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Cartographic Study and Modeling of the Bakwanga Kimberlite Massive 5 at Kasai Oriental in the Democratic Republic of Congo

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Abstract

Bakwanga kimberlite massive 5 in Kasai Oriental is part of a set of 13 kimberlite massives numbered according to the order in which they were discovered. They are located on an alignment with a more or less W-E direction making up the Northern group known as Bakwanga. The importance of the Bakwanga kimberlite massives on the country's economy in the production of diamonds sufficiently proves the interest of geological research work in this area. The objective of this work is to determine a mathematical model of the shape of the massive as close as possible to reality and through cartography. The cartographic study and modeling of this kimberlite massive were carried out using data from core samples taken on longitudinal and transverse profiles of the 50 × 50 meter mesh drilling plan intersecting this kimberlite massive. We intend to deduce the structure and lithostratigraphy of the kim-berlitic facies and the direct environment of massive 5. As a result, we note that the majority of surveys on the extent of this massive have intersected: Red clayey sand - Polymorphic sandstone - Nodular sandstone, with kaolin blocks and nodules - Epiclastic Kimberlite - Xenokimberlite - Massive Kimberlite - Mesozoic sandstone - Dolomite (enclosing). The shape of the Massive 5 model is vaguely elliptical with a W-E longitudinal axis of 575 m and N-S axis of 275 meters. Surveys have shown that Massive 5 is in fact composed of two pipes, located in the W (western pipe) and E (eastern pipe) ends of the massif. The two chimneys of the two pipes have walls ranging from subvertical at the eastern pipe to very steep walls of around 70˚ to 80˚ for the western pipe and the average diameter of the two pipes is ±50 meters. At level 600, the massive has an area of ±10.5 hectares and it gradually decreases in depth and the modeling of the latter shows a concentric decrease in the volume of the massive from the surface to depth in the shape of a mushroom. 3 eruptive phases established this Kimber-litic massive, the first two phases (old) of which formed the crater of the western pipe and the third formed the crater of the eastern pipe in the dolomites. These dolomites constitute everywhere the surrounding area of the massive; the distinction of these 3 phases is made possible thanks to Epiclastic deposits, Xenokim-berlites and massive Kimberlites.

Keywords

Massive Kimberlite, Cartography, Modelization, Epiclastic Kimberlite, Xenokimberlite, Pipe

1. Introduction

The seat of numerous magmatic phenomena, the Democratic Republic of Congo (DRC) is home to several Kimberlite occurrences. For the petrologist and mining geologist, these occurrences (or deposits) constitute sources of information of primary importance because they are in fact direct samples of the upper mantle and the main sources of diamond (Mvuemba, 1980).

The study of Kimberlite deposits, their exploitation, and even their form in depth, are subordinated to the understanding of the processes and conditions of their establishment and this understanding involves several geological studies, in particular, the study of their constitution, their origin and the determination of their structure and shape in depth (MIBA-DE BEERS Technical Report, 2009).

The importance of the Bakwanga Kimberlite massifs on the country's economy in the production of diamonds sufficiently proves the interest of geological research work in this area. Thus, the shape in depth or the modeling of these massifs thanks to the mapping of the wells based on the drilling and survey work carried out proves imperative to better circumscribe and guide the miner and geologist in their task in the mine. To this end, these studies are of interest to the miner in establishing the exploitation plan and constitute a great interest for the geologist in the interpretation of the structures of the massif as we have discussed in this work.

With a view to carrying out research work, we set ourselves the task of taking stock of the knowledge on one of the Kimberlite massifs of Bakwanga (mass-sif 5) and more precisely in the mapping and modeling associated with the interpretation of the structures, the different eruptive formations and the succession of geological formations associated with this Kimberlite intrusion.

To our field work, we associated the most recent data from drilling and survey work carried out on massif 5 by the Société Minière de Bakwanga.

2. Study Area

Geographically, the Kimberlite massive 5 is part of the 13 Kimberlite pipes that constitute the mining deposits of the Society Miniere de Bakwanga "MIBA" forming the North group. They are located in its operating headquarters commonly called the mining polygon (having an area of 6000 km^2), in the province of Kasai Oriental in the town of Mbujimayi. These kimberlite occurrences meet between the parallels 6˚ and 7˚ of South Latitude and 23˚ and 24˚ of East Longitude (**Figure 1**).

The area under study is located in a region with a 2-season tropical climate which extends throughout Kasai (Robert, 1946). It should be noted that there are two categories of materials in which the Kasai soil develops, namely:

- ✓ The products of on-site alteration of the covering formations which result from transport and deposition on the bedrock;
- ✓ Mixed materials resulting from more or less significant contamination of the first by the second (Gilson & Liben, 1960) and, finally,
- ✓ Lateritic soils.

The vegetation of the square degree of Mbuji-Mayi is characterized by a mixture of savannahs, shrub savannahs of various types, gallery forests and patches of tropophytic forest (Duvigneau & Leonard, 1953).

Morphologically, the entire South-Eastern Kasai region is part of the immense péneplaine which, starting from the Cuvette Congolaise, slowly and gradually rises towards the South where it is connected with the help of elevation focused on the main line. Congo-Zambese (Raucq, 1959). This area essentially belongs to three West-East hydrographic basins: the Lubi basin, the Mbuji-Mayi basin and the Luilu basin.

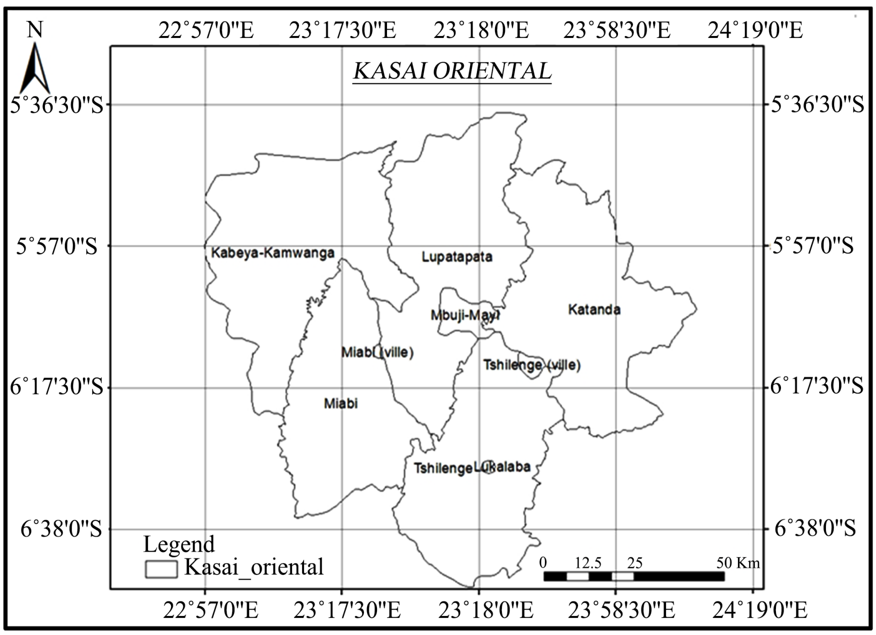

Figure 1. Geographic map of the Kasaï-Oriental province.

Geologically, the main stratigraphic groups of Kasaï Oriental are as follows (Mvuemba, 1980):

➢ The formations of the Proterozoic basement:

These are gneiss of the upper Luani, the gabbronoritic complex and migmatite of Dibaya of Archaean age, the meta-sedimentary complex of Luiza, the volcano-no-sedimentary complex of the Lulua and the super group of the Mbuji-Mayi of Neoprotero-Zoic age.

➢ Phanerozoic cover formations:

Let us note first of all that the Paleozoic is completely absent and that the covering lands are represented by the Mesozoic, the Tertiary and the Quaternary. For the Mesozoic, these are conglomerates and sandstones of the lower Kasai series; for the Tertiary and Quaternary, polymorphic sandstones (Paleogene) and ocher sands of the Kalahari system; sands, gravels and alluvium of low terraces alluvial plains.

Note also that the kimberlite occurrences of Bakwanga were able to cross the following formations:

- ✓ The Precambrian granite base;
- ✓ The Mbuji-Mayi super group;
- ✓ The sandstone layers of the Mesozoic.

Regarding kimberlite, note that it is one of the rare ultrabasic potassic rocks, rich in volatile elements ($CO_2 + H_2O$), appears in diatreme, dike or sill. Its study is profitable for two reasons, namely:

From a scientific point of view, it contains samples of the upper mantle and fragments of crustal geological formations (xenolites) encountered during the ve-nue (Mvuemba, 1980; Mvuemba et al., 1982).

From an economic point of view, it is the main primary source of diamonds which represents considerable wealth for certain countries, notably the DRC.

Kimberlites are the products of continental intra-plate magmatism whose occurrences are located in the heart of the craton or at its edge and no occurrence have been described in the oceanic environment or in young folded zones (Wagner, 1914). From the textural point of view, three genetic types have been defined (Clément & Skinner, 1985): the Crater, diatreme facies and the hypabyssal facies, each facies is associated with a particular style of magmatic activity and characterized by petrographic types such that the facies of the crater shows that the kimberlitic magma which rarely appears in the form of lava, but rather appears in the form of pyroclastic deposits, the facies of the diatreme is often dominated by kimberlitic breccias containing angular fragments of rocks on the other hand, the hypabyssal facies shows a typical kimberlitic rock without pyroclastic fragments.

Concerning the nomenclature of kimberlites, since 2002 MIBA has adopted a terminology based on the composition of the rocks and inspired by Ruse literature (**Figure 2**) (Milashev, 1963).

In Mbuji-Mayi, it is easy to distinguish between the compositions of volcanic rocks simply by their color. Thus, we qualify as:

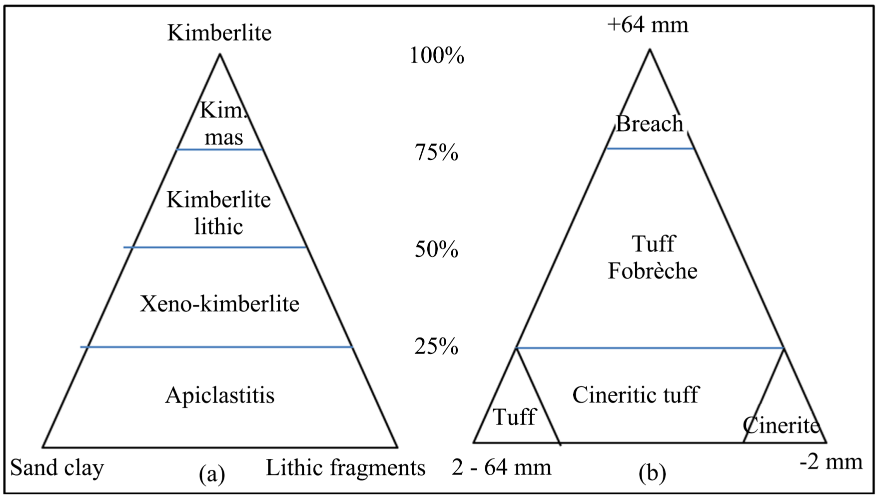

Figure 2. Triangular diagram of kimberlite classification. (a): depending on the lithological composition and (b): depending on the size of the elements (Milashev, 1963).

- Kimberlites: consolidated but relatively loose rocks, green in color and always containing more than 50% of kimberlite products;
- Epiclastics: rocks containing less than 25% kimberlitic products, red in color and not consolidated;
- Xenokimberlites: weakly consolidated rocks with 25% to 50% kimberlitic elements and red-green color.

Locally, the kimberlite of Eastern Kasai crossed the entire Precambrian (basement and its exposure) and the sandstone Mesozoic before being eroded and covered by the Tertiary and the Quaternary.

It is presented in two groups: North group around Mbuji-Mayi, between the Mbuji-Mayi river and the Kanshi river; Southern group around Tshibua.

The first (known as Bakwanga) is made up of 13 massifs (points) of which 9 are in an East-West line at N110˚ - 190˚ in a chain and 4 are contiguous. The second said Bak-wa-Kalonji is made up of 6 massifs, the largest of which follows the E-W to WNW-ESE direction along a gabbronoritic.

The essential difference between the kimberlite of these two groups lays in the absence or rather the rarity of carbonate xenoliths in the South branch. This is a difference linked to the lithology of the surrounding rock (Mvuemba, 1980).

According to Meyer de Stadelhofen (1963) the Kasai kimberlite is a breccia and was able to demonstrate the existence of three types of kimberlite breccia: leached breccia, cemented breccia and kimbelite autoliths. Demaiffe and Fieremans (1980-1981) carried out a series of relatively detailed chemical analyzes of the nodules they studied and concluded that it is a kimberlite enriched in volatiles.

Based on lithostratigraphic arguments, Fieremans (1966) postulated a Cretaceous age for the Kasai Kimberlite, Davis and Boyd (1966) determined an age of 71.3 million years from the zircons and which confirms Fieremans' (1966) hypothesis.

3. Methodology

The mapping and modeling studies of kimberlite massif 5 were carried out using data from core samples taken on longitudinal and transverse profiles of the 50 × 50 meter grid drilling plan intersecting this kimberlite massif.

By modeling, we mean the determination of a mathematical model of the shape of the massif, as close as possible to reality. A certain number of points have thus been defined to allow the computer to create a truly similar model. The method used for this purpose is that of linear interpolation on an irregular triangulated mesh.

Data Presentation

On the extensional air of the kimberlite massif 5, a total of 94 soundings were carried out by MIBA to interpret the structure and modeling of the massif including (Figure 3):

- ✓ 17 boreholes dating from the 1950s were carried out by Foraky mainly in dry setting. These surveys were of excellent quality;
- ✓ 66 rotary core drillings carried out by the "DB 450R", "DBH 747" and "Longyear LF 70" drills since 1996;
- ✓ 11 destructive rotary surveys carried out by the "Wirth L3A" probe for grade sampling at 5 meter levels.

The compilation of all this information allowed us to constitute a database of surveys shown in Table 1 and Table 2 below:

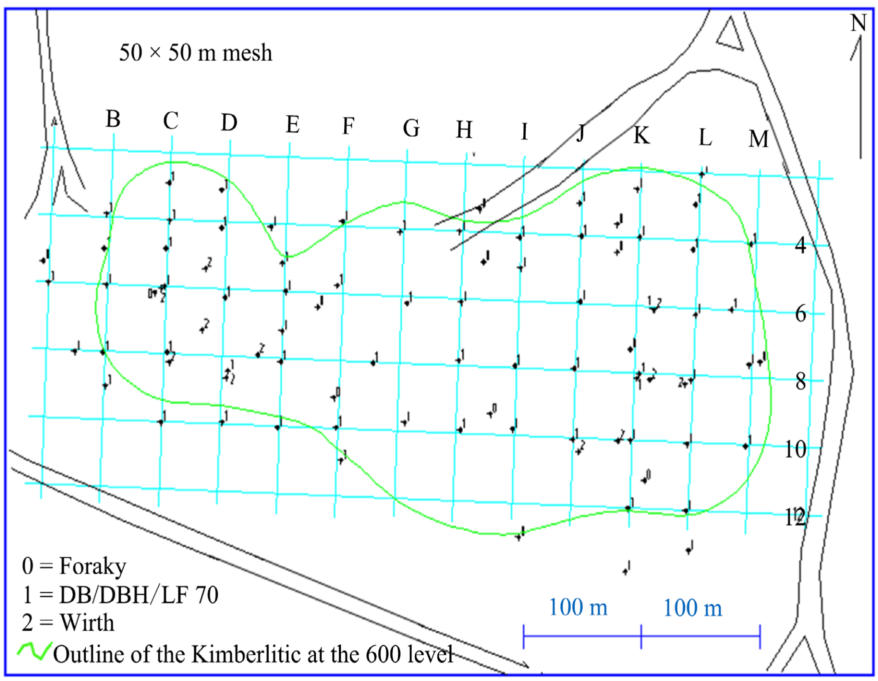

Figure 3. Situation of all surveys on massif 5.

Table 1. Contact details—Massif 5 surveys.

N°	Well	Drilling type	X	Y	Z
1	A6	DBH	5232.5	3444	604.16
2	A'8	DBH	5254.74	3392.43	603.71
3	B4	LF70	5282.19	3494.64	598.8
4	B5	DBH	5280	3469	605.15
5	B6	DBH	5281.5	3442	603.83
6	B8	DBH	5279	3392	602.84
7	B9	DBH	5281	3367	603.59
8	C3	LF70	5334.99	3517.65	605.34
9	C4	LF70	5335.79	3489.62	603.32
10	C5	DBH	5332.5	3469	605.39
11	C6	DBH	5331	3441	602.23
12	C8	LF70	5333.37	3391.88	581.42
13	C10	DBH	5328	3340	604.65
14	D3	LF70	5379.93	3512.34	605.8
15	D4	LF70	5379.74	3484.21	601.9
16	D6	LF70	5382.77	3432.39	585.19
17	D8	DBH	5385	3378	601.08
18	D10	DBH	5380	3340	603.77
19	E4	LF70	5421.58	3484.88	601.12
20	E5	DBH	5431.5	3458	601.13
21	E6	DB	5434.15	3437.29	579.78
22	E7	DBH	5431	3407.5	600.84
23	E8	DBH	5430	3385	601.24
24	E10	DBH	5427	3336	601.85
25	F4	DBH	5482.5	3489	601.86
26	F6	DBH	5478	3441.46	574.61
27	F'8	DB	5508.51	3383.71	573.23
28	F10	DBH	5477	3336	601.38
29	F11	DBH	5481	3311.5	604.89
30	G4	DBH	5531.51	3481.43	602.36
31	G6	DB	5537.32	3428.26	566.62

Continued

32	G10	LF70	5534.97	3339.54	562.26
33	H2	DB	5593.94	3540.48	609.14
34	H4	DBH	5582	3481.5	601.77
35	H6	DBH	5583.22	3429.14	568.34
36	H8	LF70	5581.09	3385.63	560.4
37	H10	LF70	5582.33	3334.17	559.26
38	I4	DBH	5633	3477	601.49
39	I5	DBH	5633.79	3454.22	572.22
40	I8	DB	5629.01	3381.67	562.05
41	I10	LF70	5627.01	3334.64	547.65
42	J3	DBH	5684	3502.5	601.77
43	J4	DBH	5685.5	3478	601.31
44	J6	DB	5684.4	3429.62	562.84
45	J8	DB	5679.15	3379.72	559.89
46	J10	DBH	5678	3327	602.07
47	K3	DBH	5733	3513	602.03
48	K’4	DB	5735.14	3477.39	558.45
49	K6	DBH	5746	3424	603.79
50	K8	DBH	5732.5	3372.5	602.24
51	K8	LF70	5734.59	3375.84	558.9
52	K10	DBH	5727	3326.5	602.24
53	K12	DBH	5725	3276	601.99
54	K14	DBH	5722.75	3229	628.33
55	L2	DBH	5788	3524	603.16
56	L3	DBH	5782.5	3501.5	603.04
57	L4	DBH	5780.5	3468	602.48
58	L6	DBH	5782.5	3419.5	603.3
59	L’6	DBH	5813	3423.5	610.27
60	L8	DBH	5778.5	3371	606.31
61	L10	DBH	5775	3323.5	608.71
62	L12	DBH	5774	3274	602.62
63	L13	DBH	5776.5	3244.5	618.45

Continued

64	M4	DBH	5829.5	3472	609.17
65	M8	DBH	5828	3382.5	608.12
66	M10	DBH	5825	3322	602.84
67	C5.5	Wirth	5366	3454	602.52
68	C6	Wirth	5328.5	3439	602.36
69	C7	Wirth	5363.12	3408.48	601.68
70	C8	Wirth	5335	3384.5	602.98
71	D’8	Wirth	5410.5	3390	601.71
72	D’8.5	Wirth	5383.5	3373	602.03
73	J10	Wirth	5683	3318	602.43
74	K10	Wirth	5716.5	3326	603.42
75	K6	Wirth	5748	3424	603.6
76	K8	Wirth	5743.5	3371.5	604.31
77	L8	Wirth	5773.5	3368	604.53
78	17	Foraky	6015	3304	645.7
79	18	Foraky	5960	3394	646.5
80	20	Foraky	6167	3220	644.2
81	69	Foraky	5989	3363	647.7
82	3	Foraky	5608	3346	643.7
83	4	Foraky	5602.5	3459	639.7
84	5	Foraky	5632	3254.5	648.2
85	6	Foraky	5323	3436	637.7
86	7	Foraky	5461.5	3425.5	639.4
87	8	Foraky	5228	3460	637.7
88	9	Foraky	5837.5	3384.5	644.7
89	11	Foraky	5475	3358	640.2
90	12	Foraky	5599	3498	637.7
91	14	Foraky	5739	3296.5	647.7
92	15	Foraky	5727	3394	642.7
93	16	Foraky	5716	3466.3	640.1
94	112	Foraky	5716	3486.8	604.7

Table 2. Massif 5–Database.

N°	Sond	Ep	Lith	Ep	Lith	Ep	Lith	Ep	Lith	Ep	Lith	Ep	Lith	Ep	Lith	Ep	Lith	Ep	Lith	Total
1	A6	57	S																	56.96
2	A’8	8.25	S	24.4	Epi															32.65
3	B4	26.4	S	70.6	Epi	3.65	C													100.60
4	B5	12.3	DC	12.2	Epi	39.7	Q													64.15
5	B6	14.4	DC	21.4	XK	27.4	Epi													63.15
6	B8	5.2	Epi	9.1	XK	50.5	Epi													64.80
7	B9	60.1	S																	60.10
8	C3	12	S	36.6	G	8.4	Epi	11	G	2.4	DC									70.40
9	C4	6	S	40.5	G	1.4	Epi	11.9	G	1.1	Epi	11	XK	4.2	Epi	3	G	3.1	DC	82.20
10	C5	60	S																	60
11	C6	10.1	DC	1.4	G	0.7	XK	0.95	S	1.5	DC	15.8	G	1.55	AB	11.7	XK	5.85	KM	144.40
	C6b	GB	0.5	XK	13.75	GB	27.6	XK	0.30	Q	5.8	XK	3	Q	28					
12	C8	17.2	G	1.6	Epi	4.2	G	19.05	XK	2.95	DC	9	XK	3	Epi	3.35	DC			60.35
13	C10	27.8	S																	27.75
14	D3	11.4	DC	1	XK	5	G	6	XK	4	DC									27.40
15	D4	20.4	G	11.1	XK	8.9	DC													40.40
16	D6	51.2	S	30.9	XK	2.65	Epi	1	G											85.75
17	D6.5	9.2	S	33.4	XK	0.1	DC	24.8	S											67.40
18	D8	11.2	S	10.7	KM	17.8	XK	21.35	S	45	XK	0.75	DC							106.75
19	D10	61	S																	61.00
20	E2	32.4	C																	32.35
21	E4	35.4	G	6.4	DC															41.80
22	E5	76.2	S																	76.20
23	E6	0.5	S	9.9	XK	22.8	G	26.8	Epi	6.2	DC									66.20
24	E7	9	S	12.4	KM	42.7	S													64.05
25	E8	8.25	S	24.4	KV	18.3	XK	36.1	S											87.00
26	E10	20.5	S	39.6	G															60.05
27	F4	51	Epi																	50.95
28	F6	26.6	KV	16.8	XK	1	DC													44.40
29	F’8	0.5	S	6.5	XK	0.6	S	3.4	XK	1.6	S	1.5	XK	3	S	7	XK	17	G	50.60
30	F10	11.7	S	12.7	XK	39.7	S													64.05
31	F11	60.2	G																	60.20
32	G4	3.05	S	52.4	XK	12.2	S													67.65
33	G6	8	KL	29.8	XK	0.7	Epi	8.5	DC											47.00
34	G10	8.5	XK	3.05	KL	15.3	XK	4	DC											30.80
35	H2	32.9	DC																	32.90

Continued

36	H4	3.05	S	3.85	KM	6.05	XK	45.05	Epi	0.75	DC									58.75
37	H6	19.4	XK	6.6	G	28.9	Epi	2	G	1.1	DC									58.00
38	H8	12.1	XK	5.31	KL	6.3	XK	8.7	DC											32.40
39	H10	5.6	S	6.7	XK	5.1	KL	16.5	Epi	4.5	DC									38.40
40	H12	21.5	Epi																	21.50
41	I4	3.05	Epi	9.15	DC	6.1	XK	27.45	Epi											45.75
42	I5	8.2	XK	6.1	G	4.7	DC													19.00
43	I8	43	XK	2	KL	3	XK	2	Epi	5.2	C									55.20
44	I10	14.2	KL	0.75	DC	6.45	KL	5	XK	9.3	DC									35.70
45	I12.5	17.2	S																	17.20
46	I13.5	10.7	S																	10.70
47	J3	3.05	DC	42	G	0.75	XK													45.75
48	J4	2.45	S	36.5	XK	3.65	GB	8.6	DC											51.20
49	J6	12.3	KV	28.6	XK	9	KV	6	XK	3	KV	59.9	XK	26.8	Epi	5.8	DC			151.35
50	J8	19.9	KV	6	XK	0.4	DC	14.6	XK	4	DC									44.90
51	J10	3.05	S	86.8	XK	11.2	S	1	DC											102.00
52	J'14	15.2	S																	15.20
53	K3	17.7	S	6.1	Epi	0.2	DC	15.05	XK	9.85	DC									48.90
54	K4	21.3	XK	6	DC															27.30
55	K6	37.1	KV	1.6	XK	18.2	KV	1.1	G	14.4	KM	24.2	XK	100	KM					196.60
56	K8	34.5	KV	85.5	XK															120.00
57	K10	15.3	XK	6.1	DC	6.1	XK	3.05	DC	18.3	XK	24.3	KM							73.10
58	K12	39.7	S																	39.65
59	K14	51.9	Epi																	51.85
60	L2	79.3	Epi																	79.25
61	L3	17	Epi	31	Epi	15.3	Epi													63.20
62	L5	18.2	Epi	35.7	XK	22.2	Epi													76.00
63	L5.5	7	DC	1.55	XK	3.05	DC	9.05	S											20.65
64	L6	8.85	Epi	46	XK	2.5	Epi	0.5	XK	27	Epi									84.80
65	L'6	12	Epi	14.8	XK	3.05	G	15.25	XK	54.85	Epi									99.85
66	L8	59.4	XK	24	Epi															83.40
67	L10	43.6	XK	6.1	G	12.1	S	3	DC											64.75
68	L12	8.5	KV	36.4	Epi															44.90
69	L13	36.7	Epi																	36.70
70	M4	69.6	Epi																	69.60
71	M8	38.6	XK	17.4	Epi	0.75	G													56.75
72	M10	12.2	XK	26.8	Epi	0.65	DC													39.65

Legend of Well Lithology: *G*-Sandstone, *DC*-Limestone debris, *Epi*-Epiclastite, *GB*-Brecciated sandstone, *KL*-Lithic Kimberlite, *KM*-Kimberlite massive, *KV*-Green Kimberlite, *Q*-Quartzite, *S*-Sand, *XK*-Xenokimberlite, *Ep*-Thickness, *Lith*-Lithologie, *Sond* -Survey.

4. Results

4.1. Cartographic Study

For the overall structure of Kimberlite massif 5, we will refer to the longitudinal and transverse profiles of the survey plan in **Figure 3** above. To this end, taking into account some of these profiles, the following emerges (**Figures 4-7**).

4.2. Modelization

The big job here is to determine just the mathematical model of the Kimberlite massif against the dolomitic surrounding area. **Figure 8** below shows this pattern for levels between altitudes 600 and 450.

This contour model of the massif as well as some longitudinal and transverse profiles given above are elements intended for the operator of this kimberlite for the development of an exploitation plan excluding the zone made up of "sterile" breccias. Located in the northwest of the massif. It should be noted that the exterior contour of the model in question represents the current limit of the Kimberlite against the dolomite host as defined on the sections and as far as possible in the field.

5. Discussions (Interpretation)

The following elements emerge from our studies:

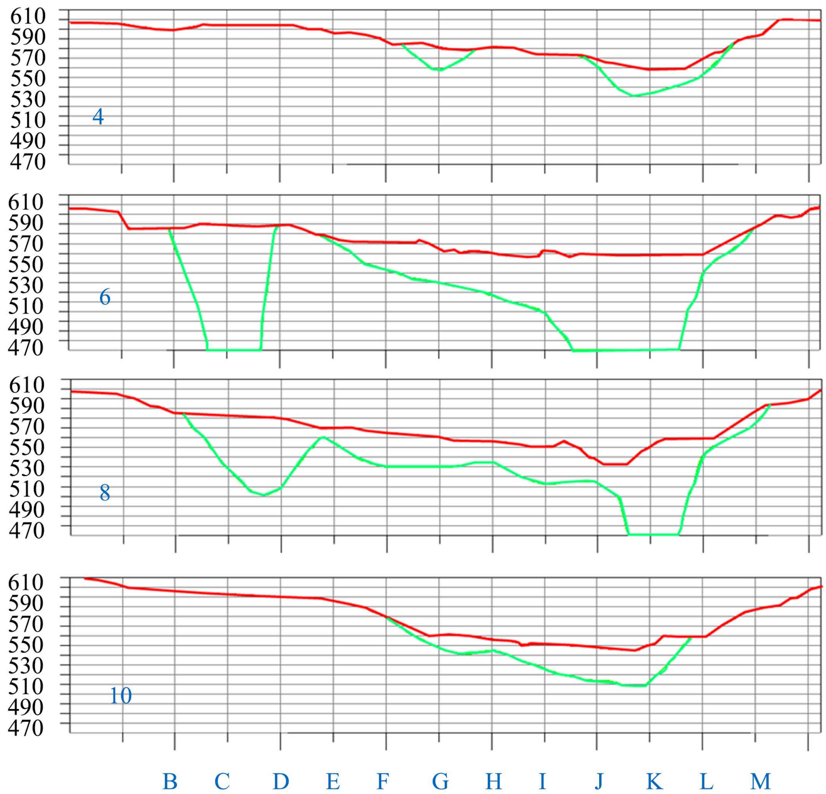

Figure 4. W-E geological profiles representative of the structures of Kimberlite Massif 5 in depth and over an equidistance of 50 m.

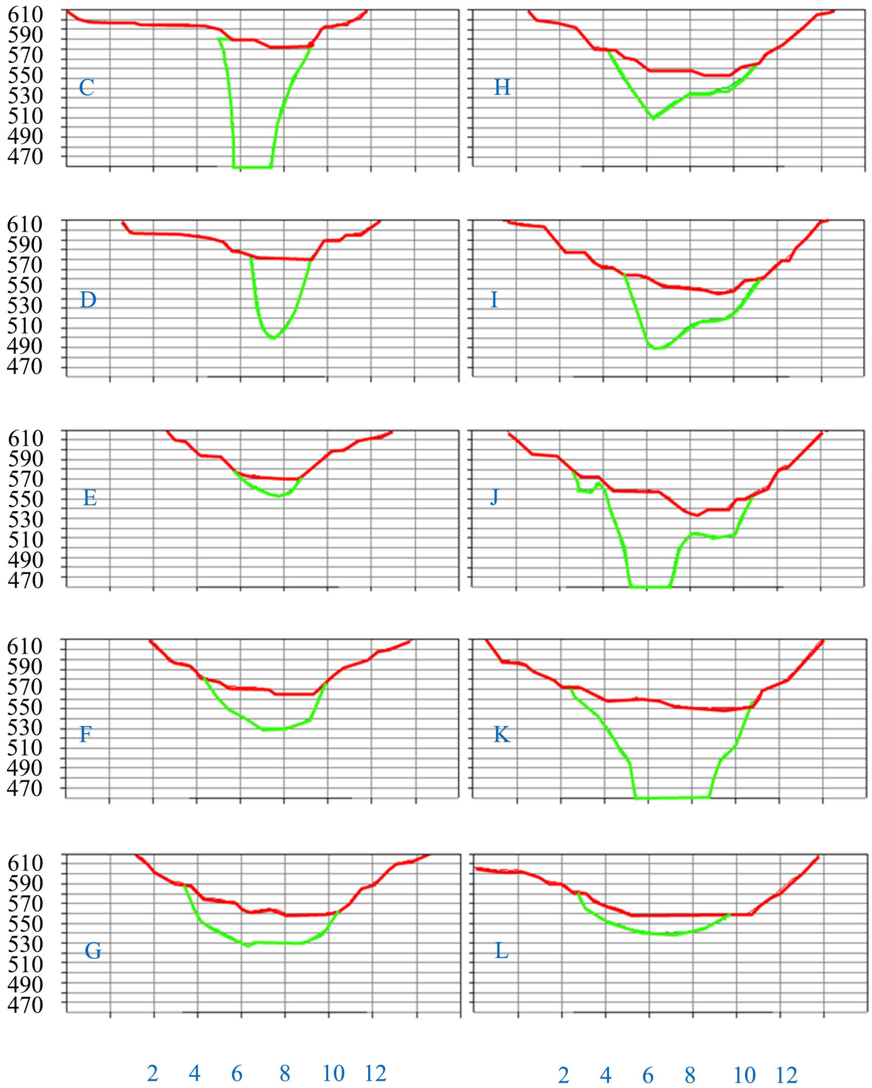

Figure 5. N-S geological profiles representative of the structures of Kimberlite Massif 5 in depth and over an equidistance of 50 m.

5.1. Geological Formations

The following succession of petrographic facies was intersected by drilling:

- ✓ Red clayey sand of recent Quaternary age, commonly called "sterile" or covering. The roof of this layer varies at an altitude of 641 m and its thickness is ±30 m;
- ✓ Diamond-bearing gravel predominantly polymorphic sandstones, also dating from the Quaternary. Variable thickness, from 20 cm to ±1.5 m;
- ✓ Gravel rich in diamonds, nodular in appearance, with blocks and nodules of kaolin and thicknesses of up to several meters (average thickness is 6 m). His age is uncertain;
- ✓ The Kimberlite, dating from the end of the Cretaceous. This kimberlite is in contact with Mesozoic sandstone breccias or with the following sandstones and dolomitic rocks, which it crossed during its volcanic eruption;

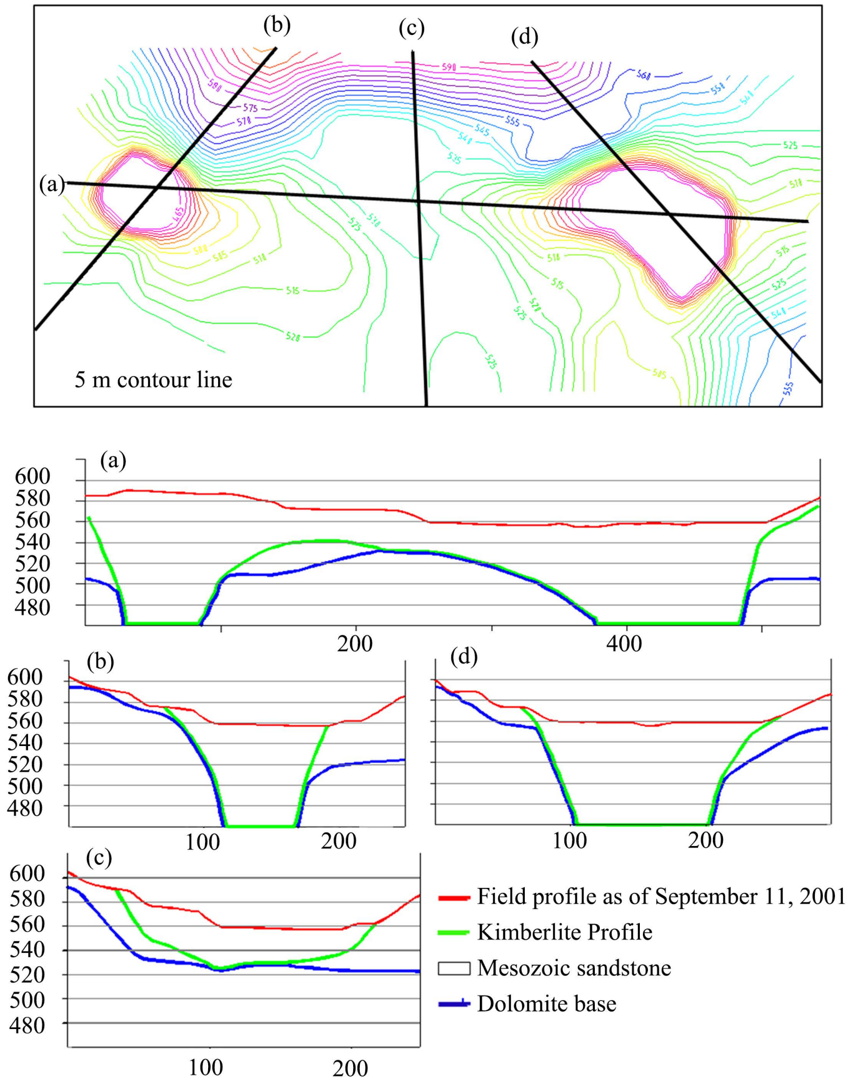

Figure 6. Profiles showing the dolomitic bedrock of Kimberlite Massif 5 at depth and over an equidistance of 50 m.

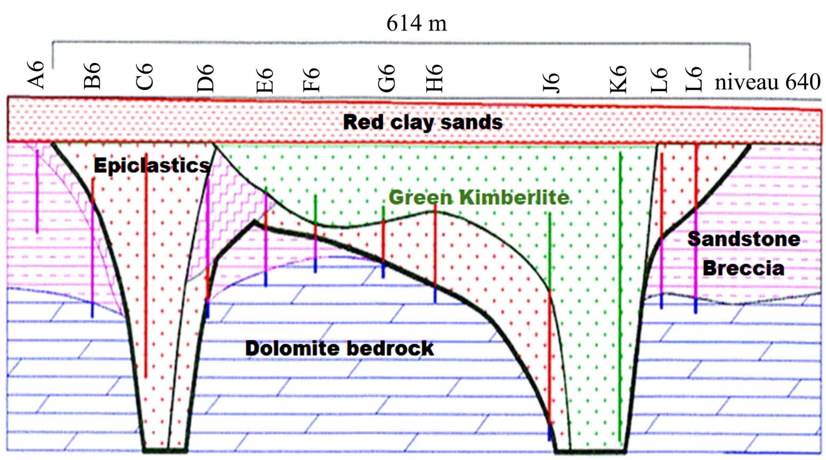

Figure 7. General W-E profile of Kimberlite Massif 5 in depth and over an equidistance of 50 m.

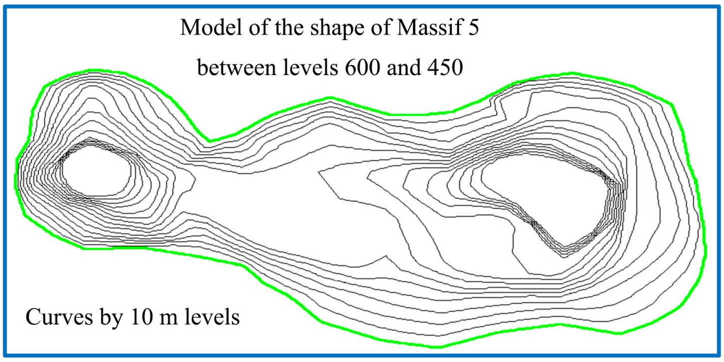

Figure 8. Contour model of the Kimberlite Massif 5.

- ✓ Mesozoic Sandstone, dating from the Cretaceous with thicknesses of up to 100 m. At the base of these sandstones we often find a layer with elements of chert or silicified limestone, which marks the proximity of the following bedrock:
- ✓ Dolomites of Precambrian age.

The kimberlite of the massif has been classified into four types, according to the attached nomenclature:

- ➢ Kimberlites: consolidated but relatively loose rocks, green in color and always containing more than 50% of kimberlite products;
- ➢ Epiclastics: rocks containing less than 25% kimberlitic products, red in color and not consolidated;
- ➢ Xenokimberlites: weakly consolidated rocks with 25% to 50% kimberlitic elements and red-green color.

5.2. Structure of Massif 5 and Eruptive Phases

The upper level of Massif 5, subhorizontal, is located between altitudes 600 and 610. It results from the erosion of the upper part of the volcanic crater which extended well beyond its current altitude (the tufa ring of the volcano and part of the crater have been completely eroded). The shape of the massif is vaguely elliptical with a W-E long axis of 575 m and an N-S axis of 275 meters.

Surveys have shown that Massif 5 is in fact composed of two pipes, located in the West and East ends of the massif as shown in **Figure 8** above. **Figure 9** below is a horizontal section (theoretical) according to level 600 and shows the shape of the massif and the two pipes which compose it.

It therefore emerges:

- ✓ The Western pipe is the oldest. The volcanic explosion was essentially gaseous and created a large, gaping crater with no consistent filling. After this eruption it was largely filled by a sandstone breccia (Mesozoic) following the collapse of the too steep sandstone walls of the volcano.
- ✓ A second eruption then took place through the same chimney. It crossed the previous deposits and placed a (friable) rock with more than 50% sand. Its color is red. The northern part of this first crater was preserved from the second eruption, composed mainly of brecciated sandstone.

- ✓ In the third phase of eruptions, we distinguish the oriental pipe, the largest. During its eruption it tore off the eastern part of the first pipe, which allowed us to determine the sequence of eruptions that we detail here. The first kimberlitic deposits of this phase were sandy rocks, mixtures of disintegrated red sandstones and green kimberlitic tuffs. Finally, we can see an installation, certainly less explosive than the first, of green kimberlites. These are of the tuffo-breccia or tuffic type. Note that there are no kimberlitic "lavas".

The western pipe has very steep walls of around 70˚ to 80˚, even though friable Mesozoic sandstones. Its eruption was probably less explosive than that of the oriental pipe.

The eastern pipe opened into a crater at the contact between the sandstones and the dolomites. This transition from chimney to crater thus occurred around level 510. The kimberlite zone between the two chimneys is in direct contact with the dolomites along a slight general slope going from East to West from level 510 to 530 over approximately 200 meters.

The chimneys of both pipes have subvertical walls. Their average diameter is ±50 meters. A Foraky drilling had crossed the kimberlite of the East chimney up to level 139. It was the deepest drilling carried out in our kimberlites, over 501 meters (Figure 10).

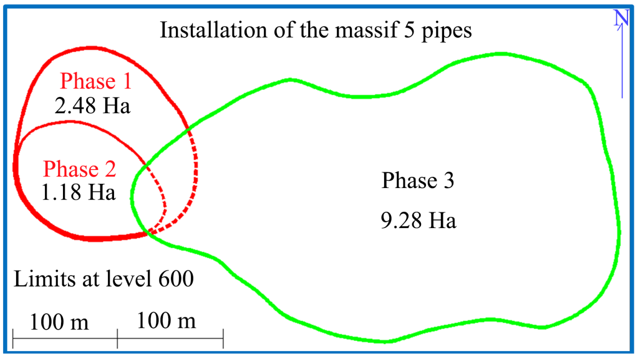

Figure 9. Installation of the Massive 5 pipes.

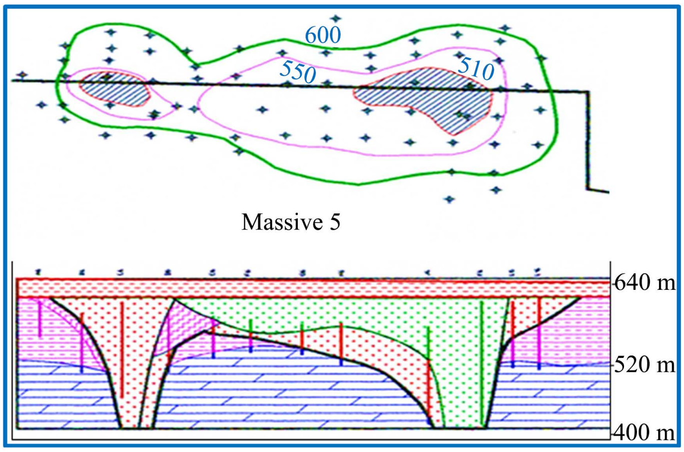

Figure 10. Geological map and model of the kimberlite Massive 5 of the Bakwanga group.

6. Conclusion

This work concerns the Cartographic Study and Modeling of the Bakwanga Kimberlite Massif 5 in Kasai Oriental in the Democratic Republic of Congo. This study was initiated on the basis of survey data by carrying out transverse and longitudinal profiles taking into account the alignment of the wells in a 50 × 50 meter grid.

After analysis and interpretation of the data, the Kimberlite massif 5 reveals the following salient points:

- ✓ The exterior shape is vaguely elliptical;
- ✓ The longest W-E longitudinal axis is 575 m and the longest N-S transverse axis is 275 meters;
- ✓ This study demonstrated that Massif 5 is in fact composed of two pipes, located in the West (western pipe) and East (eastern pipe) ends of the massif;
- ✓ The two chimneys of the two pipes have walls ranging from subvertical at the level of the eastern pipe to very steep walls of around 70˚ to 80˚ for the western pipe;
- ✓ The average diameter of two pipes is ± 50 meters;
- ✓ 3 eruptive phases set up this Kimberlite massif, the first two phases (old) of which formed the crater of the western pipe and the third formed the crater of the eastern pipe in the dolomites. These dolomites constitute everywhere the surrounding area of the massif; the distinction of these 3 phases is made possible thanks to Epiclastic deposits and Xenokimberlites;
- ✓ At level 600, the massif has an area of ±10.5 hectares and it gradually decreases in depth. The modeling of the latter shows a concentric decrease in the volume of the massif;
- ✓ The Kimberlite of massif 5 is a volcaniclastic rock belonging to the crater facies. This rock has been deeply altered and the minerals have been transformed into clay minerals;
- ✓ The depth reached by the longest drilling on the massif is approximately 471 meters;
- ✓ On this massif 5, we detected the predominance of massive Kimberlite compared to other facies (Epiclastics and Xenokimberlites).

On the lithostratigraphic level, in addition to the Kimberlite massif (with the 3 types identified), we have clayey sands, polymorphic sandstones, sandstones with a nodular appearance, kaolin blocks and nodules, Mesozoic sandstones with base of layers with elements of chert or silicified limestone and dolomite of Precambrian age.

From the western pipe to the eastern pipe, a concentric distribution of the different kimberlitic facies appears: the massive Kimberlite occupies the eastern part and the Epiclastic Kimberlite and the Xenokimberlites are located in the western part.

It emerges from the study of the survey profiles that, from the surface towards depth, these kimberlite bodies evolve in a cone and have the shape of a mushroom.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

Clément, C. R., & Skinner E. M. W. (1985). Monticellite: An Abundant Groundmass Mineral in Some Kimnerlites. In *Kimberlite Symposium 1: Cambridge (Extended abstracts)* (pp. 71-73).

Davis, B. T. C., & Boyd, F. R. (1966). The Join $Mg_2Si_2O_6$-$CaMgSi_2O_6$ at 30 Kilobars Pressure and Its Application to Pyroxenes from Kimberlites. *Journal of Geophysical Research, 71,* 3567-3576. https://doi.org/10.1029/JZ071i014p03567

Demaiffe, D., & Fieremans, M. (1980-1981). Strontium-Isotopic Geochemistry of the Mbuji Mayi and Kundelungu Kimberlites (Zaire, Central Africa). *Chemical Geology, 31,* 311-323. https://doi.org/10.1016/0009-2541(80)90093-5

Duvigneau, P., & Leonard, J. (1953). Cartes schématique des principaux aspects de la végétation du Congo belge-les naturalistes belges, 34 p.

Fieremans, C. (1966). Contribution à l'étude pétrographique de brèche Kimberlitique de Bakwanga. *Mémoires de l'Institut géologique de l'Université de Louvain, 24,* 1-92.

Gilson, P., & Liben, L. (1960). *Notice explicative de la carte des sols et de la végétation du Congo Belge et du Ruanda-Burundi.* Institut National pour l'Étude Agronomique du Congo Belge, 761 p.

Meyer de Stadelhofen, C. (1963). Les brèches kimberlitiques du territoire de Bakwanga (Congo). *Archives des sciences de la société de physique et d'histoire naturelle de Genève, 16*, 87-143

MIBA-DE BEERS Technical Report (2009). *Rapport Technique MIBA-DE BEERS sur l'exploration des massifs kimberlitiques hors polygone*.

Milashev, V. A. (1963). The Term "Kimberlite" and Classification of Kimberlite Rocks, Geol. *Geofizika, 4,* 42-52.

Mvuemba, N. (1980). *Minéralogie des mégacristaux, des xénolithes éclogitiques et granulitiques et des inclusions minérales dans les diamants provenant de la kimberlite du Kasaï-Oriental (Congo).* Thèse, MIG, Univ, Cath. Louvain la Neuve, 285 p.

Mvuemba, N. et al. (1982). *Inclusions dans les diamants du Kasaï oriental.* Zaïre.

Raucq, P. (1959). Note préliminaire sur le raccord des formations mésozoïque de la Luebo et de la région de DIBAYA (Kasaï, Congo belge). *Annales de la Société Géologique de Belgique, 82,* 201-209.

Robert, M. (1946). *Le Congo physique* (3ème ed.). H. Vaillant-Carmanne, Liège, 449 p.

Wagner, P. A. (1914). *The Diamond Field of Southern Africa*. Johnnesbourg.