FIG. 3, one-twentieth natural size. Transverse section of a large concretionary mass of compact siliceous ironstone, exhibiting cone-in-cone structure upon both upper and under surfaces, as well as in the interior of the mass, at *a* and *c*. The band *b*, *b*, is clay ironstone crowded with leaflets of *Neuropteris gigantea*.

FIG. 4, one-tenth natural size. Transverse section of a nodule of compact siliceous ironstone, entirely coated with cone-in-cone structure.

FIG. 5, one-tenth natural size. Transverse section of a large concretionary mass of close-grained ferruginous sandstone exhibiting cone-in-cone structure upon upper and under surfaces, and also a peculiar double arrangement of a spherulitic formation surrounding the cone-in-cone areas.

FIG. 6, one-twentieth natural size. Shows the appearance, on the surface of nodule in Fig. 5, of the spherulitic structures occupying the areas surrounding the cone-in-cone masses.

IV.—ON A DIAMANTIFEROUS PERIDOTITE, AND THE GENESIS OF THE DIAMOND.

By Prof. H. CARVILL LEWIS, M.A., F.G.S.

(Abstract of a Paper read at the Birmingham Meeting of the British Association for the Advancement of Science, September, 1886.)

THE discovery of diamonds at Kimberley, South Africa, has proved to be a matter, not only of commercial, but of much geological interest. The conditions under which diamonds here occur are unlike those of any other known locality, and are worthy of special attention.

The first diamond found in South Africa was in 1867, when a large diamond was picked out of a lot of rolled pebbles gathered in the Orange river. This led to the "river diggings" on the Orange and Vaal rivers, which continue to the present time.

In 1870, at which time some ten thousand persons had gathered along the banks of the Vaal, the news came of the discovery of diamonds at a point some fifteen miles away from the river, where the town of Kimberley now stands. These were the so-called "dry diggings," at first thought to be alluvial deposits, but now proved to be volcanic pipes of a highly interesting character. Four of these pipes or necks, all rich in diamonds, and of similar geological structure, were found close together. They have been proved to go down vertically to an unknown depth, penetrating the surrounding strata.

The diamond-bearing material at first excavated was a crumbling yellowish earth, which at a depth of about 50 feet became harder and darker, finally acquiring a slaty blue or dark green colour and a greasy feel, resembling certain varieties of serpentine. This is the well-known "blue ground" of the diamond miners.

It is exposed to the sun for a short time, when it readily disintegrates, and is then washed for its diamonds. This "blue ground" has now been penetrated to a depth of 600 feet, and is found to become harder and more rock-like as the depth increases.

Quite recently, both in the Kimberley and De Beers mines, the remarkable rock has been reached, which forms the subject of the present paper.

The geological structure of the district and the mode of occurrence of the diamond has been well described by several observers. As Griesbach, Stow, Shaw, Rupert Jones, and others have shown, the diamond-bearing pipes penetrate carbonaceous strata of Triassic age, which are known as the Karoo formation.

The Karoo beds contain numerous interstratified sheets of dolerite and melaphyre, also of Triassic age, and the whole reposes upon ancient mica-schists and granites. The careful investigations of Mr. E. J. Dunn demonstrate that the diamond-bearing pipes inclose fragments of all these rocks, which fragments show signs of alteration by heat. Where the pipes adjoin the Karoo shales, the latter are bent sharply upwards, and the evidence is complete that the diamond-bearing rock is of volcanic origin, and of Post-Triassic age.

The diamonds in each of the four pipes have distinctive characters of their own, and are remarkable for the sharpness of their crystalline form (octahedrons and dodecahedrons), and for the absence of any signs of attrition. These facts, taken in connection with the "blue ground," indicate, as Mr. Dunn has pointed out, that the latter is the original matrix of the diamond.

Maskelyne and Flight have studied the microscopical and chemical characters of the "blue ground," and have shown that it is a serpentine substance containing bronzite, ilmenite, garnet, diallage, and "vaalite" (an altered mica), and is probably an altered igneous rock, the decomposed character of the material examined preventing exact determination of its nature. They showed that the diamonds were marked by etch figures, analogous to those which Prof. Gustav Rose had produced by the incipient combustion of diamonds, and that the "blue ground" was essentially a silicate of magnesium impregnated with carbonates.

The "blue ground" often contains such numerous fragments of carbonaceous shale as to resemble a breccia. Recent excavations have shown that large quantities of this shale surround the mines, and that they are so highly carbonaceous as to be combustible, smouldering for long periods when accidentally fired. Mr. Paterson states that it is at the outer portions of the pipes where the "blue ground" is most heavily charged with carbonaceous shale, that there is the richest yield of diamonds.

Mr. Dunn regards the "blue ground" as a decomposed gabbro, while Mr. Hudleston, Prof. Rupert Jones, and Mr. Davies regard it as a sort of volcanic mud. Mr. Hudleston considers that the action was hydrothermal rather than igneous, the diamonds being the result of the contact of steam and magnesian mud under pressure upon the carbonaceous shales, and compares the rock to a "boiled plum-pudding."

The earlier theories as to the origin of the diamond have, in the light of new facts, quite given way to the theory that the diamonds were formed in the matrix in which they lie, and that the matrix is in some way of volcanic origin, either in the form of mud, ashes, or lava.

The exact nature of this matrix becomes, therefore, a matter of great interest. The rocks now to be described are from the deeper portions of the De Beers mine, and were obtained through the courtesy of Mr. Hedley. They are quite fresh, and less decomposed than any previously examined. Two varieties occur, the one diamantiferous, the other free from diamonds, and the lithological distinction between them is suggestive. The diamantiferous variety is crowded with included

fragments of carbonaceous shale, while the non-diamantiferous variety is apparently free from all inclusions, and is a typical volcanic rock.

Both are dark, heavy, basic rocks, composed essentially of olivine, and belong to the group of peridotites. Both are of similar structure and composition, differing only in the presence of inclusions. The rock consists mainly of olivine crystals lying porphyritically in a serpentinitic ground-mass.

The olivine is remarkably fresh, and occurs in crystals which are generally rounded by subsequent corrosion. The principal accessory minerals are biotite and enstatite. The biotite is in crystals, often more or less rounded, and sometimes surrounded by a thin black rim, due to corrosion. Similar black rims surround biotite in many basalts. The biotite crystals are usually twinned according to the base. The enstatite is clear and non-pleochroic. Garnet and ilmenite also occur, the former sometimes surrounded by biotite, and the latter often partly altered to leucoxene. All these minerals lie in the serpentinitic base, originally olivine. This rock appears to differ from any heretofore known, and may be described as a saxonite porphyry in which the base is not holocrystalline.

The diamond-bearing portions often contain so many inclusions of shale as to resemble a breccia, and thus the lava passes by degrees into tuff or volcanic ash, which is also rich in diamonds, and is more readily decomposable than the denser lava.

It seems evident that the diamond-bearing pipes are true volcanic necks, composed of a very basic lava associated with a volcanic breccia and with tuff, and that the diamonds are secondary minerals produced by the reaction of this lava, with heat and pressure, on the carbonaceous shales in contact with and enveloped by it.

The researches of Zirkel, Bonney, Judd, and others, have brought to light many eruptive peridotites, and Daubree has produced artificially one variety (lherzolite) by dry fusion, but this appears to be the first clear case of a peridotite volcano with peridotite ash.

Perhaps an analogous case is in Elliott County, Kentucky, where Mr. J. S. Diller has recently described an eruptive peridotite which contains the same accessory minerals as the peridotite of Kimberley, and also penetrates and incloses fragments of carboniferous shale, thus suggesting interesting possibilities.¹

V.—NOTE ON A BED OF RED CHALK IN THE LOWER CHALK OF SUFFOLK.

(A paper read before the British Association, Birmingham.)

By A. J. JUKES-BROWNE, B.A., F.G.S.

THE section exposing this stratum was discovered during an excursion made last June by Mr. W. Hill, F.G.S., and the author. It occurs in a quarry near West Row Ferry, about two miles west of Mildenhall;

¹ Since this paper was read, additional evidence that diamonds originate by the action of peridotites on carbonaceous rocks has been collected from many localities. The most instructive examples are from New South Wales, where the diamond gravels lie near the contact of basalts or serpentine with Carboniferous rocks, the serpentine here being an altered olivine enstatite rock. At the Bingera diamond-field a mass of eruptive serpentine is almost surrounded by Carboniferous rocks containing coal-seams. In Western America, also, the diamantiferous gravels are near higher ground, where serpentines and carbonaceous rocks occur together. Possibly a clue may be thus afforded for more systematic search.