Copper-cobalt-bearing mineralization in the Mwashya subgroup: probable solution to the renewal of mining reserves in southern Katanga

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Summary: The copper-cobalt-bearing mineralization of southern Katanga is generally located in the middle Roan formations called the Mining Subgroup (R2); however, other non-negligible concentrations are increasingly found in many other geological formations of different kinds and ages.

The Mwashya subgroup (R4) is one of those formations in which sometimes significant concentrations of copper and cobalt have been discovered in recent years, particularly in the Shituru, Tilwezembe and Mutanda deposits. The geological studies conducted on this geological unit show of the great variations of the lithostratigraphy from one deposit to the other, unlike the deposits of the Mining Subgroup (R2), which show everywhere the same succession of layers.

The most important to note for these copper-cobalt deposits of the Mwashya (R4) is that they are generally located on fault lines, whether from the Lualaba river to Kolwezi or the Shituru area in Likasi; So their subunits remain difficult to correlate from one deposit to another; The geologists are thus led to group them in lithological complexes more or less vast and rather vague called "various dolomites", "shales divers", which give them an appearance of megabrechia.

Key words: Mwashya, Roan, mineralization, Cu, Co, Southern Katanga

1. INTRODUCTION

Southern Katanga is one of the largest copper-copper-bearing provinces in the world whose reserves of these metals are in the process of being depleted. Most of these reserves are in the mining sub-group (Middle Ron). This justifies the abundance of research which has been devoted to it. Most of the deposits belonging to this geological group are either depleted, or in the process of being exploited or in the development phase. Other poorly known units contain

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remarkable deposits and require special attention to try to compensate for the deficit observed in the total reserve of the region.

The subgroup of the Mwashya (R4) constitutes the upper part of the Roan whose age would vary between 765 and 735 Ma; It is found in southern Katanga and northern Zambia. Until very recently, the geology of the Mwashya formations in Katanga was still very poorly known, due to a lack of economic interest due in particular to the limited number of deposits and to the fact of the poor state of the surface which hinders surface observations (Mashala, 2007). The economic interest of this unit is growing thanks to the discoveries that are constantly being made.

It is therefore one of the units with more or less important deposits such as those of Shituru, Tilwezembe, Mutanda, Kajilangwe and Kakonge. However, the geology of this subgroup is still very little known; only a few sporadic works have been carried out (Francotte, 1959, Lefebvre, 1974, 1976, Zakharieff, 1996, Cailteux et al, 2003, 2007, Mashala, 2007, Mashala et al., 2012).Faced with this reality, this work tries to answer the question whether research in the Mwashya can help the renewal of the copper and cobalt reserves in southern Katanga?

2. Regional Geological Context

The Mwashya subgroup is a Neoproterozoic geological age group located at the top of Roan, Southern Katanga and northern Zambia. The present study concerns the various mwashian lands in southern Katanga along a strip in the shape of an arc extending over more or less 500 km in length and 50 to 100 km in width, limited to the north and to the west by the Kibarien, To the Paleoproterozoic block of Bangweulu and to the south by the Mesoproterozoic chain of the Irumides (Fig.1).

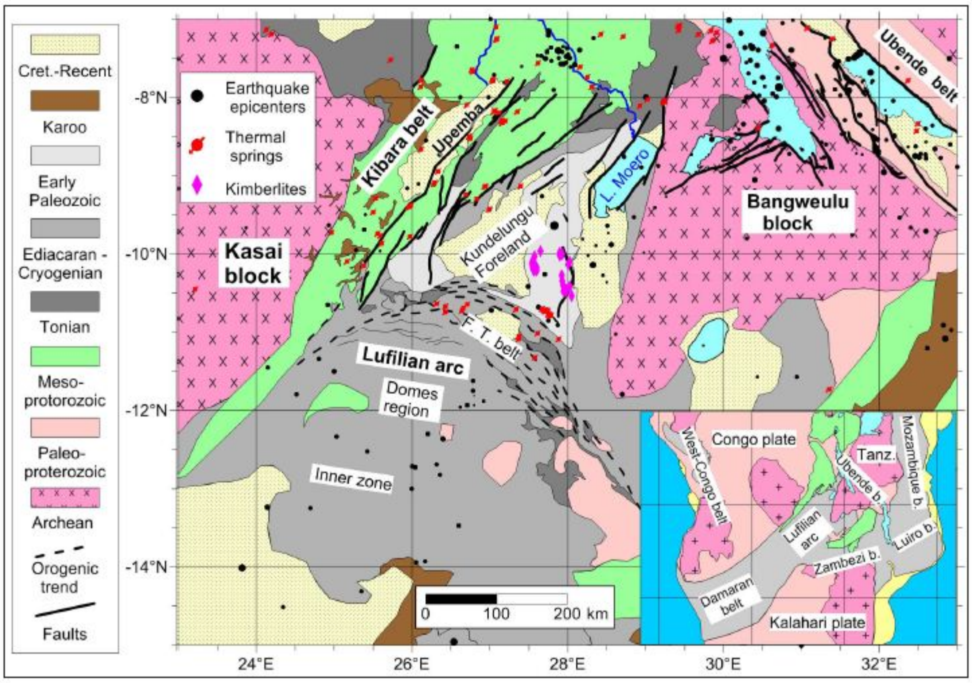


Fig.1: Spatial distribution of large geological and structural complexes in Katanga.

From the work of Cahen (1974), Cahen et al. (1984), Cailteux (1983), Cailteux et al. (1973, 1974, 1987, 1995), Lefebvre (1973, 1974, 1978, 1985), the great geological entities of Katanga are arranged in an Archean and Proterozoic base surmounted by a Phanerozoic cover.

The best-known Archean formations in the Katanga region are visible in the western part. They range from Kisenge-Kasaji to Kapanga and belong to a single complex called "Sandoa-Kapanga Complex" (Kabengele and Nawezi, 1998). This applies in particular to the formations of the Lukoshi, Kalundue and the Lulua Group (Cahen, 1954, Lepersonne et al., 1974, Kabengele and Nawezi, 1998). Their Rb / Sr age of 2.82 Ga obtained in particular on the gneissifiedgranitoids of Kapanga (Delhal and Liégeois, 1982) and Pb / Pb of 3.01Ga (Walraven, 1991) indicates their clear belonging to the Archean.

The Paleoproterozoic is represented in the region by the Ubendian chain known mainly in southeastern Katanga where the Muva formations, the Luina granitoids, Mokambo in the Congo, Kafue in Zambia and the Konkola borders Two countries, and in the region of Kalemie-Moba (Figure 2). These formations, whose aggregation is generally between 2200 and 1750 Ma, include NW-SE-oriented metamorphic rocks and quite large metamorphite-intersecting magmatic complexes.

The Kibarian chain extending to Katanga about 600 km SW-NE represents the Mesoproterozoic; It is bordered to the east by a mosaic of the continental blocks prior to the Kibarianorogeny, mainly comprising the Archean craton of Tanzania and the Paleoproterozoic Block of Bangweulu, and on the west by the Archean-Paleoproterozoiccraton of the Congo-Kasai.

The Neoproterozoic formations belong to the KatangianSupergroup, they were all affected by Lomamianorogenes at 950 Ma, Lusakian at around 950-850 Ma and Lufilienne or Panafrican at about 650-600 Ma (Cailteux, 1983, Dejonghe and Ngoyi, 1995, Mashala, 2007).

The Katanguian is over 500 km long and 60 km wide on both sides of the Congo-Zambia border. It includes sub-tropical formations flushing to the north, in particular on the Biano and Kundelungu plateaus, and the pleated formations of the Lufilian Arch in the south. This set rests uncomfortably on formations of varied age (Dejonghe and Ngoyi, 1995):

- In northeastern on the KibarianMesoproterozoic(1300 Ma)formations and on the Paleoproterozoic (> 2000 Ma) formations;
- In the southeastern on the highly metamorphosed formations of Paleoproterozoic(2000 Ma) and on Mesoproterozoic;
- To the west on formations dated only from the Mesoproterozoic.

The Katanguian lithostratigraphy comprises three groups of unequal importance (Audeoud, 1982), and the cuts were made on the basis of two known diameters known as the “GrandConglomérat” and Petit Conglomérat”, all presumed glacio-marine (Oosterbosch et al., 1962) and dated respectively to 760 Ma and 565 Ma (Robb et al., 2003). These groups are, from the oldest to the most recent (Tabl.1) and their distribution is given on Figure2:

- ***The Roan group,*** whose age is between 880 Ma and 760 Ma (Key et al., 2001), contains copper-cobalt and stratiformuraniferous mineralization in Katanga and Zambia and is characterized in Katanga by the predominance of chemicalandorganogenesis rocks, the sedimentation of which would have been largely carried out in a lagoon environment (François, 1974, 1987, Lefebvre, 1978, 1985 and Cluzel, 1986).

Table 1: Lithostratigraphy of the Katanguien (Cailteux and Kampunzu, 1994, François, 1997 and Chabu, 2003).

Age (ma)				Group	Sub-group	Formations & lithology	Environment
~ 320	L. Pz.		Karoo				
542	Early Paleozoic		Katanga Supergroup	Kundelungu	Biano (Ku3)	Red arkoses, conglom., sandstones, shales	Foreland continental clastic, lacustrine to fluvio-deltaic (semi-)arid
530	Neoproterozoic	Ediacaran			Tectonic unconformity (orogenic paroxysm)		
					Ngule (Ku2)	Sandstones, calcareous siltstones & shales, limestones	Epi-continental lagunar to marine
635					Gombela (Ku1)	Carbonated siltstones, shales	
650		Cryogenian			Petit Conglom.	Glacial diamictite	Marinoan glaciation
				Nguba	Bunyeka (Ng2)	Dolomitic sliciclastics	Proto-oceanic rift similar to the Red Sea
710					Muombe (Ng1)	Carbonated siltstones & shales; Dolomites & limestones	
750					Grand Conglom.	Glacial diamictite	Sturtian glaciation
				Roan	Mwashya (R4)	Calcareous shales	Fluviatile to lacustrine in continental. rift
					Dipeta (R3)	Dolomitic siltstones, intrusive gabbros	
					Mines (R2)	Stromatolitic dolomitic siltstones	
850					R.A.T. (R1)	Argillaceous dolomitic silts-standstones	
		Tonian	883 ± 10 Ma Nchanga garnite				
1000			Paleo- & Mesoproterozoic				

- ***The Nguba group***is a predominantly terrigenous, competent group, deposited in a neutral marine environment with a reducing agent. These formations are partially relayed towards the south of the region by organogenic rocks, as is the case of the calcaro-dolomitic level known as the "Kakontwe Dolomite" observed in the southern facies (François, 1974, 1997).
- ***The Kundelungugroup*** *is*, like the previous group, predominantly clastic rocks deposited in the marine environment. Unlike this other set, the facies and thickness (about 3000m) vary very little. François (1997) suggests a moderate transgression of the Kundelungu Group on the Nguba Group.

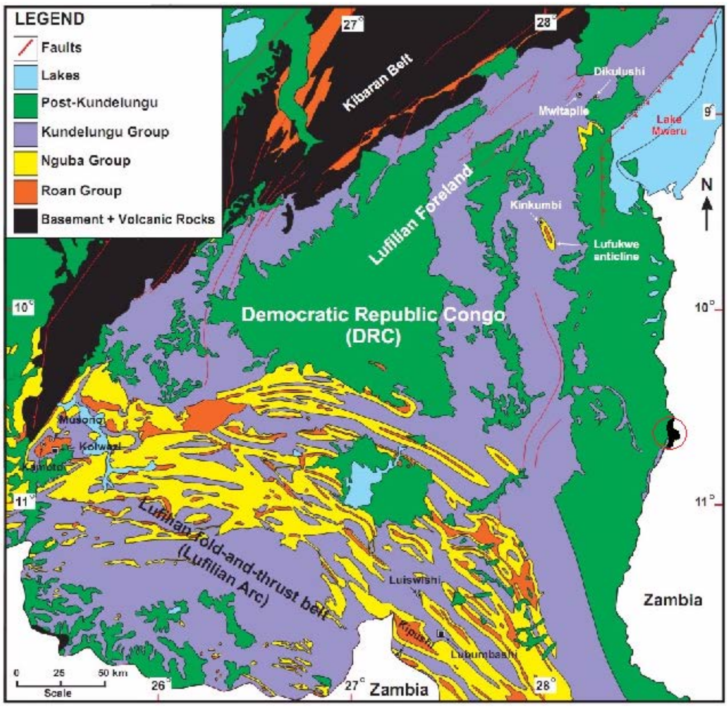


Fig.2: Subdivision of the Katanguien

The tectonics of the Lufilian chain, like that of the northern Zambezi range to the south, is related to the Angola-Kalahari plate collision with the Congo-Tanzania plate along an oriented SE-NW suture, linking the south From the chain of Mozambique to the Western Congo chain (Fig.3).

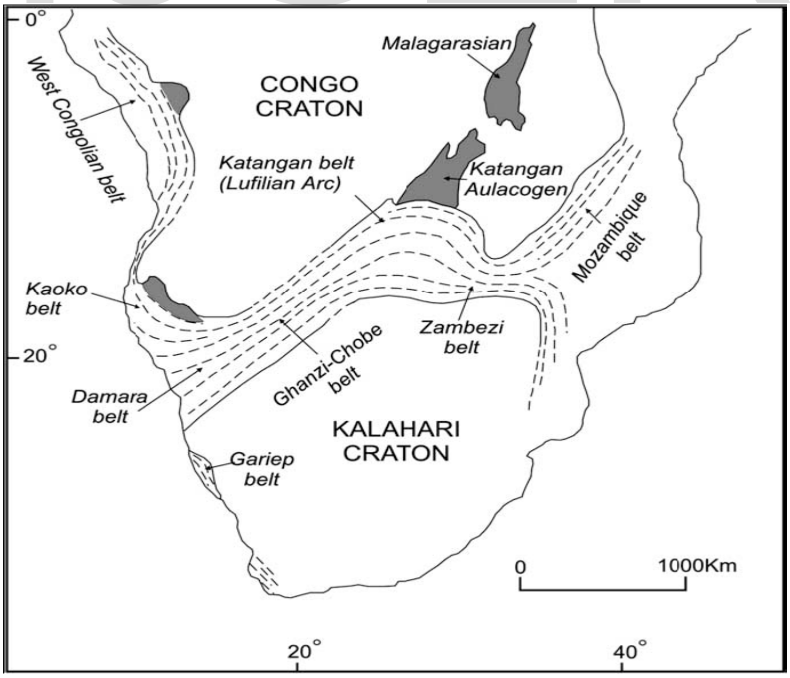


Figure 3: Situation of the Lufilian Chain between the Congo plate and the Kalahari plate (Kampunzu and Cailteux, 1999).

This collision, which occurs between 560 and 550 Ma, was accompanied by a bedload towards the N-E with deep crustal detachments and inverse faults on the platform formations and the continental slope below a superficial bedload.

From this tectonic one can distinguish three major phases of deformation (Fig. 4) in the construction of the Lufilian Arc (Kampunzu and Cailteux, 1999). It is :

- The first phase (D1), called the "Kolwezian phase", develops folds and thrust beds with an axial plane oriented towards the north. It dates from 790-750 Ma and can be correlated with the major deformation of the Zambezian chain (820 Ma). In this phase are associated southern vergence structures formerly linked to a second tectonic event called the Kundelungian phase of the Lufilian orogeny, but which are, in fact, according to Kampunzu and Cailteux (1999) D1 along the Katangian sequence and especially along the Kibarien foreland.

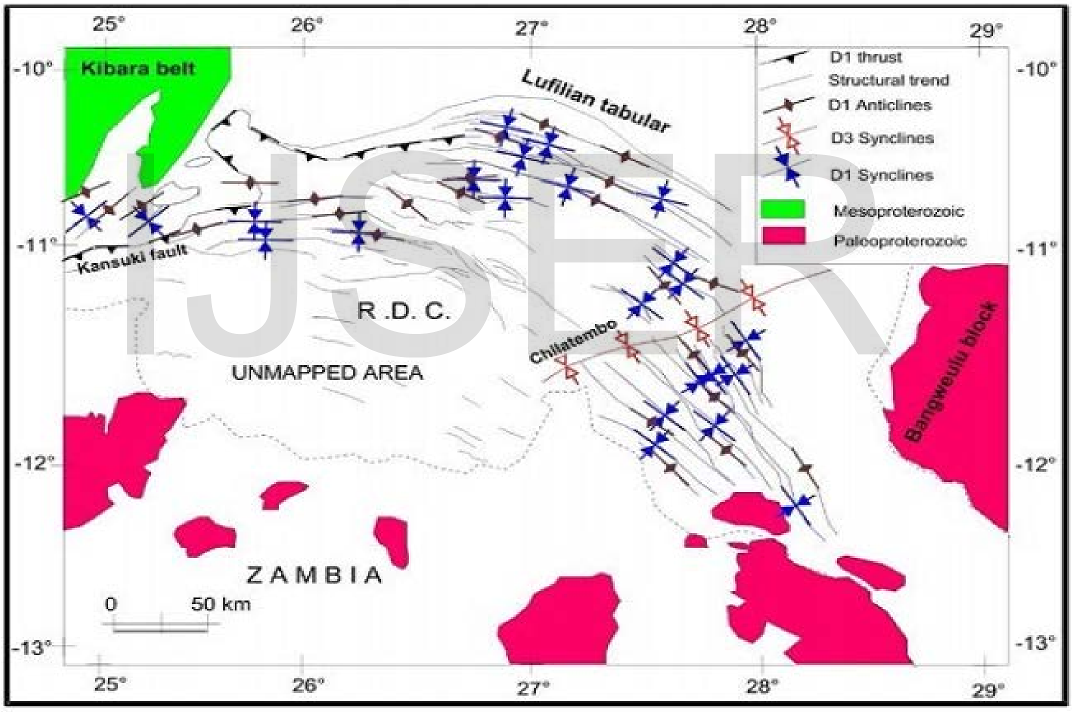


Fig. 4: Structural map of the Lufilian Arc, showing in particular the structures D1 and D3 (Demesmaeker et al., 1963 in Kampunzu and Cailteux, 1999)

- The second phase (D2) of the Lufilian orogeny is the "Monwezian phase", which includes several longitudinal faults successively reactivated in time, during which the dexter rotation of the eastern bloc of the chain takes place The current direction NW-SE of the structures D1 in this part of the Lufilian arc and its convex geometry The Monwezian phase is dated about 690 and 540 Ma.

- Finally, the third phase (D3) called the "Chilatembo phase" is the last event of the Lufilian orogeny. It is marked by structures transverse to the major direction of the Lufilian Arc (Fig.4). These deformations, as well as the upper Kundelungu sequence (Ku-3 or Biano Subgroup) are dated to less than 540 Ma, and probably belong to the Lower Paleozoic.

3. Geology of the Mwashya Subgroup in Southern Katanga

The Mwashya subgroup (R.4) represents the upper unit of the Roan group. It is underlined at its base by an important brecciated horizon which planes it and separates it from the rest of the Roan (Dipeta Group), but it remained solid with the Nguba conglomerate at the summit by a sedimentary transition (Table 2).

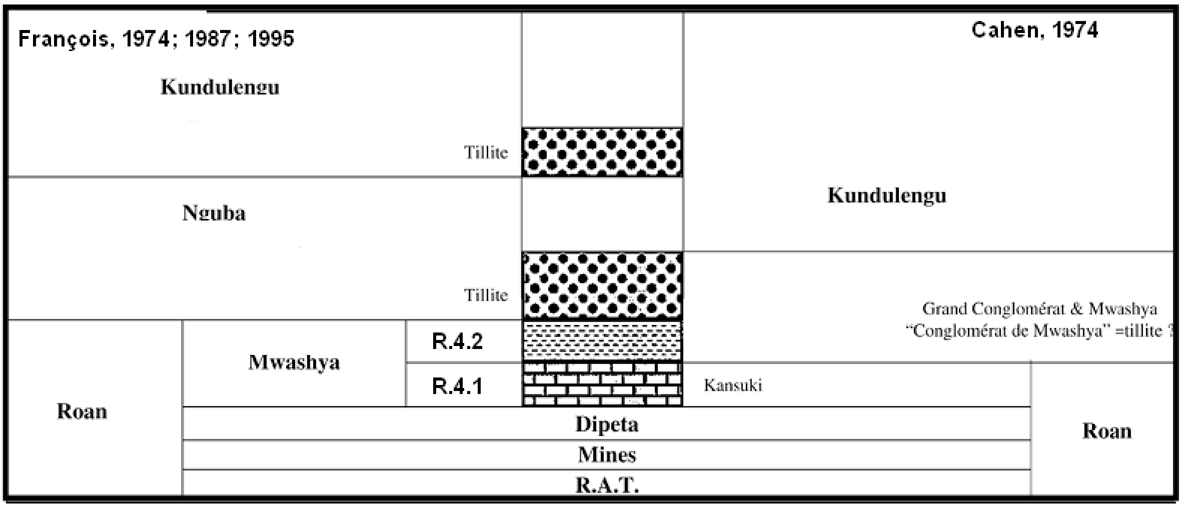
François (1974, 1987,1995) subdivided the Mwashya into two groups:

- The lower Mwashya (R.4.1), predominantly dolomitic, containing levels of pyroclastic rocks, iron and jaspoid horizons,
- And the superior pelvic Mwashya (R.4.2).

The transition between these two sets is not well known. Some authors speak of the occurrence of a conglomerate called the Mwashya conglomerate as the boundary between the lower Mwashya and the upper Mwashya, especially in the northern region of Lufilian (Francotte, 1959). In areas where this conglomerate is not observed, particularly south of Kambove, the limit corresponds to the passage between silicified dolomites, siliceous oolite beds and jasper beds belonging to the lower Mwashya and the upper Mwashya shales. It is therefore a limit placed arbitrarily where dolomitic horizons, first preponderant, disappear almost completely to make way for shales (François, 1973).

For authors such as Cahen and Mortelmans (1948) and Cahen (1954, 1974), the upper Mwashya and the Great Conglomerate constitute a single set called the "Great Conglomerate System and Mwashya" (Table 2) Entities all represent glacial to periglacial deposits. The lower Mwashya thus constituting a separate entity called the Kansuki Group (Cahen, 1974).
In their 2007 publication, Cailteux et al. proposed a new lithostratigraphy of the Mwashya Subgroup, similar to that recommended by Cahen (1974), assigning the name of the Mwashya Subgroup to the formation of the present Upper Mwashya alone.

Table 2: Synthetic Lithostratigraphy of the Katanga Supergroup in Southern Katanga by Cahen (1974) and Francois (1974, 1987 and 1995).



4. Some copper and cobalt deposits in the Mwashya subgroup

4.1. Shiturudeposit

Presentation

The Shituru deposit is located on the SE outskirts of the town of Likasi, about 1 km, between latitude 10 ° 51 'and 10 ° 58' south and longitude 26 ° 44 'and 26 ° 46' east. It extends over an area of 800m by 400m and updates the rocks of the Mwashya subgroup.

This cuprocobaltiferous deposit was discovered towards the end of the 19th century by the Belgian geologist named Jules Cornet. Its operation and that of the Likasi deposit, located at the latter's NW in the Mining Sub-group, formed the basis for the creation of the city of Likasi. These are two deposits belonging to the Shituru anticline, oriented WNW-ESE, and whose core is constituted by formations of the Mwashya Subgroups and the Mines.

About Lefebvre (1974), the Cu-Co mineralization at Shituru is the result of an important supergene enrichment following the oxidation of chalcopyrite, bornite and carrolite, mainly housed in dolomitic levels. The Cu content reported by this author was exceptionally high in the 25% region. The alteration could certainly be favored by the circulation of supergene and hydrothermal waters along numerous orthogonal and longitudinal faults, materialized by grinding zones (brecciation) which affect the lower Mwashya of this deposit.

Lithostratigraphy and mapping of the Shituru deposit

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The lower Mwashya of the Shituru deposit is a lithostratigraphic set thick from 195 to 200m which is distinguished by a lithology not very varied including (Fig.5):

- Pyroclastic rocks outcropping about 60% of the area. Several "facies" ranging from lapilli tuffs, even volcanic breccias, to fine ash tuffs have been observed (Mashala, 2007; Mashala et al., 2012).
- Dolomitic rocks forming two entities separated by pyroclastic rocks:
  - A lower set comprising at the base a massive dolomite gray to white surmounted by a dolomite, often laminar and probably algal. Some intercalations of dolomitic shales and / or micaceous dolomites are observed.
  - An upper set consisting of granulated and silicified dolomitic rocks with several pyroclastic levels as well as laminar or massive hematite beds and jasper.
- The other lithologies are mainly represented by beds of hematite, frequently associated with pyroclastic rocks, jaspers and other high-lying rocks; theses rocks are of volcanic and hydrothermal origin (Mashala, 2007; Mashala et al, 2012).

Structure of the Shituru deposit

The lithostratigraphic observations and structural measurements taken from this deposit (Mashala, 2007) have shed light on the structure of the Shituru deposit. It should be noted that:

- The stratification of the layers between N80° and N120° corresponds practically to the WNW-ESE direction of the deposit.
- The various geological sections established show southern dips of all Shituru Lower Mwashya formations with mean values between 66 ° SW and 69 ° SE, reflecting the existence of an anticlinal structure discharged to the north, and Even overlapping the northern flank which, to a large extent, has disappeared by the effect of the longitudinal faults which affect it.

This structure is undoubtedly linked to the Kolwezian phase of the Lufilian orogeny.

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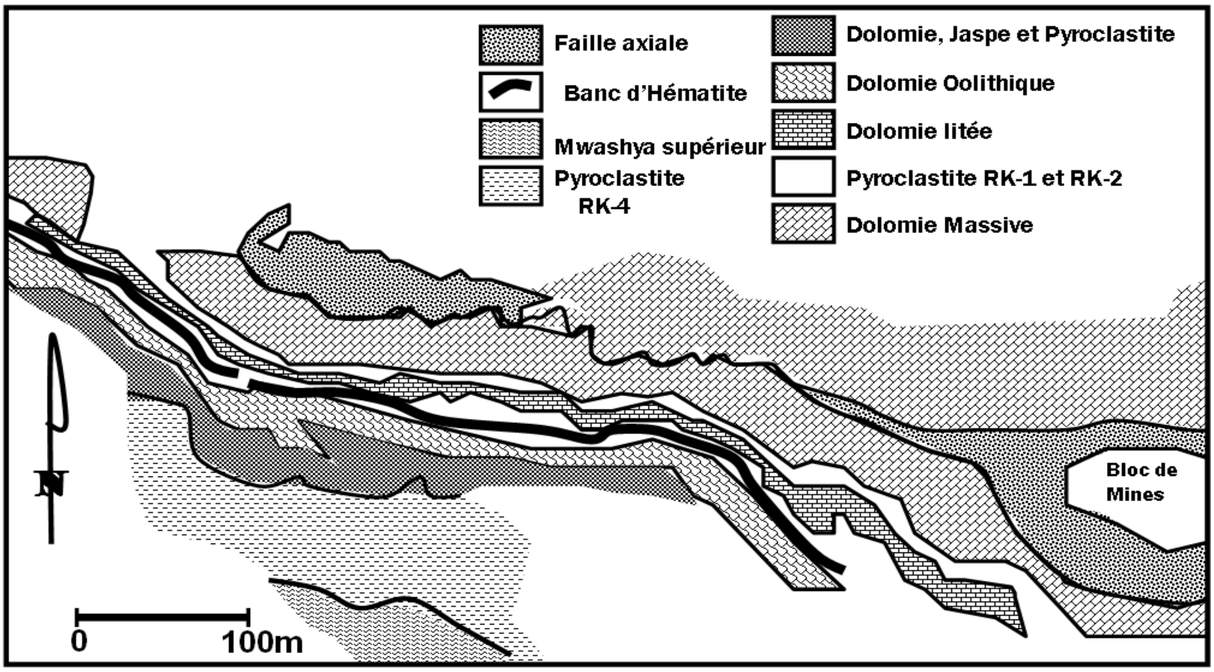

Fig.5: Geological map of the Shituru deposit (Lefebvre, 1974, modified by Mashala, 2007)

Mineralization of the Shituru deposit

The Cu-Co mineralization of the Shituru deposit is located in the various dolomitic bases of the lower Mwashya. It is divided into three groups: ocher ore formation, green ore formation and black ore formation.

- « Formation à mineraiocre » consists of pyroclastic rocks. The mineralization is related to these clastic rocks deposited in an oxidizing medium. In these horizons copper is absent, it nevertheless appears in tiny quantities disseminated in pyroclastites in the form of chalcopyrite associated with a little pyrite. Manganeseoxideisalsopresent in smallquantities.
- « Formation à mineraivert" has Cu-Co mineralization related to clastic rocks deposited in a reducing medium. It is a horizon of dolomitic pelite whose origin is ill-defined. It is comprised between the formation of Shituru and the black ore formation. Low levels of copper are observed in the form of a pyrite - chalcopyrite ± bornite association.
- « Formation à minerai noir"is a set of dolomites often impure in benches sometimes massive, sometimes finely deposited deposited in reducing context. The associated copper mineralization, which appears as a pyrite-chalcopyrite-bornite-malachite ± chrysocole association, shows high levels, which can reach 25% in places. Some salaries of these rocks are very similar to the rocks of the Mining Subgroup.

4.2. The Tilwezembe deposit

Presentation of the deposit

The Tilwezembe deposit is located about 28 km east of Kolwezi and 2 km south of the town of Mumpanja in the vicinity of the Lualaba railway station. It corresponds morphologically to a chain of hills rising at the foot of Kolwezi. It is presented as an anticline whose axis is generally oriented E-W with an axial plane discharged towards the north.

Lithostratigraphy and mapping

The Tilwezembe copper-bearing deposit does not have assises belonging to the Mining Subgroup (R2) along the axial fault as at Shituru. The geological map (Fig. 6) shows the following facies from south to north (François, 1973):

- A southern flank consisting of the tillite known as the "Grand Conglomérat" (Ki 11), the lower Mwashya formations (R 4.1), a fault breccia, a Nguba (Ki) flap and an axial fault breccia;
- A northern flank consisting solely of formations of the Kundelungu group (Ku 122).

The contact between Ki 11 and R 4.1 seems abnormal, the upper Mwashya (R 4.2) is lacking. This appears to be frequent in the Kolwezi region (Lefebvre, 1974).

Structure of the deposit

The development of the structure is attributed to the Monwezian tectonic phase. The deposit appears as an anticline that goes from the west, along the Kansuki fault, to Kisamfu in the east. Its southern slope overlaps its northern flank. The rejection decreases towards lest and saps at the height of the Kalumbwe deposit**.**

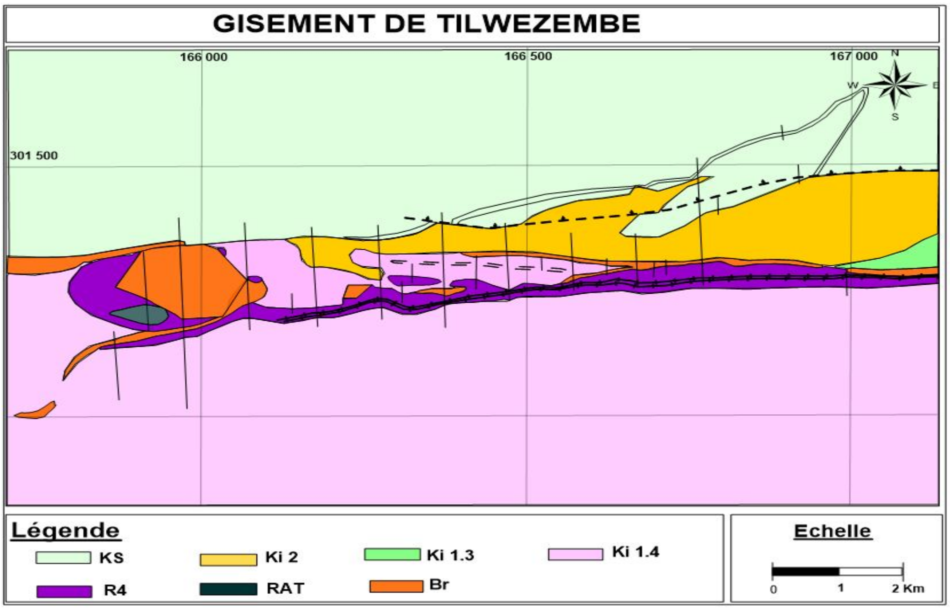

Fig. 6: Geological map of the Tilwezembe deposit

The anticlinal axis is occupied by Roan formations of variable width (low or zero up to more than 2 km wide). Several megafragments or scales of Roan (R2) have been described (François, 1973) including the Deziwa and Kalumbwe deposits. Figure 7 shows an N-S section of the Tilwezembe deposit.

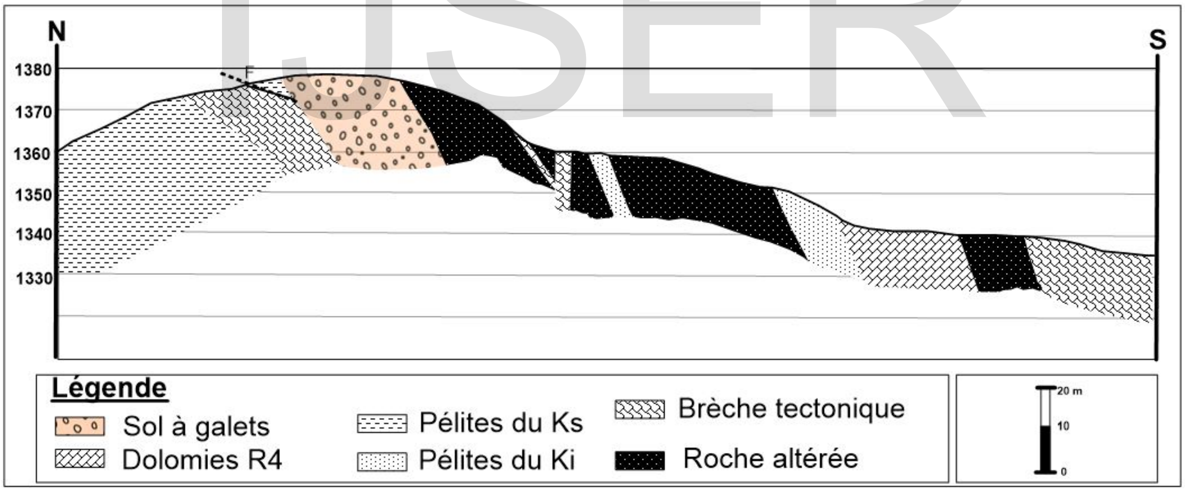

Fig. 7: Geological section of Tilwezembe

Tilwezembe mineralization

In Tilwezembe two main sedimentary facies to which a third of the "tectonic" type could be added:

- The clays or pelites whose color, varying from greenish to red, shows very variable oxydo-reduction conditions. The pelites are generally not mineralized, at least in economic ore.
- The "dolomites" mostly affected by partial or total silicification. Nuclei of hard dolomites are often surrounded by very dusty dolomites. They are also characterized by significant mineralization, both sulphurous and oxidized. The microprobe study (Zakharieff, 1996) of some samples showed the presence of numerousspherocobaltite crystals (CoCO) sometimes associated with malachite and primary sulphides such as pyrite, chalcopyrite and carrolite (CuSCoS). Copper oxides and carbonates are also accompanied in these dolomites by heterogenite which can sometimes be slightly copper-bearing, cobalt-containing goethite, tourmaline and chlorite as well as manganese oxides.
- A "tectonic" facies refers to the breccias of the axial fault (contact Ku-R_4 or Ku-$Ng_{1\ 1}$) or contact pelites-dolomites (Ng-R_4) which also affect dolomites and pelites and whose clastsare, of course, elements of dolomite, pelite and dolomitic pelite. They are only slightly mineralized.

4.3. The Mutanda Deposit

Location of the deposit

The Mutanda deposit is located 40 km east of the town of Kolwezi, just 2.6 km from the 39; 1.5 km from the Kando River and 1.3 km from the railway that runs from Kolwezi to Lubumbashi. The concession extends over an area of 676 hectares along a structure of 3.6 km from the East to the West and 1.8 km from the North to the South; At 25 ° 4838 east longitude and 10 ° 4721 south latitude (Fig.8).

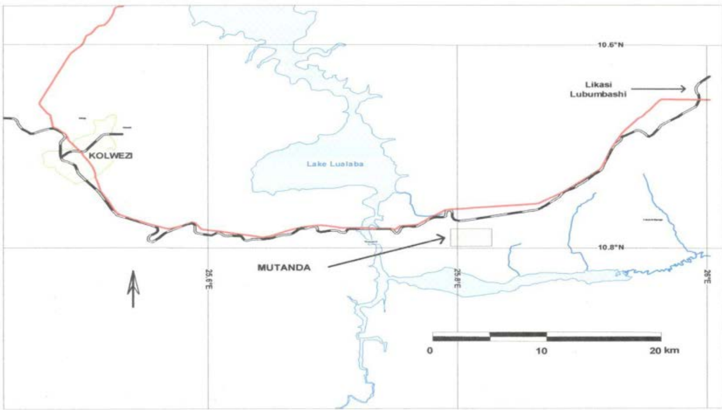

Fig. 8: Location of the Mutanda deposit

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Lithostratigraphy and mapping

From the lithostratigraphic point of view, the Mutanda deposit contains the rocks of the Nguba and Roan groups, precisely Mwashya (R.4) and Dipeta (R. 3).

These groups are separated from one another by a tectonic breccia. The lithostratigraphy of this deposit comprises, from top to bottom, the following formations (Fig. 9):

- The Nguba formations (Ng 1.3)which are dark brown-gray, sometimes gray-purplish, mass, affected by iron oxides; The invisible grain rock is a ferrous argillite.
- The heterogeneous brecciaof variable color consists of angular fragments of various rocks (Nguba shales, R4 dolomites) packed in a fine argillaceous matrix.
- The Mwashya formations (R4.1)are silicified dolomitic rocks associated with horizons of jasper, ooliths and hematite beds.
- The heterogeneousbrecciaof variable color made of various dolomites similar to those of R4 and R3.
- The formations of the Dipeta (R3)which are dolomitic rocks greyish to brownish, massive appearance and smooth feel.
- The heterogeneousbrecciawith subangular fragments of dolomites and Nguba shales packed in a fine matrix of clay.

The Mutanda deposit is subdivided into three different entities: the eastern entity, which is about 1,400 m long, is the largest deposit in Mutanda, the geological section of which is shown in Figure 10; the central lens (about 500 m) and the center-northwest lens (about 300 m long).

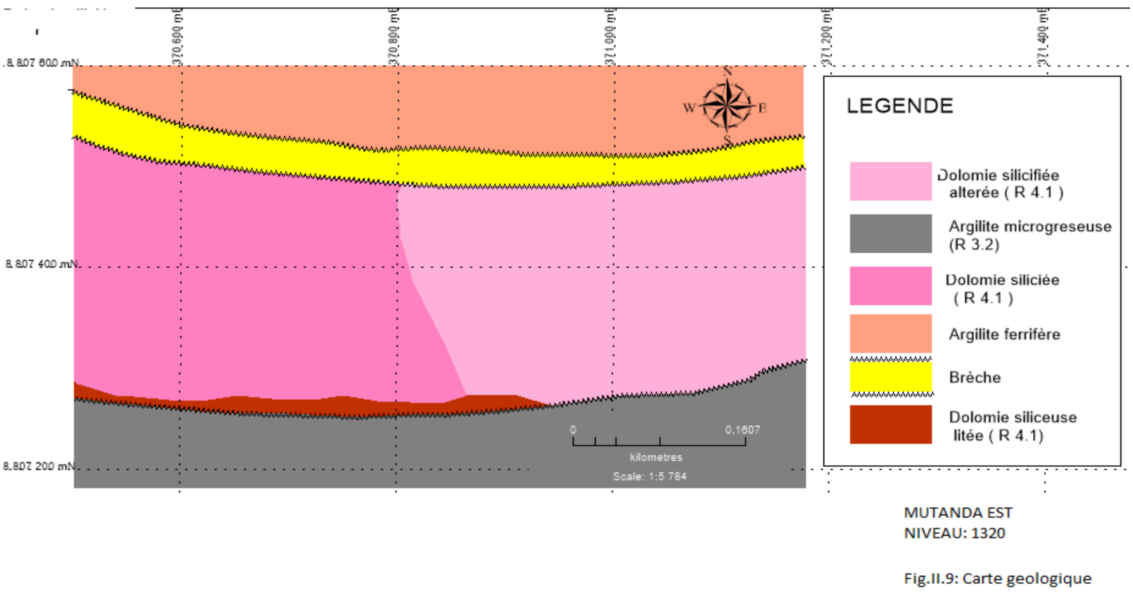

Fig. 9: Geological map of the eastern part of the Mutanda deposit

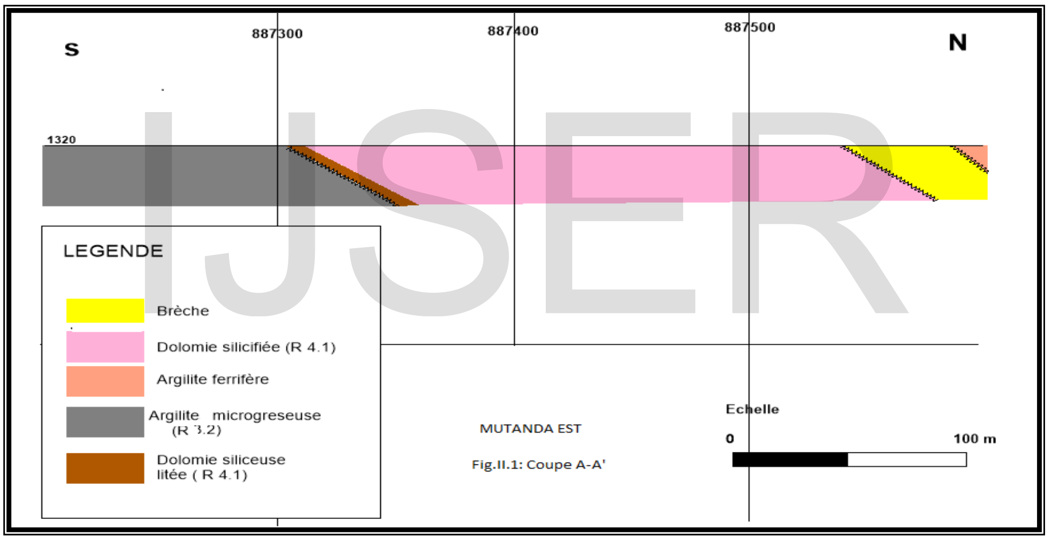

Fig. 10: Geological section of the eastern part of the Mutanda deposit.

Structure of the deposit

The Mutanda deposit consists of a diverse set of rocks attributed to the Mwashya subgroup, particularly at its lower part; It is framed by two major faults materialized by gaps pointing out abnormal contacts with the formations of the Nguba group on the one hand and those of the Dipeta subgroup on the other. The structure of this deposit is in a brecciated mass which rests on the undifferentiated formations of the Dipeta group.

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Mineralization of the Mutanda Deposit

It should be noted that the mineralization is concentrated in the Mwashya (R4), the gaps separating the Nguba group (Ng1.3), and the Mwashya (R4) and Dipeta (R3) subgroups.

This deposit is characterized by two types of mineralization:

- A primary mineralization disseminated in rock (syngenetic mineralization).
- A secondary mineralization which is epigenetic remobilization in the cracks. It isthereforeclearly post-tectonic.

The oxidized minerals found in the Mutanda deposit are malachite, heterogenite, pseudomalachite, katangite, azurite and chrysocole.

5. Comparison between the main Cu-Co deposits of Mwashya subgroup

The comparative approach of the Mwashya subgroup observed in these different deposits focuses on lithostratigraphy, mapping and mineralization.

(1) In terms of lithostratigraphy and cartography, table 3 shows the main characteristics of these three deposits.The geological cuts for each of the deposits show that both layers of pyroclastic rocks are present in both Mutanda and Shituru, but it is rather the succession of dolomites that is somewhat different.

- In Shituru massive dolomites are observed at the base of the series, whereas at Mutanda they appear towards the summit.
- In Tilwezembe one notices that a succession of massive and stratified dolomites intercalated sometimes of the pelites of the group of Nguba or of any other type.

In all cases, the succession of layers is not strictly the same in the three deposits.

Table 3: Comparative Lithostratigraphy of the Mwashya Subgroup Deposits

STRATIGRAPHIE	GISEMENTS		
	SHITURU	TILWEZEMBE	MUTANDA
R4.2	shales rubannés	absent	absent
	shales carbonés		
	shales gris verdatres		
R4.1.	pyroclastites	dolomies+pélites	
	dolomies jasperoides		dolomies silicifiées massives
	dolmies oolithiques		dolomies jasperoides
	pyroclastites		dolomies oolithiques
	dolomies litées		dolomies silicifiees stratifiées
	dolomies massives		

(2) In terms of mineralization, the various metallogenic associations observed are given in Table 4, with regard to the respective lithostratigraphic entities. Examination of this table allows to distinguish three different facies from one deposit to another. It is thus that Shituru has a copper facies, Tilwezembe a copper-cobalt-manganese facies, and a copper-cobalt facies at Mutanda.Each deposit has its peculiarity in terms of its mineralogical paragenesis.

Table 4: Mineralization in the Shituru, Tilwezembe and Mutanda deposits.

LITHOSTRATIGRAPHIE		GISEMENTS		
		SHITURU	TILWEZEMBE	MUTANDA
R4.2	shales rubannés	sterile	absent	absent
	shales carbonés	sterile		
	shales gris verdatres	sterile		
R4.1	dolomies jasperoides	Cu	absent	Cu+Co
	dolmies oolithiques	Cu	absent	Cu+Co
	dolomies litées	Cu	Cu+Co+Mn	Cu+Co
	roches pyroclastiques	sterile	absent	absent
	dolomies massives	Cu	Cu+Co+Mn	Co+Cu+Mn
	pélites	faible teneur en Cu	sterile	absent

(3) On the structural level, all these three deposits show an almost identical structure, namely the anticlines dumped all to the north, with the south flank overlapping the northern flank. We recall that this folding occurred during the so-called Kolwezian tectonic phase (Table 5). These anticlines were later torn along their axes during the Monwezian phase, which allowed the extrusion of the Mwashya (R4) rocks in the

form of mega-fragments or breccias sometimes decametric and continuous over a certain length, with mineralization often Interesting.

Table 5: Geological structure of the Shituru, Tilwezembe and Mutanda deposits

GISEMENTS	ORIENTATION	PENDAGE	STRUCTURE DE LA REGION
SHITURU	WNW-ESE	66°-69°SE	anticlinale deversé vers le Nord ; flanc sud chevauchant flanc Nord
TILWEZEMBE	E-W	55°-65° S	anticlinale deversé vers le Nord ; flanc sud chevauchant flanc Nord
MUTANDA	E-W	52°-66° SE	anticlinale deversé vers le Nord ; flanc sud chevauchant flanc Nord

6. Conclusions

At the end of this study of copper-cobalt mineralization in the Mwashya subgroup, the following observations can be made:

- The Mwashya contains copper-cobalt-bearing mineralization with sometimes sufficient reserves that can be the subject of an interesting mining project;
- These mineralizations are mainly located in the dolomitic formations with various facies, but also sporadically in the pyroclastic breccias and rocks of the lower Mwashya (R4.1);
- There are, on the lithostratigraphic plane, notable differences from one deposit to another, in particular in the succession of formations, contrary to what is observed in the deposits of the Mining Subgroup. Mwashya occurs in the form of megafragments of dolomitic rocks that somewhat resemble megabreches rather than continuous deposits.
- Mineralization in the Mwashya occurs in all of these rocks in dolomitic form linked to all faults: in Tilwezembe and Mutanda it is linked to the southern branch of the Kansuki fault, in Shituru to the Likasi-Panda fault;
- Although lithostratigraphic succession and associated mineralization can easily be recognized in M2 sub-group (R2) deposits, the Mwashya deposits do not.
- In Shituru, for example, the most mineralized rocks form a succession of massive dolomites and stratified dolomites that can easily be confused with the dolomites of the Mining Subgroup (R2); in Tilwezembe and Mutanda, mineralization occurs in massive dolomites, often altered.

- It is a discontinuous mineralization strongly affected by tectonics, it could have spread over great distances on this formation, which extends over several tens of kilometers, sometimes on both sides of the anticlines, as is the case for the Shituru anticlinal Passes through Nguya and the Shandwe anticlinal between Kapolowe-Gare and Shandwe in the vicinity of village 75 where unfortunately no trace of mineralization has yet been detected.
- The presence of primary sulphides (chalcopyrite and pyrite in dissemination) at Mutanda suggests the occurrence of primary (sulfurous) deposits in these formations.
- In any case, the existence of megafragments (scales) of the Mwashya subgroup (R4) alongside those of the Mines sub-group (R2), as observed in Kipoï, arouses enthusiasm that is likely to lead to Systematic search for Mwashya scales, which could help to deplete those of the Mines subgroup, which is a major carrier of copper-bearing mineralization in southern Katanga..

In short, at the present stage of research, the Mwashya Subgroup appears to be a very poorly known geological group which may prove very important for the renewal of copper and cobalt reserves in southern Katanga provided that serious research is carried out. It is therefore a geological unit capable of containing interesting deposits. Current investigations show the bonding of most of the deposits observed with large breaks which would have favored the rise of mineralizing deposits or the remobilization of the pre-existing mineralization. The prospecting of such deposits should, in our opinion, focus on the identification of these major accidents as metallotectes.

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