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Report

The third IGCP-450 conference and field workshop on Proterozoic sediment-hosted base metal deposits of western Gondwana, central Africa Copperbelt, Katanga, D.R. Congo

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Abstract

The third IGCP-450 conference and workshop was held at Lubumbashi (SE Congo) in July 2003, examining the sediment-hosted base metal deposits of the Congolese branch of the central Africa Copperbelt. Fifty-two geoscientists from thirteen countries joined the meeting, and 43 papers were delivered during the oral and poster sessions. The papers presented were mainly aimed at the general geology, metallogeny, lithostratigraphy, geochemistry, and tectonic evolution of the Katangan belt and other Neoproterozoic belts. The workshop covered the main Co-Cu-U and Zn-Pb-Cu deposits in this part of the belt. Discussion over the six days of the workshop focused on tectonism, ore genesis, and stratigraphy of the Katangan Supergroup. The genesis of the Roan Group breccias hosting Cu-Co mineralisation is still a matter of debate, as consensus has not reached between geoscientists working on the Katangan belt. Further studies on different aspects covering tectonism and mineralisation within the Katangan belt are still needed.

Key words: Central Africa Copperbelt, Katangan Supergroup, Sediment-hosted base metal, IGCP-450

Introduction

The IGCP-450 project examines Proterozoic sediment-hosted base metal deposits of western Gondwana. The third conference and field workshop of that project was conducted in the Congolese branch of the central Africa Copperbelt, from 14 th to 23 rd July 2003. The Copperbelt mineralisation is hosted in the Neoproterozoic Katangan Belt of the southeast Democratic Republic of the Congo (hereafter Congo).

The objectives of the project are:

- to elaborate genetic models for Proterozoic sediment-hosted base metal deposits of South America and subequatorial Africa;
- to document the inter- and intra-continental correlation of the geological, geochemical, isotopic, geochronological and mineralizing fluid characteristics of the ore deposits;
- to promote international scientific collaboration among Earth scientists of different disciplines from various countries, and to encourage joint post-graduate research and teaching;
- to prepare a metallogenic database map of Proterozoic sediment-hosted sulphide base metal (Cu, Pb-Zn) deposits in Africa and South America (Western Gondwana).

The IGCP-419 project, which focuses on Katangan stratigraphy, also collaborated with the meeting.

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The central Africa Copperbelt

The central Africa Copperbelt is essentially formed of Neoproterozoic sedimentary rocks known as the Katangan Supergroup. This 10 km thick supergroup is subdivided into three main units, the Roan, Nguba, and Kundelungu Groups, from base to top (Table 1). This lithostratigraphy was established on the basis of the presence of two diamictites/tillites within the succession. These units serve as regional markers (François, 1973a, 1987; Wendorff, 2000; Cailteux, 2003). The older tillite, the Grand Conglomérat, separates the Roan Group and the overlying Nguba Group, and the younger Petit Conglomérat separates the Nguba and Kundelungu Groups.

The Katangan sedimentary sequences were folded and thrust to the north during the Lufilian Orogeny between 700 and 540 Ma (Kampunzu and Cailteux, 1999; Porada and Berhorst, 2000). The belt represents a 700 km long and 150 km wide, northward convex Lufilian Arc, as exposed in SE Congo and NW Zambia. Structurally, two different domains have been distinguished: the folded Katangan, here referred to as the Lufilian Arc; and the "tabular" Katangan, which consists of subhorizontal strata known as the Katangan "Aulacogen" exposed in the extreme north of the belt (Fig. 1). Similarly, the intensity of metamorphism associated with this orogeny increases southward, from greenschist to amphibolite facies in the north to higher grades to the south, especially in the Zambian section of the belt (e.g. Drysdal et al., 1972; Vrana et al., 1975; François and Cailteux, 1981).

Two types of mineralisation occur within the Katangan succession, making the Lufilian Arc one of the largest Cu-Co belts in the world. Stratiform Cu-Co-(U) mineralisation is hosted in the Roan Group and stratabound or vein-type

Table 1. Lithostratigraphy of the Neoproterozoic Katangan Supergroup (François, 1973a, 1987; Cailteux, 2003).

	Supergroup	Group	Subgroup	Formations	Lithologies
Ordovician Cambrian			Plateaux Ku 3		arkoses, with occasional beds of sandstones sandy shales or conglomerates
			Kiubo Ku 2	Ku 2.2	more or less dolomitic sandy shales or shales rare beds of impure limestones
				Ku 2.1	dolomitic siltstones, sandy shales or shales beds of feldspathic sandstones
		Kundelungu (Ku)	Kalule Ku 1	Ku 1.3	dolomitic siltstones, sandy shales or shales pink oolitic limestone at the base
				Ku 1.2	siltstones, marly or sandy shales pink dolomite ("calcaire rose")
				Petit Conglomérat Ku 1.1	diamictite/ tillite
Neo-Proterozoic	Katangan		Monwezi Ng 2		more or les dolomitic siltstones or sandy shales and shales
			Likasi Ng 1	Ng 1.3	slightly dolomitic arkosic siltstones, sandy shales and shales
		NGuba (Ng)		Ng 1.2	dolomites and limestones shales and sandy shales
				Grand Conglomérat Ng 1.1	diamictite/ tillite
			Mwashya R 4	Upper R 4.2	Shales, carbonaceous shales or sandsones
				Lower R 4.1	Dolomites, jasper beds, pyroclastics and hematite; local stratiform Cu-Co
			Dipeta R 3	R 3.4	Dolomites with siltstones and sandstones; doleritic or gabbroic bodies (760 Ma)
				R 3.3	
				R 3.2	
				R.G.S. R 3.1	Dolomitic siltstones
		Roan (R)	Mines R 2	Kambove R 2.3	Laminitic, stromatolitic, talcose dolomites and dolomitic siltstones
				Dolomitic Shale R 2.2	Dolomitic shales, carbonaceous shales, dolomites, sandstones or arkoses
					Dolomitic shales, sandy dolomite at the top; stratiform Cu-Co (Upper Orebody)
	~900 Ma			Kamoto R 2.1	R 2.1.3 "Roches Siliceuses Cellulaires (RSC): Cu-Co at the top and the bottom
					R 2.1.2: bedded dolomites with siltstones (D.Srat); Cu-Co (Lower Orebody)
					R 2.1.1 "R.A.T grises": dolomitic siltstone; Cu-Co at the top
			R.A.T. R 1	R 1.3	Pink-lilac, hematitic, chloritic-dolomitic massive siltstones
				R 1.2	Pink to purple-grey, hematitic, siltstones; sandstones,stromatolitic dolomite
				R 1.1	purple-red, hematitic, slightly dolomitic bedded siltstones
			base of the R.A.T. sequence unknown		

Pb-Zn-Cu mineralisation occurs in the Nguba Group. Mineralised Roan Group rocks within the Lufilian Arc occur as allochthonous units or thrusted breccias along fold axes. Mineralisation in the Roan Group occurs in two distinct orebodies (lower and upper) separated by a non-mineralised siliceous unit (R.S.C., Table 1). The second type of mineralisation in the Katangan belt is known mainly at Kipushi, Kengere, and Lombe (Fig. 1).

Symposium

The oral and poster presentations included 43 papers delivered over two and a half days, by fifty-two geoscientists from thirteen countries. Oral presentations were given in five sessions. The first session contained papers on general geology and metallogenic aspects, the second session covered lithostratigraphy, geochemistry and tectonic evolution on the central Africa Copperbelt, and in the third session papers treated on Neoproterozoic sediment -hosted stratiform Cu-Co deposits in the central Africa Copperbelt. The fourth session included papers on Neoproterozoic sediment-hosted Zn-Pb-(Cu) deposits. Other Proterozoic-Neoproterozoic sequences and base metal deposits were examined in the fifth session.

J. Cailteux (Forrest International Group) and co-leaders of the IGCP-450 project organized the symposium and workshop. Several mining companies and organizations sponsored the meeting. An abstract volume of 223 pages (Cailteux, 2003) including the field guidebook was distributed to all participants.

Field Workshop

Lithostratigraphic, tectonic and metallogenic aspects of the Katangan Belt were discussed during the six-day field workshop. The main localities visited are shown on Fig. 1.

Day 1: July 17th

The Luiswishi-Kimbembe area was visited on the first day. The first stop was the Luiswishi Cu-Co-U stratiform deposit located 26 km NW of Lubumbashi city (Fig. 1). This deposit is located along a NW-SE elongated and northeasterly verging thrust sheet. It is situated in the extension of the Rwashi anticline, which also hosts the Etoile, Rwashi and Luishya Cu-Co deposits. The Roan Group rocks hosting the mineralisation form a breccia that to the north is in contact with the top part of the Kundelungu Group (Ku 1.3-2.1 Formations). To the south, this breccia is in contact with Mwashya Subgroup (upper Roan or R 4). Within the breccia, blocks of Nguba and

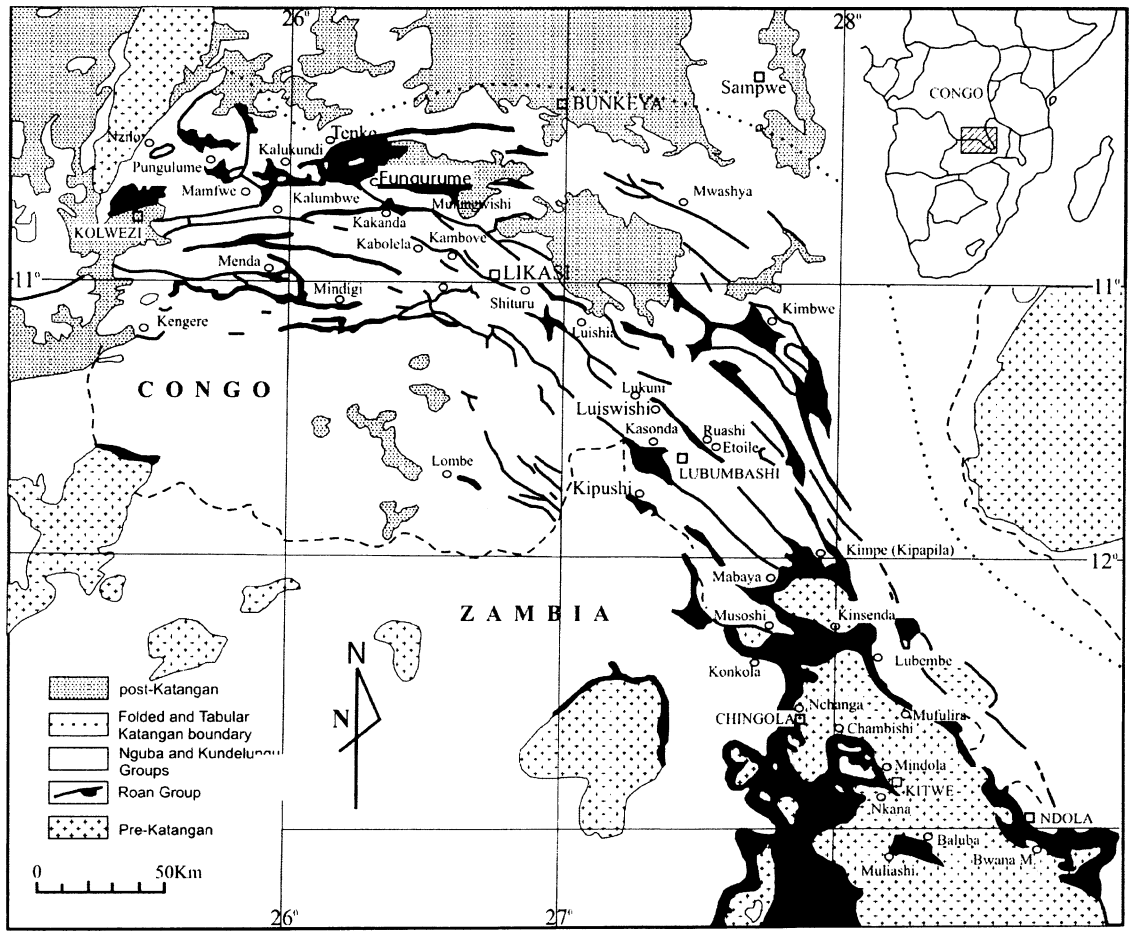

Fig.1. The Neoproterozoic Katangan belt with main localities visited during the workshop (François, 1987).

Kundelungu Group rocks were recognized.

In the Luiswishi open pit, Mines Subgroup rocks define a north-verging isoclinal syncline. The mined ores occur above the water table (oxidized zone) and primarily consist of Cu and Co oxides. Heterogenite (Co-bearing ore), malachite, chrysocolla, pseudo-malachite and Mn-Ni oxides are essential minerals, however scarce sulphides occur mainly in the R.A.T. (Roches Argillo-Talqueuses) Subgroup. The mined ore grade is ≥ 1.1 wt% Co and ≥ 2.5 wt% Cu. Current reserves are adequate for 12 years mining activity.

Kawama Hill located north of the Luiswishi deposit was visited at stop 2. Folded Ku 2.1 Formation shales, siltstones and sandstones occur at this site. These rocks are characterized by presence of intraformational conglomerates, ripple marks and mud cracks that allow interpretation of the formation as tidal flat deposits.

Outcrops of other Katangan units around the Luiswishi area were visited. The contact between the Lower and Upper Mwashya Formations was observed. This is characterized by the "Conglomérat de Mwashya" (François, 1973a). The conglomerate is monogenic, but there was no consensus among participants concerning the conglomeratic nature of this unit. The Grand Conglomérat and Petit Conglomérat were also examined. The Petit Conglomérat is characterized by thin and scarce clasts of quartz, carbonate, quartzite, sandstones and granite in this area. This is its typical facies in the southern part of the Lufilian Arc. The northern facies of the conglomerate (not observed during the workshop) is characterized by abundant clasts of quartz, quartzite, rhyolite, granite and feldspar mainly ranging up to 20 cm (Batumike et al., 2002).

Day 2: July 18th

The Zn-Pb-(Cu) Kipushi deposit near the border with Zambia was visited on day 2. The mineralisation here occurs in the Nguba Group, mainly in the Kakontwe limestone (Ng 1.2.2). Ores are also hosted in breccia and blocks of dolomitic sandy shales of the Ku 2.1 Formation called "Lambeau" by mining geologists. Cd, As, Ga, Co, Ag, Ge, Ge, Mo, and Rh mineralisation is associated with Zn, Pb and Cu oxides or sulphides. In oxidized ores the following minerals occur: cerussite, malachite, smithsonite, hemimorphite, cuprite, zincite, hydrozincite, brochantite, anglesite, veszelyite, pseudo-malachite, vivianite, autunite, pyromorphite, vanadinite, cuprodoscloisite, dioptase, chrysocolla, and willemite. Sulphides include pyrite, sphalerite, tetraedrite, chalcopyrite, bornite, galena, chalcocite, covellite, digenite, tenantite, gallite, germanite,

briartite, pyrrhotite, arsenopyrite, molybdenite, linnaeite and bismuth-sulphides. Native silver is also observed.

The principal deposit is located at the contact of the "Série reccurrente" (Ng 1.3), Kakontwe limestone (Ng 1.2.2) and the fault. Copper ores run from 2 wt% and zinc ores from 14 wt%, but mixed ores (Zn-Cu) can grade up to 8 wt% Cu and 7-14 wt% Zn. Resources for Zn are 5 millions tons and 600,000 tons for Cu (1-2 wt%).

Participants descended to the 1150 m level underground where a cross section from the Petit Conglomérat (Ku 1.1) to the Grand Conglomérat (Ng 1.1) was examined. Massive Zn ores and Cu or Zn oxides and sulphides were observed. The day ended by observation of about 1100 m of drill cores collected from the same level visited underground.

Day 3: July 19th

We visited Likasi town, situated 120 km west of Lubumbashi. In the morning, the Shituru stratiform Cu-Co open pit was explored. The ore is here hosted in the Mwashya Subgroup (R 4), in which pyroclastic units occur. The deposit is hosted in a NW-trending and NE-verging isoclinal anticline forming the same lineament as the Etoile-Rwashi-Luishia anticline. It is bordered to the north and south by the Jadotville and Likasi faults. Lower and Upper Mwashya Formation rocks occur at both flanks of the anticline. Finely alternating grey to green shales, stromatolitic dolomites and sandy dolomites constitute the Lower Mwashya (R 4.1), which also contains pyroclastic rocks, iron oxide beds and jaspers. The Upper Mwashya (R 4.2) contains silty shales (R 4.2.1), black shales (R 4.2.2) and banded shales (R 4.2.3). Interbedded silicified dolomites and shales mark the transition between the Lower and Upper Mwashya. The passage from Upper Mwashya to the Grand Conglomérat is characterized by load deformation figures, slumps and intraformational breccias.

The sulphide resources are estimated at 85,000 tons of ore averaging 2 wt% Cu and 0.05-0.1 wt% Co. The oxidized zone at the deposit was mined between 1919 and 1954. Banded haematite occurs in the pyroclastic unit, and in places pyroclastic beds alternate with haematite beds.

In the afternoon, we examined several hundred meters of cores of the Mwashya Subgroup (R 4), Kakontwe Limestone (Ng 1.2.2), and the Manfwe (Fig. 1) breccia. A visit to the Gécamines Museum followed by a friendly party organized by a local golf club successfully ended the day.

Day 4: July 20th

The first stop of the day was the Kakontwe open pit, 6 km NW of Likasi town. In this open pit Kakontwe Limestone (Ng 1.2.2) is mined for cement and lime (Franç ois, 1973b). The rocks consist of grey, more or less carbonaceous limestone enclosed by dolomite at the base and top. Oncolites indicating biologic activity are present. In this area, the Grand Conglomérat is overlain by black, carbonaceous, banded shales and dolomite (known as "dolomies tigrees") forming the Ng 1.2.1 member. This is overlain in turn by the Kakontwe Limestone (Ng 1.2.2). Massive pelites containing calcite-chlorite-haematite nodules overlie the Kakontwe Limestone. The open pit contains essential resources for production of cement and lime, and calculated reserves for good quality limestones (> 5 wt% MgO, < 7 wt% SiO_2, < 2 wt% Al_2O_3) are 50 Mt up to 1150 m altitude.

The second stop was the Kamoya deposit, situated 4 km E of Kambove and 25 km NW of Likasi. The deposit is also located along the NW-SE trending Kambove-Shituru-Luishia-Luiswishi-Etoile lineament, and occurs in a thrust sheet lying on Ku 1.3-2.1 sedimentary rocks to the north. The contact is marked by a breccia containing blocks of Roan Group, Nguba Group and Kiubo Subgroup rocks. The ores are hosted in the Mines Subgroup, and both ore bodies are present. Sulphides including bornite, carrolite, chalcopyrite, and pyrite constitute the essential minerals. The mineralisation is stratiform, but in places is remobilized in veinlets.

Outcrops of folded Nguba and Kundelungu Groups were examined on the road to Fungurume. The last stop of the day was the Grand Conglomérat outcrop near Fungurume city. Here the Grand Conglomérat is massive, typically unsorted as usual and matrix-supported conglomerate containing both rounded and angular clasts. It contains sulphide crystals, and some clasts are also sulphide-rich.

Day 5: July 21st

We visited the Fungurume deposits, which form part of the Tenke-Fungurume mining district located halfway along the road between Likasi and Kolwezi (Fig. 1). Ores are hosted in Mines Subgroup rocks, and form part of a vast thrust sheet occurring at the convergence of three anticlines faulted along and planes of the fold. The Tenke and Fungurume deposits are separated by the 8 km long "Dipeta" syncline, in which Mines Subgroup units occur in the core.

The lower and upper ore bodies in the Fungurume I, II, III, IV and VII deposits in the Fungurume-Est area contain oxidized Cu-rich ores, but are poorly mineralized in cobalt. Bornite, chalcopyrite, carrolite and chalcocite are the sulphides observed in the lower ore body. Cobalt ores are mainly hosted in the upper ore body of the Fungurume VIII, IX, X, XII, XIII and XV deposits, and in the Tenke deposits (François, 1973a).

At the Kazinyanga deposit, we observed the continuous sedimentary transition between the D-strat (Stratified dolomite)-grey R.A.T. (Mines Subgroup) and red R.A.T. Subgroup. Here Cu-oxidised ores occur only in the upper ore body.

A visit to the Mofya open pit located north of Fungurume city ended the day. Massive silicified carbonates (limestones) that form the Mofya formation crop out at this open pit. Locally limestones show alternating whitish and grayish beds, wavy bedding, intraformational conglomerates, and soft sediment deformation. These features are considered to be evidence for tidal flat

deposition. Several pores identified within the rocks were interpreted as the result of evaporite dissolution. Stratigraphically, the Mofya formation overlies the Mines Subgroup, but is older than the Nguba Group. Therefore, it is considered to be equivalent to the Dipeta or Mwashya Subgroup.

Day 6: July 22nd

The transition between the folded and tabular Kundelungu was examined in the Mwendo-Mukose area. In this area the dip generally decreases continually from south to the north, but near the tabular Kundelungu the formations dip northward. This change suggests that the folded Katangan underlies the tabular Kundelungu. However, this observation is not similar to that in the Bunkeya region, where the dip decreases continuously without change of direction. The suggestion that the folded Katangan could underlie the tabular Kundelungu may have implications for mining resources, because the Roan Group and its mineralisation may then be found in this region beneath the tabular rocks.

The Mwendo-Mukose Hill was the last stop of the field workshop. Red sandstones and shales of the Ku 2.2 Formation crop out at this locality. The rocks dip 5° to 15° NW, and cross bedding and intraformational conglomerates were observed. These rocks and the Plateaux Subgroup rocks observed further north are considered to represent foreland deposits.

On July 23rd, we returned to Lubumbashi, where all participants were invited to an evening dinner hosted by the Belgium Consulate.

On July 24th, the IGCP-450 business meeting was held, and the workshop concluded with the closing dinner that evening.

During the field workshop, discussions focused on ores genesis, the relation between tectonism and mineralisation, and the stratigraphy of the Katangan Supergroup. Mining geologists and geoscientists working on the Katangan Belt explained major aspects of the Katangan geology and mineralisation. Consensus has not yet been reached concerning the genesis of the Roan breccias, which host the important Cu-Co mineralisation, or the origin of the mineralizing fluids. Further studies on these aspects are still needed.

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（要　旨）

J.M. Batumike・吉田　勝・J. Kokonyangi, 2004，コンゴ，カタンガの中央アフリカコッパーベルト，原生代の西部ゴンドワナの堆積物に保有された卑金属堆積物に関する第3回IGCP-450会議ならびにフィールドワークショップ．島根大学地球資源環境学研究報告，23，79-84

IGCP-450会議とワークショップが南東コンゴのルンブンバシで2003年7月に開催された．その会議では，中央アフリカコッパーベルトのコンゴブランチの堆積物に包有された卑金属堆積物に関する検討がなされた．この会議には13の国から52人の地球科学者が参加し，口頭，ならびにポスターセッションで43件の発表がなされた．発表の主な内容はカタンガ地帯ならびに他地域の新原生界の一般地質，金属成因，岩相層序，地球化学，そして構造発達に関するものであった．ワークショップでは，この地帯の主要な産出金属である，Co-Cu-U包有堆積物，Zn-Pb-Cu包有堆積物についても扱われた．6日間にわたるワークショップでの議論ではテクトニクスや鉱床の成因，そしてカタンガン累層群の層序に関することが扱われた．Cu-Co包有堆積物を含むロアン層群の角礫岩の成因についてはいまだ議論の途上で，地球科学者間の議論でもこのカタンガ地帯のワークショップでも結論にいたらなかった．テクトニクスや結晶化作用などを含む異なる側面からのさらなる研究がこのカタンガ地帯では必要である．