ART. LXIII.—*The Geological Survey of Brazil. First Preliminary Report made to the Counsellor Thomaz José Coelho de Almeida, Minister and Secretary of State for Agriculture, etc.*; by CH. FRED. HARTT, Chief of the Geological Commission of the Empire of Brazil. Rio de Janeiro. 1876.*

ON the first of May, last year [1875] I had the honor of being appointed chief of the Commission charged with the undertaking of a geological survey of the Empire. At the same time Dr. Elias Pacheco Jordao was chosen assistant, and Messrs. Orville A. Derby and Richard Rathbun were appointed assistant geologists. The government having given me authority, I engaged, as the photographer of the Commission, Senhor Marc Ferrez, photographer of the Royal Navy.

While awaiting instructions, and with the permission of his Excellency the Minister of Agriculture, I went with Commander E. P. Wilson to the district of São Gonçalo, in the southwestern part of the province of Minas Geraes, for the purpose of inspecting the auriferous tract pertaining to a grant in which the latter was interested. I examined with care the region between Bella Vista, on the Don Pedro II railroad and São Gonçalo, including the gold mines of that locality and in the vicinity of the city of Campanha, verifying the occurrence of gold in three distinct deposits.

First, it is found in gneiss of what appears to be the upper part of the Archæan series (Laurentian), the metal being distributed in more or less irregular veins, apparently conforming in direction with the stratification of the rocks. Throughout this section the gneiss is very much decomposed, remaining, however, *in situ*, the decomposition at times extending to a depth of 30 meters or more. While in the solid gangue the proportion of gold is not great enough to pay the cost of working, it has been extracted with profit in many places from the decomposed portion of these same lodes. It is quite probable that this softened rock contains proportionally more gold than the solid gneiss, owing to the accumulation of the contained

* Translated and arranged for publication in this Journal by Theo. B. Comstock, Ass't Professor, in charge of Geological Department, Cornell University, Ithaca, N. Y. This document has not yet been published in Brazil. A copy of the original manuscript in the Portuguese language has been kindly furnished to the translator, with full liberty of action. The report has been shortened by the omission of not a little concerning the details of the Survey, which can have no special interest to the readers of this Journal. The mode of arrangement and construction of sentences differs somewhat from the original, but mainly in cases in which conciseness is gained without the sacrifice of perspicuity. Statements of fact or opinion will be found to correspond as closely as possible with the ideas of the author. Explanatory words within brackets are added by the translator. Words enclosed in parentheses occur thus in the original.—[T. B. C.]

metal of the lower portion in this part of the vein. Action of this nature was first demonstrated by Dr. James E. Mills in the auriferous district of Rio Grande do Sul and has been confirmed by the observations of Viscount de Barbaçena in his mineralogical studies of the auriferous gneiss of Minas Geraes.

Secondly, the gold occurs in the lower part of a deposit of red earth, which covers the whole surface of this region. This is a mechanical mixture of the ingredients of the decomposed gneiss, the local origin of which is not perfectly evident. All parts of the earth are not equally rich, and the gold is probably distributed in some relation to the outcrops, as has been shown by Dr. Mills in the eastern part of the province.

Thirdly, some gold is found in the alluvial deposits of the river-valleys, and in the vicinity of the ancient excavations of Sao Gonçalo and Campanha; the abundant "waste" also contains a considerable quantity of the metal.

Notwithstanding the small amount of gold and the fact that the richer deposits have already been extensively washed, this section appears to be worthy of scientific study, and, probably, by the application of methods similar to those employed in the California *placers*, the region may yet become productive. To this end are required the detailed exploration of this part of the country, the limitation of claims and the introduction of a cheap method of extraction. A survey of the character mentioned will probably be soon made.

Last year, Dr. Mills spent about six months in the study of the auriferous region of Minas Geraes, where he succeeded in discovering and applying the law of the distribution of gold, especially of its occurrence in the series of rocks characterized by the presence of *itacolumite*,—a law extremely important in its bearing upon the future development of the resources of that province. This gentleman has promised to give me a complete report, in which he will not only enunciate and illustrate this law, but will also include all the scientific results of his interesting explorations.

For several years past I have been engaged in the systematic examination of the border of the Brazilian plateau for the purpose of discovering and critically studying the different geological formations, which are there better developed and more fossiliferous than in the interior, being convinced that I could thus most quickly obtain a sure basis for the study of the general geology of the country. Having received instructions for continuing those studies by beginning in the northern provinces and proceeding southward, I judged it best to inaugurate the labors of the Commission by the exploration of the coast of Pernambuco. On the 10th of July [1875] I left Rio for that province, accompanied by Drs. Jordao and Freitas, and Senhor

Ferrez. Opening a provisional laboratory [in the City of Pernambuco], I commenced the examination of the vicinity, soon discovering limestone beds of the Cretaceous formation containing many species of fossils. The explorations were continued northward as far as Catuáma. At Maria Farinha, Cretaceous rocks were found so rich in fossils that several weeks were spent in carefully studying the formation, making a map of the locality, determining accurately the position and sequence of the strata, and collecting enormous quantities of fossils, among which are very many new species. Other collections were obtained from the vicinity of Olinda, from Iguarassú, from the island of Itamaracá, and at Catuáma.

I studied with especial care the limestones which are used for lime-making, analyses of which will be given in my report, and I am also preparing for the same report a chapter on the manufacture of lime and the construction of calcining furnaces.

The examination of the coast was then continued as far as Santo Agostinho, including a reconnoissance along the line of the railroad to Una, with excursions from several points upon both sides. The geology of this portion of the country is, however, extremely monotonous and of little interest.

At the same time I examined carefully the reefs along the coast,—whose geological features are of the highest importance to the country. As I have already indicated to your Excellency, these are of two classes: 1. *Coral Reefs*, composed of calcareous material derived from the débris of certain species of Polyps, Acalephs, and calcareous plants, and 2. *Consolidated Praias* [Beaches], made up of compacted siliceous sand. The reef of Pernambuco is a representative of the latter class. This I examined very minutely, and, with the aid of Drs. Jordao and Freitas, made a map of a portion of it. Senhor Ferrez, under my direction, procured a fine series of photographs exhibiting its structure and appearance.

In the study of these reefs a magnificent collection of corals was obtained, including hundreds of large specimens, with many new species. Along with these, and with very little trouble, we gathered large numbers of marine animals, such as fishes, Echinoderms, Crustaceans, etc., etc., among which there is an extraordinary variety of unknown forms.

In September I went with the members of the Commission to make a reconnoissance along the Sao Francisco River to a point a little above the rapids of Paulo Affonso. We ascended the river in a sailing-boat as far as Piranhas, the limit of navigation. At that place, thanks to Senhor Ventura, we found prompt conveyance to the falls, where we remained eight days. Senhor Ferrez took a series of views of the most characteristic points. This was an extremely laborious task, and I cannot but com-

mend him for the firmness with which he struggled against great difficulties and for the good results that he obtained. As the rocks of the *cachoeira* [rapids] are excessively black and the water is white, it was very difficult to photograph both at the same time. On this account I thought it better to make several separate photographic studies of parts of the *cachoeira* which could be mounted as one picture. I hope that I shall be able, by means of the geological, topographical and photographic material collected, to present clear and exact ideas of this wonder of Brazil.

From this place a trip was made to the Serra* de Maria Farinha, distant about five *leguas*.† From the summit of this ridge, at an altitude of two thousand feet or more, may be seen a very large portion of the provinces of Sergipe and Alagoas, with parts of the provinces of Bahia and Pernambuco, and thus a very accurate idea of the topography of the included area may be obtained. All this portion of the country is composed of gneiss and related rocks, forming a plateau less than one thousand feet in height, and nearly level or with very slight undulations. As the region is arid, there has been scarcely any decomposition of the rocks, and the effects of water action are not very evident, owing to the absence of rain during the greater part of the year. There is no vegetable mould, but the rock is covered with a layer of sand a few inches in depth. The vegetation is such as is peculiar to arid plains—gigantic cactuses, the *xique-xique*, *faxeiro*, *mandacarú*, etc., being abundant. The rivers run in shallow channels, and are completely dry during a great part of the year, as are also the small lagoons which abound on the plain just as upon its continuation in the interior of Bahia.

From point to point peaks or short *serras* rise abruptly from the plain, like islands in the sea, seldom attaining an altitude greater than twenty-five hundred feet. In the provinces of Sergipe and Alagoas the *serras* are commonly composed of gneiss or some other rock of the same series. Between Piranhas and the rapids, however, small ridges of sandstone are encountered, and in the provinces of Bahia and Pernambuco, in the neighborhood of the Sao Francisco River, there are large *serras* and high *chapadas* [table lands] composed of the same rock. Such are the *serras* of Tacaratú. Long ago this sandstone covered the whole of this region; but by the action of the sea during the elevation of the Brazilian Plateau, and afterward by the action of the pluvial waters, these beds were denuded over a large portion of the country, leaving only the isolated fragments now forming the table-topped hills which abound in the valley of the

* The term *serra*, as used in Brazil, signifies a rocky ridge, usually more or less serrated in outline, although even table-topped hills are often thus designated.—

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† The Portuguese *legua*, or league, is equivalent to nearly 1.6 English miles.—

[T. B. C.]

Sao Francisco. This river once ran over these beds at a height of one thousand feet, more or less, above its present level, excavating its channel in the sandstone until it had cut through to the gneiss. Above the rapids the river now courses almost over the surface of the plain, its channel being but slightly indented; but upon arriving at the rapids it is suddenly precipitated by a series of magnificent waterfalls through an exceedingly narrow gorge, the depth of which immediately below the rapids is from 80 to 90 meters. This gorge, or cañon, with its walls nearly or quite vertical, extends as far as Piranhas, the river in this portion being much broken by rapids. Below Piranhas the river valley still maintains its cañon-like character, although its width is increased.

Like Niagara, these falls are slowly retroceding, but in a different manner. * * * *

At the Cachoeira de Paulo Affonso the water passes over gneissic rocks. These do not here suffer decomposition or disintegration by frost, but they are much eroded by transported sand and stones, which produce extraordinary effects, by excavating innumerable pot-holes that soon communicate and allow masses of the rock to fall away. In my final report, the region of the cachoeira will be very carefully described, as well as the geology and physical geography of the lower Sao Francisco.

We returned to Pernambuco at the end of six weeks, and a few days later the bulk of the collections, filling sixty large boxes, were sent to Rio de Janeiro.

Dr. Jordao becoming ill at this juncture, I permitted him to return to the capital [Rio.] As my two assistants, Messrs. Derby and Rathbun, had not yet arrived, and beginning to feel the need of help, I called upon my former assistant, Mr. John Caspar Branner, who, being then in Rio, came at once to my aid, performing very valuable services. He is still employed by the Commission.

After shipping the collections, I returned to Maria Farinha, with Dr. Freitas and Mr. Branner, in order to finish the study of the Cretaceous beds and to examine the coral reefs. In ten days we returned again to Recife [another name for the city of Pernambuco] with a large vessel loaded with fossils, etc. Having been informed that your Excellency desired to exhibit some of the results of the Commission at the National Exposition [held at Rio Janeiro, January, 1876] the new collections were packed in seventy more cases, and I returned with them to the capital in December, accompanied by Senhor Ferrez. * *

While at Pernambuco, I procured a large barque from Mr. Frederico Soares, of Maria Farinha, and sent Dr. Freitas and Mr. Branner to explore the geology of the coast and its reefs as far as Parahyba do Norte,—a trip which was made with good results.

Afterward, Dr. Freitas returned to Iguarassú, where he obtained a fine collection of Cretaceous fossils, including many specimens of shark's teeth and of the teeth of an enormous reptile which is unknown to me. Mr. Branner then continued his study of the coast south of the Cape of Santo Agostinho, examining the reefs, from which he has sent me an interesting collection of corals and other objects, embracing many new species. He also sent photographs of a number of important points. In the beginning of February [1876], Messrs. Freitas and Branner, after sending me forty additional boxes of specimens, went to Aracaju, in the province of Sergipe, to study the Cretaceous deposits. They have already [March 5] made a large collection of fossils, especially of *Ammonites*, *Ceratites*, *Natica*, *Janira*, etc., with numerous forms not before obtained from Brazil. * *

Upon arriving at Rio de Janeiro, a building was hired, the collections were unpacked, and I began to arrange a series of specimens for the Exposition, Dr. Mills assisting me in the work. About the middle of the month [December, 1875] Messrs. Derby and Rathbun arrived, bringing new collections, including a typical series of the Carboniferous and Devonian fossils of the Amazonas and some North American fossils to compare with them. These gentlemen at once aided me in the preparations for the Exposition, and while this lasted they took charge of the other collections. In the meantime Senhor Ferrez mounted for the Exposition a collection of one hundred photographic views and prepared two albums containing a nearly complete series of the photographs taken for the Commission. As it was possible to expose but a small portion of the collections, there were exhibited only a series of the Cretaceous rocks and fossils, with another series illustrating the structure of the reefs, and the collections brought by Messrs. Derby and Rathbun. * *

On the 1st of February, Messrs. Derby, Rathbun and Ferrez were sent to Bahia, to commence the study of the geology of the vicinity and to continue the examination of the reefs. They established themselves at the station of Plataforma, and have to this date [March 5] been engaged in tracing the limits of the areas occupied by the different formations at the northern part of the Bahia de Todos os Santos [Bay of All Saints], in collecting Cretaceous fossils, and in the study of the reefs. Already they have obtained a large quantity of fossils,—teeth, bones and scales of reptiles and fishes, together with Mollusks and Crustaceans. In connection with the study of the recent formations and the reefs, they have also made a splendid collection of marine animals.

Two years ago, Mr. Herbert H. Smith, one of my assistants on the Morgan Expedition of 1870, was engaged in scientific studies in the province of Pará [on the Lower Amazonas], in some measure under my direction. Since that time he has

gathered a very extensive collection of insects, numbering, as he assures me, many thousands of species. This collection is now owned by Mr. Smith, and it is of so great value that I feel it my duty to call the attention of your Excellency to the matter, suggesting that it may be advisable to take steps toward securing at least a complete set of the species for the National Museum.

In accordance with the request of your Excellency, I accepted the Directorship of the geological section of the National Museum. After inaugurating the plan and arranging the work for my assistant during my absence, I propose to leave the city to continue my studies in the north.

My prospective journey is as follows: to leave Bahia for the diamond fields, and after examining these to proceed as far as the Rio Sao Francisco, to a point not yet determined. I intend to visit the watershed between the Sao Francisco and Tocantins rivers and to determine its character, afterward descending the Sao Francisco to the vicinity of the rapids of Paulo Afonso. From thence I expect to make a trip to the Serra de Araripe, and then to visit the locality of fossil fishes to examine the Serra de Ybiapaba, striking the sea coast probably at Ceará.

After making this expedition and reviewing the work of the assistants, who will be left along the coast in the provinces of Bahia, Sergipe and Alagoas, I ought to have a somewhat clear idea of the general geology of the northeastern portion of the empire, a region concerning which we have now very little information. This journey will probably occupy about four months. At the close of the exploration I propose to return to Rio de Janeiro with the members of the Commission to arrange and describe the collections and to prepare a report *in extenso* upon all the results obtained by the Commission with descriptions and engravings of a large number of Brazilian fossils.

ADDENDUM BY THE TRANSLATOR.

A letter received from Professor Hartt, bearing date, Rio de Janeiro, March 25, 1876, gives some particulars concerning the work accomplished since the writing of the foregoing report. He states that Messrs. Derby and Rathbun have met with most excellent results at Bahia, while Dr. Freitas and Mr. Branner have made yet another very large collection of Cretaceous fossils from the Maröim region. Mr. H. H. Smith had also done characteristic work upon the Amazonas, amassing extended and valuable collections. Professor Hartt himself was about ready to start for the interior.

By the same mail a letter was received from Mr. O. A. Derby, dated Santo Amaro, near Bahia, March 26, 1876. He writes: "We have found some rich deposits of Cretaceous fishes and

reptiles in this vicinity and are working them up with care. I do not know as yet what we have, but am certain of several species of Crocodiles and think we have *Iguamodon*. * * * Branner reports quantities of fine Cretaceous fossils from the Province of Sergipe, where he is now." * * * * *

"We are now engaged in an exploration of the bay [Bahia de Todos os Santos] and are in a little town four hours by steam from the city [Bahia]. The geology of this vicinity is mainly Cretaceous and Tertiary and quite interesting, though one should have a dozen pairs of eyes to study it. Sections are hard to find and when found more difficult to understand properly. The rock is much decomposed and about a dozen different things present almost the same appearance when in a state of decomposition."

"I have visited a diamond locality. * * * They occur in gravel which is either late Tertiary or modern."

A collection of Brazilian auriferous ores, Professor Hartt writes, will be exhibited at the Centennial Exposition in Philadelphia. The friends of the Professor will be pleased to learn that he has removed with his family to the mountains back of Rio, where all are safe from the ravages of the yellow fever.

Letters for the members of the Commission should be sent enclosed to Major O. C. James, Secretario do Commissao Geologica, Caixa no Correio No. 126, Rio de Janeiro, Brazil, to whom all business connected with the survey may be entrusted. Questions which can be answered by the undersigned will receive due attention.

THEO. B. COMSTOCK.

Ithaca, N. Y., May 5, 1876.