MOBILITY OF CU AND CO IN METALLIFEROUS ECOSYSTEMS: comparison of soil profiles and experimental results

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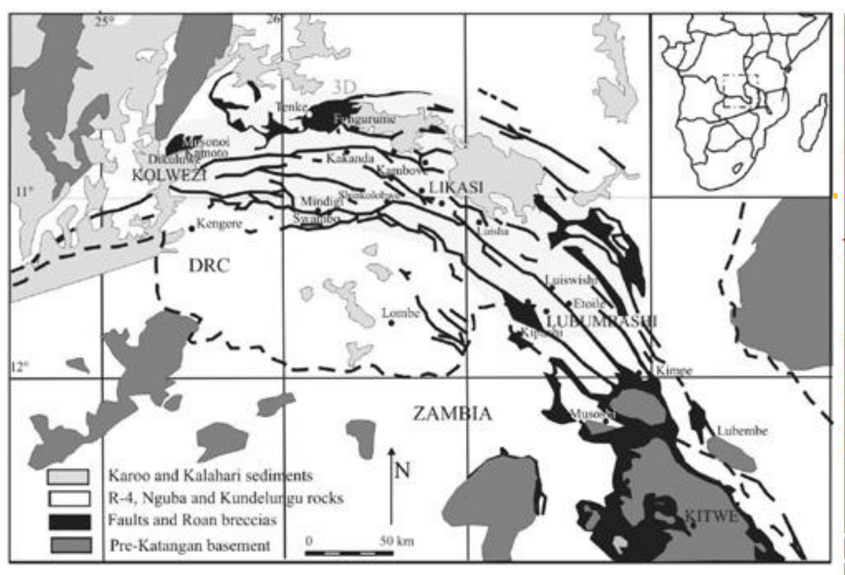
CONTEXT

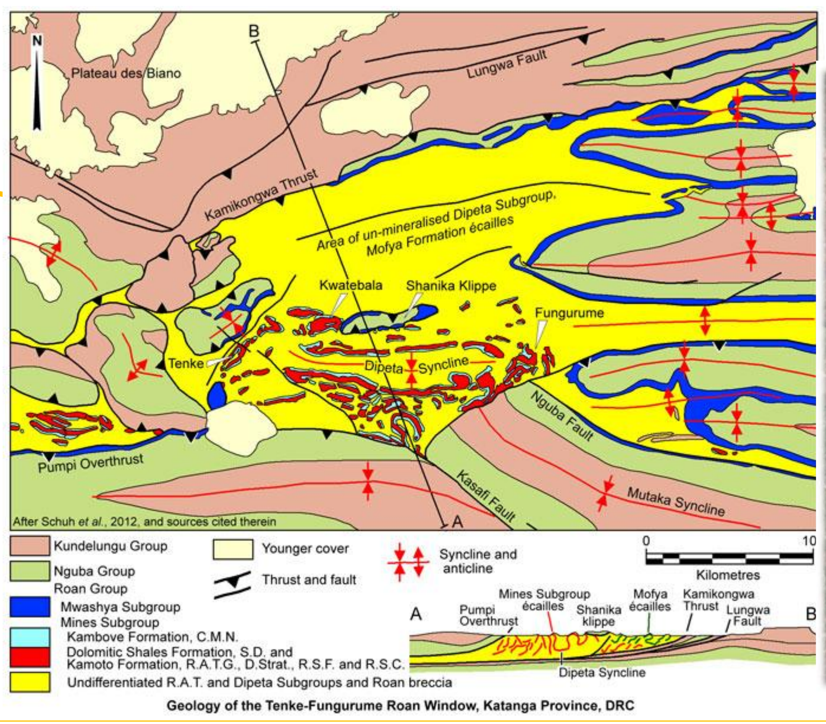
Numerous soils in Katanga have been contaminated by the Cu-ore extraction and treatment activities. The copper-belt hosts ecosystems which have been able to adapt to metalliferous conditions. Research are conducted in natural ecosystems of the copper hills to evaluate mobility of Cu and Co in soil-plant systems (Kaya et al., 2012).

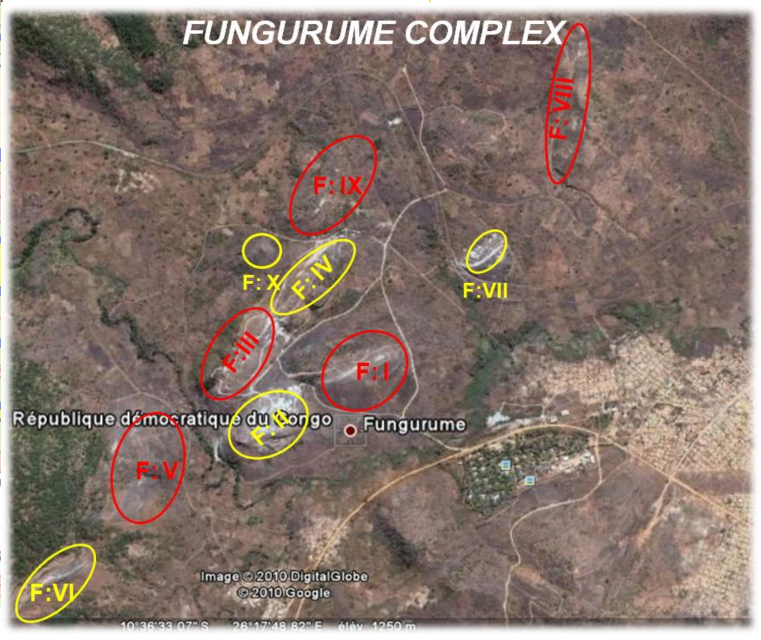
A view from a mining site in Katanga

Typically, the relief in metalliferous hill of Katanga is driven by differential erosion of folded formations of the Mines and RAT subgroups of Roan group (Kampunzu *et al.*, 2009). The more resistant silicified dolomites which host Cu and Co deposits outcrop in the upper part of the hills over less resistant argillaceous dolomitic siltstones.

Cu and Co are transported along the slope as solid particles inside rock clasts by gravity and surface erosion.

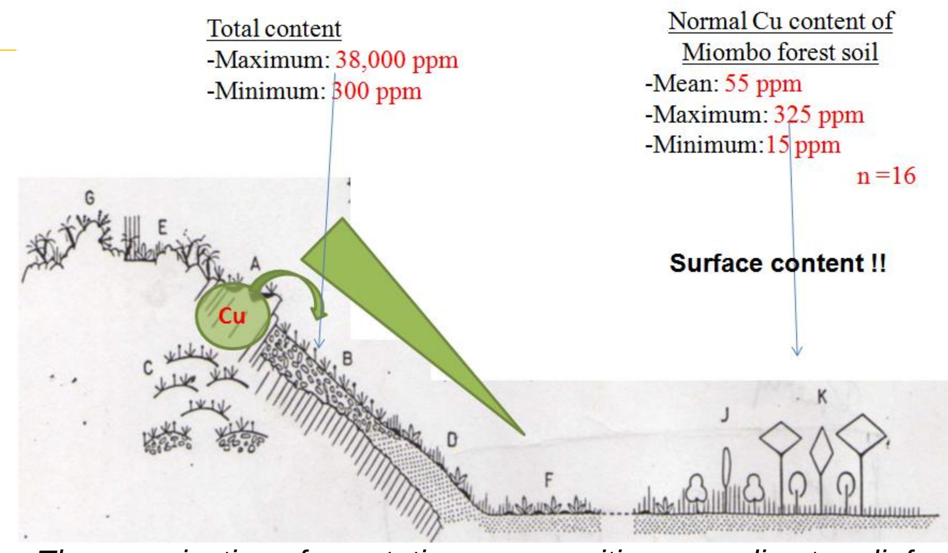






The Copper belt in Katanga, theTenke Fungurume geology and the studied hills of Fungurume complex

These contaminations have created a stressful environment for vegetation and only steppic or lawn species have been able to survive on the hills while the surroundings are occupied by the miombo forest (Duvigneaud et al., 1963).



The organisation of vegetation communities according to relief and metal gradient (modified from Duvigneaud)

OBJECTIVES

Up to now, it is not known if the contaminations are limited to the soil surface and what impacts pedogenesis and biological activity can have on Cu and Co mobility in the entire soils. This paper compares the results of soil profile characterization and lysimeter experiment in order to find evidence of mobility of Cu and Co

MATERIAL & METHODS

Soil profiles

42 soil profiles from 7 hills were described and analyzed for pH (H_2O and 1N KCl), Total organic Carbon (TOC - Walkley-Black), granulometry (Robinson pipette), Cationic Exchange Capacity (CEC - Metson). Total content in elements (Cu, Co, Al, Fe, Mn) were measured by atomic absorption after triacid-HF digestion; available elements after extraction with CH_3COONH_4+EDTA at pH 4.65 (Lakanen-Erviö) and mobile elements after extraction with 0.01N $CaCl_2$.

The organisation of vegetation communities depends upon metal gradient. To the right the levels of Cu and Co are 10 to 100 times higher than to the left.

Lysimeters and batch sorption

Small (1-L) lysimeters were built up and filled with mixtures of soil (800g) and rock (50g) samples from Fungurume outcrops. They were installed in open-air condition in the experimental garden of the University of Lubumbashi during one rainy season. The percolating solution was collected and sent in Belgium for analysis of Cu and Co content.

Sorption isotherms of Cu and Co were performed on surface and subsurface horizons of a ferralsol from miombo in order to characterize their retention potential. Details are given in Kaya *et al.* (2013)

RESULTS

We found some variability in the morphology of soils across the hills. The levels of Cu and Co contents in soils were very high compared to forest soils. Total, available and mobile contents appeared significantly correlated. Multivariate analysis indicate that pH and TOC might be important factors regarding distribution of elements in soils (Figure 1).Typical Cu profiles show homogeneity, at « low » or high level of Cu, surface contamination or relative depletion

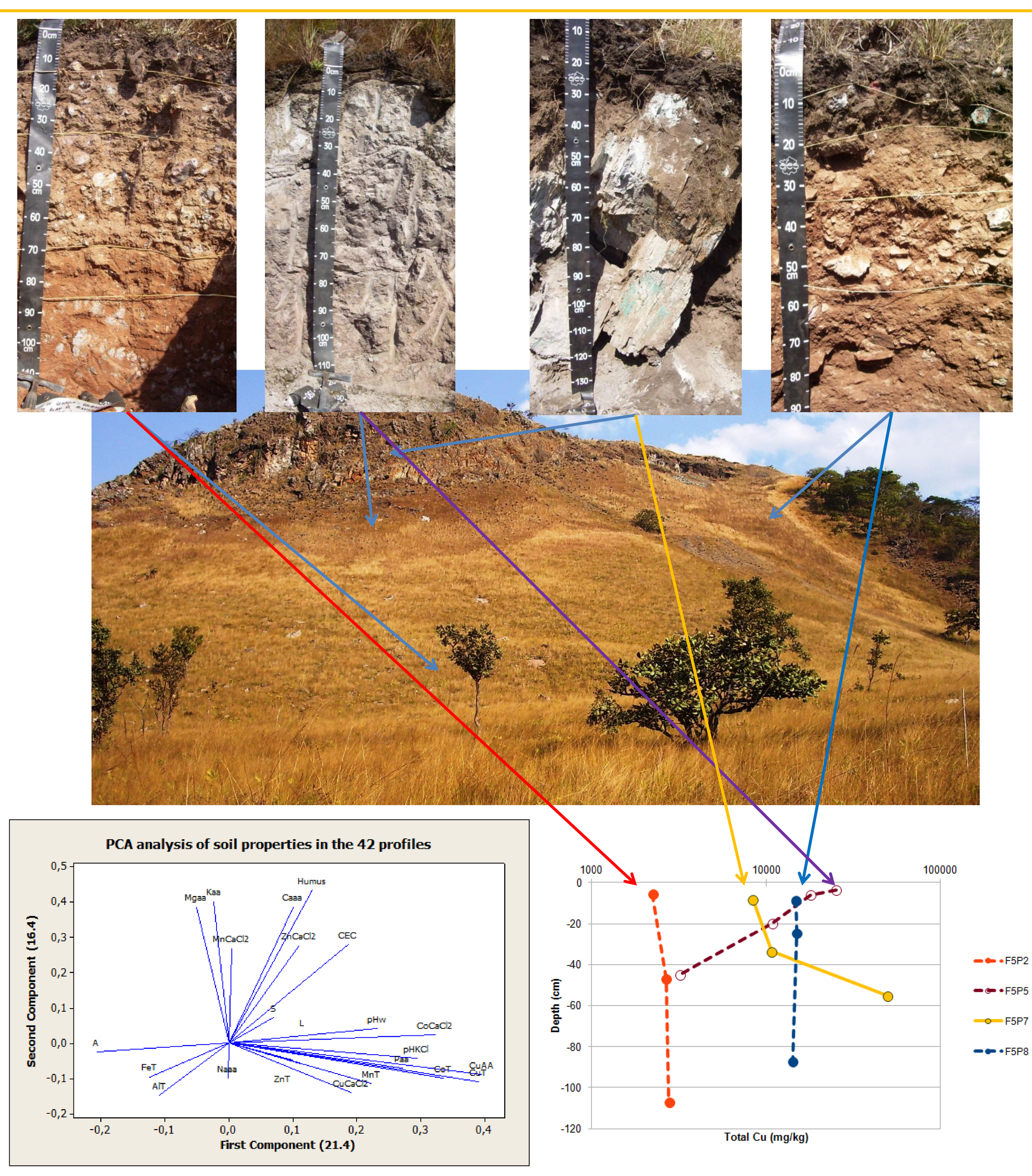


Figure 1: Examples of soil profiles observed in one copper hill. Factors of chemical composition. Typical profiles of total Cu.

The quantities of lixiviated element logically follow the content of the rock but the effect of pH appears crucial as well as the solubility of the rock (SDB >>) (Figure 2).

The adsorption experiment shows that the retention potential of the A horizon is close to 10 times higher than for B horizon.

The ratio of retention potential of Cu to Co is close to 10, too, due to specific sorption on organic matter.

Mobile and mobilizable pools within the soil were affected.

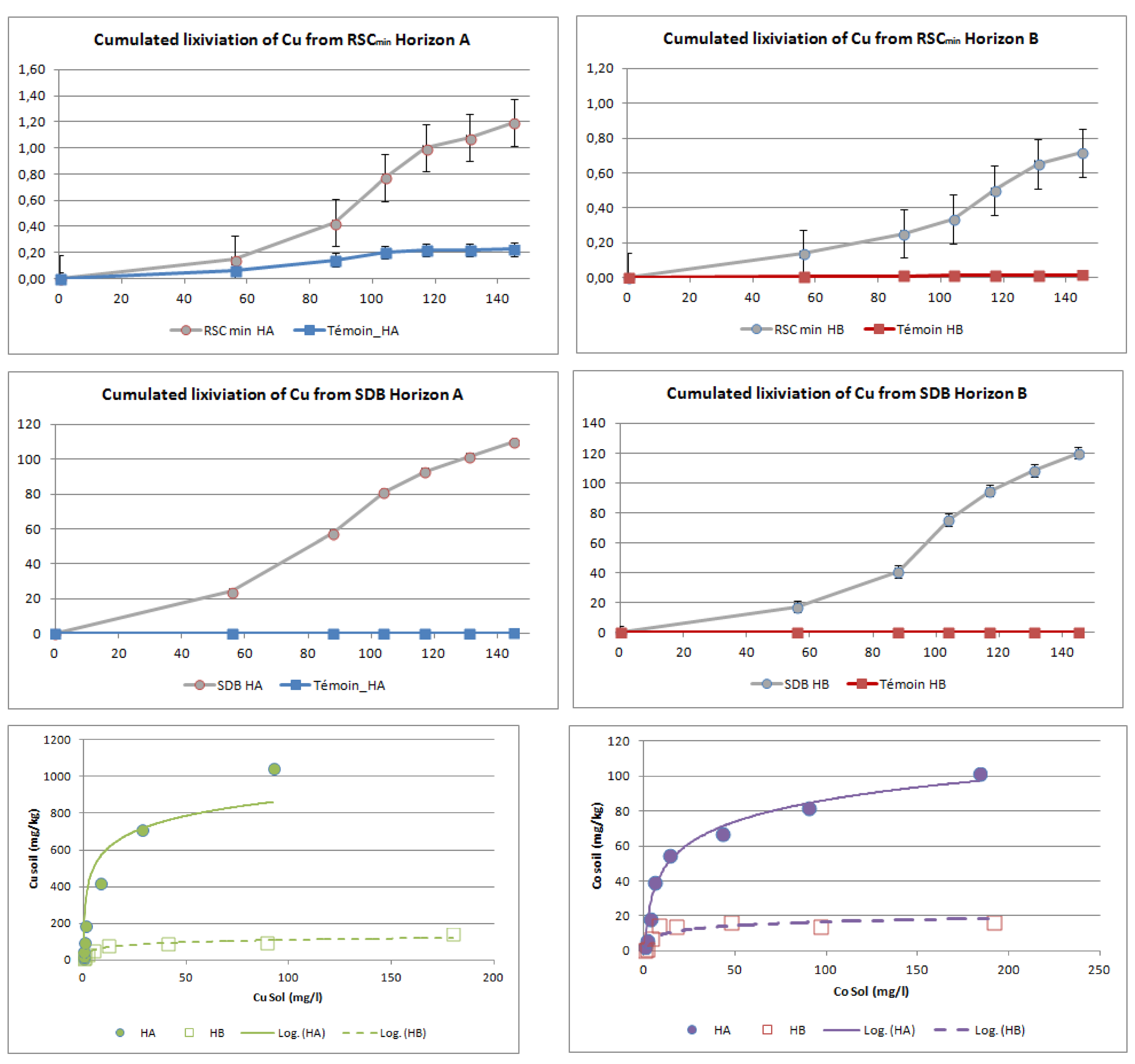


Figure 2: Cumulated lixiviation of Cu (mg) for RSCmin and SDB mixed to A and B horizons. Adsorption curves of Cu (left) and Co (right) on the two horizons.

CONCLUSION

Our results converge to evidence of transformation and migration of Cu and Co in soils of the metalliferous sites. The soluble fractions of Cu and Co are prone to migrate through soil with percolating water. pH and organic content play a crucial role in the retention of Cu and Co in soils. Moreover biological transportations (worms, ants, moles…) should also be taken into account to deepen the understanding of relationships between soil constituents and plants.

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