

ART. III.—*Modes of occurrence of the Diamond in Brazil*; by
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THE diamond washings of the vicinity of the city of Diamantina, in the province of Minas Geraes, afford examples of several modes of occurrence of the diamond, which, so far as known at present, may be taken as types of all the washings of the empire.

The diamond region of Diamantina is situated along the crest and on both flanks of the Serra do Espinhaço, the great interior mountain range of Brazil which divides the waters of the São Francisco from those of the Doce, Jequetinhonha and other rivers. The general height of the watershed in this region is about thirteen hundred meters above the level of the sea or about five hundred meters above the general level of the elevated plains of the São Francisco valley, lying immediately to the westward. The prolongation of this range to the northward includes the diamond region of Grão Mogol in the province of Minas Geraes and that of the so-called Chapada Diamantina in the neighboring province of Bahia.

The general geological structure of this region is represented in the following section based on the observations made in three journeys by different routes between the river São Francisco and Jequetinhonha.



A, River São Francisco. B, Gurvea. C, Heights of Guinda. D, Diamantina. E, Heights of Curralinho. F, River Jequetinhonha.

a—White gneiss exposed in a long narrow zone running N.-S., to the southwest of Diamantina near the village of Gurvea. In the journey made farther to the northward going directly west from Diamantina this series did not appear.

b—Series of hydromica schists, schistose granular quartzites (itacolunites) and itabirites. *c*—Series of granular quartzites passing at times to conglomerate. *d*—Series of argillaceous shales and slates, limestones and sandstones. *e*—Horizontal shales and sandstones.

The point in which this section differs most materially from the descriptions of the region hitherto published is the separation of the upper quartzite (*c*) as a distinct formation, unconformable to the series containing the itacolunites or lower quartzites, with which it has generally been confounded. This confusion is easily explained by the fact that most travelers have confined their observations to the eastern side of the watershed where, owing to the two quartzites having the same

strike and the same easterly dip, the unconformability of stratification is not very apparent and the close lithological resemblance of the two rocks throws one off his guard in regard to it. Having recognized the unconformability of these beds on the western slope of the range where in places the dip is in opposite directions, I took pains to look for it elsewhere and found many evidences of it on the eastern side as well.

The junction of the two quartzites is in many places specially interesting. The schistose beds of the lower quartzite enter tooth-like into the mass of the upper, and the two former are apparently homogeneous rock in which only the closest scrutiny can detect the line of junction, indicated by a few scattered pebbles or a very slight difference in the intimate structure of the beds. Away from the line of junction this discrimination of the two series is more difficult and, if no pebbles can be found in the rock, is often impossible, so close is the resemblance between the finer portions of the upper quartzite, and the lower to which I would to restrict the name of itacolumite.*

The relations of series *c* and *d* have not been clearly worked out as the two have not been seen in contact, and it is possible that they should be united. The differences in the lithological characters of the rock and in their distribution is, however, against this view. The limestone of series *d* is the only rock of the region that has afforded fossils. At Bom Jesus da Lapa, on the São Francisco, some distance to the northward I found specimens of the corals *Favosites* and *Chaetetes* which indicate Silurian or Devonian age. Liais reported fossil cirripeds of the genus *Pollicipes* in the same limestone at Lapa do Urubú on the Rio das Velhas, but at this locality I only found plates of white calcite which might be mistaken for fossils. The fossil oyster of the same author from the sandstone of the Abacté (series *e*) appears to be based on structure lines in the rock. I failed to find any evidence in support of his view of the Secondary age of these rocks, and on the contrary have direct evidence in opposition.

These preliminaries are necessary for a correct appreciation of the phenomena presented in the various washings which will now be described. The miners established a distinction, which it is convenient to retain, between river washings (*servicos do rio*) and prairie washings (*servicos do campo*). Of the former the most famous are in the bed of the Jequetinhonha where I had an opportunity of examining three, the only ones that have been worked of late years.

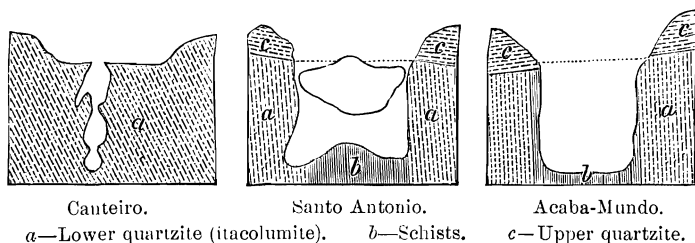
These mines are situated to the eastward and southeastward

* Both series occur in the Serra do Itacolumi at Ouro Preto from which the rock takes its name. It is only the lower one however that affords, and that rarely, the flexible variety to which the name is more particularly applied.

of Diamantina at distances of from 6 to 15 miles from the city and three or four miles from each other along the course of the river. The upper one, the Canteiro, is situated a mile or two below the bridge on the road to the provincial capital. The Santo Antonio mine is a little above and the Acaba-Mundo a little below the confluence of the Jequetinhonha with its equally famous tributary, Ribeirão do Inferno. The Jequetinhonha is here a wild mountain torrent flowing in an exceedingly rugged and picturesque narrow gorge. The river had been turned for short distances by means of temporary dams and wooden sluices and the sand and gravel had been removed from those parts of the bed thus exposed which were known or supposed to be unworked.

The rocky river-bed was found to be excavated in a most remarkable manner to a depth of 75 to 100 feet below the normal bed, presenting what may be called subterranean cañons filled with fallen rocks, sand and gravel up to the natural level of the rocky and sandy bed. These cañons had served as natural laundries in which at some time rich diamond-bearing gravel had been deposited. Some of them had been more or less thoroughly cleaned out by former workings and of course refilled immediately when the river took possession of its bed. This newly deposited gravel is not considered worth washing, although it contains some diamonds, and in fact since diamond-washing commenced in the river the newly formed deposits consist of material that has already been more or less thoroughly washed.

Each of these submerged cañons presents some peculiar features dependent on the character of the beds and the relation of the river to them. A diagrammatic section of each is given below.



At the Canteiro mine the river runs N. 25° E. along the strike of a series of beds of the lower quartzite, dipping 60° to the eastward. The cañon, several hundred metres long, is formed of a line of pot-holes which are generally confluent below the surface so as to form a nearly continuous underground channel. Some of the pot-holes widen out to three or four metres but in general they are much narrower. Some are

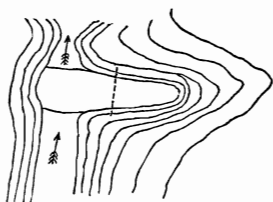
regular from top to bottom, while others present constrictions as represented in the diagram. The upper levels of these pot-holes had been worked out by former owners and were found filled with new unproductive gravel but in the lower levels rich virgin gravel was found.

At Santo Antonio the cañon occupies the whole width of the river-bed and has even widened out below so that the walls are overhanging. The river has here cut through the upper quartzite so as to meet the junction of the two series at about the present natural level of the river-bed. Flowing along the strike of the lower series, it has encountered the thin layer of softer beds of schists and schistose quartzites which form the floor of the cavern, enclosed between the more massive beds which form the walls. The cañon which is about 100 feet deep was filled with fallen masses of rock and gravel which had been removed at the two extremities of the working, but a large rock tightly wedged in between the walls, and which had formed a small fall in the river, had been left, and shored up by stout wooden braces, while work was being carried on underneath by the light of torches.

The Acaba-Mundo cañon is similar in many respects to that of Santo Antonio, but is remarkable in being transverse to the bed of the river which it cuts completely across. The position of the beds is here approximately as follows:

Upper quartzite, strike N. 40° W., dip 15° S.W.
Lower " " N. 20° W., " 80° E.N.E.

This extraordinary *cul-de-sac* cut nearly 100 feet below the natural river-bed, which is here quite shallow, appears at first sight to be an old river channel. That this is not the case is proved by the fact that on the right side (where it was open to examination) it abuts against a hill, as is shown in the accompanying plan. The small stream which, flowing from this hill,



Plan of the river bed at Acaba-Mundo. The dotted line shows the position of the cross section.

falls into the head of the *cul-de-sac* is too insignificant to have excavated this channel as wide as that of the main river which above and below the cut has exercised but little excavating power. The true explanation of its formation is to be found in the fact that the river here flows across the strike of the lower beds and that, having cut the compact upper beds, it found a soft bed of schist cutting across its course and enclosed between two harder beds. The soft bed now forms the soft clayey bottom of the cañon, and though decomposed still shows its schistose character. The constrict-

tion in the river just below would naturally form a back-water with eddies at this point. The small stream mentioned may have facilitated the process by cutting a narrow channel through the upper quartzite, and thus admitting the river to undermine it by the excavation of the softer bed below. The cañon was filled with fallen blocks, and with sand and gravel. The latter, having been introduced since a former working a number of years ago, was unproductive. It was on the supposition that the former cleaning out had been incomplete that work was undertaken again, but as the event proved only unimportant remnants of the original gravel were met with.

The gravel of the Jequetinhonha is very varied. Professor Gorceix gives a partial list of 28 minerals, which he has recognized among the finer and heavier pebbles which the miners distinguish under the name of *diamond formation*, and which they consider as indicative of the presence of the gem, and notes the abundance of quartz, the oxides of iron and of titanium, tourmalines, and the presence of chlorophosphates (Comptes Rendus, No. 25, 1881). The coarser material of the gravel is evidently derived from the rocks of the two series through which the river flows at the mines and has not been transported very far. The finer material including many rare minerals with the diamond may have come from greater distances, either from the main river, or its tributaries, but there is a strong presumption in favor of the view that this also has been derived from one or the other or both of the two series. Having followed the river for nearly the whole of its course between the Acaba-Mundo mine and its source, and having crossed the upper valley along several lines, I have never seen any evidence of the existence of any other series from which the gravel can be supposed to be derived. It should be mentioned that at many points along the river the upper series presents a conglomerate character.

Of the *servicos do campo* some of the most extensive are situated on the high ridge between Diamantina and the Jequetinhonha, known as the Heights of Curralinho. Of these the most interesting are those of Bom Sucesso and Boa Vista which almost overlook that of Acaba-Mundo. The heights of Curralinho are capped by a heavy mass of coarse boulder conglomerate belonging to the upper quartzite series. Bom Sucesso and Boa Vista are situated on opposite sides of a small valley at the northern extremity of the conglomerate ridge and the material washed is the disintegrated conglomerate, parts of which have been redistributed by water while other parts have never been disturbed.

A similar mode of occurrence is seen on the high ridge to the southwestward of Diamantina at Guinda and Sopa. These

localities are on opposite sides of a high rounded ridge forming the divide between the Jequetinhonha and the Rio Pardo, an affluent of the Rio das Velhas. This ridge is composed for the most part of schists and quartzites of the lower series, with occasional outliers of the upper series. At the Sopa mine a deep excavation near the top of the ridge shows at the top a layer of red soil with a thin bed of gravel beneath; then a thick layer of reddish sand with scattered pebbles which passes into a coarse gravel containing pebbles of various kinds and boulders of quartzite and schists. The bottom of the excavation is formed by decomposed schists and schistose quartzite in highly inclined beds traversed by veins of lithomarge and smoky quartz. These beds present an irregular surface which is evened up by the sand and gravel deposit.

There is a marked difference between the upper and lower diamantiferous gravel beds of this place which though hard to define has been recognized by the miners who give a special name, *Sopa* (soup), to the lower gravel. I take the upper bed to be the usual superficial and modern gravel deposit due to sub-aerial denudation, and the lower one to be a decomposed conglomerate, belonging to the upper quartzite series. At the neighboring locality of Guinda the conglomerate character of the deposit is even more apparent, and I am convinced that both of these deposits can with safety be referred to the same category as those of Bom Sucesso and Boa Vista.

About 100 miles to the northward of Diamantina on a stream called Corrego dos Bois near the city of Grão Mogol, there is a famous locality where the diamond has been mined in a solid rock which has always been classed as itacolumite. Neither Claussen von Helmreichen, nor Heusser and Claraz, who visited this locality, recognized the distinction between the upper and lower quartzites, and their descriptions therefore leave one in doubt as to which series the diamond-bearing rock should be referred. The rock is described as a compact itacolumite enclosing rounded concretionary masses of the same character as the gangue, in which they are embedded, and which are well described by the miners' name of "pigeon eggs."

The presence of these masses led von Helmreichen to consider the view, which he ultimately rejected, that this was a regenerated rock, that is, a conglomerate. I have elsewhere (Archivos do Museu Nacional, vol. v), maintained the opinion that these masses are true rolled pebbles, and that this rock belongs to the upper quartzite series.

The conglomerate character of the diamond-bearing rock has now been clearly established by Professor Gorceix who was so fortunate as to obtain at Diamantina a specimen showing a rolled pebble of hyaline quartz alongside of an embedded

diamond (Comptes Rendus, No. 25, 1881). Professor Gorceix considers, however, that this rock may possibly belong to the lower series since conglomerates with pebbles of hyaline quartz have recently been discovered in that series as well. In von Helmreichen's complete memoir, which I have only recently seen, there is a sketch of the locality which shows conclusively that both quartzites occur at the Corrego dos Bois, and that the diamonds are found in the upper one just above the line of junction of the two series. This sketch is interesting also as showing how close must be the resemblance of the two rocks to have led so able a geologist (as von Eschwege also, in other places) to overlook such unmistakable evidence of the existence of two unconformable series.

In the four localities of Bom Successo, Guinda, Sopa and Grão Mogol the diamond occurs with rolled pebbles derived from older rocks and must itself be regarded as a pebble in its secondary deposit. In many other *servicos do campo* it occurs in gravel deposits that are clearly of modern origin. The facts above presented proving the existence in this region of a conglomerate formation or of a quartzite containing scattered pebbles which has suffered extensive denudation, will explain the origin of these deposits without recourse to theories of glaciation or of former systems of drainage different from the present ones. I may mention here by way of parenthesis that in many other parts of Brazil, where anomalous gravel deposits occur that in northern latitudes would be set down without hesitation as of glacial origin, I have recognized the presence of pebble-bearing formations. In other washings the gravel consists of angular fragments of vein quartz left on the surface by the wearing down of the soft beds traversed by the veins. In these cases the matrix of the diamond must be near at hand, but so far as I am aware it has never been sought for.

By far the most interesting of the *servicos do campo* is that of São João da Chapada, situated some twelve miles to the west of Diamantina on a high rounded ridge lying between the Caethémirim, a famous affluent of the Jequetinhonha, and a stream flowing to the Rio das Velhas. The singular feature of this mine is the occurrence of the diamond in clay or earth (*barro*). It has been examined and described by Heusser and Claraz, von Tschudi and Burton, but its true character was first pointed out by myself (Archivos do Museu Nacional, vol. v, 1881), and by Gorceix (Comptes Rendus, No. 25, 1881).

Two mines, the Barro (clay) and the Duro (hard), opened on opposite sides of the ridge, have been worked until they met at the center producing an excavation several hundred meters long and some twenty or more meters deep which closely resembles a railroad cutting the sloping sides of this cut show

a layer of red soil above, with some coarse ferruginous gravel at the base, resting on soapy parti-colored clays. The disposition of these clays is much obscured by slides, but in a number of places it may be seen that they result from the decomposition *in situ* of unctuous (hydromica) schists underlying a bed of itacolumite which is well exposed at the entrance of the Barro mine. This bed strikes N. 5° W. and dips 40° E. The direction of the cut is approximately N.-S., showing that the diamond-bearing material has been followed along the strike of the beds.

The diamond-bearing clays are found in layers up to 1½ meters in thickness intercalated in the midst of the barren clays. Three distinct layers have been described of which I only saw specimens of two in considerable masses that had been dislocated by slides. One was a soft bluish black mass showing on a fresh fracture thin alternating layers of white clay and black powdery hematite. The second mass consisted of a section of a quartz vein adhering to a mass of reddish mottled earth about half a meter thick. Layers of red decomposed schist adherent on one side to the quartz, and to the earth on the other, prove beyond a doubt that this, as well as the quartz, belongs to a vein. The third layer is described by Professor Gorceix as consisting of lithomarge with crystals of quartz presenting the same aspect as the topaz-bearing lithomarge veins of Ouro Preto.

The reddish earth of the second mass is the diamond-bearing material of that layer. It is evidently a decomposed rock consisting of a clayey and a sandy portion. The sand consists, according to Professor J. W. Mallet, who has kindly examined specimens for me, of quartz grains, microscopic tourmalines, and another black silicate. The clayey portion consists largely of iron. The original character of the rock from which this material is derived can only be guessed at. The only rock known to me in the province which might produce on decomposition such a mixture of quartz, iron and tourmaline is that of the veins of pyrites with quartz and tourmaline of some of the gold mines, notably that of Passagem near Ouro Preto, where the vein occurs under somewhat similar circumstances and in the same geological series. The quartz portion of the São João vein is much splintered and full of brilliant plates of specular iron.

Professor Gorceix states that the diamond-bearing layers or veins accompany the stratification of the enclosing beds, and notes the great similarity of this diamond mine to the topaz mines of the vicinity of Ouro Preto, as well as the marked identity in the minerals which in one place accompany the diamond and in the other the topaz. The most important

minerals obtained by him in washing several tons of material from the different layers were, besides the diamond, anatase, rutile, specular iron, martite, and tourmaline.

In the Diamantina region, therefore, the diamond occurs *in situ* in its original matrix in more or less well-defined veins traversing the hydromica schist and itacolumite formation. It occurs also as a transported pebble in the upper quartzite formation. In the superficial gravel beds of the highlands, it occurs in its second or third place of deposit according as these have been derived from the wearing down of one or the other of the older diamond-bearing series. In many places it is probable that the superficial gravels contain an admixture of diamonds from both these series, and it is certain that this is the case in the river gravels, which may also contain diamonds washed from the superficial gravels and that are therefore in their fourth place of deposit.

If an observation made to me by Mr. Meziel F. de Aguiar, owner of the Sopa mine, be exact, the diamond-bearing veins are persistent over long distances. He stated that a straight line drawn from the São João mine through the Sopa and prolonged to the southward would pass through or near some half dozen of the most noted *campo* washings. Such a line would have a length of about twenty miles, and it corresponds exactly with the general strike of the beds in this region. In fact I noticed at the Sopa mine that the line of strike prolonged would cut the deep excavation of São João which was plainly visible at a distance of four or five miles, I have reason to suspect, from the information given by this intelligent miner, that the true *barro* formation occurs also at the Sopa, though it has never been recognized as such.

Near the river São Francisco there is a rich river washing on the river Jequetahy, which flows over beds of series *e* of the general section which here consist of conglomerates that have probably furnished the diamonds. The same conditions are repeated on the river Abaeté on the opposite side of the valley. The divide between the São Francisco and Upper Parana valleys, which has rich diamond washings on each slope, presents a repetition of the geological features of the Serra do Espinhaço, and so far as can be learned the general geological structure of the diamond fields of the provinces of Bahia, Goyaz, Matto Grosso and Parana is substantially the same as that above described for the central part of the province of Minas Geraes.