Geology of the lower Amazon region / Charles Schuchert.

Reprinted from the JOURNAL OF GEOLOGY, Vol. XIV, No. 8, Nov.-Dec., 1906

GEOLOGY OF THE LOWER AMAZON REGION

CHARLES SCHUCHERT

PRINTED AT THE UNIVERSITY OF CHICAGO PRESS

Reprinted from the JOURNAL OF GEOLOGY, Vol. XIV, No. 8, Nov.-Dec., 1906

GEOLOGY OF THE LOWER AMAZON REGION

CHARLES SCHUCHERT

PRINTED AT THE UNIVERSITY OF CHICAGO PRESS

GEOLOGY OF THE LOWER AMAZON REGION[1]

CHARLES SCHUCHERT

Dr. Katzer has shown remarkable ability in writing local geological treatises of a comprehensive nature. His largest and best work is *The Geology of Bohemia;* and the smallest, *The Geology of Bosnia.* The present admirable memoir under review is the third one of his local summaries. All are written in the German language.

Much of Dr. Katzer's knowledge of the geology of Brazil (more especially of Pará) was obtained during the seven years he was state geologist and stationed in the Museu Paraense; yet it is quite evident that he is also familiar with the literature, in many languages, treating of the geology of South America.

The present article chiefly calls attention to the general geological sequence in the lower Amazon region. Those desiring further information must consult the *Grundzüge* itself.

The succeeding pages give, in the language of the reviewer, a condensation of the chapter entitled, "The Geological Development of the Lower Amazon Region" (pp. 237–62). Following this statement, the present writer will take up the Paleozoic formations in more detail, especially those of the Devonic.

PART I. KATZER'S SUMMARY OF AMAZONIAN PALEOGEOGRAPHY

Katzer states that the general observation, that the present relation of the Atlantic Ocean to Brazil was the same in the older geological epochs—i. e., that the old oceans spread upon the land from the east—is not supported by the facts.

The distribution of the Archean shows that in the north and east occur the oldest rocks of the lower Amazon region. Upon these rest fresh-water deposits of Tertiary and Quaternary age. The

[1]This paper is largely based on Friederich Katzer's *Grundzüge der Geologie des unteren Amazonasgebietes (des Staates Pará in Brasilien)* (Leipzig, 1903; pp. 298, a geological map, numerous text-figures, and 16 plates of fossils; 8vo). The writings of Hartt, Rathbun, Derby, and Clarke have also been liberally drawn on.

northern and eastern portions of the state of Pará represent a very ancient continent, and probably formed the margin of the Paleozoic seas. This land extending across the broad and deeply eroded valley at the mouth of the Amazon, and uniting with the Archean mountains of the state of Ceará and east Brazil, apparently continued to exist in younger Tertiary time. The above hypothesis, therefore, cannot be true for pre-Neogenic time, because across the mouth of the present Amazon there then stood a highland uniting Guiana with the present highland of Ceará.

This old land is folded. West of Pará the folds strike southwest-northeast; farther east, in the region of the Serra Tumuc-Humac, nearly east and west; and along the Atlantic, northwest-southeast. This bowlike trend of the basal mountains continues northward into the Orinoco lowland; in fact, into the Caribbean Sea, while to the southeast of the mouth of the Amazon they extend along the Atlantic coast into the state of Ceará.

This folding took place before the metamorphic sedimentaries underlying the Siluric originated, the exact age of which is unknown. In their petrographic habit they closely resemble the Archean, but are separated from it by a discordance, while above they seem to grade without disturbance into Siluric strata.

According to the present distribution of the Paleozoic deposits, the sea was open to the west, as the younger formations occur with great regularity farther and farther away from the Archean. The Carbonic apparently attains the Parú, the Devonic probably continues to Maraca, and the Siluric possibly reaches the Araguari.

The Siluric and Devonic fossiliferous deposits of the lower Amazon region are tolerably coarse-clastic in character, and undoubtedly were laid down in a shallow sea. The Devonic faunas are very similar to those of North America, and this is all the more remarkable when one considers the great distances by which they are separated. This leads to the conclusion that this old Paleozoic sea had free communication between North and South America.

As no young Middle and Upper Devonic deposits are known in the Amazon region, it appears that beginning with that time great changes took place in the distribution of land and water. This seemingly connects, on the one hand, with the outbreaks of eruptive rocks

beginning in the lower Devonic, and, on the other, with the breaking-down of the old Atlantic-Ethiopean continent. This hypothetic event, which separated the probable great continents of younger Paleozoic time—Atlantis and Gondwana of Suess[1]—gave rise to a sea transverse to the present Atlantic, and this apparently occurred at the beginning of the Upper Devonic. [This is the mediterranean named by Suess "Tethys."] The shallow sea then retreated from northern and middle South America.

It must therefore be concluded that toward the end of Devonic and the beginning of Carbonic time the greater part of South America was land.

In the southeast there was apparently a continuous elevation of land; in the west (Chile), partial elevation; and in the northern region—i. e., Bolivia, Peru, and Brazil—there was a widespread sinking which led to another transgression of the sea.

In these countries of South America the marine Carbonic is that of the Upper Carbonic. It is worthy of note that this sea occupied about the same area as that of the Devonic. The transgression begins with sandy deposits with traces of plants, as *Lepidodendron* and *Calamites*, but there are no beds of coal.

All undoubted marine deposits of the Carbonic of South America appear to be closely interrelated, but the fossil evidence outside of the Amazon region is scanty and in the main depends upon brachiopods. Upper Carbonic fossils are known from the east base of the Cordillera Oriental, Peru; Lake Titicaca at Yarbichambi and Yampopata; Arque in the province La Pag, vicinity of Cochabamba, and Santa Cruz, Bolivia; Choapa valley, at La Ligua, Chile; in Brazil, other than the Amazon region, in southern Matto-Grosso and the adjoining regions of Paraná and São Paulo. Katzer regards this distribution as indicating that toward the end of Carbonic time there were flat and swampy islands and peninsulas separated by comparatively deep marine bays and straits. This peculiar distribution made it possible for the South American sea to have communication in all directions, but the author wisely adds that the great similarity of these faunas with those of Europe and Asia may be due to a loose identification of the species.

[1] *Antlitz der Erde*, Vol. I, p. 516; Vol. II, p. 317.

The Amazon faunas are regarded by Katzer as Upper Carbonic, with partial extension into the Permic. For the other regions (Chile, Peru, Bolivia) nothing more can be said than that they are Upper Carbonic. It should be mentioned that the latter are far more closely related to those of North America, as Arkansas, Missouri, Kansas, Nebraska, and Nevada, than are these North American regions to those of the Amazon.

Reviewing the Carbonic and Permic of Asia, Katzer thinks it certain that the Amazon Carbonic is to be correlated with the Schwagerina or Ufa stage of the Ural, especially the limestone of the Sim region, in part with the uppermost Carbonic of central Russia, and in part, also, with the Artinsk stage.

While the Amazon region and adjoining lands and nearly all of western South America were covered by the Carbonic sea, the eastern margin and the entire southeastern portion of South America remained land. The Carbonic deposits of the latter regions are of terrestrial origin, and in Santa Catharina, Rio Grande do Sul, Uruguay, and Argentina the coal-bearing deposits are well known; but in Paraná, Bahia, Piauhŷ, and apparentlý also in Maranhão there are plant-bearing Neo-Carbonic beds without known coal-beds. All these deposits, according to Zeiller, belong to about one epoch, namely, Lower Permic or transitional to Permic. The flora is a mixed one and embraces an older Permic flora of the Northern Hemisphere, with elements of the Glossopteris flora of the Southern Hemisphere. This flora lends support to the acceptance of a great Brazil-India-South African and Australian continent, known as Gondwana Land, on the northwestern coast of which lay the Amazon sea. At the same time, the eastern Amazon continent was possibly a portion of that bridge over which the southern Brazil floras connected with the European boreal Carbonic.

At the close of Neo-Carbonic time, the sea of the Lower Amazon retreated, and thereafter the interior of this extended land, as far as observations will permit of judging, was not again subjected to marine deposits.

Of marine Triassic and Jurassic there is not a trace in the Amazon region, and the same is true of marine Cretacic in the interior of the land. Along the Atlantic coast one only meets with a narrow fringe

of young Cretacic marine sediments, and the same condition prevails in the southern states of Brazil, as Parahyba, Pernambuco, Alagóas, and Sergipe. A great marine Cenomanian Cretacic transgression, as given in several geological works, is not true of the interior of Brazil nor of the Amazon valley. This development is as follows:

With the beginning of the Mesozoic, to the old Guiana-east-Amazonian land, there was added the young Paleozoic deposits, and the resulting Guiana-Brazilian continent formed the eastern shore of the Triassic sea whose deposits are found in the Andes. The southern Pacific continent of this time remained as it was during older Paleozoic time. At the close of the Jurassic the sea extended and spread toward the east.

The first indications of the Atlantic and its transgression upon the land of northern South America took place in Upper Jurassic time.

The Guiana-Brazilian continent, which extends southward across the Amazon region, was maintained, although decreased in size along the east, and dissolved into islands toward the southeast. Similarly, there still existed the old land connections between South Africa and southern South America on the one side, and on the other with Australia and New Zealand.

Between these two continents the inclosed sea of about Middle Cretacic time began to enlarge and covered portions of the state of Sergipe, where Cretacic deposits rich in ammonites discordantly rest upon the Paleozoic. Dr. Charles A. White referred these beds to the Upper Cretacic; F. Kossmat, to the Cenomanian; Douville, to the Upper Albian (Gault). In all probability they belong to the transition zone between the Lower and Upper Chalk, and indicate a restricted Cenomanian marine extension over this part of Brazil.

Incomparably larger, however, was the transgression of the youngest Chalk (Senonian, in part Danian), which also touched the lower Amazon region. This transgression was from the south, attaining first Sergipe, later Pernambuco, and finally also Pará. The main part of the Sergipe Chalk belongs at the base of the Upper Cretacic, but some faunal elements indicate the presence of higher zones (Turonian, even Senonian). In Pernambuco the Senonian prevails and in Pará, only Senonian, with some transition to the Eocenic.

During the continuance of the east-Brazilian Cretacic trans-

gression there existed on the north side of the Guiana-Amazonian land an old ocean strait extending over the Antilles, Venezuela, and Columbia, to Peru. These are the Hippurite and Actäonella deposits of Jamaica, the Gault and Lower Senonian of Venezuela, the Chalk of Columbia, and the Upper Albian and Senonian of Peru.

During the Tertiary the lower Amazon region remained land—i. e., in the sense that it was not covered by the sea. The land waters continued to flow into the Pacific until Miocenic time, before the elevation of the Cordilleras. In Middle Miocenic, the drainage was reversed, lakes were formed, and finally a great lake covered the entire low land between the Guiana-east-Amazon land on the east and the continually rising Cordilleras in the west, extended from Naute to Madeira and from middle Parú to the Rio Negro.

As a result of the continued elevation of the Cordilleras, the connection between the Atlantic and the Pacific ceased in young Miocenic time, and South America was then united with North America. At this time *Mastodon* came from the north, as *M. humboldti* and *M. andium* are found in the young Miocenic deposits of the middle Amazon (Parú) region.

"A retrospect over the present short presentation brings out most clearly that the entire younger geological history of the lower Amazon region, beginning with about the Permian, took place upon the land. From this it follows that the local floras and faunas must have been continuous and that they were spared great disturbances. This, in fact, is shown by certain details, as the very ancient forms of fishes, as Lepidosiren, have been enabled to continue to the present. This hypothesis, however, will become clearer when the organic remains of the Tertiary deposits are better known. Their gathering and study are now the most important task of geological investigation on the sunny shores of the majestic great river: Amazon."

PART II. SILURIC SYSTEM

The Siluric strata, Derby (**6**:167) states,

> appear on the Guiana side in a belt of a few miles in width, which extends in the direction east-west for a considerable distance, if not along the whole southern margin of the metamorphic region to Guiana. They have been recognized on the Trombetas, Curuá, and Maecurú, and . . . . I judge that they extend eastward nearly to the Atlantic. I estimate the total thickness of the series at about 1,000 feet.

In the valley of the Trombetas this series rests unconformably upon felsite or eurite (6:145). It

> consists almost exclusively of hard argillaceous and micaceous [variously colored, white, yellow, red, and purple] sandstones, generally thin bedded, but with some massive beds of pure sandstone. . . . . One set of beds of cherty schist, about 20 feet thick, is found at the base of the series, in contact with syenite. . . . . Just above the cherty rocks there is a bed of fine-grained, yellowish sandstone containing a few fossils (6:168).

These fossils, according to Clarke (5), are of the following species, restricted to Brazil: *Lingulops derbyi*, *Orbiculoidea hartti*, *Pholidops trombetana*, *Orthis callactis amazonica*, *Dalmanella freitana*, *D. smithi*, *Chonetes* cf. *novascoticus*, *Anabia paraia*, *Anodontopsis putilla*, *A. austrina*, *Tellinomya pulchella*, *T. subrecta*, *Clidophorus brazilianus*, *Bucaniella trilobata viromundo*, *Tentaculites trombetensis*, *Conularia amazonica*, *Primitia minuta*, *Bollia lata brasiliensis*.

In higher beds occurs *Arthrophycus alleghaniensis*.

Clarke (5) regards this fauna as transitional between Ordovicic and Siluric or Middle Siluric, but quite different from that of the island of Anticosti. Derby (6:168) states that it indicates "a close correspondence with the Medina sandstone." Katzer refers it to the lower portion of the Siluric.

The correlations of these authors are harmonious, but the question is raised: What is meant by transitional between Ordovicic and Siluric? In other words, is the Brazilian Siluric fauna comparable with the Medina of the Appalachian region or with the Middle Siluric of Anticosti? Nothing definite can be said in regard to Anticosti Divisions 1 and 2, as these faunas need to be restudied in the light of modern knowledge. In regard to the Medina no new reading could be given, were it not for considerable evidence gathered by Ulrich in the Mississippi valley from Iowa south into Arkansas, and as yet unpublished. Underlying unmistakable Clinton faunas of the Interior type (Dayton, Ohio) he has found a zone usually quite thin and intimately connected with the highest Ordovicic or the uppermost Richmond member of the Cincinnatian division. In this zone, near Edgewood, Mo., Ulrich has collected a Stromatoporoid of Siluric character, *Zaphrentis* n. sp., *Favosites* near *asper*, *Calapoecia canadensis*, *Tentaculites incurvus*, *Dalmanella* of the *meeki* or *jugosa*

type, *Leptaena rhomboidalis*, *Schuchertella missouriensis* (earliest appearance of this genus), *Rhynchotrema* n. sp. (near *inaequivalvis*. No *R. capax* occurs in this fauna, the diagnostic species of the Richmond formation), *R.* near *dentata*, *Triplecia* n. sp. (a form externally with the characters of *Atrypa rugosa* or *A. marginalis*), *Clorinda* (all other forms of this genus are Siluric), *Atrypa* near *marginalis* (a decided Siluric reminder), *Zygospira putilla*, *Cypricardinia* near *arrata* (earliest occurrence of this genus), *Conradella* near *dyeri*, *Encrinurus* of Siluric character, *Calymene* near *niagarensis*, and *Homalonotus*. In other places at about this same horizon have been found *Halysites*, *Lingulops*, *Pholidops*, *Orthis* near *callactis* and *Rhynchotreta* near *cuneata*. This fauna therefore immediately suggests the Brazilian Siluric and links it unmistakably also with the Richmond below, but less so with the Clinton above. More recently Ulrich has re-examined the Medina deposits of the Appalachian region, more especially in Pennsylvania, Virginia, and Tennessee, and has concluded that they are the eastern shore deposits equivalent to the Richmond series of the Ohio and Mississippi valleys. This result therefore forces stratigraphers to place the line separating the Siluric from the Ordovicic, not at the base of the Medina formation of the New York standard section, but at its uppermost limit and beneath the Clinton. *Arthrophycus harlani*, which should be written *A. alleghaniensis* (Harlan), and *Daedalus archimedes*[1] are therefore not the guide fossils to indicate the base of the American Siluric, but mark the marginal littoral facies of the sea toward the close of the Ordovicic. This reference of *Arthrophycus* to the Ordovicic is in harmony with its similar occurrence in Portugal. It will eventually be shown by Ulrich that the Medina is Ordovicic in age, and when his work appears it will be seen that the Brazilian fauna fits in well with the Mississippi valley highest Richmond, and that the lost time interval between the Ordovicic and Siluric is not long. This reference of these formations to the Ordovicic is also in harmony with the sequence in Russia along the shore of the Baltic Sea. Here the Lyckholm and Borkholm beds have many Siluric corals and brachiopods, but the European stratigraphers always regard these formations as belonging to the Ordo-

[1] Sarle, "Arthrophycus and Daedalus of Burrow Origin," *Proceedings of the Rochester Academy of Sciences*, Vol. IV (1906), pp. 204–10.

vicic. Then follow faunas comparable with those of the American Clinton and the higher Niagaran formations.

DEVONIC SYSTEM

The Devonic of the state of Pará consists of marine littoral deposits. All the fossil localities are to the north of the Amazon.

The most complete development of the Devonic is that of the valley of the Rio Maecurú. Here, according to Katzer (p. 191), the sequence is the following (zones 2 and 3 are referred by the present writer to the Ereré formation of Derby, and 4, 5, and 6 to the Maecurú of Derby):

Upper Carbonic.

Unconformity.

1. Black, in part thin-layered shales, with lenticular beds of sandstone and very large concretions of highly bituminous blue-black limestone. Toward the top the beds are rich in pyrite. Thickness not determined, but considerable. The only known fossils are *Spirophyton* and *Nuculites ererensis*. Curuá formation of Derby.

2. A series of reddish, micaceous, sandy shales or shaly sandstones. Thickness not given. The only fossils are *Spirifer pedroanus*, *Camarotoechia dotis*, and *Tentaculites eldredgianus*.

3. Dark-gray or blackish, rough-layered sandstone, without fossils. Thickness, 10^{m}.

4. Hornstone. Thickness, 10^{m}.

5. Sandstone full of fossils. It is from this horizon that most of the fossils of the Rio Maecurú are derived. (See faunal list.) Thickness not given, but on the Rio Curuá, about 10^{m} thick.

6. Thin-layered sandstones interspersed with shales. Thickness not given, but probably about 10^{m} to 15^{m}.

Siluric sandstones.

West of the Rio Maecurú (about 25 miles), on the Rio Curuá, the entire thickness of the Devonic is about 50^{m}, and the system seems to rest comformably upon the Siluric. The development in both places is analogous.

To the east of the Rio Maecurú (about 75 miles) there is another good exposure of the Devonic in the bays of the Campo of Ereré. The exposures indicate a thickness of about 75^{m}. In many places

this Devonic is traversed by dikes of diabase. Here the sequence is the following (zones (1?) 2 and 3 are referred by the present writer to the Ereré formation, and 4 is the top of the Maecurú):

Upper Carbonic.

1. Black shales, in part sandy and micaceous. Locally fossiliferous. Thickness estimated at from 15^m to 20^m, but increases to the north. Toward the top these beds are interbedded with, and finally covered by, masses of "schalstein," attaining a thickness up to 40^m.

2. Thin-bedded to shaly sandstone, with hematite particles colored rose to brown-red. Single thin zones are very rich in fossils. (See faunal list.) Some interspersed beds are gray; others, white. Thickness, probably not less than 25^m.

3. Alternating dark-gray to black sandstones and black bituminous and coaly shales. Toward the top occur rarely *Orbiculoidea lodensis*, var., and small *Lingula*. Thickness, about 20^m.

4. Black, tough, thin-bedded hornstones, with interbedded seams of sandy or clayey beds. These weather to light gray, also red and banded. Traces of fossils. Thickness, about 10^m. This zone is correlated by Katzer with zone 4 of the Rio Maecurú section.

Balance concealed.

The above sections indicate that the Devonic of north Brazil is not less than 100^m thick (about 325 feet), 75^m of which occur above the base of the hornstone zone and 25^m beneath the same formation. This hornstone bed is provisionally suggested as the one distinguishing between the Lower Devonic and the Middle Devonic. This is done, because, on the one hand, it is the only place where a sharp lithic difference exists in the section; and, on the other, on account of the two distinct faunas occurring one beneath and the other above the hornstone zone. Whether a time break exists here cannot be determined from the published record, but the faunas indicate that the one from the Rio Maecurú and Rio Curuá, found beneath the hornstone, is to be correlated with the Oriskany, while that above the same zone, or the fauna of Ereré, is indicative of lower Middle Devonic.

Before proceeding to a general discussion regarding the interrelation of the Devonic faunas of South and North America, it will be best first to note the peculiarities of the Amazon faunas. A complete list of these faunas is given at the end of this paper.

Notes on the fauna of the Maecurú formation (=*Oriskany*).—Clarke (5:80) states that the trilobites

> indicate very strong early Devonian (Hercynian) traits. In fact, no other element of the fauna bears so strongly the impress of the earliest Devonian. . . . . It must therefore be conceded that the very early Devonian expression of the trilobitic element of the Maecurú fauna affects the time value of the entire faunal association.

Of the gastropods, the laterally compressed species of *Platyceras*, as *P. whitii*, *P. hussaki*, and *P. steinmanni*, are related to *P. compressum* Nettelroth, of the Louisville Onondaga. *P. hartti* is the type found in the Helderbergian and Oriskanian. The bellerophontids are of the type found in the German "Spiriferen-Sandstein" (=Lower Devonic). *Bucania freitasi* is of the *Bellerophon leda* type of the Hamilton, and *Ptomatis forbesi* has its nearest ally in *P. patulus* of the Onondaga and Hamilton.

Of the pelecypods, *Actinopteria eschwegii* is closely related to *A. boydi* of the Hamilton of New York and the Onondaga of Louisville. *Modiomorpha helmreicheni* and *M. sellowi* are representative of forms in the Schoharie grit and the Onondaga. *Taechomya rathbuni* and *T. freitasi* have affinities with Onondaga and "Spiriferen-Sandstein" species. *Cimitaria karsteni* is another form of the latter type.

Of brachiopods, *Productella maecuruensis* is related to *P. shumardiana* of the Louisville Onondaga. *Chonetes freitasi* is closely related to *C. macrostriata* Walcott, of the Lower Devonic of the Eureka District. *C. jerseyensis* Weller is another species of this type. *Anoplia nucleata* is a North American Upper and Lower Oriskanian and basal Onondaga species. Clarke (5:87) states that its existence in the Maecurú and Curuá faunas is of much significance. *Rhipidomella musculosa* is another characteristic North American Oriskanian form. Of alate *Spirifer* of the Oriskanian *S. cumberlandiae-intermedia* type there are three species (*S. buarquianus*, the guide fossil of the Maecurú formation, *S. coelhoanus*, and *S. derbyi*, *S. lauro-sodreanus* is of the *S. macropleura* type, and a similar undescribed form occurs in the Frog Mountain, Alabama, Oriskanian. *Anoplotheca flabellites* is one of the most characteristic Oriskanian brachiopods. In North America *Amphigenia elongata* is an Onondaga species, but in the Oriskanian of Illinois and Tennessee occurs the small variety *A.*

curta. *Tropidoleptus carinatus* is known in a single example from the Oriskanian of Maryland; it is also abundant in the Lower Devonic of Germany, and, as Williams has shown that this shell is also known in the Chemung, it therefore has lost its diagnostic value as a marker of the Hamilton formation. *Vitulina pustulosa* is thus far in eastern North America a good Hamilton marker, but in South America it is always found in faunas that have an older aspect.

This Maecurú fauna has ninety-two species, and of these the following six Oriskanian forms are known in it: (1) *Rhipidomella musculosa*, (2) *Leptostrophia perplana*, (3) *Anoplia nucleata*, (4) *Amphigenia elongata curta*, (5) *Anoplotheca flabellites*, and (6) *Tropidoleptus carinatus*. Certainly numbers 1, 3, and 5 are diagnostic of the Oriskanian, and are usually regarded as guide fossils. Combining these occurrences with the other facts mentioned above, it seems to the writer that there cannot be any doubt that the Maecurú fauna holds the horizon of the North American Oriskanian. If further proof of this is required, the reader is referred to Katzer's Plates X, XI, XII, and XV. On the other hand, the view of Clarke (who has studied nearly the entire fauna by the specimens), while not exactly that of the writer, is still not widely different (hardly one formation apart). He states (**5**:91, 92) the following:

> The opinion expressed by Derby [**6**:169] and Rathbun that the Maecurú and Ereré groups bear about the same stratigraphical and paleontological relation to each other as the Upper Helderberg group to the Hamilton, is supported by all evidence now accessible.
>
> It is indeed probable that the Maecurú group embraces elements of faunas that elsewhere precede those of the Upper Helderberg (Schoharie grit, Corniferous limestone), a fact indicated by the earlier expression of the trilobitic element and by the presence of certain molluscan species (*Platyceras hartti*, *Anoplia nucleata*) of the same import.

Notes on the fauna of the Ereré formation.—Hartt (**2**:213) in describing the Ereré locality states:

> This fauna has an unmistakable Devonian facies, but it is difficult to determine its exact equivalency. In some features, as for instance in *Spirifer pedroana*, which closely resembles *S. varicosa*, the fauna recalls that of the Corniferous, while in the occurrence of *Tropidoleptus* and *Vitulina* it approaches the Hamilton.

Rathbun (**3**:260) in his first studies of the Ereré brachiopods concludes:

The Brachiopod fauna, such as it is, resembles so closely that of the Hamilton group of New York state as to leave no doubt that the beds in which it was found, the sandstones and shales of Ereré, represent about the same horizon as the Hamilton group of North America.

This view is repeated four years later (4:38).

Clarke (5:90), regarding this fauna, states:

The middle Devonian composition of this fauna as determined originally from a study of the brachiopods is decided. It may well be regarded, in this respect alone, a miniature of the Hamilton fauna. The two trilobites *Homalonotus Oiara* and *Cryphaeus Paituna*, Hartt and Rathbun, all that are here known, fortify this resemblance presented by the Pelecypoda and there is no lack of harmony on the part of the Gasteropoda and Pteropoda. . . . . It is, with all its resemblance to the Hamilton, a more typical and better defined middle Devonian fauna than that.

The present writer does not *now* see wherein the Ereré fauna is "a miniature of the Hamilton fauna,"[1] and while he would refer it to a horizon about that of the Onondaga (Corniferous), he holds that it has no close faunistic relationship with it. It will therefore be well to examine more carefully into this conclusion of most students, that the Ereré horizon is that or about that of the Hamilton, to learn on what it is based.

The Ereré fauna consists of 45 species, 35 of which are restricted to the formation. Of the 45 species, 41 are found in the sandstones and 4 are restricted to the black shales beneath the sandstone. The 10 species also found in the Maecurú formation are *Dalmanella*

[1] In a former paper (*American Geologist*, September, 1903, p. 152) the writer stated that "the southern portion of the Indiana basin also was open during Onondaga, Hamilton and Genesee time, establishing communication between the Mississippian sea and Brazil. Evidence of this is seen . . . . in the very similar faunas of the Hamilton of the Mississippian sea and that of the Ereré formation of the State of Pará." When this was written, too much reliance for correlation was given the Ereré species *Tropidoleptus carinatus*, *Vitulina pustulosa*, *Orbiculoidea lodensis*, and *Lingula spatulata*. On the other hand, at that time *Rhipidomella musculosa* and *Anoplotheca flabellites* were not known in the Maecurú, nor *Tropidoleptus carinatus* in the Maryland Oriskanian.

The writer still holds to the above statement that "the southern portion of the Indiana basin also was open during Onondaga, Hamilton and Genesee time," but with this correction, that the Mississippian sea did not have open faunal communication with Brazil; nor did either area have connection with Tethys at this time, because the Mississippian and Brazilian seas did not receive the *Calceola* nor the *Stringocephalus* fauna so characteristic of this mediterranean.

nettoana (Clarke thinks that the small Ereré specimens should be separated from the larger Maecurú form), *Vitulina pustulosa*, *Schuchertella agassizi*, *Chonetes comstocki*, *C. herbert-smithi*, *Camarotoechia dotis*??, *Spirifer pedroanus*, *Trigeria* (?) *wardiana*, *T.* (?) *jamesiana*, and *Tentaculites eldredgianus*. None of these perduring species appear to have significant stratigraphic value, either for Middle or Lower Devonic correlation.

Concerning the species restricted to the sandstone horizon, the following notes will help to a clearer understanding: *Lingula spatulata* is certainly not this New York Upper Devonic species. *Orbiculoidea lodensis* may be the New York Genesee form. However, any student of brachiopods knows how variable the species of those genera are, and that no safe identification can be made in similar forms so widely separated as those of the state of Pará, Brazil, and Kentucky. This is because in *Lingula* and *Orbiculoidea* there are so few characters present for comparison; further, when the shells are preserved in shales, they are invariably flattened. On the other hand, *Orbiculoidea lodensis* occurs beneath the Ereré fauna and not above it. *Tropidoleptus carinatus* in North America is now known in the Oriskanian, Hamilton, and Chemung, and is no longer diagnostic for the Middle Devonic of this continent. *Vitulina pustulosa*, it is true, is known only in the Hamilton of North America, but in South America it certainly occurs in older formations. *Chonetes onettianus* is related to *C. scitula* of the Hamilton and Chemung. Clarke suggests that *Spirifer pedroanus* may include two species similar to *S. mucronatus* and *S. audaculus*, two characteristic Middle Devonic forms. This species, however, as figured by Katzer, recalls the Lower Devonic *S. cumberlandiae*. *Modiomorpha pimentana* seems to be related to *M. concentrica* of the Hamilton. *Nuculites ererensis* suggests *N. oblongata* of the Hamilton. *Leda diversa* Hall and *Pholadella parallela* Hall are Hamilton species. The other forms not noted here do not teach anything specifically from the standpoint of the Hamilton or of the Middle Devonic.

In the Ereré fauna there are therefore four Hamilton species—*Tropidoleptus carinatus*, *Vitulina pustulosa*, *Leda diversa*, and *Pholadella parallela*. The first is no longer regarded as diagnostic for limited correlation within the Mississippian sea, and the second,

outside of this area. The last two species, it is true, are Hamilton forms, but it would be claiming too much for them to state that their presence in the Ereré formation correlates it with the Hamilton. Knowledge of pelecypods is as yet too fragmentary for safe stratigraphic correlation. The genera present in the Ereré are almost without exception those of the Maecurú. The exceptions are: (1) *Goniophora*, (2) *Leda*, (3) *Pholadella*, (4) *Edmondia*, (5) *Tropidocyclus*, (6) *Pleurotomaria*, and (7) *Cryphaeus*. Numbers 1, 6, and 7 are known in the Lower Devonic or in still older formations. Numbers 2 and 4 have no restricted stratigraphic range. One is therefore limited to *Leda diversa*, *Pholadella parallela*, and the genus *Tropidocyclus*.

Viewing this proposition from another standpoint, it is seen that all the characteristic Hamilton corals, brachiopods, gastropods, and cephalopods are absent in the Ereré. This is also true for the Onondaga.

As the Amazon Devonic deposits are of a littoral nature and the combined known sections about 400 feet in thickness, one should not expect them to represent a long duration of time. At least 100 feet are of Lower Devonic age, comparable with the North American Oriskanian. The remainder appears to be about that of the Onondaga in age, but from the preceding remarks it seems clear that the two widely separated areas had at this time little, if any, free interchange of faunas. On the other hand, it is clear that there was considerable faunal intercommunication between the seas of Maecurú and the Oriskanian of the southern states of North America.

The presence of two Genesee brachiopods in the Ereré formation—*Orbiculoidea lodensis* variety and *Lingula spatula*?—led Clarke (**5**:91) to state that "we may regard these beds in the Ereré group [black shales] as embodying the equivalent of this Genesee shale fauna." The zone in which the former and three species of *Lingula* are found is, according to Katzer, the next one below the Ereré sandstone, and it cannot therefore be referred to the horizon of the Genesee without placing there also the entire Ererè fauna. The experience of the writer is that *Lingula*, *Orbiculoidea*, and other related inarticulate brachiopods have little stratigraphic value for correlation in widely separated areas.

Conclusion.—The present knowledge of the Amazon Devonic stratigraphy and faunas indicates that the Maecurú formation is near the top of the Lower Devonic, and is comparable with the North American Oriskanian, not only in its facies, but also in its having six of the guide fossils of the class Brachiopoda of the latter formation. These facts indicate, further, that the two areas (Brazil and the Oriskanian of the southern United States) were at this time in communication. The northward extension of the Amazon Maecurú fauna is known sparingly about Frog Mountain, Alabama, for here occurs *Spirifer arenosus*, **S. murchisoni*, and *Amphigenia*. This fauna is better represented in the region of Armuchee, near Rome, Georgia, as here are found **Rhipidomella musculosa*, *Stropheodonta magnifica*, *Anoplotheca dichotoma*, **Spirifer tribulis*, *Ambocoelia umbonata*, and *Meristella rostellata* n. sp. The best of the southern localities are in the Camden formation of Tennessee and southwestern Illinois. The more important forms found at the last-named localities are *Lingulopholis terminalis*, *Chonostrophia reversa*, **Anoplia nucleata*, *Metaplasia pyxidata*, **Spirifer tribulis*, **Anoplotheca flabellites*, *Eatonia peculiaris*, **Amphigenia curta*, and *Megalanteris condoni*.

The southern Oriskanian sea appears not to have connected openly, but rather sparingly northward, either across western or eastern Tennessee, with another basin of the same age whose deposits are found in the Appalachian (Cumberland sea)—Gaspé region. The northern basin is characterized by *Edriocrinus*, *Hipparionyx proximus*, *Spirifer arenosus*, and *Rensselaeria*, none of which are in the southern facies of the Oriskanian—the Camden-Armuchee-Frog-Mountain-Maecurú faunas. On the other hand, this southern Oriskanian has *Spirifer* of the *S. macropleura* type, *Amphigenia*, *Tropidoleptus* (one species has been found in Maryland), *Vitulina*, *Productella*, many pelecypods strongly reminding one of the American Middle Devonic faunas, and *Styliolina*, that either do not occur in the northern Oriskanian or make their appearance with the pronounced southern invasion of Onondaga time. In other words, the Oriskanian of the United States is not only an outgrowth of the Helderbergian fauna, but also has received many migrants from the southwest Brazilian-Pacific region and from the North Atlantic (Gaspé) along a path not

*Either the same or a very closely related species also occurs in Brazil.

yet clearly made out, but seemingly more probably down the St. Lawrence-Connecticut depression than by way of the St. Lawrence-Champlain troughs.

The Ereré fauna is a direct outgrowth of the Maecurú and probably follows it without a time break. It seems to hold the horizon of the American Onondaga, hardly that of the Hamilton, and certainly there is nothing in it that indicates the Genesee fauna. The connection existing between Brazil and the lower Mississippi embayment during the Maecurú was destroyed during Ereré time, as all of the guide fossils of the Onondaga and Hamilton fail of representation in the Amazon formations.

CURUÁ FORMATION OF DERBY

Above the Ereré formation occurs a series of "black [lower 300 feet] and red shales, passing at times into a shaly sandstone" (Derby **6**:170). Their thickness is estimated to be about 600 feet. This formation occurs on the rivers Maecurú, Curuá, Trombetas, and Tapajos, and near Ereré.

"In both the black and red shale, near the junction of the two," Derby (**16**:171) found *Spirophyton typum* Hall and the sporangia *Protosalvania braziliensis* and *P. bilobata.* The relation of these beds to the Devonic and Carbonic is not yet established, according to Katzer, and he refers them provisionally to the Carbonic, as did Hartt. Derby and Clarke, however, place them in the higher Devonic. Clarke also reports the presence of the Ereré species *Nuculites ererensis.*

Katzer states that *Spirophyton* is found with *Productus cora* and *P. sublaevis* in the Carbonic limestones of Dompierre. In the Flysch of Europe this fucoid or "hieroglyph" (=a burrow probably of a polychaete worm) is widely distributed. As the occurrence of *Spirophyton* has no satisfactory time value, Katzer refers these black and red shales with concretions to the Carbonic.

GENERAL DISCUSSION

The older Devonic deposits of the Amazon region are also known in the Brazilian states Matto Grosso and Parana; also in Bolivia, Peru, Argentina, and apparently also in Paraguay and the Falkland

Islands. Everywhere the petrographic character of these deposits is similar and points to littoral conditions. Katzer states that this distribution forces the conclusion that in the north and east, in the region of Guiana-Cegra, there was a bordering Archean continent, to the south of which lay the sea in which the Amazon sandy deposits were laid down. The land was actually but the western end of the *Atlantic-Ethiopian continent.* A second continent in the southwest extended from southern Chili and Patagonia westward over a portion of the present Pacific Ocean and probably beyond southern Georgia. This Katzer has named the *Southern Pacific Continent.*

The Brazilian Devonic sea, the author continues, is connected on the one side with that of New York (it would be better to say North America), and on the other with South Africa (Cape Colony), because the faunas of these two areas are to a great extent harmonious.[1] Less decided, but still surprisingly great, when one takes into consideration the long distances, is the harmony between this older or Lower Devonic fauna and those of Australia, Asia, and Europe.

The Lower Coblenzian faunas of Rhenish Germany remind one forcibly of American Oriskanian. To bring out this fact more clearly in this place, but a short account of the Siegen fauna can be given, the following being the more important forms: *Craniella, Orbiculoidea anomala* (like American *O. ampla*), *Schizophoria provulvaria, S. personata* (like *S. oriskania* soon to be published), *Leptostrophia explanata* (like large Oriskany species). *Stropheodonta sedgwicki* (type of *S. demissa* now known in Maryland Oriskanian), *Schuchertella gigas* (often reported as a *Hipparionyx*), *Eatonia, Rhynchonella papilio* (type of *Plethorhyncha barrandei*), *Rennselaeria* (?)

[1] The lower Devonic fauna of South Africa has recently been described by Reed (*Annals of the South African Museum*, Vol. IV, Pts. III and IV, 1903–4). These Bokkeveld beds are faunally very closely related to the Amazonian, and especially to the Falkland Islands faunas. Common to two or more of these areas may be mentioned the following: *Orbiculoidea baini, Schuchertella sulivani, Chonetes falklandicus, Spirifer orbignyi, S. lauro-sodreanus, Ambocoelia umbonata, Leptocoelia flabellites, Vitulina pustulosa, Tropidoleptus carinatus.* Nearly all the gastropods and pelecypods of the Bokkeveld beds are compared by Reed with Amazon species. There are at least fifteen such forms. "The presence of a true *Cryphaeus* and of spiny forms of *Homalonotus* indicates that the beds may be referred with certainty to the Devonian, and it is probable that they belong to the lower division of that formation" (Reed, Vol. IV, p. 202).

crassicosta (these shells look more like *Plethorhyncha speciosa*) *Trigeria* (?) *oehlerti* (*Leptocoelia* with excessive fold and sinus), *Tropidoleptus carinatus rhenanus*, *Megalanteris*, *Spirifer primaevus* (type of *S. murchisoni*). The following remind one strongly of the Maecurú facies: *Actinodesma*, *Cypricardella*, *Leptodomus*, *Goniophora*, *Grammysia* (large forms), *Modiomorpha* (large forms), *Sphenotus*, *Pteronites*, *Limoptera*, *Cryphaeus*, and *Homalonotus*.

For a modern work on this fauna, see Dreverman, *Palaeontographica*, Vol. L (1904), pp. 329–87, 5 plates. Even a glance at these plates will lead American workers to see an earlier development of their Hamilton fauna. European stratigraphers invariably regard the Siegan as Lower Devonic.

Compared with North America, the Amazon Devonic, according to Katzer, proves to be a mixture of Oriskanian, some Helderbergian and more especially New York Hamilton. Formerly Katzer regarded all the Devonic of the Amazon as Middle Devonic. He now considers that the Hamilton cannot be considered as uppermost Middle Devonic, but that part of it must be referred to the Lower Devonic—a view in which he will have few, if any, followers. This conclusion is largely based on the early occurrence in South America (Maecurú) of *Vitulina pustulosa*, *Tropidoleptus carinatus*, large *Grammysia*, *Leioptera*, *Actinoptera* of the *boydi* type, and the high or Hamilton occurrence of these types in North America.

Katzer's difficulties would have vanished if he had correlated the Maecurú and Curuá deposits with the Oriskany of the Lower Devonic. That this correlation is a more accurate one is borne out by the fauna, as has been shown by the present writer.

It has also been shown that the Ereré fauna has not the facies of the Onondaga nor of the Hamilton. This dissimilarity is partially explained by the Amazon coarse littoral deposits, an unnatural habitat for an extensive coral fauna as that of the American Middle Devonic. However, the Ereré fauna is wholly a direct outgrowth of that of the Maecurú, while the Onondaga (Corniferous) is a development out of the Oriskanian of the type of the northern province plus an eastern North Atlantic invasion (the *Spirifer cultrijugatus* fauna of the Rhine at the base of the Middle Devonic), and another from the south through the Mississippi embayment bringing in some of the

prolific coral faunas so abundantly developed about Louisville, Kentucky.

The reason why the Lower Devonic faunas of northern Europe, North America, and South America have so much that closely binds them together is because the oceans of these areas were in communication. This is strikingly shown in the great pelecypod development of the Coblenzian of the Rhine region—genera upon genera almost unknown in the Oriskanian making their first appearance in some force in the Onondaga, and being in full development in the Hamilton. The Coblenzian pelecypod development in Europe is very largely wiped out or changed by the great Euro-Asiatic invasian coming in just above the *Spirifer cultrijugatus* fauna, which is known as the Calceola fauna holding the horizon of the Onondaga in this country. This fauna continues without very great change into the Stringocephalus fauna holding the horizon of the Hamilton. While this great invasion of Middle Devonic Euro-Asiatic faunas was proceeding normally in Europe, the North American Middle Devonic had but little connection with that region, and the fauna of a lower Devonic facies was continued to the end of Hamilton time, when another great physical change occurred, and northern Europe and America were once more in communication.

CARBONIC

The marine Carbonic of the Lower Amazonas is divisible into two divisions—a lower consisting essentially of sandstone, and an upper of limestone. Of each division about 10^{m} thickness is known. The limestone is locally very rich in well-preserved, often silicious fossils, and these indicate that it is of Permo-Carbonic age. The sandstone is devoid of fossils and of coal-beds, and, further, as the stratigraphic relation to the limestone is nowhere clearly shown, its actual age remains undetermined. The best exposures are those of the Tapajos. Beneath the sandstone is a series of shales and shaly sandstone—the Curuá group of Derby, and referred by him and Clarke to the Devonic (see statement under Devonic), but provisionally referred by Katzer to the Carbonic.

During the time of limestone deposition there were effusions of

diabase and porphyry, giving rise to hornstones and dark limestones with the fossils transformed into silicious pseudomorphs.

Much of this fauna remains unworked. Some of the leading fossils are: *Lophophyllum* near *proliferum*, *Lonsdaleia rudis*, *Rhipidomella penniana*, *Orthotichia morganiana*, *Schuchertella tapajotensis*, *Streptorhynchus hallianus*, *Orthotetes correana*, *Chonetes glaber*, *Strophalosia cornelliana*, *Productus semireticulatus*, *P. lineatus*, *P. cora* and seven other species, *Spirifer cameratus*, *S. condor*, *S. rockymontanus*, *Spiriferina transversa*, *S. spinosa*, *Reticularia perplexa*, *Ambocoelia planoconvexa*, *Hustedia mormoni*, *Seminula argentea*, *Cleiothyris royssii*, *Aviculopecten occidentalis*, *A. herzeri*, *Lima retifera*, *Pinna peracuta*, *Myalina kansasensis*, *Allorisma subcuneata*, *Platyceras nebrascensis*, *Pleurotomaria speciosa*, *Euphemus carbonarius*, *Bellerophon crassus*. (For a complete list, see Katzer, pp. 162–67.)

Another well-known area for Carbonic is that of the Trombetas. The observed thickness is a little over 6^{m}. The fauna here is a smaller one (seventeen species) than that of the Tapajos (115 species), but the species are the same in both areas.

Katzer regards the Tapajos faunas as highest Upper Carbonic, and not of Lower Permic age as did Waagen. Derby (6:173) states:

> The fauna shows the closest relationship to that of the Coal Measures of the Western States, more than half of the species being identical. I have already shown that the Bolivian and Peruvian Carboniferous faunas, as far as they are known, are equivalent to the Brazilian, and to that of the North American Coal Measures.

To the north of the Amazon River the Carbonic is known along the river Curuá and in the region north of Alemquer (Katzer). It consists here of sandstones and gray sandy-calcareous shales with a thickness estimated at 200^{m}. The fauna obtained here Derby regards as of the same age as that of the Tapajos.

> Of all the Palaeozoic deposits of the Amazonas, those of the Carboniferous occupy the most extensive area and, at the same time, present the greatest difficulties to study. Composed for the most part of soft beds, they suffered extensive denudation, during the interval between the close of the Carboniferous and the beginning of the Tertiary, during which time they were, for the most part, exposed above the level of the sea. . . . . Mr Smith, who has best studied these deposits, is of the opinion that their total thickness is not less than 2,000 feet, and, although the data for the calculation is very defective, I cannot say that it is exaggerated (Derby, 6:171).

TABLE OF DEVONIC FAUNAS

(Unidentified species and species without decided value are not listed here. c=common; r=rare.)

	Lower Maecurú Formation	Upper Maecurú Formation	Rio Curuá	Ereré Formation Zone a of Section
CORALS				
Pleurodictyum amazonicum Katzer	c			
BRYOZOA				
Rhombopora ambigua Katzer	c			
Reptaria stolonifera Rolle	x			
Chaetetes carvalhoanus Katzer	x			
BRACHIOPODA				
Lingula spatulata (not *L. spatulata* Hall)				x
" ererensis Rathbun				x
" rodriguesii Rathbun (from zone 3 at base of Ereré)				r
" stauntoniana Rathbun (from zone 3 at base of Ereré)				x
" gracana Rathbun (from zone 3 at base of Ereré)				r
Orbiculoidea lodensis Hall variety (from zone 3 at base of Ereré)				c
Dalmanella nettoana (Rathbun)	c		x	x
Rhipidomella hartti (Rathbun)	c		x	
" musculosa (Hall)	x			
Leptostrophia perplana (Conrad)	c		c	
Stropheodonta (?) hoeferi (Katzer)	x			
Tropidoleptus carinatus (Conrad)				r
" " maecuruensis Katzer	c		c	
Vitulina pustulosa Hall	c		r	c
Schuchertella agassizi (Hartt)	c		x	c
Chonetes comstockii Hartt	c			c
" onettianus Rathbun (related to *C. scitula*)				x
" herbert-smithi Hartt	x			c
" freitasii Rathbun	c		x	?
" curuaensis Rathbun	?		r	
Anoplia nucleata (Hall); identified by Clarke	x		x	
Productella maecuruensis Rathbun	r			
Rhynchonella ererensis Rathbun (not figured; based on one dorsal shell)				r
Camarotoechia dotis (Hall) ??	c	c		r
" cf. sappho (Hall)	x		x	
Amphigenia elongata Hall	c		c	
Spirifer buarquianus Rathbun	c			
" " var.contracta Katzer	c			
" " " alata Katzer	c			
" coelhoanus Katzer	c			
" clarkei Katzer	r			
" duodenarius Hall ? (probably not this species)	c			
" derbyi Rathbun (related to *S. murchisoni*)	r			
" hartti Rathbun	r			

TABLE OF DEVONIC FAUNAS—*Continued*

	Lower Maecurú Formation	Upper Maecurú Formation	Rio Curuá	Ereté Formation Zone 2 of Section
BRACHIOPODA—*Continued*				
Spirifer lauro-sodrianus Hartt (related to *S. macropleura*	r			
" pedroanus Hartt	r	x	r	c
" valenteanus Hartt (not figured; a poor species)				r
Cyrtina (?) curupira Rathbun				r
" maecuruensis (Rathbun)	r		x	
Anoplotheca flabellites (Conrad)	x			
Terebratula rathbuni Clarke	x		x	
" derbyana Hartt				c
Trigeria (?) jamesiana (Hartt)	c			c
" " wardiana Hartt	r		r	c
Oriskania (?) navicella Hall & Clarke (identified by Katzer)	r			
This is no Oriskania, nor is it H. & C. species				
PELECYPODA				
Actinopteria eschwegii Clarke (related to *A. boydi*)	c		r	
" humboldti Clarke	c			
Leiopteria browni Clarke	r			
" sawkinsi Clarke			r	
Aviculopecten coelhoanus Katzer	r			
Modiomorpha helmreicheni Clarke (of the early depressed type)	c			
Modiomorpha sellowi Clarke (related to *M. complanata* of the Onondaga)	c			
Modiomorpha pimentana Hartt & Rathbun				c
Nucula bellistriata parvula Clarke (a Hamilton form)	r			
" kayseri Clarke				r
Nuculites ererensis Hartt & Rathbun (also in higher				
" Curuá)				r
" majora Clarke				c
" branneri Clarke				c
" smithi Clarke	x			
Palaeoneilo sulcata Hartt & Rathbun	x			
" pondiana (Hartt & Rathbun)				r
" (?) simplex Hartt & Rathbun				r
" orbignyi Clarke	c			
Leda diversa Hall (a New York Hamilton species)				r
Guerangeria (Nyassa?) ortoni Clarke	r			
Goniophora woodwardi Clarke				r
Toechomia rathbuni Clarke	c			
" freitasi Clarke	c			
Sphenotus gorceixi Clarke				c
" bodenbenderi Clarke	r			
Cimitaria karsteni Clarke	r			
Cypricardella hartti Clarke	c			
" (?) pohli Clarke	r			
Pholadella parallela Hall (a New York Hamilton species)				r

TABLE OF DEVONIC FAUNAS—*Continued*

	Lower Maecurú Formation	Upper Maecurú Formation	Rio Curuá	Ereré Formation Zone a of Section
PELECYPODA—*Continued*				
Grammysia ulrichi Clarke				r
" pissisi Clarke	c			
" burmeisteri Clarke	r			
" lundi Clarke	c			
" gardeneri Clarke	r			
Edmondia sylvana Hartt & Rathbun				r
GASTROPODA				
Bellerophon stelzneri Clarke			r	
" morganianus Hartt & Rathbun				c
Bucaniella coutinhoana (Hartt & Rathbun)				c
" reissi Clarke	x			
Bucania freitasi Clarke	r			
Plectonotus derbyi Clarke	r			
" (?) salteri Clarke	x			
Ptomiatis forbesi Clarke	r			
Platyceras whitei Clarke	r			
" " curua Clarke			r	
" hussaki Clarke	r			
" steinmanni Clarke	r			
Platyceras hartti Clarke (related to *P. ventricosus*)	x			
" symmetricum Hall?				r
" " maecuruensis Clarke	r			
" meerwarthi Katzer	r			
" tschernyschewi Katzer	r			
" coutoanus Katzer	r			
" gracilis Katzer	r			
" subconicum Katzer	c			
Diaphorostoma furmanianum (Hartt & Rathbun)				x
" darwini Clarke	x		c	
" (?) agassizi Clarke	r			
Strophostylus varians Hall	x			
Tropidocyclus gilletianus (Hartt & Rathbun)				c
Pleurotomaria rochana Hartt & Rathbun				c
PTEROPODA				
Tentaculites eldredgianus Hartt & Rathbun	c	x		c
" stübeli Clarke	c			
" tenellus Katzer	r			
" osseryi Clarke			c	
Styliolina clavulus (Barrande); according to Katzer	x			
TRILOBITES				
Homalonotus (Trimerus) derbyi Clarke	c			
" (?) acanthurus Clarke	r			
" (Dipleura) oiara Hartt & Rathbun				r
Phacops brasiliensis Clarke	c			
" menurus Clarke	r			

TABLE OF DEVONIC FAUNAS—*Continued*

	Lower Maecurú Formation	Upper Maecurú Formation	Rio Curuá	Ereré Formation Zone 2 of Section
TRILOBITES—*Continued*				
Phacops scirpeus Clarke	r			
" (?) pullinus Clarke	c			
" goeldii Katzer	r			
" (?) macropyge Clarke	c			
Dalmanites (Odontocheile) maecurua Clarke	c			
" " australis Clarke	r			
" (Acaste) galea Clarke	c			
" (Hausmanni) infractus Clarke	r			
" " tumilobus Clarke	c			
" " gemellus Clarke	r			
" " ulrichi Katzer				r
Cryphaeus paituna (Hartt & Rathbun)				c
Species in each horizon	92	3	22	45
Restricted species	71	0	5	35

Common to Maecurú and Curuá	16
Common to Ereré and either of the others	10
Common to Ereré and Maecurú	10
Common to Ereré and Curuá	5
Entire Devonic fauna	131

LITERATURE CITED

1. CLARKE, JOHN M. "As Trilobitas do grez de Ereré e Maecurú estado do Pará, Brazil." *Archivos do Mus. Nac. Rio de Janeiro*, Vol. IX (1890), pp. 1–58.
2. HARTT, CH. FRED. "Contributions to the Geology and Physical Geography of the Lower Amazonas." *Bull. Buffalo Soc. Nat. Sci.*, Vol. I (1874), pp. 201–35.
3. RATHBUN, RICHARD. "On the Devonian Brachiopoda of Ereré, Province of Pará, Brazil." *Bull. Buffalo Soc. Nat. Sci.*, Vol. I (1874), pp. 236–61, Pls. 8–10.
4. RATHBUN, RICHARD. "The Devonian Brachiopoda of the Province of Pará, Brazil." *Proc. Boston Soc. Nat. Hist.*, Vol. XX (1878), pp. 14–39.
5. CLARKE, JOHN M. "The Paleozoic Faunas of Pará, Brazil. (1) The Silurian Fauna of the Rio Trombetas. (2) The Devonian Mollusca of the State of Pará." *Archivos do Mus. Nac. Rio de Janeiro*, Vol. X (1899; author's English edition, 1900), pp. 1–127, Pls. 1–8.
6. DERBY, ORVILLE A. "A Contribution to the Geology of the Lower Amazonas." *Proc. American Phil. Soc.*, Vol. XVIII (1879), pp. 155–78.