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Multiphase origin of polymetallic Zn-Pb-Cu (Au-Ag-Fe-V) ore deposits in the Bamba-Kilenda, in the foreland of the West Congo Belt (WCB), Kongo Central (Democratic Republic of Congo)

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---***ABSTRACT***---

The Bamba-Kilenda deposit, once exploited, will come to a standstill shortly before the independence events of 1958. However, archival data present usable economic reserves. Recent scientific studies on this deposit and other deposits raise many questions about the genesis of these minerals. Our field observations enriched by those of our predecessors, given the time allotted for our stay in Bamba-Kilenda, allowed us to present the staging of the vein deposits observed in the survey FK2 /4, which corroborates a multiphase emplacement of the deposit of Bamba-Kilenda:

- Phase 1: Installation by-basinal hydrothermal fluids having drained feldspar layers of schisto-sandstone enriching with potassium;

- Phase 2: Placement by ascending Orogenic fluids and iron having particularly collected potassium from the schisto-sandstone roof and ores of the first phase;

- Phase 3: Infiltration of sedimentary fluids in the brecciated zone enlarged by the dissolution of the wall limestone along the Masungu fault. This mode of penetration accompanied by dissolution of carbonates is attributed to the last phase of mineralization at Bamba-Kilenda which is the richest in iron.

The supergene weathering has finally reshaped the deposit at great depth, since the vertical discharge of the fault is estimated after to nearly 600 m. The superficial alteration of the sulphide primary mineralization is responsible for the formation of copper oxides, hydroxides, silicates and carbonates in the superficial oxidation zones and supergene secondary enrichment observed in the deposit. The vanadates of Pb, Zn and Cu (Vanadinite and Descloïzite - Mottramite series) that we observe in the Bamba-Kilenda deposit come from the oxidation of mineral base metal concentrations.

Keywords*: Bamba-Kilenda, hydrothermal, West Congo Belt (WCB), Masungu, Alteration*

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I. INTRODUCTION

In the western part of the Democratic Republic of Congo, where researchers have discovered in the past various indices and occurrences of mineralization (Cu, Pb, Zn, V, Fe, Au, Ag ...) located in the West-Congolian group that is part of the Aracuai - West Congo Orogenic Belt, formed during the amalgamation of the Supercontinent Gondwana; these mineralizations are related to faults. Bamba-Kilenda is in the foreland the West-Congolian Basin. This is an intracratonic basin that was formed shortly after the Kibarian orogeny (1000 Ma). Thus formed, it appears as a pre-country basin in the context of a long-lived collision (> 100Ma) with base metal concentrations. This pool of active margin will evolve into a pool of passive margin that will be occupied by the ancient sea (Adamastor) with gradual input of sediment, hence the term "aulacogen" given to the West Congo Supergroup.

In the vicinity of Bamba-Kilenda village, a large vein of chalcosine was discovered in 1938, in the valley of the Masungu river is one of the examples of this mineralization linked to the fault zone (LAVREAU, 1977 and NOËL, 1983). Other regional mineralization observed in the Western-Congolian foreland (Figure 1a), are also related to faults and would be distributed over great distances (CORTESÃO, 1958; BUFFET et al.,

1987) and would have the same potential in metals as the Katanga deposits with a slight advantage due to its geographical position (close to the ocean), which would facilitate the transport of minerals.

The Bamba-Kilenda deposits, once exploited, will come to a standstill shortly before the independence events in 1958. The evaluation of this deposit by LAVREAU (1977) and NOËL (1983) on the basis of data from previous surveys of the BAMOCCO Syndicate makes state of 2 million tonnes (2MT) of proven ores with a composite metal content (Cu + Pb / 2 + Zn / 2) of 5.1 to 7.2% or between 100 to 140 thousand tons of copper equivalent, with uncertainty factors of 1.5 to 2 times higher for these reserves. These data provide sufficient evidence of the existence of economically unprofitable resources. Nevertheless, recent scientific studies (KABONWA, 1999; VERHAEGEN, 2004 & 2005 and ARNE LESAFFER, 2014) on this deposit and other deposits around raise many questions about the genesis of these ores. In this frame that our research is inscribed to improve the knowledge on these mineralization's which would greatly increase the chances in this part of the country to find other mineral concentrations with a real economic potential, like the deposits of Bamba - Kilenda.

1.1. Regional geology

The various lithostratigraphic units observable in the region belong to the West - Congo Supergroup, mainly the Lukala subgroup, the Mpioka subgroup, the Inkisi group and the Phanerozoic lands.

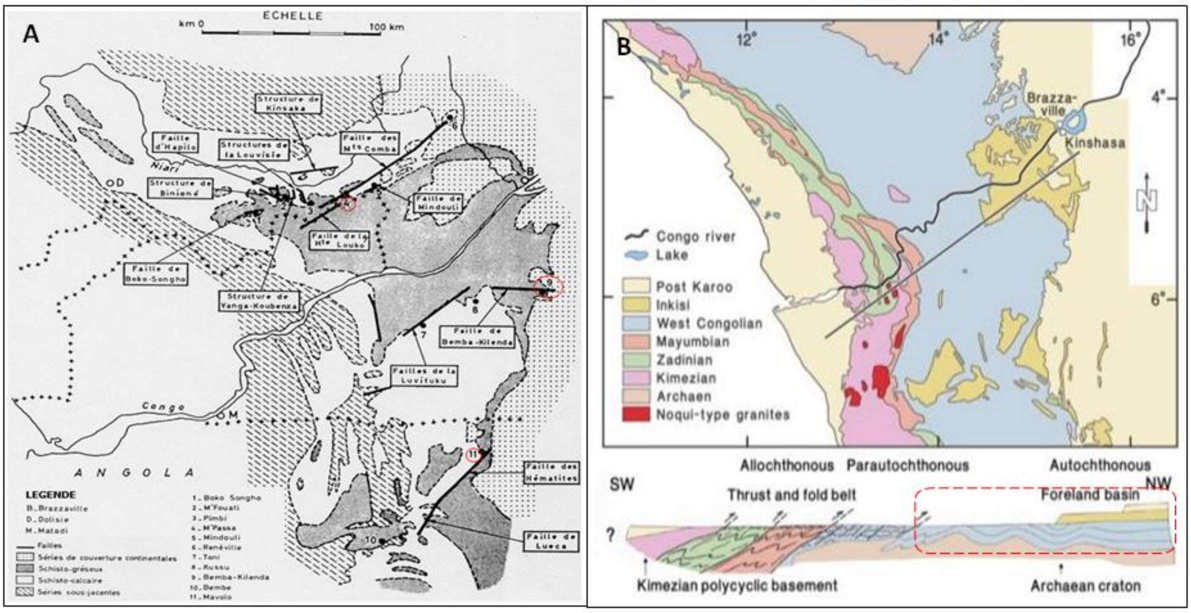

Figure1: A) Major mineralization of Cu-Pb-Zn and V related to subvertical faults, in the foreland of the West Congolian Belt ; **B)** Map and profile of the West-Congo chain at Kongo Central (TACK et al., 2001).

Republic of Congo, Gabon, Democratic Republic of Congo and Angola are countries crossed by the West Congo Belt. The Bamba-Kilenda deposits (Figure 1a) forms with the deposits of Mpassa (Mindouli, in the south of the Republic of Congo) and Maïvo (North of Angola), a small metallogenic province in the western part of Africa. Figure 1b, shows the three main tectono-metamorphic units thus defined from east to west, the passive margin, autochthonous external to the belt, the active margin separated into a sub-autochthonous unit and an allochthonous western unit, internal to the West-Congolian Belt (TACK et al., 2001).This figure highlights the type of metamorphism encountered in the West Congo Belt, in Kongo Central; it is the type Low Pressure and High Temperature, BP-HT affecting more the central region (Matadi and its surroundings). The degree of metamorphism evolves from the center to the west, that is, from greenschist facies to amphibolitic facies, and disappears eastward from the greenschist domain in tabular (sedimentary) regions leaving the place to diagenesis in the foreland of the West Congo Belt. The synkinetic metamorphism noted in this section is associated with Pan-African orogeny (TACK, 1975; FRANSSEN and ANDRE, 1988).The age of the main pan-African orogenic phase of the West Congo Belt (NW-SE) is poorly understood at c.566 Ma. In the western part of the chain (most deformed and metamorphosed region), called the "Crystal Mountains", it is characterized by an abundance of milky quartz veins, "exudation". A later orogenic phase, brittle, transverse direction NE, called "Combianne", and pre-Karoo age, controls the deposit conditions of the Inkisi Supergroup. Relative to the deposits of the Mpioka Subgroup; there is a change in direction of sediment input (to the NW). To do this, the tectonics in the region is dominated by Pan-African orogeny materialized by NW-SE faults (Main Phase), NE-SW faults and E-W (Late or “Combienne Phase”).

1.2. Local geology and mineralization

The Bamba-Kilenda deposit is located in Kongo Central Province, between two border territories, including the Kasangulu Territory (Lukunga-Mputu sector) and the Madimba Territory (Fuma Kibambi and Ngufu sectors), located between 15 ° 20'00 " and 15 ° 40'00 " East Longitude and 4 ° 50'00 " and 5 ° 0'00 " South Latitude (Figure 2b). The various lithostratigraphic formations observable in the Bamba-Kilenda sector belong to the West Congo Supergroup, mainly to the subgroups of Lukala, Mpioka, the Inkisi group and the Phanerozoic lands. The succession is described by CAHEN (1954); LADMIRANT (1964 and 1971); LAVREAU (1977); BAUDET et al., (2013).

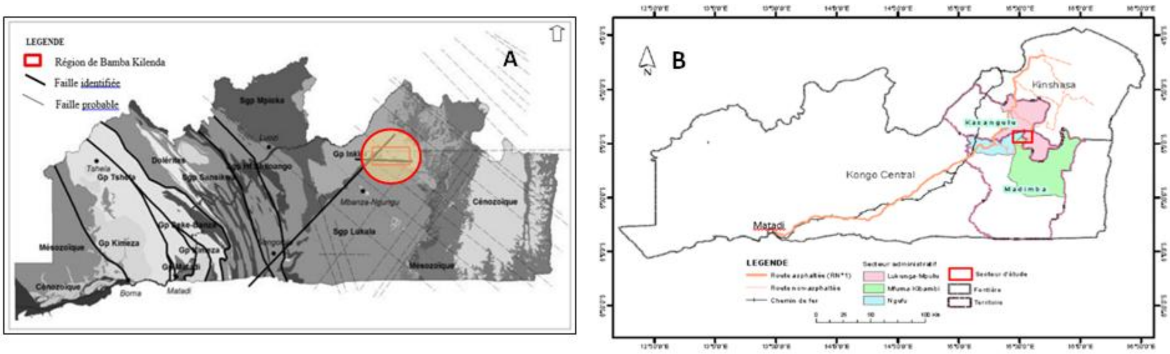

Figure 2: **A)** Simplified geological map of Kongo Central Province (from BAUDET et al., 2013); **B)** Location map of the study area (Bamba-Kilenda) in Central Kongo Province.

Recall that the direction of the fold axes of the West Congolian orogeny, oriented North West - South East, in the western part of Kongo Central, undergoes a transfer and takes in the eastern part, a direction North East - South West and these directions become East-West, as we observe in the area of Bamba-Kilenda (Axial disposition of the anticline) and its surroundings (Figure 2a and 3a, b).

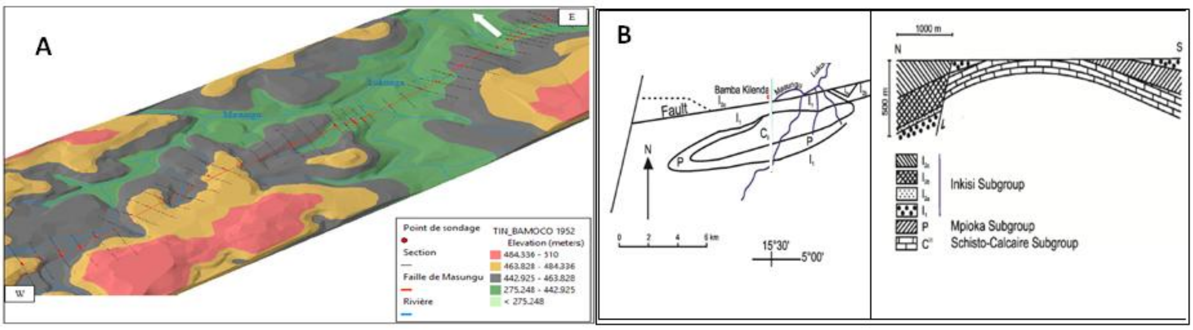

Figure 3: **A)** Bamba-Kilenda sample groups (in 3D simulation mode); **B)** The structure of the Bamba-Kilenda anticline, intersected by the Masungu fault. Left figure : Simplified geological map of the site. Figure to the right: Synthetic geological section of the Bamba-Kilenda anticline, with I: Inkisi; P: Mpioka, C: Schisto-Limestone (After LADMIRANT, 1964).

It should be noted that the folding of the Mpioka subgroup was followed by post-Mpioka erosion, from which the Inkisi Subgroup is discordant on Mpioka Subgroup where it sometimes rests directly on the limestone of Schisto-Calcaire Subgroup. The deposit is an anticline with an E-W fault (Masungu Fault) that intersects, both Inkisi, Mpioka and limestone, hence the post-Inkisi fracturing. Observed N-S faults would result from the phenomenon of rejuvenation, from which the hypothesis of the existence of a rift which these faults have replayed at the Pliocene (phenomenon of rejuvenation) is the most likely.

II. METHODOLOGY

Given the difficult terrain conditions due to the density of the forests, the thick cover and the scarcity of the outcrops, as well as the strong weathering affecting the outcrops, we proposed to pursue studies in this sector focusing more on the archive data of Bamba-Kilenda which are stored at the Royal Museum of Central Africa in

Tervuren (Belgium, RMCA) and on the results of some current surveys of the company CMBK (Compagnie Minière de Bamba -Kilenda).
Our observations on the ground were enriched by those of our predecessors given the time allotted for our stay in Bamba-Kilenda. Our challenge during this study consisted of:
- The documentary analysis of the Bamba-Kilenda archives at the CRGM (in Kinshasa), at the RMCA (Belgium,) and the memoirs of the UNIKIN students (in Kinshasa) and the Belgian universities, as well as books and articles on the geology of Kongo Central and Katanga;
- The compilation of data on metalliferous occurrences, categorization and spatial analyzes using the Geographic Information System (GIS) tool.
- The compilation and reinterpretation of geological, sedimentary, and structural data of the study area.
- Petrographic, mineralogical, geochemical studies of mineralization and gangue by macroscopic and microscopic description as well as XRD (X-Ray Diffractometer) and geochemical analyzes.
- Calculations of alkalinity index (K + Na / Ca) based on that of seawater (27,224) provided information on the nature and the generating process of metalliferous fluids (INTIOMALE, 2014).

In addition, the alkalinity index (K + Na / Ca) confirmed the metamorphic origin of Kipushi zinc fluids proposed by HEIJLEN et al. (2008) and the multiphase establishment of the same deposit (INTIOMALE, 1982) confirmed by HAEST and MUCHEZ (2011).

III. RESULTS AND DISCUSSIONS

Here we give the few macroscopic and microscopic observations, the results of XRD analyzes, the staging of the FK2 / 4a probes and the paragenesis.

3.1. Petrographic studies

3.1.1. Macroscopic observations (Figure 4).

a) Oxidized superficial ores

The secondary mineralization consists of: baryte, covelline, chalcosine, siderite, native Cu, cuprite, chrysocolla, planchetite, shattuckite, dioptase, malachite, cerusite, azurite, manganese oxides, etc. The various iron hats ("Iron Hat") are reddish, massive, associated with oxidized minerals (hematite, cuprite) or hydroxydés (limonite or goethite), carbonates (malachite), silicate (dioptase), native (native Cu) and rarely sulphured Cu, Pb and Zn (chalcosine, galena, sphalerite, etc.) as well as vanadates (mottramite), gold (Au) and silver (Ag) contained in Inkisi or in the limestone of the sub -group of the Lukala.

b) Sulphurous ores

According to LAVREAU (1977)], VERHAEGEN (2005), LESAFFER (2014) and our petrographic observations on the different drill cores, we have identified the following primary mineralization: Pyrite, sphalerite, chalcopyrite, chalcosine and galena. Other observations have revealed the mixed appearance of chalcosines, that is, primary and secondary varieties in the same place. This shows two episodes of crystallization for this same type of mineral.
The main mineralized bodies are either irregular lens of chalcosine and galena decimetric hosted in carbonates or iron caps which are none other than ferruginous impregnations in areas of weakness.

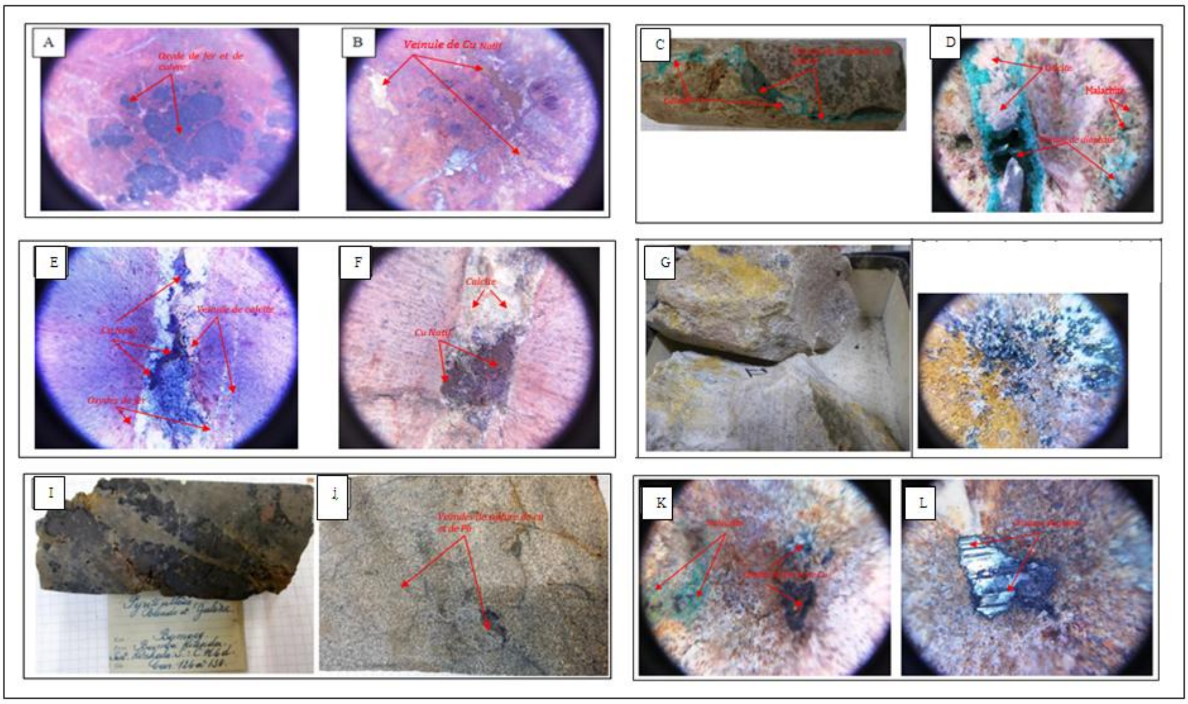

Figure 4. **A)** FK2 / 4b : Core n ° 742: Sandstone rock, variously fractured and impregnated with iron oxides and native copper and **B**) Core n ° 738: calcareous ferruginous rock with native copper veinlets; **C)** FK2 / 4, Core No. 696; **D)** Macroscopic view with limestone magnifying glass, light gray, very fine grain, with calcite veinlets, dioptase and greenish minerals (malachite) in its breched part. This part shows the recrystallization of carbonates (recrystallization calcite) due to remobilization; **E)** Survey FK2 / 4a, Core n ° 499 and **F)** Coret n ° 493: Pinkish brown limestone, with calcite veinlets, uneven bedding, iron and copper oxide, as well as native copper; **G**) Pink gray sandstone, cracked with yellowish and greyish mineral coating; **I**) CK6d survey: Core n ° 129: weathered pyrite, sphalerite (ZnS) and galena (PbS) on sandstone G1K10b: **J**) Core n ° G1K10b: Sandstone, light gray with Cu and Pb sulphide veinlets respectively chalcosine and galena; **K**) Sounding FK4 / 6b: Core n ° 390: Sandstone rock, brownish gray, fine grains, fissured with veins of iron oxide, greenish traces (Malachite?) and galena (PbS); **L**) Core n ° 389: Sandstone rock, brownish gray, fine grains, fissured with calcite and iron oxide veinlets, as well as galena crystals (PbS) (Catch using the 20X21mm magnifying monocular magnifier).

3.1.2. Microscopic observations (figure 5).

It should be noted that our microscopic observations (thin and polished sections) were made on the basis of the Verhaegen blades (KULeuven, 2005), which also worked on the Bamba-Kilenda deposit. Our own microscopic observations can be summarized as follows:

- We have identified plagioclases through the various twins and sometimes these feldspars are altered and appear in a brown color under a microscope, in LPN light (Unphased Polarized Light). Others appear as crushed and have quartz in inclusion and a brownish appearance which attests the alteration;
- The micas have been identified by their laminated appearance and in relation to their optical properties. These minerals were identified in the Inkisi rocks (I1 and / or I2);
- We had to observe sandstone and arkoses. The latter have feldspar grains with fuzzy borders while the former have clear contacts between the grains of feldspars. The method of "Border of Becke", helped us for their differentiation;
- As for limestones, they are mainly represented by a generation of fine-grained limestone and another generation with coarse grain, which attest that they are the result of recrystallization. In fractures, there are also two phases, one with fine minerals and the other with more developed minerals;
- The observation in polished sections allowed us to identify the primary minerals in the limestones and arkoses of Inkisi, it is: pyrite, galena and chalcosine. These minerals are associated with iron oxides.

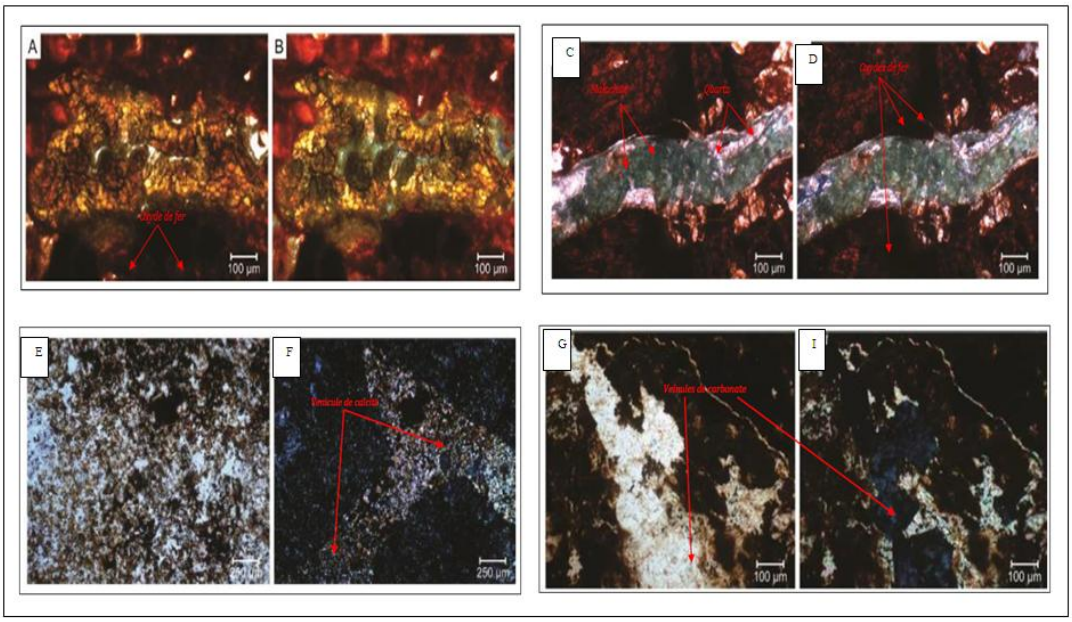

Figure 5: **A**) Photo 4.21: Mottramite-Duftite series occurring in association with iron oxides; LN and (**B**) LPN (FK2 / 4a, core 190); Malachite veins associated with secondary quartz intercepts iron oxides **(C**) LN and (**D**) LPN (FK2 / 4a, core 173); Aggregates of calcium carbonate (**E**) LN and (**F**) LPN (FK2 / 4a, core 190); Calcium carbonate and barite (gray interference) **(G**) LN and **(I**) LPN (FK2 / 4a, core 190). Carbonate veins intersect iron oxides in photograph G and I.

3.2. X-Ray Diffractometer (XRD)

Most of the samples analyzed in Table 1, below, take the oxidized and / or hydroxylated minerals. The samples were analyzed using the X-Ray Diffractometer (XRD). This attests enough to the action of the oxidation and hydrolysis phenomena that affected the different mineralized cores. Hydroxy vanadates of lead, copper and zinc have been identified. The results of these analyzes highlight the phenomenon of alteration and remobilization evoked by LESAFFER [2014], said phenomena would have allowed vanadium to combine with the aforementioned metals in a supergene environment.

Table 1: X-ray Diffractometer Analy sis Results (Bamba-Kilenda)

#	ID_MRAC	Site	Sondage	Minéraux et formules chimiques correspondante
1	RG 3420	Kinkala		Quartz (SiO2)
				Oxyde de Vanadium et Rhodium (RhVO4)
2	RG 3760	Kinkala	FK6b	Quartz (SiO2)
				Descloizite - PbZn(VO4)(OH)
				Silicate hydraté de phosphate de Sodium et d'Aluminium (Na9.6Al3PO7Si136O283.56H2O)
				Hydroxyde sulfate de Zinc (ZnSO4.3Zn(OH)2
3	RG 3970	Kinkala	FK2/4b	Quartz (SiO2)
				Mottramite, (Cu-Zn)PbVO4(OH)
				Descloizite, Cuprian – Pb(Zn,Cu)VO4(OH)
				Copper Phosphate Hydroxide Hydrate- Cu3.96(PO4)2()H)1.92 2H2O
4	RG 3972	Kinkala	FK2/4b	Goethite -Fe+3O(OH)
				Mottramite – (Cu, Zn)PbVO4(OH)
				Quartz-SiO2
				Lead Uranium Oxide – Pb11U5O26
				Duftite – PbCuAsO4(OH)
				Lead Copper Zinc Vanadium Hydrate oxide – 2PbO 2(Cu,Zn)O V2O5H2O
5	RG 5170	Kinkala	FK1	Calcite – CaCO3
				Hematite – Fe2O3
				Goethite – FeO(OH)
				Mottramite – (Cu,Zn) PbVO4(OH)
				Volborthite – Cu3(VO4)2 3H2O
				Descloizite, Cuprian – (Zn,Cu)PbVO4(OH)
				Potassium Titanium Oxide – K1.35Ti8O16
6	RG 5114	Kombo	AKo	Calcite magnesian – (Mg.064Ca.93)(CO3)
				Lead Copper Zinc Vanadium Hydrate Oxide – (Pb,Ca)Cu(VO4)OH
				Mottramite, calcian – (Pb,Ca)Cu(VO4)(OH)
				Duftite – PbCuAsO4(OH)
				Vanadyl Arsenate – VOAsO4

3.3. Tiering of ores

Based on analyzes of the drilling hole surveyed FK2 / 4a (Table 1), we can arrange the ores in five categories according to the alkalinity indices (INTIOMALE, 2014) of the samples analyzed:

1) From 0 m to 55 m deep, the oxidation ores result from weathering with meteoric fluids rich in iron and calcium, with an alkalinity index of less than 0.14. The contents of the hypogen (Rb, Sr, Nb) are low;

2) From 55 m to 65 m, the primary ores were spared by the supergene alteration. These hydrothermal fluids that generated it are low in iron and calcium. They were enriched in potassium from the Mpioka subgroup and the overlying Inkisi group. The contents of hypogenic metals (Rb, Sr, Nb) are high;

3) From 65 m to 97 m: The ores were deposited by Orothermal fluids, rich in iron, low in calcium, having inherited the potassium of the Schisto-Gréseux group. The contents of hypogen metals (Rb, Sr, Nb) are close to those of the primary ores;

4) From 97 m to 102 m: The ores were altered by meteoric fluids like those of the superficial zone, rich in iron and calcium, poor in alkalis. The contents of hypogen metals (Rb, Sr, Nb) are lower than those of the preceding hydrothermal fluids;

5) Under the depth of 102 m, the ores were deposited by sedimentary brines, very rich in iron and very poor in alkalis, infiltrated against the limestones of the wall and the pre-existing deposit. The contents of hypogen metals (Rb, Sr, Nb) are the lowest of all the ores. However, these ores are the richest in vanadium attesting the supergene origin of this metal.

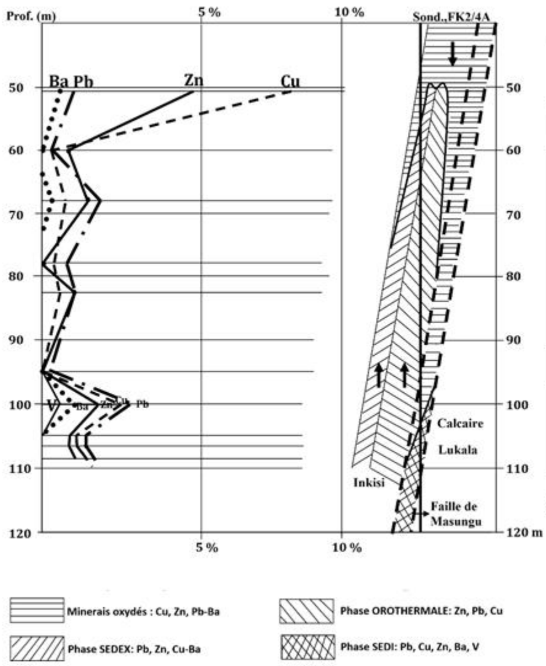

Table 2. Percentage content of elements in ores of Drilling hole FK2 / 4a

Prof. (m)	K_2O	Na_2O	CaO	Fe_2O_3	TiO_2	Rb (ppm)	Sr (ppm)	Nb (ppm)	Alc	T°C	Type de fluides	Etagement minerais
51,5												
Moy.	0,17	0,04	5,44	36,0	0,18	10	56	3	0,04	-	Météoriques	0 à 55 m
60												
Moy.	2,80	0,08	0,16	1,92	0,62	65	203	12	20,85	376,8	SEDEX-C	55 à 65 m
67	0,45	0,04	0,13	62,27	0,32				4,34	-		
77	0,39	0,03	0,14	35,92	0,31				3,46	-		
82,5	0,50	0,04	0,13	49,58	0,24				4,79	-		
95	0,43	0,03	0,09	24,57	0,56				5,90	-		
Moy.	0,44	0,04	0,12	44,09	0,36	21	193	7	4,62	-	Orothermaux	65 à 97 m
100												
Moy.	0,04	0,04	5,42	68,70	0,11	5	146	2	0,02	-	Météoriques	97 à 102 m
105	0,04	0,01	0,21	69,96	0,01				0,27	-		+ 102 m
107	0,04	0,01	0,21	69,92	0,01				0,27	-		
109	0,04	0,01	0,33	72,41	0,01				0,17	-		
Moy.	0,04	0,01	0,25	70,76	0,01	2	27	0	0,23	-	Sédimentaires	

Source : Laboratoire du Musée Royal de l'Afrique Centrale (2014).

Figure 6. Ore Scales and Grade Evolution along the Drilling hole (FK2 / 4a)

3.4. Paragenesis

According to LAVREAU [1977], VERHAEGEN (2005), LESAFFER (2014) and our petrographic observations on the different drill cores, we have identified the following primary mineralization: pyrite, sphalerite, chalcopyrite, chalcosine and galena. The secondary mineralization consists of: baryte, covelline, chalcosine, siderite, native Cu, cuprite, chrysocolla, planchetite, shattuckite, dioptase, malachite, cerusite, azurite, manganese oxides, etc.

The various iron hats are reddish, massive, associated with oxidized minerals (hematite, cuprite) or hydroxyls (limonite or goethite), carbonates (malachite), silicates (dioptase), native (native Cu) and seldom sulphured Cu, Pb and Zn (chalcosine, galena, sphalerite, etc.) as well as vanadates (mottramite), gold (Au) and silver (Ag) contained in Inkisi or in the limestone of the sub -group of the Lukala.

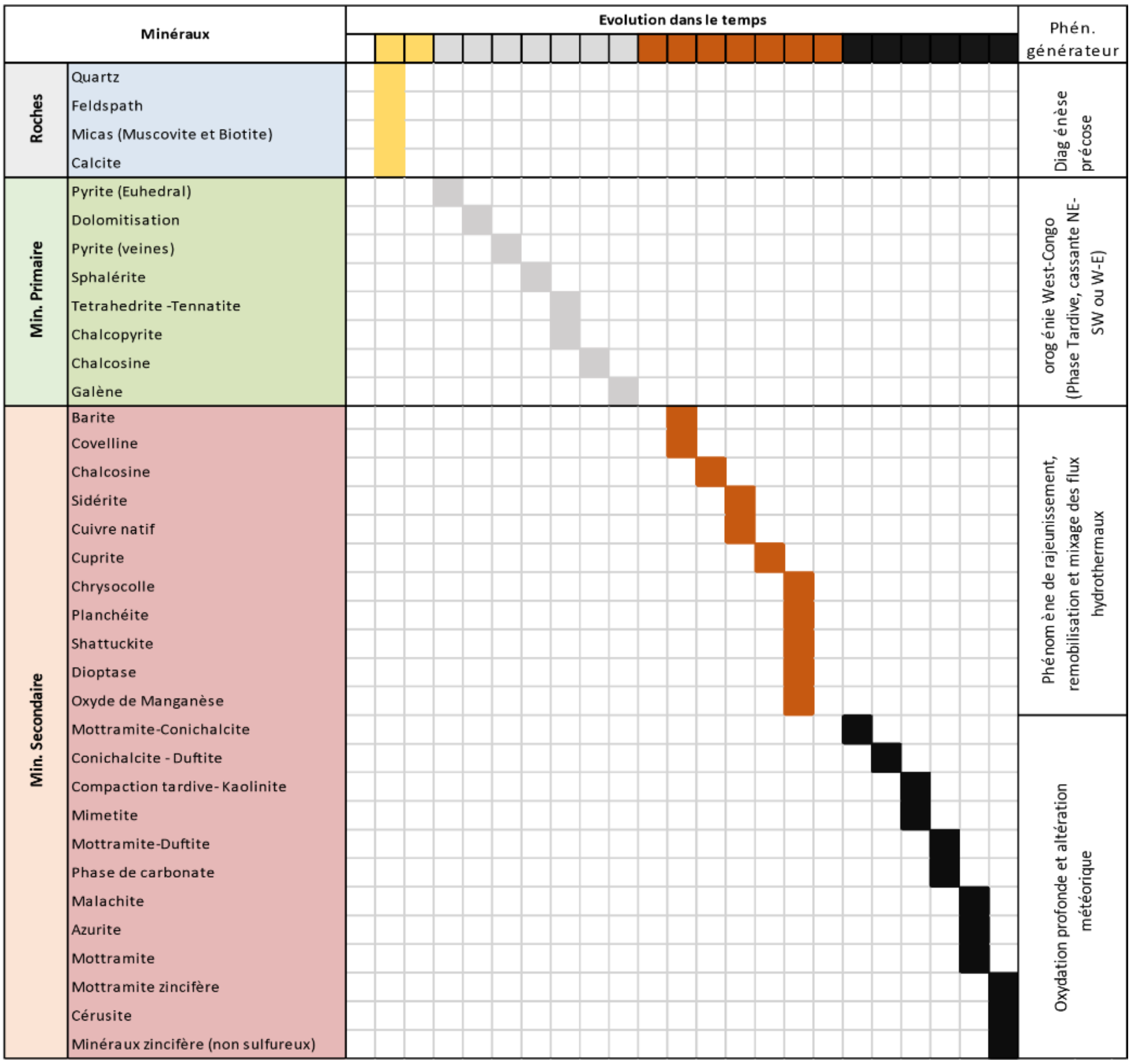

Figure 7: Synthesis on the evolution of mineralization in the Bamba-Kilenda deposit (Paragenesis adapted from LAVREAU (1977), NOËL (1983), KABONWOA (1999), VERHAEGEN (2005) AND ARNE (2014).

3.6. Origin of the mineralization

The above observations on the Bamba-Kilenda deposit support a polyphase emplacement (Figure 6 and Table 2) in the proximity conditions of a rift, the same one that caused the doubling of the Bamba-Kilenda fault; cut blocks between longitudinal faults. Three phases (Figure 7) have been highlighted, including:

1. The first phase of mineralization is generated by basal hydrothermal fluids related to the rift. They were enriched with potassium from the Mpioka subgroup and the overhanging Inkisi group.

2. The second phase of mineralization consists of orogenic fluids (ascending Orothermal) having followed the basinal fluids from which they drew a little potassium while remolding the deposit and precipitated sulphides of Zn, Pb and Cu. This second deposit phase has been relatively enriched with iron.

3. The third phase of mineralization results from sedimentary solutions infiltrated along the fault zone enlarged by the dissolution of the limestones of the wall and consists of secondary minerals. Its iron-rich ores recall the emplacement of pyritic clusters observed at the Kakontwe base in Upper Katanga at Kisanga and Kipushi. These clusters are altered in hematite and limonite Cupro-zinciferous as well as in siderite (INTIOMALE, 1994) like the ores of Bamba-Kilenda. The enrichment of ores with iron is consistent with the assumptions of HEIJLEN et al., [2001, 2003] on the evolution of fluids in developing sedimentary basins. These fluids could act per descensum and per ascensum along fractures.

These three phases can be defined in two major episodes spatially and temporally distinct from the emplacement of the Bamba-Kilenda mineralization (Figure 7).

The first episode of the Cu-Pb-Zn-Fe primary mineralization occurred during the late phase of pan-African orogeny (pre-Karroo age), which would have deformed all sediments in the group. West - Congolese and Inkisi Supergroup and allegedly caused WE and NE-SW-oriented faults in the Bamba-Kilenda area. The work of VERHAEGEN (2005) on fluid inclusions by microthermometry based on the determination of the transient phase by the cooling and heating of fluid inclusions reveals three temperature measurements that would have led to the determination of the composition, the salinity and the temperature during the flow of fluids. According to the author, this mineralization consisting of different types of sulphides was set up at temperatures ranging between 150 - 190^0 C from hydrothermal fluids with high salinity (22.923.1 eq.wt% NaCl). These fluids interacted with the predominantly carbonated and silico-clastic host rocks, resulting in enrichment of certain chemical elements (potassium) during percolation. The corresponding sulphides would come either from the concentration by sulforeductive bacteria (micro-organisms) which would have favored the complexation of chalcophilic metals in sulphates and pyrites at the beginning of diagenesis with the enrichment in sulphide particles (containing Fe, Cu, Pb, Zn, ...), either by the reduction of organic matter (MUCHEZ et al., 2008) or by thermochemical reduction of sulphates in seawater during diagenesis.

The second set-up episode, that of secondary mineralization, is the consequence of the reactivation of the earlier faults (WE and NE-SW) accompanied by the merging and remobilization of the pre-existing primary mineralization going up along the faults and then going on mix with cold fluids (meteoric waters) that infiltrate, hence the decrease in the salinity level reported by VERHAEGEN (2005) in the secondary mineralization (1.2 - 4.2 eq.wt% NaCl).

Secondary faults intersect for the most part the primary mineralization: they are posterior to it. These faults were probably introduced during the rejuvenation phenomenon that would have given rise to the first wave of secondary mineralization. This would also explain the mixed aspect of chalcosines, ie the coexistence of primary and secondary varieties; which shows two episodes of crystallization for this same type of mineral (Figure 7).

Surface alteration and intense and deep oxidation would have affected pre-existing (sulphide) mineralization. This oxidation with secondary supergene enrichment would be at the origin of the formation of oxides, hydroxides, silicates and copper carbonates. The vanadates of Pb, Zn and Cu (Vanadinite and Descloïzite Mottramite series, Table 1 and Figure 7) observed in the Bamba-Kilenda deposit come from these deep oxidation zones.

IV. CONCLUSION

The various lithostratigraphic formations observable in the Bamba-Kilenda sector belong to the West Congo Supergroup, mainly the subgroups of Lukala, Mpioka, the Inkisi group and the Phanerozoic lands.

Our observations on the Bamba-Kilenda boreholes have shown that the Masungu fault intersects limestones of the Lukala, Mpioka and Inkisi subgroups as well. As a result, primary mineralization is as well identified in limestones of the Lukala subgroup as in the Inkisi arkoses. These conditions show that the mineralization is posterior to the sedimentation of the Inkisi group and its fracturing.

The staging of the vein deposits observed in the FK2/4, corroborates a polyphase emplacement of the Bamba-Kilenda deposit:

- Phase 1: Placement by fluids - basin hydrothermal having drained feldspar layers of schisto-sandstone enriching in potassium.
- Phase 2: Placement by ascending Orothermal fluids and iron having particularly collected potassium from the schisto-sandstone roof and ores from the first phase due to their remobilization.
- Phase 3: Infiltration of sedimentary fluids in the failed zone widened by the dissolution of the limestone of the wall along the Masungu fault. This mode of penetration accompanied by dissolution of the carbonates is attributed to the last phase of Bamba-Kilenda which is the richest in iron. The supergene meteorological alteration has finally come to reshape the deposit at great depth.

From the above, the Bamba-Kilenda deposit is a "multiphase vein deposit" of structural control (Masungu Fault). As for the age of the primary vein, it is necessary to take into account the Mpioka erosion and post-Inkisi fracturing in two phases (EW and NS) which generated various Ba- (Fe) and Zn-Pb veins. This age would be pre-Karroo, C.320 m.a. The absolute dating had given 500 m.a. and 180 m.a. [LEPERSONNE, 1960], but the origin of the lead (Pb) tested is controversial [LAVREAU, 1977].

We believe that this improvement of knowledge on this mineralization in the current reference frame of the state of geological knowledge and new techniques, will greatly increase the chances of finding other mineral concentrations with a real economic potential in this part of the country, like the Bamba-Kilenda deposits.

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