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SPECIAL SIERRA LEONE GEOLOGICAL POTENTIAL REPORT

Part 2. A BRIEF OVERVIEW OF THE POTENTIAL OF SIERRA LEONE DIAMOND DEPOSITS

for Mr. Bader Al Monawer

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CONTENT

1 GENERAL OVERVIEW OF SIERRA LEONE

The Republic of Sierra Leone (Fig.1) is located on the West Coast of Africa, between latitudes 7 and 10 north and longitudes 10.5 and 13 west. It is bordered by Guinea to the north and east, Liberia to the southeast, and the Atlantic Ocean to the west and southwest. Sierra Leone covers a land area of 71,621 km2 and a total area of 71,740 km2. It has a population of 5.4 million (est. 2011). The capital and biggest city is Freetown (approx. 1.1 million, 2003), other important cities are Bo (174,354), Kenema (143,137), Makeni (87,679) and Koidu-Sefadu (87,539). The Republic of Sierra Leone is composed of four regions, the Northern Province, Southern Province, the Eastern Province and the Western Area. The first three provinces are further divided into 12 districts – Kambia, Port Loko, Bombali, Koinadugu, Kono, Tonkolili, Moyamba, Bo, Kenema, Kailahun, Pujehun, and Bonthe. The districts are further divided into 149 chiefdoms. The Western Area is divided into the Western Area Urban and the Western Area Rural.

Fig. 1. Relief map of Sierra Leone

Several ethnic groups make up Sierra Leone, including the Temne (30 %), the Mende (30 %) and others (30 %); Creole (Krio) 10 %; refugees from Liberia's recent civil war, small numbers of Europeans, Lebanese, Pakistanis, and Indians [2, 4]. Languages: English (official), Mende (southern vernacular), Temne (northern vernacular), Krio (lingua franca). Religions: Islam 60%, Indigenous 30%, Christian 10 %.

Since gaining independence from Britain in 1961, Sierra Leone has had a chequered history. Periods of democratic government have been punctuated by military coups - the first in 1967 and the most recent in 1997. The country experienced a brutal rebellion that started in 1991 and ended in 2002, following British and UN intervention. The rebellion caused great damage to the country's human, infrastructural and economic resources.

Prior to the civil war, Sierra Leone had established an active mining sector built upon significant exports of diamonds, rutile and bauxite. Although relatively modest by global standards, the sector was significant in terms of the country's population and GDP. Mining and quarrying provided a livelihood for over 250,000 people, and employed about 14 % of the total direct and indirect labour force. Despite the sector operating at only a fraction of its potential, its contribution was significant enough to qualify Sierra Leone as a resource-rich country. Sierra Leone slipped off the investment radar for most major mining companies wellbefore the outbreak of hostilities in 1991.

The end of hostilities marked the start of a strong economic recovery. Double-digit economic growth during 2001 and 2002 led to a significant period of economic expansion. Real GDP growth averaged nearly 8 % per annum for the period 2003 to 2006 and is forecast by the International Monetary Fund to continue at over 6 % per annum in the medium-term. The mining sector has played an instrumental role in Sierra Leone's nascent economic recovery. The rate of growth recorded in the mining sector has exceeded that in the remainder of the economy. The resurgence of the mining sector has been twofold. First, the Government – with external support – has had considerable success in increasing the proportion of diamonds mined that pass through official channels. Official exports have increased to 582,000 carats in 2006, with 84 % of this amount being mined by artisanal and small-scale miners. The U.S. dollar value per carat has also increased significantly, suggesting that larger, more valuable diamonds are increasingly returning to official export channels. Second, three mechanized mines have been reactivated. The country's first kimberlite diamond mine has been operating since 2004 and is progressively expanding production. Also, both of the rutile and bauxite deposits that were developed before the war are once again being mined. The resumption of rutile and bauxite mining has reestablished the two mines as two of the largest private sector employers in Sierra Leone. Prior to their closure these mines employed over 3,000 workers. The vast majority of income-earning opportunities generated by the mining sector, however, are in artisanal diamond mining. The World Bank has estimated that up to 40,000 people are directly engaged in mining for diamonds and that the associated population of immediate family dependents could include 100,000 to 200,000 people. If those people that are indirectly dependent on artisanal diamond mining through forward and backward linkages are included, the World Bank estimate reaches 200,000 to 400,000 people dependent upon artisanal mining for the greater part of their livelihood. This represents between 4 percent and 8 percent of the population.

2 GENERAL INFORMATION
ON THE DIAMOND FIELDS

The Sierra Leone diamond fields cover an area of about 20,000 km2 (about one quarter of the country) in the south-eastern and eastern parts of Sierra Leone (Fig. 2). The actual diamond producing areas are concentrated in the Kono, Kenema and Bo Districts and are mainly situated in the drainage areas of the Sewa, Bafi, Woa, Mano and Moa Rivers.

Alluvial diamonds were first found in Sierra Leone in 1930 in an area which later became the Yengema lease of the Sierra Leone Selection Trust (SLST). This company was formed in 1934 to develop and mine the diamonds in the streambeds and terraces of fight bank tributaries of the Bail River, a major tributary of the Sewa River. Diamonds occur along the course of the Sewa below its confluence with the Bail and often spectacular high grade recoveries were made by local people in potholes.

Kimberlites, the primary host rocks for diamonds, have been by SLST in 1948 near Koidu and subsequently two small pipes and numerous dykes, located in about 30 parallel dyke zones, were found in the Yengema area. Two similar kimberlite dykes were found by SLST in 1952 in the Tongo area, 50 km to the south of Yengema. The Sierra Leone Geological Survey, following up the trace of workings by local miners, found similar dykes at Panguma, west of Tongo, in 1960.

Sierra Leone is known for producing mostly gem quality diamonds including some spectacularly large stones of very high value. The largest ever discovered (February 1972) was a 969.8 carat

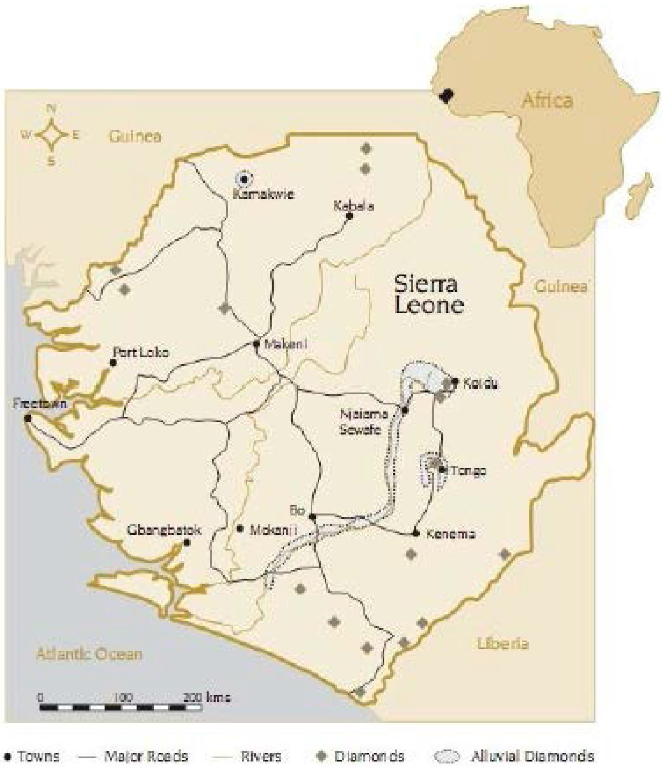

Figure 2.The diamond fields of Sierra Leone

Kimberlite occurs mainly as dykes, but also small pipes and a dyke-enlargement ring complex structure are also recorded. In depth they are all related to dykes following deep-seated fractures in the granitic shield. They occupy two fault-bounded basins in the east of the country, developed across migmatized gneiss, and granodiorite, intruded by late kinematic granites and enclosed by hill ranges of amphibolitic supracrustal rocks. Two main areas contain kimberlite, the Yengema-Koidu and the Tongo Leases, 50 km apart (Fig. 3).

The regional structural control of kimberlite magmatism in Sierra Leone and West Africa as a whole is based on the association of possible major ocean fracture zone continuations in continents with fundamental Archaean lineaments (Fig. 3).

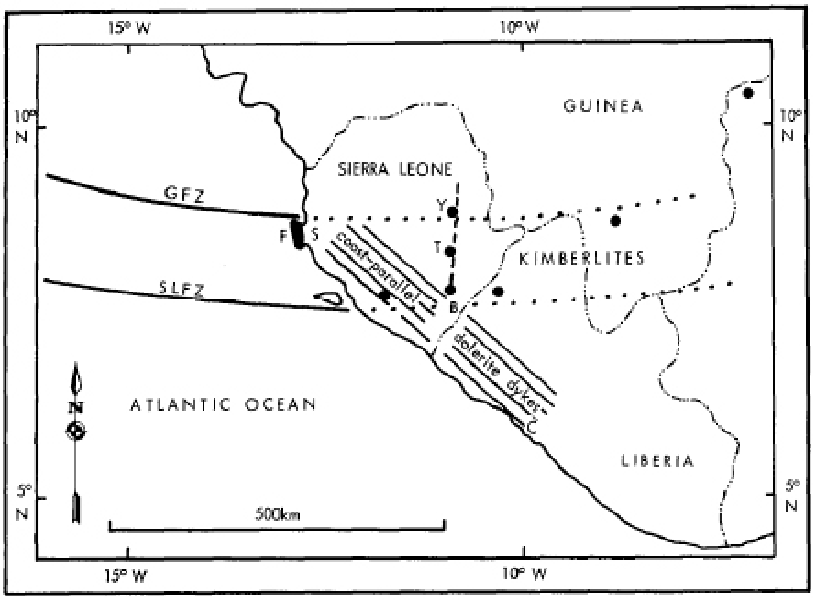

Figure 3. Relationship between magmatism and regional structure in Sierra Leone and adjacent countries. B, Bagbe; C, Cape Mount; F, Freetown Complex; S, Songo; T, Tongo; Y, Yengema; GFZ, Guinea Fracture Zone; SLFZ, Sierra Leone Fracture Zone; solid circles, kimberlite; dotted lines, hypothetical continental continuations of fracture zones; dashed line, major fault controlling kimberlite magmatism.

The dyke zones are bordered to the E and W by 2 N-S trending regional fault zones, and within these faults the dykes generally trend WSW-ENE (striking consistently at 70° to 74° from true north), cutting other Archaean faults and Permo-Triassic dolerites. The dyke dips are steep to vertical.

The kimberlites intruded into the Archaean basement during the Cretaceous (96 Ma by 87Sr/86Sr method), and the presence of feldspathic sandstones, shales and basaltic rocks in the kimberlite breccias indicates erosion of pre-Cretaceous rocks not represented at the present erosion level. Estimates of this erosion are upwards of the order of 300 m, based on the quantities of diamonds released into the drainage system. The coincidence of kimberlite intrusions with sea-floor spreading structures suggests that the timing of kimberlite magmatism is coincident with change in plate movement.

3.1 THE KOIDU KIMBERLITES

The Yengema-Koidu Area (8°38'N; 10°59'W) consists of three Mesozoic kimberlite pipes, a ring-dike structure, and multiple sets of 4 en-echelon kimberlite dykes zones (Dyke Zone A, B, C, and D). A small blow on Dyke Zone A, and another blow on Dyke Zone B were discovered by Koidu Holdings in 2005. The dykes occur as vertical, curvilinear arrays, with individual dykes between 50 mm and 1 m wide and up to 300 m long and altogether make up a total strike length of 192 km (Fig. 4).

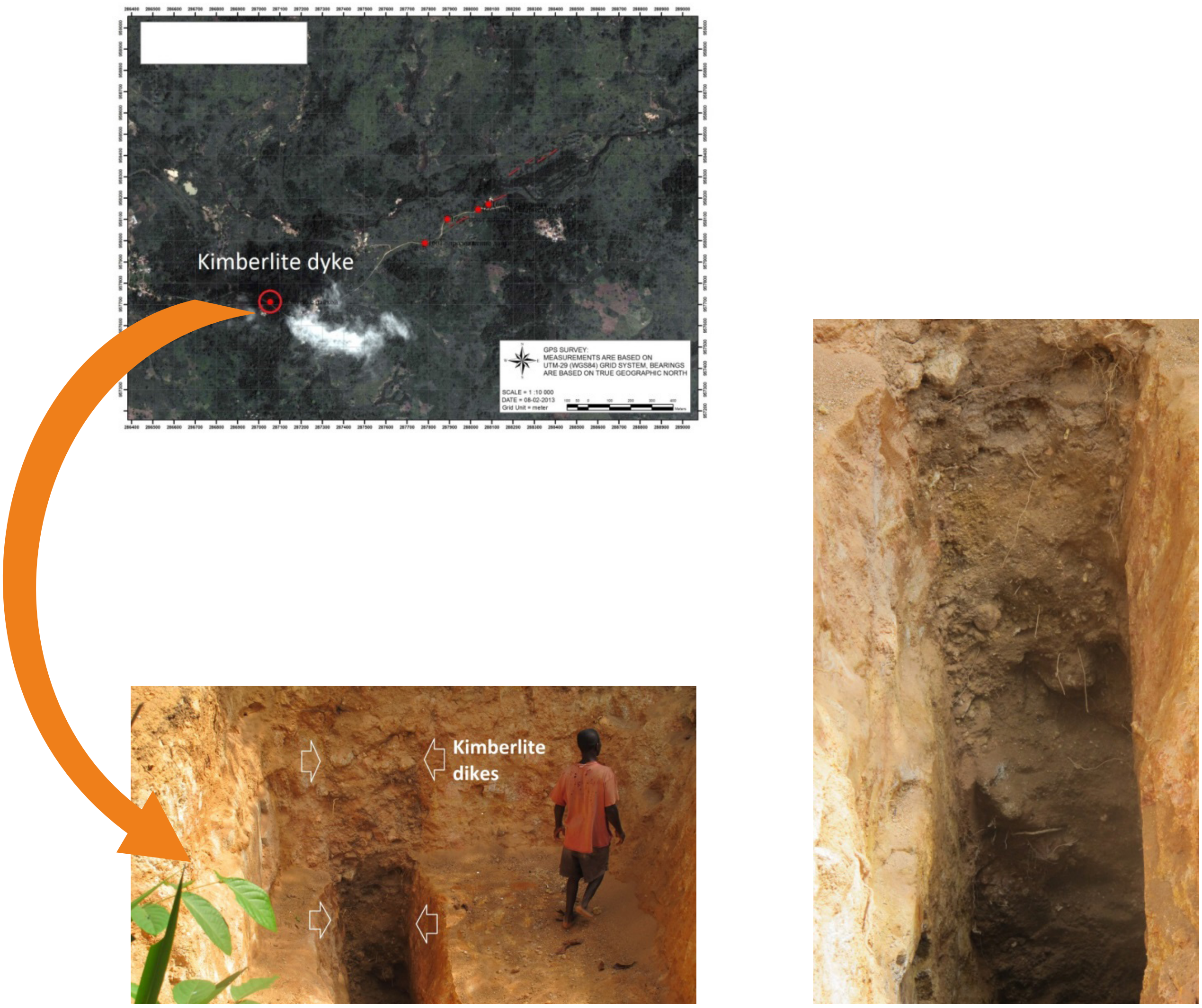

Figure 4. Tipical Kimberlite Dyke from the zone of weathering crust crystalline rocks (Koidu region, Sierra Leone)

The dykes, some dilational and others replacive, contain abundant xenoliths of the granitic host rock. Progressive enlargement of dykes at intersections with faults ultimately leads to pipe formation. The kimberlite dykes strike N55°E and are both older and younger than the kimberlite pipes. Three small pipes have been discovered with surface areas of 2,000 m2 (Pipe 1), 4,500 m2 (Pipe2), and 2,500 m2 (Pipe 3). The dykes and a dyke-enlargement complex in the Yengema Lease are surrounded by 3 m aureoles of fenite and calcite, talc and analcite mineralization. Breccias within the pipes contain a variety of mantle and crustal xenoliths.

A detailed description of the Koidu kimberlites has been given by Grantham and Allen (1960) who showed that these rocks were correctly named, and some of the features described here have already been noted in their paper.

The kimberlite occurs principally in the form of narrow dykes which intrude the granite; all have a near-vertical dip, and their strikes all lie between 60° and 70° true. Individual dykes are short, in most cases less than 1000 feet in length, but they are numerous and are disposed in a series of parallel zones within an area 14 miles by 6 miles. All the known outcrops in this region are within the Yengema field Lease of Sierra Leone Selection Trust. Each dyke is a composite body consisting of a series of anastomosing thin dykes and stringers, the aggregate widths of which vary along the strike, from a few inches to several feet. The structure of the kimberlite is in fact closer to that of a vein, rather than to what is normally understood by the term "dyke".

Immediatley to the south of Koidu Town an exceptionally dense swarm of dykes crops out, and it is here that values are highest and dyke widths greatest, the average aggregate width being about 2 feet. A detailed sampling programme carried out here by the company has shown that the average gradeof the weathered dyke kimberlite is 0.87 carats per cubic yard. This figure, however, is by itself of little significance since each dyke in fact consists of several sub-parallel flat bodies interleaved with barren granite, and all must perforce be mined and treated together. Calculations have therefore to be made on the basis of values over the mining width. This is the minimum stoping width necessary at any point to include all branches of the dyke, with an overriding minimum value of 3 feet. The averagemining width of the Koidu dykes is about 4 feet, with an average mining grade of 0.46 carats per cubic yard.

All dykes contain porphyritic kimberlite, normally without inclusions although the occasional dyke does include a scatter of small granite xenoliths. Near the surface, dyke kimberlite weathers to a greenish-brown clay to depths of 30 feet or more, and is far more susceptible to weathering than the enclosing granite. It has been possible to study the unweathered rock in a dyke which is exposed in underground workings near Koidu, at a depth of 300 feet. The dyke was found to be composite and to contain different types of kimberlite. The commonest rock type was a blue-green porphyritic kimbelrite; less common were a dark greenish-black rock with abundant small green phenocrysts, and a dark grey fine-grained rock somewhat resembling limestone.

The petrography of the different rock-types may be summarised as follows.

Normal porphyritic kimberlite. Abundant closely-packed oval olivine phenocrysts, partially serpentinised, in a fine-grained matrix of phlogopite, calcite, serpentine and magnetite. Scattered books of coarse phlogopite. Rare perovskite. One large rounded mass of ilmenite, with corroded margins. One irregular garnet grain, enclosed by phlogopite, both enclosed by olivine.

Black olivine-rich kimberlite. Abundant small rounded olivine phenocrysts, mostly aligned parallel to the dyke walls. Very slight serpentinizatrion only, along cracks. One broken olivine crystal, with separated fragments. Groundmass of magnetite, calcite and a trace of serpentine. Very rare phlogopite (Fig. 5).

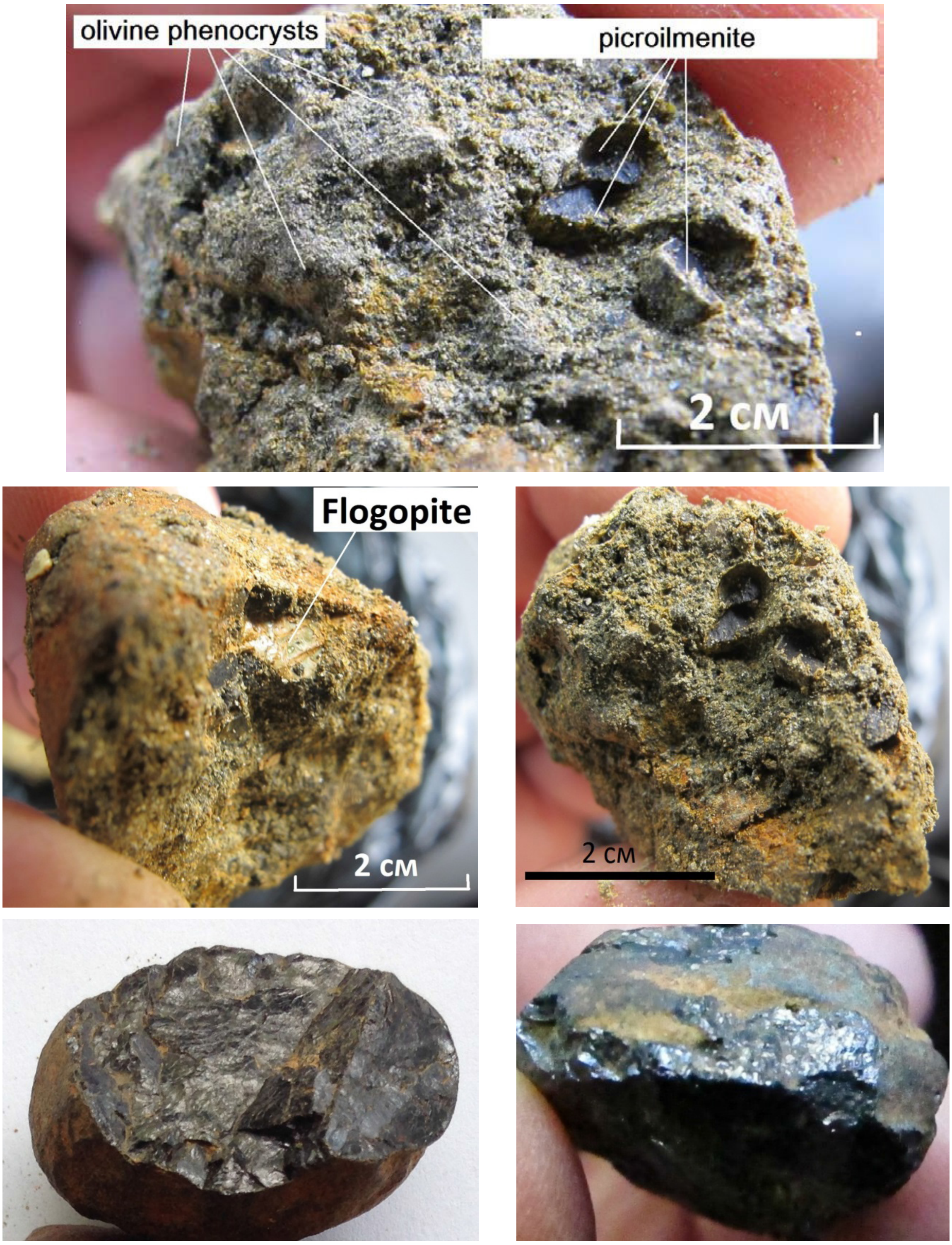

Figure 5. Comparison of authentic phenocrysts picroilmenite kimberlite (a, b, c) with a sample of picroilmenites from delluvium SL-5 (d) a, b, c - clastic kimberlite with phenocrysts of olivine and phlogopite picroilmenites; a fragment derived from kimberlite picroilmenite; d-picroilmenite

Grey carbonate-rich "kimberlite". An aggregate of dine-grained carbonate, phlogopite and magnetite. Small clumps of phlogopite, particlaly chloritized. Small oval granular carbonate pseudomiorphs olivine. This is not, strictly speaking, a kimberlite.

In the Koidu area there are in addition to the dykes, four small pipes which are related to the dykes

PIPE 1. Number 1 Pipe crops out 4000 feet south of Koidu and is a tgrue pipe, filled largely with kimberlite breccia. Although it lies near a kimberlite dyke zone, there is no doubt that it is a separate body, not a dyke enloargement. At the surface it is very roughly oval in shape, with a maximum diameter of 230 feet and a surface area of about 28,000 square feet.

In order to begin the underground development of Pipes 1 and 2 and the adjacent dyke zones, Sierra Leone Selection Trust have sunk a shaft to a depth of 300 feet; Number 1 Pipe has already been intersected by a drive at this level and bulk-sampling has been carried out by means of a series of crosscuts. The pipe appears to plunge at 78° to the south, and at the 300 feet level it still has a cross-sectional area of about 28,000 feet, although the cross-sectional outline has become rather rectangular. 98 feet to the south-east of the pipe margins, the drive passes through an 8 foot thick dyke of kimerlite breccia which appears to dip towards the pipe and is probably an offshoot from it. No trace of this offshoot has been found at the surface. 2200 carats of diamond were recovered from the first 1800 cubic yards of pipe breccia to be milled, giving an average grade of 1.22 carats per cubic yard or about 0.07 carats per long ton. This is, rather unexpectedly, only a little lower than the values that were found during bulk sampling of the decomposed near-surface material between the 12 foot and the 24 foot levels.

The polymict rock which fills the greater park of the pipe is by convention termed a kimberlite breccia but it is in fact misnamed and could be more accurately described as a volcanic conglomerate. The xenoliths, which make up 60% to 70% by volume of this rock, vary considerably in size bu the majority are between 1 inch and 3 inches across. The matrix consists of a grey-green kimberlite adulterated by pink felspathic debris and containing abundant rounded phenocrysts; serpentine psedomorphs after olivine, oval phlogopite books, magnesian ilmenite and pyrope. The fine groundmass consists of carbonate, serpentine and magnetite, with a little phlogopite. Olivine has not been seen in the pipe breccia.

Representatives of many rock-types are found among the xenoliths, and some of them pose awkward problems. The following have been noted so far:

Granites and granodiorites. These are generally pink hornblende-rich varieties, but the xenoliths are often stained green and desilicated at the margins. At the 300 foot level they constitute about half of the total xenoliths, but near the surface they are far more abundant. Some resemble the granites that enclose the pipe.

Hornblende rocks. A very wide variety of hornblende-rich rocks have been noted, ranging from pure hornblendite to amphibolite. Similar rocks are of common occurrence as lenses and partically granitised inclusions within the granites of the Koidu area.

Basalt. Basalt xenoliths, sometimes several inches across, are common at the 300 foot level but rare near the surface. The basalt is a fine-grained grey-black rock consisting of an ophitic aggregate of plagioclase and augite, with scattered pyrite cubes. Vesicles contain an unidentified dark green mineral and aggregates of very small crystals that may be either leucite or analcime. This would appear to be a rock which originally consolidated from a surface flow; its appearance in the breccia can only be explained by assuming that the pipe reached the surface at the time of intrusion and that on this surface was a basalt flow of pre-kimberlite age. Disrupted basalt became incorporated in the pipe and in some way managed to descent several hundred feet. Basalts do not occur on the present surface in the Koidu area, but there are numerous dolerite dykes which could well have been the feeders of basalt flows on older planation surfaces.

The suggestion will no doubt be made that the rocks which have been identified as basalts could in fact be the chilled margins of dolerite intrusions cut by lower levels of the pipe. This appears at first glance to be a credible explanation, but its acceptance is prevented by the complete absence, among the xenoliths, of normal dolerite, which one would expect to be present in excess of the chilled material.

Kimberlite. Numerous small xenoliths of a brownish-black micaceous variety of kimberlite have been noted in the breccia. These must represent earlier kimberlites which were intersected and disrupted by the pipe.

Kikmberlitic Tuff. Fragments of a fine-grained purple-grey or purple-brown rock of shaly appearance are sparingly distributed throughout the breccia. Some of them have a layered or bedded structure, and they were originally thought to have been derived from formations of the Rokell River Series*, which they resemble. Thin-section examination shows, however, that the rock consists of small grains of carbonate, feldspar and serpentine in a very fine-grained brown matrix (Fig. 6).

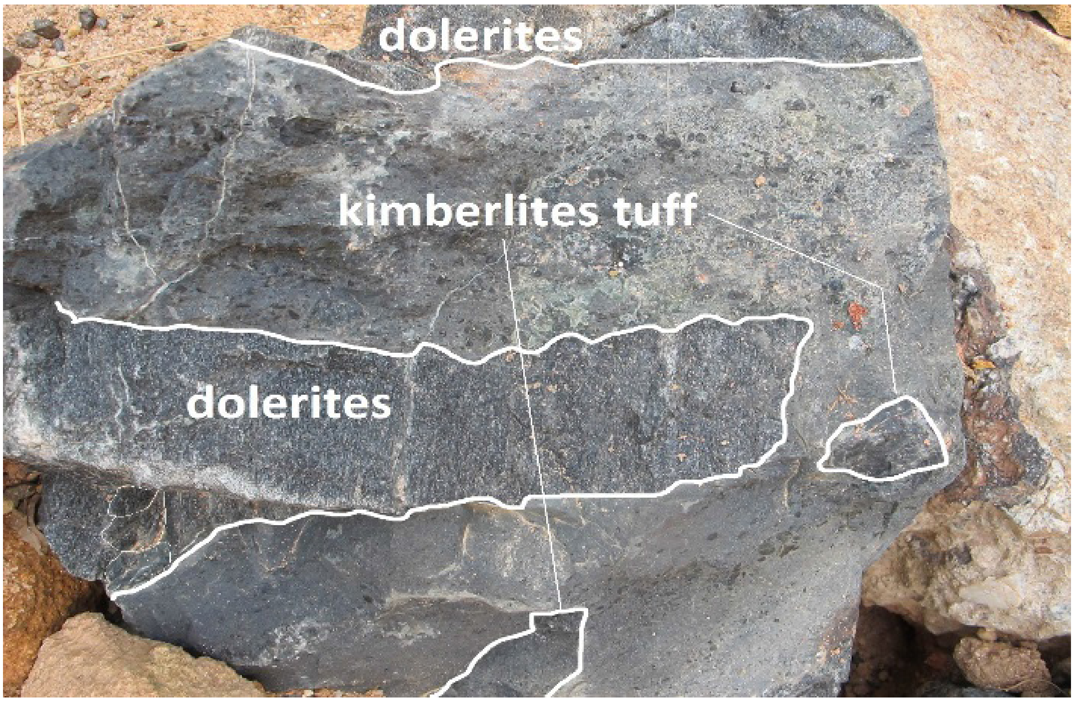

Figure 6. Kikmberlitic Tuffs

A little phlogopite can be detected in the matrix, but most of it is unidentifiable. This rock is now considered to be a tuff, formed by explosive comminution of the pipe filling, and deposited in the original crater.

Carbonate grit. Rare and fascinating inclusions are those which resemble pieces of sandstone. One specimen has been obtained and has been found to consist principally of rounded, sub-angular and angular grains of carbonate. Some are fragments of larger crystals, others are microcrystalline. The granular material encloses parallel flat lenses of dine-grained grey-green material which appears to consist of comminuted carbonate and serpentine, and similar material is present in the interstices between the granules. Flakes of phlogopite are present in the lenses, and are oriented parallel to them. This would appear to be a water-laid deposit of kimberlitic material and is therefore also classified as a tuff.

Eclogite. Eclogite inclusions are rare. The single specimen examined by the author consisted of pink garnet and green much-altered clinopyroxene, and was cut by veinlets of carbonate. Grantham and allen describe a similar example, and suggest that the garnet is a pyrope-almandine and that the pyroxene is a dioside-jadeite. Eclogites are not known to occur elsewhere in Sierra Leone (except in other kimberlite pipes).

PIPE 2. The existence of Number 2 Pipe, half-a-mile to the east of Number 1, has been known for some time but the detailed investigation has only recently begun. Number 2 Pipe was originally thought to have an outcrop area of about 30,000 square feet but it now appears that its actual extent may be two or three times this figure.

The portion of the pipe now exposed originally formed the bedrock of a shallow stream-flat, and the delineation of the pipe margins in the adjacent slopes is now proceeding. This is by no means straightforward since both the tuffisite and the boulder breccia weather to mottled lateritic clays, with ferruginous nodules, which are virtually indistinguishable from weathered granodiorite.

The pipe structure is complex, and the data available at present are too limited to allow the relationship between the different components to be conclusively determined. Three masses of boulder breccia lie on top of the other pipe components and are believed not to continue at depth. They would appear to be basal remnants of a formerly continuous body, with a somewhat irregular base, which formed a capping to the pipe. The close correspondence between the boulder rock and the country rock shows that the boulders have not moved very far from their source level, and the lack of variety of rock-types makes it difficult to believe that the boulder breccia represents erupted material which has fallen back into the crater. It seems more likely that it represents the top level of a pipe which failed to blow out at the surface.

Four distinct types of kimberlitic material occur in the pipe:

1) Porphyritic kimberlite, in the form of irregular masses, dykes, and possibly sills, all connectedto a network of dykes which cut the adjacent granite.

2) Polymict kimberlite breccia, similar to that which forms the bulk of Number 1 Pipe. Abundantxenoliths of a wide variety of rock-types in a predominantly kimberlitic matrix.

3) Fine felspathic kimberlite breccia, which consists principally of fine granitic debris intimatelymixed with a little kimberlitic material. The term "tuffisite" appears to be applicable, and is certainlyless cumbersome, and will be used throughout the following discussion.

4) Boulder breccia, which consists of close-packed, well-rounded granite boulders up to 3 feet indiameter in a tuffisite matrix. The boulders consist either of pink porphyroblastic granodiorite,identical with the pipe country rock, or of amphibolite, which is common in the form of inclusionswithin the country rock.

All these four components of the pipe contain diamonds, and values appear to be highester in the porphyritic kimberlite.

The boulder breccia is usually, but not invariably, separated from the underlying polymict kimberlite breccia by a layer of tuffisite which may be up to 15 feet in thickness. Where the kimberlite breccia has been exposed by removal of the overlying formations it can be seen that much of it has been displaced by porpyhritic kimberlite. The core log of a vertical diamond drill hole, put down some years ago into the centre of the pipe, shows that the pipe at depth consists principally of polymict kimberlite breccia which contains a few large granite blocks and is cut by several bodies of porphyritic kimberlite.

The granodiorite country rock adjacent to the pipe outcrop is intersected by numerous dykes and stringers of porphyritic kimberlite, most of them with their strikes approximating to the usual kimberlite strike, 65° true. It is clear that the emplacement of these dykes took place after emplacement of the pipe breccias, since some of the dykes cut through the breccias and tuffisite and are connected to the large irregular masses of porphyritic kimberlite which displace much of the breccia in the present pipe exposures.

The injection of porphyritic kimberlite seems to have occurred as the final phase of an intrusive cycle, and is possibly related to consolidation and subsidence within the quiescent degassed pipe. Ion the case of this particular pipe, the field evidence indicates that the kimberlite dykes, injected into the fractured granite during this final phase, penetrated to much higher levels than the pipe itself.

PIPE 3. Number 3 Pipe is situated to the northwest of Pipes 1 and 2 along the Dyke Zone D, but little else is scientifically known because it lies under a swamp. The dykes are distinctive and differ from the pipes by being free of crustal xenoliths, significantly finer grained, and mafic in colour. Five major classes are recognized based on the alteration of olivine to serpentine, serpentine + calcite, calcite, or by being partially altered or completely unaltered.

3.2 THE TONGO KIMBERLITES

In the Tongo Area (8°12'N; 11°4'W) only dykes are found which can be divided into four zones. The dykes are of similar composition, structural setting and age as those in the Yengema-Kuido Lease. The kimberlite rock is usually a porphyritic to fine-grained grey to green material composed predominantly of serpentine, phlogopite, olivine, pyroxene and carbonate. Pyrope and picro-ilmenite megacrysts are common and are used as indicator minerals during prospecting. The rock is cut by numerous veins of calcite and serpentine, the former often fenitizing the adjacent wall-rocks. The magma shows signs of chilling against the upper crustal xenoliths, which are frequently very well rounded. The penetration of the magma into the granitic host rocks on an intimate scale suggests that it was of a very low viscosity. The kimberlite dykes tend to form branching stringer adjacent to the main dike, as for example in the Lando zone in Tongo which is up to 12 m wide but only contains about 3 m of kimberlite.

Hall also mentions the Panguma kimberlites southwest of Tongo as a kimberlite group of its own, which nowadays are included into the Tongo Lease.

4 ALLUVIAL DEPOSITS

Since their extrusion, the diamondiferous kimberlites and the surrounding country rocks have probably been eroded by at least 1,000 m. During this erosion, diamonds in excess of 50 Mcar have been released from the two kimberlite outcrop areas at Koidu and Tongo and become widely dispersed down the Bari-Sewa and Moa River systems and their antecedents throughout most of the Cainozoic.

Consequently the diamonds have been repeatedly sorted, deposited released by renewed erosion of alluvial deposits during succeeding erosion cycles, and then re-deposited. These mechanical processes have concentrated the diamonds in the gravels and improved their quality. Diamonds have travelled at least 100 km in the river systems from their sources. The processes of concentration have also affected other resistant minerals, particularly corundum, zircon, limonite, rutile, chromite, and tourmaline, which have become trapped in depressions in the beds of streams, in joints, behind rock bars, and in crevices. In most cases the diamondiferous gravels lie next to the bedrock and may be covered by 20 m of gravels, silt, and clay.

The present Atlantic-directed drainage has probably been evolving since the initiation of Atlantic rifting in this area about 185 Ma ago and must have been a well-developed river system by the time of kimberlite intrusion. The regional tectonic situation is that of a slowly subsiding continental margin allied to a steadily uplifting watershed area, and this has produced an incising river network on the resulting regional slope. This incision, perhaps accelerated by Quaternary climatic and sea-level fluctuations, has given rise to an apparently superimposed drainage network cutting across the major rock formations and shows close correspondence with more minor structural features at a local level. River capture has been relatively frequent in such circumstances, as the incising river network has adjusted to the variations in the underlying structural framework, and this has resulted in a rather wide distribution of diamond deposits in some areas away from the trunk streams, the Sewa and the Moa.

During transport diamonds are sorted by size such that the farther from the source, the smaller the average size of the diamonds. A diamond population is not just composed of diamonds of differing sizes but also of varying colours, crystal forms, and diamond types. Diamond populations from different sources thus are composed of varying percentages of bort, octahedra, dodecahedra, cleavage stones, translucent or coated diamonds, etc.

Quite clearly there is a preferential loss of bort and coated stones during transport. It seems probable that the bort is lost by breakage into tiny particles. The consistent reduction in the proportion of coated diamonds down the Sewa may be due to the effects of surface attrition, since the green coatings on the Sierra Leone diamonds are frequently rather shallow and are particularly brittle.

The characteristic features of each types of alluvial deposit are summarised in **Table 1**

Type of Deposit	Occurrence	Nature of the Diamond-Bearing Formation	Typical Gravel Thickness	Maximum Observed Gravel Thickness	Nature of the Overburden	Typical Thickness of Overburden	Distribution of values	Groundwater Conditions
RIVER CHANNEL GRAVELS	On beds of major rivers in diamond fields, Sewa, Bafi, Male and Moa Rivers	Coarse, clay-free gravels, Numerous rounded quartz pebbles. Usually iron-stained, sometimes bleached	Extremely Variable, From 3" upwards	30'	Sand and sandy gravel	5'	Normally in the basal gravel, but very low values also present in fine gravel of the overburden. In pools, very thick gravels may occur with good values throughout and no bottom concentration.	Most of payable gravels are below low-water level. Dry season water depth varies from 5' to 70'. Rock-bar deposits are exposed in the dry season.
FLAT, OR FLOOD PLAIN GRAVELS	Below the Recent Flat, a semi-continuous wide strip of flat alluvial ground which occupies lowest part of river or stream valley. Scarce along major-rivers (Sewa, Moa).	Coarse to medium, clay free quartz gravel. Often bleached on decomposed granite bedrock. Continuous sheet underlies floor-plain, except over buried rock-bars.	1'3"	4'	Mud, clay, silt, sand, sandy gravel. Loose and unconsolidated.	15'	Highest values in the basal gravel, with concentration of diamond at the bedrock/gravel contact. A few diamonds in top few inches of bedrock.	In dry season, water table is in gravel bed or near base of overburden. In wet season, water table rises in overburden and maya reach surface. Effluent water makes pit sides unstable.
LOW TERRACE GRAVELS	As long discontinuous strips flanking both major and minor rivers in diamond fields, but rarely along streams.	Coarse to medium quartz gravel. May be clay-rich. Usually stained, sometimes cemented, by iron oxides.	1'3"	4'	Loam, clay, silt, sand, sandy gravel. Always semi-consolidated and free standing because of incipient lateritisation.	12'	As above	Dry season water table is in basal gravel, or may fall below bedrock surface. During wet season, may rise to within few feet of surface.
HIGH TERRACE GRAVEL IN PLACE	As short discontinuous strips along river valley sides. Also commonly along old courses, now abandoned by river.	Coarse to medium brown-stained quartz gravel. Often clay-rich. Varying degrees of induration: loose and sandy; clayey with concretions; hard laterite.	1'6"	8'	Loam, lateritic clay with some laterite nodules, cemented sands and gravels	6'	As above, but with increasing proportion of diamonds in top few inches of decomposed bedrock	No water in dry season. During wet season, gravel may become water-bearing.

HIGH TERRACE: DISTURBED GRAVEL	Capping low flat-topped hills and ridges along river valleys and old courses. Flanking lower terraces. This is dissected First High Terrace.	Abundant deeply-stained rounded quartz pebbles in matrix of lateritic gravel. Base and top of pebble-bearing zone not sharply defined.	3'0" (including 18" of underlying lateritic gravel).	6'	Thin sandy loam	9"	Values irregularly distributed through disturbed alluvial gravel and underlying 1' or 2' of lateritic gravel.	None
HIGH TERRACE GRAVEL RESIDUE	As above, and also as irregular patches on slopes and crests of subdued topography, usually within a few miles of major river. May be dissected First or Second High Terrace.	Rare stained and corroded quartz pebbles in surface loam. Heavy minerals distributed through a and B soil horizons. An eluvial formation containing some alluvial materials	4'0"	10'	Usually none, but occasionally a thin bed of barren loam or lateritic clay overlies the diamond bearing lateritic gravel in level areas	nil	Values, usually poor, distributed through thick zone of lateritic gravel and decomposed bedrock. May be concentration at ground surface if heavy soil erosion has followed farming.	None
SWAMP GRAVELS	Below swamps, which form ¾ of drainage network throughout diamond fields. High proportion of swamps diamondiferous in certain areas e.g. Yengema, Tongo, Lower Sewa. Elsewhere, more scattered	Angular quartz gravels, continuous sheet below swamp. Usually bleached. Coarse to fine, clay-free or clay-rich. An eluvial formation usually containing some alluvial material.	10"	2'	Organic material, mud, clay, silt and sand	5'	Values restricted to basal gravel	Water table invariably above bedrock surface, but actual level and rate of discharge into excavations are extremely variable.
PENETRATION DEPOSITS	Below low and high terrace deposits in certain parts of Yengema field.	Granit or schist bedrock thoroughly decomposed to gritty clay.	6'0"	10'	Gravel plus overburden of either low or high terrace	variable	Values usually poor. From upper surface, increase steadily to peak at certain depth, then rapid cut-off with increasing depth.	If under high terrace, generally dry. If under low terrace, water enters from terrace gravel.

In accordance with Hall the Yengema-Koidu divides field into seven areas of alluvial diamonds: Koidu area, Yengema area, Lower Moinde, Yomadu-Shongbo, Gbobora, Tefea area, and Upper Sewa. The Sewa fields along the Sewa River they divide into 15 areas: Nimiyema, Jagbwema, Barma, Boajibu, Kobundala, Baoma Oil Mill, Leveuma, Yamandu, Jomu, Sembehun, Wubunge, Petewoma, Hima, Sumbuya, and Bagbo.

Alluvial deposits around the Tongo kimberlites get divided into three areas: the Tongo drainage, Woa and tributaries, and Luya.

13 other areas are listed in their report in the Kenema District: Bundoye, Panguma, Foindu, Beeya, Kenja, Lower Woa, Male, Putehun, Segbwema, Middle Moa, Zimmi, Moro, and Malema.

Minor occurrences are Teye (Mongeri), Koye (Selu), Kendi (Gau), Tabe, Lower Waanje, Masau, Mongo, and Kankana.

4.1 YENGEMA-KOIDU FIELD

The Koidu Area. Within this area are all the deposits of the Meya/Moinde drainage above the confluence of the two streams. The Koidu area was without doubt the richest alluvial diamond district in Sierra Leone and probably in the world, and about 9 million carats have been mined from the alluvials within a radius of 1½ miles of Koidu town. The three principal deposits of this area were the flats of the Woyie stream, the flats of the Meya stream, and the Wongoyie swamp with its tributaries.

In the flats of the lower and middle Woyie a 4th order stream of low gradient over 200,000 cubic yards of gravel under shallow overburden contained average values of over 5 carats per cubic yard throughout. Large blocks of ground gave recoveries of 20 carats per cubic yard or more, and recoveries up to 77 carats per cubic yard were recorded from some of the prospecting pits. During mining operations many large diamonds were recovered from the Woyie gravels, the largest being the 770 carat clear stone found in 1945.

The Wongoyle swamp and its tributaries drain the outcrop areas of the principal kimberlite bodies, and its shallow gravels contained, in some sections, even higher values than those of the Woyie, although the total gravel yardage was much less. The highest recorded recovery in Sierra Leone came from a prospecting pit in the Wongoyie which yielded 265 carats per cubic yard. Mining of the Woyie and the wongoyie deposits was completed some years ago, and their valleys have now been partially flooded to form a reservoir.

The Meya is a well-graded 5th order stream which flows from south to north across all the kimberlite dyke zones and receives numerous diamond-bearing swamps and streams, including the Woyie as tributaries. Wide flats and low terraces extend along the Meya valley, with over burden up to 20 feet in thickness covering the thick diamond-bearing gravels. Gravel yardages were originally substantial and most of the ground carried values between 1 and 5 carats per cubic yard. This deposit has for many years been the mainstay of the Yengema production, and about one-third of it still remains in reserve.

The Meya and the Woyie valleys were flanked by low terrace deposits, although in the case of the Woyie these were narrow and fragmentary, but it is remarkable that there are no true alluvial high terrace deposits in the area. There are several blocks of diamondiferous ground classified as high terrace for mining purposes, but these are in fact eluvial deposits overlying or close to kimberlite outcrops.

Another major stream in the Koidu area is the Moinde, which is joined by the Meya near Penduma. Above this confluence, the middle Moinde is a 5th, order stream and its deep flats, now in process of valuation, are believed to contain payable values as far as Boma. In addition to the principal deposits described above, most of the smaller streams and swamps within two miles of Koidu carried diamonds, with values varying over a very wide range, many of them being completely un-payable.

Stimulated by the high alluvial concentrations, the Company has been carrying out intensive kimberlite investigations in the Koidu area since 1947. It has been established that several kimberlite dyke zones, carrying good values at the surface, cross the Koidu area south of the Woyie. Three small pipes of kimberlite breccia are associated with these zones, and underground exploration of these has now begun. More dyke zones and a fourth small pipe occur to the north of the Woyie, but these appear at present to have only low values.

The Yengema Area. This area, centred roughly on the mine headquarters at Yengema village, is defined to include only the Bandafaiyi stream and all its tributaries. Over half of the total drainage network in this area was diamond-bearing, and about one=-third, including all the principal streams, contained payable gravels. Values in these gravels ran generally between 0.3 and 1.5 carats per cubic yard, but were often higher than this in the flats of the Oyie and the Gaiya, which contained a high proportion of the total reserves.

The principal producers in past years were the Oyie and Gaiya streams. The Oyie flats contained good values almost the whole way from the source of the confluence with the Bandafaiyi; these flats are now largely mined out, but some reserves remain in the low terraces. The flats of the lower Gaiya are also mined out, and mining continues now in the upper Gaiya, although reserves there are rather slim. Along the Bandafaiya stream itself there has as yet been little mining, and the flats still contain substantial reserves of payable gravel.

The Yengema area is similar in extent, density of diamondiferous drainage, and pay gravel yardages to the Koidu area, but average values in the deposits were on the whole much lower and the total reserves therefore considerably less. Occasional large diamonds have been found in various deposits, the largest being a bort stone of 783 carats from the upper Gaiya.

Kimberlite exploration in the Yengema area has been less intensive than at Koidu, but several kimberlite dykes have been encountered in the course of mining operations. The main kimberlite zones of the Koidu area, designated zones A to G on the mine plans, continue across the Yengema area with the same approximate strike of 67° true. The actual dykes on each zone are, however, short and discontinuous and diamond values appear to diminish from east to west. In addition to the normal kimberlite zones, two small kimberlite dykes have been discovered beside the Oyie near Bumpe. These contain high values, but are also abnormal and of exceptional interest in that their strike is about 12° ture, which is parallel to that of the large Oyie-Shongbo fault zone on which they are situated. Grantham (1960) has drawn attention to the fact that none of the kimberlite dyke zones can be traced to the west of this fault. As there are no exposures, dyke-fault relationships at the points of intersection are obscure and urgently await clarification. This fault zone is also remarkable for the occurrence along or near it of the puzzling deep penetration deposits, which are not known to occur elsewhere.

It is generally recognised that the few known kimberlite dykes in the Yengema area are inadequate to account for all the diamonds in the alluvials. The explanation which has been widely accepted in the past is that a large proportion of the Yengema diamonds were carried there from the Koidu area by an ancient large river, and there is of course some supporting evidence for this. Both Koidu and Yengema are basin-like areas of moderately flat country and they are connected by the "Motema Gap", furthermore many of the stream gravels carry quartz pebbles whose degree of roundness is inconsistent with the stream order. The theory of an ancient river was first put forward in 1935 by A.C. Clarke (Pollett, 1937) who also, however, drew attention to the principal objection to it, that is,the markedly differing colour and shape characteristics of diamonds from different alluvial deposits.He pointed out that these differences could not have resulted from fluvial concentration processes andthat a common source is therefore excluded. It has been possible, by comparing output of differentPan Plants, to confirm that these differences do exist, and Clarke's objection is therefore regarded asconclusive. It follows that the greater part of the alluvial diamonds in the Yengema area must beattributed to local sources, ancient drainage being responsible only for local redistribution andconcentration, and it is therefore to be expected that further exploration will uncover many additionalkimberlites.

The Lower Moinde. Only the Moinde river and its tributaries, from the Moinde-Meya confluence downstreatm to the northern Mining Lease boundary, are included within this area. The Lower Moinde is a 6th order stream whose valley is narrow and straight, its alignment being rigidly controlled by the Moinde Falut, and it seems unlikely that the drainage here has ever deviated appreciably from its present route. The mean gradient of the valley floor is only 6 feet per mile, however, consequently the course of the actual river channel is tortuous in detail, and the valley floor contains numerous graded sections where gravel has accumulated and flood-plain has formed.

These flats, from which production has only recently begun, contain substantial diamond reserves which probably form the most important section of the remaining alluvial reserves of Yengema field. The pay gravel in the flats lies below deep unstable over burden with a continuously high water table, and this has so far protected it from the illicit miners. There were also, originally, several low terrace deposits and some strips of high terrace, all of which contain good values. These, however, have all been laid waste by illicit miners and could not now be worked at a profit.

Payable gravels also occur in the small streams of the Komau area, associated with a kimberlite dyke, but apart from these there are only a few small scattered low-grade deposits in Lower Moinde tributaries. It is generally assumed that the Lower Moinde diamonds have come principally from the Koidu kimberlites, and this assumption could be essentially correct, as these kimberlites are only a few miles away and are all drained by the Meya, the principal Moinde tributary, following a drainage route of long standing.

The Yomadu-Shongbo Area. This area covers a three-mile section of the Bafi river to the south and east of Yomadu, and various Bafi tributaries. There is no flood-plain along this section of the Bafi, but the channel gravels carry diamonds and there are strips of high terrace and low terrace.

In the Bafi channel, no reliable method of sampling the channel gravels has yet been devised, but during prospecting operations good values were recovered from rock-bar deposits, and there is a high incidence of illicit mining by divers. Whether the bulk of the Bafi diamonds can be profitably recovered is at present open to question. Sierra Leone Selection Trust installed an experimental jet-lift dredge in 1962 but although this successfully mined and treated the river channel deposits, average diamond recoveries were too low to cover operating costs and mining ceased in 1964. Many of the minor Bafi tributaries contained moderate diamond values but all those on the north bank, together with the Bafi tributaries contained moderate diamond values but all those north bank, together with the Bafi terraces, have been stripped by illicit miners, who have a convenient base at Yomadu.

The major exploitable deposits of the area are those of the Shongbo River and its tributaries. The gravels of the Shongbo flats carried diamonds throughout, but much of the middle Shongbo is now mined out, recoveries having been mostly between 0.5 and 1.5 carats per cubic yard. Reserves remain in the Upper and Lower Shongbo; the Upper Shongbo contains only small reserves, whilst the Lower Shongbo deposits have not yet been closely sampled and the available data indicate that they may be unworkable because of low average values.

Heavy minerals of kimberlitic origin are rare in this area and there are no known kimberlite outcrops, although the Komau zone should cross the Shongbo headwaters. Large diamonds are also rare. The Shongbo diamonds have, in the past, been attributed to the Koidu source area, and it has been supposed that they were transported thence by the hypothetical early drainage, which is assumed to have swung northwards after passing Yengema. There is of course, no evidence whatsoever to support all these suppositions, and until there is, the simpler explanation must be preferred and these diamonds attributed to a local source, one deficient in the usual heavy minerals.

The Gbobora. This area contains the Gbobora stream from the point where it enters the Mining Lease to its confluence with the Bafi, and a section of the Bafi River extending three miles upstream and three miles downstream from the Gbobora confluence. In 1930, the first Sierra Leone diamond was discovered in this area, at Fotingaia on the Gbobora, which was a most surprising site for the discovery in view of the fact that the deposits in the vicinity are of very low grade and unlikely ever to be mined.

The Peyima Area. The Peyima area was for many years the scene of exceptionally intensive mining activity, and total production to date is estimate at 856,000 carats. The principal deposits were those of the Bafi and Lower Moinde rivers.

The flats and low terraces of the Lower Moinde (1) contained gravel of uniformly high grade below 15 feet to 25 feet of over burden. These deposits are now virtually worked out, but they were sampled in 1962 by the Geological Survey, and the average grade was then estimated to be at least 2.0 carats per cubic yard. The gravel included a proportion of well rounded quartz pebbles, but this feature is consistent with the stream order, which is 6th. The heavy mineral concentrates were not particularly abundant, about 15 c.c. per cubic yard, and contained chrysoberyl, tourmaline, epidote, magnesian ilmentie, pyrope and unidentified round grey concretions in addition to the ubiquitous corundum, zircon and normal ilmenite. The median size of the diamonds recovered was 0.45 carats, about 405 of them being coated stones, and half of the clear stones were of poor quality with numerous inclusions. The Lower Moinde diamonds are generally assumed to have been transported directly from the Koidu area by the Moinde-Meya drainage, a few possibly having been added by minor kimberlite zones crossing the Moinde valley, and there are at present no grounds for questioning this assumption.

The deposits of the Bafi River (2) appear to be a direct downstream continuation of the Moinde deposits, since the diamonds have similar characteristics, and values cut off abruptly in the Bafi above the confluence. The Bafi channel was formerly very productive, mining having been carried out for many years by diving and by the construction of coffer dams, but most of the accessible gravel has now been removed and there is little activity at present. Fairly substantial reserves remain in the deeper parts of the channel and are suitable for exploitation by a small mining company. In 1961 and 1962, an attempt was made by a Native Company to drain the Bafi loop to the north-east of Dandiadu by diverting the river through a channel cut across the neck of the loop. Unfortunately, the excavation of the channel by dragline was never completed and the project was abandoned, apparently through exhaustion of capital.

This section of the Bafi has almost continuous flats and low terrace deposits (2 and 3) from which about half the gravel has now been mined. Some of the remaining reserves have been disregarded because of deep unstable overburden, but the greater part exist as remnants and pillars between old paddocks. Average values were good, about 0.72 carats per cubic yard, and the basal gravel was usually 18 inches to 24 inches thick beneath about 18 feet of overburden. In some places, however, the gravel is absent, the overburden lying directly on hard rock, and this has been taken into account when calculating the average gravel thickness. High terrace deposits have been mined at Dandiadu (4)and north of Peyima, but in neither of these areas have values been particularly high. Heavy mineral concentrates along the Bafi are similar to those of the Lower Moinde, but magnesian ilmenite and pyrope are very rate in the +1mm faction, although reasonably common in the -1mm material.

An interesting small deposit is that along the Peyi stream beside Peymia town (5). Here there is a wide stream flat and blanking low terrace, with a maximum aggregate width of 800 feet. The overburden is from 9 feet to 12 feet in thickness, and the gravel contains a few small well-rounded quartz pebbles. All these facts are inconsistent with the size of the present stream, which is only 4th order, and indicate that the Peyi follows the old course of a larger stream. An inspection of the topography shows that this might have been either the Moinde or the Shongbo, both of which carry diamonds, but whichever one is chosen, it then becomes necessary to account for the barrenness of the terrain between its present course and the Peyi deposits. Values in the Peyi were not particularly high but the deposit has been quite intensively mined because the stones recovered had an exceptionally high median size and consequently realised high prcies per carat. ~From the inadequate data now available, the median size is estimated to have been about 2¼ carats. A trace of magnesian ilmenite occurs in the Peyi concentrates but no pyrope has been observed.

The Middle Bafi. All activity in this Block is based on the town of Yomadu which lies not within the Block but inside the S.L.S.T. Mining Lease. The main diamond producer has been the Bafi river and its low terraces and flats, from the Lease boundary to Hemakono. Intensive mining began illicitly in this area in 1953, and contained under licence after the introduction of the Alluvial diamond Mining Scheme in 1956.

Beginning from the Lease boundary, the first one-and-a-half miles of Bafi channel (11) may justly be described as the most intensively mined section of river channel in Sierra Leone. Here the techniques of aqualung diving were first introduced by E.I. Bragg. Recoveries of 10 to 15 carats per cubic yard were made from gravel selectively mined by Bragg from natural channel-floor riffles on exposed hard schist bedrock, and good recoveries were common throughout this section. Very little gravel remains now, except in the centre of the large deep pool opposite the Kamayi confluence. The margins of this pool have been mined by coffer dams but, at the time of the author's last visit in 1965, the centre had not been tackled.

From the Sumunji confluence down to the Hemakono area extraction of gravel has been less complete, and the character of the channel changes somewhat. Many sections of the channel are narrow, with a floor of smooth hard rock and little sediment accumulation. Numerous small pools exist in the wider sections, however, and good recoveries have been made from most of these. Near Hemakono, the river crosses the eastern margin of the main Nimini Hills schist Belt and enters a narrow gorge. Two pools with water depths of 85 feet and 100 feet occur at the entrance to this gorge and were successfully mined by Bragg in 1964. Downstream from this point, there has been very little mining, partly no doubt because of the relative inaccessibility of the area and also because of the generally deep water. Possibly, also values may be poor. Certainly it can be said that many interesting pools remain untouched.

Flats and low terraces occur only in the first 1½ mile section of the river (12), and are usually less than 200 feet in width. These have been very intensively mined in the last five years, consequently less than half of the original gravel now remains. In the widest part of the low terrace, opposite the Singapanda mouth, exceptionally good values were recovered from some of the paddocks and the gravel from one yielded 12 carats per cubic yard.

There are various swamp and high terrace deposits (13 to 19) in this Block, and all appear to represent old courses of the Bafi river. The most important deposits were the Singapanda. The high terrace deposit consisted of a disturbed gravel which the miners had completely stripped down to hard lightly decomposed granite, long before Geological Survey examination. Consequently the estimate of recoveries is very approximate indeed, based only on the examination of tailings and verbal reports.

The Singapanda swamp (14) contained a normal swamp gravel with high average values of about 1.6 carats per cubic yard and was mined repeatedly for several years. It is now regarded as mined out, but diamonds still remain in tailings, small pillars between old pits, and top bedrock; a few miners can usually be found making small recoveries from these sources. The presence of water worn corundum and a few pebbles in the gravel show that this is an old river course which must be presumed to have been occupied by the Bafi river although, from an inspection of the topography, the Kamayi would appear to be equally eligible.

Diamond characteristics in the middle Bafi differ slightly but no decisively from those in the Peyima area. In the few parcels seen by the author, the median size was somewhat higher and the clear stones were in general of better quality. All the diamondiferous gravels in this Block contain small quantities of kimberlitic heavy minerals in the concentrates. It is probable that the diamonds here have come partly from the Koidu area and partly from sources in the Shongbo area, and that the relatively high alluvial concentrations are caused by the frequency of schist bodies in the bedrock. These bodies intersect both present and ancient drainage routes at an angle. The possibility of a local source cannot be altogether excluded, however. Some of the swamp deposits, for example that in the Kamayi tributary (17) and that in the north fork of the Singapanda, are a little oddly situated in relation to old Bafi courses.

Nimikoro. This Block contains one major deposit, that of the Gbobora below Mjaiama Nimikoro, together with a number of minor deposits from which there has been only insignificant production. They are all of unusual interest, however, in that although they are adjacent to the Yengema area, the diamonds are unquestionably distinctive and must be attributed to local kimberlites, which have not yet been found.

For a distance of about 1¼ miles upstream from the S.L.S.T. Lease boundary, the Gbobora flats (22) are about 400 feet in width and formerly contained thick course gravel under overburden of 10 to 15 feet thickness. Values in the gravel were about 0.6 carats per cubic yard, not especially high but consistent and large yardages were present. In the adjacent low terraces, values were somewhat lower, but the overburden was shallower. The flat is now mined out, together with most of the payable sections of the low terrace. The high terrace (23) has been only sporadically mined, and pitting by the Geological Survey in 1961 showed that only unacceptably low values are present.

The gravels of the Gbobora flats were remarkable for their heavy mineral concentrates. Those with good diamond values carried up to 200cc of coarse concentrate per cubic yard, the bulk of this concentrate being black, purple and grey water worn corundum. Topaz and tourmaline were common. Ilmenite, purple garnet, chrysoberyl, chromite, cassiterite and gold were also noted. About 300 cc of fine concentrate per cubic yard of gravel was usual, and this concentrate consisted principally of ilmenite and zircon, with some topaz, red garnet, chromite, rutile and gold, and rare grains of magnesian ilmenite.

Values in the Gbobora appear to cut off just to the north-east of Njaiama, but reappear again in two upstream tributaries, the Konta (25) and Kenyeyima (26) swamps. These swamps contain patchy diamond concentrations with values up to 0.5 carats per cubic yard, and abundant corundum concentrates. Near the head of the Kenyeyima, the gravels contain large quantities of very coarse corundum, some of it well-rounded. In both swamps, most of the corundum is apparently of exotic origin, but its distribution bears little relationship to the distribution of diamonds, and it seems fair to assume therefore that the diamonds are of very local origin. Several grains of magnesian ilmenite were detected in the fine concentrates from both swamps. In 1961 the Geological survey spent some time endeavouring without success to find the course bodies. It was concluded that the sources were probably small discontinuous kimberlite bodies below the swamps, but as the water table in the swamps was high and they Survey at this time possessed no pumps, systematic trenching to check this conclusion could not be undertaken.

The Masaye stream (27) flows south from Njaiama in a deeply incised valley whose floor is 200 feet lower than that of the Gbobora. Low, patchy values rearely exceeding 0.2 carats per cubic yard have been found at a few mining sites between Boaia and Gondama in thick course gravels containing much rock debris. Corundum with varying degrees of angularity is usually abundant but values generally appear to be associated with the present of a few well-rounded quartz pebbles in the gravel. Above Boaia, neither pebbles nor diamonds occur.

In the course of their regional sampling programme, the Diamond Exploration company found kimberlitic heavy minerals in numerous streams in this block, and in the Masaye these minerals were traced to their source. According to Stracke (1963), the course was a narrow kimberlite dyke about 20 feet in length, striking at 90° and cutting the bedrock of the Masaye flats about one mile upstream from Boaia. No diamonds were found, either in the kimberlite or in the associated alluvial gravels.

Intermittent licensed mining has taken place along the flats of the Fayei stream (28) for about one mile upstream from the Lease boundary. Many licence holders have failed to find diamonds in workable quantities, and most of the others have only been able to recover between 0.1 and 0.25 carats per cubic yard. Small well-rounded quartz pebbles occur in the gravel, and their presence is inconsistent with the size of the present stream, which is 4th order. Kimberlitic indicator minerals were found by the Diamond Exploration Company.

Parcels of diamonds from this Block are readily identifiable. Coated stones are rare; among the clear stones, many have a brownish tinge, and a distinctive pale green colouration is also common. Good octahedral are rare, most tones having a very irregular shape.

All the facts available tend to show that the diamonds of block 3 come from sources which are within the Block and are as yet undiscovered. It seems probable that these sources either constitute an extension of the Koidu-Yengema dyke zones or are related in some way to the Gborboa-Masaye fault, itself an extension of the Oyie-Shongo fault, one of the significant structures of Yengema Field.

The part played by ancient drainage routes is not yet understood, since these cannot be reconstructed with any confidence. The rapid headward retreat of the Masaye source along the major fault has apparently destroyed the valley of a form large Gbobora tributary.

4.2 THE SEWA FIELDS (MAIN BLOCKS)

Nimiyema. This is the first of the important Sewa Valley blocks and is the furthest upstream, being situated immediately to the south of the S.L.S.T. Lease boundary. The most important deposits it includes are those of the Sewa channel and terraces, and there are no deposits within the Block which cannot be related either to terraces or to old courses of the Sewa. The Sewa here drops steeply from the Thousand-foot Surface to the Coastal Plain Surface in a series of rapids and falls, the most impressive of which is Big Kongo Falls, near Punduru, in the stretch of rapids and minor falls between Big Kongo and Ngawama, the river drops 200 feet, and further upstream at Jopowahun rapids there is a drop of about 40 feet. Between these major rapids and falls, the remaining reaches of the river consist of mile-long sections of very shallow gradient separated by minor rapids. The course of the Sewa, in this Block is exceptional in that it is not closely controlled by a major fault, but it exhibits instead several bends which are related to minor structures. An earlier deep valley of the river lies to the west of, and parallel to, the present valley, but now contains only a small stream, the Yombi.

An examination of the Yombi valley shows clearly that, by the time the Sewa River abandoned it, the steep nick-point in the river profile between the Coastal Plain and the Thousand-foot Surfaces had advanced to a point just north-west of Nyandehun. In contrast, in the present profile, the corresponding nick-point (Big Kongo Ngawama) is still far to the south of Nyandehun. As a result, the floor of the upper part of the Yombi valley is at a much lower level than that of the nearby present Sewa valley, and at Nyandehun village it would be possible at only moderate cost to divert the Sewa through a short tunnel into the Yombi valley. If this was done, eight miles of Sew channel containing an estimated 425,000 carats of diamond would then be dry, apart from the discharge of minor tributaries, which could be channelled into leats where necessary. Unfortunately this is scarcely a practicable scheme at present, because the security problems presented by the deposits of rich, easily-mined gravel thus exposed would be insuperable.

A diversion scheme may eventually be of interest if a demand for hydro-electric power arises within reasonable distance of this area. The Sewa, diverted at Hyandehun by a dam 90 feet high, could be made to drop a vertical distance of 300 feet into the adjacent Yombi valley. These figures are based upon a rapid compass, tape and Abney level survey of the Nyandehun watershed.

Mining of the Sewa channel, both by diving and by damming, has continued from 1956 until the present with little diminution of interest, and recoveries have in general been high. Most pools have yielded values in excess of 2 carats per cubic yard. One pool in the centre of Jopowahun rapids (39) is estimate originally to have contained 800 cubic yards of gravel with an average grade of 10 carats per cubic yard before it was mined in 1961. In 1962, the Geological Survey took random samples, 3 cubic yards in aggregate, from the tailings dump beside this pool and recovered 5 diamonds of 2.3 carats total weight. Numerous pools remain to be mined, chiefly the deeper and larger ones. One of the most interesting contains an estimate 96,000 cubic yards of gravel under thick sand over burden and 8 fathoms of water.

The Sewa has developed no flood-plain in this Block, but there is one long strip of low terrace (34) between Nyandehun and Jopowahun. Mining of this deposit has been rather sporadic because of the combination of deep over burden with exciting values. On the other hand, high terrace deposits, which are very extensive, have been closely prospected by the diggers and all the payable sectors mined. The outstanding deposit of this type was undoubtedly the Kpakama terrace (37), where there were large areas of gravel-in-place and disturbed gravel. Recoveries between 1.0 and 3.0 carats per cubic yard were made from most of this ground, which is now worked out.

Most of the swamps in block 4 intersect high terrace gravels (41, 42, 43, 44 and 45) and recoveries of 0.3 and 0.4 carats per cubic yard have been general. The Kpakama swamp (46), beside the rich Kpakama terrace, appears to be a comparatively recently abandoned channel of the Sewa, possibility comtemporaneous with the low terrace deposits elsewhere, and it contained thick well-rounded quartz gravels below deep overburden. ~average values were good, about 0.5 carats per cubic yard, and some pits gave recoveries of three or four times this figure. The deposit is now mined out. The Bawi swamp (47) also contained moderately good values in normal thin angular gravel under shallow over burden. Here there are no indications of terrace material on the adjacent hill slopes, but the swamp gravels contained rare rounded quartz pebbles and some water worn corundum.

The flat floor of the Yombi valley (38, 39, 40) is largely occupied by a flat terrace in which the gravel is overlain by between 6 feet and 12 feet of semi-consolidated over burden. This terrace is cut by the flats of the under fitted Yombi stream and by several tributary swamps, but there is usually very little difference in ground elevation. In the lower sections of the valley (39, 40) terrace flat and swamp have all been continuously mined during the past ten years and there is now very little workable gravel left. The upper section of the valley (38) which is two miles in length, contains poor values and has been only sporadically mined. All the Yombi gravels are coarse, containing a high proportion of only semi-rounded quartz cobbles. Well-rounded cobbles and pebbles are present, but are not as common as might be expected, in view of the valley's history.

In general, the diamonds of this Block are not markedly different from those of other parts of the Upper Sewa. The median size of stones recovered from the river channel is about 1.1 carat, and usually between 30% and 40% of the stones are coated. Few parcels were seen from the river below Big Kongo Falls, but in these parcels the clear diamonds always appeared to be of exceptionally good colour and were largely free of inclusions. In the Lower Yombi deposits, the median size of stones recovered is about 1.5 carats, which compensates for the somewhat low average grade of the gravel.

Heavy mineral concentrates tend to be abundant in the Sewa channel, up to 4000 c.c. per cubic yard having been noted during the present survey, and they contain about 85% tourmaline and 10% corundum. Other minerals noted were reddish-purple garnet, ilmenite, zircon, rutile, magnetite and gold. The same mineral suite occurs in swamp and terrace gravels, but the tourmaline/corundum ratio is reversed in all those deposits which are not very close to the river. In the Yombi gravels, tourmaline is rare. Magnesian ilmenite can be found in small quantities in the fine concentrates from most deposits, but it is rare in the Yombi, fairly common at Kpakama (46) and very common in the Sewa channel gravels near Jopowahun (29, 30).

The source of the diamonds in this Block, as elsewhere in the Sewa valley, is still a matter for conjecture. Here, the evidence is rather conflicting. On the one hand, all deposits are related to the Sewa river, past or present, and the diamonds bear a general resemblance to those of the Yengema Field. On the other hand, there do appear to be slight variations in diamond characteristics between individual deposits, and magnesian ilmenite, a kimberlitic indicator material, occurs in unlikely concentrations in some of the Sewa gravels.

Jagbwema. In this Block, and also in Block 6, the Sewa flows through the straight and narrow Sewa Gorge, which has an average width of about one mile. The floor of the gorge is part of the Coastal Plain Surface, and the sides of the gorge are formed by the dissected scarp of the Thousand-foot Surface. Below the village of Nyawama, the river has achieved a very stable mean gradient of about 2.5 feet per mile and there are only very minor widely-spaced rapids or breaks-of-slope. The river channel has begun slowly to swing, forming low-amplitude curves which are to a large extent uncontrolled by bedrock structures. Under these conditions some flood-plain deposits have accumulated inside the curves, but because of the extremely slow rate of meander formation at this gradient, the process has periodically been interrupted by slight re-grading of the channel. As a result of this, most parts of the flood-plain deposits are now slightly elevated with respect to the channel floor, and are therefore classified as low terrace.

The Lower Falima Valley, through which the Sewa must formerly have flowed when it occupied the Yombi valley (Block 4), contains extensive high terrace deposits (50) which underlie the villages of Bambarakalima and Laborye. Stain, sub-angular quartz gravels occur beneath 10 feet of over burden, and diamond values vary from 0.1 to 0.5 carats per cubic yard. Only sparse water worn corundum is present in the concentrates from the terrace gravels, and there appear to be no rounded quartz pebbles. This is very odd, unless the deposit is attributed not to the old Sewa but to the Falima itself, which might have reworked the old Sewa gravels, removing all the pebbles but leaving some of the diamonds behind. Much of the payable gravel has now been mined from this deposit, and although substantial yardages remain they are barely payable and are partly covered by the two villages. The falima flats have been little exploited; over burden is thick, and values are likely to be low.

Apart from the Falima deposits, no other high terrace deposits occur n this Block, and diamonds are found only in the channel, flats, and low terraces of the River Sewa. No swamp or tributary deposits have been found. The Sewa channel is the major producer (51 to 56) and has been intensively and continuously mined since the inception of th Alluvial Diamond Mining Scheme. Sediment deposition has been less erratic than is usual in the Sewa, and areas of river bed without gravel are rare. Most coffer-dam operations have exposed four to five feet of coarse pay gravel below five to eight feet of sand and barren gravel. Values also are less erratic than usual, falling generally between 0.5 and 3.0 carats per cubic yard.

In the absence of islands and rock-bars in this part of the Sewa, coffee-dams can only be constructed in semi-circular or semi-elliptical form, based on the river bank. Furthermore, their exact locations are controlled by the distribution of suitable sound foundations in the form of bedrock on which sediment is absent or thin. In several sections of the channel, therefore, the presence of thick sand on the bed precludes the construction of coffee-dams, and those that are built usually fail to enclose the deeper parts of the channel. In consequence, in spite of ten years of intensive mining, there still remain substantial areas of river channel which have been mined only by divers.

At the extreme south end of the Block, below Dambara, where the channel swings against the western wall of the gorge, there is a long deep pool which has never been mined because of the depth of water. Nothing is known of the bottom sediments. The channel here may well be rock-floored, scoured of all sediment, but if not, any gravel present should contain above-average values. This pool merits the attention of any mining company which has some capital resources, but before any major expenditure on equipment is undertaken, experienced divers should be employed to inspect the channel floor and the occurrence of gravel should be confirmed by platform-mounted Banka Drill.

Flats and low terraces (57, 58) have been fairly intensively mined in the vicinity of the principal riverside villages, but only sporadically mined elsewhere, and considerable reserves of gravel therefore remain. Values in the exploited ground have ranged from 0.4 to 1.2 carats per cubic yard.

The diamonds from most deposits in this Block have a median size of about 1.0 carat and about 40% of them are coated stones. The only marked exception to this general description is the low terrace deposit to the north of Jagbwea (57), where coated stones constitute 50% of the total recovery and the median size is about 0.4 cart. Course concentrates are relatively abundant throughout and consist predominantly of water worn tourmaline, with from 5% to 15% corundum and a trace of ilmenorutile. The fine concentrates consist largely of ilmenite with some magnetite and rutile, and rare fragments of red and purplish garnet. Only one - 1mm grain of magnesian ilmenite was found in the concentrates of this Block.

All the diamond deposits here are in Sewa sediments and appear to represent a simple downstream extension of those in Block 4. although average values are higher than in Block 4, this is probably due entirely to the shallow gradient. There is no evidence for the existence of local sources.

Barma. This Block has been the outstanding producer of alluvial diamonds for many years. Total production to the end of 1965 is estimated to have been almost two million carats, and the biggest part of this has come from the northern half of the Block, the Konta-Barma area.

Much of the topographical description of Block 5 applies equally to Block 6. The Sewa Forge remains straight and its width remains constant at about one mile, but in the river, mean channel gradient has increased slightly to about 3 feet per mile and curves are fewer. The profile is interrupted by several minor sets of rapids, though many of which there is a narrow fault-controlled main channel. At two of them, however, river width has trebled and braided channels appear at low water; these are the rapids at Konta (60, 61) and Barma (66 and 67) which have been the focal points of the extensive mining activity.

Mining of the Sewa channel, prosecuted for many years with tremendous fervour, is now diminishing steadily because of the increasing difficulty of finding accessible un mined gravels. Recoveries from channel gravels were normally between 1.0 and 5.0 carats per cubic yard, though occasionally higher, and in the Konta and Barma areas it was in fact hard to find barren virgin gravel, even where the deficiency of other heavy minerals indicated that little concentration had taken place.

The wide Konta and Barma rock bars were covered to a large extent by boulder beds, gravel banks, and sandbanks underlain by gravel. All these were exposed and accessible to low water and were therefore among the first deposits to be exploited. Although they are now regarded as worked out, only sand and tailings remaining, yet a few miners manage nevertheless each year to make small recoveries, and it is a matter for speculation whether all the diamonds they recover were left in the tailings by the early miners or whether some have been contributed by the river at high water stage.

Substantial reserves of un mined gravel remain in the Sewa channel in this Block, for the same reasons that applied in Block 5, but they form a smaller proportion of the original resources. This is because extraction of gravel has been virtually complete in certain areas where the deposits have been exposed at low water or where the presence of rock bars and islands has assisted the construction of coffee-dams.

Little difference was observed between parcels of diamonds from different parts of the Barma block. All consisted of what might be described as a typical Upper Sewa selection, the median size being about 1.2 carats, 30% to 40% of the stones being coated, and, among the clear stones, slightly flattened or distorted octahedral predominating with layered faces, few flaws and good colour. There have been frequent reports of the discovery of large stones here, but the only one which could be confirmed was that of a 95 carat clear stone, found near Baram in 1961 and seem by the Area Superintendent of the Mines Division.

Heavy mineral concentrates, which occur in quantities up to 2000 c.c. per cubic yard, consist principally of tourmaline but also contain about 20% corundum and some ilmenite, ilmenorutle and purple garnet. In most deposits, one or two grains of magnesian ilmenite can be found by thoroughly searching the fine concentrates from several cubic yards of gravel.

Although the deposits of Block 6 are a continuation of those in Block 5, there appears to be no alluvial explanation for the higher values per square yard, and it is difficult to accept that all the diamonds are of exotic origin. Some could well have come from a local source, and the most probable situation for this is considered to be to the north of Konta, in or near to the river channel.

Boajibu. At the northern end of block 7, the Sewa Gorge widens out to become the Sewa Valley, which has a width of four to five miles but is still flanked by the dissected scarp of the Thousand-foot Surface. The river still flows on the Coastal Plain surface, but the mean channel gradient has increased to 5 feet per mile with the result that the course is largely controlled by the principal basement lineaments and is predominantly straight. Average values in the river channel deposits are appreciably lower than in the upstream Blocks, but values in the terrace deposits are fairly comparable. Tributary stream and swamp deposits, which are notably absent from Blocks 5 and 6, are common here on the eastern side of the valley, although rare on the west.

The Sewa channel here contains several rock-bars and small islands, and in consequence a great deal of coffee-damming has been possible, particularly in the sector to the west of Boajibu (83, 84, 88). As there has also been intensive diving in this central sector, and there are few pools deep enough to be inaccessible to the divers, there is little payable grave left. Immediately upstream, extending from the double bend to the northern Block boundary, is the three-mile sector of channel which was the subject of an experimental dredging operation by the Diamond Exploration Company from 1961 to 1965. (Forristal, 1965).

Prior to 1962, mining activity in this northern sector was never particularly intensive, but this was generally attributed to the deterrent effect of large areas of moderately deep water. In the course of the experimental dredging operation, bulk samples were mined from thirty separate sites, and the section dredge demonstrated its ability to dig gravel, clean bedrock and recover diamonds at all water depths between 5 and 60 feet. The mining operation itself is more fully described in Part I, section D (ii).

The results of the dredging provided valuable data on the variations in thickness and grade of the Channel gravels, and established that diamonds could be effectively recovered from the irregular Sewa bed by suction dredge. Unfortunately, they also established that overall grades were extremely low in this sector and that the value of diamonds recovered could not even cover the running costs of mining.

At Gendema Ferry, the long deep pool was found to be rock-floored and scoured free of sediment. Above the ferry, the channel floor was still mainly of hard rock with very little sediment, and the average grade of the small yardages of sand and gravel which could be found was 0.007 carats per cubic yard. Below the ferry, there were extensive gravel deposits of irregular thickness overlain by sand. 63,093 cubic yards of sand and gravel were mined and treated giving an average recovery of 0.047 carats per cubic yard. In the best cut, the grade was 0.139 carats. Using estimated sand; gravel ratio of 3½:1, the grade of the basal travel would appear to be about 0.2 carats per cubic yard overall and 0.62 carats per cubic yard in the best cut.

The accuracy of these results is unquestionable, but they are anomalous and some explanation must be sought. Even low terrace deposits in the Boajibu area usually give better recoveries than those listed above. In the stretch of river immediately downstream from the dredged sector, recoveries by the Geological Survey from License=-holder's gravel, obtained by both diving and damming, have ranged from 0.5 to 2.0 carats per cubic yard. It would appear that the three-mile sector sampled by the dredge was an especially unfavourable one. Above the Gendema Ferry, the scouring of the channel floor is an obvious adverse factor. Below the ferry, where the channel gradient is very low and the bedrock irregular, there has been sediment accumulation under favourable conditions, and there is no apparent reason for the shortage of diamonds.

In the southern part of the Block, from the elbow (88) down to the Block boundary, the Sewa channel is very straight and much of it is narrow. Mining by diving has been rather sporadic, and there have been only a few coffee-dams. Values in gravel extracted have, however, generally been about 1.0 carat per cubic yard (94, 96), and the low incidence of mining activity is due mainly to the difficult river conditions. Much of the channel is very deep, and cannot be tackled either by diving or by damming, whilst many of the shallower parts are rock-floored, with little gravel. There are several deep ppools, and gravel reserves are known to exist in some, but nothing is known of the bottom conditions of the majority, and it is to be expected that many of them are scoured of all sediment. The pool immediately below the Bohun rapids is considered to be the one with the best diamond potential.

Along all sectors of the river, the banks and low terraces have been mined since 1958, and very few are left which have not been exploited. Reserves of diamondiferous gravel remain, but only in the form of pillars and patches in erratically-mined ground. Values are generally attractive, between 0.4 and 1.0 carats per cubic yard, but the deep overburden, makes the extraction of pillars, after the initial random pitting, a most arduous task. It has only been attempted at the Paninga deposit (82) where values were higher than average, and even here about 30% of the diamonds have been left un mined and un- mineable. It is in these and other low terrace deposits along the Sewa that the unsuitability of the current licensed mining techniques is most in evidence.

Several high terrace deposits have been discovered and mined, but the most important was undoubtedly the Gendema terrace (79) where there were two payable gravel beds in place under thin over burden. The upper gravel bed consisted of a semi-laterised fine pebbly gravel whose thickness varied from 1 foot to 4 feet and which carried values up to 0.4 carats per cubic yard. Below this was a 5 feet thick bed of mottled semi-laterised sandy clay which carried a negligible heavy mineral content and no diamonds. The basal gravel underlay this false bedrock and varied in thickness from 6 inches to 3 feet. It consisted of large and small quartz pebbles, most of them sub-angular, in a matrix of semi-laterised clay, and it carried values which varied from 0.3 to 0.8 carats per cubic yard. It lay on a very irregular bedrock surface of decomposed granite cut by numerous quartz reefs.

The high terrace deposit between the Sewa (84) and the Kamada swamp (86) was mined in 1960 by the Lebafric Company. The diamonds were found in disturbed alluvial gravel and the underlying lateritic gravel to depths of three to six feet below the surface. The ground mined consisted of those blocks which contained values up to 0.6 carats per cubic yard. Mining ended when these blocks were exhausted, as the remaining ground carried only 0.1 or less, which could not cover mining costs. The 'pay streaks' were found to be randomly oriented.

Several tributary deposits have been mined in the Boajibu block, but the bulk of the tributary production has come from the Kamanda swamp (86) and the Legbiye flats and swamp (90).

The Kamanda swamp has become something of a legend because of the high values and the very large numbers of miners that worked there during the years 1955 to 1957. It is estimated that the swamp gravels originally contained average values of about 1.0 carats per cubic yard, but diamond distribution would have been uneven, as is usual in swamps, and recoveries much higher than this must have been made from some pits. Stones up to 8 carats in weight were reasonably common, and larger stones appeared occasionally. The swamp has been worked over several times, and no vestige of the original gravel now remains. A few diamonds are left, but they are dispersed through tailings, overburden and top bedrock. In recent years, a high terrace gravel residue has been discovered and mined on the slopes to the south of the swamp, and in this deposit, values of 0.25 carats per cubic yard occur in the top 4 feet of soil and lateritic gravel, together with sparse water worn corundum and rare stained pebbles.

The Legbiye flats (90) contained a normal flood-plain gravel under fairly shallow over-burden. Average values were only a fraction of those a Kamanda, but gravel yardages were very much greater, and consequently years of steady mining have resulted in a comparable production. Considerable yardages of original gravel remain, but these are the portions rejected during each episode of successive mining and therefore not only contain unacceptably low values but are also interspersed with accumulations of tailings and dumped over burden. There is no detectable high terrace deposit near the Legbiye.

Following the Legbiye deposits upstream, the values in the main flats cut off just before the stream passes under the motor road, but low values persist up the roadside tributary swamp. These values diminish northwards and finally cut off entirely as this swamp passes under the road. To the east of the road, and to the east-south-east of Boajibu, the headwater branches of the swamp cross an interestingly level crypto-alluvial area of about one-fifth of a square mile. This area is underlain by thick uniform sand, in which a gravel probe will penetrate to a depth of 15 feet without bottoming. It was hoped to investigate this area with a Banka Drill, but unfortunately, the opportunity did not occur.

The sand looks like a fluvial deposit, and it is therefore possible that it may fill a buried old channel of the Sewa. If it does, then it is likely also to be concealing a deposit of diamondiferous gravel.

To summarise the alluvial mining picture in Block 7, it can be said that licensed mining activity has been diminishing steadily for many years and is likely to diminish still further owing to the near-exhaustion of accessible payable ground. Most of the small remaining known reserves are in the Sewa banks and low terraces. Substantial additional resources may possibly exist in some of the deeper Sewa pools in the southern part of the Block, and also in the conjectural buried channel to the east-south-east of Boajibu.

Heavy mineral concentrates are considerably less abundant in the gravels of this block than in those of the upstream Blocks, and the proportion of fourmaline has decreased 70% of the course concentrates consist of tourmaline and 25 of corundum, together with kyanite, metamict zircon and chrysoberyl. Fine concentrates contain ilmenite, zircon, garnet and epidtoe. Forristal (1965) records the occurrence of haematite, pyrite, topaz and staurolite in the dredge concentrates, in addition to the above mentioned minerals. No kimberlitic indicator minerals were found in this Block by the Geological Survey, but the Diamond Exploration Company reported the occurrence of a few small grains in two of their samples. Little can be said at present concerning the origin of the diamonds in this Block except that they all appear to have been transported to their present locations by the Sewa River.

4.3 TONGO FIELDS

Tongo field is a unit, a group of closely related deposits, yet for convenience in description some subdivision must be attempted. The most important deposits are those of the Tongo river and its tributaries. Of secondary importance are the downstream deposits in the Woa, and the peripheral deposits of the Luya and the small Woa tributaries.

The deposits of the Tongo drainage. For most of its course, the Tongo River, a tributary of the Woa, flows in a shallow valley across the 750 foot surface. A pronounced nick point occurs in the profile where it enters the Mining Lease in the west, and this marks the scarp between the 100 foot surface and the 750 foot surface.

The flats and terraces of the Tongo carry diamonds over its entire length within the Mining Lease, from the western boundary to the confluence with the Woa. Most of the tributary streams and swamps also carry diamonds right up to their various sources, and the diamondiferous stream network in fact drains an area of 20 square miles. This whole 6th order network flows on the 750 foot surface, consequently profile gradients are universally low, and long sections of the stream are well graded and have formed flood-plain deposits. The flood-plain gravels of the lower Lando and the Middle Tongo all carry values in excess of 1 carat per cubic yard, whilst the gravels of the Upper and Lower Tongo, the Kundo, the Allilooya, and Njaiye, the Gelia and the Weyakilo have occasional high-grade sections interspersed with sections of lower-grade but nevertheless payable ground. Values in general are much lower than those which obtained in Yengema field, and although small reserve blocks of 2,3,4 and 5 carats per cubic yard do occur, nothing comparable to the Woyie and Wongoyie deposits exists and the average tenor of the known reserves in the Tongo drainage is little more than 1 carat per cubic yard.

The mining of parts of this drainage began in 1956. The deposits of the Lower Lango and Allilooya streams are now worked out, but mining of the other tributaries and of the Tongo itself has only recently begun, consequently the greater part of the gravels are still in reserve.

The Tongo drainage is cut by two kimberlite zones which both have a strike of approximately 60° true. The Sierra Leone Selection Trust Prospecting Department has traced the zones on the ground by the use of heavy mineral sampling techniques, and trenches have been laid across the zones to expose and sample the kimbelrites. The kimberlites are in the form of narrow discontinuous dykes which resemble those at Koidu but contain higher values at outcrop. The Lando Zone, which appears to be the most important, begins near Bumpe on the Upper Lando and follows the Kundo-Lando-Lower Tongo line almost to Yendema, a length of almost 5 miles. This zone has been thoroughly explored and several dykes have been traced, the average width at outcrop being 0.9 feet. It is almost certainly the source of the diamonds in the Lando and the Lower Tongo.

One mile to the south-east of the Lando Zone lies the Middle Tongo Zone, which is only two miles in length. Little work has so far been done on it and only two kimberlitic dykes have been detected. The kimberlites of this zone may have provided all or part of the diamonds in the Middle Tongo alluvials but little more can be said on this subject until the zone is known in greater detail.

The Woa River. The Tongo is a tributary of the Woa river, and several minor diamondiferous streams join the Woa below the Tongo confluence. The Woa channel gravels are known to carry diamonds from the confluence down, but values are believed to be low, and virtually nothing is known of the flats and low terraces. Most of the diamonds in the Woa were probably contributed by the Tongo.

Small deposits occur in many of the minor Woa tributaries, but the four most important are the Sandama deposits, the Boyei deposits, the Gandorhun deposits and the Classifaiya deposits. In the Sandama area, payable values occur in several swamps and small streams, and they are related to a kimbelrite dyke which, although apparently isolated, lies on the line of strike of the Middle Tongo Zone, five miles to the south--west. Payable values are found in the Boyei stream and it tributary swamps just to the west of Laoma. These might possibly be related to the Peyima kimberlite zone, which is only one mile to the south.

In the Gandorhun area, diamonds occur in all the gravels of the Bwendai stream and its tributary, the Peyima stream. This drainage is cut by a kimberlite zone which is three miles in length and from which the diamonds of this area have obviously been shed. This is referred to as the Peyima Zone, because trenching has shown that the dykes are best exposed near the Peyima, and a small pipe of kimbelrite breccia, 20 feet by 50 feet, cuts the principal dyke near the point at which it crosses the stream. Values are very low in the Lower Bwendai, but increase to payable levels in both branches above the Peyima fork. Values in excess of 1 carat per cubic yard occur only in the Peyima flats near the kimberlite zone, and the highest values of the deposit are found upstream from the kimberlite intersections.

Extensive low-grade deposits, with values not exceeding 0.1 carat per cubic yard, occur in the Classifaiya stream and in some of its tributary swamps. These would appear to be related to the small deposits on the opposite side of the QWoa and to the Naiagolehun deposits (381) outside the Lease boundary, together with which they form a zone of approximate 60° strike. No kimberlite indications have been reported.

The Luya Deposits. The Luya is a third order stream at the south-west corner of the Mining Lease and a tributary of the Mamaye. The gravels of the stream flat, which were mined out some years ago and yielded less than 1 carat per cubic yard, contained numberous rounded quartz pebbles, showing that the stream follows an old river channel. No name can be given to the river concerned since it was part of a drainage system which has now vanished comopletely, but it is perhaps permissible to equate it with the ancient river which can be shown to have flowed south from Talama (348) and to have been subsequently captured and diverted through the present Allilooya valley. It is therefore conceivable that this river may have brought the Luya diamonds from the Talama kimberlites, or even from the Lando Zone. However, the existence of kimberlites in the Luya region is indicated by the occurrence of kimberlitic ilmenite in the Siawur stream near Sewaoma.

OTHER FIELDS

Kenja. This Block contains the southern half of the narrow continuous deposit which extends from Foindu to the Moa River, and it begins at the Beeya/Kenja confluence, which conveniently corresponds with the 1:5,000 Sheet boundary. Above this confluence the Kenja gravels are barren; below it, they contain diamonds all the way to the Moa.

The Kenja is a 5th order stream and is not so obviously underfitted in its valley as the Beeya, but there are many terrace deposits of rounded gravel not attributable to a stream of this size, and these show that the valley is that of a much larger river. With the exception of two tributary swamps, diamonds have been found only in the flats and terraces of the Kenja valley, which differs again from the Beeya valley in that the distinction between flat and low terrace of similar elevation can readily be made in the field. Moreover, the flat valley floor is flanked by high terrace deposits of all types.

The gravels of the flat and low terrace all contain a proportion of well-founded quartz pebbles and are generally free of clay. Grades vary; the highest values recorded during sampling were in the flat gravels at Pava (380), which contained 1.5 carats per cubic yard; elsewhere, licence-holders recoveries have been between 0.2 and 1.0 carats per cubic yard. There seems to be no completely unpayable ground, as the poorest gravels yield 0.15 carats, which will give the licensed miners a bare living. These deposits have been mined steadily for several years, but in spite of this, substantial reserves remain and licensed mining can be expected to continue here for another six to eight years with production decreasing annually.

The high terrace gravels were almost ignored for many years but began to attract the miners' attention in 1960 and are now regularly mined at several sites during each wet season. The deposits are of various types; semi-lateritised gravel-in-place under shallow over burden often exists on the lower slopes near the flat, whilst gravel residues may cover the upper slopes or adjacent planed hilltops. At Pava, there are several high terrace levels. Those on the middle and lower slopes and gravel-in-place under shallow over burden and are now almost mined out; there is also an extensive upper terrace surface whose lateritic gravel contains pebbly alluvial residues which have not yet been exploited. All along the Kenja valley there are reserves of high terrace gravel, and although values are generally low, selectric mining based on corundum concentrations enables the miners to make reasonable recoveries, consequently mining is expected to continue for several years.

The heavy mineral concentrates of the Kenja are remarkable for their abundance. Quantities between 100 and 500 cc per cubic yard of gravel are usual and on one rock bar (377) south-east of Hangha, 2000 cc per cubic yard were present in the Geological Survey sample. These concentrates consist principally of corundum, both water worn and angular, together with some chromite and zircon, and traces of epidote, actinolite and topaz. No kimberlitic minerals whatsoever are present.

The Kenja diamonds are all clear stones, with a median size of about 0.7 carat. Generaly they are of good quality, but it is noticeable that in all deposits in the vicinity of Pava a majority of the stones are marred by inclusions. Stones of up to 15 carats have been found in the Kenja flats, and a 57 carat stone was recovered from high terrace ground beside Nyanyahun Bwema, which is on the eastern side of the Kenja at the north end of the Block.

The Kenya deposits appear to be a simple downstream extension of the beeya deposits, the diamonds having been brought from the north by the old river whose former course the Beey and Kenja now follow. However, the occurrence of occasional large stones suggests that the exotic diamonds may have been augmented from local sources. At Pava, a few small fragments of material which closely resembled weathered kimberlite were found in high terrace gravel tailings, but it was not possible to locate the parent bedrock exposure in the overturned terrace ground.

Lower Woa. This Block covers the minor deposits which exist around the south-eastern margins of Tongo Field, and these deposits comprise only the channel, flats and terraces of the Woa river, and the Naiagolehun swamp.

The Woa is an 8th order stream, and its valley represents a longue of the Coastal Plain Surface which penetrates the dissected margins of the Tongo Surface. The channel gradient is only 3.5 feet per mil,e and much flood-plain is now forming. There are few rock-bars or rapids and transport of coarse and heavy material appears to have been at a minimum for some considerable time.

The Woa channel contains values, but these are not very high in the Wilima area and diminish to negligible levels as the confluence with the Male is approached. This, and the difficulties of working this sand-filled type of channel, , have discovouraged licensed mining activity. The few rock-bars have been thoroughly cleaned-out of course, a few small coffee dams have been attempted, and there has been sporadic diving activity, but the aggregate production has been small.

Flats and low terrace occur along most sections of the valley but have been mined only in the Wilima area (382, 383). Here, thick gravels of rounded quartz lie beneath over burden which varies in thickness from 10 feet to 25 feet, and they carry values that are occasionally as high as 0.6 carats per cubic yard. These deposits are now regarded as worked-out, but virgin gravel remains in the deeper parts of the flat and in pillars in the low terrace. Downstream there are large areas of untouched flat and low terrace; nothing is known of the values, but for the purpose of resources estimation, an average of 0.1 carats per cubic yard has been assumed.

The wide strip of high terrace near Wilima is now also mined-out. This contained rounded gravels-in-place below shallow over burden, and included a few small high-grade patches among large areas of barely payable ground. Below the south-east corner of the S.L.S.T. Lease boundary, values in the high terrace gravels (384) are very poor, averaging 0.02 carats per cubic yard, and there is little scope even for selective mining.

The diamonds of the Woa deposits are mostly clear, with a very small percentage of coated stones, and a median size of about 0.6 carat. Heavy mineral concentrates consist principally of water worn corundum, together with chromite, zircon, and rare small grains of magnesian ilmenite. The Woa diamonds are generally assumed to have been carried by the drainage from the kimberlite zones of Tongo Field.

The only other deposit of importance in this Block is the Boyei swamp (381) near Naiagolehun. Here, diamonds occurred n the swamp gravels, in which values averaged 0.2 carats per cubic yard over a distance of 8000 feet. The swamp is now mined-out, but mining continues in the terrace gravels along the sides and at the head. These terraces have angular quartz gravels below 7 feet of overburden and represent the flood-plain of a former 4th order stream which must have played a principal part in the distribution of diamonds both here and along the Classifaiya stream.

Middle Moa. This Block has been defined to include the channel, terraces and tributary swamps of the River Moa for a distance of 20 miles downstream from the Male confluence. The Kenja stream discharges into this section of the Moa, which would thus appear to be most favourably situated from the pont of view of alluvial diamond occurrence, since both the Kenja and the Male carry diamonds. However, although there are diamonds in all the Middle Moa deposits, values are in fact extremely disappointing.

The Middle Moa flows across the Coastal Plain Surface with a mean profile gradient of 4 feet per mile. The channel is in a stable semi-graded condition and has assumed a braided form, cotaining numberous islands and islets but few rock-bars or rapids. The actual discharge is comparable to that of the lower Sewa, but the channel is much broaded and shallower. All the Moa sediments contain far more sand than the corresponding Sewa deposits, and the gravels tend to be finer and to contain a high proportion of well-rounded quartz pebbles. These features of the gravel may possibly be the result of a greater profile length, but in the absence of suitable maps of the Moa headwaters it is not possible to decided whether or not the Moa is of a higher stream order than the Sewa. A contributory cause of the gravel characteristics could be a deficiency of quartz veins in the local granitic basement; such a deficiency has been noted in most exposures examined, but this may be fortuitous.

The only mining in the Moa channel has been in the form of sporadic diving, coupled with some illicity pitting of isaldns and the adjacent shallow rocky areas. Recoveries have generally been rather poor, the maximum obtained by the divers being 0.5 carats per cubic yard. The average width of the channel is 1500 feet and there are few scoured sections; gravel yardages are thus very great but values can only be guessed and are almost certainly at levels which will yield a small profit only to skilful selective mining.

The Moa low terraces appear to be quite extensive, but some of the ground which has been mapped as low terrace may in fact be flood-plain. They contain fine well-sorted gravels of bleached rounded quartz, overlain by thick bleached sandy overburden with thin gravel lenses. Only a little mining has been attempted by the diggers, and recoveries have never exceeded 0.2 carats per cubic yard. Exploration of the low terrace deposits of the Maka area (418) was carried out by Minerals Research Synidcate in 1962, but average recoveries were only about 0.1 carat per cubic yard. Very substantial yardages of gravel certainly exist, but it is questionable whether any can be extracted at a profit.

Only a few strips of high terrace gravel are known along the Moa, and values in them are very low indeed’ no mining has been attempted. With one exception, the swamp deposits have all been formed by the reconcentration of Moa low terrace gravels, and moderate recoveries have been made from small selected patches of ground. The swamp gravels consist of bleached rounded quartz and contain much water worn corundum. The exception is the swamp at Dia (417), where values of 0.25 carats per cubic yard occurred in angular quartz gravel below 1500 square yards of swamp. Rounded pebbles were absent, but the corundum concentrates included a little water worn material. Pitting by Minerals Research Synidcate established that diamonds were completely absent from other parts of the same swamp.

Another, less known alluvial diamond fields can be found in the Kamakwie area in the north of Sierra Leone. The Northern Province has been known traditionally for large deposits of iron ore in Port Loko District and gold in Tonkolili and Koinadugu Districts. The existence of diamonds in the North was first noted in the mid-1980s when it was rumoured that a resident of Kabatha village had found a diamond. Theories about the existence of diamond deposits in the Northern region have been based on trial and error, due to a lack of scientific research.

The Geological Survey has now conducted short intensive reconnaissance surveys of the areas in question- the Kamaranka-Kamakwei and the Kambia zones. The former is underlain by basement granite and gneiss, and the latter by the Kasila gneisses, and basement granite. Mineralogical Studies of heavy mineral samples have clearly indicated the presence of kimberlite indicator minerals, picro-ilmenite and pyrope garnets, g6 and g7 garnets. The latter two have been used in South America to uncover kimberlite dykes and pipes and this supports the original suspicion that the provenance of these diamonds have been formed from small numerous and thin kimberlite dykes which have been weathered to a lesser or greater extent. These diamonds are associated with gold, which has quite recently been recovered as a primary and secondary product.

The first official mining license was issued in the North in 2002, thus, legitimizing diamond mining in the region for the first time. Nevertheless, there are indicators that small kimberlite dykes exist in the Northern Province. In 2005, the Acting Deputy Director of the Geological Survey in the Ministry of Mineral Resources told that the kimberlitic structure in the North points to neighboring Guinea. The Sierra Leone Diamond Company (now knows as African Minerals) was carrying out prospecting work around Kamakwie to assess the viability of these kimberlite dykes. Meanwhile, the ministry has issued an appreciable number of new diamond mining licenses in the Northern Province – about 60 in Bombali District by late 2004, 18 in Kambia District and two in Port Loko. Many others are in the works, and by the end of 2004, an estimated 16 dealer-agents and four dealers had set up shop in the area.

5 DESCRIPTION OF SIERRA LEONE DIAMONDS

A detailed description of diamonds from Koidu has been given by Grantham and Allen (1960) and the characteristic features they record occur throughout the diamond fields. Although there are marked differences between the productions of separate fields, these are usually differences only o proportion of the various types. In all parcels, the most important distinction to be made is between the clear and the coated stones.

Most of the clear stones are colourless and of good quality, but a few yellowish, pale green and pale brown stones occur in some deposits. About 20% of the clear stones contain small black inclusions, often surrounded by radiating cracks and in a few cases the inclusions are so abundant as to render the stone valueless as a gem. The dominant crystal form is the octahedron, usually slightly flattened and sometimes twinned or distorted. Doceahedra are rare and cubes do not occur among the clear stones. The octahedra may exhibit various growth features such as plates, layers, shields or crinkling but a good proportion, especially from the Yenegma and Koidu areas are “glassy”, with plain faces. The corners and edges are sometimes chipped or worn even among stones taken from kimberlite.

The coated stones vary in external colour from pale greenish-grey to dark green and they normally consist of a clear inner stone covered by a layer of translucent green diamond. This coating may be as much as 3mm thick, although the average is about ½mm in crystal form. Also, the coated diamonds differ from the clear being generally regular symmetrical octahedral, dodecahedra or cubes, with faces unmodified by plates or shields and exhibiting rough or matt surfaces. In many cases the crystal form assumed by the whole coated stone is different from that of the inner clear diamond.

The relative proportions of clear and coated stones vary from one deposit to another. In addition irregular shaped grey-black bort occurs in small quantities in most deposits. The overall ratios in the production from the principal fields are estimated to be as shown in Table 3.

The range of sizes over which the Sierra Leone diamonds occur is a large one, and in any standard month’s production the weights of individual stones will vary from 0.03 carat to 50 carats from the Yengema area. At the other end of the scale, a few perfect octahedral which are estimated to weigh as little as 0.002 carat each have been detected in the fine fraction of pan concentrates from weathered kimberlites.

The question of average diamond weight which interests many people, is not an easy one to approach. In the first place essential data are lacking because diamonds are never counted and classified by weight in the sorting rooms or the buying offices. In the second place there are different methods of calculating the average. Average weight is usually assumed to be the Arithmetic Mean of individual weights, but this is in fact a most misleading figure to employ since the very small diamonds have a disproportionate effect on it.

According to last Monthly Economic Review of the Bank of Sierra Leone by August 2018 in the mining sector, production performance was weak, explained by decreases in all mineral products except diamond. Bauxite production declined by 5 per cent to 149.03 thousand metric tons, rutile production decreased by 29.24 per cent to 9.17 thousand metric tons. Similarly, Ilmenite production dropped by 4.45 per cent to 5.15 thousand metric tons, while Gold production slumped to 30.05 ounces from 10,797.05 ounces last month. Diamond production grew by 7.97 per cent to 79.75 thousand carats comprising of 42.1 thousand carats of industrial and 37.65 thousand carats of gem.

According to www.mining-journal.com Sierra Leone diamond exports dipped in volume and value in 2017. The Sierra Leone National Minerals Agency (NMA) reported a 22.51% fall in diamond exports for 2017 versus 2016, with total diamond exports for the latest year at 288,978.73 carats worth more than US$123 million.

The average price per carat received during 2017 was US$426.11. A total of 179 Kimberley process certificates were issued to facilitate the exports.

Figure 7. The stunning 709.41 carat Peace diamond was one of two huge special stones recovered in Sierra Leone in 2017

The country's total 2017 diamond production haul included 166,594.57 carats of gem diamonds – 58% of the total – and 122,384.16 carats of industrial diamonds.

Artisanal production with a volume of 183,216.54 carats, valued at US$79.08 million, accounted for 63.40% of the total exports. Kimberlite production of 105,762.19 carats, worth US$44.05 million, contributed 36.6% of the export total.

The NMA said mêlée and industrial category diamonds accounted for 88% of total exports.

"This can be attributed to the value attained by the two special stones – the 709.41ct Peace diamond owned by the government, and the 476.97ct Prosperity diamond owned by Meya Mining" (Fig. 7).

"Indications are that the run of mines (ROM) trend did shift a bit in the melees and industry categories, relative to the year 2016. There was a 17.37% carats drop in the melees category and a corresponding 18.12% increase in the industry category," the agency said.

Although there was a drop in volume of 27.23% in the special stones category, its value was the highest across all categories.

With the fluctuations in the world market price for diamonds and the huge showing on the two special stones, Sierra Leone's average price per carat for diamonds increased to a new high of US$426.11, an increase of 47.24% [from the $289.39/ct average the previous year].

"The general price per carat index steadily remained at above $300 per carat but jumped to over and above $500 in the last two quarters of the year under review due to the rise in diamond prices in the last six months of 2017."

The NMA said with recent investment by Koidu Ltd in expansion of its operations, "it is hoped that the coming years will see more than double the export figures of the previous years".

EXPLORATION AND MINING

Following, only middle- and large-scale mines will be mentioned, due to the fact that artisanal and small-scale diamond mining activities are widespread in the Kono District as well as Kenema, Bo, and Pujehun Districts. About 1,700 artisanal mining licenses are currently operating in these areas.

The two big players in large-scale kimberlite diamond mining in Sierra Leone are Koidu Holdings S.A., wholly owned by BSG Resources Ltd, and Stellar Diamonds PLC, a London (AIM:STEL) listeddia-mond mining and exploration company.

Koidu Holdings S.A was granted a 25-year Mining Lease (ML 6/95 ('KKP ML')) over the 4 km2 Koidu Kimberlite Project, which hosts 2 kimberlite pipes (Fig. 8) and at least 4 kimberlite dyke zones. The company also holds the Exploration Licence for the Tongo Diamond Field Project, and have applied for a mining lease to commence operations there.

At the Koidu Lease, a geological model for No. 1 Pipe was created by incorporating in-pit geological mapping, as well as core drilling data from three phases of drilling undertaken in 2003, 2006 and 2007. In total, 26 drill holes measuring 8,116 m were drilled at No. 1 Pipe, delineating the pipe to a depth of 471 m below surface (i.e. elevation of -80 m below mean sea level).

A geologic model of Pipe 2 was based on two phases of drilling in 2003 and 2007, with 20 drill holes totalling 5,507 m, as well as in-pit geological mapping. The resources extend from the current open pit floor at approximately 325 m amsl (above mean sea level) to -165 m bmsl (below mean sea level), a depth of 490 m.

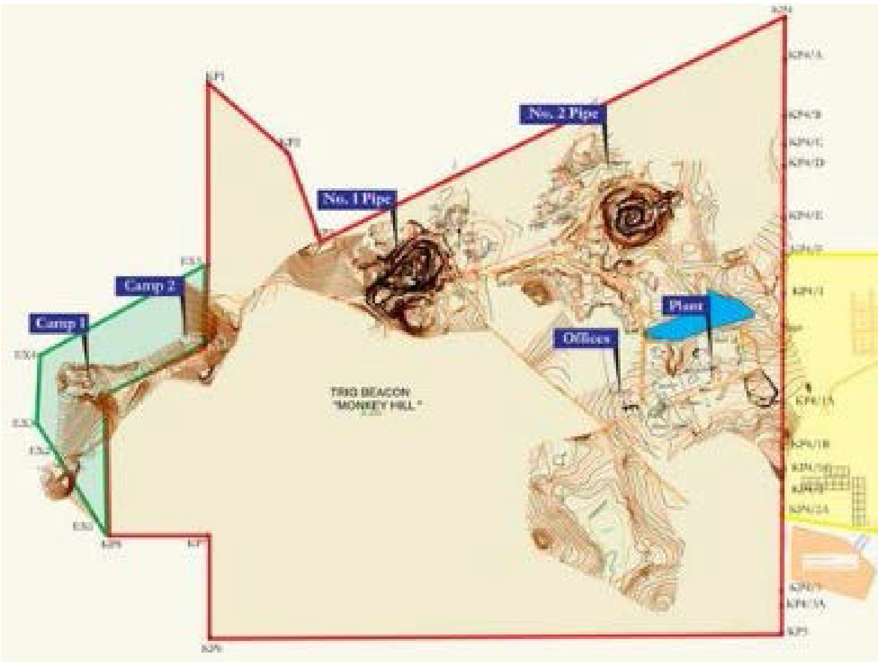

Figure 8. Surface Plan of the Koidu Kimberlite Project - Koidu Holding Ltd.

Dyke Zone A Blow is a small kimberlite pipe measuring approximately 330 m² in surface area and was drilled to a depth of 160 m below surface in 2007. A bulk sampling program commenced in November 2007, with 6,644.980 carats being recovered from 12,061 t and a grade of 0.55 ct/t.

The small blow on Dyke Zone B measures approximately 900 m² where exposed in the ramp to No. 1 Pipe vertical pit and was drilled in 2007, with 10 drill holes totalling 1,165 m delineating the blow to a depth of 160 m. These models lead to estimated reserves of 6.3 million carats at Koidu.

At the Tongo Lease, Koidu Holdings S.A. obtained an exploration licence (EXPL 4/04) over an approximately 88 km² portion of ground in the Lower Bambara Chiefdom (Kenema District, Eastern Province of Sierra Leone) in May 2004. The Tongo Field exploration licence area contains four historically documented and sampled diamondiferous kimberlite dyke zones (Kundu, Lando, Tongo and Peyima) and a blow at Peyima. In addition, the distribution of diamondiferous gravels associated with the drainage patterns suggests that other kimberlite sources could exist within the licence area. In 2008, Koidu Holdings was formally notified that its application for a mining lease over the 88.6 km 2 Tongo Diamond Field Project had been approved by the Minister of Mineral Resources. The Company completed the exploration and bulk sampling program in accordance with the obligations set out in the Exploration Licence and immediately commenced with mining feasibility studies. The results of these studies indicate that a dyke mining operation would be economically viable, despite the narrow dyke widths. The mining lease is for a period of 25 years and includes diamonds, gold and base metals. The exploration leads to estimated reserves of 3.2 million carats.

Stellar Diamonds PLC's Kono properties are situated within the renowned Koidu diamond mining district in eastern Sierra Leone (Fig. 9). Stellar commenced exploration on the 200 km2 licence areas in 2002 and discovered a number of high-grade diamondiferous kimberlite dykes. Some of these dykes represent the on-strike extensions of the Koidu Holdings Mine, where an indicated and inferred diamond resource of over 2 million carats has been established. Some six shafts have been sunk into different kimberlites where samples were recovered for diamond testing. The trial mining became focused on two of these shafts, Pol-K and Bardu where development drives and trial stope mining have been undertaken. Many more kimberlites still remain to be tested.

Figure 9. Stellar Diamonds PLC's Kono Properties in the Koidu mining district.

At Pol-K the first trial mining stopes have been opened at the 65m level below surface (Level 1). The shaft is currently at 85 m below surface and at a depth of 95 m the second level of stope faces are planned to be developed. At the 30 m level an advance drive was opened up and the dyke traced for 173 m in the south west direction and 94 m in the north east direction.

The kimberlite keeps a relatively consistent width of between 60 cm and 70 cm. Based on the presence of artisanal diamond mining, surface mapping and IKONOS satellite imagery the Pol-K kimberlite is estimated to have a strike length in excess of 5 km, so there is considerable scope for the sinking of additional shafts. The in-situ grade of Pol-K has consistently been around 65 cpht. Taking into consideration the mining dilution the "run of mine" grade has ranged between 30 cpht and 40 cpht. The largest diamonds produced from Pol-K weight 11.95, 11.45 and 10.55 carats.

The Bardu shaft is currently at a depth of 45 m. The width of the fissure is relatively consistent at 90 cm to 100 cm, though at 100 m to the south west of the shaft the kimberlite opened to a width of 3 m representing a localised swell. This narrowed to 1.5 m at 115 m from the shaft where the current development drive reached. The grade of Bardu ran at approximately 65 cpht to 75 cpht. However, the swell has yielded significantly higher grades at 140cpht with better quality diamonds being clearly evident. This is a new kimberlite zone which requires further development to assess its continuity. The largest diamonds from Bardu to date weigh 4.4, 2.90 and 2.65 carats.

A total of 4,213 carats of diamonds (+1mm) have been produced (as at 30 April 2010). Of these, Pol-K has yielded 3,209 carats and Bardu 867 carats. The balance of diamonds came from other kimberlites that were tested, but have not yet been developed further. Stellar Diamonds' Tongo property (100 % owned by Stellar Diamonds' subsidiary company Sierra Diamonds Limited) comprises a single Exploration Licence (EXPL05/07), covering 33 km 2 . The EXPL lies on the eastern extension of the diamondiferous Tongo dykes in the heart of the well-known Tongo Diamond fields. To the southwest, Koidu Holdings owns the adjacent property and has bulk sampled some dykes yielding grades of between 200 and 300 cpht.

Stellar has delineated four diamondiferous kimberlite dykes, with thicknesses up to 1 m, through mapping, sampling, ground geophysical surveys and drilling. These are designated Dykes 1 to 4 going from south to north. Dyke 1 has a mapped length in excess of 2.5 km and the potential for further extensions on all dykes is not unrealistic to assume. Work conducted by Stellar to date includes the collection and processing of some 24 mini-bulk samples of up to one tonne in the early exploration phase. These samples gave very encouraging results in that diamonds were present in most samples and grades of up to 385 cpht were calculated. Two surface samples from Dyke 1 and Dyke 4 were excavated by hand from depths of around 10 m. Dyke 1 comprised very competent and fresh kimberlite with a width of between 70 cm and 100 cm. Dyke 4, however, was strongly decomposed and as a result was more difficult to sample. Due to the impact of the rainy season no samples were collected from Dykes 2 and 3. Both mini-bulk samples were initially stockpiled and then trucked to the diamond processing plant at Kono where they were treated separately, giving grades of 90 cpht and 100 cpht for Dykes 1 and 4 respectively. Encouragingly of the 130 carats recovered from Dyke 1, some eight stones were larger than one carat, with the largest stone weighing 4.8 carats. Collection of the bulk sampling from the surface is ongoing and should be complete, with full results, by the end of Q4–10. These results will determine the next phase(s) of work which are likely to comprise shaft sinking and underground trial mining, similar to that conducted at Kono, during the course of 2011.

Sandor/Nimikoro – Baoma Rough Diamond Mining Projects. In May 2007, the Company transferred the diamonds properties it acquired from open acquisition ('buying') which had a book value of $577,500.00 to the US Corporation DITRI, Inc. (Diamonds In The Rough, Inc.) in exchange for 59% interest of SCRX's rough diamonds production with an exclusive mandate to buy out the 30% and 11% of concession owners' and SCRX's interests, respectively, in each completed production cycle. The exchange was recorded at book value as it was a transaction between companies under common control. By December 2007, DITRI raised $1.7m to finance the full-scale commercial development of SCRX rough diamond production interests in Sierra Leone. The immediate priority was to fast track SCRX's two production projects—the Sandor/Nimikoro and Baoma alluvial diamond projects in Kono to full scale production and cash flow. But the US Corporation (DITRI) did not survive the economic recession in the United States as such failed to raise the $1.7m required to fast track SCRX's two production projects.

SCRX is therefore now seeking other capable investors for the production of diamonds from the underground mining of diamond-bearing kimberlite dykes defined within SCRX's two contiguous license areas (Sandor/Nimikoro - Baoma in the Kono diamond district in east Sierra Leone. This is in the heart of the renowned Kono diamond fields that has yielded some spectacular diamonds, including the third largest diamond found, the 972-carat Star of Sierra Leone. Under the terms of the agreement the concession owners will earn 30% interest, SCRX earning 11% and the investor(s) earning a whopping 59% interest.

Any underground mining on the Sandor/Nimikoro – Baoma kimberlite fissures has the potential to produce over 3,800-carats of diamonds monthly, with stones recovered of sizes ranging 17.95, 16.45 and 13.55 carats in weight. The kimberlite dykes are on average 60cm in diameter with an in-situ grade of approximately 65 carats per hundred tons ("cpht"). At a depth of 98m stope mining will commence between the depths of 68m and 98m. This is expected to be achieved and will lead to an increase in tonnage being delivered to the processing plant.

SEWAFE PREDICTED KIMBERLITES PIPES. Seawright Mining started to explore the kimberlites during the drilling at its Upper Sewa Exploration tenement in the Kono and Kenema districts of Sierra Leone.

Using a suite of proprietary Satellite data combined with Ground based Geo-radar traversing on the ground, The Geophysical and Geological outfit of Trinity Geomining Services (SL) Ltd generated several targets for further follow up through drilling and additional higher resolution ground geophysics and indicator mineral chemistry testing.

With supervision from Trinity Geomining Services (SL) Ltd, core drilling by Seawright Mining intersected kimberlite in the second bore hole sited to test and prove the Geophysics anomalies (Fig. 10).

The inclined (angle 65° and azimuth 100°) core hole intersected kimberlite at a down-hole depth of approximately 92m after drilling through a highly fractured and brittle migmatitic-granite country rock (Fig. 11)

THE PUNDURU STRUCTURE.

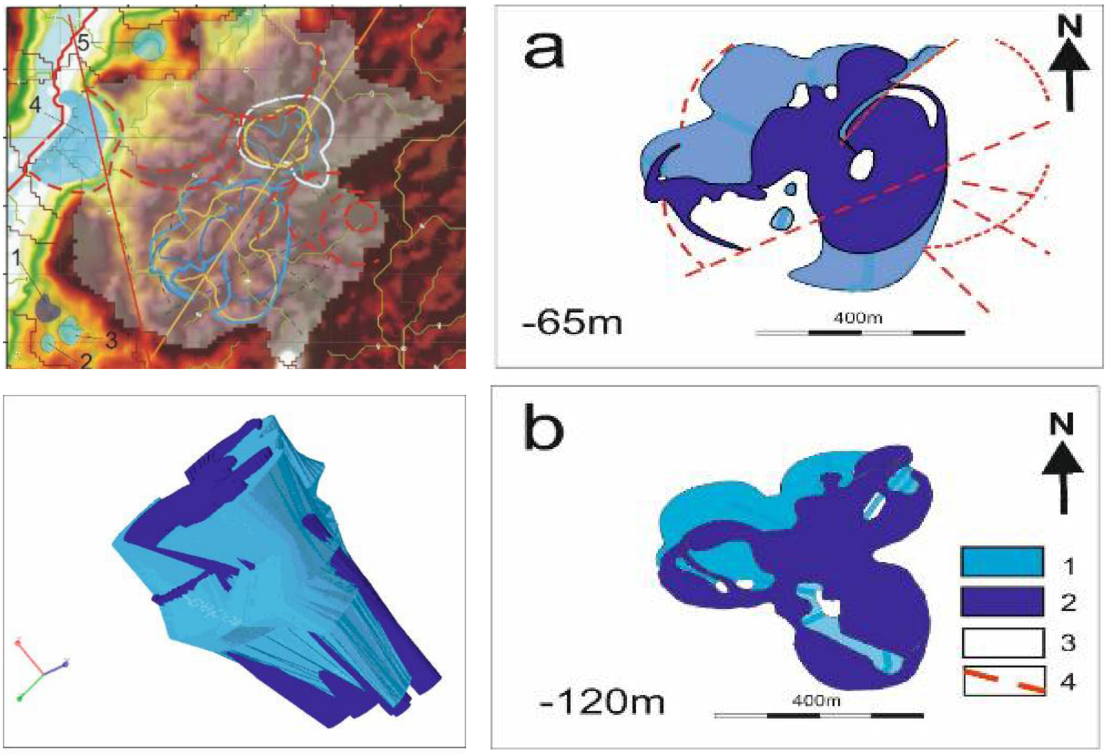

Figure 10. Localization of geostructures (identified by electrophysical profiling data) on a large-scale model SRTM

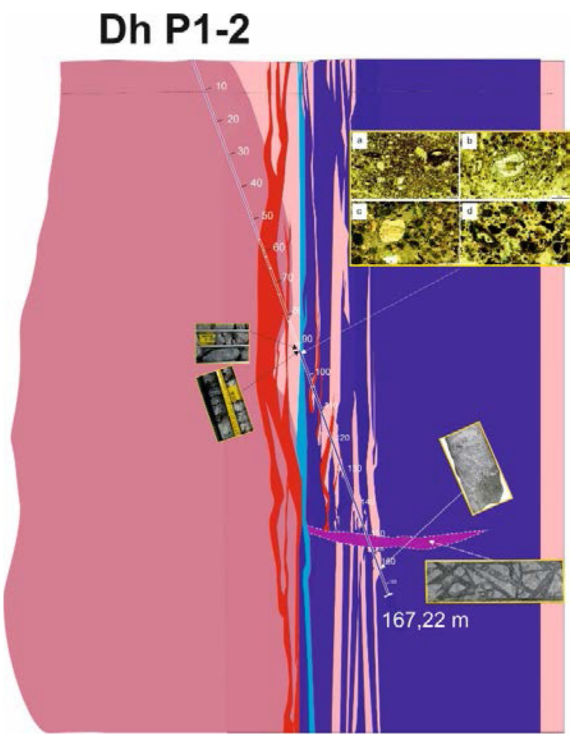

Figure 11. Geological cross section of the bore hole P1-2 (kimberlite Dyke – blue color)

Brief information about the key type of rocks. Sample P1-2/3, depth 92,0m (Bore hole № P1-2) (Fig. 12)

Changed ***porphyry micro plate of basalt-type kimberlitic rocks*** (chemical analyzes, average from 8 samples: SiO_2 -25,88; Al_2O_3-3,99; Fe_2O_3-1,14; FeO -6,29; TiO_2 – 2,90; MnO-2,70; CaO-21,44; MgO-15,79; P_2O_5-1,260; K_2O-2,25; Na_2O -0,47; SO_3-0,05; BMP-17.98; -99,71; -H_2O-1,53). Also we can see elevated levels of content such trace elements as: Ti (>10000); Mn (2400); P (5470); Zr (900); Ba (3740); Cr (1340); Ni (694); Cu (118); Co (108); Sr (6200).

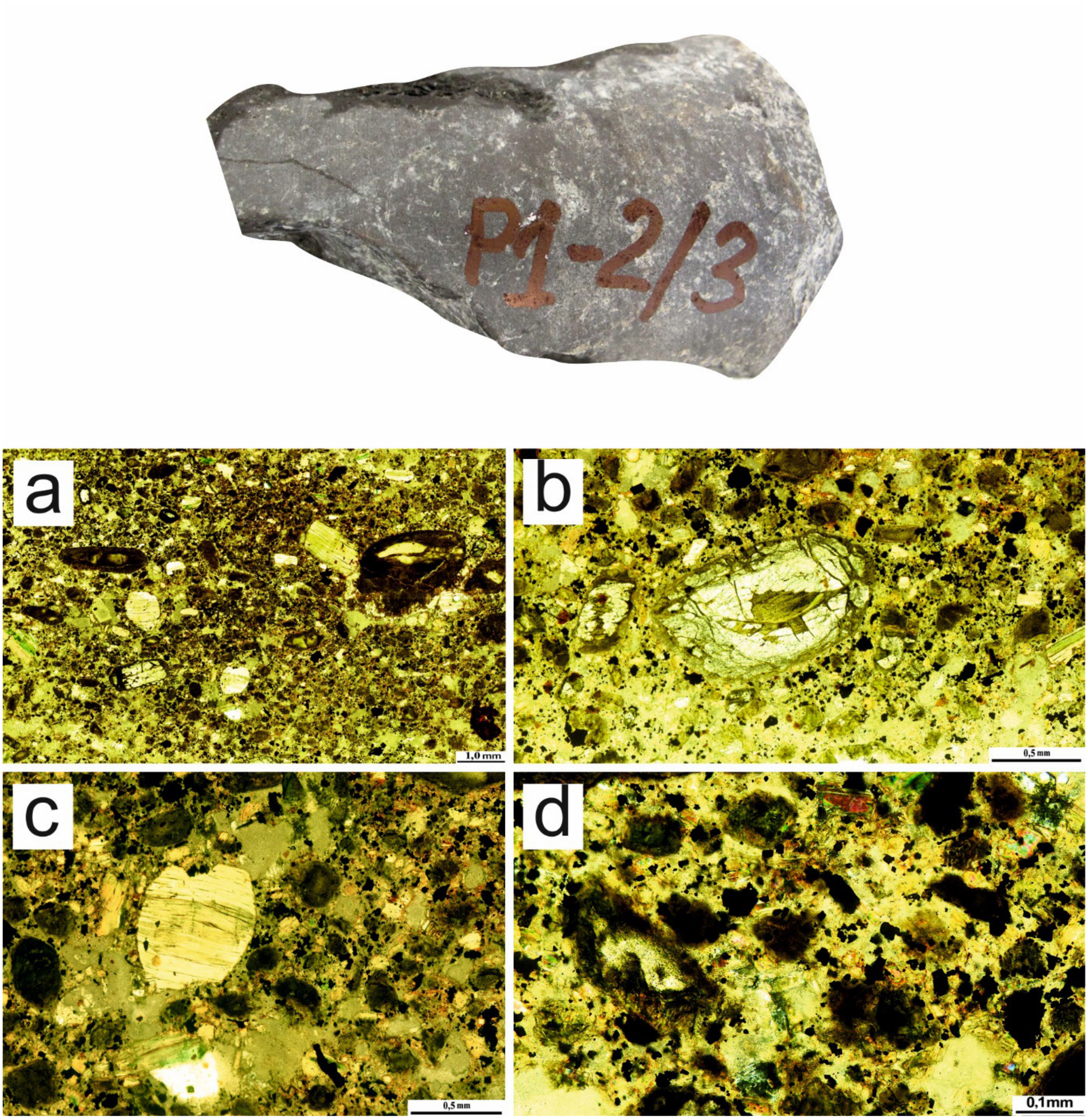

Figure 12. Thin-section of kimberlites (sample P1-2/3, depth 92,0 m)

a- the general panorama of the breed is shown (this is evident from the scale), which in this case is (without any doubt) porphyry kimberlite of a basalt-type type with a microlite main mass. It is worth pointing out that the breed itself has changed very much (for kimberlite it is a normal phenomenon). Structure of porphyry. The impregnation is represented by pseudomorphoses of the carbonate-serpentine composition of olivine and single phlogopite scales. The bulk is characterized by a relic micropory structure. As the microporiferous inclusions, olivine crystals of the second generation stand. The rock matrix is carbonate. The carbonate is represented by thin-crystalline calcite, or substituted by dolomite. In addition to olivine, in the bulk, there are relics or pseudomorphoses with phlogopitum, magnetite, perovskite (it can be replaced by magnetite) secondary apatite of Nicholas II.

b-porphyritic megacryst of olivine (in the center), which is replaced by a carbonate-serpentine (greenish) aggregate. Dimensions of inclusions from 1 to 2 mm. It is surrounded by the bulk of the mass. Nicole II.

c- porphyry scaly phlogopite is partially replaced. The substitute product - serpentine. Dark without clear contours of interspersion around the scales - pseudomorphoses in microliths of olivine of the second generation. Nicole II.

d- the main mass of kimberlite. Present pseudomorphoses on olivine without clear contours, light areas - carbonate, separate microlith phlogopite or pseudomorphosis on it, ore minerals - magnetite and perovskite. They are virtually non-separable under the microscope, and the integral forms are identical. Nicole X.

Sample № P1-2-43 (Fig. 13). The rock is represented by a serpentinized mucous olivinitis with a vein of orthopyroxenitis. Microtexture is massive. The primary structure of the panalotriomorphic grains, due to the fact that more than 95% of the rock is composed of olivine, a small amount of rock is composed of magnetite and a small number of scales of mica. The newly formed loop structure is due to the partial destruction of olivine in the form of loop fracture development. Serpentine is intensively developed in fissures in greenish color and, to a lesser extent, in the form of magnetite powder. The latter cracks the cracks, defines individual grains and is located in the grain of the grain. This situation is presented **a-b** on the Fig. below.

The olivine part of the breed is characterized by the development of loose vein, along with loops, the newly formed serpentine and secondary magnetite are common (**c-d** on the Fig. below).

Fluorescent beads are colorless, almost completely replaced by muscovite. They are found in the mass of the breed among olivine (**a-b** on the Fig. below), and in the zoolbands of the orthopyroxenite loop (**d** on the Fig. below).

The intensity of rock change does not always allow you to determine the boundaries of individual olivine grains. The ratio of olivine and serpentine (85/15) suggests that the breed is serpentinized (slightly serpentinized) with olivinitis. The search interest in this case was not found.

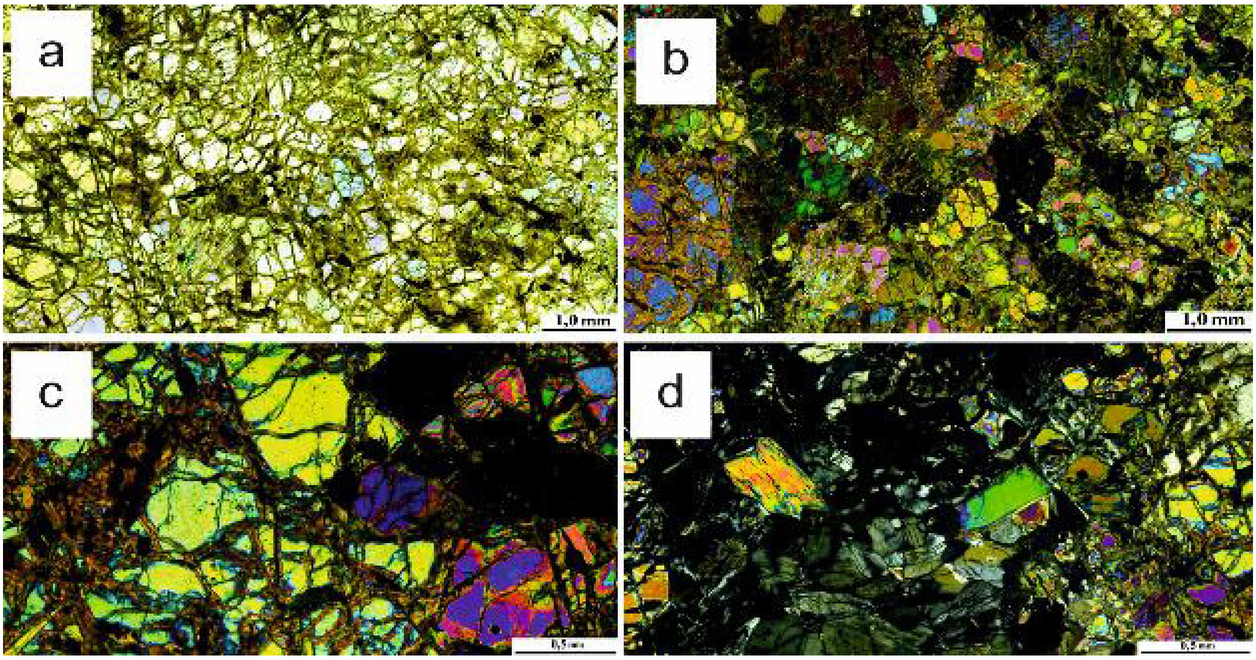

Figure 13

a-Panoramic image of the internal structure of the rock under a microscope with II nicolas. Primary, partially preserved, structure of panidiomorphic grains, secondary - loop. On cracks develops greenish different shades of serpentine and secondary magnetite. Separate grains of primary magnetite can be seen. In addition to these minerals, there are scales of mica (phlogopite).

b- Panoramic image of the internal structure of the rock under a microscope, similar to Fig. 1a. The fragmented parts of the olivine grains are clearly visible. The structure of the primary panidiomorphic grains, the newly formed loop due to wavy cracks in the olivine, which intersecting form a cellular lace. On the cracks serpentine and magnetite. As a result of secondary changes, the shape of specific grains is not read. Nicole X.

c- A detailed image of Olivine relics, cut into cracks that form the loop structure of the breed. For cracks, postterior minerals - serpentine and magnetite. Nicole X.

d-The vein of orthopyroxenitis in serpentinized olivinitis. The veins stretch subvertically. On both sides of this vein there are scales of muscovite. From the left and right side you can see the olivinite zhland wool. Nicole X

The YOMBY Structure.

The structure is located in the North-West part of the License Area (Fig. 14). The structure was revealed as a result of conducting a complex of geophysical studies (GPR and magnetic profiling) and at the moment is studied by drilling (Fig. 15).

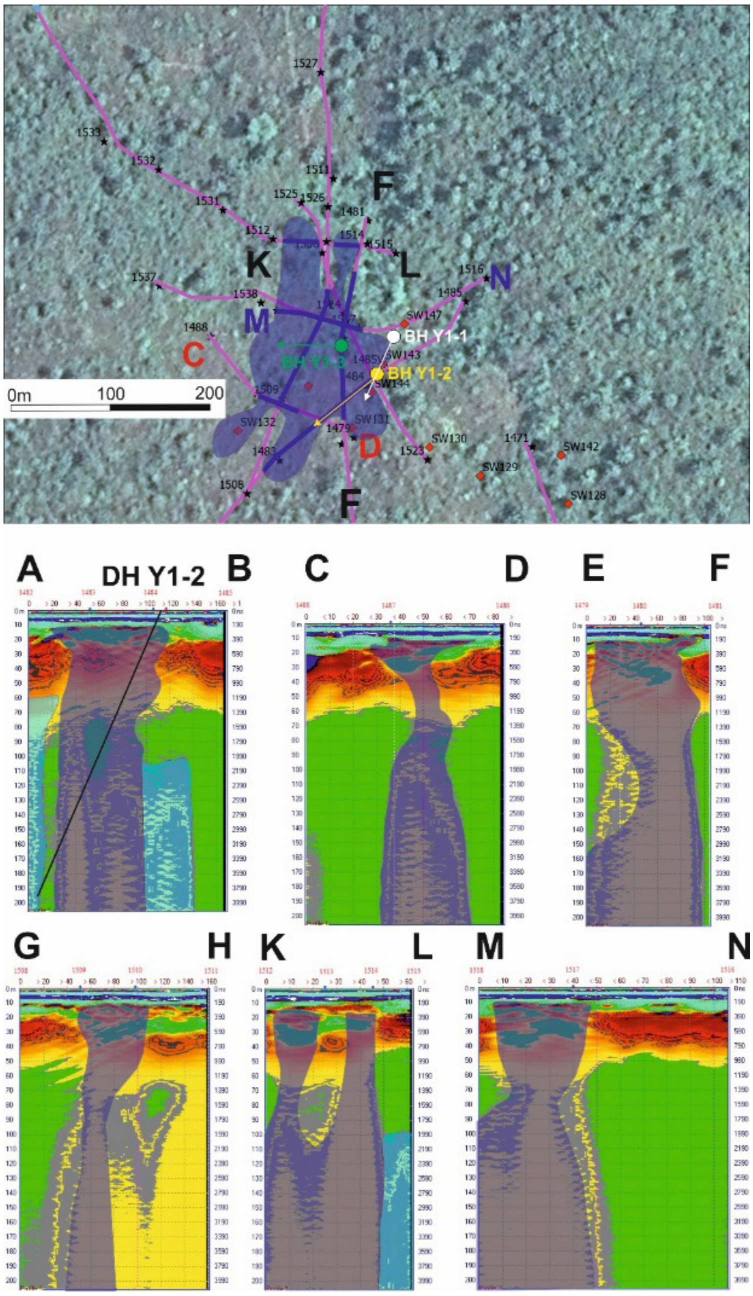

Figure 14. Boreholes Y1-1 and Y1-2 position and GPR cross sections

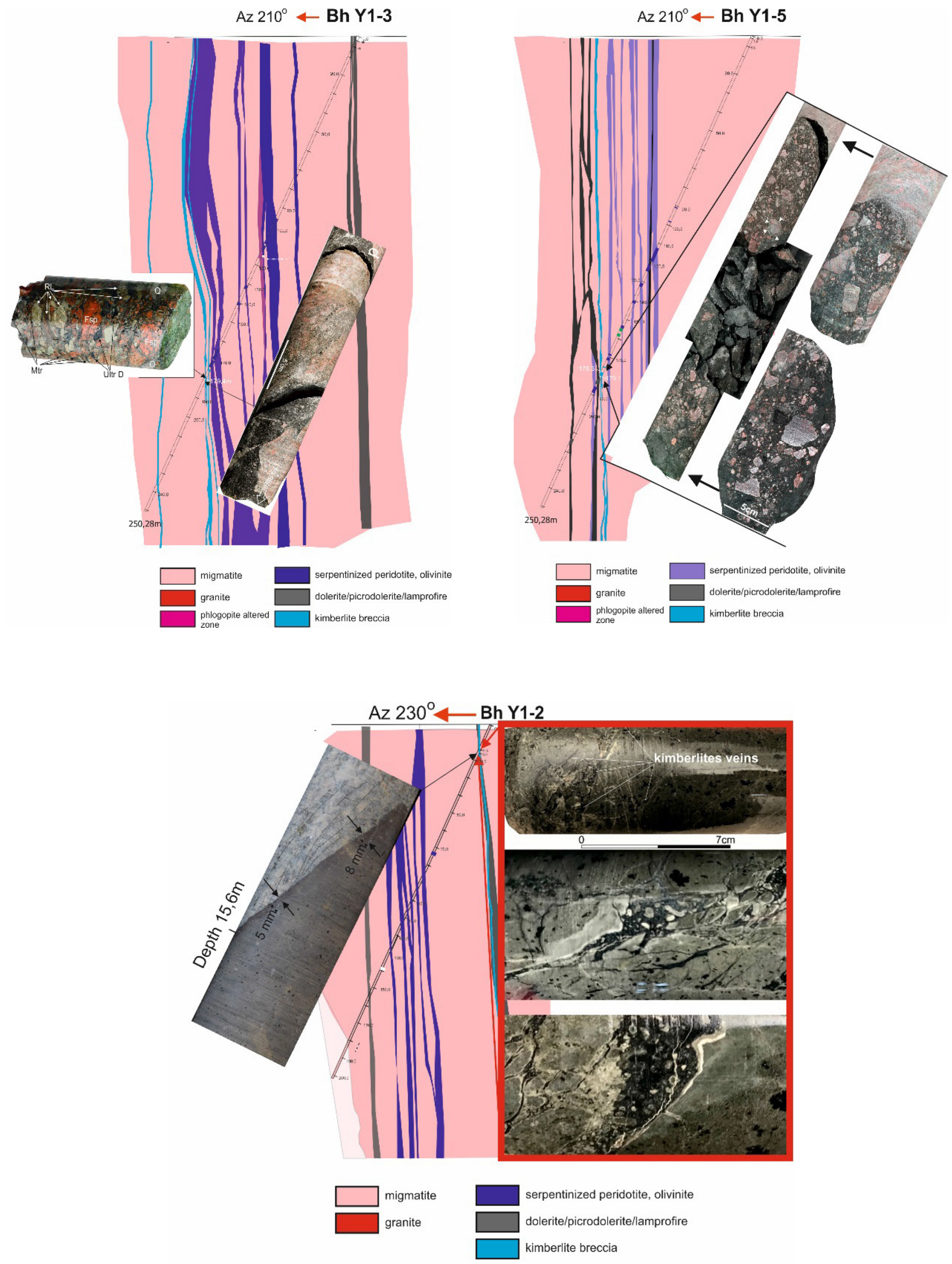

Figure 15. Key drilling results within the Yomby structure

In 2018 Seawright Mining Co and Trinity Geomining Services Co intersected presumably kimberlite dyke body and traced this dyke more than 2 km. At present, the studying is continued.

Alluvial diamond deposits are mined by mining companies, as well as artisanal miners in the Koidu and Tongo area and along the Rivers Sewa, Moa, and Mano and their antecedents (Fig. 16).

Figure 16. Mining process

Here, only an excerpt of different alluvial diamond mining companies is given. The Bambaya and Sowadu diamond projects are situated in AMR's Fiama exploration licence, east of Koidu.

ARM's Tefaya gold and diamond lease encompasses an area of 0.15 km2 on the riverbank and terrace of the Bafi River.

ARM's Kathumpeh diamonds project close to Kamakwie in the upper reaches of the Makoti River drainage in the Sella Limba Chiefdom.

African Minerals (formerly known as Sierra Leone Diamond Company, SLDC) purchased African Gold and Diamonds SA's mining plant and equipment at Tefaya in the Kono district of Sierra Leone. The plant was subsequently renamed in "Konama mine" LDC'S alluvial operations are currently focused in the Kono district of Sierra Leone, along the Middle Bafi River area and centred around the town of Tefaya. [28].

The Hima License (EPL 1/94 - Cream Minerals and Casierra Development Fund) area lies some 10 km north-east of the town Sumbuya, is some 10.5 km long and 1.8 km wide and contains the present course of the Sewa River along with adjoining flats and terraces.

Within the licence area the river has a relatively low gradient but is bounded both upstream and downstream by sections of the river with much steeper rapids forming gradients. The licence area therefore appears to be a depositional portion of the river resulting in deeper overburden on the terraces and with little or no exposure of gravels within the river course itself. These factors have limited the amount of hand mining, which could be carried out by local or artisanal miners on the license.

In the Upper Part of the Sewa River initial phase of exploration by Trinity Geomining Services (Sl) Ltd was started. A limited amount of work on its preliminary geological exploration was performed on the order of Bright Mining Technical Services and logistics Company (SL) Ltd. As a result, the work established two types of geological objects.

The first one is represented by modern (Neogene-Quaternary) burial and overlapped sedimentary deposits of the paleo-placer cover along the Sewa River. In this case, all places of possible localization of placers in the satellite valleys of the basin of the Sewa River basin are associated objects of study.

The second is geological objects, localized in the crystalline rocks of the Early and Pre-Cambrian, and also the Phanerozoic (and possibly younger) manifestations of kimberlite magmatism on the Leono-Liberian shield.

This License Area have a great possibility to placers location on the north part (Fig. 17, 18). Here the placer continues in the south direction already explored placer, located in the north - within another License Area.

Trinity have been performed GPR- profiling with variations of antenna types and their location (this is necessary to achieve maximum resolution and measurement accuracy).

After this been performed magnetometric profiling.

The combination of two completely different methods of research allowed the most reliable interpretation of the results obtained and provided information not only on the sedimentary rocks of the cover (placers), but also on their crystalline basement - the rocks of which lie lower and are an important object of prospecting.

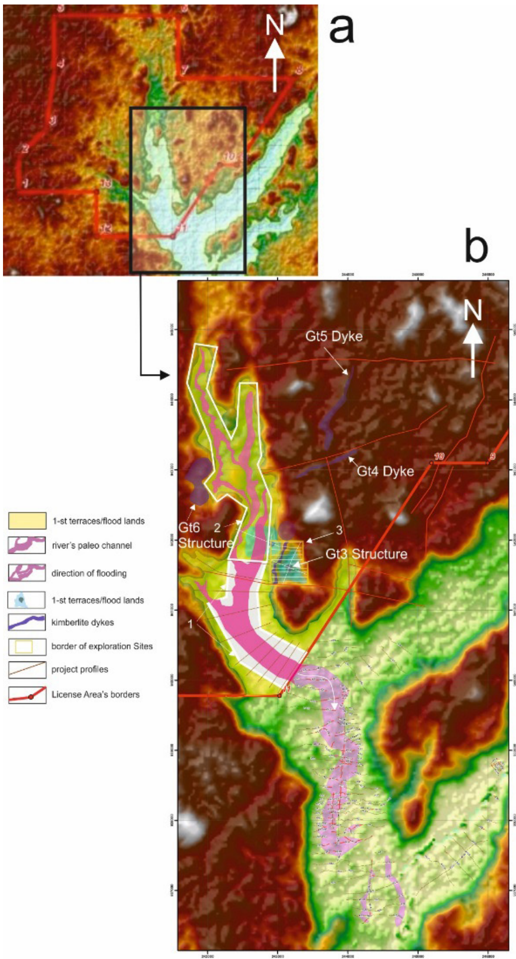

Figure. 17. Exploration targets location on the South-East corner of License Area EL11/2011

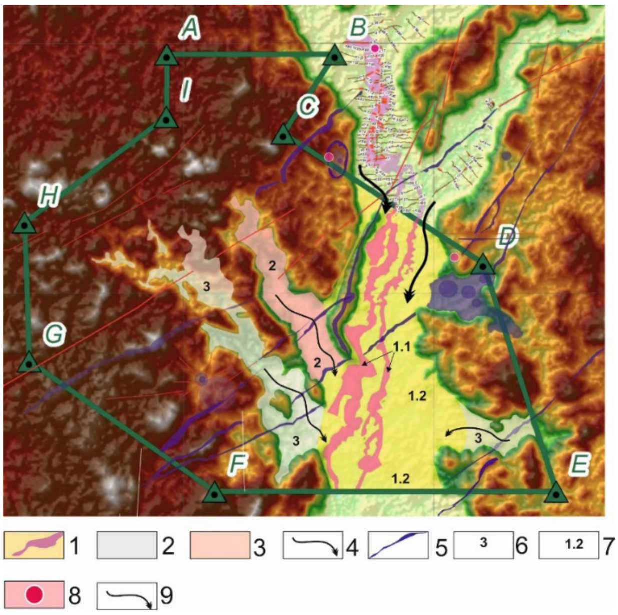

Figure 18. Forecast map of the License Area EL 34/2017 location and boundaries on SRTM basis and modern state of geological and geophysical study of the Concession

1-Alluvial with diamond (channals - 1.1/ terrases - 1.2);
2-Alluvial rocks in general (source 2 and 3 West);
3-Alluvial rocks in general (3 East);
4- Debris demolition direction;
5-Kimberlite/picrodolerite dykes;
6-Numbers of alluvia with different source;
7-Alluvia flats and terraces of Sewa River;
8-Authentically established: diamond-bearing or rocks responsible for diamondiferousness;
9-License Area counter

Figure 19. Gravel horizons

Based on the fieldwork results (Fig. 19) of the geological interpretation of the obtained geophysical sections , a series of large-scale maps are constructed. For example, such as maps of equal capacities of the productive horizon, maps of the surface relief of the paleochannel (Fig. 20), and others.

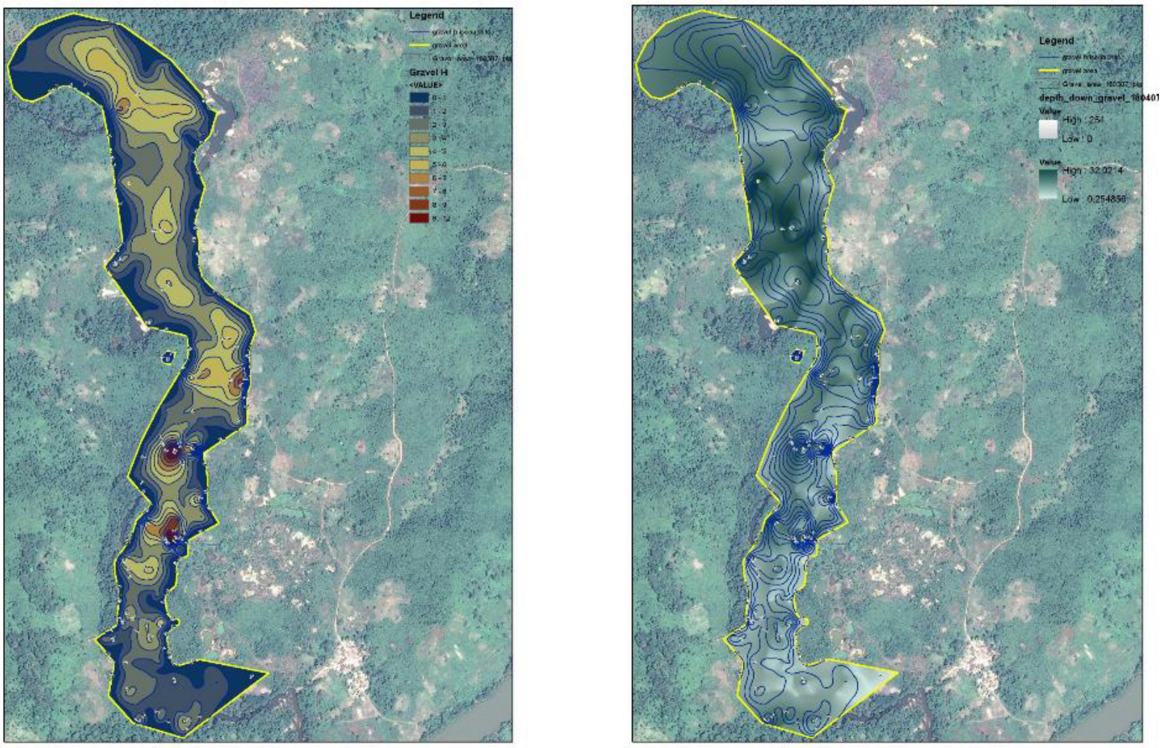

Figure 20. Gravel thickness map (on the left) and bottom relief of the paleo channel's placer

7 CONCLUSIONS

This report reviews a desk top study from historic, published and unpublished sources. It is intended to only hi-lights background information with particular reference of Diamond mineralization and occurrences relating to Sierra Leone.

Kimberlites, the primary host rocks for diamonds, have been discovered in the Koidu and Tongo areas. The primary deposits were found to lie in a ENE-WSW zone, a little to the south of Koidu, with some uncorrelated deposits farther afield. After detailed work conducted by Geological Survey in 1946 concluded in an unpublished report that the diamonds were of local origin and derived probably from kimberlite. Dr. N, R Junner in 1946 postulated that the primary source was in the Woyei Valley near Koidu for a number of reasons;

- The incoming of large concentrations of diamond accompanied by pyrope garnet similar with the pyrope from South Africa
- The occurrence of very large diamonds up to 770 carats
- The presence of unusual amount of framesite and bort

Two well separated areas, pits struck dykes of clayey material, brown at the surface but slightly greenish at the depth of 3.6 m yielded diamonds, pyrope garnet and magnetite. Although the nature of the heavy minerals was suggestive of kimberlite, numerous dykes were located after drilling was conducted.

Another zone of kimberlite dykes was discovered subsequently some 30 miles to the south, the Tongo dykes. Although those dykes were not examined in detailed, recent years of geological work narrowed down economic and mineable deposit in the Tongo area.

Extensive alluvial diamond fields in many parts of the region and an exceptionally rich group of deposits in the Koidu area were also identified by Geological Survey Department. The diamond producing areas are concentrated in Kono, Kenema and Bo Districts and are mainly situated in the drainage areas of the Sewa, Bafi, Woa, Mano and Moa Rivers. To a lesser extent, alluvial diamond occurrences have been reported in some parts of the northern province in the areas of Kambia and Bombali Districts. Alluvial diamond concentrations occur in river channel gravels, flood-plain gravels, terrace gravels, gravel residues in soils and swamps.

The mining industries sector in Sierra Leone is at a transformative stage in its development. Sierra Leone has a long history of mining and, although relatively small by international standards, the sector is extremely important for the national economy.

Notwithstanding its relatively small size, Sierra Leone is widely recognized as a highly prospective target for mining activities. The return to political stability in Sierra Leone coupled with positive global developments in the mining sector now offers the ideal opportunity to rejuvenate the domestic mining sector and to allow it to once again underpin the formal economy and support the Government's developmental objectives.

Positive exploration results, e.g. new diamond and kimberlite findings, and several new diamond projects, approve Sierra Leone's extraordinary mineral potential.

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