The Role of Intrusion in the Metallogeny of Tin-Niobium-Tantalium ore Deposits of Cogolese Kibaran Belt, Case of Kalehe and Masisi Terotories/DRC

During the magmatic differentiation and crystallization, volcanic materials reach the surface whereas plutons abound the bottom being grained.The felsic/ acid intrusions are the most metallotectic of the Stanniferous and Colombo-tantaliferous occurrences. This mineral association is more concentrated into granites and their related pegmatites. Actually, tin is in high demand due to the increase of thechnologies. The metallogenic role of intrusions on the establishment of Sn-Nb-Ta deposits in the Kibaran is important to undesrtand in the Masisi and Kalehe region, Kivu/DRC. Granites are typically accompanied by pegmatites and, all batholiths can be Tin-bearing or Tin-absent in the pegmatitic phases. In the case of Masisi and Kalehe, granites remain underground and the pegmatites are flush on the surface. Today all these pegmatites are linked to two granitic intrusions, Hango and Sula. In the case of Masisi in North Kivu, the pegmatite is visible in the Mumba region and kaolinized in the Rubaya region and is more stanniferous than Niobo-tanteliferous. In addition to this mineral association, while manganese mineralizatio is present, the occurrences at Bishasha remain uneconomic. In the Kalehe region, the body is too altered and its petrography study is diffcult due to its neogene mineralogy, the richness in potassium Bearing minerals opposes it high. The role of the intrusion is more pronounced because it remains the only economic Stanniferous intrusion in these region. Placers deposits are rare, with only alteration halo overhanging the healthy body being mineralized. However, the lithomarge remains deeper and no drilling is done to verify the interface. Granite intrusions have played a double role, directly and indirectly impacting the genesis of Tin-bearing bodies including the Sn-Nb-Ta tripod. This mineralization remains disseminated or vein hosted in the surrounding areas forming part of the halo. But In the case of the DRC, there are several models. A drilling campaign for the purpose of scientific knowledge of the parental granites of these pegmatites is worthwhereas in the region. Considering the structural behavior around, this concludes on the source and correlation with visible granites or deduces those sub-outcropping.

Keywords: *tin, ore, granites, minerals, kivu, drc*

Introduction

The deposits are not evenly distributed over the surface of the globe. Vast expanses of land are devoid of viable deposits, while other territories, which the Anglo-Saxons call “metal provinces”, have an unusual proportion of deposits of one or more types. . (Nicholas T. Arndt, Clément Ganino, 2010). Precambrian crustal evolution in central Africa extends from the Archean to the Neo-Proterozoic (YONTA.C.N, 2010). Each of the geological periods has its mining features. The Kibarian belt of Central Africa is defined in the existing literature as being a Mesoproterozoic belt consisting mainly of Metasedimentary rocks and

some Metavolcanic rocks (Meta gabbro and Amphibolite) intruded by ss-type granitoid massifs and late mafic bodies serving as metalotects of magamatofils including 3T.

The Kibaranne range, whose age varies from 1400-950 Ma (Mesopoterozoic), occupies most of Kivu and constitutes the extension of the Kibaran from Katanga and continues towards the NE in Burundi and Rwanda where it bears the name of Burundian, Tanganyikaa and Uganda where it is referred to by Karagwe-Ankole (CAHEN L., DELHAL, J. and DEUSCH.S., 197). This Kibaranne chain is structured NE-SW in Shaba and the Great Lakes region before becoming NW-SE and even E-W in the West and NW of Lake Kivu then NE-SW around Lake Edward.

The Kibarien forms a metallogenic province of Central Africa which includes different types of granites with associated mineralizations: Cassiterite, Colombo-tantalite, Tungsten, Gold, Monazite, Amblygonite, Beryl, etc. Primary mineralization occurs in the form of Quartz veins and Pegmatites. Cassiterite and Tungsten are essential raw materials that large industrial firms cannot do without due to their high melting points (Afazili Simba, 2012).

In Congo, the tin group metal production areas are spread over the provinces of Katanga, Maniema, North Kivu, South Kivu, *Figure N°1*. According to the International Tin Association, ITA, the demand for the metal in the Lithium-Ion battery industry is expected to explode in 10 years with an annual volume of 60,000 tones (***K***IGHANA.M.E, BARATA.S.G,2018). The firm Aphamin Bisie of Terraitoire de Walikale, which has acquired one of the world's most fabulous deposits of starvation, will undoubtedly influence the world market. But some analysts point out that the East is a region plagued by instability and even subversive armed groups almost 20 years ago. This could affect the production of the Bisie mine in the medium to long term unless the eastern authority takes hold in the region over time.

According to the World Bank, three African countries were among the top 13 largest tin producers in the world in 2018, namely the DRC, Nigeria and Rwanda. Other nations of the continent have tin including Namibia, Morocco.

The same bank adds that in 2016 the prospects for the larch of raw materials, the Top 3 of the major African tin producers consists of the DRC, the 9th largest producer in the world; from Nigeria, 11th in the world and from Rwanda 12th. https://www.mediacongo.net/article-actualite-59244_etain_l_est_de_la_rdc_a_nouveau_dans_les_viseurs_des_predateurs.html

Figure 1. *Identification of the DRC Tin Belt*

Material and Methods

The open pits of tin exploitation of Rubaya in the north kivu and Nyabibwe has diferent metallogeny events. The documentation by reading existing wiritings is one of used technics. The collection of datas has been possiblbe by a field survey determining the location of open pits and their relationships with acidic batholotis in the halo, model of exploitation and the ore deposits form. Indefication of exploitated quartz veins and its relationships with hoted rock samples for petrography thin sections and flouvered rocks for geochemical analyses. XRF, ICPM model was used to make a sweetable data base of lithologies geochemistry and less lithoclases mixed with other gitology events for understing the ores fromation styles.

Location of the Work Area

The deposits are not evenly distributed over the surface of the globe. Large areas of land are devoid of viable deposits, while other territories which the french call“ *provinces metalique*”,carry an unusual proportion of deposits of one or more types of magmatic affiliation, or metamorphic or sedimentary.

In the DRC, notable examples are the alignments of huge copper deposits, the fragments of the copper belt in the subgroup of mines in Katanga, the groupings of lead-zinc deposits in this same southern region in limestones, the tin deposits in intrusive granites of metasediments in Kivu (GUNTHER M.A, 1990. For geological and economic reasons, it is important to know some main features of

the distribution of deposits. From a geological point of view, the distribution of deposits provides important clues about mineralizing processes; From an economic point of view, the uneven distribution strongly influences the price of metals and world trade.

The Kibaran belt of which our working environment is a part extend from Katanga, in the south-east of the Congo, to Uganda through the provinces of Kivu, to the East of the Congo, Burundi and Rwanda is characterized by tin and gold deposits (Sn, Au, etc.) whose establishment took place around 970Ma (POHL W., 1992) (GUNTHER MA, 1990) and is characterized by the vein procession found in the tin granites or G4 granite (CAHEN L., SNELLING NJ, DELHAL J., VALL JR, BONHOMME M., LEDENT D., 1984), (CAHEN et al, 1984).

From a metallogenic point of view, the mineralization of the tin and gold group found in the Kibaran formations is related to the G4 granite (GUNTHER M.A, 1990). This author points out that the connection of gold concentrations to the G4 granite remains speculative and very doubtful. The intrusions which we are going to cover in this text are located in North and South-Kivu in the Territory of Masisi and Kalehe all bordering Lake Kivu. In North Kivu, the mineable Rubaya pegmatite is in the locality of Bwanga-Lukala in its eastern part and Lukala. In South-Kivu province, the targets of tin on Nyabibwe are in its North-eastern part and in the south lodges Lake Kivu, in the Groupement de Mbinga Nord.

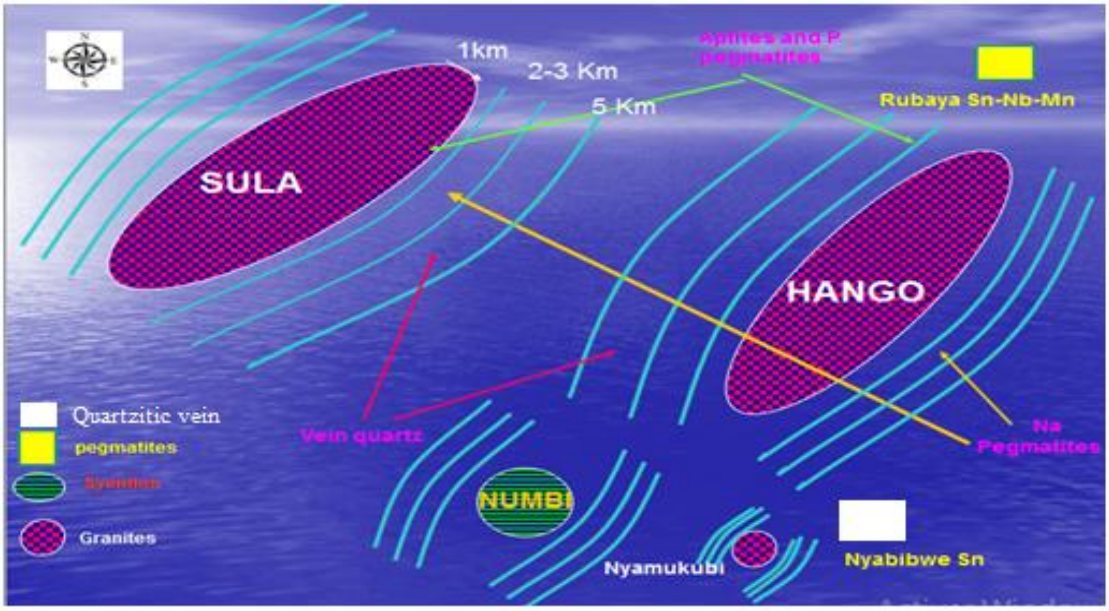
In the Kivu region in general, the presence of geological formations is a function of their chronology: the Precambrian ones with three chains had been defined: the lower Proterozoic with the Ruzizian chain (Ubendienne), the middle Proterozoic with the Kibarian chain (Burundian) one of the most extensive in Central and Eastern Africa and the upper Proterozoic chain (Pan-African chain) known as neoproteroaoic with the presence of granitic magmatic intrusions of alkaline tendency, nephelinites-syenites, monzonites and basic and ultrabasic rocks such as gabbros, dolerites and peridotites (Muhima.KA and Tulengi K. D, 2013 - 2014).The Great Lakes region is characterized by volcanism linked to the opening of the East African Rift, inside a plate or hot spot. It is the intersection of fracture systems and outcrops in three main areas: The Toro-Ankole volcanic area shared between Uganda and the DRC, The North Kivu volcanic area is characterized by the volcanism of the volcanic chain of the Virunga, that of South Kivu, part of which is in the east, Idjwi Island of Lake Kivu and extends from the south of Kamanyola to the north of Kalehe and overflows into the western part of Rwanda and NW Burundi (ZIRAGOBORA .T. C and KANZE. MC, 2019). The pegmatites remain until today without geologic relation with these volcanics of which the tholeites dominate.

In the DRC, the most important deposit is that of Manono-Kitotolo (Katanga) exploited within the metamorphic shales of the Kibarien. Several other deposits exist in the Kibarian tin belt (Katanga, Kivu, Maniema). They also exist at the Kikole, Wuto, Shienzi and Mwanza sites north of Luena (MAKABU.K.G, 2018).

The tin-bearing intrusions in these two territories, Masisi and Kalehe, come from the granitoids of Hango and Sula illustrated schematically by the *fig N°2*. The same figure indicates trhe approximative location of mined ores. From this representation the site of Rubaya is a pegmatite venu accopagning the hango

granitic seen in mumba oppositevelly the mined Tinous ores of Nyabibwe is in the metaphorphic result in the halo.

Figure 2. *Mumba Stanniferous District, Location of the granites of Mount Hango and Mount Sula, Nyamukubi*



Geology and Tectonic settings of Tin Intrusions

The different types of tin group deposits are characterized by their location in the pegmatite zoneography and their lithological and structural environments. The discovery of tin deposits dates back to 1926 when the first mining began in 1932 and 1935 for wolframite. The geological literature relating to the Kivu tin deposits is scarce and generally very old. Much of the geological research in South-Kivu has focused on mined tin deposits. This research carried out by mining companies, geological services and special development committees such as the CNKI (national committee of Kivu), resulted in the publication of geological maps and sections. The most important works are those carried out by Salée (1930), Blaise (1923 and 1934), Boutakoff (1933 a, b, c and 1939), Blaise and Boutakoff (1934) Salée et al. (1939), Arsel berghs (1939), Agassiz (1959) (MAKABU.K.G, 2019). In North Kivu and South-Kivu the pegmatites are larger than those of Maniema. They reach 10 m thick and over 100 m in length. There is no net internal zoning. The regional metamorphism is more pronounced than in Maniema; contact metamorphism is also more intense. We see the appearance of minerals such as andalusite, staurotide, garnet and micas, which are retromorphosed into biotite or muscovite (MAKABU.KG, 2015). We know, following in particular the work of N. BOUfAKOFF (1939) that the basement of East Kivu is made up in the neighboring region of Lake Kivu of an association of various granites and metasediments (J. LAVREAU, 1977).

The same author adds that two granite masses (Massif of Mount SULA in the West and Mount HANGO in the East), a less important syenitic massif (Nurnbi),

of intermediate position, and a small granite massif located to the south of the region (Nyamakubi), are placed roughly in the heart of anticlinal structures determined by weakly metamorphic sedimentary rocks. It is to these sterile bodies that stanniferous pegmatites emanate in the Masisi, the case of Rubaya and Kalehe, the case of Nyabibwé. As everywhere else, the geochemistry of magmatophiles is to be sought in the late phases of crystallization. In Kivu, acid plutons were reported from the first geological studies, they were all linked to the Precambrian.

The Kibaro-Burundian chain was intrupted by post -orogenic granites with Etain-Niobium (1010-925 Ma) and by late pegmatites (975-875 Ma) (Cahen, L., & Lepersonne, J., 1971). The lithology of this chain consists mainly of Quartzite, gneisses, mica schists, quartzophyllades, sandstones, quartzose schists and amphibolites located immediately to the west of the African Graben, whose faults and dislocations have spared it. In this part of the chain, with regard to the other granitoids, the geochronological data relating to the east of the DRC lead to the definition of 6 groups: the Granites of the Ante-Burundian basement, of an age prior to 1600 Ma; the Granito-gneiss Kibariens, porphyroids or not of 45Ma; Gneissic, Heterogranular, Biotite and Muscovite Granites, and 25Ma granitic Gneiss; the Leucocrates Granites with two mica and Tourmaline of 9Ma; the Pegmatites and veins of 20Ma; the Equigranular Granites, Leucocrates, with Muscovite dominant on Biotite and with 10Ma tin mineralization; Pegmatites and tin and sulphide veins: about 950Ma (AGASSIZ J-F, 1954). Of all these phases or granitizations not all are tiniferous. The mineralization of the Masisi territory is the result of intrusion mixed with hydrothermalism and is mainly Stanno-Wolframiferous. In this territory, vein fields have appeared in metamorphic terrains of sedimentary origin and are undoubtedly related to the two granite massifs whose contribution. In this part of the province, as in all batholiths, Zonality is proven. The internal zone, closer to the granite massif, extends roughly from the granite itself to 1 km from the boundary with the mica schists. It is characterized by intrusions of black tourmaline pegmatite, aplite and quartz, on the other hand, the middle zone includes complex Cassiterite pegmatites and pierces the ground at 1.2 and 3 km from the massif, the outer zone is vein, of tiniferous quartz, it is the furthest from granite. (RUMVEGERI.B.T) the case of rubaya batholite is accompagned by aq pegmatitic veins series in sedimentary rocks ; in the Nyabibwe sites, veins are mostelly made of quartz with generla stike NE-SW trending in East sides.

Rubaya

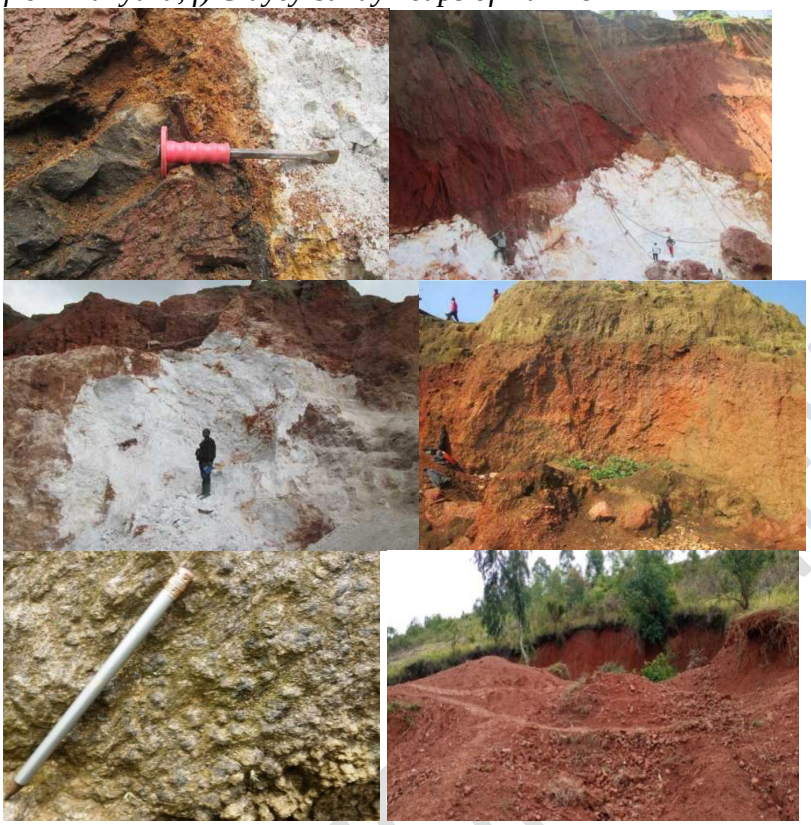
Two large granite massifs in particular that of *SULA* in the West and *HANGO* in the East are present in the region, their contribution from a metallogenic point of view is considerable given the significant mineral proportion in the region (AGASSIZ J-F, 1954). Before 1972, almost all of the cassiterite-wolframite and colombo-tantalite production was ensured by the exploitation of detrital deposits favored by the action of a well-fed hydrographic network, which deeply dissected the tin belt located in a region reactivated by rift tectonics.

Known by the name of Mumba, the host facies of the Stanno-Tantali-Manganesiferous mineralization of Rubaya are mainly made of pegmatites impregnated in the ss to micaceous schists, surmounted by a Schisto-quartzite ensemble. The closer we get to Lake Kivu, from the batholiths in the south, outcrops of green rocks are shown to have a low extent, as is the case of amphibolites in the Sake region. The sodolithic pegmatite veins are parallel to each other and at the limit of the granite massifs. In certain places in the granite-gneissic massif of Lukala, the systematic pegmatitic veins are carried in pegmatites themselves to justify the intrabatolithic model. Around these granito-gneissics, pegmatites are visible, further north of these granitoids, the same rock forms subvertical dykes more than 100m long and more pronounced in width intruded into the Metasedimentary, this is the case of the pegmatite mined for Sn-Nb-Mn around Mumba, Photo N^{o}.1a, b, c; which makes Rubaya a mining town. In this exploitable part, the pegmatite is Kaolinized weakly mineralized in Ta-Nb but rich in Cassiterite with trace Mn. In this region, the exploitable pegmatitic intrusion would have followed a granitization and generated a contact metamorphism which the nodular gneisses are witness to, photo N°1e. however, a pyrolytic blanket of slag and ash with horizontal grading can be recognized in this region.

Nyabibwe

In the province of South Kivu, pegmatites abound and are recognized for their mineral wealth. The Kobokobo pegmatite was one of the main beryllium deposits in the world and also provided production of Colombite and Cassiterite. It also has a fairly high concentration of Phosphate and a particular Uranium and Thorium mineralization along the Kamituga road (A. Safiannikoff and L. Van Wambeke, 1967). In general, the territory of Kalehe presents occurrences, in the Mbinga North grouping, we recognize the site of Kalimbi, Muzimu, Ruhunde,… The geology of Kalimbi includes a series of weakly metamorphosed schists and monotonous sandstones, almost without benchmark. A gradual transition between shales and sandstones can be observed. The Kalimbi Mining Concession (KMC) is operated by two mining cooperatives, the Kalimbi Mining Cooperative, COMIKA and the Kalehe Community Welfare Mining Cooperative, COMBECKA. They all mine Cassiterite included in quartz veins. Unlike the Rubaya site where the pegmatitic occurrences house the weakly metamorphosed shales, in this entity the Quartz veins are impregnated in the ss shales whose rate of alteration is appreciable photo N°1d. These veins would be injected by a batholith, the lifting of which with a hammer is still unknown, with presumptions of outcropping as shown by a point on the track between the mining sites and the city. Investigations of small wells and / or boreholes are worth the effort to identify the feeder rock. Being flush, the erosion of some veins resulted in the placers, photo N ° 1f.

Photo 1. *The Lithologies of the Roosts in the Study Area. C) Pegmatite surmounted by a layer of weathered schist, d) Weathered schist, e) Eyed gneiss from Kanyaru, f) Clayey-sandy heaps of Kalimbi*

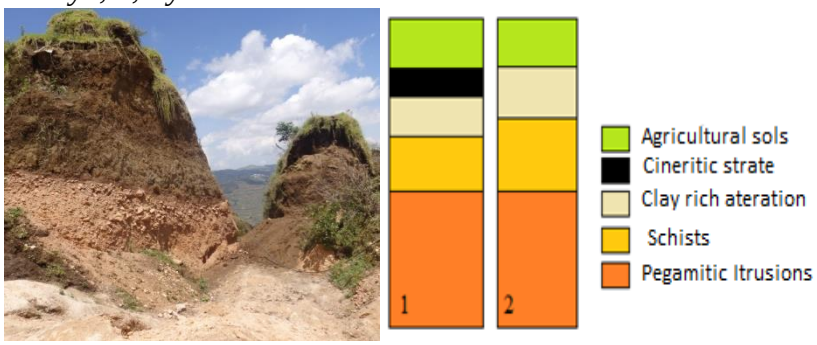


Lithostratigraphy

In Masisi sidess, the lower or Burundian lower series begins with the granitic halo gneisses and mica schists. The former are very rare everywhere and alone on the western edge of SULA. The mica schists are in contact with the granite, moving away they change their less metamorphic appearance.

The upper Burundian begins in the western part with a Conglomeratic level, sometimes with micaceous schists with biotite. It alternates between sandstone biotite schists with a few isolated pebbles and clearly conglomeratic levels. Rifting phenomena are associated with a very significant volcanism (500000Km3) BAKER et AL, 1972.

Figure 3. *Field Photo, Illustration of the Stratigraphy of the Work Sites with: 1, Rubaya; 2, Nyabibwé*



In the stream bed can be seen altered boulders on which we can identify the mineralogy of the original rock. In some cases, these boulders, two mica, quartz and feldspar are the major mineralogy which predicts granitoids in the flanks. At other points of the blocks individualized round, quartz-feldspathic nodules, the bedrock was an eyed gneiss. In the same valleys, there are other hard blocks, resistant to weathering thanks to their silica content; black micas, grayish spots and blackish grains. In South Kivu, the stratigraphic and geological knowledge of the Kibaran chain covers only a relatively limited area around the town of Bukavu (VILLENEUVE & GUYONNET-BENAIZE, 2006; RUMVEGERI et al., 2004; WALEMBA & MASTER, 2005) . In South Kivu, for this article, intrusions near Lake Kivu are more of the dioritic family than those of granitoids except in the rare cases of Ruhunde. Acidic plutons are still abundant south around Nyamukubi and far east over northern Idjwi Island. Admittedly, a juxtaposed cohabitation of these two rocks, pegmatite-diorite, appears in Ruhunde. In the

From this volcanism, cinerites are present in the region of Rubaya opposite to Nyabibwé. The soil profile is all clayey in diverse color, Reddish rich in Oxy-Hydroxide, Brownish and Grayish in Silt and Kaolinite, *Figure N°3*.mining town of Nyabibwe, an intrusion at an advanced rate of alteration, with traces of potassium pegmatite, is a tin-bearing deposit, sometimes causing popular uprisings; besides this intrusion, the other anomalies are seen in the Metasedimentary, Muzimu and Tanganyika. The units carbonate and ferruginous are present in the vicinity of this open pit mine; the image in Figure 1 only takes into account the apex of the orebody. In all, opposite we hastily illustrate without any drilling what the deposits would reflect in the two study points. Both similar except cineritic fault at Nyabibwé.

The North-South Kivuscan interface tin

The tin group includes Cassiterite – Wolframite – Colombo-Tantalite – Beryl – Monazite. This mineralization is located in the eastern part of the Congo, thus forming a belt of more than 700 km from Katanga to Ituri via the Kivus. The various deposits of the tin group are characterized by their location in the granitoids zoneography and the more the pegmatites and their lithological and structural environments are richer. The main known deposits of the tin group in

South-Kivu are: The Kamituga deposits, Lulingu deposits, Kobokobo deposits (see beryl), Nzovu deposits, Luntukulu deposits, The deposits of the Kamituga mining district (Sn -At).

As mentioned above in the title of this paper, the indices and occurrences belonging to the two territories, Masisi-Kelehe, make these two provinces a stanniferous pillar in the North East of the DRC. In North-Kivu, tin-bearing deposits are mainly located in two territories namely Masisi and Walikale and in showings in the territory of Beni. The cottages of Masisi with Mumba, Bishasha are made up of Sn-W-Tourmaline. The topographical continuity is seen extended in South-Kivu with tin-bearing occurrences exploitable in semi-industrial mode in Kalehe, precisely in Nyabibwé and artisanally in Tanganyika north of Nyabibwé. However, the distance between these two regions, Mumba and Nyamibwé, is dotted with Gungus-Numbi deposits with a series of basic plutons, diorites and acid ones, the granito-gneissic complex and their pegmatitic allies. Further north of this tin bearing azimuth, in the territory of Walikale 600 km south of Kisangani are Bisie, Mutiki, Obaye, Nkumwa and Lukayayo whose gitological model remains unknown in this writing. The most famous North Kivu tin deposit is: Mumba in Masisi. Sn is accompanied by Ta, Nb, Mn and further, to Bishasha W is added. Located in North Kivu; unexploited, occupies a close-folded synclinal structure oriented NE-SW. It is limited to the west by the granite massif of Mount Hango and to the east by the granite massif of Mount Sula. To the south, the nepheline syenite massif of Numbi is exposed, mineralized in Tourmaline, Coltan and Cassiterite. The granites are chemically calc-alkaline to monzonitic, towards their periphery, facies with Muscovite, Tourmaline, Topaz and Garnet appear. The highest contents are observed in the greisenized zones where Cassiterite and Colombo-Tantalite abound up to 300 kg SnO_2/m^3. The pegmatites are either highly Kaolinised or sound. Kaolinized pegmatites are weakly mineralized in fine-grained black cassiterite, sometimes associated with colombo-tantalite (AKILIMALI.M.S, 2016). In this case, they are essentially made up of Muscovite and Quartz (type 5 pegmatite according to Varlamoff 1951).

Results

Intrusions and Tin Metallogeny

During crystallization, the magmas resulting from fusion evolve from dioritic terms to more acidic terms for the pluton. The granitic magmas expel the fluids associated with the evolution of intrusions which are at the origin of Tin (SnO_2), Tungsten and Molybdenite mineralization. Other fluids have various origins, these are sometimes meteoric fluids which are set in convective motion in the surrounding area by the heat of the pluto. Nevertheless, in all cases the fluids will have a very variable metallic element content either borrowed from the host rocks by leaching of the preconcentrates, or from the magma itself. The deposition of fluids can take place by several mechanisms, including cooling, a drop in pressure that can cause boiling. The case differs depending on the sites and deposits.

The role to be played by magmatism in the establishment of ortho-magmatic, pegmatitic and hydrothermal deposits is by far the driving force behind all magmatic occurrences. The late phases of magmatic activity is more acidic and constitutes the effusions of magmatic chambers and/or chimneys. These geological bodies appear as a result of the decay. In these corners of the metallogenic tin-bearing province of Congo, pegmatites outcrop either in mass or vein state, while no parent granite remains blind.The model of tin richness and its associates attributed to the intrusions results from the presence of a few veins of lepidolite quartz which are locally mineralized in Cassiterite running through the surrounding areas. The veins of aplites, pegmatites and quartz occupy well-defined positions in relation to the granite massifs, Photo N ° 2a. In fact, the following rocks can be recognized there: - internal zone: it extends up to 1 km from the edge of the granite, corresponding to the limit of the internal zone of contact metamorphism. It contains veins of aplite (or albites) and veins of black tourmaline potassium pegmatite. - medium zone: It extends between 2 and 3 km from the edge of the granite massifs and contains sodolithic pegmatite veins. The Bishasha deposit at W Located on the western edge of the Hango granite massif, 25 km north of Masisi, not far from the deposits of the Mumba district to which the Rubaya tin-bearing pegmatite described above is part.

The circumscribed granite massifs are considered as intrusive by most of the authors BOUfAKOFF, AGASSIZ, PASTEELS, BUCHSTEIN et al. Cited by (M.F.KIGHANA. And S.G.BARATA, 2018), their establishment being moreover accompanied by a contact metamorphism superimposed on regional metamorphism. JL BLES does not, however, agree with this opinion: considering that the granites and their internal pegmatites are affected by the same schistosity as the metasediments of the Kirotshe region, he sees in these granites the base on which the metasediments have been deposited, which obviously leads him to deny the existence of a contact metamorphism and to reduce the existence of intrusive relations to mobilizations in the heart of capped domes occurring during the 3rd deformation. In our opinion, the presence of gneisses around this pegmatite confirms the regional metamorphism coupled with that circumscribed from the batholiths currently exploited. From this tectonic mix emanates specific structural virgations. Besides this primary stanniferous mineralization, the secondary one is found under the placers in the form of alluvial and eluvial deposits. In fact, the tropical climate present in the Kivu region has favored an intense weathering which has reached the granite intrusions of high altitudes and the pegmatite. This alteration coupled with the erosion of quartz veins, albites led Cassiterite to partly accumulate in alluvial deposit gravels as well as in the beds and terraces of rivers. This secondary Cassiterite mineralization is associated with other minerals such as Wolframite/Ferberite and Colombite-Tantalite.

Pegmatites of Rubaya Tin Ore Deposits

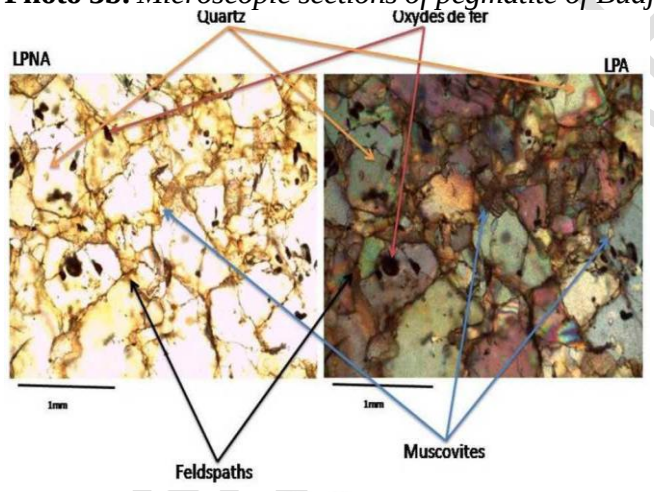
In this part of the Masisi, lively exploitation is seen here and there, everywhere the host rock is unique whatever the mineralogical composition. A

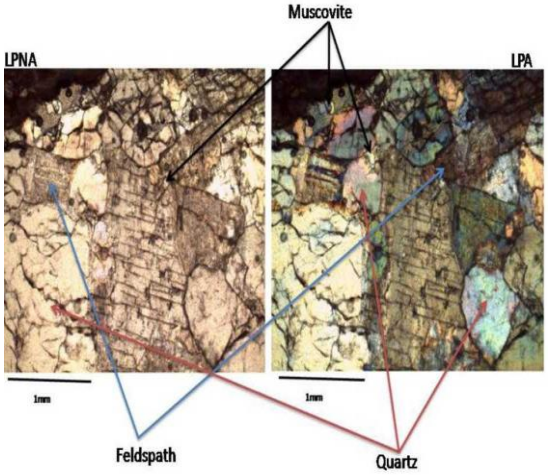
mining site named Nyange Photo !!!! is the lung, located at the top of the city of Rubaya besides this site, we recognize Mataba, Gakombe, Gasasa, leucocratic quartzite appearance, Photo N°2d. quartz crystals devoid of Micas give the rock a The geode trace is visible. The metals sought are both official Tin, unofficial Manganese and Tourmaline. In this unit, the veins of the quartz-rich pegmatites form the skeletons and the tin poor are taken in gangue, Photo N°2c. The section of natural and artisanal polished light of lithologies indicate the pegmatites within iron oxydes, Photo N°3b

Photo 2. *Geology of the Rubaya mine. a) veins of pegmatites in the surrounding them, b) panoramic view and treatment water conditions, c) quartz veins, d) tin-bearing Kaolinite mining panel*

Photo 3a. *Mineralization of pegmatite. a) in Mataba, b) in Gakombe, c) in Gasasa; communication from researcher Barata Sadiki*

Photo 3b. *Microscopic sections of pegmatite of Budjali and Mataba*





Luwowo and Bundjali open pits are mined rock in a sodistic feldspars pegmatite rich and phenal being at altitudes, the concentration being hydrometallurgical, the storage and use of water from the suction pump is common, Photo 3b.

Rubaya mineralization

Being micropegmatite, the richness in sadistic feldspars and quartz makes the rock clear white, Rubaya pegmatite is related to granitoid and not to migmatites.By concentration of normally rare elements (Li, No, Ta, Zi, U, Th, lanthanides, etc., which can give rise to exploitation) particular minerals are formed, called pneumatolytic: lepidolite, phlogopite, topaz, beryl, tourmaline, ... Located at the outer edge of a granite massif and at its periphery, pegmatites occur in veins or ovoid masses whose general composition varies with the distance from the granite (Raoult and Foucault, 2010). Pegmatites are true 3T paragenese deposits (Tin, Tungsten, Tantalum) in currently exploitable sites, in addition to Cassiterite, Coltan and Manganese are also present. The gangue and the concentrate take color depending on the slice of the feldspars. Photo N°3. Most of Masisi tinous ores are located in schistes. However in Robaya the minerals are diseminated in the pegmatite unities.

Photo 4. *View of surface mines in the Rubaya pegmatite. Respectively, the site of Mataba, Gakombe, Gasasa, Luwowo, Bundjali, the underground mining*

Table 1. *Geochemical Analyse of Rubaya Tinous Ores*

Sample	Sites	Lithology	SiO_2	TiO_2	$K2O$	Na_2O	MnO	CaO	A_2O_3	Fe_2O_3	Ta	Nb	Sn
2	Matab a	Pegma tite	2,46857 143	0	0,39 6	0	0,243 75	2,2956 730	0,779827 7	0,00 36	370 0	54,16 666	85 0
3	Gako mbe	Pegma tite	2,39142 857	0,21052 632	0,38 4	0,0107 142	0,443 75	1,7283 653	1,735547 3	0,03	505 0	341,6 666	55 0
4	Gako mbe	Pegma tite	2,48392 857	0,19298 2	0,44 4	0,0857 142	0,812 5	3,1274 038	1,255842 5	0,01 6	490 0	254,1 666	45 0
5	Gako mbe	Pegma tite	2,395	0,33333 3	0,42 8	0	0,481 25	1,4687 5	0,896678 9	0,00 3	105 50	429,1 666	15 50
7	Gasas a	Pegma tite	2,34107 143	0,24561 4	0,36 4	0	0,312 5	1,9615 384	0,691266 9	0,02 6	800	8,333 333	16 00
9	Luwo wo	Pegma tite	2,85142 857	0,28070 1	0,33 2	0	1,187 5	1,9254 807	0,413284 1	0,18 4	485 0	229,1 666	14 00
10	Luwo wo	Pegma tite	2,92357 143	0	0,30 8	0,0096 428	10,18 75	1,6562 5	0,296432 9	0,06 4	590 0	387,5	16 50
11	Bundj ali	Pegma tite	2,27178 571	0,21052 6	0,26	0	0	2,9038 461	1,370233 7	0,38 4	465 0	45,83 333	44 50
12	Bundj ali	Pegma tite	2,34857 143	0,77192 9	0,03 92	0,0110 714	1	2,1730 769	1,565805 658	0,62 6	255 0	37,08 333	56 00

According to the table N°1, the contole of tin ores in the sites of Rubaya is directly linked to the granitoide lithology in the pegamatitic franction. These pegmatites are aosociated within the granitic batholoithe of Mumba. The site of Gakombe is the most Nb-Ta rich. Sn is morever in Bundjali open pits assisted by Luwowo and Gasasa. For all case, the Sn is the principale mined metal in the acide belt of the Rubaya in Masisi. The pararagenese is Ta-Sn-Nb.

Stanniferous Sites of Nyabibwe

The ongoing workings around Nyabibwe tinious ore is essentially corried by the quartz veines incoreporated in metasedimentary rock, schiste. In some cases, the schist is rich than viens, this affiliation of tin if the metasediments is a stress to be undeline and reinforce to significant the roles of ancien sedeiments in the tin metallogeny on the sites. This tin core is located and has a easting evelvong.

Actually four sites are mined (*Muzimu, Chanyi, T20, Tanganyika*). Some of them are directlly havested. Only the studies of Rumvegeri 1984 (RUMVENGERI BT, 1984), 1987 (RUMVENGERI BT, 1987) recently completed by Walemba 2001, 2005 (WALEMBA, 2005) and some mining company like BANRO Mining, MGL, SOMINKI have described the formations of this chain in South Kivu. And more recently by the regional campaign of the University of Bukavu. The main source of tin is Cassiterite (SnO_2) a magmatic mineral, which crystallizes in a particular type of granite. These granites, called “tin granites” have a very limited spatio-temporal distribution; they are very rare in the Precambrian and become much more abundant in more recent periods (Nicholas T. A, Clément Ganino, 2010). South Kivu, part of the Kibaran chain, brings part of the alignment of stannic assets to Nyabibwé. In contrast to Rubaya where the control of mineralization is magamatic, intrabatholitic, Nyabibwé has hydrothermal control attested by the exploitation of quartz veins in schists. This metallogenic control thus recalls and dictates the operating method, several galleries are erected depending on the position of these bodies, Photo N° 5.1abc. We can think that although at the end of the placement of granite, pegmatitic bodies, the late

Burundian quartz veins, the tin were lodged in the Kibarian beds and later in this point of the metalliferous alignment (MAKABU .KG, 2015). It should be concluded later that from *figure N°2*, the gites of Nyabibwé are, with the qauartzeux landfall in Kalimbi, Muzimu, Kashebere, Tanganyika; all veins hosted in schists, a pre-terminal zone of crystallization. Their source is in connection with two plutonic bodies, that of Namukubi and Numbi which are the closest.

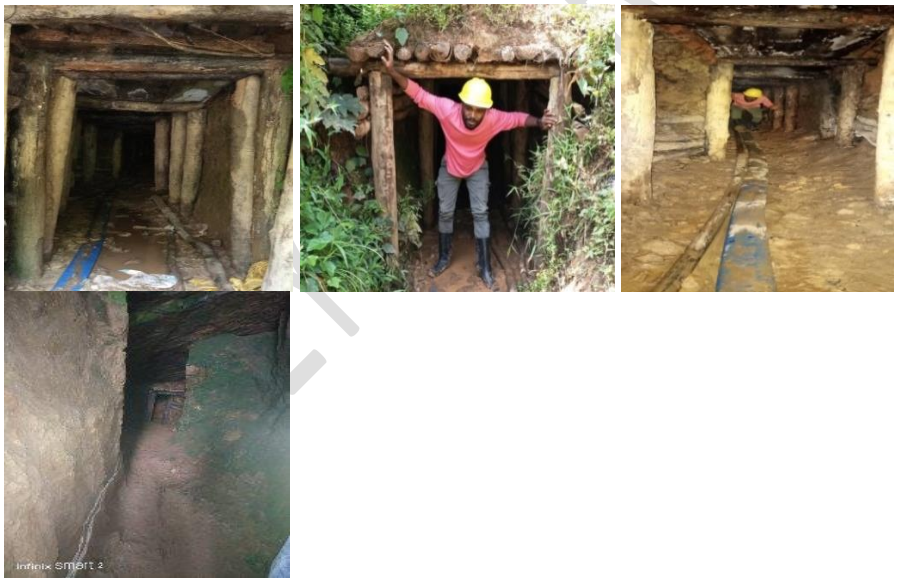
Site says T20

This is the tin hill in this area. At this point of the ore body, the hunted veins are embedded in the altered shale whose geomechanical conditions are weak, making artisanal to semi-industrial work quite complicated. The tin-bearing mineralization is vein, in quartz matrix, brecciated and/or ferruginous hosted in shales. In addition to cassiterite, veins also contain arsenopyrite and tourmaline taken from non-chargeable sources. With a thickness varying between 30cm and 1m, the veins have a tin content of the veins varying between 2 and 15% SnO2 and increases with depth, which would support an intrusion not yet exhibited. The average monthly production based on recent years is around 30tons of cassiterite pre-concentrates with a 50-55% Sn content. Cassiterite is well crystallized and appears mainly as a veneer on the walls of the veins. On this site, the Veins are oriented on NE-SW, 320° of stike with a dip of 20° treding in Eastern, the works or galleries are generally oriented 244°NE. Some points of the veins are in the form of boudined Photo N°5, band riched by Iron that colored the ore as a coal Photo N° 5.ac. The last photograph of this sery is a Quartz vein inserted in a dioritic unity.

As in the North Kivu with Rubaya, tin is doubly exploited, open and or closed pite. The site of T20 is essentially undeground and galleries are guided by the need and geometical behavior of the veins. Most of them are SW-NE, NE-SW of azimith occording to the flank of the hill. Someones have holdercells however not for others.

Photo 5. *Form of tin mineralization of nyabimbwe respectively in Kowet, T20 and Chanyi*

Photo 5a. *Underground mining. Exploitation galleries of the so-called T20 mine in Kalimbi*



Maternity-Koweit site

This side of the hill has the name of the river that serve as hydrothermalous workings. Side to side of the river, tinoous workings are based on the existance of parallele viens. As over the entire Nyambbwé extent, the tin host is a quartz vein embedded in schist. Following to the seconomy crisis and geomechanical conditions, the site was abandoned for a moment following the arrival of the water

table and the inability of the dewatering. Actually, the site is reopened by targeting the unity from other ways.

Photo 6. *Waterwashof promary mineralization of tin in the site of Kowet and Maternité*

Photo 6.1. *undergraound tin mining, respectivelly, execution of the galery, vertical galery and wood sopports*

Photo 6.2. *Nyabibwé Cassiterite enrichment work*

This site seems to be the first to be exploited from the colonial period, attestation of traces of distored wall ofriverblock for exhore. It's arround this best schist is apprecited.

A part the primary mode of mineralization, this site has sedimentary exploited tin. This sedimentary deposit is due to the erosional and landslide with the veins outcropping above the hill, *Photo N°6.* The production according to the former miners was 100 tonnes of cassiterites per month. The vein extends from 20 cm to 1.5m thick. Motherhood would be the most productive of all, Photo N°6.2 The metalogenic model of tin ore in this site is a result of hydrothermalism of preconcentarions in sourounded unity.

Chanyi openpit site

Positioned around 5km in the south East of T20, he mining opperations begun in the borders of the lake Kivu where the scarcity poushed miners to abandon the ore. The same vein is outcripping on the line land in the lake, however on this position the vein is becoming clear and monomineralized (silica) and consequaneslly poor of any mineralizations. Opposited to Rubaya, the presence of acide lithologies in and or around Nyabibwe is a dream to verify morever.

The site seems to be newly discoverd by agricultural activities in a coffe fied. The specificity of this point is to have a tin value in the superficial lands, it means culvitated soils. Off course the origin of this tin dispersion in soils is an hypothese of an alterated blind quartz vien. Due to the land's irregularities, the holy quartz vein is visible in the valley Photo N°8. In the coffe planatation and cassava fields landholders are becoming tin miners as the enrichment process is so quick and peinless. The ore body is one and unique quartz vein exploited on its sequence outcropping on more than 1.5Km of distance. This veins doesn't structuraly differ from the exploited in T20 and Koweit-Maternity. Its parallel with them, NE-SW, trending in NW, Photohraph N°7. This site has also undegrouund workings with or no supports in the bottom valle. Photo N°8.

The tin ore deposit of Nyabibwe is clearly different from the exploitated tin in the Rubaya sites. The difference is not only to the lithologies but also to the model of formation. Magmatically controled in the North kivu while tectonically setted in the south Kivu mainly by hydrothermalism. For the last case, the preconcntration in hosted metasedimantary rocks or alloctonic source of tin is an other reseach.

Photo 7. *Tin Exploitation in soils, respectivelly large vieuw of site section, abandoned blocks and poor soils, clays spoiled in the valley, traces of plantation in the mined place*

Photo 8. *Underground mined tin exploitations in chanyi site*

As elsewhere in the west flank of Lake Kivu catchment, diorite are in the bottom of topography and only the ridje or medium of slop can have granithoids that are tinphiles. Diroiticrocks are seen Near the lake and no relationship with this mined livingfull geological mane for land and local peoples. According to the geochemical analyses, Table N°2, the tinous ore of Nyabibwe is different from the mined ore of the rubaya open pits where the metaliferous association is made of Ta-Sn-Nb. From this paper, the analyse shows the paragenese of W-Sn with rare or less Ta. The same analyse clarifys truelly that in chanyi and lake bordering open pit the metalotect is the lithology and not necessary a tectonic settings.

Schists are richs of W-Sn than Viens. The explication is to be affirmed by the mining ways, here, agricultural soles are mined more than the quartz veins. As the alteration colomne is thinkeness, the excavation is superfial. This controle is not tectonically endorsed but linked to an metamorphosed clay placer made leading to W-Sn sshist. In the group of Kowette, the W tendancy is dark, thus the Sn is showing a clarity that most of targeted beiring Sn is the schist too. Some metallogenical accidents in the veins is to understand a slighty implication of the tectonic events. However the key model of this metal association is the metamophism of a W-Sn clay palcer, actually schist whose dip and trends are not demostrated in this paper. Reinforcing the metaphosed Halo of the *fig N°2*, the presence of viens here isn't responsable of W-Sn they are normal veins as elswhere. The Sn in this tectonic cells is a metallogenical nosense.

Table 2. *Geochemical analyse of Nyabibwe Tinous ores*

Sample	**Sites**	Lithology	**AI203**	**SIO2**	**Mn0**	**Fe203**	**Ca0**	**Na2O**	**Ti02**	**W**	**Sn**	**Ba**	**Sr**	**As**
CH01	Chanyi	Schiste	1,160	2,56	0,25	0,244	0,892	0,352	1,254	161,29	120	3,44	0,05	34
CH03	Chanyi	Schiste	1,617	2,485	3	0,88	1,101	1,167	1,745	1612,9	1815	31,16	0	8600
CH12	Chanyi	Qz vein	0,892	1,723	0	0,484	1,228	0,614	1,745	0	0	0	0,14	0
CH13	Chanyi	Qz vein	1,117	1,738	1,09	0,606	1,143	0,778	1,647	32,25	0	1,8	0	96
CH05B	Lake	Qz vein	1,432	1,375	0,03	1,406	1,977		2,352	40,32	6000	4,88	0	11640
LK05A	Lake	schiste	0,641	2,252	0,44	0,352	0,991	0,467	1,411	80,64	0	2,8	0,45	60
ECH07	Kowette	Qz vein	1,024	1,943	0,24	0,556	0,782	0,753	1,098	0	0	1,4	0,61	2
ECH06	Kowette	Schiste	0,711	2,397	0,14	0,386	0,275	0,510	1,529	8,06	4230	4,36	0	11040
ECH10	Kowette	Qz vein	0,713	2,632	1,2	0,38	0,275	0,5	1,078	8,0	3175	1,88	0,08	252
T6 13	Kowette	Qz vein	0,811	1,713	0,1	0,22	0,606	0,589	0,882	88,70	465	1,56	0	536

Conclusion

The Congolese Stanniferous Belt is mostely localized in the east along the rift. In addition to tin, it contains Niobium, Tantalum and or Tungsten, Manganese, Tourmalines, Beryllium. The geology of the sites of Rubaya and Nyabibwe is Middle Proterozoic generally metamorphosed with black schists or argillites constituting the very large part of the Kibaran range. Above these are generally advanced argillites, reddish and gray-white depending on the case. The mineralization is either vein or intrabatholitic with dissemination. In the case of Rubaya, the gitology and metallogenic role of acide intrusions is direct cause of the polymetallic impregnation with the Sn-Nb-Mn mineral association within the pegmatites. For this case the source of the tinious ores is linked with no nearest magmatic events. The healthy granitic rock is far, under from being reached by open-air work. The cashed tin in light and glassed quartz veins of Nyabibwe attests a monometallic hydrothermal source. Its granitic intrusion to be taken as

parental cause of this tin ore in nyambibwe is to deep with deepth again by special inoved surveys methodes. Dates back to the hydrothermal model which without having remobilized the tin-bearing preconcentrations because the host rock of the veins is sterile and or poor of the mineral association, case of Chanyi openpits.

References

AGASSIZ ***J-F, 1954,*** *Géologie etPegmatites stannifères de la région Mumba-Numbi, Kivu* (Congo Belge)***, Art., série n°7, Bruxelles, 65 p.***

Afazili simba, 2012, *Genese_Structure_et_Mineralogie_des_Gisements Stanno-Wolframifère de la ceinture mobile de l'est de la RDC*, Mémoire de Licence UniLu, Inédit

AKILIMALI.M.S, 2016, *gitologie, metallogenie et exploitation miniere artisanale dans le Kivu : Bref aperçu sur les gisements stannifères* in Vol.1, N º 2 Cah. BEGE-RDC, Journal pour la promotion des géosciences.

CAHEN L., DELHAL, J. et DEUSCH.S., 1972, *A Comparison of the ages of granites of SW Uganda with the Kibaran of Central Shaba*

CAHEN L., SNELLING N.J., DELHAL J., VALL J.R. , BONHOMME M., LEDENT D., 1984, *The geochronology and evolution of Africa*. Clarendon. Press, oxford

Cahen, L., & Lepersonne, J., 1971, Données et interprétations nouvelles concernant l'orogenèse Katangienne dans le Nord-Est de la Rép. Dém. du Congo.Mus. roy. Afr. Centr., Dépt. Géol. Min., Rapp.

GUNTHER M.A, 1990, *Flussigkeitseinchlusse und AU-lagerstatter (Rwanda und Burundi) Thèse doctorat sci-univ. Techn. Braunschweig (R.F.A*)

J. LAVREAU, 1977, *contribution de l'imagerie spatiale problèmes géologiques a au lac Kivu résolution (Zaïre) de certains la region situéeàa l'ouest du lac Kivu*

MAKABU.K.G, 2018, *Cours de Gitologie et Métallogénie du Congo, inédit*

MAKABU.K.G, 2019, *Cours de Gitologie et Métallogénie du Congo,* inédit

MAKABU.K.G, 2015, *Cours de Gitologie et Métallogénie du Congo,* inédit

MAKABU.K.G, 2015, *Cours de Gitologie et Métallogénie*

M.F.KIGHANA. et S.G.BARATA, 2018, *Etude géologique de la pegmatite de Luunje : aspect Géochimique et lithofacies associés,* Mémoire inédit, Université de Goma.

Muhima.K.A et Tulengi K. D, 2013 – 2014**,** *Etude cartographique, petrographique, metallogenique et structurale du complexe Granito-Gneïssique du Mont Lukala (Masisi, Nord-Kivu),* Mémoire

Nicholas T. Arndt, Clément Ganino, 2010, *Ressources Minérales, Origine, nature et exploitation*, Dunod, Paris, ISBN 978-2-10-055081-4

POHL W., 1992, *Kibarian evolution and metallogeny in Central Africa: A synthesis at the and of I.G.C.P.*, 255, Newsletter, 4-8

*Safiannikoff. A.et L. Van Wambeke, 1967,****Minéralium Deposita, Pg****119-130*

Raoult et Faoult, 2010, dictionnaire de géologie, 7e edution.

RUMVEGERI.B.T, *les intrusions granitiques du Kivu. Pg16*

RUMVENGERI B.T, 1984, *Etude lithostratigraphique et structural du Précambrien de la région de Bunyakiri. Modèle d'évolution géodynamique de la chaine Kibaran en Afrique Centrale et Orientale*. Mém. D.E.S., Labor. Pétrologie, Univ. Lubumbashi, Fac. Sci Dépt. Géol., Vol.1, 279p.

RUMVENGERI B.T, 1987, *Le précambrien de l'Ouest du lac Kivu (Zaïre) et la mise place dans l'évolution géodynamique de l'Afrique centrale et orientale. Pétrologie et tectonique*. Vol I.

WALEMBA, 2005, *Le district stannifère et aurifère de Kadubu et de Luntukulu de la chaine Kibaranne*

WALEMBA et MASTER, S. 2005, *Neoproterozoic diamectites from the Itombwe synclonorium, Kivu province, Democratic Republic of Congo: palae climatic significance and regional correlations*. Journal of Africa Earth sciences 42(2005), 200-210p.

YONTA. C. N, 2010, *Contexte géologique des indices de talc de la région de Boumnyebel (chaîne panafricaine d'Afrique Centrale, Cameroun*)

ZIRAGOBORA .T. C et KANZE. M.*C*, 2019**,** *Contribution à l'étude géologique du secteur de Kibabi et ses environs : approches pétrographique et métallogénique***,** Unigom, Mémoire de Licence UniLu, Inédit