"A facility for the physical and chemical treatment of coltan in Kivu and application studies", a Research Project for Development (RPD) funded by the Higher Education and Research Academy of Belgium (ARES) Jan 2019 – Aug 2024

This 0.5 M€ RPD project involved the university of Namur and the university of Liège in Belgium and two partner institutions in Bukavu, capital of the South Kivu Province of the DRC: the Higher Education Pedagogical Institute (ISP) and the Catholic University of Bukavu (UCB).

A man gets out from a mine gallery dug by hand into a hillside. He carries a bag of ores on his back

The artisanal mining sector in the Democratic Republic of Congo (DRC) supplies an important fraction of strategic metals that are critically needed in modern technology. This activity sector directly or indirectly employs hundreds of thousands of people in remote locations of the Eastern provinces of the DRC.

This sector has been widely reported for its deplorable working conditions, often under the threat of armed militias. As a result, international legislation has gradually been formulated to impose due diligence on companies sourcing metal minerals from conflict zones. A significant challenge these measures address is the traceability of minerals in the DRC. In parallel, the Congolese government has introduced a new mining code in 2018. Among its many provisions is the requirement for natural resources to undergo local processing before export.

Conceived in this context, the present Research Project for Development specifically focused on coltan, a mineral rich in tantalum (Ta) and niobium (Nb) abundantly found in the North and South Kivu provinces. The target audience of the research plan included workers at the first stages of the coltan supply chain up to traders. During seven campaigns in artisanal mining zones, on-site interviews were conducted to study the relationships among the various actors of the supply chain, to understand their perceptions of the mining code developed in Kinshasa, and to assess their feeling about the numerous local and international interventions already devoted to their situation. The research highlighted perverse impacts of ostensibly beneficial measures. For example, women excluded from mining activities for obvious protective reasons were relegated to poorly paid support roles. Stark social inequalities are evident along the supply chain, with the poorest groups being those directly involved in ground operations (diggers, porters, and washers). Among these actors, diggers are the most indebted and therefore compelled to work tirelessly. Numerous comments and recommendations targeting this audience have been formulated [1].

Mineral nuggets are washed in a puddle to remove the lightest particles

Another objective of the project was to characterize the extracted minerals. Using an X-ray fluorescence spectrometer, the tantalum, niobium, and other metal contents of well-identified samples were determined. These measurements feed in a database integrating location, topography, and chemical characterization, which are crucial for coltan traceability. Chemical mapping aims helping artisanal miners to assess the true market value of their production, which is currently set by the traders based solely on the tantalum content.

Magnetic pre-treatment of samples specifically used to eliminate iron oxide particles

During the project, a new research laboratory, named Unit for Innovative Science and Technology in Materials and Environment (URSTIME), has been created at ISP/Bukavu. This unit is open to the mining sector and has conducted analyses revealing that coltan residues from physical pre-treatment contain sufficient quantities of transition metals and rare earths to be exploited further.

To comply with the obligations of the mining code, part of the project focused on purifying minerals under the conditions present in the DRC. It was demonstrated that coltan dissolution via fluoride or alkaline leaching achieves an extraction yield similar to industrial processes that rely on highly polluting hydrofluoric acid. Additionally, the research showed that tantalum and niobium ions can subsequently be extracted using organic solvents or amines, with selective ion stripping based on the solution pH. These promising findings have resulted in a PhD thesis [2] achieved by a Congolese researcher and seven publications [3-9] in international journals. A pilot plant is yet to be constructed to demonstrate the overall efficiency of the process, contingent on funding availability through URSTIME.

Finally, the project explored new application niches for tantalum and niobium that require minimal quantities of these resources, potentially strengthening the coltan sector by reducing its dependence on current market dynamics. Computational simulations conducted from Bukavu on supercomputers in Belgium revealed that perovskites such as $KNbO_3$, $NaNbO_3$, and $AgNbO_3$ have ferroic properties comparable to lead-based perovskites. Ferroic materials are central for the design of non-volatile memory devices, among other high-tech applications. Given that lead, recognized as environmentally hazardous, may require authorization under the REACH regulation as of January 2024, finding alternatives to lead-based perovskites is crucial. Alkaline niobates and tantalates could serve as these alternatives. Notably, the perovskites $KNbO_3$ and $KTaO_3$ can be synthesized from pure tantalum and niobium oxides, which were produced during the doctoral thesis using a well-established technique. This research yielded a master's thesis [10] and two publications [11-12].

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