussed already.[11] It seems reasonably certain that the majority of the disturbances which have occurred there are local and are of the rockfall type. I have seen some landslips which have resulted from the slipping of the sediments, particularly the shales, over one another along bedding planes. If these are large enough, they can easily set up vibrations which would be recorded by seismographs.

Other disturbances have been of greater intensity and were due to displacements along the line of contact between the sediments on the western side of Guimaras Island and the igneous formation on the east.

It is possible, also, that other differential movements have taken place between the valley alluvium and the mountain mass, which would give rise to seismic disturbances.

There is no evidence as far as I know of vulcanism on the island since the Pleistocene, at least, to which we could attribute any of these disturbances. Whatever their origin, they have been of minor importance, and Panay is now one of the most stable parts of the Archipelago.

## SUMMARY AND CONCLUSIONS

The relation of geology to the topography and indirectly the bearing it has upon the distribution and activities of the people has been shown.

The vegetation of the country shows the devastating effects of the caiñgin system, and the effect of this upon the economic welfare of the people has been indicated.

The existence of a hitherto suspected but unverified new-old formation, almost certainly Jurassic in age, has been proved.

Attention has been called to new prospects in mining and the favorable geologic features connected therewith. Deeper drilling for oil in the vicinity of Janiuay is recommended.

The ground-water resources of a portion of the island have been touched upon, and the possibility of utilizing the water contained in the ancient buried gravels of the Iloilo plain has been pointed out.

Attention has been called to the seismic geology. Panay is one of the most stable parts of the Archipelago, and the majority of the few earthquakes occurring on the island are due to rockfall and hence are local.

[11] Saderra Maso, Miguel, and Smith, W. D., *This Journal, Sec. A* (1913), 8, 199.

# ILLUSTRATIONS

PLATE I. PHOTOGRAPH OF A RELIEF MAP OF PANAY.

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