

# LCM of metals supply to electronics: tracking and tracing "conflict minerals"

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**Abstract** The effectiveness of life cycle management (LCM) of metals supply to electronics is examined, with focus on understanding challenges to implementation of the US regulation on so-called "conflict minerals", which are of concern for financing warfare and human rights violations in the DRC. By analyzing a study that attempted to track (down the supply-chain) and trace (up the supply chain) cobalt, tantalum and tin, and using the concept of material stewardship, it is suggested that physical aspects of the metal supply chain, such as the mixing of sources and transformation of minerals to metals, create the biggest challenges to LCM of these "conflict minerals." Thus, the proposed US regulation, which requires documented chain-of-custody, is flawed. Industry initiatives on LCM of these metals supply to electronics address some of the physical challenges and confront management challenges, but are incomplete.

## 1 Introduction

Since 1996, human rights and environmental issues have been of significant international concern with respect to so-called "conflict minerals" in the Democratic Republic of Congo (DRC) [1, 2]. Several metals are derived from minerals mined in the DRC, and feed the global market, ultimately ending up in various products including electronics (Table 1). In the eastern DRC, sales from minerals are financing armed militia that are perpetrating high levels of civil violence, particularly gender- and sexually-based humanitarian violations [2-6].

In terms of life cycle management (LCM), the response to this crisis has been "choice influencing" [7] demonstrated by NGO groups exerting pressure on stakeholders, and "choice editing" [7] via companies endeavouring to remove unsustainable materials from their supply-chains through vendor selection. NGO groups have tried for years to reach industry actors in the supply chain, as well as

government and end-consumers using a variety of tactics [2, 4, 5, 8, 9]. For example, the makeITfair campaign has urged European youth to question the product composition and provenance of metals in popular brand-name mobile phones [8], gaming devices and portable computers, emphasising the idea that consumers share responsibility along the value-chain [10], but also encouraging these young consumers to communicate their concerns around social and environmental issues to brand electronics companies [8]. Industry actors have responded to these concerns, with electronics companies, metals industry groups and international associations, notably the Global e-Sustainability Initiative (GeSI) and the Electronic Industry Citizenship Coalition (EICC), working to coordinate committees, studies and communications to examine how electronics brand-name multinational companies can address global socio-environmental performance associated with mining and supply of metals used in electronics end-products [11].

**Table 1: Background and status on potential conflict minerals and associated metals (sources: [12-15]).**

<b>Metal (symbol)</b>	<b>Gold (Au)</b>	<b>Cobalt (Co)</b>	<b>Tin (Sn)</b>	<b>Tantalum (Ta)</b>	<b>Tungsten (W)</b>
"Conflict mineral" as defined by the USA	gold	-	cassiterite	coltan	wolframite
Use of global supply going into electronics	<9%	<25%	<35%	60%	<35%
Fraction of global mining production in DRC	<0.6%	41%	1-6%	12.5-14% (in region)	<1% (est.)

The natural occurrence of metals in the DRC is high, but the production represents a mere fraction of global production (see Table 1), less than 15%, with the exception of cobalt. The electronics sector uses substantial amounts of the global supply of these metals. Global Witness ranks cassiterite of highest concern to finance militias, followed by coltan (the name used in the DRC region for tantalum ore) and wolframite [2]. Much of the gold is not derived from a mineral ore, but occurs naturally as a metal in the DRC and neighbouring countries, which along with its inherent value, makes its trade particularly difficult to monitor [2]. Although cobalt is mined outside of the eastern DRC conflict zone, it is associated with human rights issues and conflict between artisanal miners and large mining companies [13].

In 2009, governments in Europe and North America initiated legislative efforts to control the supply chain of conflict minerals, in order to address humanitarian and

social conditions in the DRC. The USA “Conflict Minerals Act of 2009” is a far-reaching law aimed at corporate transparency and control of minerals originating from the DRC [12]. The US Securities and Exchange Commission (SEC) is regulating the Act through a Rule, first proposed in 2010, that affects companies listed on USA stock exchanges through the following elements [16]:

- "Conflict minerals" are defined as the minerals coltan, cassiterite and wolframite and the element gold, or derivatives thereof . (Note that the definition of "conflict mineral" is indiscriminate. It covers compounds that are not associated with any conflict and it covers materials that, technically, are not minerals. For example, gold alloy used in jewellery manufacture is deemed a "conflict mineral", even if it is sourced in Canada or recycled from stocks of metal that predate the DRC.)
- Exchange listed companies that use "conflict minerals" in manufacturing must report this to the SEC.

A separate public report by each regulated company would detail [16]:

- "Conflict minerals" from the DRC with an explanation of measures of due diligence and chain-of-custody;
- "Conflict minerals" not from the DRC with a third-party audited report disclosing country of origin and the facilities used in their processing.

## 2 Purpose

We examine the effectiveness of LCM of metals supply to electronics with particular focus on understanding challenges that underpin the US regulation regarding sourcing of "conflict minerals", and how industry has responded to these sourcing challenges. This is accomplished through an analysis of two fundamental sourcing concepts that were hypothesized by the authors in 2008 [13]:

- **Tracking** of materials from mine to end-use of metals is difficult, but possible.
- Metals cannot be effectively **traced**, as distinct from tracking, from end-use back to mine sources.

## 3 Methods

This research was approached largely by considering the science and the physical "life cycle" of the metals in end-products, with lesser emphasis around the "management" approaches to LCM associated with decision-making and

associated systems of information and documentation. Sustainability over the life cycle is interpreted here to focus on the issue of corporate social responsibility, particularly with respect to human rights violations in the supply chain.

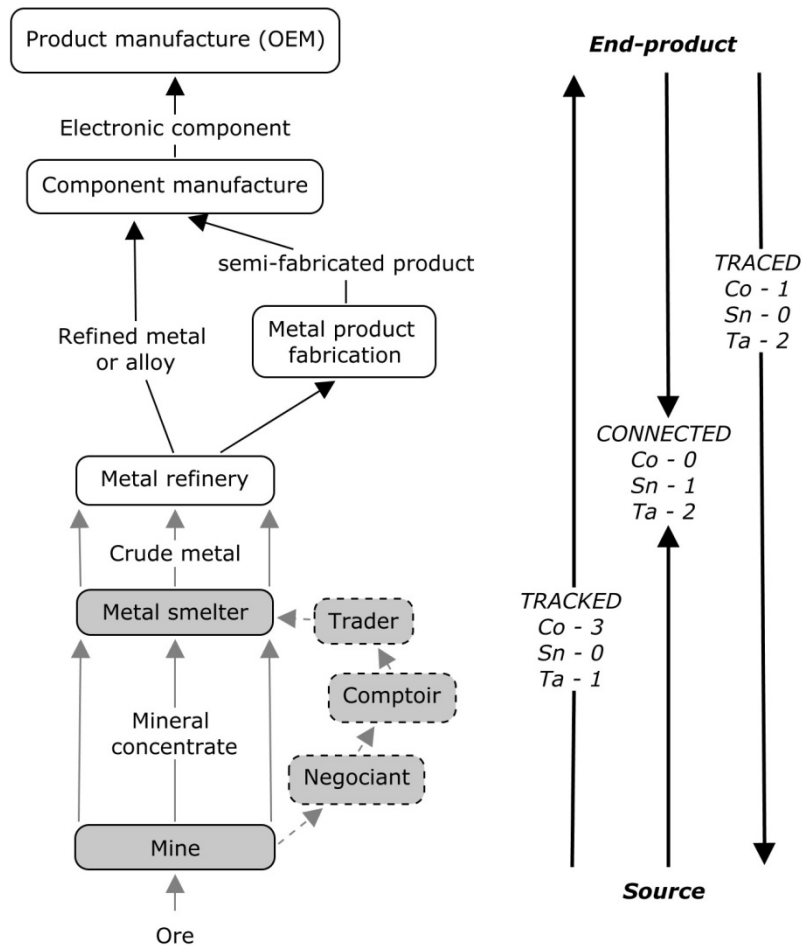
The analysis was conducted by considering the results of two industry research projects, both of which were commissioned by the EICC/GeSI Extractives Work Group, whose members comprise major original equipment manufacturer (OEM) consumer electronics companies [11]. The first project was the authors' 2008 foundation study "Social and Environmental Responsibility in the Metals Supply to the Electronics Industry" [13]. The other study was conducted in 2009-2010 by Resolve, a non-profit consultancy that focuses on collaborative approaches to sustainability challenges [17]. Resolve built upon the first research study, to test the original analysis regarding LCM of metals in the electronic supply chain. On behalf of EICC/GeSI, and using information from 12 OEM companies (Apple, Dell, HP, IBM, Intel, Microsoft, Motorola, Nokia, Philips, RIM, Sony and Sun), Resolve undertook an online survey, starting from the OEMs, and "working up the supply chain toward the mine," to trace suppliers [17]. Additional data were collected by tracking metals downstream from mines and smelters towards end-products. In six months, they had engaged 39 companies in the cobalt supply chain, 32 for tantalum supply and 50 for tin, with an overall response rate of 24% [17].

#### **4 Analysis and findings**

In order to analyze the feasibility of implementing the USA Conflict Minerals Act, which puts the onus on companies using "conflict minerals" to show documented "chain-of-custody" [12], the following analysis considers physical and management aspects of LCM by first discussing the challenges of tracking and tracing metals through the supply chain, and then analyzing the attempt by Resolve to address these challenges. The perspective of materials stewardship is introduced to help understand the basis of these challenges, particularly the physical and management aspects of tracking and how they relate to tracing.

It is important from both a scientific and management perspective to establish a clear distinction between tracking and tracing of materials along the life cycle [13]. Tracking follows a unit of material downstream, in the direction of life cycle activities (e.g., from mine to smelter to processor and eventually to product end-user); tracing works in the other direction, moving upstream, and seeks to discern

the source of a unit of material (e.g., from end-product to manufacturer to components to processor and eventually to original source) (Figure 1).



**Fig. 1: Results of 2009-2010 tracking and tracing of metals supply to electronics for cobalt (Co), tin (Sn) and tantalum (Ta), based on over 120 companies surveyed. Metals flows are black arrows; mineral flows and processes are shaded grey. Note that mineral concentrates typically enters the smelter from multiple mines; and crude metal may feed a refinery from multiple suppliers. Data are from [17].**

Resolve relied on management chains or "paper trails" to establish the identity of actors at stages of the life cycle from mine to OEM. Tracing was accomplished by surveying players in the supply chain, and collecting information about the next

supplier upstream in the chain. However, Resolve did not physically follow actual units of material from facility to facility, nor did they visit sites [17].

The survey analysis illuminated the length and complexity of supply chains from mining to electronic end-products for each of cobalt, tin and tantalum [17]. Management chains from 5 to 9 links covered a range of actors: mine, negotiant, comptoir, trader, smelter, refiner, processor, component manufacturers, and OEM (see Figure 1). Although over 120 companies were engaged (and known to trade actively together), only 3 complete chains were traced, for example where a single company controlled several parts of the supply chain or provided "line-of-sight" along the supply chain. After encountering difficulties in tracing, Resolve tracked metals from known mines in 4 cases, and an additional 3 chains were connected via a combination of tracing and tracking methods (see Figure 1). Resolve only identified mine locations in 5 cases, none of which were in conflict zones [17]. Overall, they had difficulty in establishing trails in the management chain and in verifying suppliers along the chains [17].

There are two main reasons why tracking and tracing are difficult, as discussed in 2008 by Young et al. [13]. First, there are issues related to the management of the supply chain, such as confidentiality of commercial information and complexity of the supply chain. For example, confidentiality was identified by Resolve as a limitation in their tracing and tracking study [17], while industry groups have emphasized the "extreme complexity" [18] of the electronics supply chain, emphasising the number of actors, the number of layers, and the fragmented character of many supplier locations in around the world. One industry association used a simplified diagram showing 6 layers of actors between OEMs and suppliers of refined metal plus additional layers from refiner to mine [18]. Nokia suggests 4-8 layers in the supply chain are common [19], and Apple traced their products and identified approximately 100 metal smelting facilities feeding their product supply chain (12 for tantalum, 43 for tin, 13 for tungsten, and 41 for gold) [20].

The second reason that tracking and tracing of metals is difficult is due to physical aspects of the metal in the supply chain. In the metals market, sources are "mixed together within the global pool of a metal commodity ... [and] shipped around the world in a variety of forms, including ore, mineral concentrates, crude metal, refined metal, alloys, semi-fabricated metal, manufactured products and scrap metal" [13]. Resolve also noted that minerals typically lose their traceability because of 1) mixing of ores prior to smelting; 2) use of multiple sources feeding smelting and refining; and 3) re-melting and re-processing of metals [17]. They concluded that "end-use companies...cannot assert 100% sourcing certainty about

individual metals or the product as a whole" unless significant supply chain changes are made or new assurance mechanisms are created [17].

The challenges of tracing and tracking, acknowledged by Resolve and the electronics industry, can be explained by the materials stewardship concept developed in 2001 by Young et al. [21]. This concept suggests that materials exhibiting fundamentally different physical structures demand different strategies for effective LCM [21]. These strategies for materials eco-efficiency have been elaborated and widely propagated by the International Council on Mining and Metals [22].

By considering three very different types of materials -- cellular, molecular and metallic -- the issues of tracing and tracking of metals can be illustrated. Plant materials (e.g., wood and coffee beans) are made-up of cellular structures (e.g., fibres and plant cells) that are preserved from original growth to final consumer. For example, certification mechanisms, such as Fair Trade coffee, rely on tracking the source of coffee, using chain-of-custody certification to provide assurance on material origin. This is accomplished by tracking and tagging a material batch (e.g., bag of coffee beans) in a supply chain from source (e.g., plantation) to end-use (e.g., roasted beans to consumer). Molecular-scale materials, such as diamonds, are in the form of a crystal that is maintained intact from mine source to final consumer (even as diamonds are cut and polished), making it possible to use assurance programs such as the Kimberley Process.

Metallic materials, on the other hand, are valuable because pure atomic elements can be melted, alloyed, heat-treated and reprocessed into valuable metallic compounds and materials [21]. Minerals, before they are processed and refined into metals, can be identified based on mineralogical and chemical composition as coming from a particular deposit or region, which is one of the reasons that coltan "fingerprinting" initiatives present potential for tracing sources [23]. However, concentrates from different mineral sources are typically crushed, blended and mixed before smelting and refining, and remelting, thus making the smelter and/or refinery a key point for tracking or tracing metals in the supply chain, since this is where the physical transformation from mineral to metal occurs (see Figure 1). Consequently, the provenance of each atom or unit of metal is lost at this point. The tin industry association, for example, notes that "one shipment container of mineral concentrate, typically 24 tonnes, will usually contain material from hundreds of miners" [15].

Thus, it is obvious that there are significant management issues related to the length and complexity of the metal/electronics supply chain, but it is the physical attributes of the mineral ores that undergo transformations at the smelter and the refinery that **breaks the chain** of supply for metals, making tracking not possible. In exceptional cases, particularly for supply chains and end-products that are simple, the physical chain-of-custody has been maintained for metals, thus allowing certified sourcing. Two examples are the copper roof at the Eden Project in the UK [24] and the Fairtrade and Fairmined 2010 standard for gold, which sources artisanal metal from mines in South America [25].

## 5 Implications to “conflict minerals”

It is suggested based on the authors' previous research, the Resolve study, and the logic of materials stewardship, that the proposed US regulation is significantly flawed and will require considerable revision to be effective. The USA Conflict Minerals Act is well intentioned in its aims to improve humanitarian conditions in the DRC. However, the proposed requirement to prove country of origin of material is not physically feasible. So-called "conflict minerals" as defined in the regulation, are in all likelihood blended and mixed from various regions or countries at smelters, and are changed in physical form by melting and remelting, making physical chain-of-custody impossible.

Given the indiscriminate definition of "conflict minerals" used by the SEC in their proposed regulation [16], much of the world's stock of tungsten, tantalum and tin and all gold would be labelled "conflict mineral." Industry groups have called this terminology "inherently misleading" [14] and "highly misleading" [15]. Manufacturers, upon consideration of the science and physical realities of their metals life cycles, will be forced to state that they are unable to determine the origin of their so-called "conflict minerals" even after undertaking a "reasonable country of origin inquiry" per SEC requirements [16]. Further, although supportive of the goals of eliminating conflict minerals expressed in the Act, industries are criticizing implementation of the regulation and are concerned about its costs (see list of comments available at [26]). Some groups have specifically highlighting the challenges of traceability, transparency, and certification: “establishing a minerals chain-of-custody is nearly impossible for an electronics manufacturer” [18]; and "it is virtually impossible to trace the origin of any gold to its original source" [14].



To try to address human rights concerns, and meet the US regulation, industry associations have coordinated electronics companies in collective, deliberate and incremental approaches to metals supply chain responsibility. The EICC/GeSI Extractives Work Group is developing a long-term initiative focused in the DRC region to enable responsibly sourced, certified and traceable minerals [11], and this is supported by a world-wide "conflict-free smelter" initiative [27], which recognizes the smelter/refinery as the key point in the supply of metals where the control of minerals can be managed. In collaboration, the ITRI Tin Supply Chain Initiative (iTSCi) aims to track minerals and verify mine sites of cassiterite and coltan in the DRC [15]. Thus, the industry is attempting to install mechanisms for purposes of social sustainability management, by controlling the supply of upstream metal to the pool of material that enters the economy.

However, even though it is possible that smelters can be certified as being "conflict mineral free" (by fingerprinting incoming ores if necessary), there is no physical or management basis for tracking the metal from the smelter to downstream points in the supply chain. The tin industry makes salient points, consistent with our analysis, stating that to make "a direct link between mine and metal produced after smelting and refining of mixed sources is technically impossible" [15] and noting further that tracking "exact batches of metal through their supply chain ... [is] impossible to establish" [15]. An academic research group notes that of the three international corporations that refine 80% of coltan, only two have declared that they will not use DRC source mineral concentrate, meaning that unrestricted tantalum could flow into electronic manufacturing processes in the USA, Germany and elsewhere [28].

Lastly, it should be noted that this analysis has not directly addressed the status and means of improvement of human rights conditions and sustainable development in the DRC. Even if mechanisms were to be put in place to establish mineral and metal traceability, which would require substantial changes to industrial and management practices, these still need to be supported by very significant local development, financial and governance initiatives to improve the humanitarian, economic and social circumstances of miners and others inhabitants in the region [28].

## 6 Conclusions

Our examination of metals supply to electronics exposes the need in LCM to establish a basic understanding of the science and physical life cycle of the materials supply chain before supply chain management can be effective.

Our two hypotheses, which distinguish tracking and tracing, are largely supported from empirical evidence and industry data on metals/electronics supply chains:

- Tracking of materials requires a physical chain along the life cycle. In the metals/electronics supply, this chain is broken as minerals are both mixed from multiple sources and undergo physical transformation when smelted (and refined) into metals, making metal tracking not possible.
- Tracing of materials from end-use back to mine source requires either a physical trail (which for metals is not present) supported by a documentation trail, or material that can be chemically fingerprinted to a source. Although minerals can be fingerprinted based on chemistry, metals provenance is not identifiable.

Thus, the US regulation proposed to implement the Conflict Minerals Act is flawed, as it does not recognise physical characteristics of the metals supply chain, and assumes metal tracing to be a management issue rather than a physical challenge.

Industry approaches to addressing the upstream life-cycle of the minerals-chain from mine to smelter are reasonable; however, companies will also need to overcome management challenges concerning the length and complexity of the metals-chain, including issues like commercial confidentiality.

## 7 References

- [1] Hayes K, Burge R. *Coltan Mining in the Democratic Republic of Congo: How tantalum-using industries can commit to the reconstruction of the DRC*. Fauna & Flora International, 2003.
- [2] *Faced with a Gun, What Can You Do? War and the Militarization of Mining in Eastern Congo*. Global Witness, 2009.
- [3] United Nations Security Council. *Final Report of the Group of Experts on the Democratic Republic of Congo, S/2008/773*. 2008.

- [4] Pendergrast J, Lezhnev S. *From Mine to Mobile Phone: The Conflict Minerals Supply Chain*. Enough Project, 2009.
- [5] Global Witness. <<http://www.globalwitness.org/campaigns/conflict/conflict-minerals>>, (Accessed 20.3.2011).
- [6] Smith, JH. Tantalus in the Digital Age: Coltan ore, temporal dispossession, and “movement” in the Eastern Democratic Republic of the Congo. *American Ethnologist*, Vol. 38, No. 1, 2011, 17–35.
- [7] UNEP/SETAC. *Life Cycle Management: How business uses it to decrease footprint, create opportunities and make value chains more sustainable*. United Nations Environment Programme & Society of Environmental Toxicology and Chemistry Europe, 2009.
- [8] makeITfair. <<http://makeitfair.org/>>, (Accessed 12.1.2011).
- [9] Enough Campaign. <<http://www.raisehopeforcongo.org/>>, (Accessed 12.1.2011).
- [10] Young SB, Fonseca A, Dias G. Principles for responsible metals supply to electronics. *Social Responsibility Journal*. Vol. 6, No. 1, 2010, 126-142.
- [11] <<http://www.eicc.info/extractives.htm>>, (Accessed 2011.04.22).
- [12] US Congress, *Dodd-Frank Wall Street Reform and Consumer Protection Act*, Section 1502. Pub. L. 111-203, 124 Stat. 1376. July 21, 2010.
- [13] Young SB, Dias G, Fonseca A, O’Keefe MS, *Environmental Responsibility in Metals Supply to the Electronic Industry*. GHGm report. Electronic Industry Citizenship Coalition (EICC) and the Global e-Sustainability Initiative (GeSI), 2008.
- [14] World Gold Council <<http://www.sec.gov/comments/s7-40-10/s74010-95.pdf>>, (Accessed 11.04.2011).
- [15] ITRI <<http://www.sec.gov/comments/s7-40-10/s74010-61.pdf>>, (Accessed 10.04.2011).
- [16] U.S. Securities and Exchange Commission. *17 CFR Parts 229 and 249. Release No. 34-63547, RIN 3235–AK84, Conflict Minerals*. Proposed Rule. 2010.
- [17] Resolve, *Tracing a Path Forward: A Study of the Challenges of the Supply Chain for Target Metals Used in Electronics*. Resolve, 2010.
- [18] IPC-Association Connecting Electronics Industries <<http://www.sec.gov/comments/s7-40-10/s74010-131.pdf>>, (Accessed 11.04.2011).
- [19] <<http://www.nokia.com/corporate-responsibility/supply-chain/substance-management/origin-of-raw-materials>>, (Accessed 11.04.2011).
- [20] *Apple Supplier Responsibility 2011 Progress Report*. Apple Inc. Feb. 2011.
- [21] Young SB, Brady K, Fava J, Saur K. *Eco-efficiency and Materials*. Five Winds International. International Council on Metals and the Environment, 2001. Available at <[www.icmm.com](http://www.icmm.com)>.
- [22] ICMM. *Maximizing Value: Guidance on implementing materials stewardship in the minerals and metals value chain*. International Council on Mining and Metals, 2006.
- [23] Melcher F, et al. Fingerprinting of conflict minerals: columbite-tantalite (“coltan”) ores. *SGA News*. No. 23, June 2008.

- [24] <<http://www.edenproject.com/foundation/2046.html>>, (Accessed 3.6.2008).
- [25] <<http://www.communitymining.org/index.php/en/fairtrade-and-fairmined-standard>>, (Accessed 20.2.2011).
- [26] <<http://www.sec.gov/comments/s7-40-10/s74010.shtml>>, (Accessed 11.04.2011).
- [27] EICC-GeSI Conflict-Free Smelter (CFS) Assessment Program, Frequently Asked Questions. February 2011. <<http://www.eicc.info/documents/Conflict-FreeSmelterFAQ.pdf>>, (Accessed 11.04.2011).
- [28] Nathan D, Sarkar S. Blood on your mobile? *Economic & Political Weekly*. Vol. XLV, No. 43, 2010, 22-24.