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MORPHOLOGICAL FEATURES FROM SEGUELA DIAMANDIFEROUS CRETACEOUS WEATHERED KIMBERLITES COLLUVIA AND ALLUVIA DIAMONDS PLACERS IN CENTRAL-WESTERN OF CÔTE D'IVOIRE.

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ABSTRACT

Seguela diamond in Central-western of Côte d'Ivoire, derived from wethered kimberlites and colluvia and alluvia diamond placers. Kimberlite mineralogy component mainly are olivine, enstatite, phlogopite, amphibole, chromite, Mg-ilmenite, and diamond. Twenty-six (26) diamond samples description in termsof size, weight, morphology, color, fluorescence and inclusions of microdiamonds through macroscopy, microscopy and MEB lead to show morphological features. The most informative trends reflected by the seguela diamonds is probably that increasing development of dodecahedral forms at the expense of octahedral.

These trends associated with the relative abundance of transitional forms indicate that most diamonds apparently originally as octahedral and many were later modified dodecahedral forms Dissolution is principal morphological process. Seguela diamond bearing prospect product stones which weight varied from 0.3 carat to 4 (27 carats the most imporant). Most microdiamonds are either non fluorescent or only very weakly fluorescent. Concentrations of minerals inclusions range from colorless to pale green to black and some have been tentatively identified as garnet, olivine, pyroxene chromite, spinel and graphite.

Keywords: Kimberlite, octa-dodecahedral forms, diamond, dissolution, Seguela, Côte d'Ivoire.

Introduction

An important diamond-bearing field is located in the central-western part of Ivory Coast, 30 km north of Séguéla (Fig. 1,2,3). Diamonds, averaging 0.3 ct, are disseminated into eluvia, colluvia and alluvia and originated from the two main kimberlitic dykes of Bobi and Toubabouko. The richer parts of the field were formerly mined by two companies. Now, only individual diggers are working in all the area. The dykes, trending N170°, crosscut the granitic plutons and amphibolites of the Palaeoproterozoic Birimian formations of the West-African craton [1]. One granite is dated at 2.091±8 Ma [2]. The dyke of Bobi (BD) is 2.5 km long and 25 to 50 cm wide. Length of the dyke of Toubabouko (TD) reaches 4.5 km and its wideness, 80 cm to 1 m. In the northern part of this dyke, a particularly enriched zone was recently dug in a large area in a 80-m-indiameter and 30-m-deep pit (N 8°15′22, W 6°37′57). Here, we discovered a typical kimberlitic diatreme with its complete lithostructural features. Diamonds have been isolated from weathered kimberlite, colluvial, and alluvial diamond placers. Twenty-six (26) diamonds crystals have been recovered in purpose of morpholigical features studies and physical process responsible for these stones. The Diamonds quality has been arbitrally subdivided into two groups gem quality and non-gem stones.However the major objective of this pape rise to report on the occurrence of diamonds in the Seguela area from Cote d'Ivoire and to indicate the general trends of physical properties observed in stones recovered.

1. Geological setting

We distinguish three petrographical types: *sensu stricto* kimberlite, kimberlite enriched in olivine nodules, and micaceous kimberlite or lamproite. The common kimberlite is a fine-grained aphyric rock at thedyke margins, or moderately phyric inside the two main dykes and intothediatreme. Phenocrysts consist of olivine totally replaced by serpentineat depth, magnetite grains, xenomorphic Mn-ilmenite, and accessory magmatic minerals: apatite, titanite, zircon, baddeleyite, monazite, priderite, jeppeite and diamonds. Abundant secondary mineralogy in the groundmass consists of Mg-chlorite (penninite), saponite, celadonite, talc, anatase, iron hydroxides, calcite and quartz. The walls of the pit exhibit a pile of breccias consisting of decimetric and more or less rounded blocks of aphyric kimberlite highly altered into talc and celadonite. Blocks are cemented by accumulation of 2-mm to 2-cm fragments of pegmatitic granite material with mono- and polycrystalline debris of quartz, potassic and sodic feldspar, muscovite and rare biotite. This cement reaches 30 to 40% of the breccias. In the deeper part, there are larger blocks, around 1 m, embedded in stratified granite clasts. No xenoliths were found. At the upper middle bench of the eastern wall, a finely stratified and horizontal sedimentary clay layer overlies the lower breccias and is slightly curved against the breccias of the flank. It is made of kaolinite millimetric beds including silty-sized quartz, potassic and sodic feldspar angular grains, iron hydroxides and alternation of cumulated flakes of phlogopite altered into smectites [1], [2], [3]. This layer corresponds to a lacustrine sediment. If we extend to the centre axis of the pit of the strata preserved on the bench, we reconstitute a 1.5- to 2.5-m-thick clay layer, which was in the middle part of the breccia area, and, before the digging, below the overlying colluvia and alluvia placers. This kind of sediment was deposited in a pond of a kimberlitic breccia crater, i.e., in a maar. At some one hundred of meters in the northern prolongation of the dyke, two additional occurrences of kimberlitic breccia are partly exposed. That means the dyke emplaced at a very shallow level and evolved to explosive diatremes at its northern end.

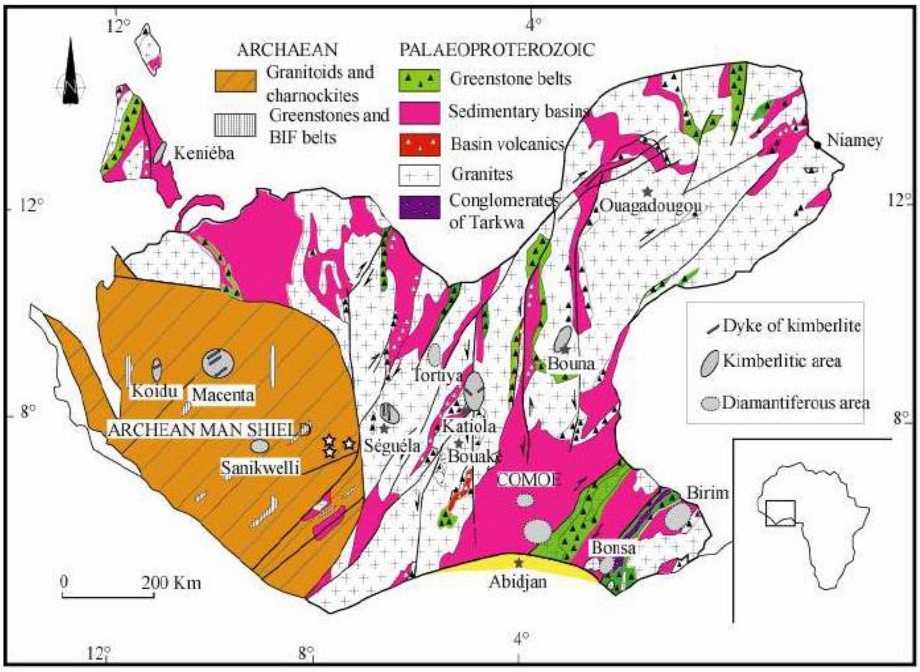


Figure 1: Geological map of Archean and Paleoproterozoic formations in Man shield (modified after [4]).

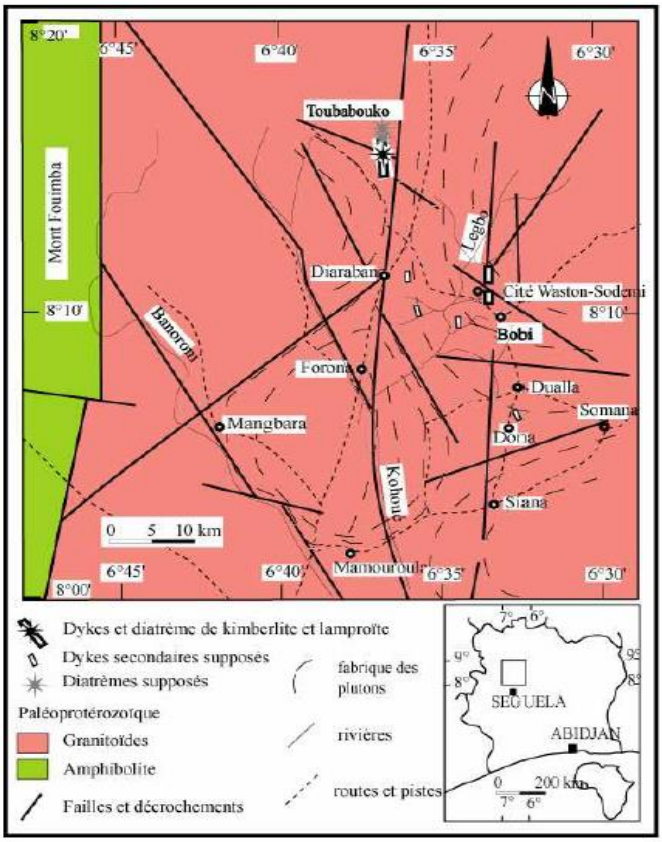


Figure2: Geological map modified of Seguela North (after[1]).

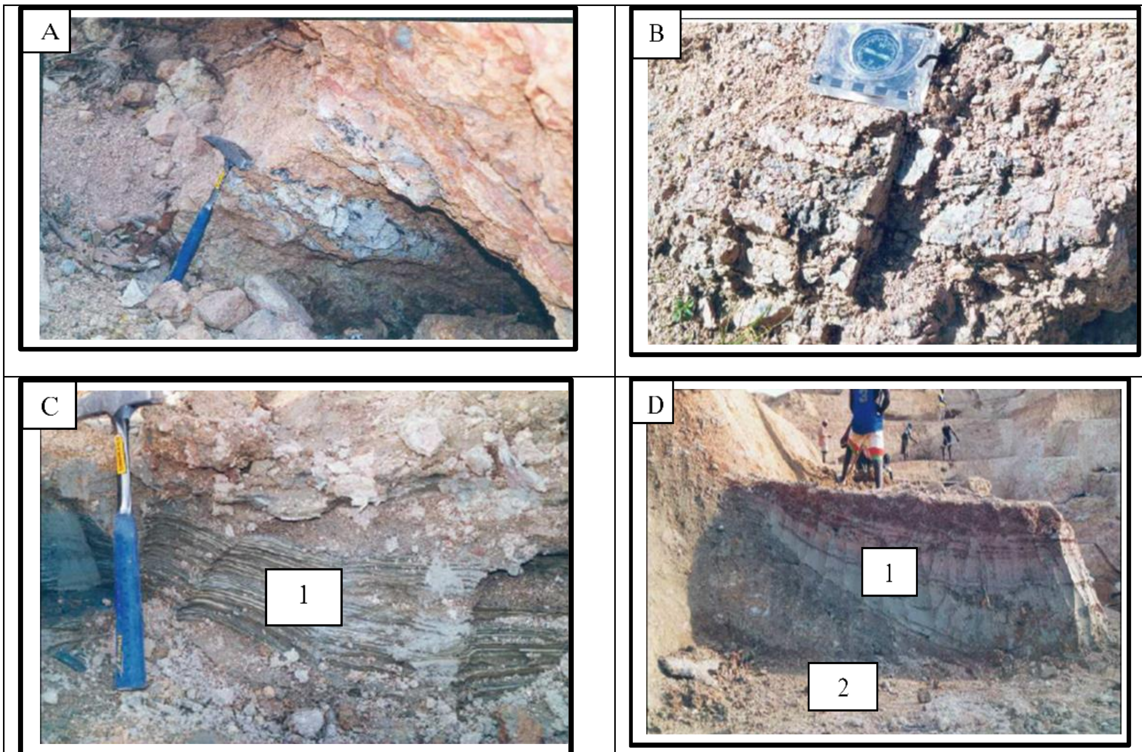


Figure 3 :Kimberlitic diatreme. A : Olivine kimberlite from Toubabouko dyke ; B : Bobi dyke kimberlite ; C 1 et D 1 : sedimentary deposit ; D 2 : Surface feature of de Toubabouko dyke

2. Methodology

The twenty-six (26) were collected from Bobi, Toubabouko, Forona, Diarabana samples. Crushing and settling process had been used to recovered diamonds samples in kimberlite. The samples were sieved through 3.3mm and 1.5 screens. Material larger than 3.3mm was scanned visually but no diamonds have been recovered from this samples fraction. The remaining heavy mineral concentrate was then examined under a regular binocular microscope and suspected diamonds were tested under a polarizing microscopic for isotropy and refractive index. A number of crystals have also been examined by scanning electron microscope (MEB) in order to better evaluate surface features. The diamonds are described according to the six-fold classification of [5]. This system is based on predominant crystal forms and subdivides stones into octahedra, rhombic dodecahedra, fattened dodecahedra, macles aggregates, and irregular shapes. For octahedra-dodecahedra forms, all crystals haing more than 75% (111) faces are classified as oactahedra, whereas those with more than 75% (110) faces are designated dodecahedra. All crystals with intermediate combinations of (111) and (110) faces are assignated to the octahera-dodecahedra transitional group. Broken or partially formless crystals are classified according to the relative percentage of faces present or preserved. Most aggrgates are comprised of octahedral forms and complex interpenetrations of octahedra. Diamonds show degree of fluorescence in ultraviolet light varying from pale to bright-yellow colors. Concentrations of mineral inclusions in the various diamond types identified by microscopy (KSW4000 AKrüss optometric) or MEB analysis range from colorless to pale green to black.

3. RESULTATS

3.1. General morphological features

Most of the diamond have at least few octahedral faces; in octahedral transitional octahedra-dodecahedra, and aggregate types these faces are generally aboundant and well-developped. Dodecahedral faces, although subordinate to octahedral forms are prominent in many of the aggregate as well as the various dodecahedral types. Many of the dodecahedral faces are characterized by the presence of fine ridges or seams along the short diagonals of the unit rhombs producing a partial development of the tetra kishexahedral forms.

3.1.1. Surface features

Lammelar buildup of thin platelets on (111) surfaces is very prominent in octahedral forms.

Where layers are only partially developed on faces, triangular –shaped growth platelets are or terraces formed similar to those described. Trigons (triangular shaped pyramidal or flat-bottomed depressions) are relatively common particulary on (111) surfaces of octahedral, although they have been observed in dodecahedral forms. The trigons are oriented in a reverse direction to that of the face on which they occur and they are considered to be solution features. The ecth pits commonly in association with abundant near-surface mineral inclusions may give a corroded appearance to the crystal.

Surface features are related to the morphology of the diamonds. With specific features restricted to dodecahedral faces, and others seen only on octahedral faces. As a consequence of the dominance of the dodecahedral stones in the sample set features created by the resorption of octahedral growth layers dominate. These features include hillocks and terracing. Trigons (triangular shaped pyramidal or flat-bottomed depressions) are relatively common particulary on (111) surfaces of octahedral, although they have been observed in dodecahedral forms. The trigons are oriented in a reverse direction to that of the face on which they occur and they are considered to be solution features. The ecth pits commonly in association with abundant near-surface mineral inclusions may give a corroded appearance to the crystal. Dark green spots were recognised on samples. Plastic deformation line visible on resorbed faces are commonly associated with brown colouration. Rare surface features includes tetragones on (100) fracture face and observed in only one case microdisks patterns. These physical characteristics for diamonds consist of octahedra, dodecahedra, twins, aggregates, by the latter being dominated by grey resorbed forms. Two (02) broken stones are represented by samples (DT 09, DT 25). Sample DT 08 is characterized by cleavage on faces. Samples DT 20, 21, 22, 23, 24, 25 and 26 presented irregualr shapes forms. This leads to problem of stones identification. Dissolution process is responsible for these physical characteristics.

3.1.2. Gem quality diamonds

Diamonds are generallly colorless. However, together diamonds present a great variety : early yellow to green samples (DTN 5, 8, 9,15) ; then grey diamond (DTN 12, 13) ; brown samples (DTN 1, 3, 4, 18, 19, 16) finally colorless diamonds (DTN 2, 6, 7, 10, 14, 11, 17).

A) Octahedra diamonds

Stones include regular and distorted planar and laminated types and they grade into dodecahedral forms. Most of the octahedra stones present pronounced lamellar buildup on (111) surfaces (figure 4B, 4J), and the largest crystal recovered to date from the Bobi princess dike is a 0.76 carat distorted octahedron with prominent growth platelets (figure 4B, 4J). Well laminated octahedra present a ronded appearance that is caused by the progressive decrease in platelet size on (111) surfaces.

B) Transitional Octahedra-dodecahedral

Octahedral stones forms become progressively more rounded as dodecahedral faces are developed (figure 4A, 4L). Many of the dodecahedral faces in the transitional series show partial formation of tetrakishexahedral forms (figure 4A). Crystals of the transitional category present octahedral and dodecahedral faces in combinations. Rounded octahedra-dodecahedra transition crystals were recognized.

C) Rhombic and Flatened dodecahedra

Stones present in excess of 75% dodecahedral faces they are characterized by one axis. Crystals are well developed dodecahedron (figures 4A, 4C, 4G, 4P). It exhibits tin lamellar growth platelets that converge on one of the triad axes and small trigons one several faces. Relict octahedral faces have preserved and poorly developed tetrakishexahedral forms are defined by fine ridges along short diagonals of many rhombic faces. The flatened dodecahedra are characterized by rounded edges and curved to irregular elongated faces that locally are conchoidally fractured and pitted (figures 4A, 4C, 4G, 4P). Prominent growth lamellae are present on some surfaces and trigons are locally abundant

D) Macles

The macles crystals category include the generally flattened crystals that are twinned according to the spinel twin low (figures 4D and 4N). Several of the macle show a somewhat distorted triangular shape (figure 4N.). Although most typically express two irregular triangular (111) faces paralleling one another across a spinel twin plane.

3.1.3. Non-gem quality diamonds

Non-gem quality diamond are mainly colored gray to brown. Stone are considered as borts. Morphological characteristics of these stones are described and consigned in figures below.

Flattened brown stone with trigons 0.1435cts to 0.0287 g physical features are described in figures below.

A) Aggregates

Aggregate diamonds are those comprised of two or more crystals that have grown together either randomly, as interpenetrant twins, or as combinations. Although intergrowths of octahedra predominate, dodecahedral forms are also common and generally occur in combination with octahedral forms (figure 4K and 5F). Lamellar platelet buildup is very prominent on many of the (111) faces present in the aggregates, and well-defined triangular platelets, trigons and etch pits are locally abundant. Many of the octahedra intergrowths are controlled by interpenetrant twin laws. The most common twin type involves a series of uniformaly oriented intergrowth octahedra that have mutually parallel «a» axes.

B) Irregular shapes

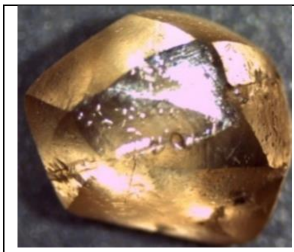
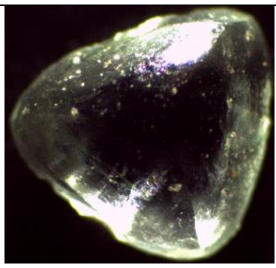
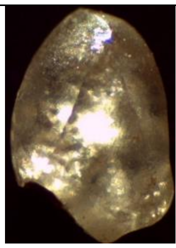
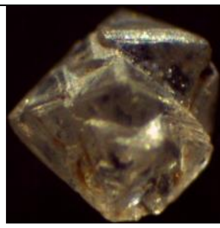
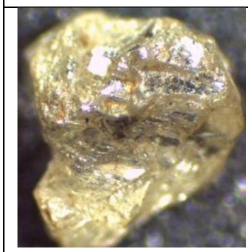
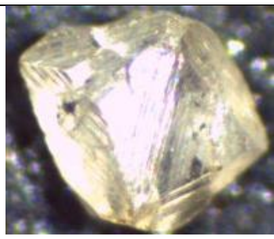
It has irregular rounded surfaces, shows growth lamellae on the margins of a local depression and has abundant irregular shaped etch pits (figure 4 E, O and figure 5A).

3.2. Color

Diamonds are generally colourless. However, together diamonds present a great variety : early yellow to green samples (DTN 5, 8, 9,15) ; then grey diamond (DTN 12, 13) ; brown samples (DTN 1, 3, 4, 18, 19, 16) finally colorless diamonds (DTN 2, 6, 7, 10, 14, 11, 17). A high proportion of the diamonds have a pale colour, typically yelow to brown. Whilst yelow diamond colour is cauded by nitrogen impurities, brown colouration is attributed to defects in the crystal lattice due to strain. The remaining stones are classified as colourless.

3.3. Mineral inclusions

Based on microscopic examination, mineral inclusions in Seguela diamond appered to be peridotitic in paragenisis, with abundant Mg-chromite, spinel, olivine, pyroxene and garnet ; observed in figure K,L, M and O. Assertion justfied by [1],[3].

 G : x80			
A :Rhombic-dodecahedrons howing well developed partial tetrakishexahedral form	B : Octahedra curved faces courbes et lisses.	C :Rhombic-dodecahedron curved faces	D: Macles
 x80			
E:Irregular Crystal surfaces	F : Octaedra planes faces	G: Rhombic-dodecahedroncurved and planes faces	J: Octahedra planesfaces

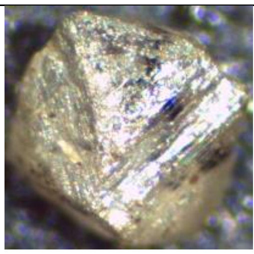
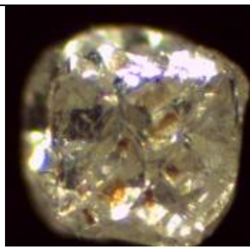
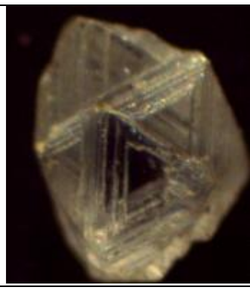
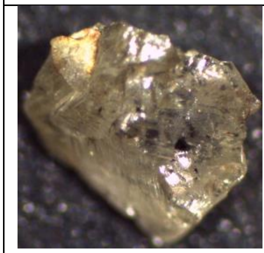
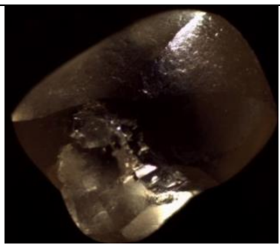
	 G :x80		
K : Aggregate distorded with black inclusions	L :Transitionnaloctahedra-dodecahedral resorbed form withmineralinclusions	M : Cubo-octahedra, glassy with trigons on surfaces	N: Macle withtrigons
 X80			
O:Irregular shape with black inclusions.	P:Dodecahedrawithrounde d faces	Q : Irregularshape	

Figure 4: Gem quality diamonds from Seguela in Côte d'Ivoire

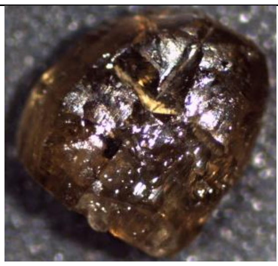
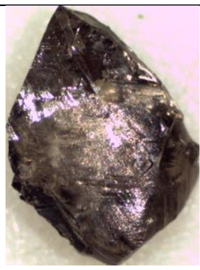
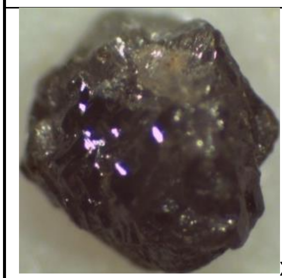
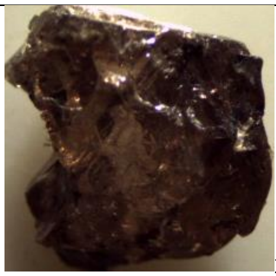
		 x80	
A :Irregular dodecahedra flattened	B: Rounded dodecahedra faces with 2 plans of cleavage.	C: Stone with trigons on surface.	
 x80	 x80		
F: Irregular shape	F: Aggregate form	H: Aggregate : Rhombodo-decahedra broken curved faces	

Figure 5: Non gem quality diamonds from Seguela in Côte d'Ivoire

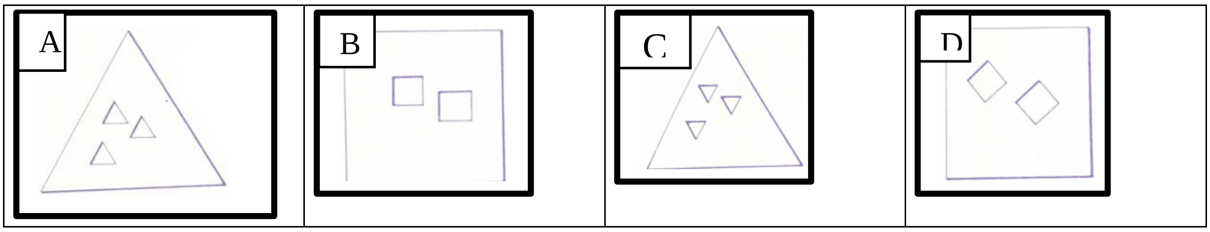


Figure 6 : A et B : Triangular growth platelet on surface ; C et D : Corroded faces

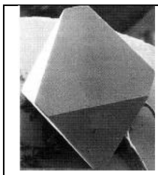
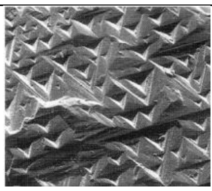
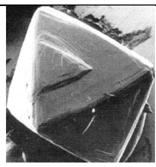
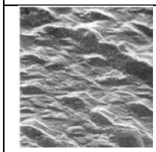
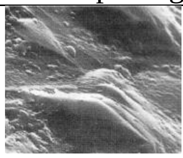
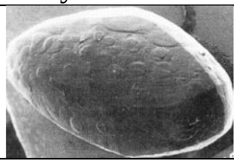
		
A: Octahedra faces	B: Morphological well	C: Pyramidal faces
		
D: Laminated surface	E: Corodedoctahedral surface	F: Disk form

Figure 7: Photographies au microscope électronique à balayage des formes des diamants de Seguela (Côte d'Ivoire).

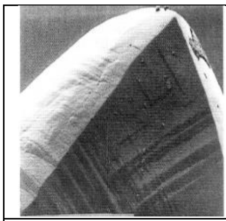
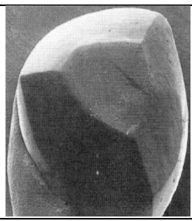
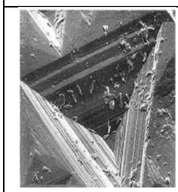
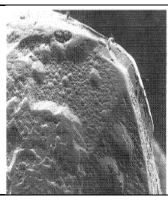
		
A: Parquetry form	B: Trisodecahedral (111) associate to curved faces	C: irregular Face
		
D: Etch pits on surface	E: Growth hillockon surface	F: disks patterns

Figure 8: Microscopic Electronical Photography of growths features faces observed on Seguela diamonds (Côte d'Ivoire).

Tableau 1 : Indicator values of Seguela diamonds from Côte d'Ivoire.

Groups	**Weight (Carat)**	**Current rate (F CFA/ct)**	**Max rate (F CFA/ct)**	**Observations (forms)**
White stones	0.50	12 500	80 000	See distorsion
	0.50 – 1.00	100 000	150 000	

	1.15 – 3.00	200 000	500 000	
Brown stones	0.50	7500	10 000	See distorsion
	0.50 – 1.00	12 500	25 000	
	1.15 – 3.00	30 00	80 000	
Fancy stones		5000	5000	
Broken		2500	2500	

4. DISCUSSION

Seguela kimberlites and sedimentary deposits (alluvia, coluvia) diamonds, are mainly characterized by three types of facial crystals forms which are plane, curved and combined. They are associated to geometric figures features observed on growth and corrosion oriented faces. Diamonds faces often show corroded octahedral features forms like triangular base. Growth features are represented by, orientated triangles. In opposition corrosion features angles are different compared to octahedra faces (figure sometimes, two or many crystals are combined or associated to octahedral face [6]. There are twin which depend on symetry operation. Stones faces correspond to diamond octahedral faces (111). Perfect crystals are represented by octahedral habitus. Rarely faces planes stones with some features as hillock, pyramidals are observed.

Rhombicdodecahedra, octahedral and dodecahedra diamonds show that there are partially resorbed by oxydation process during ascension from lithospheric mantleto earth surface [7],[8]. However, microdiamonds presents the same features as macrodiamonds which support the cogenetic source.

Seguela kimberlite derived from primitive mantle peridotites [9], [10],[11],[1]. In West -Africa we observed three kimberlitic diamonds origin process: firstly kimberlitic origin is date to 2200 (±100 Ma), and derived from primitive mantle peridotites. Weathered kimberlite, lamproite and peridotite process leads colluvia, alluvia from Tarkwa in Ghana and conglomeratic paleoplacers from Tortiya and Seguela in Côte d'Ivoire formation;

Secondly kimberlitic magma origin is date to 1429 Ma, and materials are péridotitic micaceous dike associated to metasomatism observed in Côte d'Ivoire (Seguela) and Gabon. Thirdly kimberlitic diamond originis Cretaceous (92 Ma) and mainly characteristics are kimberlites, dikes, and pipes. They are most economical importance and represented by colluvia in Sierra-Leone, Guinea, Mali, Côte d'Ivoire (Seguela) and Nigeria [2].

Conclusion

Seguela diamndiferous kimberlite area is well known in Côte d'Ivoire. Wethered kimberlite and sedimentary deposit ores are principal components. Gem or non-gem quality diamonds recovered crystallines forms which are mainly characterized by octahedral or dodecahedra, macle and aggregate habitus. These forms are distinguished by faces number, type and accessories features from each faces. Seguela diamonds faces are plane, flattened, curved or combinated forms. Curved faces observed on octahedral or dodecahedra Seguela stones have been considered as dissolution products. Trigons (hallow faces) represented accessories features resulting from growth and dissolution process or combined process. Stones which derived from corrosion as disks or pyramidal forms derived from combined process. Resorption process are responsible for microdiamonds population formation. In view of all this we can conclude that macrodiamonds are older than microdiamonds. Petrology nature of kimberlite and lamproite are characterized by peridotitic or eclogitic source.

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