"Coltan environmental management": Sustainable restitution/recultivation of artisanal tantalum mining wasteland in Central Africa - a pilot study

Biryabarema, M.[1], Lehmann, B.[2], Muwanga, M.[3], Nahimana, L.[4], Ntagoma, J.B.[5], Pohl, W.[6], Rukazambuga, D.[7]

[1] Kigali Institute of Education, Kigali, Rwanda; mbiryabarema@yahoo.com
[2] Technical University of Clausthal, Clausthal, Germany; bernd.lehmann@tu-clausthal.de
[3] Makerere University, Kampala, Uganda; amuwanga@sci.mak.ac.ug
[4] Université Nationale du Burundi, Bujumbura, Burundi; lnahimana@yahoo.fr
[5] Université Catholique de Bukavu, Bukavu, DC Congo; jhkush@yahoo.com
[6] Technical University Braunschweig, Braunschweig, Germany; walter13pohl@gmx.net
[7] National University of Rwanda, Butare, Rwanda; dnrukazambuga@gmail.com

Background

Tantalum is a high-tech metal used for microelectronics and rocket engines. About 25 % of the world mine production of tantalum is currently from Central Africa (Figs. 1 and 2). This share will significantly increase during the next years when prices will rise due to the shut-down of the Australian Wodgina mine end of 2008 which so far was the biggest tantalum producer.

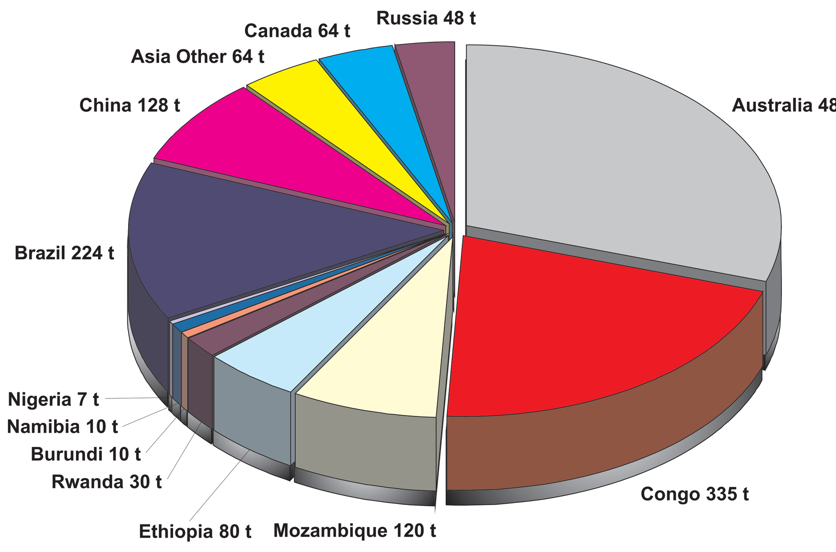

Fig.1. Wold mine production (estimated) for 2008. The total production is ~1800 tonnes of Ta metal. Note the large share of the DR Congo which is mostly from the Kivu province.

Fig 2. Tantalum ore (called "coltan" in Central Africa) consists of the Ta-rich member of the columbite mineral group, $(Mn,Fe)(Ta,Nb)_2O_6$, which occurs as a black, heavy accessory mineral in rare-metal granite pegmatites.

The mining of tantalum in Central Africa (here called "coltan") is from artisanal and small-scale mines. Hundreds of larger, and thousands of smaller unregulated artisanal mines were and are worked in recent years in northern Burundi, eastern Congo (Kivu), Rwanda and southwestern Uganda. Similar to the famous "gold rushes" of the past, both environment and people suffered heavily - and are still affected - from these disruptive activities. Extremely weak governance due to civil war and the genocide in Rwanda, and the fighting in Kivu that spilled over into neighboring Burundi and Uganda, have aggravated the situation. Meanwhile, a somewhat tenuous peace has been re-established in the region. Only the Kivu province in Congo still experiences a near-absence of government. Burundi, Rwanda and Uganda are struggling to establish environmentally acceptable mining practices while several projects of exploration and industrial mine development are established. However, scientific and practical fundamentals to guide this endeavor are scarce.

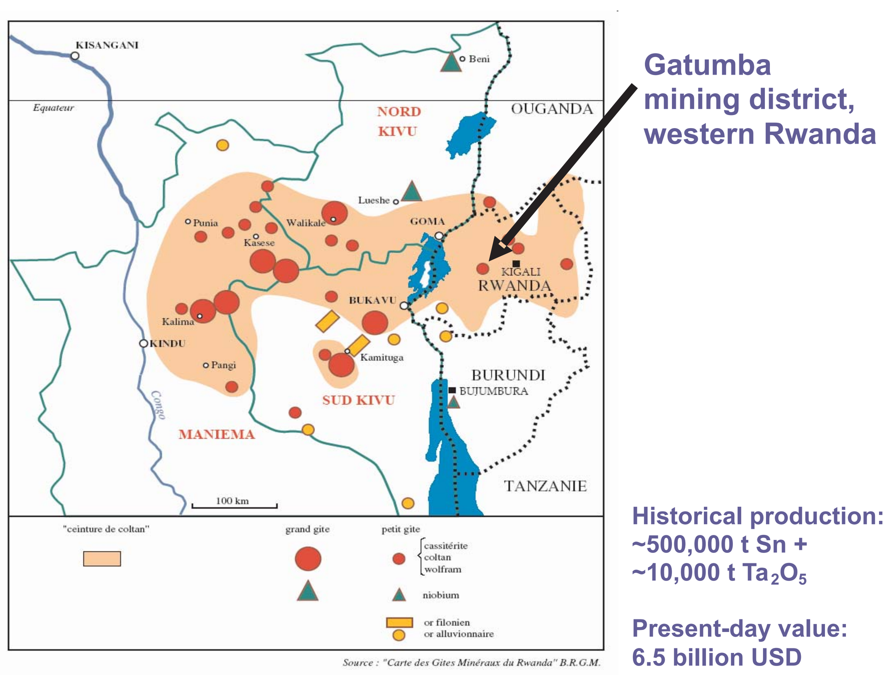

Fig. 3. The Central African tantalum-tin province, and location of the project test area of Gatumba in Rwanda. The total historic production of the Central African tantalum-tin province is about 500,000 t Sn and 10,000 t Ta_2O_5. The Gatumba district has a historic production of about 20,000 t of cassiterite and columbotantalite concentrate combined.

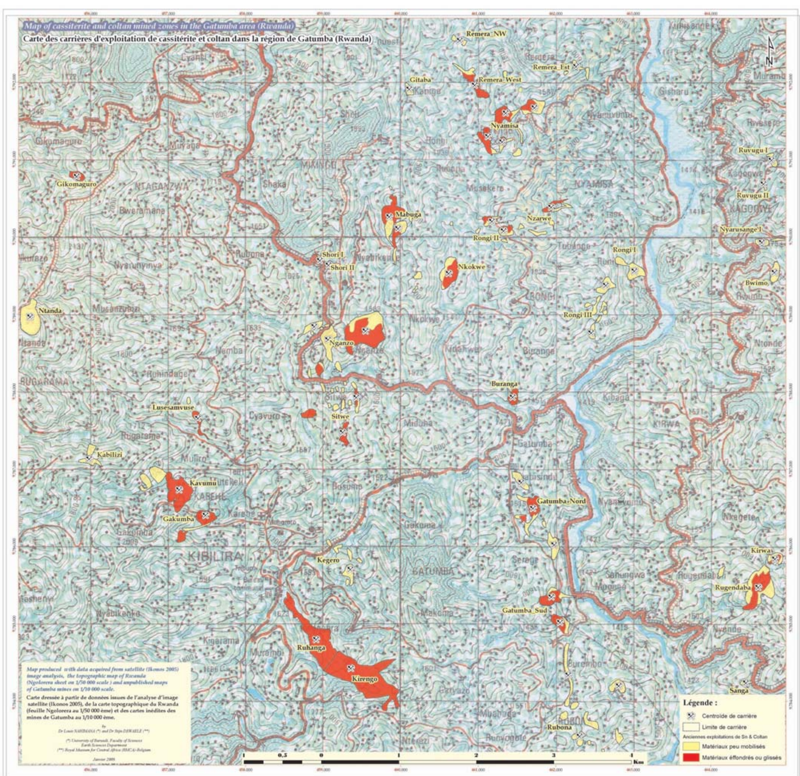

Fig. 4. The Gatumba mining district in Rwanda. Red and yellow areas show tantalum-tin mining sites which are always focussed on weathered pegmatites.

Problem statement

Earlier industrial mining of tin and tantalum during mostly colonial times had declined tens of years ago because of various reasons. These operations and the recent boom of artisanal mining left land wasted, chemically and physically hazardous, and unproductive. The natural soil cover is removed and washed away, barren rock is exposed, and natural water courses and valleys are flooded with coarse tailings. Debris and mud -flows continue to threaten the valleys. Deleterious (toxic or radioactive) elements leached from the newly exposed rock may be a danger for people, environment and for water resources. In the environs of former and operating mines, the population may suffer from degraded conditions of employment, health, and farming.

Objectives and approach

The Coltan pilot project was designed to combine earth, biological, social and economic sciences for an exploratory holistic analysis of the state of a sample area at Gatumba in Rwanda that is typical for affected lands (Figs. 3 and 4). Considering the important role that sustainable mining may have in the region for future economic development, the long-term aim of the project group is to provide science-based, but tangible "how-to-do" mitigation strategies. In addition, the larger problem of improvement of tropical soil fertility by using alkaline volcanic rocks as rock fertilizer needs testing, given the abundant occurrence of such rocks in the Lake Kivu area.

Reconnaissance study of the Gatumba mining district

The Gatumba district has about 20,000 people who mostly live from small-scale farming (only 30% of farms have >1 ha whereas >50% have <0.7 ha). Coltan (and tin ore) mining at Gatumba was active in a semi-industrial manner from 1929 to 1985. Since then, mining in the district is limited to artisanal activities, targeting local high-grade ore pockets (Figs. 5 and 6). A joint venture between the Rwandese Government and African Resources is currently exploring the area with the aim to re-establish industrial mining.

A total of about 20,000 tonnes of cassiterite and columbotantalite concentrate were produced, and more than 50 million tonnes of weathered rock were moved in the past. Because mining took place mainly by hydraulic methods ("ground sluicing"), most of this mass was washed downslope from hillsides into nearby valleys, leaving behind narrow and steep ravines (Fig. 7). Bottoms of stream valleys adjacent to mines were buried by loose sediment. Stream gradients were locally changed. A sizeable part of the ore was extracted from alluvial placers in the valleys proximal to primary deposits. In that case, the stream sediments were also shifted downstream, which disturbed the natural bedding of the valley fill and left an irregular hummocky landscape (Fig. 8).

Fig. 4. Artisanal tantalum mining at smallest scale: Lonely young boy recovering a heavy-mineral concentrate by washing with a shovel in flowing water (Nkokwe, Gatumba district, Rwanda).

Fig. 5. Artisanal tantalum mining at the Ruhanga quarry. Gatumba district, Rwanda.

The Gatumba district is in most aspects a typical Central African tantalum-tin mining district. Results from research in this area will be applicable to hundreds of similar medium-sized mines, and to thousands of smaller ones.

Fig. 7. Artisanal mining of weathered tantalum-rich pegmatite by "ground sluicing" (Kabarore area, northern Burundi). The economic portion of such deposits is only about 500 g per tonne ore. The 99.9 % of waste is washed down into the valley where it spills over large areas of fertile soil.

Fig. 8. Waste rock is washed down the valley from the quarry in the background, and re-worked for alluvial tin-tantalum (foreground). Nganzo area, Gatumba district, Rwanda.

Preliminary results and future research priorities

- **Health:** There is no indication at Gatumba that (past) mining or the abandoned quarries affect public health. Health problems in coltan mining camps in the Kivu province, DR Congo, are not due to mining per se but due to societal disruption that can only be solved by better governance.
- **Toxic elements:** Moderately elevated arsenic and uranium contents have been found in soil, stream sediments and tailings at Gatumba, but surface (stream) water is below the WHO safety levels. Precise sources of arsenic and uranium have yet to be determined. The pathways of these elements from primary anomalies, dispersion in soil and river sediments to food plants, animals and humans need investigation, as well as possible ways of mitigation.
- **Erosion:** The current mining practice of artisanal ground sluicing destroys large areas of fertile soil. Accelerated erosional processes characterize quarries, waste rock and stream valleys. Investigations must find mitigation techniques to minimise erosion and large-scale spread of mining waste downhill, in both active and abandoned mines. Optimal water management must be designed and applied, as known from small-scale mining regions in other parts of the world.
- **Soil fertility:** Agricultural research must develop best practices for rapidly improving the fertility of mine site soils, and controlling soil erosion. Are there cash crops (cassava?) that prefer soils such as mine waste? Can the nutrient-poor soils be upgraded by applying rock flour from nearby alkaline lavas? There is already a programme of liming of acid soils (Fig. 9), but rock flour of alkaline tuffs from the Cenozoic volcanism around Lake Kivu may not only have a pH effect on the soils, but can also supply nutrients such as phosphorus and potassium (Fig. 10).
- **Natural habitat:** Forestry and botany research have to develop methods to re-introduce valuable native tree and bush species to mine sites that are not suitable for cultivation. Can parts of the quarries be made islands of special ecological value?
- **People and sustainable mining:** Socio-economic studies about past and present coltan mining have to be deepened. Cost-benefit analysis will be applied to all mitigation measures. The local population must feel to be seriously consulted and involved, and to have communal and individual advantages from mining operations. This is a central condition of sustainable mining. Research must find ways how best to realize these demands.

Fig. 9. Artisanal mining of Quaternary travertine terraces for liming of acid soils near Ruhengeri, northwestern Rwanda.

Fig. 10. Quarry of recent alkaline tuff near Gisenyi, northwestern Rwanda, which is used for the cement industry. This loose and highly reactive (glassy) alkaline volcanic rock will be tested as fertilizer and liming agent for nutrient-depleted soils in the Gatumba district, about 50 km southeast.

Further reading

Biryabarema M, Rukazambuga D, Pohl W, eds (2008) Sustainable restitution/recultivation of artisanal tantalum mining wasteland in Central Africa – a pilot study. Études Rwandaises <Éditions de l'Université Nationale du Rwanda, Butare> 16: 1-174

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