

Septa excessively numerous, the longer ones alternating with the shorter; septa or pali, furnished with numerous synapticolæ.

*Formation and Locality*.—The same as the last-named species.

## EXPLANATION OF PLATE XI.

- FIG. 1. *Cyrena sinuosa*, Deshayes, subfossil, Sumatra.  
 „ 2. *Pectunculus* (cast of), Tertiary Clay-marl, Island of Nias, W. Coast of Sumatra.  
 „ 3. *Venus* ? *non-scripta*, Sby., Island of Nias, W. Coast of Sumatra.  
 „ 4. *Perna*, sp. (fragment of hinge) „ „  
 „ 5. *Pecten asper*, Sby. (flat valve) „ „  
 „ 6. ———, Sby. (convex valve) „ „  
 „ 7. *Aspergillum (Javanum)* ? „ „  
 „ 8. *Acanthocyathus*, sp., Tertiary, Grey Sandy Clay, Island of Nias, West Coast of Sumatra.  
 „ 9. *Montivallia*, sp., (a) side-view; (b) view of top.  
 „ 10. ———, (a) side-view; (b) view of the interior of the calyx. Tertiary Clay Marl, Island of Nias, West Coast of Sumatra.  
 „ 11. *Fungia*, sp. (view of under-side), *loc. ibid.*

(To be continued in our next Number.)

IV.—ON THE CUDGEGONG DIAMOND FIELD, NEW SOUTH WALES.<sup>1</sup>

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Communicated by R. ETHERIDGE, jun., F.G.S.; of the British Museum.

The next appearance of the *older* lead is at the “Rocky-ridge,” where the river, after running northerly for three-quarters of a mile, along the strike of the metamorphic beds, turns abruptly to the west. This ridge is a basalt-capped hill on the north side of the river, running in a north-west direction; it is about a mile long, with a bold rocky escarpment on its west side, facing the Sandy or Cudgebeyond Creek. Some tunnels have been driven in, and shafts sunk on this hill, and tolerably rich deposits of gold were found, but never followed out. Only in the southern half of the hill have diamonds been found (all more or less spotted). The drift is remarkable for the number and size of the agates it contains. The northern half of “the ridge” is underlaid by another outlier of the before-mentioned doubtful purple conglomerate, into which some tunnels have been driven in the western escarpment. The basalt is merely a fringe here, resting against the flank of the conglomerate hill to the east. A few inches of drift rest upon this conglomerate, in which a small quantity of nuggetty gold was obtained; and from one to two inches thickness of lignite, or carbonaceous clay, is seen between it and the bottom of the basalt. The basalt is intersected by numerous veins of a mineral allied to kaolin. The purple conglomerate is similar in character to that near “the flat,” and contains, on some of the joint faces, small spherical crystalline aggregations of chalybite (carbonate of iron). At the extreme north end of “the ridge” are great quantities of ironstone and conglomerate, but, from their mode of occurrence, I should imagine them to be part of the Carboniferous series, which is largely developed further north. The first diamonds which found their way to Melbourne were obtained

<sup>1</sup> Concluded from page 412.

from "the Rocky," at Hill's, or the diamond Claim, in the bend to the south-west in the centre of the hill. A short distance to the east of this claim is Ryan's, from which as much as two ounces of gold to the load were obtained, as well as a few diamonds. Crossing the Cudgebeyond Creek, in the bed of which is a horizontally bedded mass of conglomerate (some part of the Carboniferous series, or possibly Mesozoic), we arrive at another basalt outlier. The hill itself is composed of slates, capped with purple conglomerate. A ring-like fringe of basalt surrounds it, leaving the top uncovered; while between it and the basalt, Tertiary ferruginous cement and drift crop out on the flanks of the hill. The decomposed basalt, from shafts on the north side of the hill, is very full of kaolin. The metamorphic beds crop out again a short distance to the west of this hill. It is difficult to imagine the course taken by the old river from this point; it could not have gone westerly, as the country consists of high schist ranges, intersected by numerous greenstone dykes, running as usual in the strike of the slate rocks. On the south-west flanks of the "Rocky-ridge" the surface is covered with a wash of drift, which is continuous across the river (here running westward) to the "Horseshoe bend." The late Professor Thomson suggested that the basalt, on arriving at the Cudgebeyond Creek, may have flowed or been backed up by this tributary for some distance. The old junction of this creek with the river was probably near the centre of the "Rocky-ridge."

The "Horseshoe bend," on the south side of the river, is a semi-circular basalt-capped hill, having its concave side facing the river, and its convex one resting against the side of the purple conglomerate hill, first mentioned as occurring to the north-west of the "Two-mile-flat." The basalt of this hill, like the others, is underlain on its north or river side by older drift; the lead dips into the hill on its western side, but it was not rich either in gold or diamonds. A few diamonds were obtained in the shallow ground of the northern concavity, and the associated gems were larger there than anywhere on the whole course of the lead. A fine example of columnar basalt occurs in a shaft at the south-west horn of the hill. Between this hill and Hassall's fence, on the river, the greenstone dyke, west of the "Two-mile-flat," which disappeared under the purple conglomerate-capped schist hill, again crops out, and crosses the river. Its course is now somewhat altered, both it, and the accompanying band of metamorphic rocks, being thrown a few chains to the west, probably by a fault. From the "Horseshoe bend," in about half a mile south-westerly, we reach Hassall's Hill, adjoining Mr. Hassall's property. These hills are separated by a low schist range.

"Hassall's Hill," like the "Horseshoe bend," is nearly semi-circular, with the horns flattened inwards so as to form two parallel shoulders, and with its convexity towards the river,—it consists of basalt overlying older drift. The south-west portion of this hill is lower than the north-eastern, the denudation having only left a thickness of about thirty feet of basalt, whilst at the highest part

of the hill there is from 80 to 90 feet. The drift underlies it in two distinct leads, from north to south, in the centre and west of the hill, but not on the east. The leads form a sort of elongated ellipse. The concavity of the hill faces south-west and the horns are nearly connected by the lower or more denuded portion of the flow. In the innermost portion of the concavity, which rises gradually to the table-topped main mass, a shallow hole exhibits a fine friable thin-bedded greyish white sandstone, inclosing perfect, but minute, double hexagonal pyramids of quartz. This is evidently the top of a hill or island, round which the old river, and subsequent lava-streams, have flowed. The denudation not having been so extensive here as on the upper portions of the lead, a greater width of basalt and increased thickness of the underlying drift is the result. In the easterly lead, where it curves round to the south horn, as much as one ounce of gold to the load was obtained; but, from the length of time occupied in sinking the shafts (over five months), it was unprofitable. Some very long drives were put in, and a few diamonds were obtained, but the area was never specially worked for diamonds. The rock on the top of the hill consists of from thirty to forty feet of loose concretionary basalt, getting denser below, and resting on vertical columnar basalt. The whole of the upper stratum has been denuded away from the lower ground. On the south face of the central sandstone hill is a small shallow lead, which must be the edge of the older drift, resting against the sandstone island, and now exposed by denudation. A similar instance occurs again near the apex of the southern horn; where the basalt of the northern horn nearly joins that of the southern one, the ground is quite shallow (about 12 feet deep), but deepens westerly to 30 feet, and contains very large semi-angular blocks of quartz, and much "cement." The south side of the southern horn was worked, and yielded a few diamonds, but not much gold. The drift is full of large semi-angular blocks of quartz, and is a side wash, as the ground dips to the north. The quartz, from its character, is, in a great measure, derived from veins in, or in the neighbourhood of, greenstone. In the deepest parts of the leads the quartz boulders are all perfectly rounded. The richest diamond claim discovered was situated at about the centre of an imaginary line joining the two horns; it was owned by a working party of miners—Messrs. Cooney, Hennessy, Ward, and others. Their shaft, sunk to the depth of 51 feet, shows 27 feet of basalt, resting on brownish-yellow sand, and that again on alternating sandy, gravelly, and pebbly beds, mostly loose and friable, with occasional thin layers of ferruginous "cement." The whole of the drift below the basalt had to be very securely slabbed, as the fine sand runs like water. In their southern drive there are three distinct veins of very loose granitic quartz detritus, separating, and alternating with, the gem-bearing veins. These gradually cut out, going north, and the gem-wash becomes more solid. There is also a bed consisting entirely of loose and open quartz pebbles, superficially covered with a brownish-black greasy-looking coating of

oxide of manganese. In one of the drives they cut through what appears to have been a portion of a large tree, lying horizontally in the cement on the "bottom,"—the wood itself had entirely disappeared, and nothing but a hollow casing or shell of oxide of iron remained,—this was internally longitudinally striated, and was composed of several coats. On the inside were some peculiar metallic efflorescences presenting the appearance of small round black velvet buttons, composed of confusedly foliated plates of a substance, which, when rubbed, assumed the metallic appearance of graphite, and soiled the fingers. Fragments of drift wood had been found on the bottom; not silicified like that derived from the Carboniferous rocks. The gem-stones can be traced most thickly in slightly cemented (by silica) flesh-coloured veins. The total thickness of the drift is 24 feet, and the bottom dips westerly. On driving northwards the bottom rose and fell again, and the diamonds became scarce.

Adjoining the above claim was another, belonging to Messrs. Scott and Allen, which was 54 feet deep. The ferruginous "cement" in this claim inclosed abundance of pleonaste, zircon, sapphire, and topaz, with small fragments of brown ferruginous wood, like that occurring in most of the Tertiary cements in Victoria. The "cement" forms but a very small proportion of the drifts, and occurs in irregular thin veins, sometimes fine- and at others coarse-grained. Other shafts were sunk west and east of these rich claims, but unsuccessfully, as they did not appear to possess the few bottom feet which contained the diamonds. To the north of this, and on the river-side of the northern horn, another shaft yielded a very heavy drift, giving an average of one diamond and five pennyweights of gold to the load. The basalt increases in thickness to the west at Hassall's fence, whilst the drift diminishes; a shaft there passing through 32 feet of basalt, and 15 feet of drift. Messrs. Cooney and party had, up to April, 1870, obtained over 1000 diamonds, and Scott's party about 700. The lease of the former party had then been proved for a distance of 300 feet along their main drive (N. 35° W.) with a breadth of over 100 feet. A washing of 33 loads yielded 306 diamonds, weighing  $74\frac{1}{2}$  carats (largest  $1\frac{3}{4}$  carats). They have washed from 1 to 15 diamonds to the load, but the average was about 5, with 3 dwts. of gold. A washing of from 12 to 15 loads of Scott's gave at the rate of 8 diamonds and 3 dwts. of gold to the load. The small quantity of gold obtained is due to the fact of the diamonds not being on the bottom, while the gold is, and consequently, a thickness of as much as 5 and 6 feet of wash dirt had to be taken out, thus reducing the gold per-centage. The southern face of the northern horn is very shallow ground.

The basalt runs westerly through Mr. Hassall's fence and into his paddock, where it is concealed by alluvial soil, and nowhere crops out again. The diamond ground was supposed to run in that direction, but, being private property, it had not then been prospected.

Between this and the river,—which, after running a mile westerly from the "Rocky-ridge," turns abruptly to the south, and keeps this

course for two miles,—we cross another greenstone dyke running in the same direction as those before mentioned, and crossing the river about midway in the bend to the south. There are some extensive alluvial flats between Mr. Hassall's house and the ford, where the Wellington Road crosses, in which some good gold leads may probably exist.

Above this crossing place a rocky bar spans the river, consisting of a dark grey breccia, having a gneissose appearance and associated with flinty beds. About a mile along the road to the north of this, on Mr. Lowe's property, and about  $1\frac{1}{2}$  miles due west from Hassall's Hill, is another small basaltic outlier, resting on drift; there are also several drift or "made" hills uncapped by the basalt. These had been formerly worked for gold. Below this there is no trace of basalt for seven or eight miles down the river, till a little below Laby's Farm, at Uumby, where there is a very small outlier on the river bank, but whether the older drift underlies it or not, had not been proved. "Made" hills of drift, apparently the *newer drift*, skirt the river-banks on both sides to its junction with the Macquarie River, but there is no further trace of basalt on the Cudgegong River; although there are outlying remains down the valley of the Macquarie River of a former sheet of basalt, which had perhaps flowed down the valley of that river, and covered up the Tertiary drifts, which have been worked for gold, at a considerable elevation above the present river. The rocks down the river are similar in character to those above, but are less metamorphosed and more shaly, with interbedded brecciated conglomerates. Syenitic granite crops out occasionally, and quartz-reefs are very numerous.

About a mile to the north of the northern end of the "Rocky ridge" there has been a small "rush" (Cunningham's) to a gully and "made" ridge under the schist ranges forming the eastern watershed to the Sandy or Cudgebeyond Creek. A nugget weighing 36 ounces was found there, but no diamonds. The sinking varies from 12 to 20 feet, very little quartz occurs in the wash dirt, and what there is is angular; but magnesite occurs in considerable quantities, both massive in large lumps, and as peculiar curved cylindrical concretions. The ranges at the creek head are everywhere intersected by small quartz veins.

This, then, being the history, at the time of my residence there, of the diamond-bearing localities, I will next enumerate the various drifts and the materials of which they are composed.

There are, on the Cudgegong, at least six drifts of different ages, the oldest of which the late Rev. W. B. Clarke took to be as young as Pleistocene. I differed from his view, and placed them temporarily with Older Pliocene, following my Victorian experiences, and later, in working out the discovery, at the "Welcome rush" near Stawell, Victoria, of a bed of marine littoral fossils overlying a gold drift, I came to the conclusion (see Progress Report of the Geological Survey of Victoria, No. 3, p. 264) that these fossils were probably of Upper Miocene or Lower Pliocene age, and the gold drift under them much older. I am now of opinion, after reading the report of my friend

and late colleague, Mr. C. S. Wilkinson (Mines and Mineral Statistics of New South Wales, 1875, p. 77, et seq.), on the Tin-mines of New South Wales, that the older diamond drifts must be of the same age as the older Tin "leads" of Borah Creek, which also contain diamonds.<sup>1</sup>

In ascending order, commencing with the oldest, they would probably occur as follows:—

1. UPPER MIOCENE, OR } Older Drift, possibly fluvio-marine, underlying basalt,  
LOWER PLIOCENE. } and containing gold, tin, and gems—no fossils to prove age. This drift may again be sub-divided into two—one containing semi-angular quartz (a reef wash), and the other rounded boulders.<sup>2</sup>  
Lapse of time, during which were formed—
2. MIDDLE PLIOCENE.—The Gulgong deep leads with plant-remains, the latter described by Baron von Mueller. These leads perhaps drain into an old lake-basin at the head of Reedy Creek.
3. Basaltic overflow, filling lake and flowing down the Cudgegong Valley.
4. Wash of conglomerate pebbles, etc., over the surface of the basalt.
5. UPPER PLIOCENE.—Newer Drift, fluvialite, and derived from all the above during the cutting out of a new river channel. To this or the next division may belong the "leads," higher up the river, containing fossil bones at the Pipeclay Diggings, and cinnabar near the village of Cudgegong.<sup>3</sup>
6. PLEISTOCENE.—The older river channels, now silted up, and below the level of the present river-bed.
7. RECENT.—The present river-bed.

With regard to these *older* drifts, it must be borne in mind that they vary much in position; they are below the river-bed at the Reedy Creek, and much above it at the Two-mile-flat, the present river falling at a greater rate than the old river.

The *older* diamond-bearing drift, underlying the basalt, is a coarse and heavy deposit,—some boulders in it weighing several hundred weights,—for the most part loose, but portions of it united into a compact conglomerate. It varies greatly in thickness, from a few inches to 30 feet, according to the irregularities, in some cases, of its own upper surface, which is not uniformly level; and in other cases, due to the old river-bed. Huge blocks of hard slate, sandstone, quartz, greenstone, and felspathic rock, the two latter often decomposed into masses of clay, still retaining the original shape of the boulders, lie at the base of the drift in many parts.

The following are the contents of this drift, which is, however, very variable in different localities: large and small boulders and pebbles of quartz, generally coloured a reddish-yellow or brown externally by oxide of iron; sand of various degrees of fineness; pebbles and sand cemented by oxides of iron and manganese, or by both together, the iron coating the quartz in concentric rings, and

<sup>1</sup> These are considered by Mr. Wilkinson to be of Miocene age.—R. E., jun.

<sup>2</sup> At the time of the formation of the *older drift*, the Carboniferous rocks to the east and south-east may have been above the reach of marine action, and so escaped the denudation; thus accounting for the absence of any traces of them in the drift. The denudation of the Carboniferous rocks may have commenced after the basaltic outbursts, and during the cutting out of the new river valley.

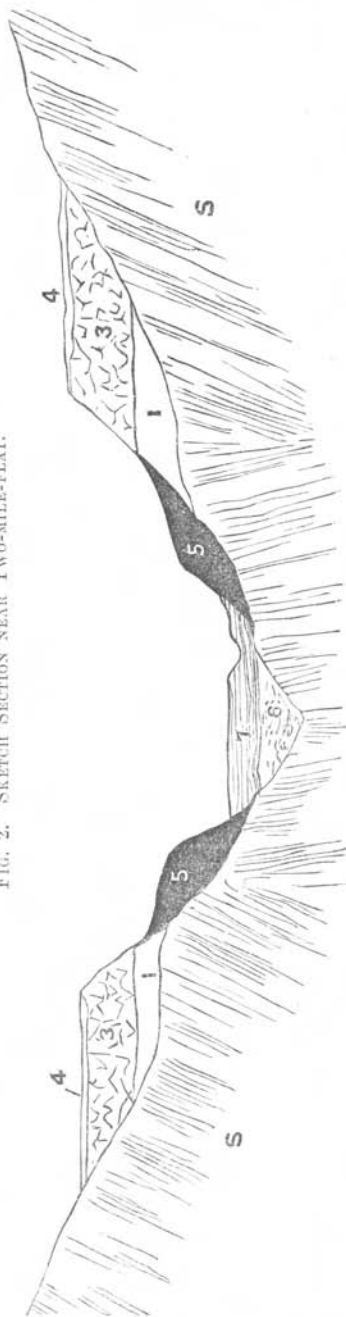
<sup>3</sup> At the Cudgegong cinnabar mine, boulders of coal and sandstone occur in the drifts, with large sapphires and zircons, but no diamonds or topazes, nor did I find ruby, though it is stated to occur there.



FIG. 1. SKETCH SECTION AT REEDY CREEK.



FIG. 2. SKETCH SECTION NEAR TWO-MILE-FLAT.



G. Granite.

M. Mesozoic.

S. S. Silurian

1. Upper Miocene or Lower Pliocene. 2. Middle Pliocene. 3. Basaltic overflow. 4. Wash of conglomerate pebbles. 5. Upper Pliocene. 6. Pleistocene. 7. Recent.

the manganese in dendritic markings, or as if smoked, and soiling the fingers when rubbed; a white siliceous cement, sometimes coloured apple-green by silicate of iron (probably derived from the veins of green clay, mentioned before as occurring in the joints of the basalt);<sup>1</sup> quartzite; white, grey, and black flints and slates, the latter showing oblique lamination, and reticulated with veins of white quartz, and passing into a breccia; a greenish silico-felspathic rock or felstone, weathering yellowish-white to a depth of an inch or more, and ringing, when struck, with a metallic sound, and generally sculptured into curious forms; hard altered siliceous sandstone; schorl rock (a quartzite with nests of schorl); a peculiar hard white stratified rock, with flattened annular concretions, having depressed centres, very numerous on the bedding planes; black or smoky quartz, sometimes inclosing felspar; orthoclase in waterworn crystals; double hexagonal pyramids of quartz, occasionally rounded; bluish opaline quartz in pieces about the size of a pea, showing, when wetted, a yellow ray; amethystine quartz; silicified wood and wood opal; jasper (occurring also in the form of beans, since called by the Bingera miners "morlops"), which the miners suppose to be an unerring indication of the presence of the diamond, for what reason they could not themselves explain; agates, generally of inferior quality and colour; carnelian; chalcedony; tourmaline in rounded crystals; common corundum or adamantite spar, in flattish pieces showing distinct cleavage planes; black corundum; blue, yellow, and green sapphire, occasionally double-coloured, in flat plates and rounded crystals; olivine (?); white and brown zircons in rounded crystals and as a fine sparkling heavy sand; large quantities of brown and greenish-black rounded pieces of pleonaste; thin lenticular plates of pink and violet ruby; white, yellow, and pale-blue crystallized and rounded topaz, generally of a larger size than any of the other gems, and showing distinct cleavage planes; beryl (?); a new variety of corundum in rounded opaque grey six-sided prisms, tapering towards one end; brookite in flat plates; titanite iron, and probably chromite; magnetic iron, sometimes in quantity; and lastly a jet-black glistening vesicular variety of pleonaste, in flattish conchoidal grains, exceedingly hard, and cutting glass nearly as well as the diamond, the vesicles being filled with a magnesian clay. Wood tin occurs also rarely, and fragments of brown ferruginous wood have been detected in the cement.

The *newer* drift, derived from the above, is composed of the same contents as the *older* drift, with the addition of boulders of greenstone and basalt. Semi-angular blocks of the metamorphic rocks occur, as also the white kaolinic clay from which the magnesite already mentioned is produced. Osmiridium has been found in minute silvery scales after amalgamating the gold. A noticeable feature in this drift is the quantity of small pebbles of flesh-coloured quartz, derived, I believe, from the Carboniferous conglomerates.

<sup>1</sup> The pebbles from these cements have sometimes a very peculiar resinous glaze on their surfaces, which is certainly not due to friction, as the cavities are equally glazed as the exposed surfaces. It is probably siliceous.



In the drift also may occasionally, though rarely, be found some Carboniferous conglomerate pebbles. Rounded pebbles of coral (*Favosites Gothlandica*) are not uncommon; shales with *Glossopteris*, and various Upper Silurian, or Devonian fossils (*Orthis*, *Spirifer*, and Crinoidal stems), as before mentioned, together with silicified wood, have been observed in this drift in the so-called "floating reef." The *newest* drifts (upper and lower), comprising the present river-bed, and the older and deeper channels, contain pebbles, boulders, and shingle of the neighbouring sandstones, slates, calcareous grits, red flinty porphyries, felstone, Carboniferous conglomerates, quartz of all kinds, greenstone, and silicified wood. A very noticeable feature in these drifts is the prevalence of blackish quartz pebbles and grains, inclosing crystalline felspar, which are evidently derived from the granite of Aaron's Pass, on the Mudgee Road, south of the village of Cudgegong. The basalt, which might have been expected to be present, must, from its easy decomposition, have been entirely washed away, and is nowhere seen except in the immediate neighbourhood of basalt escarpments. Garnets, in minute brown rhombic dodecahedrons, with angular replacements, occur, and also cubes of oxide of iron (pseudomorphs after iron pyrites), locally termed "Devil's dice." Many diamonds were obtained from the river-bed; but in every case, only where the older drift has been discharged into the river by the miners during gold-washing operations.

The following are descriptions of the gems and other minerals, found in the diamond drifts, with the analyses of some of them by the late Professor Thomson.

*Diamond.*—The diamond itself is distributed through the older drift very sparingly and irregularly, and does not appear to be confined to any particular level in the drift deposit, though the lower five or six feet are generally taken out by the miners, in consequence of the certainty of finding gold in that portion. The fact of the very frequent occurrence of diamonds on the waste heaps round the mouths of the old shafts sunk for gold, is enough to suggest that the diamond may occur in the higher portions of the deposit, since the bottom layers only have been carted to the river for gold-washing. One diamond, *in situ*, occurred three feet from the bottom, imbedded in a mass of loosely cemented quartz pebbles the size of peas. As regards the weight of the diamonds, the following parcels afford a fair average:—

106 diamonds weighed	74 $\frac{1}{2}$ carats,	the largest	1 $\frac{3}{4}$ carats.
81        "        "	19        "        "	1 $\frac{1}{2}$ "	
110       "       "	26 $\frac{1}{2}$ "       "		
16        "       "	6        "       "		
700       "       "	151 $\frac{1}{2}$ "       "		

giving an average of 0.23 carats each, or nearly one carat grain. The largest gem discovered was a colourless perfect octahedron, weighing 5 $\frac{5}{8}$  carats; it was found in the river, between the "Two-mile-flat" and the "Rocky ridge," at a spot where the *older* drift had been discharged in gold-washing. Another large stone, weighing 3 $\frac{1}{4}$  carats, was found, by a boy, lying on the sandy bed of a dry

creek, running down the centre of the "Two-mile-flat." During the first five months of systematic washing, over 2,500 diamonds were discovered, and several thousands more were afterwards obtained; but, as the collectors were generally rather reticent as to their finds, the exact numbers could not be ascertained. The gems were mostly pellucid and colourless; many have a straw-yellow tint, and tints of brown, light or dark bottle-green and black are more rarely met with. One or two opaque black ones have been found, and another of a dark green colour, with the external appearance of having been polished with black lead. Black specks within the crystals were not uncommon. The specific gravity, deduced from a number of crystals, is 3.44. They all show a well-defined crystalline form, though irregularities of development are frequent. It is very rare to meet with fractured stones, and these only on cleavage planes; water-worn stones I never saw from any direct treatment of the undisturbed *older* drift. Some shapeless diamonds occur, but, if water-worn, the process has not impaired their lustre. They are never found coated superficially with any foreign matter. When dull or lustreless, an examination proved it to be caused, not by any water-wearing or incrustation, but by multitudes of minute angles and edges of structural planes, which gave a frosted appearance to the crystal. The forms met with were the octahedron, twin-octahedron, dodecahedron, tris-octahedron, and hexakis-octahedron; the two latter are often hemihedral, with curved faces, and are sometimes developed into flat triangular twins. One specimen of the deltoid dodecahedron or hemihedral triakis-octahedron was found.

The above-named curious triangular twin crystals are, according to the late Professor Thomson, derivable from the tris-octahedron. If we regard the latter as an octahedron with a low triangular pyramid on each of its faces, and out of the eight pyramids we imagine that only two, corresponding to opposite and parallel octahedral faces, are developed, on applying these two pyramids together, they would not form a closed figure, but, by twisting one 180° round, we form the triangular twin crystal; or, more simply, if we inspect a twin-octahedron, there are but two of the original triangular faces entire; these are opposite and parallel, and, by replacing these two faces by the corresponding planes of the tris-octahedron, the rest of the faces of the twin-octahedron may be obliterated, and the triangular crystal will result. The structural laminae are very distinct in some crystals, and many of the octahedrons show these successive layers of growth in a very marked and beautiful manner. A few show indented angles, and sunk triangular depressions on their faces, having the apices of the triangles pointing to the centres of the sides of the triangles in the main crystal.

*Gold*.—Occurs fine, scaly, and occasionally inclosed in quartz. The quantity is variable, the average being about three pennyweights to the load of "wash dirt."

*Osmiridium*.—In minute silvery scales after amalgamation and retorting—only from the *newer* drift.

**Metallic iron.**—Hackly fragments of slightly rusted metal, evidently derived from the tools used. Analysis failed to detect any trace of nickel.

**Wood tin.**—Rare, and in small pieces.

**Titanic acid.**—Probably brookite, in flat red transparent or reddish-white translucent plates, with striated surfaces, but too worn to distinguish the crystalline form. The plates vary in thickness up to one-twelfth of an inch, and are often one-fourth of an inch across; hardness, 6; specific gravity, 4.13; composition found by analysis to be pure titanic acid, with only a minute trace of iron.

**Black magnetic iron sand.**—Common.

**Black titaniferous iron sand.**—Common.

**Tourmaline-schorl.**—Rolled black prisms half an inch long are common; small nests of schorl in quartz pebbles rare.

**Garnet.**—In minute brown icositetrahedrons, rare and only occurring in the recent river drifts.

**Black vesicular pleonaste.**—Occurs in small grains from one-twentieth to one-fourth of an inch in diameter, and is very abundant. It has a dull black surface, but shows a brilliant fracture. Some pieces are coated bluish grey or rusty brown; but the interior is the same in all, the external differences seeming to be the result of decomposition. It never occurs in crystals, nor shows any traces of faces, and has no cleavage; its fracture is conchoidal and jet black, with a strong vitreous lustre; hardness 8; streak grey; composition found by analysis:—

Silica (and undecomposed) ... ..	2.75
Alumina ... ..	64.29
Chromic oxide ... ..	4.62
Magnesia ... ..	21.95
Ferrous oxide ... ..	4.49
	<hr/>
	98.10

Oxygen ratio 3.2 : 1; Specific gravity 3.77.

The mineral is amorphous and vesicular. The latter character is remarkable, and the grains do not all show it in the same degree. One variety (the least abundant) with a lustrous surface shows it best, the grains resembling a perfect cinder when seen through a lens. Several pounds weight of this mineral were obtained from each load of gravel washed, more especially from the *newer* drift.

**Topaz.**—In waterworn fragments, and sometimes in imperfect crystals, with terminal planes; transparent and usually white, rarely yellow or light blue. This is the largest of the associated minerals, varying in size up to half an inch in diameter.

**Zircon.**—In small rolled pieces, and as a fine heavy sparkling sand in abundance; transparent, brown, very pale red, or colourless. They rarely exceed one-fourth of an inch, and are mostly smaller; but are found higher up the river, and above the diamond fields, in pieces of much larger size and richer in colour.

**Corundum.**—

Var. (a). *Sapphire.*—Transparent, blue, green, yellowish, and particoloured; too small and of bad colour to be of value.

(b). *Adamantine spar.*—Hair-brown and black with chatoyant lustre.

- (c). *Barklyite*.—An opaque magenta-coloured variety first discovered in Victoria and named after Sir Henry Barkly.

All the above occur in small fragments (larger higher up the river) in great abundance.

- (d). A variety, locally termed "mouse dung," which it much resembles, is characteristic of the locality. It occurs in six-sided prisms, slightly barrel-shaped or tapering, with flat end faces; one-fourth of an inch long, and one-twentieth of an inch in diameter; bluish white, with a few dark blue spots, opaque; hardness 9; specific gravity 3.59; composition found by analysis:—

Alumina	...	...	...	...	...	...	...	98.57
Ferric oxide	...	...	...	...	...	...	...	2.25
Lime	...	...	...	...	...	...	...	.45

101.27

- (e). *Ruby*.—A transparent pink variety, found sparingly in flat grains one-tenth of an inch in diameter; its shade often passes into violet and blue; hardness 9; specific gravity 3.96; composition found by analysis:—

Alumina	...	...	...	...	...	...	...	97.90
Ferric oxide	...	...	...	...	...	...	...	1.39
Magnesia	...	...	...	...	...	...	...	.63
Lime	...	...	...	...	...	...	...	.52

100.44

- (f). A few large rolled oval pebbles of corundum have also been noticed, exceeding half an inch, of a mottled dirty white and pink colour, perfectly opaque. From their low and variable specific gravity (3.21 to 3.44 and upwards) they appear to be impure massive forms of the mineral, and possess the requisite hardness. They look like jasper pebbles, and are probably what are termed "morlops" by the Bingera miners. Their specific gravity accounts for their association with the diamonds in washing off.

*Quartz*.—Opaque double hexagonal pyramids, one-eighth to one-fifth of an inch in diameter, are very common. Quartz pebbles occur of all sizes. The varieties comprise *agate* of poor quality, *carnelian*, *jasper*, *rock crystal*, *smoky quartz*, *amethystine quartz* (rare), and a bluish opaline variety. Fragments of grey quartz, imbedding felspar, derived from the granite of Aaron's Pass, 40 miles up the river, are common. A geode of chalcedony, having the cavity filled with quartz crystallized in rhombs, was also found.

Having thus fully described the geology of this diamond field, and seeing that the diamond occurs in an old river drift, we are led to inquire whether the diamond has been drifted, like the other minerals with which it is associated, and, if so, which of the formations—Igneous (granite, greenstone, basalt, etc.) or Sedimentary (Upper Silurian, Devonian, Carboniferous or Mesozoic)—has afforded it? or, has the diamond *grown* in the *older drift* in which it is now found?

Diamonds were first reported by the late Rev. W. B. Clarke (Southern Gold-fields of New South Wales, page 272) from the Macquarie River in 1860. On this river, at Suttor's Bar, they were worked contemporaneously with the Cudgegong, but, owing to heavy floods, little could be done. The Bingera field was reported on by Professor Liversidge in 1873 (Mines and Mineral Statistics of New South Wales, 1875, p. 104).<sup>1</sup> The Borah Creek (a tributary of

<sup>1</sup> See also, Liversidge, Quart. Journ. Geol. Soc. 1875, vol. xxxi. pp. 489-492.—R. E., jun.

the Gwydir River, New England District, New South Wales) tin and diamond mines were reported on by my late colleague, Mr. C. S. Wilkinson (Mines, etc., New South Wales, 1875, p. 79); and at Bald Hill, near Hill End, Lambaroora, diamonds were also reported on by Prof. Liversidge (Mines, etc., New South Wales, 1875, p. 115), where some tolerably large ones were found—one slightly over three carats (9.6 grains Troy), and another one and a half carats (4.5 grains Troy). The late Professor Thomson was shown some diamonds which were said to have been obtained in the sands at the mouth of the Clarence River; and the writer was shown one from a drift underlying basalt near Trunkey Creek, Tuena, Abercrombie River. In all these instances, with the exception of Borah Creek, the surrounding country is entirely Palæozoic, intersected, however, by dykes and masses of various igneous rocks.

The fact of the diamonds exhibiting structural or growth planes is, I think, sufficient to enable us to disregard the igneous rocks for their origin, unless some of these rocks (the granites and greenstones) are metamorphic. Wöhler asserted that the diamond could not have been formed at a high temperature, least of all by fusion. Brewster thought that the old conjecture, that diamonds were of vegetable origin, was confirmed by their optical properties, and analogy to amber.

The occurrence of tin with the diamond at Borah Creek, New South Wales, and at Beechworth, Victoria, both in granitic areas, indicates granite as their possible source; but tin always occurs with diamond, in small quantity, in the other districts mentioned, which are more numerous, and all in older sedimentary rock areas.

In Mines and Mineral Statistics of New South Wales, 1875, p. 79, Mr. Wilkinson states that the Borah Creek tin and diamonds occur in a newer drift, a wash from the older Miocene drift underlying the basalt, and that the entire watershed of the country is granitic. He also notices the occurrence of small black pebbles of jasper, which seem to him to indicate that the rock producing the diamond may have been entirely denuded away. On this field the diamonds average in weight about one carat grain each (the largest 5.5 carat grains), and their facets and edges are never waterworn or abraded. On page 88, speaking of diamonds and tin, Mr. Wilkinson states, "There seems but little doubt that they have been derived from the older Tertiary gravels; and this is an agreement with the observations of the late Professor Thomson and Mr. Norman Taylor on the Cudgegong diamond field." Mr. Wilkinson seems partly to have subscribed to the writer's view that the *older* drift is the matrix of the diamond.

In Captain Burton's "Highlands of Brazil," vol. ii. page 137, he says, "For reasons that will presently appear, it (the diamond) is evidently younger at times than the formation of gold, and it is probably still forming, and with capacity for growth." The writer failed, however, to notice the reasons that were to appear.

Professor Liversidge remarks that the Bingera diamond field is surrounded by rocks of Devonian or Carboniferous age, but that he

had no fossil evidence. The diamond drift rests on argillaceous shales with interbedded conglomerates. The miners regard these conglomerates as being diamond bearing, but without any proof. He states also that he had not detected any fractured diamonds.<sup>1</sup>

If the diamond is derived from the Carboniferous rocks, why is it not found in the present river-bed (except where tailings have been washed into it) which abounds in Carboniferous detritus; more than one-half of the pebbles and boulders consisting of Carboniferous conglomerates? Why also is it totally absent, although carefully looked for, in close proximity to the Carboniferous rocks, as at Cudgegong, and immediately under their escarpments at Tallawang, and in all the streams of the upper sources of the river? It is rare to find a trace of the Carboniferous rocks in the *older* drift, and only occasionally in the newer, whilst they are common in the most recent river drifts. The sand in the newer drifts is probably the remains of the Hawkesbury sandstones, which overlie the Carboniferous rocks, and must at one time have had a far wider extension. The late Rev. W. B. Clarke observed that the occurrence of grains of *graphite* in the Hawkesbury rocks looks like an approach towards the diamond; and, in a letter to the writer, he says that the evidence of fossil wood must be rejected, as it is found in various formations of all ages.

If the gem-stones in the *older drift* (underlying basalt) were derived from basalt, this basalt must have been older than that now covering the drift, and there is no trace of such older basalt, if we except that capping Mount Bocoble, west of Cudgegong, which is of a totally different character to the Cudgegong flow, and at nearly 1000 feet higher elevation. We are then driven to the greenstones and granites for the origin of the gems, and here we are completely at fault.

The Broombee and Cudgegong limestones (Devonian) may have supplied the rubies, as they do not occur above the latter place, nor are topaz or diamond found there.

The gems associated with diamonds are very common in most of the river drifts of Victoria and New South Wales, but in one instance only in the former colony, at Beechworth, have diamonds been found. And, if these gems are derived from igneous or metamorphic rocks, and their presence is an indication of the diamond, how is it they are associated in one place and not in another, the surrounding circumstances being apparently the same?

Why is the *corundum* family—all the members of which, or nearly all, are as hard as the diamond, and harder than all other rocks which would be at all likely to grind down their angles—rounded and fractured, and not the diamond, which, although the hardest mineral known, is brittle and easily fractured on its cleavage planes?

<sup>1</sup> The cinnabar erroneously quoted by Professor Liversidge (from the article by the late Professor and the writer) as occurring at the Mudjee diamond field, does not do so. It is found in an old river drift near the village of Cudgegong, over 40 miles higher up the river, and has no connexion whatever with the diamond drifts.



Why are diamonds, if drifted, so variable in size, being often larger down the river than nearer their supposed source?

Why are diamonds, nearly always, more or less contorted from the true octahedron, forming oblique octahedrons?

Why are the diamonds, when they occur in the largest quantity, both larger and purer than when in small quantity?

Why are diamonds *locally* variable in aspect, one spot turning out straw-yellow coloured gems, another with internal black spots, and another perfectly pure?

Any answer to the above queries must of necessity lead to the conclusion that the diamonds have been formed *in situ* in the older drift. The writer, for his own part, believes that the so-called association of other gems with the diamond is purely accidental, that these gems occur at the bottom of the older drift, with the gold; the diamonds occurring at irregular depths above it, and their association being merely due to the miners taking out some six feet or more of the drift, and thereby bringing them together in the process of washing.

All the extracts brought forward by the late Rev. W. B. Clarke, in his Presidential Address to the Royal Society of New South Wales, in May, 1870,<sup>1</sup> only prove that a large amount of unreliable and unreconcilable data have been collected, which add little or nothing to our knowledge of the true matrix of the diamond; and, as to how the diamond has been formed, taking this gem as an illustration of the purest form of the element carbon, as little is known or likely to be, as there is of any of the other elementary substances. Until chemistry throws some light upon the possible modes of formation of the diamond in nature, and demonstrates the necessity of its occurrence in metamorphic rocks, it is perhaps as easy to suppose that the gem may originate in a late Tertiary drift deposit, as in the most ancient strata of a somewhat similar origin. Quartzites and quartzose conglomerates occur in Australian Tertiary deposits having as highly metamorphosed an aspect as those in the Silurian rocks. If the diamonds have been formed in the older drift, it will account for their absence in the present river-bed; on the other hand, if the diamond has been drifted from its original matrix, either it might be expected to occur in the river, where it has never yet been detected, or, its matrix has been entirely denuded away in older Pliocene or earlier times. Large areas of Carboniferous and older strata, as well as extensive tracts of Tertiary basalt, have disappeared from the river basin; and some persons have therefore proposed to assign the original position of the diamond to local and limited deposits in the demolished Palæozoic rocks.

<sup>1</sup> See Trans. R. Soc. N. S. Wales for 1870, pp. 1—48, "On the Discovery of the Diamond in N. S. Wales;" and *Ibid.* for 1872, pp. 1—66, "On the Natural History of the Diamond."—R. E., jun.