"*Cobalt means conflict*" – Congolese cobalt, a critical element in lithium-ion batteries

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Abstract

The demand for cobalt in the past 15 years experienced a new boom: it is an essential component of lithium-ion batteries for electric vehicles. Cobalt mining in the Katanga Copperbelt had been mostly industrial in the 20th century. By contrast, artisanal exploitation increased from 2000 onwards and it is estimated that informal diggers provide about 20% of DRC's total production, which in turn accounts for 60% of world production. Environmental concerns of industrial exploitation (which therefore represents about 80% of DRC's global contribution) were neglected. Artisanal mining further adds a negative impact on the environment. After a century mining, the cobalt load in the environment became extremely high in Katanga. People are heavily exposed to it and other potentially toxic metals – among others uranium – creating serious public health challenges. This paper further addresses the possibility of a move toward a more sustainable exploitation of cobalt in DRC. It is likely that bottom-up schemes implying the artisanal and small-scale mining – which represent domestic Congolese interests – in a negotiation process could break the state-mining multinationals exclusive dialogue. It is also needed to consider the mining sector as one of the components of a wider system, including other socio-economic sectors as well as environmental parameters.

In a broader view, this local governance has to be mirrored by the setting of resource governance at the global scale.

Keywords: cobalt, Katanga, sustainability, mining, critical raw material

« Cobalt signifie conflit » – le cobalt congolais, un élément critique dans les batteries lithium-ion

Résumé

Le cobalt est un élément essentiel des batteries lithium-ion pour les véhicules électriques et sa demande a connu une forte croissance dans les 15 dernières années. L'exploitation de ce métal au Katanga a été essentiellement industrielle pendant la majeure partie du 20ème siècle puis, à partir des années 2000, elle est devenue artisanale. Aujourd'hui, on estime que l'artisanat minier produit quelques 20% du cobalt congolais, qui à son tour représente 60% de la production mondiale. L'exploitation industrielle, qui représente environ 80% de la production, ne s'est pas souciée de la question de son impact environnemental et l'artisanat minier a encore aggravé la situation. Après un siècle d'exploitation, la charge polluante du cobalt au Katanga est très élevée et la population est soumise à une exposition importante, au cobalt et aux métaux associés – notamment l'uranium – ce qui occasionne un risque de santé publique très significatif. Cet article s'intéresse aussi à la possibilité de voir émerger une exploitation plus soutenable du cobalt en RDC. Il est probable qu'une approche ascendante impliquant le secteur minier artisanal – qui représente des intérêts nationaux congolais – dans une négociation sectorielle pourrait briser le dialogue exclusif entre l'état et les compagnies minières multinationales. Le secteur minier doit aussi être considéré comme une composante d'un système intégré, incluant d'autres secteurs socio-économiques et les préoccupations

environnementales. Plus largement encore, cette gouvernance locale devrait être relayée par une gouvernance globale des ressources.

Mots-clés : Cobalt, Katanga, soutenabilité, exploitation minière, matière première critique

Foreword

The title quote is part of a statement by a community respondent, cited in a recent paper on the political economy of cobalt (Sovacool, 2019). I highlight it as evidence to the feeling I derive from my own experience in the Copperbelt over the past ten years. Although my focus has been mostly on geology, I have collaborated with Congolese state agents, stakeholders in the mining sector, Belgian diplomats and more recently, with public health experts and medical doctors. I have visited numerous artisanal mining sites (a.o. Shamitumba, Kambove, Luishia, Kawama (Kakontolwa), Kasulo, Kimpese). As co-chair of a Belgian task force on mineral resource launched by the Belgian Foreign Affairs in 2006 I was, together with my colleague and co-chair Pr. Jan Gorus (VUB), at the origin of a concept of "*bourses d'achat*" (*comptoirs* or trading centres) for the artisanal ore, in 2008. The concept has been later taken up in Eastern D.R. Congo by multilateral donors (OECD, UNGoE, etc.), for conflict minerals.

This paper is an opportunity to take a look back at this experience and to insert cobalt mining in the wider context of a constant tension between artisanal and industrial mining, between diggers and company miners, between corrupt elites and ordinary people, against a background of globalised economy.

1. Introduction

Cobalt is a metal whose status has considerably changed since the beginning of the exploitation of the Central African Copperbelt (CAC), at the end of the 19thC. It was first discovered during WWI as a residue in the copper slags, the main commodity exploited in the CAC at the time (Birchard, 1940; Lerat, 1960). Its Congolese production reached 400 tons in 1930 (Célérier & Cholley, 1930). Things changed drastically with WWII, as the need emerged for high-strength alloys, indispensable for ammunitions, aircrafts and weapons. During the peak years of the war, Africa supplied 90% of the world's cobalt and Congo became the primary supplier to the United States and United Kingdom, along with Northern Rhodesia (nowadays Zambia). Cobalt exports from the Congo to the US jumped from 820 tons in 1938 to 9,500 tons in 1943. Further, in order to overcome the inaccessibility of the Nazi-occupied Hoboken plant in Belgium, a cobalt refinery facility was built at Niagara Falls (Robequain, 1948; UMHK, 1956; Dummett, 1985). The workforce specifically dedicated to cobalt jumped from 257 to 1267 between 1939 and the first semester of 1944 (Banjikila, 1983).

Copperbelt minerals have been integrated since the onset of industrial mining in the 19thC into a globalising economy. Their production experienced significant peeks during the major conflicts of the 20thC, WWI, WWII, the Korean and Vietnam wars. Prices dropped after the first oil crisis and recovered only at the end of the 1990s (Hönke, 2010; Juif & Frankema, 2018).

The importance of cobalt has grown significantly as new uses emerged in several different industrial segments: alloys, pigments, catalysts, health care. In the past decades, the use of cobalt in rechargeable batteries has increased to the point that roughly half of the metal globally produced today is found in them. In 2019, cobalt gained a very high economic importance for the major industrialized countries (USA, European Union (EU), China, Japan) and its

production is still dominated by the Democratic Republic of the Congo (DRC). In 2018, DRC indeed produced about 64% of the worldwide cobalt, with no other countries producing more than 5% (USGS, 2019).

However cobalt is a finite – and hence intrinsically non-sustainable – resource, like all minerals. At a local scale, in DRC, the close relationship between the Congolese state and the multinational mining companies presently favours the government, which relies on revenues generated by big concessions and is little dependent on its citizens through taxation (Zeuner, 2018). Further, DRC recurrently sits in the lowest decile of countries with most international ratings – World Governance Index, Doing Business, Human Development Index, Environmental Performance Index, etc. (Trefon & De Putter, 2017; Zeuner, 2018; Sovacool, 2019). The high value of cobalt, outlined above, a fast-growing demand and a significant supply risk in/from DRC have conferred cobalt the status of "critical element" for the EU economy (Olivetti *et al*., 2017; EU, 2019).

2. Brief overview of supergene cobalt geology, mining and the cobalt supply chain in the Katanga region

The Central African Copperbelt (CAC) has deep, primary copper (Cu) and cobalt (Co) ore, comprised of Cu-Co-bearing sulphides hosted in carbonate-rich rocks of the Mines Subgroup (known as the "*Série des Mines*" in French; c. 800 Ma), within the Neoproterozoic Roan Group (Cailteux *et al.*, 2005; Dewaele *et al.*, 2006). The Roan Group has experienced some 270 million years (Myr) geological history before its major folding and thrusting in the Lufilian orogeny, which is part of the broader pan-African orogeny affecting a large part of Africa (Collins & Pisarevsky, 2005; Muchez *et al*., 2010; Cailteux & De Putter, 2019). The area was then affected by post-orogenic hydrothermal events, resulting in the formation of copper-zinc-

lead deposits, as in Kipushi (c. 450 Ma; Schneider *et al*., 2007). Little is known on the next 370 Myr of the CAC which underwent tectonically-induced vertical movements, erosion, denudation, alteration/weathering, and was probably never overlain by thick sedimentary cover. The absence of thick sediment cover means that the primary sulphide ore (either of Cu or Co) of the CAC has possibly experienced rather frequent contact(s) with meteoric fluids. The leaching of sulphide ore by shallow, mildly acidic meteoric fluids (acidified by the atmospheric CO_2) resulted in the oxidation of primary sulphides, and the neoformation of secondary metal-rich minerals, as malachite [$Cu_2(CO_3)(OH)_2$] for copper and heterogenite [CoO(OH)] for cobalt (**Fig. 1**). Such secondary ore formation occurred rather frequently in the CAC during the last 80 Myr, within a complex sequence of uplift, erosion and denudation events (Decrée *et al.*, 2010; De Putter *et al.*, 2015; Fontaine *et al.*, 2019; De Putter & Ruffet, 2020). As a result, today, the upper part of the CAC (locally up to c. 100 m in thickness) is comprised of a thick secondary, oxidized metal-rich ore blanket, with "cobalt caps" overlying copper accumulations (**Fig. 1**).

This geological setting is unique on earth, as the CAC hosts the only deposit where cobalt is enriched to the point that it forms discrete Co-bearing minerals, and becomes a commodity exploited on its own. The CAC has 3,400,000 tons of Co (proven reserves), which amounts to ~50% of the world reserve (USGS, 2019). Due to the geologic history briefly outlined above, a large part of this cobalt-rich ore is close to the surface and easily recoverable, as friable, earthy secondary ore where heterogenite is the dominant mineral (**Fig. 2**).

As a consequence of this easy access and of political and economic troubles, the artisanal and small-scale mining (ASM) has developed alongside large-scale and industrial mining (LSM) in the last 25 years, for both copper and cobalt (Trefon & De Putter, 2017; Sovacool, 2019). It is often difficult to get reliable figures for the share of ASM in the case of cobalt production,

but the proportion of “artisanally” mined cobalt has been estimated at 15 to 20% of the total cobalt mined in the DRC (BGR, 2017; Zeuner, 2018; Sovacool, 2019).

According to the new Congolese Mining Code promulgated in 2002, ASM can take place in dedicated mining sites, the ZEAs (“Zones d’Exploitation Artisanales”), and is theoretically forbidden elsewhere. Nevertheless, ASM occurs everywhere, even in towns, and is a source of modest income (30-50US$ per month) for 50,000 to 200,000 workers in Katanga (Banza *et al*., 2018; Sovacool, 2019). Artisanal miners work in precarious conditions for a buyer’s market: they sell their production in unfair conditions, mostly to Chinese “comptoirs”. Further, ASM is virtually absent of the broader, local and national, resource economy largely based on a pattern of negotiation and contracts between the Congolese government and mining multinationals (Hönke, 2010; Zeuner, 2018).

Cobalt from the ASM is “mixed” with industrial cobalt and is included in a globalized supply chain (Mann, 2017; Zeuner, 2018; Sovacool, 2019) (**Table 1**). Within DRC, this “massively complicated supply chain” (Mann, 2017) involves the Congolese government and multinational mining companies (LSM) on one side; ASM workers, traders and the smelter CDM (Congo Dongfang International Mining, a branch of Zhejiang Huayou Cobalt) on the other side. The commercial bargaining between the Congolese government and multinational mining companies leaves the other actors, including ASM miners and Chinese traders and smelter, largely out of the game, safe for deep-rooted extortion by officials acting as predators (Trefon and De Putter, 2017; Zeuner, 2018; Sovacool, 2019).

Table 1. The globalized supply chain of cobalt

	Stakeholder of the cobalt supply chain	Where?
1	Minesites: ASM, LSM and slag heap mining	DRC
2	Trading and local refining in Katanga	DRC; Chinese CDM is the main purchaser and smelter of artisanal cobalt
3	Chemical processing and refining	c. 80% of global processing capacity in China
4	Cathode/anode production	China and South Korea
5	Battery cell manufacturing	China and South Korea
6	End-users: IT, car companies	worldwide, including Asia, EU and USA

3. Exposure and public health

The geological history of the Katanga in the last 80 Myr has produced an unusual landscape in which most of the high-grade ore is located at the surface or at shallow depth – typically some tens of meter (**Fig. 1**). The combination of industrial and artisanal mining over more than 120 years has produced a major increase of anthropization and dramatic changes in the landscape: hilltop removal, deforestation, changes in river ecology, soil erosion, pollution, etc. (André *et al.*, 2018; Amisi Mwana *et al*., 2018; Sovacool, 2019). As a result of the spreading of mining activities, the dispersion of metals mined in the region has also increased, in wastelands around the main cities, Kolwezi, Likasi and Kipushi (Mees *et al*., 2013; Amisi Mwana *et al*., 2018) but also in river basins (Katemo Manda *et al*., 2010; Atibu *et al*., 2013; Kalenga, 2013) and around artisanal mining sites.

Mining companies paid little attention to the fallouts of their activities on the environment and public health prior to the 1990s. Things then changed progressively: the Mining Code, published in 2002, requires miners to take the protection of the environment into consideration. Further, "Environmental Impact Studies" (EIS) are requested since 2011 and the "Office Congolais de Contrôle" (OCC) is in charge of monitoring analyses (Kalenga, 2013).

In the last 15 years, biomonitoring studies in the CAC have largely confirmed pessimistic hypotheses on metal dispersion in the mining district (a.o. Banza *et al*., 2009; Kalenga, 2013; Squadrone *et al*., 2016). These studies reveal a substantial exposure of the population to copper, cobalt and associated trace elements, uranium, nickel, manganese, vanadium, arsenic and rare earth elements. The urinary cobalt concentrations are even the highest ever reported for a general population (Banza *et al*., 2009). Further investigation of the cobalt exposure routes, through the analysis of environmental (dust, water), dietary (uncooked food: maize, flour, vegetables, fish and meat) and urine samples, indicates that the consumption of legumes, cereals and fish – a significant input of proteins to local communities – is the largest contributor to cobalt intake in adults, while dust ingestion contributes substantially in children (Cheyns *et al*., 2014; Squadrone *et al*., 2016). As expected, artisanal miners have higher levels of cobalt in their urine and blood than people living in nearby control areas. The difference is still more pronounced for children – even those not engaged in mining activities – who also display evidences of exposure-related oxidative DNA damage (Banza *et al*., 2018).

The health impact of this high exposure is not yet fully assessed. Metals have their specific toxicity, which may be increased in the case of pollutant mixtures. Therefore, epidemiological studies of the impact(s) of this exposure should cover a broad range of endpoints, as birth defects, neurodevelopmental impairment, respiratory disorders, heart and kidney disease, and cancer. The evidence of increased oxidative DNA damage further points to an increased risk of cancer in later life, even though this risk is somewhat mitigated by low life expectancy in

DRC (59yr(m)/62yr(f) in 2016; WHO, 2020). As a cause of potential health problems for future generations, the artisanal exploitation of cobalt is now regarded as a typically non-sustainable activity (Banza *et al*., 2018).

The non-sustainability of cobalt ASM adds to the intrinsic non-sustainability of any finite mineral resource. The challenge is to reconcile mining, which brings jobs and revenues, with the well-being and development of the local population on the one hand, and with the demand for cobalt on the other hand. This issue is examined in the next section.

4. Can cobalt be mined sustainably?

The exploitation of strategic metals is an issue with considerable implications, for both consumers and producers. However it is surprisingly absent in the press and the media oriented toward a general audience, notably in Western Europe. By contrast, major NGOs and specialized newspapers frequently publish well-documented reports emphasizing the disastrous working and living conditions of miners and diggers in DRC, and often focusing on high-on-the-agenda issues, such as child labour or corruption (Amnesty International, 2016; Callaway, 2018; Walt and Meyer, 2018). A ban on "non-sustainable" Congolese cobalt is definitely not realistic, as a previous ban in 2010 had detrimental effects on the livelihoods of workers (Geenen, 2012; Sovacool, 2019). At a broader scale, DRC provides half of the world's cobalt and it is unlikely that Western industry could deal with a sudden supply shortage (Olivetti *et al*., 2017; Zeuner, 2018).

In the past years, international organizations (such as the OECD) and NGOs have most often favoured top-down approaches for the regulation of artisanal mining, where major stakeholders – the State, donors, industry and civil society (including NGOs) – were in charge of improving the ore exploitation and trade flows, notably for tin-tantalum-tungsten and gold in the Great

Lakes region. This approach has shown its limits, as the Congolese state is altogether "an omnipresent but absent state" (Hönke, 2010), and the artisanal miners have low bargaining power. As a result, the private sector has established a dominant position in these multi-stakeholders initiatives and most traceability and certification schemes set up to date were fundamentally driven by a will to maintain the fluency of existing trade flows (De Putter & Delvaux, 2013; Zeuner, 2018).

Three main stakeholders have a major role to play in the setting of a more sustainable mode of cobalt exploitation: (1) the Congolese State; (2) international mining and non-mining companies; (3) artisanal miners and their communities. Besides, the consumers of electrified devices worldwide have to recognize that their demand for green technology actually depends on exploitative and dangerous labour. As rightly stated by Mann (2017), the ideological question is: do "their ethics only apply to the environment?"

The Congolese state maintains a quasi-colonial management of its mining sector, where local governance in mining areas, considered as "enclaves of production", is quasi-outsourced on multinational mining companies (Hönke, 2010). Further, the state has a majority of the world's cobalt and favours a bargaining relationship with these companies in which power dynamics tends to shift in its favour, notably when the price of cobalt soars. Thanks to this bilateral agreement policy, the state does not depend on its citizenry for taxation (Zeuner, 2018). This negotiation process hence excludes community-based ASM, which contributes some 20% of the Congolese cobalt.

Multinational mining companies are ostensibly sensitive to reputational damage if the company is named and shamed by NGOs on allegations of exploitation, child labour or similar concerns. Hence, addressing specifically the cobalt issue, a mining company (Trafigura) and an industry consortium (BASF, Samsung, BMW) have recently stressed a will to ensure better

sustainability of the cobalt chain in the artisanal sector. Such initiatives apparently capitalize on the weakness of past certification schemes and define "people-oriented" sustainability criteria: (1) human rights; (2) working conditions; (3) environmental impacts and (4) socio-economic impacts (Transport & Environment, 2019).

Among the stakeholders, the ASM miners are most generally mining for subsistence, and they lack the resources needed to engage in legal mining, with rights (Geenen & Cuvelier, 2018; Zeuner, 2018). Further, their activity is mostly illegal, except within the "zones d'exploitation artisanale" (ZEA), created by the state. Hence, ASM miners have a minimal level of bargaining power, either with the state or the multinationals.

Today, the extraction of cobalt through partnerships between the Congolese state and mining multinationals reinforces political instability and corruption (Geenen & Cuvelier, 2018; Zeuner, 2018). It excludes artisanal miners, damages health and the environment and meets the need of Westerners consumers for green tech at a high human cost (Banza et al., 2018). Including more artisanal cobalt in the sector would theoretically reduce the influence of mining multinationals and make the state more reliant on mining communities – which represent domestic interests – for potential tax revenues. Include non-mining multinationals (stakeholders 6 in the above supply chain) in the sourcing of their metal commodity is another way to break the state-mining multinationals exclusive dialogue. For instance, these non-mining companies could finance the purchase of mineral concessions in which artisanal miners could exploit cobalt in acceptable conditions, and make this more profitable to the state by opening these mines up to the higher taxes placed on formalized mining (Zeuner, 2018). Such deals could bring forward the livelihoods or the diggers and build sustainable practical solutions based on the arrangements that are yet made among the workers, and further between the workers and other stakeholders in the artisanal mining sector (Hilson *et al.*, 2017).

It is likely that initiatives involving their potential beneficiaries and taking into account the perception and needs of the affected population and the mineworkers (Amisi Mwana *et al*., 2018; Zeuner, 2018; Sovacool, 2019) would have more chance to succeed than top-down plans elaborated in international cenacles. Further, an integrated "systemic" approach should be favoured, considering not only mining and miners but all the other activities and groups of actors interacting with the miners and involved in the everyday life, well-being and development of local communities (Michel, 2017; Sovacool, 2019). Whatever the commodity, tantalum or gold in the Great Lakes, cobalt in the Katanga, autarky of mining sites is an Achilles' heel of sustainability in the trade chain.

5. Conclusion

Cobalt, as a sought-after critical element, is a source of revenue for DRC and it should be an opportunity to foster the development of the country. However, put bluntly, the cobalt business has become a "*cash cow for those in power at Kinshasa and their acolytes in the Lualaba province*" (Callaway, 2018). The mismanagement of the mining sector is not new in the country and part of the problem may be due to the fact that this crucial economic sector is ruled by weak, corrupt or predatory stakeholders. Mega-contracts, sought-after by elites, result in deceiving performance in terms of development (Maiza-Larrarte & Claudio Quirroga, 2019). The emergence of a corporate due diligence concern for responsible business conduct and the move towards community-based development approaches might be the opportunity for a change, if people in the field, possibly assisted by NGOs, keep the sense of their common interest and develop a robust negotiation capacity. As mentioned above, it is also needed to consider the mining sector as one of the components of a wider system, including other socio-economic sectors as well as environmental parameters. In a broader view, this local governance

has to be mirrored by the setting of resource governance at the global scale (Ali *et al.*, 2017). The challenge is to manage a finished quantity of cobalt in the context of a fast-growing demand for this metal. Sustainable cobalt supply rests on several pillars: improved mineral exploration and mining, technological changes towards a better efficiency of metal use, metal recycling, and a much-needed resource governance. This paper aims at stressing the importance of the latter pillar, which is the only way to "bridge the gap" between the digger in the field and the everyday user of lithium-ion batteries, a major step towards improved sustainability.

The future of cobalt depends largely on economic parameters as the price of carbon-based energy sources: cheap oil slows the move towards e-powered devices, and has a negative impact on cobalt mining and on the search for substitutes. In DRC, the setting of a multi-stakeholders bargaining relationship taking national concerns and interests into consideration also depends on extra-Congolese factors, as the social and environmental awareness of end-users of Li-ion batteries. The way Congolese cobalt will move in the future is hence obviously and unfortunately out of Congolese hands.

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Figure captions

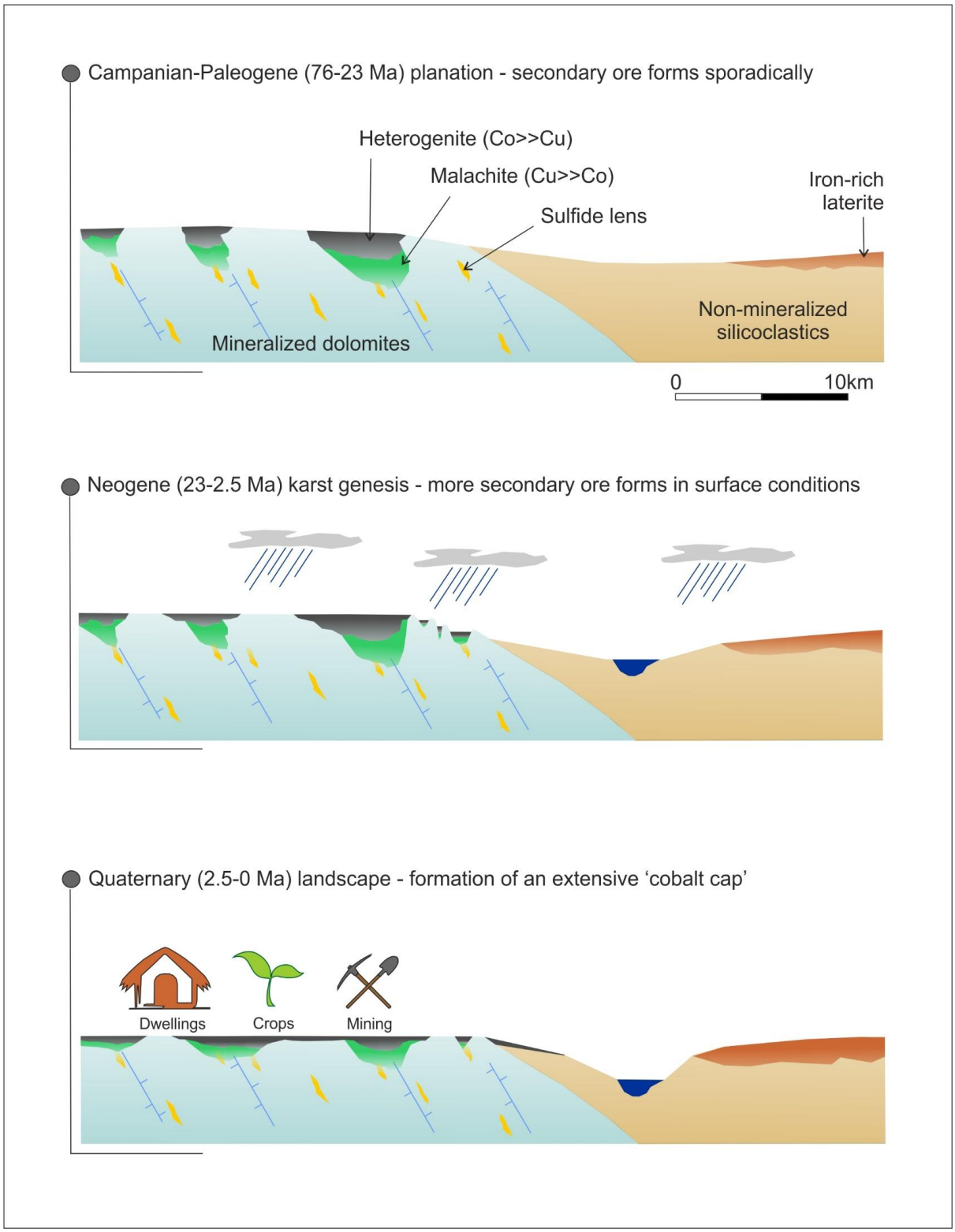

Fig. 1. Sketch showing the formation of secondary ore in the Katanga Copperbelt during the last 76 millions of year. Major planation in the Cretaceous-Paleogene interval is followed by

karst formation episodes in the Neogene, and landscape formation and river incision in the Quaternary. The lateral extent of secondary ore caps increases markedly through these different phases, reaching a unique situation for a major mining area, with most of the richest ore exposed at the ground surface or at shallow depth. Vertical scale is exaggerated, the depth/thickness of secondary ore deposits is typically less than 100 m.

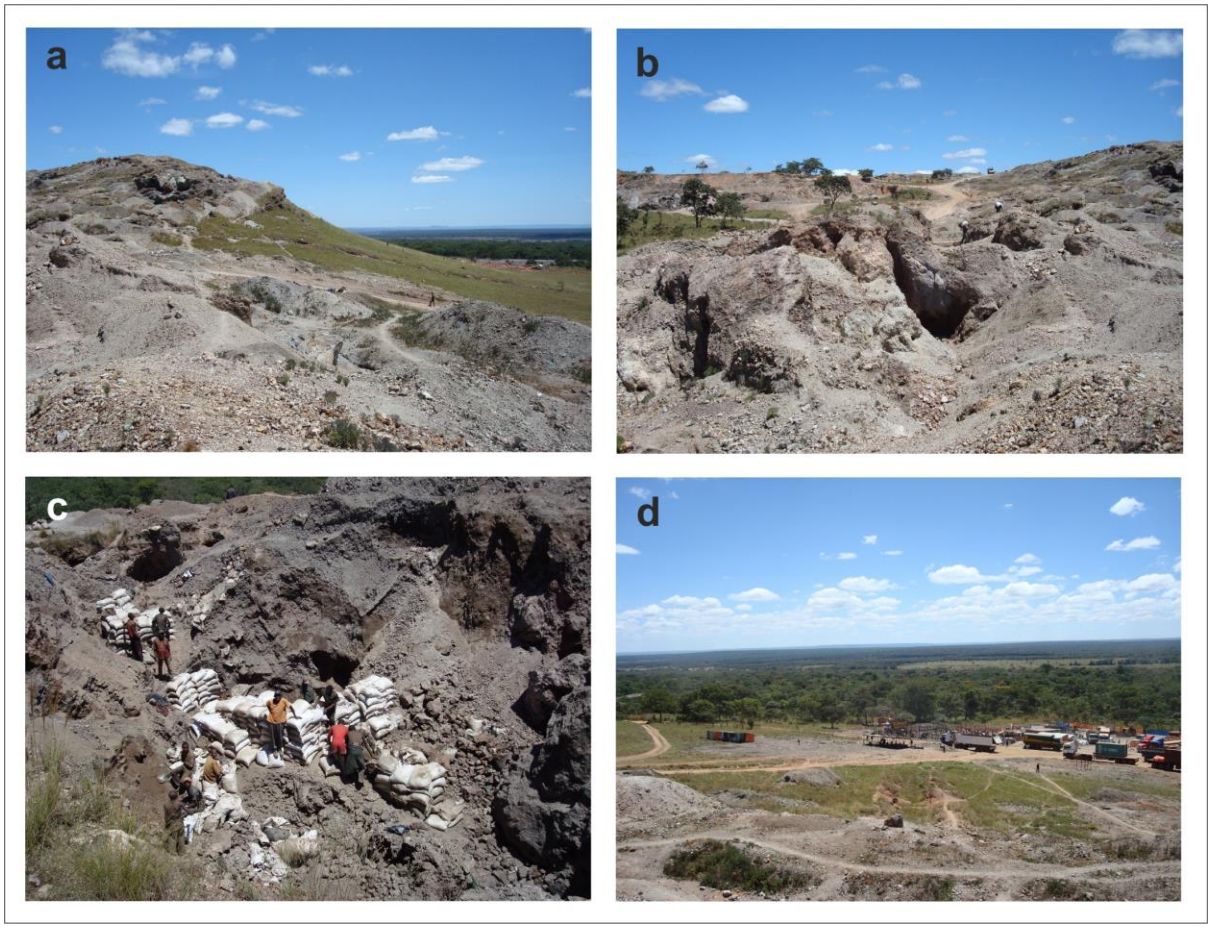

Fig. 2. Photographs of the Kawama (Kakontolwa) cobalt mine, to the east of Kolwezi (10°44’11,4’’S; 25°51’41,6’’E; alt. 1450m a.s.l.), in April 2009. a. general view of the artisanal “mine”, within a relict inselberg; b. general view of the mining pits; c. miners around ore bag stockpiles within a mining pit; d. trucks for the transportation of ore bags (all pictures © Thierry De Putter, Royal Museum for Central Africa).