

FIG. 13.—From sicular side.

FIG. 14.—From right side. The distal wall of the right theca, not completely developed, forms only a narrow band. Behind the apertural margin of the right theca appears the projection of the sicular. In the interior of the right theca and connecting canal the sicular appears to the left. To the right, on the contrary, the canal is quite open.

FIG. 15.—From anti-sicular side.

FIG. 16.—From left side. The sicular appears here in the interior to the right, the open connecting canal to the left. In the right aperture of the same one gets a glimpse of the undeveloped distal wall of the right theca.

II.—NOTES ON THE DIAMOND-BEARING ROCK OF KIMBERLEY, SOUTH AFRICA. (I) By Sir J. B. STONE, M.P., F.G.S. (II) By Prof. T. G. BONNEY, D.Sc., LL.D., F.R.S., and Miss C. A. RAISIN, B.Sc.

[At the end of last year, while on a visit to Sir J. B. Stone, I had the opportunity of seeing a very interesting series of specimens from the Kimberley mines, which he had obtained during a recent tour in South Africa. Among these were two large lumps of the breccia in which the diamond occurs. As these were in a much better condition for microscopic examination than any which I had ever seen, I asked him to let me study one of them. This request he kindly granted, and sent me samples of all that he had collected. As not very much has been written on the subject, at any rate in the English language,¹ the results of the investigation and the conclusions to which it has led may be worth publishing. At my request, Sir J. B. Stone has contributed, notwithstanding his many duties, a prefatory note on the mines and on the opinion which he formed during his visit.—T. G. B.]

(I) THE KIMBERLEY DIAMOND MINES, SOUTH AFRICA.

By Sir J. B. STONE, M.P., F.G.S.

IT may be fairly asserted that increased geological interest attaches to the deeper workings of the Kimberley Diamond Mines as they proceed. The remarkable development of underground mining, following upon the amalgamation of interests, which was the outcome of the collapse of the surface workings in 1886, or thereabout, has offered better opportunities for observation, not only of the diamond matrix-material but also of the varying characteristics of the neighbouring rock formations.

The interest created among scientists, upon the first announcement being made that the now famous diamond-bearing "Blue Clay" filled up presumed necks of volcanic craters, has not faded away, nor has the interest in the subject at all lessened. There is, if anything, an increased desire to find out the secret workings of Nature's laboratory, and to learn how the diamonds were formed,

¹ Reasons, in themselves very sad, have hitherto prevented the publication of the elaborate investigations of the late Prof. Carvill Lewis, to which reference has been made below. By a curious coincidence, his manuscripts and all the materials which he had used were entrusted to me by Mrs. Carvill Lewis, just as I had completed my share of the above paper. It is my intention to lose no time in preparing for publication the work of my lamented friend.—T. G. B.

how they came into position, and what is the precise nature of the material in which they are imbedded.

Whilst speculative theories have been propounded, which have added interest to what was already a romantic story, observations have been made at the same time, which are of more exact scientific value and have contributed to a larger knowledge of the subject. Among the facts which have been disclosed are the following: the variation of the character in the diamonds found in the different mines and localities; the varying amount and value of the "stones" from the respective mines, and even from the several parts of the same one; and the variable nature of the "Blue Ground" material.

The diamonds not only occur in all shades of colour, from deep yellow to blue-white, from deep brown to light brown, in green, blue, pink, orange, pure white, and at times even opaque, but also they vary in shape, brilliancy, and size; nevertheless so generally uniform are the particular characteristics of those of any mine, that experts, it is said, can unmistakably distinguish the products of the several workings.

As an illustration, the "stones" from the Jagersfontein Mine are worth thirty or forty per cent. more than those from the De Beers Mine, owing to their purity of colour and brilliancy, though the yield of the latter is evenly about tenfold that of Jagersfontein. Nor is this feature of variation distinguished only in the "stones," for the Blue Clay¹ also varies in its character, it being distinctly different in texture in the several workings; thus, in the De Beers Mine it is so much harder than in the Kimberley Mine, as to take quite twice the length of time to reduce it in the process of disintegration, or, to use a local word, to "pulverize" it, an operation to which all the material is subjected. The yield, too, of diamond wealth is irregular and singularly erratic: the west ends of both the Kimberley and De Beers Mines do not pay to work, whilst the north, south-east, and centres are exceedingly rich, a condition which is even more apparent where the "Blue" lies in close proximity to volcanic rock.

The disintegration of the "Blue" is an interesting process, and throws some light upon the character of the material itself. In past times the same formation, exposed at the surface to the action of the atmosphere, became oxidized and softened, and was always known as Blue Clay, and to-day similar weathering action is relied upon to soften the material which comes from the deep workings in the shape of hard rock. There are thousands of men busily labouring in the labyrinth of galleries below, at varying depths up to 1200 feet, and loads of rock are rapidly sent to the surface, quickly filling long trains of ballast trucks, which are run to the adjacent plains where the wagons are tilted and the precious material is scattered over the ground to undergo the process of weathering; this in the main being all that is needed to disintegrate it, that is if sufficient time is allowed. Violent mechanical means of crushing or breaking up the Blue

¹ This, by the way, is not clay at all when first dislodged in the underground workings, but hard rock, which has had to be "won" by means of drilling and blasting, such as is customary in rock-mining operations.

Ground are necessarily avoided, as it might damage the imbedded diamonds. Therefore weathering action alone is relied upon, subject to the mass being turned over occasionally by "harrowing" it.

The "depositing floors" cover vast areas extending to many square miles of country, which are carefully protected by fences, and the whole vigilantly guarded. The reducing process takes, not merely days or months, but years to bring the material into a condition ready for the work of washing and sorting. At the present time there is a valuable reserve, the worth of which must amount to many years' income; in other words, there are many millions of pounds worth of diamonds stored in these disintegrating areas.¹

It is not to the purpose here to refer particularly to the process of washing and sorting, or to the thousand and one interesting details that form part of the story of the gigantic and rich enterprises of Kimberley, among which the energy of the De Beers Company takes such a conspicuously leading part, but it is more pertinent to follow the material itself through the series of operations which lead to the final results, and to glean useful geological facts respecting its composition and the history of the diamonds.

The first process of washing carries away all the finer particles of mud, permits the picking out of larger "stones," of easily recognized volcanic rock, or of similar substances, and leaves a mass of granular material from the size of a pin's head to that of a small apple, the several substances amongst it being well and distinctly separated. This is now turned over to the sorters, who proceed to riddle it into classified heaps. Those consisting of the greater particles, amongst which the larger and more valuable stones may be expected to be found, are placed in the hands of confidential and responsible Europeans; the finest, from which the most minute diamonds are extracted, being examined by Kaffirs (all of whom are carefully watched), who go over the fine refuse almost grain by grain.

These granular masses in process of sorting are highly interesting. They are rich in garnets, in olivine, in pyrites, and many other minerals; and they disclose the detailed composition of the breccia of the "Blue Clay."

Among this composite material the diamonds are found in the proportion of about 1 to $1\frac{1}{2}$ carats to the ton, and in size, from the smallest grain to "stones" of the greatest value.²

A parcel of diamonds in the rough (such as, for instance, the day's product of one of the mines) is an extremely interesting subject of investigation and study. Such a bowl full of stones, amounting to thousands of pounds in value, fresh from the cleaning process of having been boiled in acids, present in their uncut and unsorted condition a general resemblance to a handful

¹ A better idea of the riches of the mines will be gleaned from the brief statement which has just publicly appeared (July, 1895), that the De Beers Company have sold the output for the year for the sum of three million and a half pounds sterling.

² One in the possession of the De Beers Company weighed in the rough state as much as 428 carats.

of saltpetre crystals. A more minute and careful examination discloses the interesting fact that many, if not most of the stones, are fractured, and are but parts of perfect crystals. This indicates that they have been subjected to mechanical forces, explosive or otherwise, and of itself seems to prove that the diamonds were not formed at the spot where they were found.

It should be stated that above the diamond-bearing rocks there are extensive beds of carbonaceous shales, and it has been supposed that chemical action, due to steam generated in the volcanic rock, formed the diamonds.¹ Of course due weight must be given to the facts adduced by those who favour the idea that the diamonds were actually formed at or near the spot where they were found, particularly the one singular fact of the prevailing similarity of stones in localities, which it is admitted remains at present unexplained; but even if the broken diamonds were not sufficient evidence, certainly the schistose surfaces of the "snake" (a hard intrusive porphyritic rock), and the glossy appearance of the crater face lying in contact with the Blue Ground, should be perfectly convincing.

No doubt some such chemical action as indicated did take place and produced the diamonds, but it is more than probable that this occurred far away from their present resting-place, the exuding mud-flow having been propelled forward by earth pressure, or some other dynamical force, and that the diamonds were fractured by extreme pressure in transit.

In conclusion, it is interesting to have to report that the De Beers Company are energetically continuing the work of sinking in the main shaft, which, it may be well to state, is through the adjacent hard rock and within a short distance of the crater funnel of the mine proper. This, to get to the 1200-feet level, has passed through the upper beds of basalt and black shale, through the hard amygdaloidal melaphyre deposit, through some 400 feet of quartzite, and into the lower shale beds.²

¹ It may be well here to quote a passage from a letter on this subject received from Mr. W. Moses, the able director of the De Beers Mines, who ventures upon a more elaborate explanation. He says: "I am inclined to stick to my theory of the formation of diamonds and the depositing of them in the present formation of Blue Ground or volcanic mud. To put it as short as possible, the diamonds were produced from carbonic acid gas under extreme pressure and changes of temperature, the oxygen being consumed by the carbon, etc., the result being the diamond. To revert to the present deposits: they were made in the crater of an extinct volcano, into which came thermal springs, which washed away the sides of the soft strata below (the volcanic rocks forming the volcanic mud of the Blue Ground), and the diamonds were introduced from below by the action of the boiling energy of the thermal springs. The blue ground or mud, if you remember, we concluded had not gone under any great heat, as the small particles of shale clearly indicated; in short, the diamonds were separately formed, and were brought into their present position from below." It has also been supposed, and with some show of probability, that with the opportune presence of carbon, under conditions of intense heat and perchance pressure, crystallization took place, the colours of the stones varying as they were affected by the presence of metals or oxides of metals.

² A letter recently received from Mr. W. Moses states that "the sinking of our main shaft still continues in the blue metamorphic shale, and no change has yet

(II) ON THE ROCK AND OTHER SPECIMENS FROM THE KIMBERLEY MINES.

By Prof. T. G. BONNEY, D.Sc., LL.D., F.R.S., and Miss C. A. RAISIN, B.Sc.

THE undecomposed rock is obviously a fairly hard breccia, exhibiting a rather irregular fracture and consisting of minerals and rock fragments in a blackish-green, slightly granulated "paste." Some of the minerals, probably fragments, can be readily identified, *e.g.*, olivine, green pyroxene, brown mica, and garnets. The fragments of rock are of various sizes up to about two inches diameter. They are generally rather compact in texture, greenish-grey in colour, sometimes exhibiting a zonal structure near the edges. The specific gravity, determined by a Walker's balance, of a specimen of the breccia measuring about $2\frac{1}{4}'' \times 2'' \times \frac{1}{2}''$ is 2.61; of a piece about one-fourth that volume, 2.66.¹

Under the microscope the rock is seen to consist of fragments large and small, becoming at last a mere powder, which are set in a serpentinous mineral and a carbonate, these acting as the cementing paste, but the latter mineral being more sporadic in occurrence. Commencing with the larger minerals² in the specimen before us, (1) Olivine is the most abundant. Its cleavage in some cases is a little more marked than usual. It occurs generally in rounded grains, partially ringed by serpentine, indeed sometimes completely converted into this mineral. The alteration usually is as follows:—Round each grain is a zone of fibrous serpentine, exhibiting a rather parallel ordering, which acts feebly on polarized light. A zone follows where the fibres are arranged in cones, the apices of which seem to pierce the olivine, as if the cone structure had gradually extended inwards and had affected indirectly that of the whole layer. Here, however, the axes of the cones are more or less parallel. This parallelism seems to depend on some structure in the olivine itself—most probably a cleavage—and not on the form of the grain. In some cases the fibrous mineral seems, from the extinction angle, to be actinolite or tremolite.³

(2) Sahlite, or lightish-green augite, occurs in grains often somewhat oblong, commonly with an alteration zone at the exterior, consisting of a fibrous mineral, which has the extinction of actinolite. The olivine and the sahlite often present considerable resemblances in their general microscopic aspect, and the same holds true of their alteration products.

taken place in the appearance of the strata. We have now passed through some 200 feet of this formation, and I am in hopes of getting a change which will be very interesting." Mr. Moses also promises to send a further box of samples when this takes place, which it is needless to say will be of additional interest under the circumstances.

¹ These specimens were given to one of the authors by C. J. Alford, Esq., F.G.S. That brought by Sir J. B. Stone was inconveniently large for weighing.

² A number of analyses of minerals are given in the paper by Prof. Maskelyne and Dr. Flight, *Quart. Journ. Geol. Soc.*, vol. xxx, 1874, pp. 408–416. In our specimens, bronzite, which appears to be common in their material, seems to be rare, if not absent.

³ As was also observed by Prof. Carvill Lewis.

(3) Mica. The flakes are somewhat irregular in outline, of a pale but rather warm brown colour, well cleaved. The pleochroism is from light dull buff to an ochre-brown. Cases of twinning occur; one of the twins sometimes greatly dominating over the other. The mica at its exterior is changed into a mass of a minute, very pale green mineral, which sometimes extends up cleavage cracks. This apparently is the material designated *vaalite* by Professor Maskelyne.

(4) Garnet: (rare in this specimen) wine-red in colour. In one case this mineral is surrounded by a zone about $\cdot 006''$ thick (except on one side, where it becomes a mere film). This zone exhibits a radial fibrous crystallization and a banded structure. It varies in colour from a rather light to a very dark umber-brown, and the constituents seem to have a straight extinction. Beyond this, in three directions, is a much broader border, variable in thickness, barely translucent, and a deep umber-brown in colour; but perhaps only a more felted mass of the mineral already mentioned. The more diaphanous part does not appear to be sensibly dichroic, and can hardly be biotite or an altered mica. It might, however, be a mixture of iron oxide with fibrous quartz, as in the so-called *crocidolite*. In another slice biotite does occur as a decomposition product of a garnet, but here the former mineral eats into the latter in a somewhat irregular manner.

(5) Chromite. Feebly translucent brown grains, occasionally octahedral in form, are doubtless chromite, but other iron oxides are present in the slide.

(6) *Pseudobrookite* (?). Other brown grains, occurring in a rudely square form or as an association of granules, are anisotropic, and sometimes exhibit, with crossed nicols, specks of rather bright colour, indicative, probably, of aggregate structure. Small crystals, however, of a mineral to be mentioned below (*perofskite*) are sometimes clustered about these grains and may mask the colour effects. We refer these brown grains to *pseudobrookite*, though the tint is less rich than usual. This, however, may be due to decomposition.

(7) Rutile. A few small crystals occur, among them a geniculate twin, and in serpentine, as observed by Prof. Carvill Lewis. We doubt, however, whether it is an alteration product.

(8) *Perofskite*. The grains, usually from $\cdot 0002''$ to $\cdot 0008''$, are sometimes hexagonal in outline, often showing a central spot and radial lines, a very faint yellowish tinge with transmitted light, and a whitish or yellowish-grey with reflected. These grains have a habit of clustering, and they sometimes wreath around fragments of crystals and rocks.

Leaving for a moment the rock fragments, we proceed with the matrix, to which, indeed, the last-named mineral might be referred. Its hardness is barely 3, though among its microscopic constituents is one which scratches glass. When powdered, it effervesces briskly with HCl. Apparently it is composed of the following constituents: (*a*) a clear colourless isotropic serpentine; (*b*) brown mica, in small films, sometimes irregular in outline, having a general resemblance

to that described above, but almost certainly of secondary origin. With mica, perhaps, may be included some rather regular hexagonal thin plates, of an apparently colourless mineral, which seem to project into interspaces; (c) chlorite (?); (d) needles, often radially tufted, clear and colourless, with low polarization tints and probably straight extinction; (e) a carbonate, seemingly varying from calcite to dolomite, filling up interspaces; and probably (f) a little opal.

As to the rock fragments, our specimen of the breccia has not afforded either granite or pegmatite, rocks which were detected by Prof. Daubrée. Those present, as described above, have a hardness generally a little less than 4, but one large fragment, paler in colour than most of them, is about 2.5. Under the microscope the outermost zone is usually thin, sometimes consisting rather largely of an aggregate of minute chlorite, followed by a second and broader zone containing films of brown mica¹ with ill-defined outlines; the third zone is often rich in minute perovskite. In other cases the external zone is richer in perovskite, and within this comes a greenish zone, which may be followed by another perovskite band, sometimes broad. The inner part of the fragments is rather "patchy" in structure, consisting, in some cases, very largely of a clear colourless isotropic material (? a hydrous glass). In this, scattered in rather varying quantities, are (a) clusters of perovskite; (b) films of brown mica (biotite) as above, in one or two cases sprouting inwards from the inner zone; (c) minute acicular prisms, giving low polarization tints and straight extinction, often forming tufted or radiating groups (occasionally almost spherulitic), which in a few cases seemingly are growing from the ends of the brown mica; (d) rude attempts at skeleton crystals, probably magnetite; (e) a carbonate (as in the matrix).

Three fragments differ somewhat from the rest. One includes serpentized olivine surrounded by a material, which exhibits a structure suggestive of a flowing. Another consists of grains and granules of serpentized olivine, with thin flakes of brown mica and pseudobrookite or chromite. The third with transmitted light looks almost pellucid, but with crossed nicols exhibits an aggregate structure, such as may be seen in a serpentine, though on a very minute scale, the constituents being grouped in lighter and darker parts, as may be sometimes observed in a scoriaceous rock. One corner, however, exhibits a spherulitic structure, which also makes its appearance here and there in other, commonly the outer, parts of the fragment.

The general aspect of these fragments (except for the zones) recalls certain varieties of much decomposed serpentine, and to this rock, though we have never seen any quite identical, we venture to refer it, believing that it is the result of the alteration of either a glassy or a very minutely crystalline peridotite. The zonal banding may be original, as it recalls that exhibited by fragments in some diabase tuffs from Porthdinlleyn,² where it is an original

¹ The biotite is variable in amount, and occasionally is wanting.

² Cf. C. A. Raisin on Variolite . . . of the Llyn: *Quart. Journ. Geol. Soc.*, vol. xlix, 1893, p. 151.

structure, such as is common in slaggy ejectamenta. Still, like the bands produced in some stained rocks, it might be a result of infiltration; but though the latter may be a modifying cause, we incline to adopting the former explanation.

The "blue clay" or "blue ground," the material obtained in the earlier and shallower workings, is clearly only a decomposed condition of the rock already described,¹ the cementing carbonate having been more or less removed²; and the "yellow ground" represents a further stage in the decomposition. We have compared the fine-grained part of the "blue ground" with some crushed and decomposed serpentine from the Lizard, and find a strong likeness between the dominant material in both, so that very probably the dust-like fragments of serpentine (altered peridotite) enter largely into the composition of the diamantiferous rock. The more durable minerals are separated from it by washing. Two packages, given some time ago to one of us by Prof. Boyd Dawkins, are divided into coarser and finer washings: the former often run from about one- to nearly three-eighths of an inch, the latter do not generally exceed one-tenth of an inch in diameter. The materials appear to be similar, though the relative quantities may differ in the two, and among the coarser some rock fragments (in one case a fine-grained peridotite, in another apparently a sedimentary rock) are present. Among the minerals in these samples, and in those brought by Sir J. B. Stone, which are roughly sorted but are of larger size, we find the following:—

(a) Garnets; more than one variety being present. The majority are from a wine-red to a purple-lake in colour (almandine); a few are orange-red to reddish resin-brown, when magnified, (? essonite). They appear to be always fragmental; this is very obvious in the case of the clear-coloured specimens, and even those which are more rounded suggest a fragmental origin. Many of the latter seem to be only dull-coloured greenish grains, but on breaking them they are found to consist of a kernel of red garnet, surrounded by an aggregated doubly-refracting substance. This may be merely some incrusting mineral, but it suggests the possibility of a decomposition zone. Some have on the exterior brown mica, perhaps also a chlorite, with another mineral too minute for identification, and if we may found an inference on the ease with which the grains break, the same material probably occupies fissures.

(b) The fragments of sahlite are often determined by cleavage planes. The colour is commonly a fairly rich celandine or oil green, but two or three of the well-rolled small grains are a very rich emerald green. These probably contain a considerable amount of chromium, but we should expect that all would afford traces of this base.

¹ The material which Prof. Maskelyne and Dr. Flight were examining was evidently "blue ground," and was taken from depths not exceeding 180 feet.—*Q.J.G.S.*, vol. xxx, 1874, p. 406.

² In the museum at Owens College, Manchester, are some large lumps of partially decomposed breccia intermediate between the ordinary "blue ground" and the specimens described in this paper.

(c) Fragments of olivine, of a greenish-yellow colour, not very numerous.

(d) Iron oxides. Grains of magnetite are very few in number—not one per cent. of the washing; most of the grains are not attracted by the magnet, have a bright metallic lustre, give a brownish streak, and a bead (with borax) of yellowish bottle-green colour. These are clearly ilmenite, as was further indicated by the usual chemical test. We have not found chromite, but, as our search has not been a very close one, it may have escaped us. It can hardly be common. A good many subrotund grains or little flattish cakes of rusty brown colour prove to be limonite.

(e) Occasional grains of pyrite and quartz, and flakes of brownish mica.

Two other rock specimens, brought back by Sir J. B. Stone, must also be noticed. One is a somewhat shapeless lump, with rather rounded surfaces, more or less slicken-sided, unctuous to the touch, and of a pale olive-grey colour. The hardness of the exterior is about 1.5, but a portion of the interior exposed by a fracture is a little less than 3. The former, when powdered, does not effervesce with HCl, and under the microscope resembles a rather decomposed serpentine; the latter effervesces briskly, and appears to be mainly calcite, perhaps slightly dolomitic. We seem, then, to have a nodule of impure calcite, of what origin it is difficult to say, enclosed in a kind of husk of decomposed serpentinous material.

The other specimen is a hard, fine-grained grit or quartzite, almost black in colour, with a thin banded structure, parallel with which it has a tendency to split, especially where a white mica (fragmental) is abundant. A microscopic section shows it to consist mainly of fragments of quartz, fairly angular to subrotund, a few being compound and possibly derived from veins. The majority contain fluid cavities, although the amount of these is variable; bubbles, frequently small, are generally present, and microlithic enclosures may be occasionally noted. Often there is a thin external zone of secondary quartz. A few fragments of felspar, including a plagioclase, and microcline also occur. The grains are set in an earthy matrix, a good deal of which on close scrutiny has a fragmental aspect, and very probably is largely made up of decomposed felspar. This part, with crossed nicols, is brightly speckled, most likely owing to the formation of a secondary micaceous product. We find also ilmenite, partly converted into leucoxene, a few flakes of altered biotite, and sundry microliths. On one side of the slice are one or two bands of variable thickness, where the rock is darker and more fissile, the fragments being smaller, and the amount of mica (chiefly white) being larger; here also are some grains of pyrite. Probably the rock is a member of the Karoo series, though possibly slightly altered.

Our observations accordingly seem to justify the following statements:—

(1) That the diamantiferous rock is a breccia, which in its unweathered condition is cemented together by secondary minerals.

(2) That it contains various rock fragments, some of them, in all probability, having been formerly peridotites.¹

(3) That it contains a considerable number of minerals of fair size in a more or less fragmental condition (*e.g.*, olivine, augite, biotite, garnet, magnetite, ilmenite).

(4) That these minerals—or at any rate most of them—are not such as are likely to have been formed *in situ*, but more probably have been obtained by the destruction of rather coarse peridotites, pyroxenites, and eclogites.²

(5) That while, since the formation of the breccia, changes to a not inconsiderable extent have taken place in the production of serpentine, chlorite, perovskite, etc., these are not such as are suggestive of a very high temperature or of very great pressure.

We are therefore led to the following conclusions:—That the diamond also was not produced *in situ* in the rock which we have been describing, but, like the garnet, etc., had its origin elsewhere, probably at a distinctly greater depth from the surface.³ We thus agree with Professor Daubrée,⁴ and differ from the views expressed by Mr. Hudleston⁵ and Prof. Carvill Lewis,⁶ both of whom regarded the diamond as produced *in situ*,⁷ but we agree with the former that the “pipes” are probably of volcanic origin,⁸ and that heated water

¹ In the specimens which we have examined it happens that fragments of shale, which according to Profs. Daubrée and Carvill Lewis are sometimes abundant, are either extremely small and rare or entirely absent. At any rate, they cannot now be identified with any certainty. [Professor A. H. Green, F.R.S., since these words were written, has most kindly lent me a number of specimens of rocks and minerals which he collected when visiting Kimberley in 1882, together with sundry notes and sections, of great interest. His specimens of “blue ground” are not quite so hard as those described above, but are in better preservation than most that I have examined. They contain fragments of black shale, in one case abundantly. One specimen also includes several angular fragments (up to a good half-inch in diameter) of a compact, slightly streaky, greenish-yellow rock, apparently a rotten serpentine (microscopic examination seems hopeless). There are specimens also of other rocks which occur as fragments in the breccia: three of these must have been of large size; two are amygdaloidal, one a compact diabase, the other a reddish porphyrite; the third an olivine basalt with some flakes of brown mica. Of smaller specimens (not more than about an inch in diameter) six are from the Bloemfontein Mine: one is a diorite, very slightly foliated; the other five are particularly interesting, for they represent a fairly coarse rock, chiefly composed of sahlite and a brownish mica, indistinguishable from that described above in the breccia. There are also specimens of the sheets of doleritic or diabasic rocks of the district. Dykes, sheets, etc., of these, according to Professor Green, are very abundant, as described in his paper (Q.J.G.S., xlv, pp. 254, 264). His sections make the “neck”-like character of the diamantiferous rock very clear.—T. G. B.]

² As described in our paper, *GEOL. MAG.* 1891, p. 412.

³ We may say that this conclusion was arrived at independently of previous writers, for we did not refresh our memory of the opinions expressed by them till our work was practically concluded.

⁴ *Comptes Rendus*, 1890, vol. cx, p. 18.

⁵ *Proc. Geol. Assoc.*, viii, p. 65.

⁶ *Brit. Assoc. Reports*, 1886, p. 667; 1887, p. 720; and *GEOL. MAG.* 1877, pp. 22–24.

⁷ Prof. Maskelyne inclines to the opinion that the diamond was produced at or near the contact of a basic igneous rock with a carbonaceous shale, but that since then the whole mass has been affected by mechanical disturbances and thermal waters.—*Q.J.G.S.*, vol. xxx, 1874, pp. 407, 408.

⁸ This was Mr. Dunn's opinion, who supposed that the diamond was produced by

has been the principal agent in producing the secondary metamorphism,¹ and we think with the latter that the association of the diamond with a peridotite is not fortuitous, though we believe that this mineral, like the others mentioned above, originated at a much greater depth in the earth's crust. This view, we were glad to find, had already commended itself to Prof. Daubrée, who makes some highly suggestive remarks on the association of diamonds and meteorites.²

III.—REVIEW OF THE EVIDENCE FOR THE ANIMAL NATURE OF EOZOÖN CANADENSE.

By Sir WILLIAM DAWSON, C.M.G., LL.D., F.R.S., etc.

II. PETROLOGICAL AND CHEMICAL.

BEARING in mind the statements made in the previous note, respecting the stratigraphical relations of the Grenville Series, and referring to the excellent account by my friend Dr. Bonney of his observations at Côte St. Pierre, and to some difficulties stated by him which merit attention, we may sum up the evidence so far, under the following statements :—

1. The limestones included in the Grenville Series and their associated quartzites and schists bear so strong a resemblance in mineral character to metamorphosed Palæozoic calcareous beds of organic origin and their associates, as to warrant at least the careful consideration of any forms apparently organic contained in these limestones.

2. The occurrence in these limestones of nodular silicates, of graphite, of pyrite, and of apatite, affords additional reason to suspect their organic origin.

3. The presence of large beds as well as of veins of graphite and of thick deposits of iron ore in the Grenville Series constitutes an additional analogy with Palæozoic formations holding organic remains.³

These facts were adduced by Dr. Sterry Hunt and Dr. J. D. Dana in evidence of the probability of life in the Laurentian period, even before the discovery of Eozoön. Certain particulars connected with them, however, now demand somewhat more detailed attention, in connection with that discovery, and with recent objections to the organic nature of Eozoön.

Dolomite or magnesian limestone is a not infrequent associate of Palæozoic fossiliferous limestones; and I have remarked in previous metamorphism of the carbonaceous material in the shales.—Q.J.G.S., vol. xxx, 1874, p. 54; vol. xxxiii, 1877, p. 879; vol. xxxvii, 1881, p. 609. Prof. Green informs us that his examination led him to the conclusion that the 'pipes' were volcanic necks.

¹ This may have been the last stage in a series of volcanic disturbances, of which the flows noticed by Prof. Green (*loc. cit.*) may have been the earliest.

² *Loc. cit.*, pp. 20-24. Prof. Lewis had already called attention to certain points of likeness in the diamantiferous rock and meteorites.

³ See papers by the author on the Graphite and Phosphates of the Laurentian Rocks, Quart. Journ. Geol. Soc. London, 1869 and 1876.