To

WITH THE AUTHOR'S COMPLIMENTS.

A Diamantiferous Gem-Gravel from the West Coast of Africa.

BY

F. H. HATCH, Ph.D., M.Inst.C.E.

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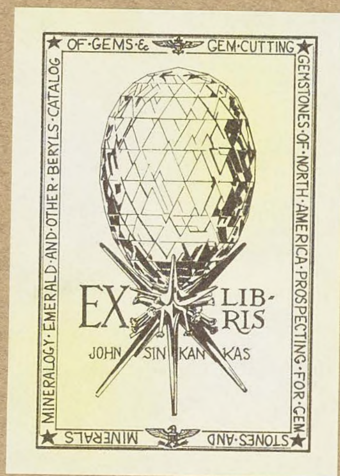
OF·GEMS·&c GEM·CUTTING
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Description of a Diamantiferous Gem-Gravel from the West Coast of Africa.

By F. H. Hatch, Ph.D., M.Inst.C.E., Vice-President of the Institution of Mining and Metallurgy.

THE material described in this paper was handed to me by the Liberian Development Company (to which I acted for some time as technical adviser) and was obtained in the course of prospecting operations prosecuted by that Company at Banja Ta (Montserrado) on the Jiblong and Bor Rivers (tributaries of the Junk River), some thirty miles inland from Monrovia, the chief port of the State of Liberia.

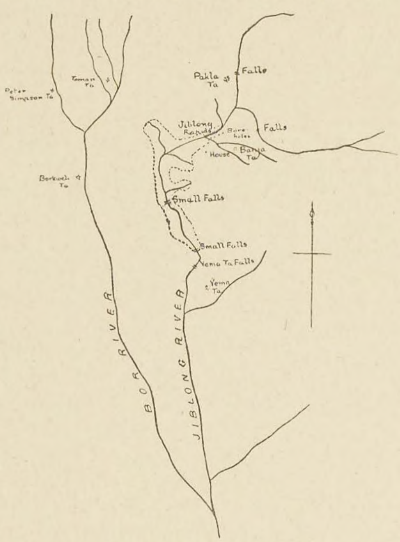
Diamonds and gold were discovered in the alluvial gravels of these rivers by the late Mr. George G. Dixon, and the concentrates submitted to me for examination were brought to this country by Mr. Dixon at the end of 1910. Mr. Dixon returned to Liberia soon after I had seen him; but unhappily he succumbed to an attack of malarial fever early in 1911. The subsequent prospecting work was carried on under the direction of his assistant, Mr. S. M. Owen, who at the end of the working season of 1911 brought me a series of rock-specimens and cores from boreholes (most of which were put down near the rapids to be referred to presently), so that I am enabled also to give a brief description of the solid geology of the district.

The bed-rock on which the alluvial gravels rest consists of an ancient floor of crystalline rocks, comprising: quartz-felspar-biotite gneiss with accessory sphene and zircon; garnet-hypersthene-biotite gneiss, composed of abundant red garnet, strongly pleochroic hypersthene, brown mica, chlorite, together with granulitic quartz and a small quantity of striated felspar; and coarsely foliated hornblende schist, consisting of green hornblende, plagioclase, quartz and sphene. All these rocks present a well-marked banding, the general strike of the country as reported by Mr. Dixon being N.E. and S.W., with a dip to the S.E.,[1] and give the impression of belonging to an ancient sedimentary series which has been profoundly modified by metamorphism. Associated with them are dark-coloured basic intrusions which, as the microscope shows, consist of water-clear plagioclase, green hornblende and hypersthene with marked granulitic structure, constituting a rock of the pyroxene-granulite or norite type.

Except in the bed of the River Jiblong itself, where comparatively unweathered specimens of the rocks can be obtained from the bars that stem the flow of the water and thus give rise to falls and rapids, all the rocks are entirely replaced at the surface by red and yellow lateritic or whitish kaolinized products; but excellent material for microscopic examination was obtained in the shape of cores from the diamond drill which was freely used in the prospecting operations of the Company. The object of the prospecting was two-fold: (1) to ascertain the quantity and value of the diamantiferous gravel, and (2) to find if possible the source from which the diamonds came. It was with the latter object that the borings were made. To ascertain the extent and value of the diamantiferous gravel the following method of prospecting was adopted: First, sites for pits were marked out at

[1] Cf. J. Parkinson, "A Note on the Petrology and Physiography of Western Liberia": Quart. Journ. Geol. Soc., vol. liv, 1908, p. 313.

fixed intervals across the alluvial flats. The pits were then sunk, the overburden being discarded and the gravel washed. Concentration was effected by the ordinary methods of sluicing and sizing by sieving, the final product being obtained by hand-jigging. From this the diamonds were recovered by hand-picking. The following is the number and weight of diamonds found during the prospecting operations carried on during 1910 and during the first part of 1911: 247 stones, weighing $85\frac{49}{64}$ carats, in the Jiblong River, and 22 stones, weighing $4\frac{13}{64}$ carats, on the Bor River. The largest stone found weighed $4\frac{49}{64}$ carats. Diamonds were found in the Jiblong River and in its alluvial flats for a distance measured along the river of a little over a mile and a half. This stretch of the river is situated between the rapids below the Pakla Ta Falls and the small falls above the Yema Ta Falls (see Map). This stretch of country is comparatively flat, but measured[1] from the top of the Pakla Ta Falls to the bottom of the Yema Ta Falls the river has a total drop of about 100 feet.



Sketch-map of the Jiblong and Bor Rivers from a survey by S. M. Owen. Scale, 1 inch = 2 miles. The area in which diamonds have been found is indicated by a pecked line.

The average width of the flats in which the diamonds were found is 238 feet. The average thickness of the diamantiferous gravel between the overburden and the bed-rock was found to be 6 feet. Diamonds were also found in the Bor River which joins the Jiblong at Careysburg, three miles below the Yema Ta Falls, but no extensive deposit exists in this river valley.

The samples of the 'deposit' or concentrate from which the diamonds had been picked, consisted of a mixture of heavy minerals, together with quartz, limonite, and rock fragments. The quartz was

[1] According to a survey of Mr. S. M. Owen, A.R.S.M.

easily removed by a preliminary treatment with bromoform of density 2·9. The residue still contained limonite, some rock fragments, and particles of tourmaline, the bulk of which was removed by treatment with a borotungstate of cadmium solution, having a density of 3·4. A mixture of heavy minerals was then obtained which could only be separated by hand-picking with the aid of a lens. This, although a tedious task, was found to be quite practicable; and a number of parcels of distinct minerals were thus obtained, the final determination of which was arrived at by taking the density, testing the hardness and streak, and, where practicable, measuring the crystal angles. In those cases where there was sufficient material, chemical tests were also made, both by dry and wet methods.

For permission to carry out this work in the Chemical Laboratory of the Mineralogical Department of the University of Cambridge, I am indebted to Professor W. J. Lewis, F.R.S., and for assistance in making a few goniometric measurements of crystals, I have to thank Mr. Arthur Hutchinson, Demonstrator of Mineralogy in the University of Cambridge.

Of the samples examined the two principal ones were: A (No. 30) gravel from the upper flats, and B (No. 31) from the lower flats. Sample A consisted of kyanite, corundum, pyrites, ilmenite, zircon, rutile, epidote, and gold. Sample B consisted of garnet, kyanite, pyrites, chromite, magnetite, hæmatite, zircon, and diopside. It will be observed that in sample B from the lower flats the minerals garnet, chromite, magnetite, hæmatite, and diopside occur, which are not represented in the sample from the upper flats; and, moreover, the garnet occurs in great abundance. It is obvious, therefore, that some source of supply was available for the formation of the gravels of the lower flats which did not exist in the upper reaches of the river. In all probability this was the garnetiferous gneiss already mentioned. The presence of gold in sample A was accidental, as the gold from both samples had been previously removed. The particle of gold found in the sample was coated with amalgam, and its true character only became apparent after driving off the mercury by heat.

Diamond.—Of the uncut diamonds still in the London office of the Liberian Company and examined by me, some are perfect octahedral crystals showing the usual rounded edges and striated faces due to vicinal forms. Others are irregular cleavage fragments showing no original crystal faces, while others again are partially bounded by original faces and partly by octahedral cleavages. There are also flattened rudely triangular forms (macles) due to twinning on the spinel type. In many cases the faces are smooth with occasional triangular pittings; and, as a rule, there is no sign of true abrasion. Some of the faces of the crystals, however, have a roughened, fretted, or frosted surface which must, I think, be attributed to corrosion while the crystals were still in the igneous magma in which they were formed, rather than to any subsequent attrition. Many of the stones are pure white and flawless; but some have a yellow or brown tinge and there is the usual proportion of spotted material. The average value of the whole parcel has been appraised by A. E. North and Co., of Hatton Garden, at £2 11*s*. per carat.

Gold.—An examination of the gold obtained by washing and now in the London office of the Liberian Company shows that it has the usual characteristics of the noble metal when obtained from alluvial sources. It is fairly coarse, but not nuggety; the grains are of irregular shape and are usually somewhat flattened. The colour is a beautiful dark yellow, due to the low proportion of silver, the fineness on assay being 971 per 1,000 parts.

Kyanite.—This, the most abundant mineral in sample A and the second most abundant in sample B, occurs in pale-blue to pale yellowish-green glassy fragments bounded by faces of the prismatic zone with predominant macro-pinacoid (100) and perfect cleavages parallel to the same face. Many of the fragments are flecked with minute black inclusions apparently of an iron-ore (magnetite?). The density was determined as 3·72.

Corundum.—This mineral is abundant in sample A, but absent from sample B. It occurs as cleavage fragments with no signs of rounding; colour, a dull pink with imperfect translucency. The basal plane (111) shows the triangular reticulation of fine lines due to lamellar twinning on the rhombohedron (100). The density was determined as 4·0.

Garnet.—This, the most abundant mineral in sample B, is absent in sample A. It is a blood-red variety, probably that known as pyrope. The fragments are of an irregular shape, determined by the uneven fracture and imperfect cleavage characteristic of the mineral, and present no crystal faces. The density was determined as 3·98.

Rutile.—This mineral is fairly abundant in sample A, but was not found in sample B. The fragments present dominant faces of the prism zone with vertical striation. The metallic-adamantine lustre is a predominant characteristic. Fractured surfaces show a reddish colour and there is a slight translucency at the edges. The density was determined as between 4·1 and 4·4.

Zircon.—A few crystals of zircon were found in both samples. One or two are almost perfect crystals—the prism (110) terminated by the pyramid (111). Colour, dark brown; lustre, vitreous. The density was determined as 4·75. Some colourless crystal fragments in sample B possessing strong double refraction and a high index of refraction (greater than that of methylene iodide) appear to be a special variety of this mineral. A goniometric measurement of the angle between two adjacent faces gave 48°, which corresponds closely to the angle (111) (110) = 47° 50′.

Chromite.—This mineral is fairly abundant in sample B, in rather small iron-black grains with sub-metallic lustre, giving a blackish-brown streak. As a rule the grains are irregular with conchoidal fracture or rounded, but one showed the spinel type of twinning. Fusion with borax gave the characteristic chromium reaction. The density was determined as 4·92.

Ilmenite.—This mineral occurs in sample A in tabular iron-black fragments with brilliant metallic lustre. Goniometric measurement gave the following results:—

$$111 : 100 = 57° 59'$$
$$111 : 31\bar{1} = 61° 44'$$

which agree sufficiently closely with those of ilmenite.

The presence of titanium was also proved by the yellow colour obtained with peroxide of hydrogen in the sulphuric acid solution, and by the blue colour obtained with tin in the hydrochloric acid solution. The density was determined as 4·72.

Hæmatite.—A few rounded reddish-black grains of this mineral were found in sample B. They are characterized by a brilliant metallic lustre on the surface, but are partially converted to limonite in the interior. Hence the low density obtained, viz. 4·6. The streak was cherry-red.

Magnetite.—A few small black grains with metallic lustre are present in sample B. They are strongly attracted by a small bar magnet.

Iron Pyrites.—This mineral is present in both samples in irregular fragments, but is more abundant in sample A.

Diopside.—One grain of this mineral was found in sample B. It is green and translucent with a refractive index of 1·69. It shows the rectangular prismatic cleavage and two pinacoidal cleavages, one of which appears to be a diallagic parting. The density was found to be 3·4. It is probably the chrome-diopside variety.

Epidote.—One cleavage fragment of this mineral was found in sample A. It presents the characteristic pistachio-green colour and basal cleavage.

From this examination it is evident that the bulk of the particles making up the finer material of the gravels consists almost entirely of minerals that possess a high capacity for resisting weathering—such as quartz, the various oxides of iron, corundum, kyanite, garnet, tourmaline, zircon, and diamond. On the other hand, the readily decomposable minerals, such as members of the felspar, amphibole, and pyroxene groups, are, with one exception, conspicuous by their absence. The obvious conclusion to be drawn from this fact is that these alluvial gravels are not derived directly from the crystalline rocks, but come intermediately from the lateritic weathering products by which these are replaced at the surface and which would naturally fall an easy prey to river erosion.

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