ORBITOIDES FROM THE BINANGONAN LIMESTONE.

(WITH SOME NOTES ON EARLY CONNECTIONS BETWEEN FORMOSA, THE PHILIPPINES, AND JAVA.[1])

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On looking over some samples of fossiliferous limestone collected by Mr. H. M. Ickis, of this Bureau, from the classic Binangonan locality, some forms which resembled *Orbitoides* were noted. Some time later it was possible for the writer to make a trip to this same locality, on which occasion he collected more material and obtained some data with reference to the field relations of the formations.

On closer study, the forms were seen to be, without an exception, species of *Orbitoides,* and no *Nummulites* were detected. However, Richthofen [2] may have seen *Nummulites* there also. Thin sections were made and studied in connection with the admirable sections of similar forms from Formosa and the Riu Kiu Group,[3] which were sent by Professor Koto, of the Imperial University of Tokyo, to Messrs. Newton and Holland and described by them.

In 1862 the late Baron von Richthofen visited a limestone quarry about $4\frac{3}{4}$ mile northeast of the pueblo of Binangonan on Laguna de Bay, and, according to his account, collected some *Nummulites,* and ever since that date this formation has remained unquestioned, save by Mr. Becker, and referred to the Eocene. So far as we know, Richthofen never figured or described these forms.

[1] This paper the writer intends to serve as an introduction to a field of investigation which he has been assigned to develop as time and opportunity permit. This field, as interesting and important as it is from a scientific point of view, must be made subordinate to the economic work which the writer and his colleagues of this Bureau are at present engaged in. However, it is hoped that articles bearing on this and related subjects will from time to time appear in the numbers of this JOURNAL.

Many statements herein may have to be modified as future work progresses, so that the present conclusions should be regarded more in the light of a working hypothesis than as a definite and final opinion.

[2] *Zeitschr. d. geol. Gesell.* (1862), **14**, 357–360.

[3] R. B. Newton and R. Holland: "On Some Fossils from the Islands of Formosa and Riu Kiu," reprinted from *Jr. Coll. Science Imp. Univ. Tokyo* (1902), **17**, art. 6.

This is not the first instance of the finding of *Orbitoides* in the Philippines, for in 1901, Mr. Martin,[4] the recognized authority on the little-known paleontology of these Islands, published a short statement concerning *Orbitoides* which were found by Semper in a marl from Alpaco, Cebu.

The importance of *Orbitoides* in the Philippine and Malayan stratigraphy can not be brought out too strongly, for it is a typical zone fossil—i. e., widely distributed, but restricted in vertical range—and from it we have been able to make some interesting and highly important correlations which will be mentioned in the following pages.

FIELD RELATIONS.

Binangonan is situated on the western side of the western of the two peninsulas which extend southward into Laguna de Bay, due east from Cavite. It is reached by launch from Manila by way of the Pasig River.

The surface rock throughout the country immediately north of Laguna de Bay is volcanic and consists of very recent trachytic and basaltic flows, while farther to the north and south is a vast tuff area, familiar to geologists from the literature of Abella, Von Drasche, Semper, Becker, and others. As one goes northeast along the old trail to the limestone, the ground rises rather gradually, until the backbone of the peninsula is reached, at an elevation of about 350 feet, from which altitude the surface drops away in a series of poorly preserved terraces to a broad, flat-bottomed valley on the east.

That this valley was at one time an arm of the Laguna and also of the sea there seems to be little question, for on the highest bench just below the limestone cliff (fig. 1) two shells belonging to the genus *Crassatellites* (marine) were found.

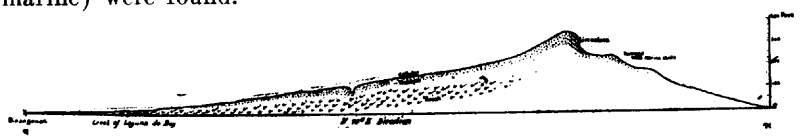

FIG. 1.—Ideal section of part of Binangonan Peninsula.

Almost identical species are living in Philippine waters to-day.

On the western slope of the peninsula also, the evidence of recent uplift is indicated by the deep U-formed stream gorges.

THE VOLCANIC ROCK.

At Binangonan the lava is a dense, bluish-black, clean-cut basalt very much like some phases of the rock from Talim, but a little to the northward in the old city (Manila) quarry, whence the rock was taken for road metal, it becomes lighter colored and more cellular. A section of this has been examined with the petrographic microscope and found to be

[4] K. Martin: "Orbitoides von den Philippinen." *Centralblatt für U. G. P.* (1901), 326, 327.

typical olivine basalt. (Pl. II, fig. 2.) The principal minerals are labradorite, olivine, a green augite, and magnetite. The trachytic texture is very pronounced in the thin section. Zonal structure is very common in the feldspars and an occasional twin in the shape of an X can been seen.

As we travel up the slope to the divide we find the lava becoming more porous and lighter in color, until in the neighborhood of the limestone it is practically a scoria. From the rather limited observations the writer was able to make here, it appears that these flows probably poured out over the country from Talim, leaving a small peak of limestone in part exposed.

THE LIMESTONE.

The limestone, which is the tomb of *Orbitoides,* is exposed in a cliff-like mass, a hundred feet or more in height, and seemingly dipping steeply to the east, though this may prove to be not true bedding, but some secondary structure. In color the rock varies from a light cream to a dirty, bluish-gray. The lighter and denser portions are more fossiliferous. On microscopic examination it was found to contain *Orbitoides,* differing somewhat from the forms described by Messrs. Newton and Holland, and which the writer proposes to call *Orbitoides richthofeni,* some fragments of *Operculina complanata?* Def., and a very imperfect form which is suggestive of *Lithothamnium ramossisimum* Reuss.

DESCRIPTION OF SPECIES.

The genus *Orbitoides* differs in one radical respect from *Nummulites,* namely, in that the chambers of *Orbitoides* are arranged concentrically and not spirally as in the latter form. All the specimens we have found belong to the Lepidocycline group, this terminology referring to the lozenge-shaped chambers along the median plane. It is probable that more than one species is represented, and there is a great difference in the size of some of the specimens.

Orbitoides richthofeni sp. nov.

(Pl. I, fig. 1.)

The type of this is the largest specimen found in this locality, but unfortunately it is not a perfect one. The one we have depicted by Plate I, fig. 1, has lost a portion at each extremity, but if restored would measure in the neighborhood of 36 millimeters in length and 8 millimeters in width at its thickest portion. These tail-like appendages are very characteristic and give to the whole the appearance of the head of a pick.

The initial chamber is not shown, or it is exceedingly small. Instead, along the median plane are developed lozenge-shaped chambers arranged at right angles to the long axis of the form and continued out into the

caudal appendages. The remainder of the chambers are considerably larger and are in certain sections roughly pentangular in outline. Plate I, fig. 2, shows the central portion of the large specimen, much enlarged. In the photomicrograph it is the black band running through the center. Just what the meaning of this is, the writer is unable to determine at the present time, as he has not seen it in a sufficient number of specimens to ascertain whether it is accidental or is some characteristic feature.

Plate I, fig. 2, shows one of the commoner, smaller forms measuring approximately 8 by 4 millimeters. This is unusually circular, but many specimens are almost identical with those figured in Plate 1, fig. 4, of Newton and Holland's paper, and coming from Irometé Island.

We have as yet seen none from the Philippines to correspond to *O. angularis*, figured on Plate I of their paper.

CONCLUSIONS.

As von Richthofen merely mentioned his having discovered *Nummulites* in the Binangonan limestone and never discribed, nor, to our knowledge, figured, any of the species, and as we have not yet found a *Nummulite* from that horizon, we can not find much evidence for calling this formation Eocene.

Furthermore, Orbitoides (*O. verbeeki* Newt. and Holl.), probably the same as our smaller forms (Pl. II, fig. 1), have been found in limestone, in the Riu Kiu Group, which the British paleontologists, Newton and Holland, have placed in the Miocene, and they have been encountered still farther north, in Japan, with *Lithothamnium*. Also Martin[5] has declared the orbitoidal marl of Cebu equivalent to the "Java Gruppe" in which *Vicarya callosa*, the type fossil of the Miocene, was found.

In this connection it is both interesting and due to Becker,[6] who, though he was greatly handicapped in his work at the time of his stay in the Islands by the unsettled state of the country, nevertheless saw enough to make suggestions invaluable to all succeeding workers, to quote him.

> I must confess that the paleontological evidence as to the existence of the Eocene in the Philippines seems to me far from satisfactory. * * * I can see no reason as yet why the Binangonan limestone may not be Oligocene or even Miocene.

Very recently the writer has examined some sections from the Benguet and Lepanto limestones which Mr. Eveland, his colleague, submitted to him, and which lead him to think it quite likely that these beds are the northward extensions of the Binangonan formation. This is not surprising, for we should certainly expect some intermediate occurrences between the Riu Kiu Group and southern Luzon. In certain beds of limestone

[5] *Loc. cit.*

[6] G. F. Becker: "Geology of the Philippine Islands," *21st Ann. Report, U. S. G. S.* (1902), 552.

in the coal field of Batan Island[7] the writer also found *Operculinæ*, although as yet no *Orbitoides*.

The fact that Martin's *Orbitoides* came from a marl, while these we are at present describing occur in a limestone, does not in the slightest degree prevent the inclosing beds from being contemporaneous although they may not be strictly homotaxial.

The bearing of these facts upon the paleogeography, and consequently upon the distribution of the flora and fauna of these Islands, would seem to be exceedingly important. If it can be satisfactorily proved, and these facts appear to contribute something to that end, that the islands of this Archipelago are remnants of a former, more extensive, land mass which was connected with Formosa and Japan to the north and Borneo, Java, and the Malay Peninsula to the southwest, and even with Indo-China and India, much that is now problematical with regard to floral and faunal distribution in this region will have been solved.

This highly interesting problem has been attacked by many naturalists, foremost among whom are R. A. Rolfe[8] and A. R. Wallace.[9] These authors have demonstrated the great and almost confusing mixture of Australian, Indian, Chinese, Formosan, and still more northern types of plants and animals, more particularly the latter, with the endemic forms of the Archipelago. These will not be detailed here, but we shall discuss the distribution and origin of some of these forms.

Mr. Wallace gave two views as to the ancient geography of this Archipelago, one of which, expressed in 1876,[10] maintains that the Islands are truly insular and volcanic and that the union with other Malayan Islands was not of such a nature or duration as to permit of any extended migration on the part of animals. Later, in 1902 in the third edition of Island Life,[11] he gives expression to a second view as follows:

> It is evident that the Philippines once formed part of the great Malayan extension of Asia, but that they were separated considerably earlier than Java and have since been greatly isolated and much broken up by volcanic disturbances; their species have for the most part become modified into distinct local forms, representative species often occurring in the different islands of the group. They have received a few Chinese types by the route already indicated, and a few Australian forms owing to their proximity to the Moluccas. Their comparative poverty in genera and species of the mammalia is perhaps due to the fact that they have been subjected to a great amount of submersion in recent times, greatly reducing their area and causing the extinction of a considerable portion of their fauna.

[7] W. D. Smith: "The Coal Deposits of Batan Island," *Bull. Min. Bur.* (1905), No. 5.

[8] R. A. Rolfe: "On the Flora of the Philippine Islands and Its Probable Derivation." *Jour. of the Linnean Society, Botany* (1884), 21, page?

[9] A. R. Wallace: *Island Life.*

[10] A. R. Wallace: *Geographical Distribution of Animals* (1876), 1, 344.

[11] A. R. Wallace: *Island Life*, 3d edition (1902), 389.

Mr. Rolfe, writing in 1884, favored the former of Wallace's views, but states that "geological evidence will probably in future throw much light on this point."

It appears to the writer that Wallace's later view is more nearly in accordance with the facts. He was familiar at that time with the presence of submerged banks connecting the now isolated groups, but he did not have any paleontological evidence.

Rolfe repeatedly speaks of migrations of southern types from the Malayan and Australian regions northward to the Philippines, but from lack of material he was unable to discuss the great infusion of northern types which must have migrated southward from Siberia, and even North America, through Japan, south China, and Formosa, and which are found in the highlands of northern and central Luzon.

The writer, accompanied by Mr. Merrill, botanist of this Bureau, has recently made the ascent of some high mountains in northern Luzon, where many species of plants identical with, or closely related to, those of Formosa, southern China, and Japan were observed, and also some identical with North American forms, which apparently have migrated from that region by way of the Aleutian Islands, Japan, and Formosa to Luzon.

That there have been in the past repeated land connections between Japan and North America, by the closing of Bering Straits, has substantially been proven by the periodic migrations of molluscan faunas between those regions in past geologic periods.[2] Of course, at the inauguration of the glacial period these plants and animals would migrate far to the south and even into the Tropics. It is expected that future paleontological work will corroborate this view by revealing a decided infusion of Japanese forms in the molluscan fauna of the Pliocene and Pleistocene beds.

If there were such a land connection in Miocene times, as we have already indicated, it is probable that it continued nearly to the time of the present flora, previous to which disruption may have taken place through volcanic disturbances, this break occurring early enough, however, to allow sufficient time to elapse during which the flora and fauna of these Islands could take on their present insular aspect.

We should not fail here to refer to work in a somewhat different field—namely, to the investigations on the distribution of the avifauna in these Islands—made during a number of years by Messrs. Worcester and Bourns.[13] Although their work gives evidence of a great break between the Philippine and Bornean groups, we do not believe their

[12] J. P. Smith: "Periodic Migrations Between the Asiatic and the American Coasts of the Pacific Ocean," *Am. Jr. Science* (1904), **17**, page?

[13] Dean C. Worcester and Frank S. Bourns: "Contributions to Philippine Ornithology." *Proc. U. S. National Museum* (1898), **20**, 549.

conclusions are greatly at variance with our own, for the present distribution of the avifauna might not, and probably did not, go very far back in point of time. Furthermore, birds being far more capable of migration than plants or invertebrate animals, their distribution could not be considered as having as much weight in the evidence as that of the latter. Unfortunately, these investigators did not extend their observations beyond this Archipelago, so that we do not know what their views would have been on this broader problem.

However, it should be stated that the conclusions given above can only be tentative until more is known of the ancient faunas and flora of these Islands and until further study of a comparative nature of the present fauna and flora of China, Japan, Formosa, and the Philippines has been undertaken. It should be stated that Mr. Merrill is now carrying on this work on the flora, and the results of his investigations will be awaited with great interest by all naturalists.

In further support of Wallace's view should be mentioned the occurrence reported, and presumably in the Miocene of Mindanao, of remains of *Elephas* (*Stegodon*) recently identified by Professor Osborn, of the American Museum of Natural History. This *Stegodon* formerly ranged all through southern Asia and is the ancestor of *Elephas indicus,* the living elephant of India.

ILLUSTRATIONS.

(Photomicrographs by Martin.)

PLATE I.

FIG. 1. *Orbitoides richthofeni*, sp. nov.
2. *Orbitoides* sp.?

PLATE II.

FIG. 1. *Orbitoides verbeeki* (?) Newton and Holland.
2. Binangonan basalt.

FIG. 1.

FIG. 2.

PLATE I.

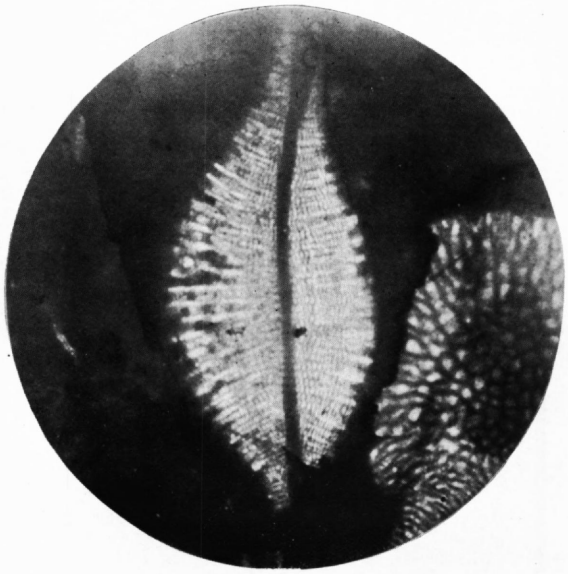

FIG. 1.

FIG. 2.

PLATE II.

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