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# Social and Environmental Responsibility in Metals Supply to the Electronic Industry

Prepared for:

Electronic Industry  
Citizenship Coalition



Global e-Sustainability  
Initiative



By:

**GHGm**

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- Improved conditions for workers.
- Economic development.
- A cleaner environment for local communities.
- A better understanding of and/or reduced risks to supply chain and business continuity.

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## LIST OF ACRONYMS AND ABBREVIATIONS

Al	Aluminum
ARM	Association for Responsible Mining
ASM	Artisanal and Small-scale Mining
Au	Gold
CASM	Communities and Small-scale Mining
Co	Cobalt
CRJP	Council for Responsible Jewellery Practices
CSR	Corporate Social Responsibility
Cu	Copper
DRC	Democratic Republic of Congo
EICC	Electronic Industry Citizenship Coalition
EIR	Extractive Industries Review
EITI	Extractive Industries Transparency Initiative
EOL	End-of-Life
GeSI	Global e-Sustainability Initiative
GMI	Global Mining Initiative
GRI	Global Reporting Initiative
IAI	International Aluminium Institute
ICMM	International Council on Mining and Metals
ILO	International Labour Organization
IRMA	Initiative for Responsible Mining Assurance
LME	London Metal Exchange
LSM	Large Scale Mining
MCEP	Mining Certification Evaluation Project
MMSD	Mining, Minerals and Sustainable Development
NGO	Non Government Organization
Pd	Palladium
PGM	Platinum-Group Metals
RER	Recycling Efficiency Rate
RIR	Recycling Input Rate
SER	Social and Environmental Responsibility
Sn	Tin
WBCSD	World Business Council for Sustainable Development
WBG	World Bank Group
WEEE	Waste Electrical and Electronic Equipment
YTC	Yunnan Tin Company

## EXECUTIVE SUMMARY

This study was commissioned by the Global e-Sustainability Initiative (GeSI) and the Electronic Industry Citizenship Coalition (EICC). The overall objective was to help these organizations understand how aluminum, cobalt, copper, gold, palladium and tin are mined, recycled, purchased and where they are used in electronics products. Based on the study's findings, conclusions are drawn and recommendations are made on whether and how the members of these organizations can effectively influence social and environmental issues associated with production of metals used in electronic products.

The methods encompassed an extensive literature review, interviews and personal correspondence. A limitation to this study is that much of the information and data reviewed was not specific in its definition of "electronics." Thus, for the purposes of this report, electronics are defined broadly and cover a wide spectrum of devices and equipment, including consumer electronic products, industrial devices, as well as components embedded in other products like automobiles and household appliances.

The types and amounts of metals in electronics products vary from product to product, from brand to brand, and also change as technologies evolve. This, coupled with the lack of precise tracking of metal use across sectors, makes it challenging to provide an accurate estimate of the fraction of metal supply going into electronics. By making certain assumptions, as detailed in this report, the electronic industry was estimated to use, as a fraction of global annual metal supply, a maximum of 36% of tin, 25% of cobalt, 15% of palladium, 9% of gold, 2% of copper, and 1% of aluminum.

The metals of interest in this report are commodities traded globally. The majority of trade is executed through direct contracts between sellers and buyers, with prices established in reference to those set on commodity exchanges. A small but important fraction is traded through commodity exchanges, such as the London Metal Exchange, where future pricing allows for management of risks associated with supply and demand. The buyer-seller relationship depends on commercial conditions, wherein neither party may be prepared to divulge details of commercial transactions.

Metals are sourced from both the earth, through mining, and from the existing economy, via recycled production. Both sources may also be mixed together within the global pool of a metal commodity. Metals are 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. Each producer at each stage of production may mix different flows from different sources, depending on economics and availability. Given these patterns and the present lack of stewardship schemes, it is difficult to clearly track the physical flows and trade of metals through the market. Further investigation is needed to reveal a more quantitative understanding of metal delivered through exchanges compared to those going through the direct market, particularly in the context of responsible supply chain management. It is expected that volumes traded will vary from commodity to commodity, from year to year, and will depend on market

influences like economic prognosis, investor behavior, supply disruptions, and shifts in manufacturing demand.

The annual supply of metals come from mining, inventories (e.g., investment stockpiles), and recycled production. Some metals, such as gold, are mined in more than 75 countries, whereas others, such as tin and palladium, have a more concentrated geographic source. For some metals, such as cobalt, aluminum and copper, the loci of metal mining differ significantly from the loci of metal processing (including smelting and refining). Approximately 150 of the major companies control 83% of mined value. Companies vary from large multinational corporations with dozens of sites, to state-owned firms that focus on production of one or a few metals from a country's mineral reserves, to intermediate-sized producers with only one or two mines. Additionally, there are artisanal and small-scale miners that operate manual and informal operations at a much smaller scale.

Despite this diversity in locations, it was possible to identify fifteen countries that account for the majority of the current mine production associated with these metals, with about half of these being among the top producers of three or more of the metals addressed here. Some countries, such as the Democratic Republic of Congo (DRC) and Chile, are especially important because of their high contribution to the global supply of cobalt and copper, respectively. Australia, Canada, China, Indonesia and Russia are relevant because they have both a diverse and intense level of primary metal production. To identify precise mine locations for each of these metals is possible, but was out of the scope of this study.

The profile of mining and sources of metal is further complicated in cases where the proportion of artisanal and small scale mining (ASM) is high, as for gold (20 to 25% of global production) and tin (approximately 50%). Generally characterized by manual extraction with simple tools and equipment, and little or no management controls, ASM is poverty-driven, being a very desirable livelihood where there are few other options. It is frequently an illegal or informal activity within a national economy.

Metal recycling is an important contributor to the dynamics of material supply. Metal scrap and refined recycled metal contribute substantially to the global metal commodity supply and international trade. Even though statistical information on recycling varies for the metals addressed in this study, to contribution to metal production by recycling was found to range from about 25 to 40%.

The general constraint to greater levels of metal recycling is not a lack of demand for recycled metal; rather it is the availability of old scrap from end-of-life products, which can be economically recycled. Recovery and recycling of metals from electronic products is low compared to other end-use products, like automobiles and industrial equipment. Reasons include the very small amounts of metal present in any given electronic product; many different metals present in each product; some metals are much more valuable than others in quantities present; and electronic products are diverse and are dispersed during use. Together, these factors present challenges in the collection of metal from these products (estimated globally at less than 30%) and in the ability to recycle the metal content (where yields from electronics recycling that range from 25 to 95%). Economic, environmental and resource incentives are driving efforts to

increase the fraction of metals (particularly targeting the valuable elements gold and palladium) recycled from electronic products at end-of-life.

Discussions related to mining and the ability of the sector to contribute to sustainable development are contentious and polarized, given the non-renewable character of mineral resources and the legacy of negative social and environmental impacts caused by their extraction. Metal mining can generate wealth, create jobs, and allow for technological improvements. This positive role can contribute to sustainable development, but depends on the ability of governments, companies and other stakeholders to share mineral wealth and manage the associated social and environmental challenges that inevitably arise with metal extraction.

Depending on the location and scale of mining activities, as well as on the particular geological occurrence, social and environmental impacts can vary substantially. General environmental concerns related to metal mining and processing include natural resource depletion, land degradation, water and air pollution, and greenhouse gas emissions. Social concerns include ineffective sharing of wealth generated by mining projects, government and company corruption, human rights violations, native land rights disagreements and aboriginal people displacement, disruption of traditional communities and health and safety issues. ASM, in particular, is prone to serious concerns related to local environmental pollution, social issues like child labor, and worker health and safety. On the other hand, ASM production, especially when formalized by the state-government, provides an important opportunity for local employment and wealth creation. Similar challenges and opportunities are present in small-scale product disassembly and metal recycling, particularly in less-developed countries.

States typically own mineral resources in their territory. Their governments are expected to oversee, regulate and manage socio-environmental issues in connection with mineral developments. The last decade, however, has witnessed the emergence of non-state initiatives trying to play a positive role towards improving the sustainability of the mining industry. Stakeholders include industry associations, financiers, research organizations and civil society. Among the on-going, prominent initiatives are the industry group International Council on Mining and Metals (ICMM) and the government-focused Extractive Industry Transparency Initiative (EITI).

Progressive metal producers, including major mining companies have adopted codes of conduct, and are operating social and environmental programs that in some cases surpass compliance with local laws and regulations. Among other drivers, mining companies are motivated to improve corporate responsibility performance for core business reasons concerning license to operate, access to financing and access to mineral sources. However, even leading metal and mining companies, which engage in corporate responsibility initiatives and implement best management practices, continue to face significant social and environmental challenges, including continued criticisms and allegations of poor social and environmental conditions from community and non-government organization (NGO) groups.

A review of the literature on the management of social and environmental responsibility (SER) in supply chains revealed challenges, such as deciding which issues are important or relevant, avoiding overlaps among codes of conduct, and identifying boundaries of responsibility in the supply chains. In this context, it is important to determine whether the Electronic Industry Code

of Conduct is appropriate for dealing with issues at the extractives level, particularly since there already exist voluntary codes of conduct specific to mining and metals sector operations.

Based on this study's findings, there are opportunities for the EICC and GeSI members to influence social and environmental performance in mining and metals production. However, this will depend on a clearer understanding of specific metals used in components and electronic products. It is useful to make a distinction between tracing and tracking of materials though the supply chain. For metals, tracing from user to source is challenging, and the level effort needs to be assessed against the value of information gained. Tracking of materials, as-in chain-of-custody approaches, is emerging for metals, and presents an opportunity for understanding the supply chain and stimulating SER improvement of metals production.

A better understanding of the roles of the various stakeholders involved in mineral extraction is needed. The extensive work done on mining and sustainable development in the last ten years, including the independent Mining, Minerals and Sustainable Development (MMSD) Project and the World Bank Group initiated Extractive Industries Review (EIR) Process, has resulted in many companies in the mining industry and metal associations being more proactive in dealing with SER issues in the metal life cycle. The many initiatives that are trying to address SER in mining reflect the beginning of this response, but it may take time before there is widespread evidence of more sustainable development of mining and metals production. It is noteworthy that leading mining companies have advanced with respect to social and especially environmental performance over the last decade. Additionally, ICMM and member firms, and metal commodity associations, have expressed desire for "shared responsibility" of metals management across the material life cycle.

Lastly, it should be emphasized, that two general sustainability goals are to reduce the need for mineral mining in general, and to increase efficiency of resource and materials that are extracted. Towards these ends, it is clearly desirable both to enhance recovery of metals from end-of-life electronics products and to improve yields of metal recycled from electronic product scrap. These areas are already part of the scope of activity of electronic sector companies.

The following recommendations are made to the GeSI and EICC:

- The electronic industry should engage with appropriate existing SER initiatives and stakeholders, as identified in this study, possibly in partnership with other end-use sectors, to both strengthen efforts and reduce proliferation of overlapping initiatives.
- The electronic industry should continue to emphasize activities in management of end-of-life electronic products, including efforts to enhance materials efficiency after product use, and attention to recycling of metals.
- Individual electronic companies need to further characterize specific metal content and use in electronic products. This supports the tracking of metals used in electronics, helps in tracing sources of materials, and facilitates recycling.

## 1 INTRODUCTION

The Electronic Industry Citizenship Coalition (EICC) and Global e-Sustainability Initiative (GeSI) commissioned GreenhouseGasMeasurement.com (GHGm) to research the social and environmental responsibility issues related to the mining, extraction, recycling, and use of metals in electronics. The overall objective of this study was to understand how aluminum, cobalt, copper, gold, palladium and tin are mined, recycled, purchased and used within the electronic industry. Based on these findings, this study also draws conclusions and makes recommendations on whether and how the members of these organizations can effectively influence social and environmental issues associated with mining of metals used in electronic products. The metals selected by GeSI and EICC for this study were Aluminum (chemical symbol: Al), Cobalt (Co), Copper (Cu), Gold (Au), Palladium (Pd) and Tin (Sn). The metals chosen for this study are not a comprehensive list of metals in electronics; however they do represent a cross-section of metals, and associated issues, relevant to the discussion of social and environmental responsibility.

Given the timeframe and resources, the work is based on a desktop analysis including literature reviews, personal correspondence and telephone interviews. Additional references include recent industry publications, public news feeds and general internet sources. As much as possible, and understanding that there are biases in various sources depending on diverse stakeholder perspectives on metal issues, GHGm has incorporated a wide range of sources, from NGO reports and interviews, to metal mining company reports and academic literature. The credibility and usefulness of these references were weighed in their application and in the final evaluation of the information. Overall analysis was supported by professional judgment and experience from the GHGm team.

For the purposes of this report, electronics are defined broadly to include a wide spectrum of devices and equipment. Many of the information sources used here do not define electronics clearly, or possibly group together any combination of electronics, including consumer electronics and even electrical components. Consequently, the information on the purchase, use and recycling of various metals used in electronics did not distinguish between types of electronic devices, such that metal use in electronics could include its presence in a range of products from household appliances, to devices in automobiles, to medical products, to televisions, radios, and computers. The members of EICC and GeSI represent only part of the end-use industries that use metals in electronics products.

The results of this study are intended to educate the GeSI and EICC member companies and help raise the overall awareness of stakeholders (including customers, shareholders, governments, NGOs, etc.) on how the electronic industry uses metals and whether it can influence relevant mining practices. First, to provide some context to this work, a review of the current knowledge and understanding of Corporate Social Responsibility, sometimes referred to as Social and Environmental Responsibility, and supply chain management is provided. This is followed by a discussion on the value of metals, with particular attention to their use in electronics. In order to understand the movement and production of metals, a brief review of metal trade is provided.

Global metal supply arises both from mining and recycled production of metals. Mining sources are considered through an analysis of key producing regions and companies for the metals of interest. Recycled production of metal is discussed with respect to how much of the global metal supply is recycled material, how much recycled metal the electronic industry contributes to the global metal supply, and the on-going challenges for this sector. The social and environmental concerns with respect to mining are then summarized, followed by a discussion of some of the major responses and initiatives that have been undertaken to address social and environmental responsibility in mining and other sectors. Particular attention will be given to the dynamics of social and environmental issues, in order to achieve a clearer understanding of the potential opportunities that the electronic industry might have to influence the conditions under which these metals are mined. Finally, based on the findings of the research, an analysis of whether and how the EICC and GeSI, and the electronic industry in general, might influence mining practices is provided.

## 2 CORPORATE SOCIAL RESPONSIBILITY IN SUPPLY CHAINS

The last decades have witnessed the rise of Corporate Social Responsibility (CSR), with corporations increasingly responding to the concerns of its main stakeholders, as opposed to focusing exclusively on the imperatives of regulations and stockholders.<sup>1</sup> This has been translated into the adoption and implementation of voluntary international standards, codes of conduct, sustainability reporting, stakeholder dialogues, eco-efficiency programs, etc. However, the emergence of CSR does not imply that prior to this phenomenon companies were not socially responsible, since businesses may have had inherent positive social roles in society.<sup>2</sup> What CSR represents is an extension beyond companies' statutory and legal obligations in areas such as human rights, employee rights, environmental protection, community involvement, and supplier relations. The following discussion serves to highlight the opportunities and challenges which must be understood in order to determine the appropriateness of, and extent to which, CSR practices by the electronic industry can address social and environmental issues in the metal supply chain to the sector.

In spite of criticism and debate over CSR drivers, and its effectiveness and implications, it has become a mainstream practice. In expanding their responsibilities, companies are facing new actors, issues and contexts for which past knowledge and tools are insufficient. The challenges involved in the responsible management of supply chains, one of the facets of CSR, provide a good example.

Like CSR itself, the responsible management of supply chains is found under a variety of names in the literature, which reflects the evolving nature of the field. Among the preferred terms are responsible purchasing, ethical supply sourcing, purchasing social responsibility, fair trade, sustainable supply chain management, green purchasing and environmental purchasing. A study undertaken by TerraChoice in 2006 showed that over 60% of the surveyed organizations in Canada and in the United States had a Green Purchasing Policy,<sup>3</sup> thus corroborating the claim that private, public and governmental organizations,<sup>4</sup> are increasingly concerned about environmental issues related to their suppliers. As in the case of CSR, this trend stems not only from increased external pressure from investors, customers, NGOs and other stakeholders,<sup>5</sup> but also from internal management leadership and organizational culture.<sup>6,7</sup> Recent examples of external pressure are campaigns by the NGO groups WWF-UK<sup>8</sup> and makeITfair,<sup>9</sup> independent initiatives that target Social and Environmental Responsibility (SER) issues within luxury goods corporations and electronic industries, respectively.

In terms of responsible management of supply chains, specific sectors such as the textile and toy sectors in China, and now the pharmaceutical industry, have been consolidating and harmonizing ethical codes related to their supply chains. Within the electronic industry, there were several early efforts towards responsible purchasing by large electronics companies,<sup>10,11,12</sup> but in 2004, several brands in the sector worked together to develop a standard code of conduct. Others in the electronic industry decided to adopt and implement, along with several of their suppliers, the Electronic Industry Code of Conduct. According to Krueger, one of the potential advantages of

industry-wide systems is “that they might be more effective than company-specific efforts of the past. Not only might they reduce the costs and complexity of compliance for their supply chain partners, but also they might help to foster a ‘critical mass’ of industry support.”<sup>13</sup>

Supply chain programs vary in structure and goals. They may include considerations such as sourcing of raw materials, tracking and tracing product from supplier to buyers, and reporting and improvement on social and environmental conditions within operations at one or more stages along the supply chain. GeSI and EICC are concerned with SER in the manufacturing of electronic components, while others consider the handling and quality of products as they pass through the economy, or try to track and assure original sources of raw materials (like organic food and sustainably harvested wood) through to final use.

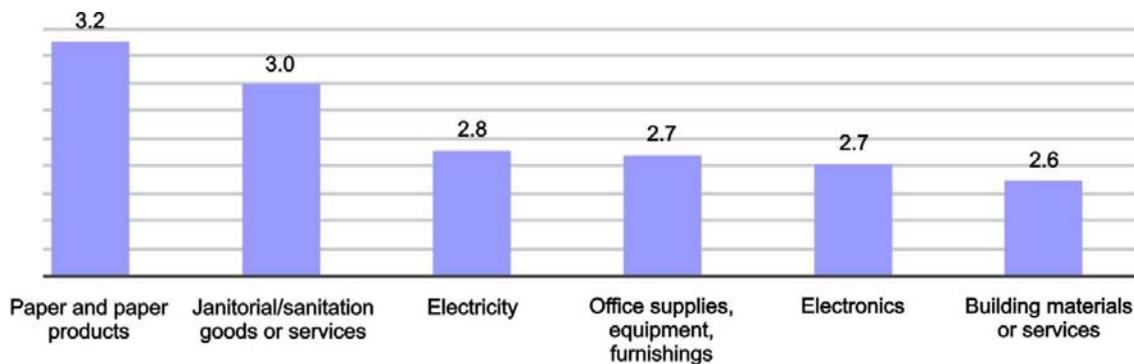
Initiatives that consider the origins of materials and certification of source can be buyer-driven, seller-driven, or third party-driven, in which the intention is to pull both buyers and sellers in a particular direction (e.g. NGOs).<sup>14</sup> Buyers are key to initiatives, as they exert economic influence on the supply system; however, the buyer is not in the best position to define appropriate actions from an SER perspective. Buyer-driven programs can lack depth on relevant issues, often do not understand the impacts of proposed initiatives within the structure of the industry supply chain, and may not be effectively designed for purposes of affecting change.<sup>15</sup> Seller-driven programs are less common, but can find targeted niches, where boutique suppliers have clear and strong motivations, such as craft producers of local goods or organic food who wish to differentiate their products to consumers. Third-party programs are increasingly common, and tend to be most effective.<sup>16</sup> These work best when an informed third party, who understands the market, is able to connect motivated suppliers with sophisticated buyers. An example of a sophisticated buyer is a large institution that uses its purchasing power and develops careful purchasing policies to exert its influence up the supply chain.<sup>17</sup>

In all of these initiatives, there are two key elements. First, there needs to be an understanding of the industry and the players involved across the supply chain. This allows the program structure to be designed and developed so that it is both efficient and relevant in its efforts to affect change and develop assurance in supply chain. A common structural barrier is the presence of “brokers” or middle-men in the chain, who often are not easily motivated to change existing practices, or to bear the burden of chain-of-custody documentation. Second, there has to be content, in terms of clear identification of the issues that are being addressed by the program. The standards or rules that an initiative proposes must be appropriate to the issues, be actionable and coherent, and show an understanding of the supply chain. All of these aspects are important in order to effect change and provide assurance along the chain.<sup>18</sup> It is important to note that with respect to the Electronic Industry Code of Conduct, although it is actionable and coherent for the manufacturing supply chain, the standards may not be directly applicable to SER of raw material processes in the supply chain of metals, including the extraction of metals; however, further research is needed to determine whether the code could be applied and whether it would be effective for this purpose.

It is important to emphasize that the incorporation of SER in supply chains, although a rapidly evolving field, is still in its infancy and lacks consistent tools, methodologies and data upon which to base corporate strategies and policies that would encompass specific company

situations. With respect to environmental purchasing, Murphy and Poist reviewed the literature and concluded that “while previous studies have made important contributions..., much remains to be learned concerning the management of environmental issues in logistics”.<sup>19</sup> Similar conclusions were found by Maloni and Brown, who in turn stressed that “the supply chain CSR literature has not been adapted to consider issues unique to most other specific industries”, without which it “will be difficult for practitioners and researchers to effectively anticipate and develop supply chain CSR strategy and operational practices”.<sup>20</sup>

Not surprisingly, there have been increasing criticisms related to the effectiveness of on-going efforts. There are concerns related to whether these initiatives are concentrating on the most pertinent social and environmental problems of the supply chain. Studies have found that human rights are usually privileged in responsible supply chain management programs, to the exclusion or detriment of other social and environmental matters.<sup>21</sup> An example is tin production in Indonesia where the main problem is environmental damage; however, the social issues, which are relatively minor, get a disproportionate level of attention.<sup>22</sup> Another example is a 2006 study on the purchasing practices of North American companies, which found that paper products were receiving the greatest consideration in organizations (Figure 1), raising questions about what and why buyers saw as the most critical environmental issues in supply chains.



**Figure 1 Frequency of green considerations when buying specific goods and services (rating scale: 1 never - 4 always).**<sup>23</sup>

One of the most challenging issues to researchers and practitioners in this field is to determine “how far do the boundaries of CSR extend?”<sup>24,25</sup> In the case of codes of conduct, boundary considerations mean understanding when and how the code should be applied to first, second or higher tier suppliers. In light of the intricate ethical, technical, commercial and legal aspects related to this boundary issue, current literature does not offer any straightforward answers for dealing with it. In this context, industry responses have been on an individual or ad hoc basis.

Previous studies have identified important barriers to achieving better working and environmental conditions in global supply chains. The World Bank pointed out three key barriers: (1) a plethora of buying codes generating confusion and inefficiency; (2) excessive top-down CSR strategies, and (3) suppliers’ insufficient understanding of the business benefits associated with making the required investment.<sup>26</sup>

To overcome such barriers and challenges, a number of scholars and institutions are proposing procedures, principles, and frameworks that go beyond earlier strategies based on supplier monitoring. Boyd et al proposed a sequence of transparent steps, based on the procedural justice literature, to be observed by managers of CSR issues in the supply chain. At the core of the procedure is the creation of a common code of conduct, as in the EICC code, and the mapping of materials flow and CSR issues throughout the supply chain. To complement these steps, companies need to assure internal consistency with the code and train and communicate it to relevant suppliers.<sup>27</sup> Some electronics companies have implemented such measures in their supply chain.

The World Bank, in contrast, does not propose a formal procedure, but a set of “options” to be observed by organizations. These include: harmonization among codes and CSR frameworks for suppliers; capacity building and worker empowerment; economic incentives for CSR; and support for further research on CSR issues in supply chains.<sup>28</sup> In addition to these “options”, the World Bank emphasizes the importance of public sector engagement. More recently, Business for Social Responsibility, which had co-authored the World Bank’s study, proposed a four-pillar framework of: (1) internal alignment; (2) supplier’s ownership of production and sustainability processes; (3) worker empowerment; and (4) public policy framework.<sup>29</sup>

While these procedures and frameworks offer important tools to enhance SER in global supply chains, there is no guarantee that they are effective in most circumstances. In addition to being generic and novel, and not sufficiently tested in practice, they seem to emphasize social problems with first-tier suppliers. More importantly, they do not necessarily help buyers bound the limits of their responsibility past the first-tier suppliers in the supply chain.

It is against this backdrop of evolving methodological and theoretical knowledge on the incorporation of SER issues in supply chain management, that this study is undertaken. Based on the recommendations from the World Bank and Boyd et al to deepen understanding of the supply chain through research, and the mapping of material flows and CSR issues, the remainder of the report addresses how metals used by the electronic industry are traded, mined and recycled. The aim is to help understand the role that EICC and GeSI members play not only in purchasing, but also in recycling of metals, and ultimately whether they can, and how they might influence SER practices at the mining level.

### 3 THE VALUE OF METALS

The diverse properties of metals have made them invaluable to the development of ancient and modern civilizations. Important characteristics, inherent to metals, include strength, formability, conductivity, durability and aesthetic appeal. Dozens of different metals are utilized in all categories of industrial and consumer goods and services, often without the end-user being aware of their presence. Metals are mostly used as “alloy” mixtures, engineered blends of two or more elements, which are available in thousands of different compositions and physical forms (sheets, blocks, powders, films, etc). Metals find diverse application in components and products in manufacturing, transportation, electrical, building and consumer sectors.

There are various categories of metals. Ferrous metals refer to any alloy that is primarily made of iron. Steel is the most common group of iron alloys. Base metals refer to a group of basic industrial metals including copper, nickel, cobalt, lead, nickel, tin and zinc. Typically, aluminum and other light metals, like magnesium, are considered separately, as both their geologic occurrence and properties are distinct. Precious metals include gold, silver and the platinum group metals (which include palladium). Other metal groups, such as the rare-earth metals and bismuth are considered “minor metals,” although they may be important in small quantities as special technical materials.

Critical to the understanding of metals, their sources, and their use and disposal is recognizing that metals are elements. The laws of physics state that elements are permanent: they cannot be created or destroyed (other than by nuclear reaction). The elemental character of metal makes it distinct from other industrial materials. For example, plastics are molecular in structure and therefore can be assembled, modified, degraded and destroyed (e.g. through chemical reactions like combustion), while wood and paper materials are fibrous, as well as molecular in their material structure, providing them with unique aspects to their properties and application.

The life-cycle of metals, in the context of environmental and resource discussions, is characterized by the following:

- The stock of metal is fixed and limited on Earth; rather it is its accessibility and utility that is critical.
- Metals are not “produced” or “consumed” in the conventional sense; rather they are extracted from nature for human use, processed and managed into the economy. Some metal is lost from use, through intentional or unintentional disposal, dispersion or chemical reactions like rust.
- Metals usually occur in nature as oxide or sulfide minerals. In areas of adequate concentration these are referred to as ore. Gold is an exception, as it can be present in low concentrations in metal form.
- Mining exposes and extracts ore. Soil, vegetation and rock overlying the ore need to be removed or penetrated before ore can be extracted.

- Mining is followed by mineral processing, which can include any number of processes of separation and concentration, where metal-containing minerals are separated from less valuable fractions. Often water and washing are used, leading to volumes of tailings,<sup>30</sup> which are disposed of nearby. The result of mineral processing is often termed concentrate.
- Metal is removed from rich minerals, like concentrates, through smelting (pyro-chemical) or hydro-chemical processes to form crude metal (e.g. 98% pure element.)
- Refining is the next step, which results in pure (e.g. 99.9%+) metallic form, which may be cast from molten form into example as ingot, slab or bars.
- Metals can be used in pure form (e.g. copper wire) or are more often mixed together into alloys that are further heated, formed and ultimately processed into useful semi-fabricated forms like sheet, wire or powder.
- Metals are prone to substitution. If the price of a commodity increases, other metals can be substituted. For example, in magnet applications, as the price of cobalt increased due to supply limits during a war in Congo, rare earth metals were used.
- Fabrication then occurs, where general forms are cut or bent or re-melted into specific pieces or components, from which manufactured products are assembled.
- At product end-of-life, or at any one of the above processing stages, scrap may result. Because inherent properties of metals do not change, scrap can be re-melted, re-refined or re-smelted—depending on economics and on how pure it is.
- The presence of different elements in alloys can decrease a metal's recyclability. For example, alloys containing beryllium may pose challenges at some facilities since this substance can be hazardous to human health.

### **3.1 Metals in Electronics**

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Because of their strength, conductive, magnetic and other properties metals play a critically important role in the functions and effectiveness of electronics and electronic components.

It is important to note that in this study the term “electronics” is defined broadly to include all kinds of equipment and products from industrial to automotive to consumer electronics. The information gathered on the electronic industry use of metals is often broad, and definitions vary by metal sector and information source. The quantitative estimates of metal use in electronic products in this report should be considered a maximum value. Available statistics do not distinguish between types of electronics devices, such that metal use in electronics could include everything from small and large household appliances, to devices in automobiles, to televisions and computers.

The presence and amounts of different metals in electronics products vary from product to product, from brand to brand, and change as technologies evolve, making it challenging to provide a generalized picture of the amount of any metal for a particular electronic product; however, as a starting point, Table 1 provides an overview of various components and hardware

used in electronics, and indicates what metals are found in them. Note that this list does not include other materials that are used to make electronics products such as plastics, rubbers, ceramics, glass, etc.

**Table 1 Metals found in various components and hardware used in electronics.<sup>31</sup>**

Hardware	Predominant Metals
Solders	Tin
Wires, cables	Copper, beryllium
Printed circuit boards	Copper, tin, gold
Component lead frames or contacts; including connectors, brass parts (such as bushings and bearings)	Copper, gold, palladium
Capacitors	Aluminum
Springs	Copper
Heatsinks	Copper, aluminum
Heatpipes	Copper
Battery electrode substrate	Copper, aluminum
Batteries	Cobalt, nickel, manganese
Hard disk drive media coatings	Cobalt
Hard disk drive	Nickel, lanthanide, neodymium
Housings, frames, lids, covers, screws, hinges	Aluminum, steel, magnesium
LCD screens	Indium, yttrium and europium

Data provided by GeSI and EICC companies, for example, suggest that a current generic personal computer assembly (including printed wire board, memory and other electronic components like chips and capacitors)<sup>32</sup> are more than fifty materials, of which twenty or more are metals. For the metals of focus in this study, the generic personal computer assembly make-up is approximately 12% copper, 8% tin, 1% aluminum, 0.0084% gold, 0.0007% palladium, with undetected amounts of cobalt. This characterization is specific to the generic personal computer assembly type, and other categories of electronics may be quite different.

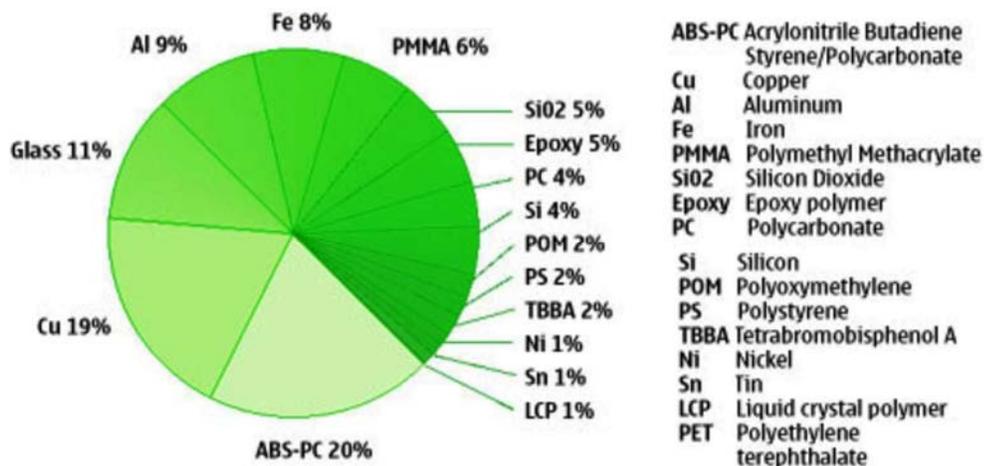
At end-of-life stage of the supply chain, a major precious metals refiner and recycler, Umicore, considered products such as mobile telephones, audio players, electronic calculators, televisions and computers in a 2007 analysis of the electronics waste stream. The Umicore data indicated variation of metal by product type. For example, aluminum content varied from 1% in cell phones to 10% in TV boards, whereas tin comprised less than 1% of most electronic products. Variation would also be expected across makes and models, and as product designs change and evolve. Table 2 shows some of the Umicore results in terms of composition and economic value of materials from three types of electronic devices entering the recycling streams of their

precious metals refinery in Belgium. Aluminum represents less than 5% of the materials in the devices, while gold and palladium represent less than 1% of the materials in the devices.

**Table 2 Scrap value analysis of electronic devices.**<sup>33</sup>

Metals and materials	Mobile telephone		Portable audio		Personal computer (board only)	
	Mass (%)	Economic Value (%)	Mass (%)	Economic Value (%)	Mass (%)	Economic Value (%)
<b>Plastics</b>	57		47		23	
<b>Glass</b>	2		0		18	
<b>Cu</b>	13	7	21	77	20	14
<b>Fe</b>	5	0	23	3	7	0
<b>Al</b>	1	0	1	1	5	1
<b>Ni</b>	0.1		0.03		1	
<b>Pb</b>	0.3		0.14		1.5	
<b>Sn</b>	0.5		0.1		2.9	
<b>Ag</b>	0.134	5	0.0150	4	0.1	5
<b>Au</b>	0.035	67	0.0010	13	0.025	65
<b>Pd</b>	0.021	21	0.0004	3	0.011	15

Figure 2 shows product-specific breakdown of materials in a mobile telephone (including battery but excluding power supply and packaging). The major metals in cell phones were copper at 19%, followed by aluminum at 9% and iron at 8%. Other metals constitute 1% of the materials in the mobile telephone.



**Figure 2 Material composition of a mobile phone circa 2006.**<sup>34</sup>

## 3.2 *Metal Use in the Electronic Industry*

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The overall use of metals by the electronic industry varies from metal to metal. The following highlights the main uses of the metals of interest for this research, and the amount of each metal used across the electronic industry.

### 3.2.1 *Aluminum (Al)*

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Aluminum<sup>35</sup> is very abundant in the earth's crust, but it has been technically difficult to extract as usable metal. Its rapid expansion of use in the twentieth century parallels the rise of modern industry and has been critical in the emergence of measures of societal progress, such as aircraft and space travel, widespread electrification, and convenience packaging. The economic mining of high-quality bauxite ore occurs where there are large surface deposits in mostly equatorial locations around the globe, often in developing countries. Greater than 60% of bauxite ore is produced by foreign companies operating in country.<sup>36</sup>

The annual production (in weight) of aluminum surpasses that of all other engineering and precious metals combined, with the exception of steel. It is highly recyclable, particularly within the closed material loop of the ubiquitous aluminum beverage can.

Aluminum is widely used in electronics as a structural material for frames, as casing for rigidity and protection of internal components, in heat exchangers to take advantage of the metal's excellent conductive properties, and in specialized parts for specific electrical and electronic purposes. On a global basis, however, it is estimated that less than 1% of aluminum goes into electronic components and products.<sup>37</sup> Electronics products, by design, tend to be low in mass and volume. The tracking of end-uses of aluminum by the International Aluminum Institute shows the vast majority of aluminum goes into much larger products such as vehicles, building materials, machinery and industrial components, and packaging.<sup>38</sup>

### 3.2.2 *Cobalt (Co)*

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Cobalt is widespread in nature but occurs in low concentrations in ores with other metals, such as nickel and copper. Because of its unique combination of properties – including strength, corrosion resistance, high melting point, magnetism – the USA government considers cobalt to be a strategic and critical metal, in that if it is not available during a national emergency, it could seriously affect the economic, industrial, and defensive capabilities.<sup>39</sup>

The largest consumption of cobalt is in specialty alloys, including so-called “super-alloys” used to make precision parts for gas turbine aircraft engines, and corrosion- and wear-resistant alloys (Figure 3). Cobalt is also used to make other products such as: magnets; high-speed steels; cemented carbides and diamond tools; catalysts for the petroleum and chemical industries; drying agents for paints, varnishes, and inks; ground coats for porcelain enamels; pigments (“cobalt blue”); battery electrodes; steel-belted radial tires; and magnetic recording media.<sup>40,41</sup>

Cobalt is used by the electronic industry for various components, such as in integrated circuits (for contacts), semi-conductors, magnetic recording media, and thin metallic films.<sup>42</sup> However,

one of the largest single end-uses of cobalt is in rechargeable batteries, where it is an essential element in most nickel-cadmium, nickel-metal hydride and lithium-ion battery cells. The use of rechargeable batteries grew dramatically between 1995 and 2000, with cobalt sales increasing from 700 to 5,000 tonnes per year during this period.<sup>43</sup> Cobalt use in rechargeable batteries accounted for nearly 25% of the world cobalt demand in 2005<sup>44</sup> and 22% of the demand in 2006 (Figure 3). Only catalysts show a comparable growth rate for cobalt use. Part of the increased demand for cobalt in rechargeable batteries can be attributed to the increase in demand for mobile telephones, particularly in developing countries.<sup>45</sup> A breakdown of electronics demand for lithium ion batteries, the largest and most important segment of the rechargeable battery market, estimates the 2008 market use will be 45% in mobile phones, 30% in notebook personal computers and 12% in audio/video applications.<sup>46</sup> The emergence of electric drive and hybrid-electric vehicle systems within the transport sector is also expected to increase cobalt demand over the coming decade.<sup>47</sup> Other uses of rechargeable batteries include power tools, toys, and small household appliances.<sup>48</sup>

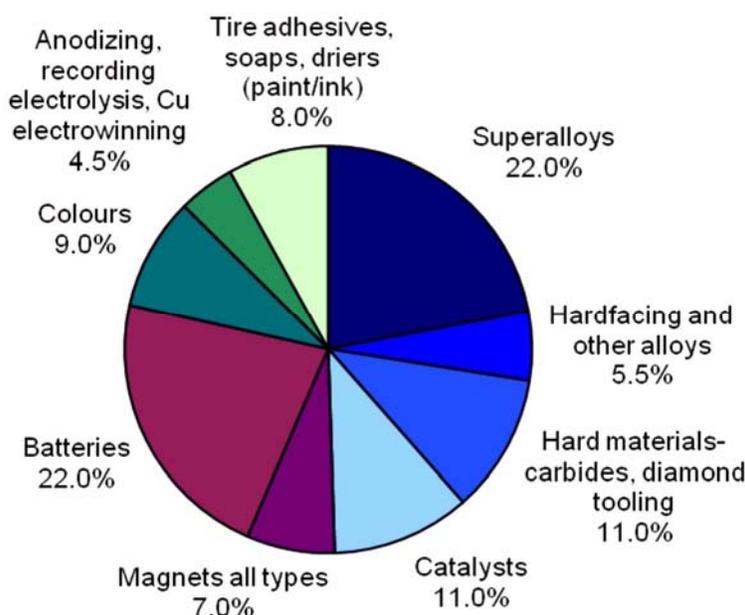


Figure 3 Cobalt end-uses in 2006.<sup>49</sup>

### 3.2.3 Copper (Cu)

Copper has been in use for 10,000 years, originally in alloys of bronze and brass. The metal is of great importance to the development of civilization, and today is critical to many industries. Its key engineering properties include ductility, corrosion resistance, and excellent conduction of both heat and electricity. The metal is widely utilized as tubing in heating and cooling systems, as wire in motors and in electrical conduction and telecommunication, and as brass or other

alloys in plumbing and industrial components. Major end-uses include construction and buildings, electric power transmission, transportation systems and electrical components.<sup>50</sup>

Copper plays a critical role in electronics and communications technologies, where its electrical and heat conductivity properties, are utilized in wires, transformers, connectors and switches in electrical connections, printed circuit boards, and copper heat sinks that assist in efficient operation of transistors and computer processors.<sup>51</sup>

The International Copper Association stated that 2% of the 22,000 tonnes annual global apparent consumption of copper in 2007 went to “electronic/data” end-uses.<sup>52</sup> The group tracks several market segments that may capture the use of copper in electronic industry products, including “consumer and general”, “electronic/data, and “communications.” In a separate communication with International Copper Association, it was estimated that less than 1% of copper is used by the electronic industry specifically.<sup>53</sup> Given that the metal can be found in a broad range of applications, beyond consumer and commercial electronics, the study has conservatively estimated that a maximum of 2% of copper production is utilized in electronics defined broadly.

### 3.2.4 Gold (Au)

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Historically gold has been a store of value. In bullion, gold is used as a stock of wealth. As currency, it has been used to facilitate exchange of goods and services. Since ancient times, gold has been used for the manufacture of jewelry and ornaments. More recently, because of its unique physical qualities, gold has been used in a wide range of industrial applications, including electronics applications.

The global demand for gold reached over 3,500 tonnes in 2007, with jewellery responsible for about 68% of the total demand. Due to its value and virtual indestructibility, the supply of gold scrap is important in the dynamics of the market.

In 2007, the electronic industry accounted for 9% of the global demand for gold.<sup>54</sup> Compared to 2006, the demand for gold in electronics (defined broadly) in 2007 increased by 3%; however, the pace of growth was slower than it has been in recent years (Figure 4). According to the World Gold Council, this rise has been a result of increasing sales of flat panel displays and MP3 players, which employ significant amounts of semiconductors.<sup>55</sup> Increasing gold prices and a climate of economic uncertainty are likely to encourage equipment manufacturers to decrease their usage of gold, resulting in a slowdown of the electronic industry demand.<sup>56</sup>

Gold plating of connectors, switches, and other components account for the main use of gold in the electronic industry. It is also used in bonding wires, finishing, sputters and solders.<sup>57</sup> The production of gold potassium cyanide, or plating salts, accounts for 70% of the gold used in the electronic industry.<sup>58</sup> The development of industrial catalysts based on gold and the evolving field of nanotechnology may lead to a rise in industrial demand for gold in the future.<sup>59</sup>

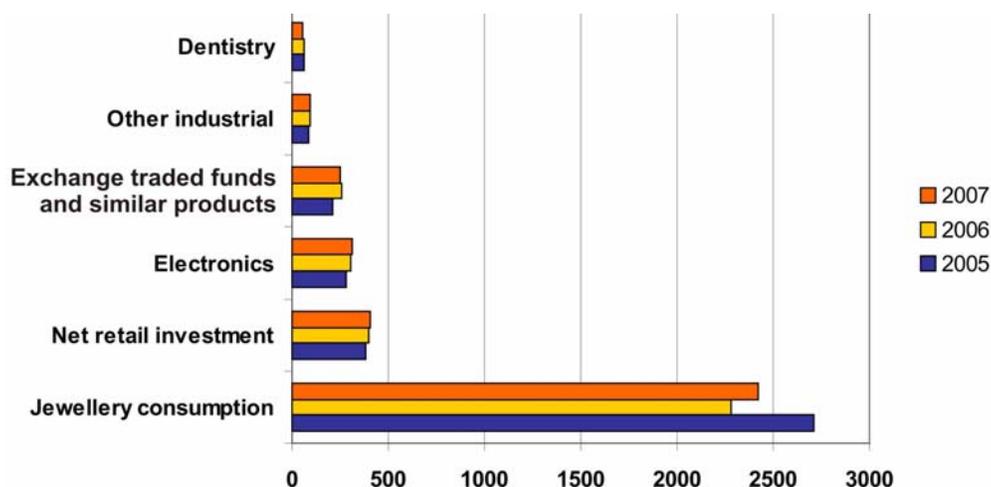


Figure 4 Identifiable gold demand (tonnes).<sup>60</sup>

### 3.2.5 Palladium (Pd)

Geologically, palladium is often found with platinum, and is one of the Platinum Group Metals (PGM). Although discovered almost 200 years ago, it was its use in catalytic converters for automobile emission standards (introduced in the 1970s) that greatly increased its usability.<sup>61</sup>

In 2006, the automobile sector, through its use of palladium in autocatalysts, represented 56% of the end-use of this metal (Figure 5), compared to use in electronics (defined broadly), which represented about 15% of the world's global production of palladium. Total palladium use, as well as the fraction used in electronics (defined broadly), has decreased since 2000, as a result of price changes and material substitution;<sup>62</sup> however, the automobile industry remained the largest end-user of palladium. Palladium in electronics is largely used in multi-layer ceramic capacitors with smaller amounts being used in integrated circuits and for plating connectors and lead frames.<sup>63</sup>

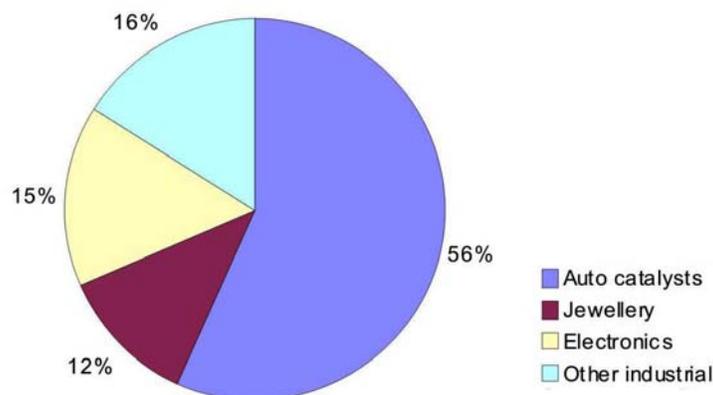
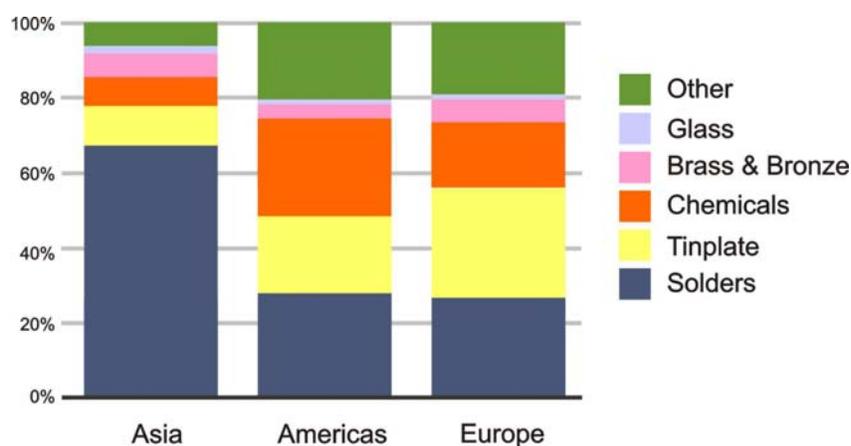


Figure 5 Palladium demand by end-use for 2006, where electronics is defined broadly (2006 global palladium production was 246 tonnes).<sup>64</sup>

### 3.2.6 Tin (Sn)

Tin is an ancient industrial metal, and a constituent of bronze. Today it is mostly used as solder in electrical and electronic applications, and as tin-plate surface finish on steel. The metal is relatively scarce in the Earth, being locally abundant in only a few regions; however, world reserves are adequate to meet projected societal needs.<sup>65</sup>

In 2006, 52% of the metal was used in solder, of which approximately 70% is used in electronics (defined broadly);<sup>66</sup> thus use in electronics represents about 36% of global tin consumption, making electronics a major end-use for tin. The electronics fraction has risen due to solder product growth, changes in solder technology and the shift to lead-free (high-tin) solder.<sup>67</sup> The latest data indicate that the trend to lead-free solder slowed down in 2007.<sup>68</sup> A disproportionate share of solder is utilized in Asia (Figure 6), with China accounting for about half of total use.



**Figure 6 Tin use by application in world regions.**<sup>69</sup>

## 4 METAL TRADE

Implicit in supply chain management of metals is the need to understand how metals are traded. Non-ferrous metals (including base and precious metals) are commodities traded on a global market, with prices set daily on commodity exchanges.<sup>70,71</sup> Commodity prices drive the business of metals and mining, with the financial performance of metals companies being linked explicitly to market demand and commodity price. The mechanism of the commodity exchange allows for efficient and open pricing, which not only facilitates trade, but also allows for investment and risk management across the market. However, only some trade occurs through commodity exchanges; the majority of physical trade is on the basis of bilateral contracts, with direct purchases between buyers and sellers of metals.

The following section describes aspects of metals as commodities and the complexities of the physical movement of metals from mine to suppliers.

### 4.1 *Metals are Commodities*

Commodities are basic goods, usually raw materials that are publicly traded in large volumes exclusively on the basis of price, on an exchange or in the cash market.<sup>72</sup> The underlying physical material can be standardized in terms of its quality and quantity by the exchange (e.g., minimum 99.95% copper, 25 tonne lot size<sup>73</sup>). A commodity price is used beyond a specific commodity exchange, as a standard reference for similar products (e.g. copper scrap or low-grade crude copper) around the world. Various grades of metal containing a range of impurities are sold under different specifications, with different levels of cost premium above the exchange price.

The physical nature of metals allows for the market to treat the commodity product as qualitatively homogeneous. A commodity is not distinguished or discriminated by origin. Physically, metal atoms of a particular element (e.g. copper) are identical to and indistinguishable from each other, whether they arise as virgin material from primary mining sourced from Australia or Africa, or recovered from recycled scrap following decades of societal use.<sup>74</sup> In trying to obtain the best prices for a metal, a buyer can source from an open commodity exchange, or develop private contracts directly with one or more sellers.

The metal miners operate and see themselves as suppliers of bulk commodities.<sup>75</sup> They provide metal commodity to the market, and with some exceptions, do not directly engage with end-customers, particularly, when metal markets continue to grow and prices remain strong.<sup>76</sup>

Aluminum is a notable anomaly. The sector is much more vertically integrated than for the base metals, meaning that a single company may own and control all stages from mining through to fabrication, and often include recycling in their operations. Some aluminum companies also brand and sell consumer products, such as aluminum foil. Additionally, large producers like Alcoa and Rio Tinto Alcan engage with and cooperate on development with end-users like automobile companies.

## 4.2 Metal Trading Mechanisms

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Metals can be traded either through commodity exchanges or through direct contracts. The percentage of metals traded through commodity exchanges is relatively low, but varies from metal to metal, from year to year, and cannot be precisely estimated. Specifically, commodity exchanges homogenize materials of different sources into a common trading pool, making tracing difficult or impossible. With direct contracts, the “line-of-sight” of metals is often lost from buyer to seller, and then to the next buyer and seller, partly because of the confidential nature of commercial contracts, and partly because of global complexities and mixing of metal flows across the supply chain.

### 4.2.1 Commodity Exchanges

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The most recognized material exchange is the London Metal Exchange (LME), which offers futures and options contracts for aluminum, copper, lead, nickel, tin, zinc, and plastics. Aluminum is the most actively traded material commodity in the world, accounting for the majority of trade on the LME.<sup>77</sup>

The main service provided by metals exchanges is pricing. This is performed on a daily basis, through a transparent mechanism (i.e. futures) where the buyer agrees to pay a price for future delivery of the commodity. In this way, prices are set for future dates, which approach the present or “spot” price. A second service of exchanges is risk management (i.e. hedging) where a buyer can always be assured of future material at a known price, and a seller can ensure a sale. Metal producers participate in exchanges as sellers both to determine global market price and in order to “hedge” protect their operations against risks of price fluctuations.

Most futures are not held to fruition; only a “very small percentage” of exchange trading results in physical delivery of the product.<sup>78</sup> Consequently, the traded quantity is greater than production. On a daily basis, the volume of metal traded can exceed total annual primary production for the commodity. The exact amount of metal that physically flows through exchanges is not quantified; however, in order to hold the many thousands of tonnes of metal that are stored for delivery, the LME licenses more than 400 warehouses around the world.<sup>79</sup> There are considerable amounts of metals stockpiled in LME and other warehouses, and this is an important aboveground stock. Exchange warehouse stocks are watched closely by traders as an indicator of market tightness between supply and demand. The fraction of material passing through exchanges varies; for example, from 2002 to 2006, the LME copper stockpile diminished from more than 1 million tonnes to less than 100,000 tonnes.<sup>80</sup> Relative to total annual copper production, this represents a shift in copper stockpile in the LME of 6% to 1% over that period.

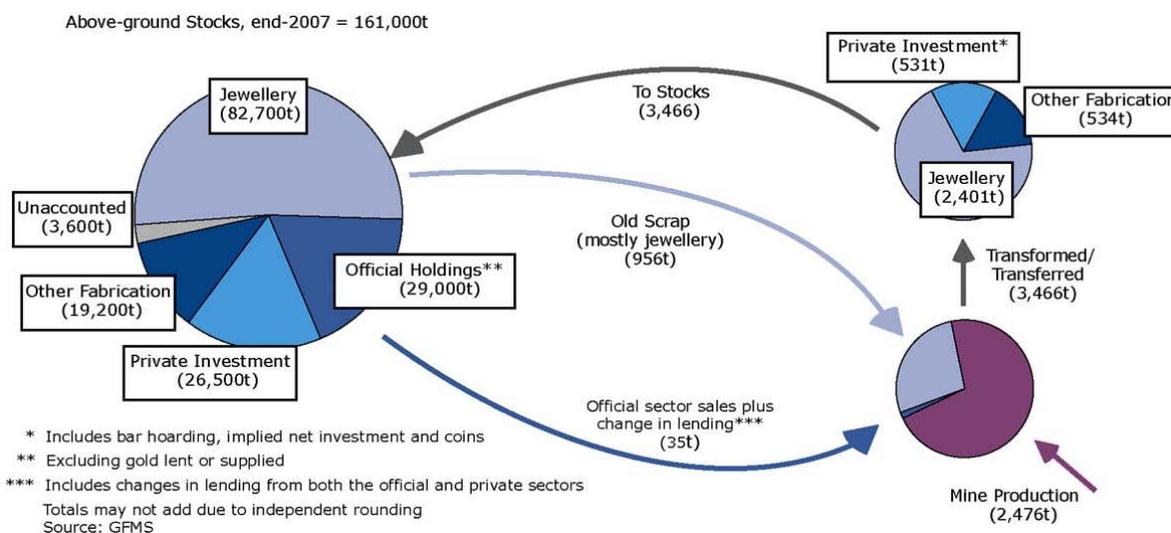
For some metals, like gold and palladium, large quantities of material are also held in stock by fabricators, dealers, banks, investment funds (like exchange traded funds) and state depositories (see Figure 4).). For example, in 2007, about 20% of the available palladium supply was not used.<sup>81</sup>

Globally, metals are traded in the following exchange markets:

- Aluminum – the LME, and Shanghai Futures Exchange, and the Osaka Mercantile Exchange;
- Copper – the LME, the Shanghai Futures Exchange, the New York Mercantile Exchange (COMEX);
- Gold – the Tokyo Commodity Exchange and COMEX;
- Palladium and other PGMs – the London Platinum and Palladium Market and the Tokyo Commodity Exchange;
- Tin – in addition to the LME, the market operates largely in Asia, with the Kuala Lumpur Tin Exchange providing the largest pricing mechanism for the metal.

Cobalt is an exception in that it is not traded on a commodity exchange, but rather through direct commercial contracts. Nonetheless, it is treated as a commodity, and prices are published online.<sup>82</sup> Commodities traders are in the process of developing new exchanges in order to facilitate investment and hedging for cobalt and other “minor” metals.<sup>83</sup>

Gold trade is unique as it is both a commodity and an important international financial product. Its supply and demand chain follows complex commercial transactions (Figure 7), with approximately three-quarters of it being used as a store of value in jewelry, investment funds or bullion stocks in official government holdings.<sup>84</sup> The price is fixed twice daily by the London Bullion Market Association.<sup>85</sup> Because gold has significant above-ground stocks, spikes in prices can be compensated by the resale of stocks, which makes gold less volatile than most commodities.<sup>86</sup> The price of gold has significantly risen in the last decade to levels of \$1000<sup>87</sup> per troy ounce; however, various producers, including private companies and developing countries, have not been able to fully benefit from these prices, and additionally have faced increases in energy, steel and other costs in the [gold mining and processing] industry.<sup>88</sup>



**Figure 7 Gold market flows.**<sup>89</sup>

## 4.2.2 Direct Buying

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The majority of metal sales are executed through direct commercial contracts between sellers and buyers. For buyers, exchange markets are not the first choice for the supply of metals. For sellers the exchanges provide a point for guaranteed sale, but it may be at a low price; consequently, most metal trade is performed directly through contracts. The negotiation of these contracts can consider relationship, timing and final destination of delivery, and form of metal provided (for example special products like metal powders). Pricing in contracts is negotiated on the basis of commodity exchange pricing.

Codelco, based in Chile and the largest copper miner in the world, reports that the company establishes long term commercial relationships through regular annual contracts with major customers, with contractual conditions possibly including specific terms and discounts from the standard exchange reference.<sup>90</sup> The firm directly supplies about two hundred copper manufacturing companies throughout the world, with one-third of 2006 shipments going to Asia.<sup>91</sup>

The specifics of direct trade are often hidden under commercial confidentiality. Neither seller nor buyer may be prepared to divulge details of transactions, such that information on the actual flow of metal from mine to refiner to fabricator to final manufacturer often remains confidential and guarded. The system is often derided by regulators as being non-transparent, subject to speculation, cash deals, and varying levels of trust between parties.<sup>92</sup> Using the internet, even the smallest sellers can find buyers. Direct trade is facilitated using services like Alibaba.com, a Chinese-based web marketplace for importers and exporters.<sup>93</sup> These portals provide forums for advertisements, which include such terms as “cash only”, “port to be determined” and “no brokers.” Metal commodities, including tin ore and cobalt, are openly posted in this forum from vendors based in the Democratic Republic of Congo (DRC) and Tanzania.

Information on metal trade flow is not readily or publicly available, nor is there clear academic literature on the specifics of metal trade. Further investigation is needed to reveal a more quantitative understanding of metal quantities delivered through exchanges compared to those going through the direct market, particularly in the context of supply chain management. Volumes traded will vary from commodity to commodity, from year to year, and will depend on market influences like economic prognosis, investor behavior, supply disruptions, and shifts in manufacturing demand.

## 4.3 Metal Pricing

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An unprecedented rise in metal prices began around 2000. Copper, cobalt and gold have each reached peak prices in the last year. Effects include new peaks in mining stock valuations, a global wave of corporate mergers and acquisitions in the mining industry, and aggressive new geological exploration, including ventures into more remote regions of the world. High demand and low supply are expected to continue to drive high prices.<sup>94</sup> For example, cobalt demand is expected to grow in the order of 30% in the next year.<sup>95</sup>

Metal demand has been driven by development in China and other emerging economies. In the case of tin, for example, LME warehouse stocks are being sold to fill market demand.<sup>96</sup> In China,

the world's largest miner of tin, domestic consumption now exceeds production, resulting in increased imports of metal and ore concentrate.<sup>97</sup> Forecasters are suggesting, amongst other prognoses, that “within 20 years, China will likely be consuming more metals and energy than do all the industrialized countries today.”<sup>98</sup> The CEO of Xstrata stated that:

*“... demand for commodities is diverging away from a historic dependence on the US and OECD countries. This decoupling is driven by the increased relative importance and intensity of domestic demand for metals, energy and other commodities in China and other emerging markets, compared to developed countries. Already, China alone accounts for over 70% of growth in global mined commodity demand.”*<sup>99</sup>

#### 4.4 Tracing and Tracking Metals

The metals market can be understood by analogy to a pool of water that is being fed by many streams. Numerous sources, including primary and recycled metal producers, supply the metals market, which is a global commodity pool that circulates and mixes freely (Figure 8). At the same time, numerous buyers withdraw from the pool, often not distinguishing source other than on price. Within the metal pool, metal is metal, where one unit of atoms is substitutable for another.



**Figure 8 Metal flows from one supplier to one buyer through a mixed pool that includes many suppliers and many buyers.**

In this report, “tracking” refers to the ability and practice of following material forward along the supply chain, following the flow “downstream,” for example from mine to smelter to refiner to fabricator to manufacturer. “Tracing” refers to an examination of flow backwards, or “upstream,” through the supply chain to determine the sources and processors of the material supplied to the end-user. Both of these practices require information at points along the supply chain, and assume that this information can be attached to, or associated with, a lot of a product or material as it flows from actor to actor.

For most metals there are a number of sub-pools, which may be regional or be segregated by grade or form of metal. Copper, for example, is traded in numerous forms: ore, mineral concentrates, crude metal, refined metal, semi-fabricated metal (e.g. as sheet or tube),

manufactured products, recyclable material and scrap metal. Each “sub-pool” is traded among sellers and buyers, in reference to the base commodity price specification.

A barrier to metal tracking or tracing of metals relates to the nature of commodity compared to that of brand products. Brand products are associated with some degree of uniqueness or differentiation from other (similar) products. Moreover, lot numbers or quality control information help provide information about the pedigree and quality of the product. Brand or manufactured products also include some implicit or explicit provision of information from seller to buyer. This might include guarantee of quality, tolerance or specification, or statements about where and how it is made. Compared to commodities, this leads to different management opportunities for supply chains related to brand products.

Another barrier to tracking or tracing metals lies in the fact that even for the fraction of contracts that are settled between seller and buyer through commodity exchanges, there may not be direct physical material flows between those same two parties. For example, when a buyer submits a warrant to pick up a metal lot from an LME warehouse, the buyer will not likely be concerned with whether the seller’s company name is stamped on the ingots as a guarantee of purity. In this way, for metal that is traded through exchanges, buyers and sellers are not actually visible to one other. From a physical perspective, again, metal is metal. Regardless of whether it has been refined in South Africa, Russia or Australia, it is equally useful to the fabricator.

The global scope of the metal flows in the commodity market cannot be over emphasized. As an example, copper concentrate from Australia might be shipped to Japan to be refined into high-grade material. It might then be mixed with primary copper purchased from Chile, plus scrap metal from Korea and the USA, and formed into copper sheets for export to China. In China, it could be manufactured into components that are assembled into consumer products for export to Europe. Clearly, to discern the pedigree or trace the “source” of such metal that goes into the final product is challenging, and may in fact be meaningless: is the “source” one of many mines, or is it the refiner, or is the recycler?

For metal that is traded through exchanges, buyers and sellers are not visible to one other. In direct contracts, mining companies provide large volumes of bulk metal to many buyers on a global market. Under these circumstances, line-of-sight of material is lost soon after sale.

Tracking and tracing metals is nonetheless desirable to stakeholders concerned about SER. Contract purchases do offer an opportunity for chain-of-custody or “line-of-sight” of the commodity; however, practices of direct buying appear to not presently accommodate this expectation. Tracking has been accomplished in a number of special SER cases (see Kennecott Copper example, below) but lack of transparency hinders tracking, with buyers and sellers intentionally shielding their identities to protect commercial relationships from competitors. Transparency is not an issue unique to metals supply. Confidentiality provisions, such as contract law, have created problems with transparency, and attract criticism with respect to supply chain relations for purposes of the Forest Stewardship Council and its certifiers.<sup>100</sup>

In some cases, suppliers and buyers establish contracts with regional metal supply (e.g. within Europe or South Asian markets) and it may be less challenging to trace. Even in this situation, the available supply of metals may arise from various mining companies or may have recycled

content. As an example, a “copper tube” maker can buy lower quality copper to mix with their own stock of pure copper, thereby producing an alloy that suits their purpose.

Tracking of metal, through various processing steps to a final user, has been achieved, and the supply chain can be quite short. Kennecott Copper (a Rio Tinto company) presently supplies both gold and silver (produced as a co-product to copper) directly to fabricators under agreement with Tiffany’s, the jeweler. In the case of tin solder used in electronics manufacture, producers like Yunnan Tin and Thaisarco provide refined metal or even solder alloy to fabricators for use in electronic components. The opportunities and challenges for tracking are emphasized by the Mining, Minerals and Sustainable Development Project:

*... trading patterns in concentrates and refined metal products among mines, smelters and refiners, and fabricators create obvious difficulties in tracking metals reliably from mine to customer. Hence, it is perhaps only the most fully integrated companies, such as aluminium firms, that currently have the potential to demonstrate that a metal has been mined, refined, and fabricated under conditions that meet sustainable development objectives.<sup>101</sup>*

Tracing a metal is even more challenging, as it suggests looking backwards, up the supply chain, to sources of metal. The viability, and meaningfulness, of tracing commodity metals is low. Part of the reason for this is metallurgical. Metals are mixed, melted, and re-formed into powders and other forms that are not recognizable from previous forms, let alone identifiable as arising from ore. Consequently, the identity of metals, and the ability to test or sample for source, is minimal compared to other commodities, such as wheat or coffee, since metal does not retain form or identifiable characteristics within a lot (for example, compare a processed coffee bean to a re-melted metal ingot).

Some electronic industry members have begun to survey their supply chains to gather accurate information on the location of sources that provide the materials that ultimately end up in their products. Initial efforts suggest that data-collection is complex and time-consuming. Moreover, the accuracy of the information gained is variable, including gaps in the picture of material supply, for example, where suppliers do not or cannot reveal sources, or where suppliers simply point to intermediate metal processors as “sources” of their metals. The implications of tracking and tracing metals are discussed further in Section 9 in Discussion and Recommendations.

## 5 PRIMARY METAL PRODUCTION

Primary metal production refers to mining or extraction of metals from the earth. In nature, metals are commonly found in oxide or sulfide mineral deposits (ores), which are identified by geologists, extracted by miners, concentrated or separated from invaluable rock by mineral processors, and finally melted and mixed, and formed into useful fabricated shapes by metallurgists. Mines can be either “underground” (accessed down a narrow hole or mine shaft) or “open pit” surface mines (large holes in the earth).

Metals often occur together, in common deposits or seams in the earth so that a single mine will often produce more than one metal. Typically, a mine will focus on a primary target metal; however, with the nature of mining, and shifting costs and prices, operators will try to maximize profit through extraction of co-product metals. For the present study, the relevant metal co-occurrences are shown in Table 3. As an example of how metals are mined, the pattern in metal occurrence and extraction shown in the table suggests that cobalt is produced most significantly as a co-product from either nickel or copper mines, while copper is a prime target metal that determines decisions around mine location and production techniques. Among the metals of interest in this study, aluminum is particularly complex in that it is one of the few metals mined in isolation (as bauxite ore) in order to satisfy strict requirements for mineral processing and metallurgical extraction from alumina (aluminum oxide) to pure metal.

**Table 3 Geological co-occurrence of metals considered in this report (metals of interest in bold).**<sup>102</sup>

Target metal	Associated co-product metals
<b>Aluminum</b>	None
Chromium	<b>PGM</b>
<b>Copper</b>	<b>Gold</b> , silver, <b>PGM</b> , <b>cobalt</b> , lead, others
<b>Gold</b>	Silver
Nickel	<b>Copper</b> , <b>gold</b> , silver, <b>PGM</b> , <b>cobalt</b> , others
<b>Tin</b>	Rarely: tungsten, bismuth, tantalum, lead, silver, indium
Zinc & Lead	<b>Gold</b> , silver, <b>cobalt</b> and others

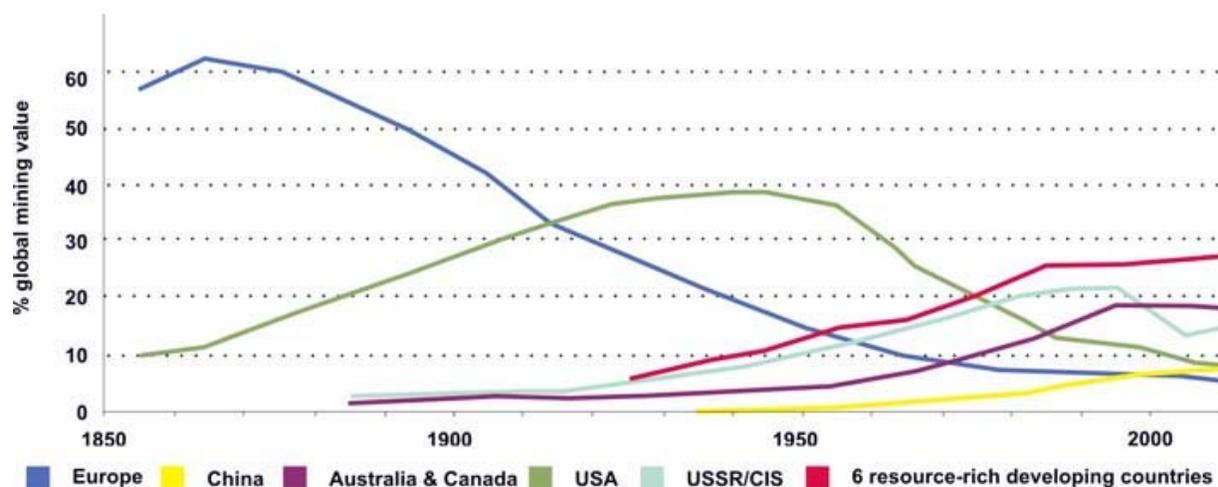
### 5.1 Industry Structure

Mining and metals companies are challenged by the cyclical nature of their business. The economic value of global mining has surged more than five-fold in the last decade, to \$320 billion per year.<sup>103</sup> This largely has been due to increased demand in Asia paralleled by higher prices for mineral commodities. The industry continues to be susceptible to economic swings, as

demand and prices are affected by increased production in end-use sectors like manufacturing, construction and telecommunications. For metals like tin, the recent boom is a long-overdue upwards adjustment to metal prices that have been depressed for decades.

In response to increasing prices, there has been an accompanying expansion in mineral exploration, including penetration into areas previously perceived as inaccessible. Analysis by the EU Raw Materials Initiative shows the long-term trend in global mining (Figure 9) shifting from the developed to the developing world. European and USA production is declining while Canada, Australia, China and the former USSR states have effectively leveled off their primary production, opening new mines as they close old ones. This leaves developing countries as areas with most substantial growth in mining. Six nations lead the activity: Chile, South Africa, Brazil, Indonesia, Peru, and China. Along with this global shift in mining activity patterns, there may be new and perhaps unanticipated environmental and social challenges, which will affect the profitability and economics of both the corporate players and the countries of mine operation.

A Swedish-based resource economics think-tank, the Raw Materials Group (RMG), estimated in 2007 that there are 4,100 mining companies globally. Their research focuses on publicly reported companies and formal mine operations around the world, thus not all mine production is covered; for example, their data exclude some Chinese production and artisanal and small-scale mining (ASM). The structure of the corporate industry is such that mine ownership is heavily weighted to a relatively small number of “majors” that control the most active production sites in the world. RMG reported in 2008 that the “top 150 mining houses make up less than 4% of the number of industry players, yet account for 80% of global metals output.” This activity is augmented by about 1,000 intermediate firms that control most of the remaining fraction of production. Junior mining firms, which constitute thousands more firms largely focus their efforts on exploration activities, and contribute less than one percent to mined value.<sup>104</sup> In addition to other issues that may arise from this exploration focus, this leads to a high risk business and investment attitude, with small firms looking for deposits that can be proven before selling to intermediates or majors.



**Figure 9 Long-term changes in the geography of global mining.**<sup>105</sup>

Most visible to the public are a relatively small number of publicly traded large multinational corporations. This group consists of about 40 companies, which have operations in multiple countries around the world and represent three-quarters of mining stock market capitalization.<sup>106</sup> In recent years there have been an increasing number of mergers and acquisitions in the industry, such as Vale acquiring Inco in 2006 and Rio Tinto acquiring Alcan in 2007.

There are also a number of large companies which are not multinational in character. Some are state-owned or state-controlled companies in countries like Mexico, Russia, Indonesia, China and Chile. A prominent example is the world's largest copper company, Codelco, which is state-owned by the government of Chile. Aluminum companies tend to be vertically integrated producers with operations distinct from other mining companies. These firms only mine and refine aluminum, and rely on distinct and energy-intensive technologies. Another notable group of companies are refiners, such as Umicore, which although not as large globally as the majors, focus on specialty processing of metal concentrates that are purchased on the market or obtained from recovered sources.

The intermediate corporations range with respect to their positions on social and environmental responsibility. The smaller intermediate and junior size companies tend to have poorer performance with “a disproportionate number of the bad actors [having] come from the sector in recent times.”<sup>107</sup>

**Table 4 Scope of artisanal and small-scale mining by metal of interest.**

Metal	Artisanal and Small-scale Mine Production
<b>Aluminum</b>	<ul style="list-style-type: none"> <li>• Estimated at 20%</li> <li>• Limited to China, where 75% of Chinese bauxite is produced through ASM<sup>a</sup> and China accounts for 26% of global bauxite mining.<sup>b</sup></li> </ul>
<b>Cobalt</b>	<ul style="list-style-type: none"> <li>• Estimated at less than 5%, with the artisanal mining of the cobalt mineral in DRC having “increased since the late 1990s”<sup>c</sup></li> </ul>
<b>Copper</b>	<ul style="list-style-type: none"> <li>• Minimal<sup>d</sup></li> </ul>
<b>Gold</b>	<ul style="list-style-type: none"> <li>• 20-25% of global gold mining<sup>e</sup></li> <li>• 2 million are directly involved in ASM of gold<sup>f</sup></li> <li>• ASM constitutes two-thirds of gold production in Ghana and Ecuador, and 90% in the Philippines<sup>g</sup></li> </ul>
<b>Palladium</b>	<ul style="list-style-type: none"> <li>• Minimal<sup>h</sup></li> </ul>
<b>Tin</b>	<ul style="list-style-type: none"> <li>• Approximately 50% of world primary production. ASM is the dominant mode of mining in both Indonesia and China.<sup>i</sup></li> </ul>

**Sources:** a. MMSD (2002, p. 318); b. USGS (2007); c. USGS (2005, p. 19.3); d. GHGm estimate; e. MMSD (2002, p. 101) and UNIDO (2003); f. Hentschel (2002); g. Hentschel (2002); h. Palladium ASM is minimal, given the known dominant producers in South Africa and Russia plus co-production associated with nickel mining in Canada and other nations. Note: artisanal sources of Pt are practically non-existent, except for this source in Colombia and others on peripheries of large-scale operations in Zimbabwe and South Africa (Levin 2008a); i. Nimmo (2008a, 2008b, 2008c).

An additional consideration with respect to industry structure is the role in the extraction of metals by large-scale mining (LSM), as conducted by the major mining companies, compared to that of artisanal and small-scale mining (ASM). ASM is practiced in many regions of the world, for various metals and precious gemstones, but particularly in developing countries. The definition of what is artisanal and what is small-scale varies, but there are some key aspects that are common to the two sectors. ASM is usually accomplished in rural areas, with simple tools and equipment and by those living in poverty.<sup>108</sup> It is often an informal economic sector (i.e. outside legal or regulatory frameworks) but offers better livelihood opportunities and generates more income than other local economic activities, such as agriculture. In fact, poverty is usually the driving factor for ASM activities.

ASM activities account for much of the extraction and production of gemstones (90-100% in most countries) and diamonds (80-100% in countries that are not major producers,<sup>109</sup> 60% in Ghana,<sup>110</sup> 100% in DRC, which is a major producer by volume<sup>111</sup>) and 75% of the bauxite in China.<sup>112</sup> Estimates of ASM production of the metals of interest for this research are shown in Table 4. The largest proportion of ASM global production is for tin production, followed by gold.

## **5.2 Primary Production by Metal**

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### **5.2.1 Aluminum**

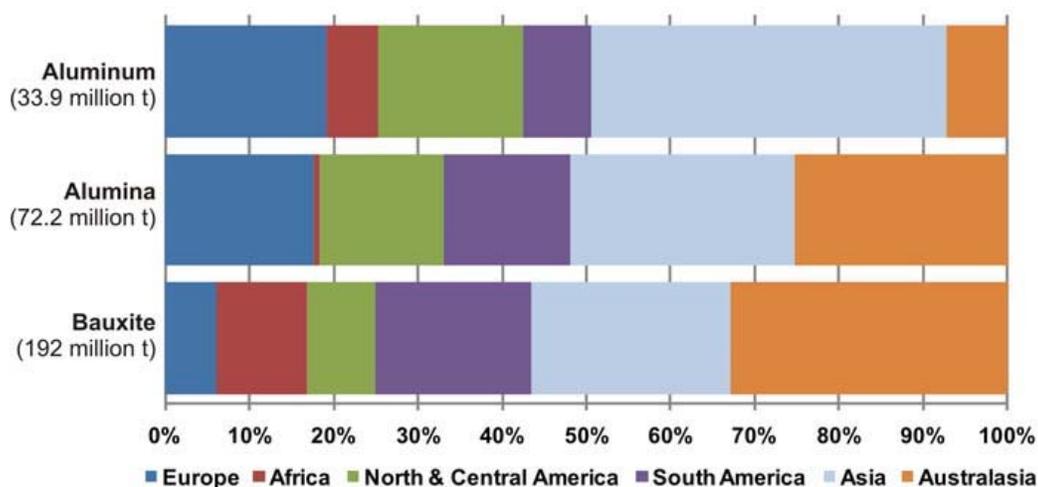
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The aluminum sector is organized in such a way that a relatively few number of large companies control the industry, from mine through to final products (for example aluminum foil, beverage cans and automobile wheels). Production of a single unit of metal is often distributed around the globe, with bauxite, alumina and aluminum operations occurring in different countries. This is illustrated in Figure 10, which shows that as primary material is processed, aluminum gets transferred from bauxite mines in Australia, Africa and the Caribbean, to alumina processors in the USA and other parts of the world, and to smelters and metal fabricators in China, Europe and North America.

The production of aluminum is the last step of a process that begins with the extraction of bauxite ore ( $\text{Al}_2\text{O}_3$ ). Mining occurs at large surface deposits in mostly equatorial locations around the globe. The top mining countries are Australia (35%), Brazil (12%), China (12%), Guinea (8%), Jamaica (8%) and India (7%) (Figure 16). Growth in bauxite mining occurs in developing countries, with more than 60% of bauxite ore being mined by foreign companies operating in the host country.<sup>113</sup>

Once mined, the bauxite is refined to obtain the alumina, which is then transported, sometimes thousand of kilometers, to smelters located in regions where there is a secure and plentiful supply of affordable electricity. For example, alumina is transported from Guinea, West Africa to Quebec, Canada. Separation of aluminum metal from alumina demands high intensity of electrical energy and is performed in large facilities under strictly controlled conditions. The electrical power requirements of primary aluminum production are significant, consuming an

estimated 3% of global electricity production.<sup>114</sup> Hydropower has been a mainstay of electricity supply for aluminum smelting. Since the 1950s, production of aluminum has occurred in developed regions like USA, Europe, Canada, Australia and Russia; however, the industry is in transition. As demand for aluminum increases, the search for large amounts of reliable electrical energy at low cost, has led to new projects in developing countries and more remote regions of the world. These projects entail either the development of new hydropower dams or the exploitation of under-utilized natural gas resources, such as in the Middle East. Consequently, the sector faces on-going and escalating social and environmental challenges. There are projects being considered, or recently implemented in diverse regions such as in Mozambique, Iceland, Russia, Orissa (India), Borneo<sup>115</sup> and Greenland.<sup>116</sup> In 2006 the top aluminum refining countries were Canada, Russia, USA, China, Norway, Australia, and United Arab Emirates (Figure 16).<sup>117</sup>



**Figure 10 Global distribution of aluminum production stages in 2006.**<sup>118</sup>

In the final phase of aluminum production, pure metal ingots are transported to markets, largely to developed countries or newly industrialized economies, where fabricators and manufacturers convert the metal to usable alloys and industrial forms for end-use applications.

### 5.2.2 Cobalt

Cobalt is not a particularly rare metal, but it is widely scattered in the earth's crust. There are only two types of ores (Moroccan and Canadian arsenide ores) that are rich enough in cobalt to make it feasible to extract it alone from these sources.<sup>119</sup> Otherwise, it is normally associated with copper or nickel and extracted as a co-product as previously discussed (Table 3).

In 2005, 41% of global primary cobalt was a co-product of nickel mines in Russia, China, Canada, Cuba and Australia,<sup>120</sup> while 53% was produced as a co-product of copper, mainly in the Democratic Republic of the Congo (DRC) and Zambia. The DRC has some of the richest cobalt

deposits in the world with one-third of the world's reserves.<sup>121</sup> The remaining 6% of cobalt production comes from small primary producers in Morocco and Uganda.<sup>122</sup> These ratios remain largely unchanged to the present day.<sup>123</sup> There is potential for considerable new production through 2010, primarily from DRC.<sup>124</sup> In the future, other regions may also contribute to cobalt production. For example a mine is planned in Cameroon, with an expected annual production rate of 4,000 tonnes of cobalt over a 22-year life.<sup>125</sup>

The 2006 top mining countries are shown in Figure 11. The DRC was the largest producer of cobalt, producing 41% of the total global production in 2006, while Zambia was the second largest producer at 12% of total global production. Cobalt refining, however, is predominant in Asia and Europe (Figure 11 and Figure 16).

The top cobalt refining companies in 2007 are shown in Figure 16. Chinese companies were responsible for almost one-quarter of refined cobalt production, with OMG the second biggest refiner; OMG is headquartered in the USA, but has its refinery in Finland.

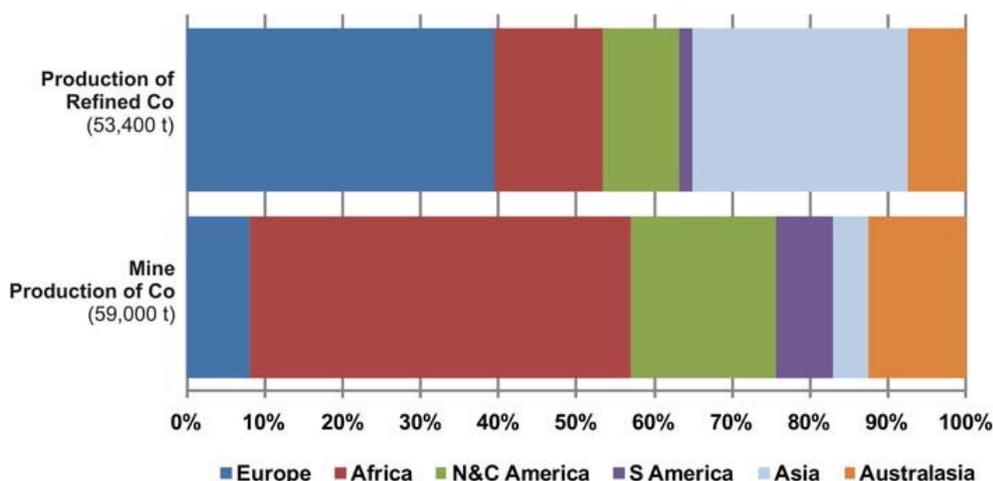


Figure 11 Global distribution of mined and refined cobalt<sup>126</sup>.

### 5.2.3 Copper

Some of the largest mines in the world produce copper and co-product metals like gold and molybdenum. These mines are typically hard rock, open pit mines. Copper is usually found in the Earth with sulfur, requiring a multi-stage mining and extraction process, which produces substantial air emissions. Although much has already been done to mitigate these emissions from legacy processes, recent technologies involving water-based metallurgical processes appear to be promising ways to avoid air pollution.

Much of the world's primary copper is produced by large companies, including Codelco (12%), Norilsk (8%), and some member companies of the International Council on Mining and Metals (ICMM). Operations are co-located, with copper mines, smelters and refineries in the same area producing refined copper that is then sold as a commodity to the market (Figure 12). The

geographic pattern of copper production and manufacturing shows that metal is mined primarily in the Western hemisphere (Chile (35%), Peru (7%), North America (8%), where much of it is also smelted. Then it is transferred to Europe and Asia for refining, before the bulk of metal ends up in Asia and Europe for fabrication and use in manufactured products.<sup>127</sup>

The limited supply of copper has been raised as an issue.<sup>128</sup> The search for mineral reserves is taking geologists and miners to more remote regions like Alaska and Mongolia.

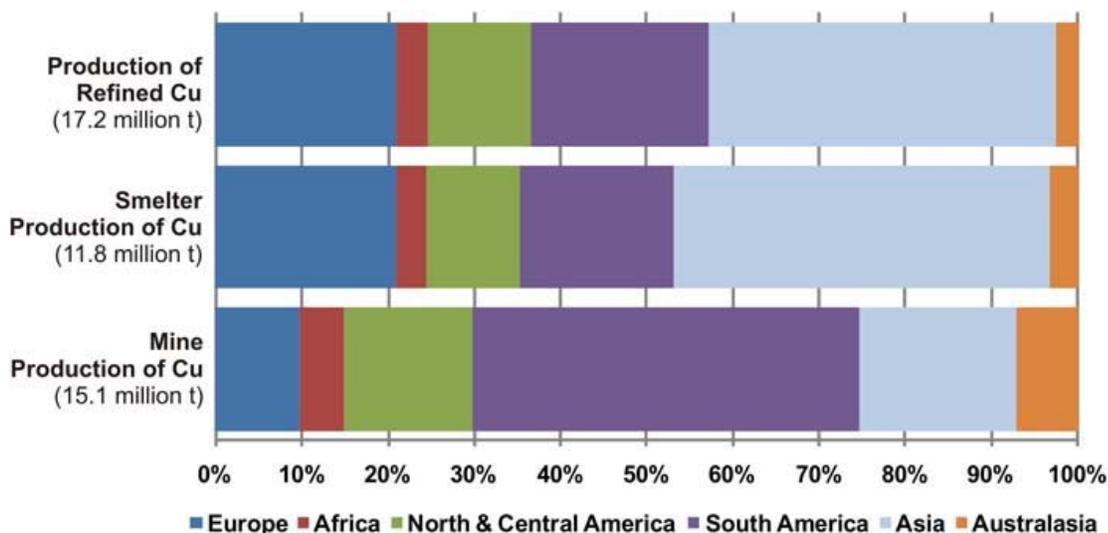


Figure 12 Global distribution of mined, smelted and refined copper in 2006.<sup>129</sup>

### 5.2.4 Gold

Measured by value of production, gold is the third largest non-ferrous metals industry, after aluminum and copper.<sup>130</sup> The geography of gold production is increasingly diversifying (Figure 13). In 2006, more than 75 countries contributed to the world mine production.<sup>131</sup> While South Africa was the leading mine producer of gold in the 20<sup>th</sup> century, in the last few years, its position has diminished as other countries have increased production, including Australia, United States and China.<sup>132</sup> About 40% of the world's gold mine production is located in China, South Africa, United States, and Australia (Figure 16). In China alone it is estimated that there exist over one thousand gold mining companies and over 1,300 licensed mine sites.<sup>133</sup> In 2006, 17 companies accounted for almost 55% of the world production.<sup>134</sup> In 2007, China became the leading gold provider<sup>135</sup> partly due to mine production setbacks in South Africa, USA and Indonesia.<sup>136</sup>

About 10 million<sup>137</sup> small-scale and artisanal miners in developing countries (mostly in Africa, Latin America and Asia) play a substantial role in the world's gold production.<sup>138</sup> The contribution of artisanal mining to global gold production was estimated to range from 20 to 30% or 500 to 800 tonnes annually.<sup>139</sup>

Gold production is increasingly taking place in developing countries, especially in those that are poor and heavily indebted. In 2005, gold was the leading export in Mali, Tanzania, Ghana and Guyana.<sup>140</sup> In several developing countries, the small-scale production of gold and gemstones ranks in the top five activities of economic production.<sup>141</sup>

The top producing gold mines are: Yanacocha (controlled by Newmont) in the Peruvian Andes; Porgera (controlled by Barrick Gold) in Papua New Guinea; Goldstrike (controlled by Barrick Gold) in Nevada, USA; Pierina (controlled by Barrick Gold) located in the Peruvian Andes; and Grasberg (controlled by Freeport-McMoRan) located in Indonesia (Figure 16).<sup>142</sup>

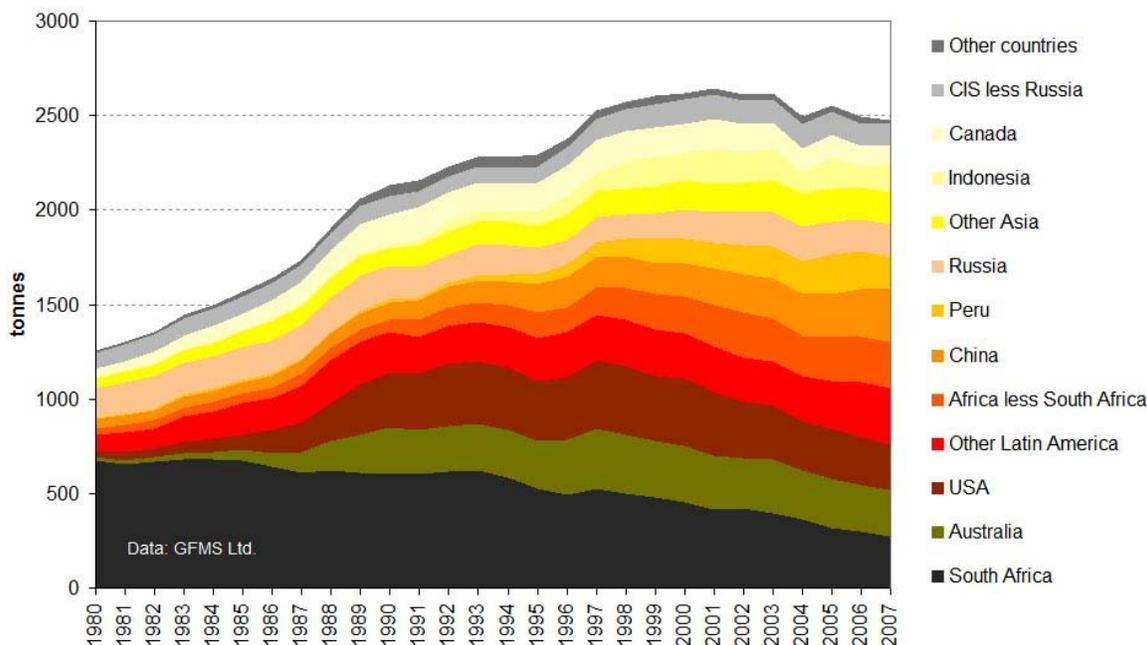


Figure 13 World gold mine production (1980-2007).<sup>143</sup>

### 5.2.5 Palladium

Russia and South Africa produce 80% of global palladium (Figure 14). In 2006, the top producing mining companies for palladium were Norilsk (50%) in Russia, plus AngloPlat (21%), Impala (6%) and Lonmin (6%) in South Africa (Figure 14). Palladium mining, smelting and refining is often collocated, such as in South African and Russian production. Other industry players include companies like Vale-Inco, which mines and process PGMs as a co-product of nickel production. Their precious metals refinery is located in London, UK, which consolidates and refines primary concentrates from around the world, as well as processing recyclates from other suppliers.

Global palladium production in 2006 was 214 tonnes, an increase of 5% from the previous year; however, the rise in global palladium output was less than that of platinum (6% rise), due to slower growth from the world's largest producer, Norilsk Nickel.<sup>144</sup> In contrast, South Africa reported a strong increase in palladium output, while higher production was also measured in

Canada and the United States.<sup>145</sup> The world reserves of palladium are more restricted than most metals and have been raised as a concern by some analysts.<sup>146</sup>

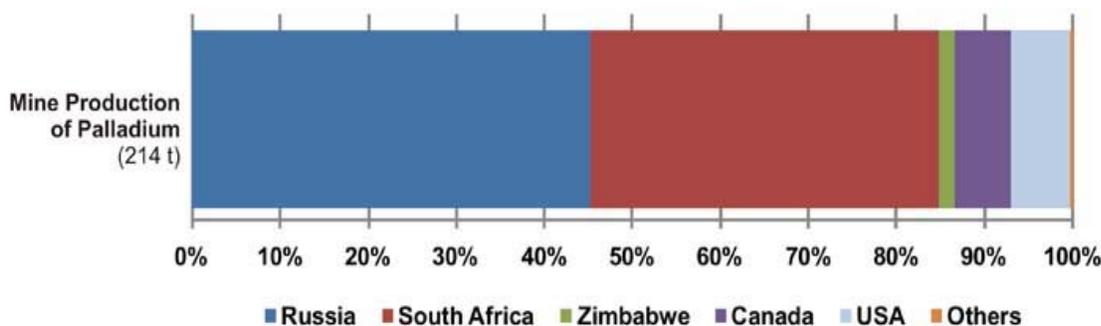


Figure 14 Global distribution of palladium in 2006.<sup>147</sup>

### 5.2.6 Tin

Intermediate-sized companies with regional operations in South East Asia or South America are the key players in the tin industry, with PT Timah, an Indonesian company, being the only state-owned company. Until late 2006, more than half of global primary tin production came from small-scale mining at illegal and semi-legal mines in Southeast Asia and South America.<sup>148</sup> Production involves three steps: mining of ore from mostly surface operations (exceptions are the underground mines in South America, Australia and China<sup>149</sup>, as well as in eastern DRC<sup>150</sup>), smelting to a crude tin metal, followed by refining to a pure (e.g. 99.85%) grade. Following this process, solder product and other alloys are produced. Two developing countries, Indonesia (31%) and China (37%), dominate two-thirds of tin mining.<sup>151</sup> South America is the next third largest mining region, accounting for about 22% of production (Figure 16). There is one integrated producer operating in Peru providing 13% of production.<sup>152</sup> In Bolivia a transition is underway involving hundreds of small cooperatives and one state-owned company. African production is minimal, with supply uncertainties and strong commodity pricing supporting sporadic and artisanal mining activity in the DRC (accounting for about 5% of global production)<sup>153</sup>. The focus for growth in tin production is on South Asian sources in Indonesia or areas like Myanmar (Burma) where Chinese and Singapore investors plan a rapid scale-up of production<sup>154</sup> that may account for 3% of world supply by 2009.<sup>155</sup>

Tin refining often occurs in the same country as mining (Figure 15). Indonesian crude tin is traded in significant portions to Malaysia, China and Thailand where it supplements domestic production and feeds established refineries. China is both the world's largest miner and user of tin, and has recently shifted from a net exporter to a net importer of the metal.<sup>156</sup>

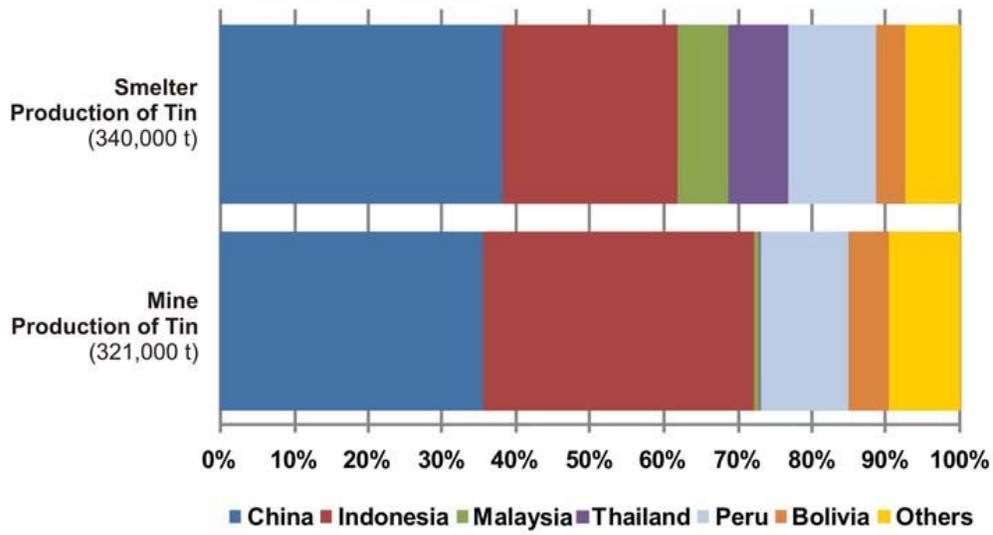
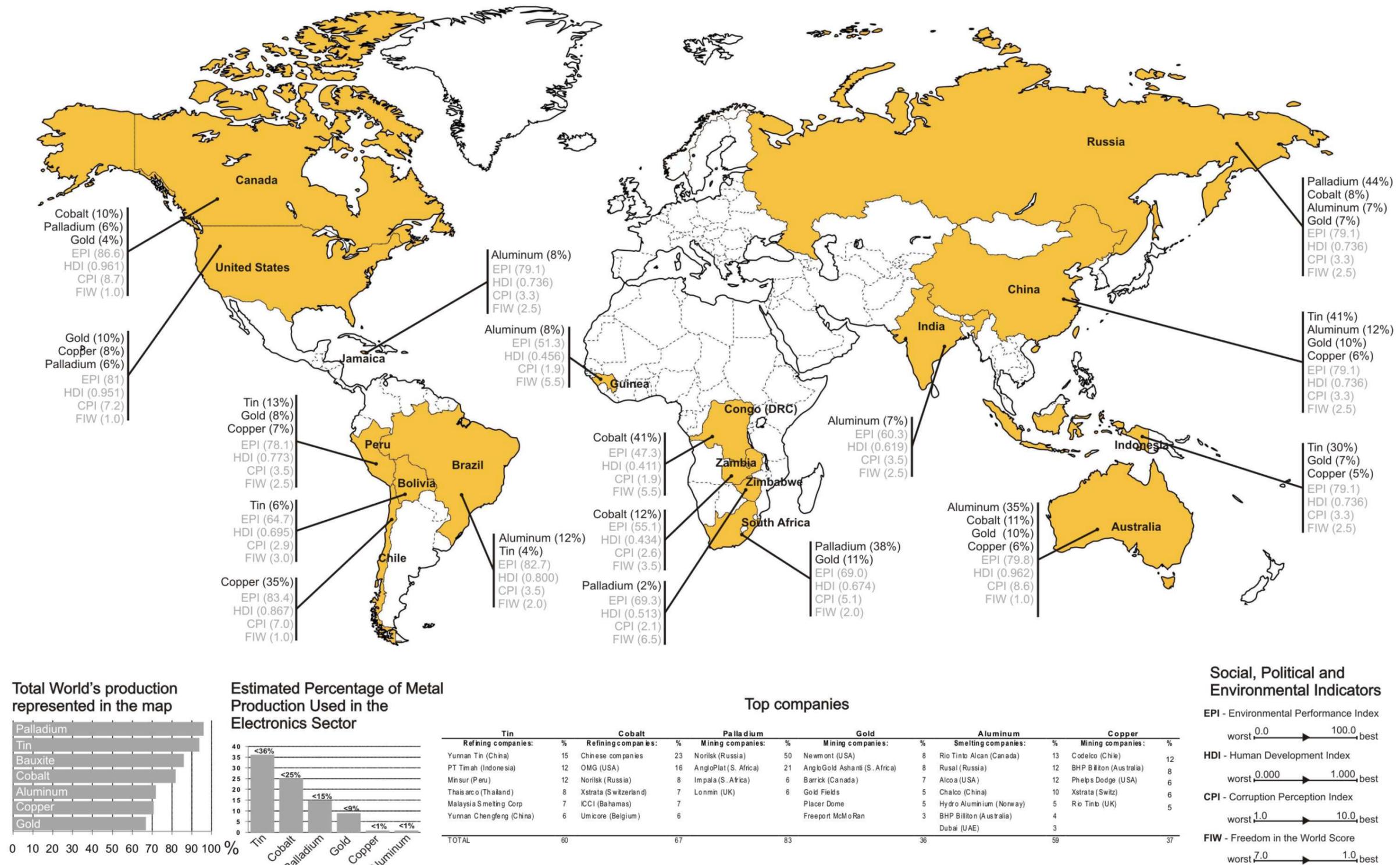


Figure 15 Global distribution of mined and smelted tin in 2006<sup>157</sup>



Sources: Mineral statistics: U.S. Geological Survey, 2008, Mineral commodity summaries 2008: U.S. Geological Survey, 199 p. EPI: Yale and Columbia's Universities Environmental Performance Index (<http://epi.yale.edu/Home>). HDI: United Nations' 2005 Human Development Index (<http://hdr.undp.org/en/>). CPI: Transparency International's 2007 Corruption Perception Index ([http://www.transparency.org/policy\\_research/surveys\\_indices/cpi/2007](http://www.transparency.org/policy_research/surveys_indices/cpi/2007)). FIW: Freedom House's combined average of the 2007 Political Rights and Civil Liberties indicators ([www.freedomhouse.org/](http://www.freedomhouse.org/)). Top Companies and Estimated Percentage of Mine Production Used in the Electronics Sector were drawn from a combination of sources referenced in the main document and based on the years 2005 and 2006. There were significant changes in the mining sector in 2006-08. In the case of gold, for example, Barrick finalized the acquisition of Placer Dome in 2006 and is presently the world's top producer. The aluminum statistics refer to the bauxite ore. Websites mentioned above were accessed in May, 2008.

Figure 16 World's 2006 mine production of aluminum, cobalt, copper, gold, palladium and tin.

## 6 RECYCLED METAL PRODUCTION

Because they do not lose properties during use, metals maintain their value and can be economically recovered and re-utilized. Recycled metal contributes significantly to global metal production, and is mixed with primary metal sources, as a result of trade and metallurgical processing. The environmental and resource benefits of recycling, along with a growing number of policies and programs, have been implemented to encourage resource efficiency and increased recycling. Growth in metal recycling has also been a response to spikes in metal prices.

With respect to issues related to the use of metals in electronics, there are two aspects of recycling that are of particular interest in this study. The first aspect involves understanding the recycled metal supply in terms of the amount of recycled metal that supplies total production of metal. The second aspect is related to the amount of metal that the electronic industry contributes through industrial recycling and as a result of end-of-life product recovery. This section discusses sources of recycled materials, challenges to recycling, the contribution of the recycled metals of interest to global metal production, and the contribution from electronics to recycled metals. Again, electronics is defined broadly in this context.

### 6.1 Sources of Metal for Recycling

The physical properties and permanence of metals means they are durable and are often integral to products with substantially long life-times (e.g. automobiles and buildings); thus, modern society possesses a significant “aboveground stock” of metal. This stock is not available for recycling until its present use is expired, which for some products, like buildings, may take decades or even centuries. Product life-times vary, as do consumer disposal practices at product end-of-life, at which point metals may be recoverable or may be lost from the system. The life-times of products, and consequently the residence time of aboveground metal stocks, are increasingly being studied by industry and academics.<sup>158,159</sup> Analysis of recycling rates of metals are further complicated by economic growth, which encourages greater supply to feed more demand. Both the data and methodologies for determining recycling rates vary. For example, the copper industry generously states that “assuming an average life span of 30 years for most products, copper’s truer recycling rate would be 85%.”<sup>160</sup> In contrast, a Yale University study more conservatively suggested a number of approximately 65% for copper.<sup>161</sup>

Supply of metal for recycling relies on the capture of material from three categories:

- **home scrap**, which includes metal flows that are recycled in-house, internal to metal producers and fabricators; these flows are usually not visible and not included in market studies,
- **new scrap**, which are post-industrial streams arising from manufacturer or fabricator discards and cuttings, and which are transferred and traded to scrap processors, and

- **old scrap**, which refers to material arising from product end-of-life material streams, post-consumer.

Statistics on recycling often aggregate these three categories, making it challenging to determine estimates of recycling recoveries and efficiencies. The generation of both home scrap and new scrap reflects production inefficiencies by manufacturers, suggesting increased energy requirements and environmental aspects; old scrap, on the other hand, is a post-consumer flow that would otherwise go to waste. In general, the collection and recycling of any scrap contributes positively to resource efficiency.

Recovered metal, regardless of scrap type, is subsequently sorted, cleaned or otherwise processed before re-melting, re-refining or re-smelting, whereby it can be returned to a specification suitable for its next use. Scrap metal of high-grade is typically recycled by fabricators or manufacturers who use this material as a substitute for primary metal. Scrap metal of lower grade, which may be contaminated or in a form that is not easily used, tends to be bought and used as feed by primary metal producers (and possibly transported to large smelters or refiners located near at mining operations), where they pay a much lower price per unit of metal than for high grade material.<sup>162</sup>

End-of-life (old) scrap recovery is widely promoted, but the level of recycling varies, depending on product-category, geographic region and national income,<sup>163</sup> and metal prices. End-of-life recovery is hampered in two ways:

- Products become physically distributed regionally and globally, making collection costly.
- There may be many different metals embedded in a single product, wherein a specific type of metal may be dispersed or mixed throughout a single product, making separation and cleaning difficult.

Cost-effective, efficient, end-of-life product recovery represents the limiting factor for increasing metal recovery, and hence metal recycling.<sup>164</sup>

## 6.2 Recycled Metal Supply

Although recycled sources represent a significant, beneficial and growing supply of most metals, the industry has not adequately compiled data on metals recycling in a manner suitable for those interested in supply chain analysis or product life cycle assessment. At present, definitions of recycling rates are not harmonized, resulting in information that is “more confusing than informative.”<sup>165</sup> This results in recycling indicators for different metals that are not necessarily comparable. The Nickel Institute makes the point that “it is important to consider this global nature of the distribution of material available for recycling” and that “only indices or ratios which will be meaningful are global.”<sup>166</sup> The recycled metal supply (i.e. the amount of recycled metal that supplies total production of metal) has been estimated for this research for some metals, although it is often difficult to quantify and be can be quite uncertain, as has been noted in the literature.<sup>167</sup>

The metals industry has recently developed an indicator, the “Recycling Input Rate (RIR)”, which approximates the measure of metal supply. It “measures the proportion of metal and metal products that are produced from scrap and other metal-bearing low-grade residues.”<sup>168</sup> The implication is that RIR includes not only end-of-life (old scrap) inputs, but also encompasses new scrap returned to refiners, and possible first-use metal from “residue”, for example transferred from other metal operations. Table 5 summarizes some of the available but disparate information for this category, including RIR information on copper. The data show that the recycling rate for most metals in the order of 30%. Palladium is an exception, and its recycling rate was not estimated. Its recycling is primarily from autocatalysts, but other sources may not be accounted for. The recycling rate for autocatalysts (10% according to one source) seems low, particularly when compared to PGMs recycling supply of 45% within Germany in 2001.<sup>169</sup> It is reasonable to expect, due to its value, that recycling rates should be similar to gold, all else being equal.

The second type of indicator describes the efficiency of scrap recovery of metal. Two standardized measures have been proposed by industry metals studies groups, but there are few data available to report on these metrics. The indicators are: Overall Recycling Efficiency Rate (Overall RER) which “indicates the efficiency with which end of life (EOL) scrap, new scrap, and other metal-bearing residues” are recycled; and EOL Recycling Efficiency Rate (EOL RER) which “indicates the efficiency with which EOL scrap from obsolete products is recycled.” This last metric considers end-of-life product management performance and may be useful to product designers, life cycle analysts, and policy-makers.<sup>170</sup>

### **6.2.1 Aluminum Recycling**

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The aluminum sector is well organized and thorough in its reporting of recycling. Recent data on the global aluminum industry differentiate materials flows for primary production, fabricator and end-use consumption, recycling flows, and indicate flux to and from the above-ground-stock of aluminum (Figure 17).<sup>171</sup> According to a 2006 supporting report completed for the International Aluminium Institute, recovered post-consumer (old scrap) and customer recycled metal (new scrap) together supplied one-third of the global aluminum supply in 2004 (see Table 5), with each of these two streams contributing approximately equal volumes.<sup>172</sup> If “fabricator scrap” (i.e. home scrap which is not generally counted in recycling), is included in the calculation, the recycled supply increases to 50% (see Figure 17). Furthermore, Figure 17 illustrates that for aluminum, the majority of metal mined and refined is still in use, and is present as “aboveground” stock, similar to what has been discussed above as a phenomenon for most metals. For aluminum, 73% of the metal ever produced is still present today in transportation, cable, and building components.<sup>173</sup>

**Table 5 Summary of global recycled production**

Metal	Global primary (mine) production	Estimated recycled supply to total annual production	Comment and source
Aluminum	33,100,000 tonnes	33%	2006 study based on comprehensive 2003 data <sup>174</sup>
Copper	15,465,000 tonnes Mine production, 2007 preliminary <sup>175</sup>	30%	Combined old and new scrap, including direct melt, 2006 <sup>176</sup> Compares to RIR of 34% for 2005 <sup>177</sup> 18% "secondary refined production" only, 2007 <sup>178</sup>
Tin	350,000 tonnes Refined production, 2007	30-40%	2007 ITRI estimate <sup>179</sup>
Cobalt	53,450 tonnes Refined production 2006 (primary & scrap refining) <sup>180</sup>	25%	Approximate, based on USA value 2006 <sup>181</sup>
Gold	2447 tonnes 2007 estimate <sup>182</sup>	27%	Recycled supply as fraction of total production in 2007 <sup>183</sup>
Palladium	226 tonnes 2007 estimate <sup>184</sup>	Not estimated	Global recycled supply of 23.8 tonnes <sup>185</sup> primarily from retired auto catalysts, amounts to approximately 10% of metal supply. See text for discussion.

Moreover, the industry is taking measures to identify and address losses of metal that occur each year, as material is dispersed, landfilled or otherwise lost from the economic system. In 2004, of the end-of-life material that became available, 31% was estimated to be lost (see Figure 17).

### 6.2.2 Cobalt Recycling

Cobalt recycling quantities are unclear. The cobalt industry tracks mining (half of which takes place in central Africa) separately from refining (which occurs in industrialized countries like Finland, Belgium, Canada and China). The Cobalt Development Institute notes that the supply of cobalt to refiners comes from both "new" cobalt from mines and recycling. Additionally, there is a new scrap re-melt loop for cobalt super-alloys within aerospace facilities.<sup>186</sup>

Refiners of cobalt accept primary concentrate from mines plus other cobalt-rich streams, likely including end-of-life batteries, recovered alloy scrap, cemented carbide scrap, and spent

catalysts.<sup>187</sup> In 2006, 25% of the USA annual consumption of cobalt was reported to be from scrap.<sup>188</sup>

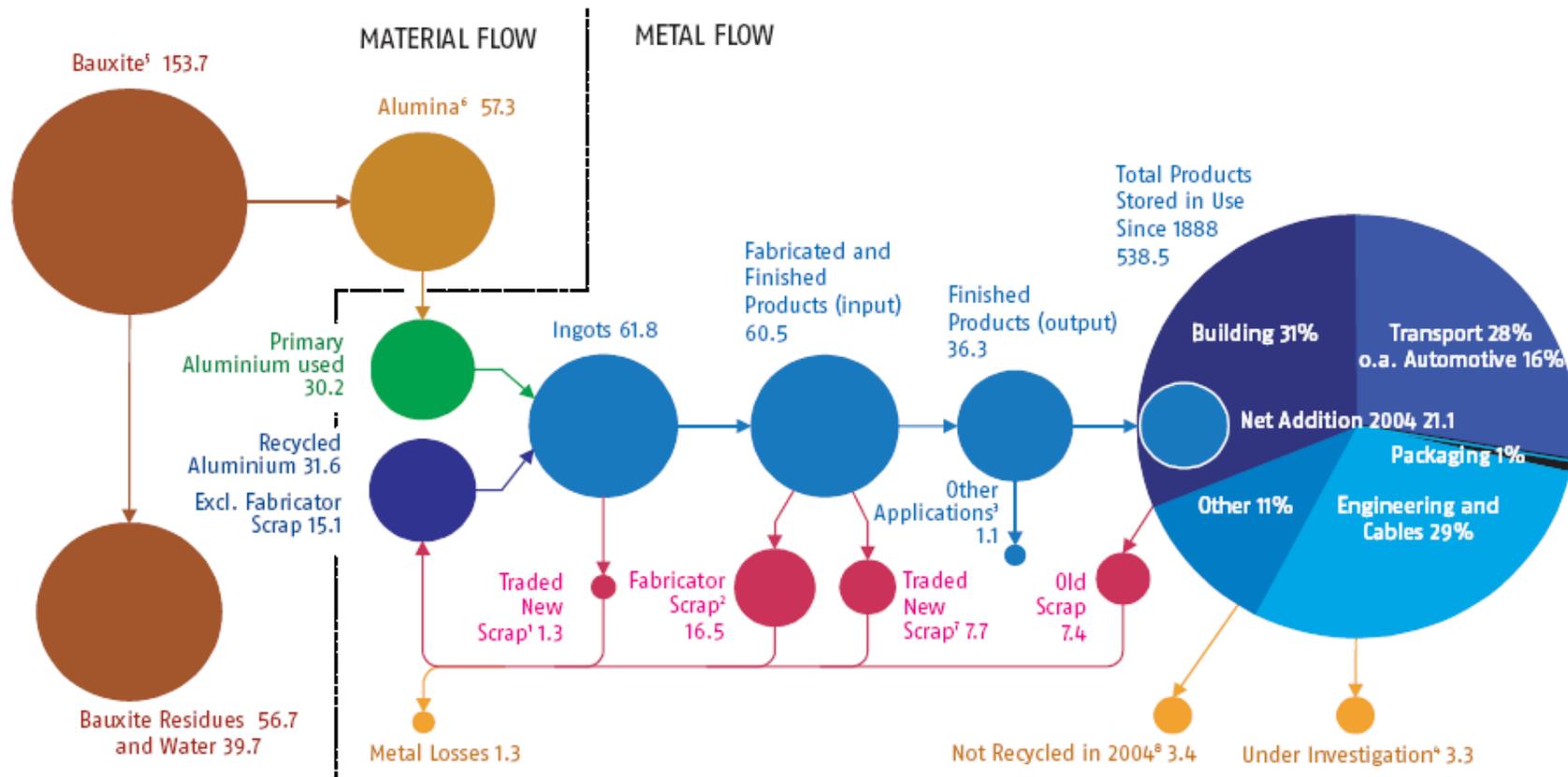
### **6.2.3 Copper Recycling**

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Scrap flows and trade are an area of considerable interest to the copper industry. According to a copper industry report, the supply of recycled sources of copper, as a percent of total world copper produced, has ranged from 28% in 2003 to 40% in 1995.<sup>189</sup> In 2006, the supply of recycled metal was estimated at about 30%.<sup>190</sup> At a more regional level, USA statistics illustrate some copper recycling facts:

- Each year in the USA, nearly as much copper is recovered from recycled material as is derived from newly mined ore.<sup>191</sup>
- USA scrap copper consumption is in a declining trend over the last decades, as the bulk of recovered copper scrap, especially old scrap, is being exported to other nations, like China and Pakistan.<sup>192</sup>
- Copper actually recycled in the USA is 80% new scrap, 20% old scrap.<sup>193</sup>
- Captured scrap is utilized mostly in non-electrical uses, often by brass mills, for example for use in tubes.<sup>194</sup>
- Electrical applications, including copper wire production, demand high purity metal, which is most economically obtained from newly refined copper (virgin, primary production) and is not from recycled supplies.<sup>195</sup>

Chinese recycled copper production is also notable, with China being the largest buyer of copper scrap in the world. In 2006, it was the leading recycler of copper, accounting for about 27% of its refined production, which supplements the country's position as the leading importer of primary copper concentrates.<sup>196</sup>



Values in millions of metric tonnes. Values might not add up due to rounding. Production stock not shown.  
 1. Aluminium in skimmings; 2. Scrap generated by foundries, rolling mills and extruders. Most is internal scrap and not taken into account in statistics; 3. Such as powder, paste and deoxidation aluminium (metal property is lost); 4. Area of current research to identify final aluminium destination (reuse, recycling or landfilling); 5. Calculated. Includes, depending on the ore, between 30% and 50% alumina; 6. Calculated. Includes on a global average 52% aluminium; 7. Scrap generated during the production of finished products from semis; 8 Landfilled, dissipated into other recycling streams, incinerated, incinerated with energy recovery.

Figure 17 Global aluminum flows 2004. <sup>197</sup>

### 6.2.4 Precious Metal Recycling

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Precious metals, including gold, platinum, palladium and to lesser extent silver are intensively recycled, with the supply of old scrap playing an important role in the dynamics of the market.<sup>198</sup> About 85% of all the gold mined since historical times is believed to be present in current “aboveground” stocks, with the remaining 15% believed to have been lost or dissipated in industrial processes, or unaccounted for.<sup>199</sup> BHP Billiton, a large mining and metals producer, estimates greater than 95% of gold is recycled.<sup>200</sup>

In 2007, the world’s gold scrap supply accounted for 27% of the total metal supply.<sup>201</sup> In the last ten years, the supply of gold scrap has risen, although it fluctuates due to economic conditions and pricing. For example, families in the populous country of India tend to use gold as a store of wealth. In times of need, or when prices are high, they tend to cash-in jewelry, converting it to other goods. It is important to note that the statistics for gold scrap only take into account traded scrap metal that is then refined back into bars; therefore, the statistics do not capture other recycling loops, such as those that may occur in jewelry fabrication shops, and which in the case of gold may include substantial amounts of unreported old scrap. Most of the old scrap comes from jewelry, with smaller amounts originating in the sectors of electronics, dentistry and coining.<sup>202</sup>

It is difficult to quantify palladium recycling because a large fraction of it, approximately 56% in 2006,<sup>203</sup> goes to durable use in automotive catalysts. Before 2000, the use of palladium was even higher, but as metal prices spiked, the automotive and electronic industries implemented substitutions for palladium, thus decreasing demand dramatically. In the next couple of years, recyclers are expecting a wave of obsolete palladium-rich automotive catalytic converters to become available. Regional analysis characterizing the flow of platinum group metals indicates that total PGM recycling is supplying 45% of demand within Germany.<sup>204</sup> Global analysis of PGM recycling rates needs to take into consideration regions that mine PGM (like South Africa and Russia) together with countries that have more automobile disassembly (like USA and Germany), so that there is a better understanding of these recycling rates; however, one set of global data suggests a global recycling rate for PGM to be approximately 10%.<sup>205</sup>

### 6.2.5 Tin Recycling

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Recycled sources are an important source of tin for refineries, but are not well characterized.<sup>206</sup> “[V]ery little is known of the sources of secondary material and the quantities involved.”<sup>207</sup> Estimates of tin recycling rates are complicated by several factors, such as region, and the type and source of scrap.<sup>208</sup> ITRI cautiously estimates that 30-40% of global tin supply is provided from recycled sources.<sup>209</sup> In 2006, the USA government estimated that old scrap provided 20% of the country’s tin consumption, while new scrap added another 5% to tin supply.<sup>210</sup>

Most tin recycling is from solder in electronic products; however, de-tinning of tinplate steel cans is important too.<sup>211</sup> In Asia, much more tin is likely recycled from electronic scrap than other sources, including both new scrap from manufacturers and old scrap arising from processed end-of-life products. In China it appears that primary tin metal feeds are supplemented by tin scrap, while in Belgium and Russia, tin refiners are mostly dependent on scrap materials.<sup>212</sup>

Since tin and copper are generally found together in old scrap, and tin and copper are metallurgically similar, the two may blend together into copper alloys, such as bronze. On a sectoral basis, the recycling of solder is limited by recovery and collection of end-of-life electronic components, not by metallurgical constraints around yield of metal separated; however, as discussed in the following section, in the case of electronics scrap, it is often gold and other precious metals that are the most valuable fractions. Consequently, strategic recyclers are designing their processes to maximize recovery of precious metals, possibly to the detriment of tin yields.

### 6.3 Recycling of Electronics

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The fraction of metal that is recovered and recycled from electronics is comprised of: (1) post-industrial scrap, mostly as new scrap from electronics manufacturing processes that is returned to metal processors, and (2) post-consumer, old scrap, that arises from end-of-life electronics products.

From a metals-industry perspective, the Nickel Institute has detailed the recycling of base metals from electronics, and suggests that there is “room for improvement.” Although they focus on nickel, their findings are relevant to other base metals (copper, cobalt, tin) and to a lesser extent, to precious metals (gold, palladium). For electronics, the institute estimates a broad base-metal recovery rate of about 30%, of which two-thirds tends to transfer into steel or plastics streams. The other 70% of electronics is dispersed by consumers or landfilled.<sup>213</sup>

The collection of electronics components faces distinct challenges since “use is mostly diffuse and technology is rapidly changing [thus] it is difficult to identify and separate [metal]-containing products.”<sup>214</sup> Once material enters recycling, further complications arise as “some goods will be crushed and fragmented (shredded) and subject to a metal/non-metal separation process. [Metal] collected in the metal fraction will be recycled but probably not into the nickel loop - into steel, copper and/or plastics.”<sup>215</sup> The same patterns are likely for cobalt and tin, although the Institute notes that “if the precious metal content of the metal fraction is high enough ... smelting facilities would extract [other metals] at the same time.” Looking to the future, it is noted that the “overall recycle rate is expected to increase significantly from the current 30% because of product end-of-life regulations [e.g. the EU WEEE regulation].”<sup>216</sup> In comparison to battery-powered electronic devices, it is interesting to note that “battery packs from hybrid vehicles [reasonably] will be 100% recycled.”<sup>217</sup>

According to Waste Online, a UK non-profit group, as of 2005:

*only a very small percentage of consumer disposable batteries are recycled (less than 2%) and most waste batteries are disposed of in landfill sites. The rate for recycling of consumer rechargeable batteries is estimated to be 5%.*<sup>218</sup>

Aluminum commodity data suggest that the rate of metal recovery from electronic products is low compared to other major product categories (Table 6). Consumer electronics, as a group, likely have lifetimes significantly less than the 12-year life span suggested in aluminum statistics for other consumer durables.<sup>219 220</sup>

**Table 6 Lifetimes of various end-products and worldwide end-of-life collection rates (2002).**<sup>221 222</sup>

Product category	Collection Rate	Product Life (yrs)
Automobiles	83%	13
Buildings	70%	40
Aerospace	75%	30
Aluminum cans	60%	0.25
Machinery & Equipment	48%	20
Electrical Cable	53%	50
Electrical Equipment	33%	20
Consumer Durables	21%	12

In a comprehensive study, Spatari et al<sup>223</sup> estimated that in 1994, the waste management system in Europe recycled about 60% of the copper from end-of-life. On a percentage basis, old scrap provided about 25% of copper supply and new scrap about 10%. Their analysis concluded that:

*[c]ontemporary management of copper in Europe suggests that recycling rates could be further increased, particularly since 40% of copper in waste goes to landfill in a given year and since waste generation rates are expected to increase in the future.*<sup>224</sup>

The same group notes that annual copper discard in Europe is 2 kg per capita, with electronics and vehicles comprising the bulk of that stream. Given a highly variable yet average recycling efficiency of about 48%, and given that waste electrical and electronic equipment “is the fastest growing waste category” they point to the need for improved electronics waste recycling strategies.

The International Copper Study Group recycling estimates that “waste electrical and electronic equipment” could provide approximately 19% of copper scrap availability; however, this is largely unrealised, as for example in 1999 the Group estimate that “office and ICT” waste accounted for approximately 1% of product end-of-life copper recovery.<sup>225</sup>

As a component of electronic products, gold has a high value given both its economic value and the volume of gold present, with generic content in electronic scrap in the order of 300-400 grams per metric tonne.<sup>226</sup> The precise amount of gold that is recovered from electronics is unknown. As gold prices have risen, the incentive to recover gold scrap has also risen. The implementation of new legislation related to electronic wastes in the European Union is expected to create incentives for gold recycling from electronics scrap.<sup>227</sup> The Umicore analysis in Section 3 (Metals in Electronics) points clearly to the economic value of precious metals recovery. Across various types of equipment, gold was the primary material of value in recycling, providing from 13% to 73% of electronic scrap worth. Palladium was often the second most valuable element by volume present, followed by copper and silver, depending on equipment type.<sup>228</sup>

### 6.3.1 Benefits of Recycling

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From an economic, as well as social and environmental perspective, two significant areas of benefits result from metal recycling:

- Recycled metal substitutes or displaces the necessity to mine new metal. Consequently, metal recycling offsets primary production processes, and their associated environmental impacts and energy consumption required to dig, crush, grind and otherwise metallurgically process virgin ore.<sup>229</sup>
- Metal scrap that is collected for recycling is material that does not have to be managed as a waste. It is a valuable resource that is converted into value-added commodities.<sup>230</sup>

For example, it is widely cited that aluminum recycling results in 95% savings in energy compared to mining the metal.<sup>231</sup> For other metals, assuming normal efficiencies and regular operating practices, the benefits may not be as great as for aluminum, but are generally very positive. Beyond the energy conservation benefits, there are additional environmental benefits, such as reduced land disturbance, water use, air emissions and waste generation. The job benefits and social impacts of metal recycling versus primary mining and processing are less certain.

Like primary metal production, the social and environmental conditions of recycling operations can be of serious concern, particularly where scrap is exported to poorer countries, where labor costs are low, but social and environmental conditions may be less controlled or illegal. Trans-border transfers and destinations of low grade copper scrap derived from electronic products such as computers are of concern because of the prevalence of uncontrolled conditions, hazardous compounds and other social and environmental concerns. “Even though China may be tightening its rules for importing electronics scrap, other poor countries may still be willing to accept these materials.”<sup>232</sup>

Recycling practices applied by the informal sector in developing countries have often efficiency as low as 25%, meaning that most metals are lost from societal use. This compares to the most sophisticated smelters and recycling plants, of which there are only a handful in the world, that can reach efficiency yields of 95%.<sup>233</sup>

Of note is the parallel between artisanal and small-scale electronics recovery and metal recycling and artisanal and small-scale mining of primary metal. Both involve poor people in developing countries, both face similar social and environmental problems and challenges, and both are difficult to address, being illegal or semi-legal activities on the margin of the formal economy. Recently it was suggested to alter the business model for the workers in the informal recycling sector.<sup>234</sup> Instead of focusing on precious metals by crude burning or leaching, they could more simply concentrate the parts that contain those metals and then sell them to a trader. The challenge would be to provide a similar income while transitioning to lower environmental and health impacts.

### 6.3.2 Strategies for Recycling

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Recycling of metals is largely driven by economic motives, and the recycling industry is well integrated into the economy. The constraint to greater levels of metal recycling is not demand;

rather it is the availability of feedstock material. Metal price determines the industry demand for metal sources, including recycled supply. Higher price stimulate more demand which in turn produces a higher availability as it becomes more worthwhile to collect previously unused stocks of recyclable material.

For metals, recycled content alone is not a good measure of environmental performance, and policies that promote purchasing of recycled metal content are likely not contributing to resource efficiency or improvements in environmental performance.<sup>235</sup> Increased buyer demand does not increase the supply of recycled metal.<sup>236</sup> In fact, it is suggested that application of a recycled content approach might create market distortions and environmental inefficiencies by shifting producers to inefficient processing or unnecessary transportation.<sup>237</sup> For example, jewelry vendors who claim to use only recycled content for their precious metals may be well-intentioned,<sup>238</sup> but are doing little to improve on environmental or social impacts at the mine level.

In terms of recycling strategy, in order to advance environmental and resource benefits, and support economic objectives, it is desirable to enhance the stock of metals available for recovery, and the efficiency by which they are recycled. Material flow studies are needed to understand how and where recycling can be improved. One viable option to enhance recycling could come from targeting old scrap from end-of-life products.

## 7 SOCIAL AND ENVIRONMENTAL ISSUES IN METAL MINING

Mining activities promise profound and numerous social benefits to communities in both the developed and developing world, such as increased general economic prosperity, improved quality of life and better public infrastructure; however, in many cases mining has negative social and environmental consequences, which are serious and continue to be of concern globally and for all types of mining. The benefits of mining must be seen in the context of the social and environmental costs that accompany this activity.

There are some general indicators that help in identifying and evaluating the social and environmental performance of a country. Figure 16, which shows global mine distribution for the metals of interest, also shows national values for various performance indicators, specifically:

- Environmental Performance Index (EPI) from Yale and Columbia Universities
- Human Development Index (HDI) from the United Nations
- Corruption Perception Index (CPI) from Transparency International
- Freedom In the World (FIW) index from The Freedom House

These indicators are not specific to mining issues, but provide an overview of the overarching concerns for various countries and regions.

Key stakeholder groups in mining issues include local governments and regulatory authorities, environmental non-governmental organizations, local and aboriginal communities, and financial institutions such as the World Bank. The diversity of perspectives related to mining is reflected in the following quotes:<sup>239</sup>

*“We need sustainable communities, not sustainable mining” Viktor Kaisiepo, West Papua, international representative of the Dewan Adat Papua (Papua Customary Authority)<sup>240</sup>*

*“Is there a market mechanism whereby countries can be compensated for ensuring that protected areas are not mined?” Simon Thuo, Kenya, Regional Coordinator, Global Water Partnership - Eastern Africa<sup>241</sup>*

*“Critics of development must reflect the local perceptions of where development is to take place” Duma Nkosi<sup>242</sup>, South Africa*

*“The issue of prior informed consent is important...but what are the boundaries around who decides” Sir Robert Wilson, Rio Tinto plc*

In many cases, stakeholders have questioned whether mining activities, particularly in the way they have been conducted in the past, is consistent with sustainable development. For example, Whitmore<sup>243</sup> estimates that based on figures from the late 1990s, mining consumed about 10% of world energy, produced 13% of global sulphur dioxide emissions, and threatened an estimated

40% of the world's undeveloped tracts of forest. In contrast, it only directly accounted for 0.5% of employment and 0.9% of 'gross world product.'

While mining of metals can provide economic benefits in the associated mining region, mining tends to disrupt ecosystems and can often be disruptive to communities surrounding the activity. Environmentally, mining disturbs soils and various ecosystems, impacts biodiversity, and can cause water and air pollution. Metals processing, including mineral crushing, smelting, refining and metallurgical recycling is both energy- and emissions- intensive. Leading operators employ substantial efforts to minimize harmful impacts while maintaining economically viable operations. "It is, however, a fact that by the very nature of our business, an individual mine is not sustainable because the ore reserves will be depleted over time."<sup>244</sup> Negative social impacts of mining range from human rights violations, labour issues, to socio-economic disturbances, corruption and conflict. In the case of both environmental and social issues, the extent and magnitude of the negative impacts of mining depend largely on the governance systems that are in place in the mining region.

Although these social and environmental issues can be found both in large-scale mining and artisanal and small-scale mining operations, there are certain issues which dominate each type of operation as discussed in the following sections.

## **7.1 Large-Scale Mining**

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Large-scale mining (LSM) operations can be very beneficial to communities, depending on how the operation is structured and how much stakeholder involvement there is. The mining activity is usually an important source of employment and wealth creation, often in areas where few other options exist. Mining can create new infrastructure, provide livelihoods, and can create positive economic spin-off benefits to communities.<sup>245</sup>

Although there are many potential benefits of LSM, these operations still suffer from a negative legacy of old, and in some cases on-going, social and environmental issues. The following sections categorize and discuss these concerns generally, and with respect to the metals in this study.

### **Environmental issues**

From an environmental perspective, key impacts associated with the extraction and processing of most metals include:

- land disturbance and its impact on ecosystems and biodiversity, plants and animals, including long-lasting impacts after mine-closure
- water pollution from tailings and effluents
- energy resources used for extraction, processing (particularly smelting) and refining of metals
- particulates, greenhouse gases and acid air pollution emissions from mining, smelting and refining operations

The concerns are also specific to the metal mined. For example, while **aluminum** is very abundant in the earth's crust, it is difficult and costly to extract as usable metal. Conversion of bauxite ore to alumina results in high volumes of hazardous red mud waste. Greenhouse gases (GHGs) are also of importance. The aluminum sector is a major direct and indirect emitter of GHGs, much more so than other mining and metals. In aggregate, primary aluminum production is responsible for about 1% of anthropogenic GHGs.<sup>246</sup>

The aluminum industry is closely connected to local governments in order to help ensure secure, long-term access not only to minerals, but also to electrical energy resources used for reduction processing and refining of aluminum. Local/regional stakeholder concerns are common in the siting of aluminum smelting facilities and associated greenfield hydro-power projects. These concerns are illustrated with respect to Alcoa (Box 1).

### Box 1- Social and Environmental Performance of Alcoa

Alcoa is widely regarded as one of the leading companies in the world, not just within the metals sector.<sup>247</sup> Alcoa's key issues with local communities largely relate to major development projects, particularly those involving hydroelectric dams. It is in this area – particularly with its green-field smelter in Iceland and various hydro related projects in South America – that Alcoa is most exposed. NGOs have targeted these projects as unsustainable based on perceived environmental threats and the necessity of relocating populations prior to dam flooding.

Alcoa's controversial dam project in Iceland continues to generate stakeholder difficulties; however the company has a comprehensive community engagement plan in place and has worked extensively with community groups in order to mitigate concerns regarding disturbance to one of the largest pristine areas in Europe. Alcoa then learns from and applies the approaches and information gathered previously when developing new operations. This method should benefit Alcoa's ability to smoothly develop greenfield projects as it expands into emerging markets like Russia, China, and South America. The company is currently expanding operations in Russia, Jamaica, Trinidad and Ghana.

There are some concerns with Alcoa's presence in countries with oppressive regimes. Alcoa is involved in bauxite mining in Guinea and various aluminum-related activities in China. Growth in China is a key strategic goal for the company, however this could entail increased sustainability risks, particularly on the human rights front. Alcoa holds an 8% stake in the state-owned Chalco aluminum company, and has initiated joint ventures with a variety of other partners. Both of these countries were considered "Not Free" in 2005 by Freedom House, a nonpartisan international organization that promotes freedom and democracy.

The company is also active in eight other countries considered to be only "Partly Free" – Argentina, Bahrain, Colombia, Malaysia, Morocco, Nepal, Singapore, and Venezuela. Alcoa will need to ensure that its corporate sustainability message gets through to these operations, as well as to its high-impact operations in Brazil, Suriname, and Guinea, since its joint-venture arrangements may loosen the firm's ability to monitor and control sustainability performance at these operations as expansion continues.

Environmental issues related to **cobalt** mining depend on whether cobalt is mined as a co-product of nickel or copper, or on its own. In Russia, Norilsk Nickel outputs copper, cobalt, palladium and other metals as co-product of nickel production. The Russian company is notorious for environmental and social concerns (see Box 2). In New Caledonia, there have been environmental concerns with the development of a nickel and cobalt mine by Goro Nickel. The company had to halt construction of a pipe to carry liquid mining waste for disposal into a lagoon. Activists, environmentalists, and locals were concerned about its potential to cause severe environmental damage<sup>248</sup> since the project is located in an area that is home to the world's greatest barrier reef system and largest lagoon, as well as unique plant and animal species. In 2006, erosion controls employed by the company failed, contaminating an important marine protected area.<sup>249</sup>

### Box 2- Norilsk Nickel Social and Environmental Performance

“Norilsk Nickel” operates in two regions of Russia, with its major site in the town of Norilsk on the Kola Peninsula in Siberia.<sup>250</sup> The Russian government considers its Norilsk operation confidential and does not allow visitors to enter without permission, and do not typically provide data on social and environmental performance.

The company ranks first among Russian industrial enterprises in terms of air pollution. Nine hundred thousand tons of sulphur dioxide is emitted by one Russian-based plant per year.<sup>251</sup> All three plants produce about two million tons of sulphur dioxide a year. This amount decreased approximately 16% since the end of the Soviet Union in the late 1980s.<sup>252</sup> According to Greenpeace Russia, the pollution from Norilsk has created a 30km (19 mile) "dead zone" around the city, and according to scientists the acid rain related to Norilsk has spread across an area equivalent in size to Germany,<sup>253</sup> with environmental damage around the city having “reached the level of ecological catastrophe, with even a partial recovery estimated to take at least 150 years.”<sup>254</sup> In Norilsk, the air quality related to Norilsk Nickel activities contributes to health risks such as chronic diseases of the lungs, respiratory tracts, and digestive systems.<sup>255</sup> The local population, and in particular children, are at high risk of illness associated to the toxic environment of Norilsk,<sup>256</sup> with Norilsk having the highest rate of child leukemia and birth defects outside of Chernobyl.<sup>257</sup>

Norilsk Nickel is beginning to take some steps towards improving its environmental performance, with representatives from the Blacksmith Institute visiting the Russian site in 2007 and confirming that the company was making efforts to address emissions and pollution. Progress is slow and emissions remain exceptionally high.<sup>258</sup> Norilsk partners with the international environmental project, the framework of the Arctic Council, whose Action Plan for 2001 calls for cleaner production and eco-efficiency.

**Gold** mining is frequently linked to significant environmental impacts. The metal is notable in that it is mined all over the world, at both large and small scales. Earthworks and Oxfam America, in a 2004 report, have pointed out impacts, such as: (1) 79 tonnes of wastes are

generated for every ounce of gold produced and (2) gold mining accounts for 96% of USA arsenic emissions<sup>259</sup> Additionally, according to the World Resources Institute, in the early 2000s more than a quarter of the world's active mines overlapped with strictly protected areas.<sup>260</sup> No Dirty Gold, a campaign led by Earthworks and Oxfam America, has identified 11 World Heritage Sites affected by gold mining.<sup>261</sup>

Due to the metal's low concentration in ores, large scale mining (which accounts for about 70-80% of the world's production) often uses a cyanide chemical cyanide extraction process. This entails risks to the environment, particularly if not well managed. In 2000, a large scale accident in a tailings dam in Baia Mare, Romania, released between 50 and 100 tonnes of cyanide to the environment, causing the death of thousands of tonnes of fish, the interruption of water supply in twenty-four localities, and other ecosystem damage.<sup>262</sup> The accident was described as the worst environmental catastrophe in Europe since 1986.<sup>263</sup>

The top-five gold mining companies (33% of the world's total production in 2006) are multinational corporations that embrace traditional tools of corporate responsibility, such as ISO certification and adoption of codes of conduct. From 1991-2006, major gold mining companies showed declining or stable levels of resource consumption of water, energy and cyanide, as well as decreasing greenhouse gas emissions.

There are several codes of conduct and initiatives directly and indirectly related to the issues of gold mining. Among the most important is the International Cyanide Management Code, an initiative of better SER performers in the sector. However, three out of the top-ten gold mining producers are not signatories of this code: Freeport-McMoRan, China National Gold Group, and Fujian Zijin Mining. Box 3 highlights some of the concerns with respect to gold mining in China.

### **Box 3-Social and Environmental Performance of China in Gold Mining**

The emergence of China as the top global gold producer in 2007 raises attention to that country's management capacity in the sector, especially considering that there have been reports of serious social and environmental problems in China's gold mining.<sup>264</sup> China was found to be the country with the largest releases of mercury to the environment from artisanal and small-scale mining.<sup>265</sup> Five Chinese companies,<sup>266</sup> whose websites do not provide substantial information on SER, are among the top gold producers. Moreover, there is very limited English-written information in the websites of China Gold Association<sup>267</sup> and of the Ministry of Land and Resource.<sup>268</sup>

The creation of the China International Mining Group<sup>269</sup> is important in this context, because it aims to serve as a forum for international mining and service companies to foster sustainable business opportunities in China's mining industry.

China National Gold Group, the 2006 world's ninth ranked gold producer, responsible for 20% of the gold production in China,<sup>270</sup> does not provide information on its website related to social and environmental issues. Although a member of the World Gold Council, the China Group is not a signatory of the Cyanide Code. Another Chinese company, the Fujian Zijin Mining, the world's tenth largest gold producer, discloses little detail of its "environmental protection work" on its website.<sup>271</sup>

Palladium production is dominated by Norilsk Nickel in Russia (see Box 2) and in South Africa, where a number of companies operate dedicated PGM mines. In South Africa, environmental concerns are related to water pollution and air quality. Water issues include use and change in water flow (water quantity) and contamination of water sources (water quality).<sup>272</sup> Additionally, there are concerns over eco-sensitive areas, particularly related to wetlands and biodiversity.<sup>273</sup> Air quality concerns are related to sulphur dioxide and particulate emissions, as well as energy use issues which impact on greenhouse gas emissions. The leading palladium producing company in South Africa, Anglo Platinum, is working to address these environmental, as well as some social concerns (Box 4).

#### Box 4- Anglo Platinum Addressing SER issues

In South Africa, Anglo Platinum is trying to improve conditions in PGM mines. Initiatives include: development of infrastructure, such as road building; supporting education through school renovations (including water and sanitation infrastructure) and teacher training; health initiatives such as development of health facilities and HIV support and care; and community capacity building through local economic development projects.<sup>274</sup> On the environmental issues, Anglo Platinum is improving technology to reduce sulphur dioxide emissions and greenhouse gas emissions.<sup>275</sup>

### Corruption

Corruption, in regions with weak governance, is one of the main obstacles in ensuring the equitable distribution of wealth from primary sector activities, including mining and minerals. These issues tend to be country-specific, and are illustrated in Figure 16 under the indicator of Corruption Perception Index (CPI). Even leading and major companies in the sector have been accused of bribing officials to secure or speed up the mine permitting process, especially in susceptible regions.<sup>276</sup> Bribery and corruption are damaging to local economies and human development as they divert revenue away from the government priorities and bring little benefit to local communities.<sup>277</sup> Mineral extractive operations can also bring about a range of negative social and environmental externalities.<sup>278</sup>

As an example, a large amount of **cobalt** is mined in the DRC, which is plagued by widespread corruption, and is still recovering from its 1997-2003 civil war.<sup>279</sup> On a scale of 1 to 10 on the CPI, DRC has a rating of 1.9, illustrating the severity of the government corruption issue.

### Social Disruption

LSM operations can have a positive impact on communities, through social development, such as education, health care, and infrastructure development (e.g. hospitals, schools, roads, communications networks); however, there are also social problems that often accompany LSM operations, through the indirect contribution of a large inflow of quick wealth to a locality. This includes widespread consumption of alcohol, local increases in gambling and the introduction of, or increase, in prostitution, often with increased incidences of HIV/AIDS. Violence in the local

community also tends to increase.<sup>280</sup> Additionally, unmanaged in-migration from other regions or countries to mining centers due to perceived financial opportunities, can overburden already inadequate public services and strained social fabrics.<sup>281</sup> Social impact assessment often identifies the potential for these indirect impacts, and in regions of strong governance, put the onus on mining companies to address these issues prior to starting operations, and to provide a plan for minimizing these issues during operation.

## Labor Issues

Although there are many companies who work hard to prevent or remedy issues when they arise, in some regions and with some companies, there are still accusations of abuses by large-scale mining companies. These abuses have either come directly from the companies or in conjunction with local governments. Accusations include abuse of employee health, safety and rights, including not paying fair wages, denying employees the right to organize unions, the arbitrary dismissal of employees, the exploitation of children for labor and the violation of women's rights.<sup>282</sup>

For example, alleged injuries to women are frequent in mining regions, and have contributed to the creation of an International Women and Mining Network and a series of international conferences on the topic.<sup>283</sup> A notable illustration of this problem took place in the Rio Tinto subsidiary's Lihir gold mine, in Papua New Guinea, where women were excluded from formal compensation negotiations.<sup>284</sup>

## Human Rights Abuses and Conflict

Mining companies have been accused of contributing to human rights abuses, and local conflict or insecurity. Accusations of human rights violations in mining regions are frequent, especially in the early stage of large mining enterprises located close to vulnerable communities and indigenous groups. Prominent examples include, in Indonesia, during the early development of the Rio Tinto's gold mine Kelian Equatorial Mining (KEM) in East Kalimantan, significant human rights violations occurred,<sup>285</sup> which were acknowledged by the company<sup>286</sup> in 2004.

Freeport-McMoRan Copper & Gold is a major USA mining company, and its subsidiary, PT Freeport Indonesia, operates the Grasberg mine in the eastern Indonesian region of Papua. This operation has been subject to considerable attention by NGO groups. A Global Witness October 2007 report raised concerns about human rights, including allegations that the company has given financial and material support to an Indonesian military garrison, used as security forces for the mine.<sup>287</sup> Further, Global Witness claims that these Indonesian troops have committed mass killings and other serious human rights abuses in the region, and that the close relationship and financial support between Freeport and the security forces is troubling for many Papuans.<sup>288</sup> Freeport has always denied knowledge of abuses, but after it commissioned an independent audit that identified several issues, including an on-going link to military,<sup>289</sup> it has openly acknowledged that problems exist, and is implementing solutions in an on-going effort.<sup>290</sup>

In the Democratic Republic of Congo (DRC), there are stories of international mining companies contributing to local insecurity. In 2004, a group of six or seven people attempted to occupy the town of Kilwa near the Australian-Canadian Anvil Mining Limited's Dikulushi copper-silver

mine in south-eastern DRC, causing Anvil to suspend work at the mine. The next day, the national army launched a military operation in Kilwa, during which they committed grave human rights violations against civilians, including arbitrary arrests, detentions, and executions. At least 73 civilians died. Global Witness reported that an Anvil press release said: “government and military response on both provincial and national levels was rapid and supportive of the prompt resumption of operations.” Global Witness also reported that mass graves were identified in the vicinity of the Kilwa mine and according to a United Nations report, “three of Anvil Mining’s drivers drove the vehicles used by the national army, and food rations were supplied to the armed forces [by Anvil] ... Anvil has also admitted that it contributed to the payment of a certain number of soldiers.”<sup>291</sup> Anvil Mining has recently become involved with an initiative in the DRC, which is addressing many of the social issues in the region (see Section 8.3.3 for details).

Other companies have reacted to allegations of abuse with positive programs. For example, an independent inquiry at a mine in Borneo found that there were a number of cases where local Dayak women and girls had been raped or coerced into having sex by local employees. Following these charges, Rio Tinto partnered with a local NGO and the Indonesian Human Rights Commission to examine the issue in an open and transparent forum. The company has also helped to raise awareness of human rights issues at the operation.<sup>292</sup>

### **Community Displacement and Land Claims**

Community and native displacement, as well as land claims issues are common to mining operations, regardless of scale or location. In Latin America, the majority of newly developed mining regions occur on inhabited land. As a result, the resistance towards mining investment has led to an increase in conflicts between Latin American poor and indigenous communities opposing foreign multinational, though mainly Canadian, mining companies.<sup>293</sup> Resistance against large mining operations is common across regions, however this resistance is significantly pronounced in Latin America (Box 5).

These issues are also prominent in Africa and South Pacific regions. For example, Goro Nickel mine, in New Caledonia in the south Pacific, has been plagued with concerns over social issues, relating to land rights, with allegations that native Kanaks are in strong opposition to the project, citing the project’s potential social and environmental impacts as a concern.<sup>294</sup>

The development of the Mindoro nickel and cobalt mine in the Philippines was also strongly opposed by the residents and local government and churches. In a letter to their government, the local authorities stated that:

*At the outset, we stress the undisputed fact that Mindoro Nickel Project does not have any iota of social acceptability on the part of the people of Oriental Mindoro. The entire political leadership of this province represented by the Governor, the Representatives of the two congressional districts of the province, all the 15 city/municipalities of Oriental Mindoro, have categorically and unconditionally opposed the Mindoro Nickel Project. Thus, these local Sanggunians have not issued any endorsement for the Mindoro Nickel Project.*<sup>295</sup>

### Box 5- Social Issues in South America-Indigenous rights and lands

In Colombia there have been reported concerns over Canadian companies' involvement in violence carried out in the mining industry. Conquistador Mines Ltd has been exploring gold deposits in the southern province of Bolivar, where 'guerrillas and paramilitaries are violently fighting for support of local residents and where human rights groups, including Amnesty International, argue "massacres carried out by paramilitaries have sown terror among peasants and miners who are opposed to foreign firms' activities."<sup>296</sup> *The Toronto Star* has reported "[Canadian] companies are functioning inside a civil war zone, a war that has everything to do with wealth and power. Nobody—least of all the foreign gold miners—are [sic] neutral"<sup>297</sup>

There are also extreme conflicts developing between the Canadian corporation Skye Resources and indigenous peasants in Guatemala, the Mayan Q'eqchi.<sup>298</sup> In Ecuador Ascendant Copper is in opposition against activists who are struggling against the company's Junín mining project. In Mexico the community of Cerro de San Pedro is resisting the Canadian gold mining company Metallica Resources Incorporated.<sup>299</sup> Da Capo Resources mining corporation—which later merged with the USA corporation Granges Incorporated, becoming Vista Gold Corporation—reportedly laid the groundwork for the Christmas Massacre in the Bolivian mines of Amayapampa and Capasirca in 1996. Ten civilians were killed and 40 others wounded as a result of military repression of protests supported by the corporation. Two of the dead were 15 years old.<sup>300</sup>

According to the Philippines Indigenous Peoples Links website, the project violates the lands and rights of Mangyan indigenous peoples in several communities. Indigenous communities were not adequately consulted on how the project would affect their land, and in particular the potential of the project to affect the local economy, which is predominantly farming and fishing.<sup>301</sup> This case highlights the contentious issue of obtaining free and informed prior consent for mining, as discussed in Section 8. In contrast, GeoVic had been preparing an extensive SER plan to address many issues related to social responsibility, including land rights (Box 6).

The Bench Marks Foundation cites the following as major social issues arising from mining platinum/palladium in South Africa: land claims issues and lack of appropriate compensation for relocation; benefits of mining not trickling down to communities; poor housing conditions;<sup>302</sup> and changing flow of water, which affects farmers and communities who are left without drinking water.<sup>303</sup> Additionally, a 2008 Action Aid report alleges that Anglo Platinum is conducting intrusive mining activities that are damaging homes and environment, that it is taking legal action in response to community challenges to land take-overs, and mine expansions are contributing to further community displacements.<sup>304</sup> See Box 4 for Anglo Platinum response to other concerns.

### Box 6-GeoVic Mining- A Best Practices Plan in SER

GeoVic, the world's first primary cobalt producer, is expected to start production on its cobalt mine in the Cameroon in the near future, and has developed a plan reflecting best practices for socially and environmentally responsible development of this resource. The plan addresses social issues, land rights, sustainable livelihoods, and environmental stewardship.<sup>305</sup> The effectiveness of this plan in addressing these issues will only be known once it has been implemented.

### Health and Safety Issues

Mining has many health and safety risks associated with it, regardless of the scale of a mining operation, and LSM is not free from this issue. Mining activities are generally unsafe with an above-average number of risks for employee safety. Underground metalliferous mines have the highest rate of fatalities of any industry. The gold industry, which mostly consists of large-scale operations (about 75% of gold is mined by LSM), suffers the highest average number of fatalities. For example, there has been one fatality per year in every 1000 people in gold mines in South Africa in the period from 1990– 2000.<sup>306</sup>

Safety for miners in the platinum/palladium mines of South Africa are also a major concern,<sup>307</sup> since the very deep underground mines are not easily mechanized, requiring human labor to extract the ores. In 2007, there were 40 fatalities in South Africa's platinum mines.<sup>308</sup> Anglo Platinum is responding to safety issues through technology changes and education and by moving away from subcontracting.<sup>309</sup> Health and safety issues, such as Noise Induced Hearing Loss (NIHL) are being addressed through changes in technology and ear protection.<sup>310</sup>

## 7.2 Artisanal and Small-Scale Mining (ASM)

A large fraction of some metals, such as tin and gold, is mined by ASM. The complexities of the ASM issue require case-by-case awareness to provide appropriate incentives and solutions to overcome the issues that plague this livelihood. ASM already contributes positively to sustainable development and livelihoods, and has the potential to make further positive contributions, but it must be developed in such a way that it is appropriate to the local needs and circumstances.

Industry studies and academic literature provide some direction on how to address ASM issues, recognizing that one of the main goals of ASM reform is poverty reduction. Some recommendations include:

- Recognition of the importance of ASM by governments, donors, and NGOs,<sup>311</sup>
- Recognizing ASM as a distinct sector that requires institutional support by government and bankers,<sup>312</sup> and incorporation of ASM activities into regional and local development programs,<sup>313</sup>
- Governments need to develop appropriate, consistent, and transparent policy and regulatory framework to facilitate, manage, and most importantly formalize ASM with incentives,<sup>314</sup>

- Recognition of the connection between large-scale mining and ASM.<sup>315</sup>

The major social and environmental concerns related to ASM operations are discussed in the following sections.

One of the environmental impacts of greatest concern is mercury pollution associated with ASM gold mining.<sup>316</sup> Mercury is released in two ways. First, there is natural mercury that is freed because of human disturbances of the landscape, such as through road-building and digging. Second, because of its availability and low cost relative to alternative technologies, mercury is widely used by artisanal and small-scale mining to dissolve gold into an amalgam, allowing for separation of valuable metal from the remaining sand. Mercury is then evaporated off, often in an uncontrolled manner over an open flame, leaving pure gold metal. Mercury is potentially lethal. However, unlike cyanide, mercury poses additional long-term toxicity risks because its concentration in the environment grows over time (bioaccumulates) resulting in harm to fish and other biological populations. Inefficient amalgamation techniques are estimated to result in the release of 800 to 1000 tonnes of mercury to the environment annually;<sup>317</sup> and more than one-third of this amount is released in China (see Box 3) and Indonesia.<sup>318</sup>

Other environmental aspects of ASM activities include: direct dumping of tailings and effluents into rivers; threats from improperly constructed tailings dams; acid mine drainage;<sup>319</sup> water pollution and river damage/siltation;<sup>320</sup> erosion damage and deforestation;<sup>321,322</sup> and landscape destruction.<sup>323</sup> The environmental externalities associated with ASM activities can create social costs on the order of 10% of the annual GDP of a country.<sup>324</sup>

Informal tin mining in Indonesia has had a negative environmental impact on drinking water, fishing and tourism. Municipal water supplies have been contaminated and in some cases, shut off all together.<sup>325</sup> Local fishermen can no longer catch fish in coastal waters contaminated with tailings and the tourism industry complains about dirty waters and beaches.<sup>326</sup>

Wide-scale environmental degradation has marred two islands in Indonesia, between Sumatra and Malaysia, which account for about one-third of global tin mine production. Recent reports of environmental damage describe a landscape “so devastated by mining that it bears an eerie resemblance to the surface of the moon” and craters “as big as football fields” filled with acid water.<sup>327</sup>

‘Rush’ operations, where there are newly accessible finds and the perception of quick wealth, can also lead to social disruption and conflict. This can include the high incidence of prostitution, and the spread of HIV/AIDS.<sup>328</sup>

## Human Right Abuses and Land Claims

Land conflicts are prevalent in small-scale mining, and can have serious negative impacts on the natural environment and the well-being of the local population. Most artisanal miners have no ownership rights to the land that they mine, meaning that there is no incentive for managing the resources in a sustainable manner.<sup>329</sup> Additionally, large scale mining companies will often establish mining sites in areas of traditional artisanal and small-scale mining, leading to potential conflicts related to ownership and livelihoods, a problem that is exacerbated in post-conflict states,<sup>330</sup> such as the DRC.

In 2006-2007, governments with large tin resources initiated an industry transition towards formalizing and legalizing acceptable forms of small-scale and informal mining, via the use of regulatory and police actions. The Indonesian government enacted a sudden clampdown on illegal small-scale mining and illegal smelters in 2006.<sup>331</sup> On the island of Bangka regulators and police shut down more than thirty illegal smelter operators, most of whom operated without land licenses.<sup>332 333</sup> Similarly, in Bolivia in 2006, “thousands of cooperative workers were integrated into the state metals company.”<sup>334</sup> In October 2006, workers from “mining cooperatives and state-employed miners clashed, resulting in 16 deaths and 61 wounded.”<sup>335</sup> After involvement of the country’s president, conflict subsided.<sup>336</sup>

The overall social consequences of moving away from small-scale production to more regulated and managed production of tin has not yet been clearly explored (e.g., unemployment/displacement of workers in Indonesia and China). ITRI suggests the small-scale mining will always remain an important part of tin supply due to the nature of tin deposits, and therefore will be important to development of those areas<sup>337</sup> if properly developed and managed. The key issue is not that small-scale mining activity exists, but that ASM tends to be informal, poorly managed and difficult to regulate.

### **Gender Issues**

Gender issues are also significant in ASM because approximately 30% of the world’s artisanal miners are women.<sup>338</sup> Women’s roles in ASM range from labourers (e.g. panners, ore carriers and processors), to providers of goods and services (e.g. cooks, shopkeepers). The contribution of women to artisanal mining varies with region. In Asia, few miners are women (less than 10%), while in Latin America, the number of women involved is somewhat higher (about 10 to 20%).<sup>339</sup> The highest percentage of women in artisanal mining is found in Africa (between 40 and 50%).<sup>340</sup> Women are often overlooked by initiatives and development programs for transforming artisanal mining into a sustainable activity.<sup>341</sup>

### **Child Labor**

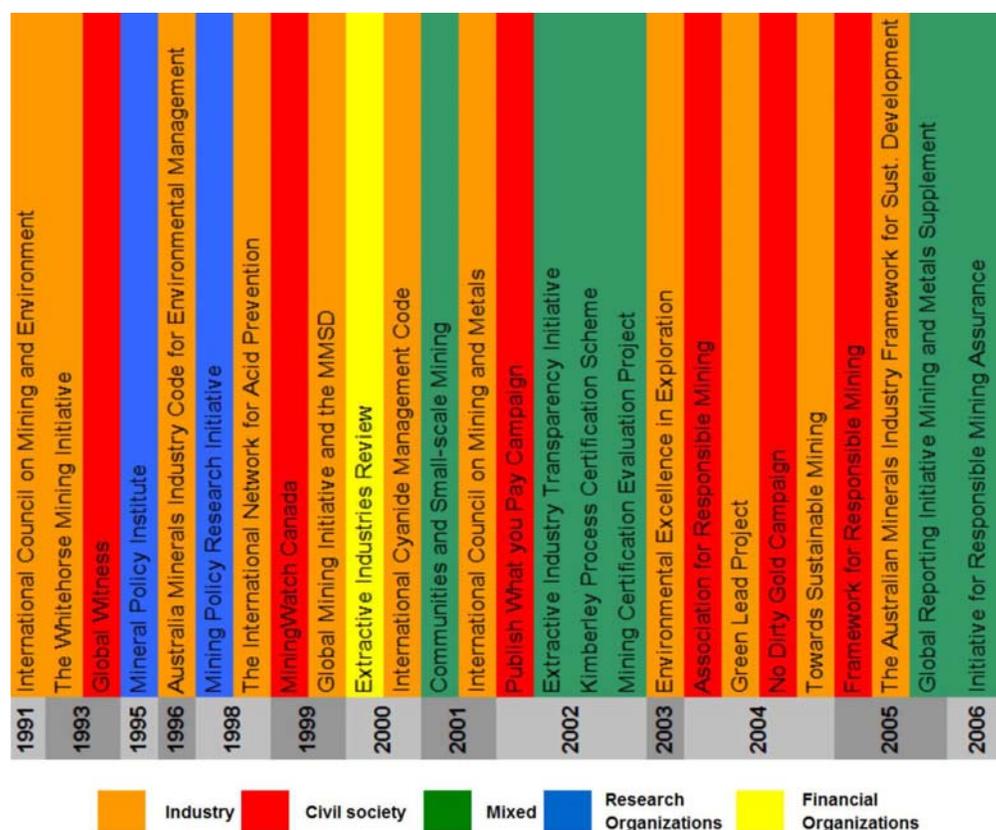
Child labor is also a major concern. According to ILO an estimated one million children work in small-scale mining and quarrying around the world, under appalling conditions, including long hours in surface and underground mines, crawling through small spaces, and exposure to harmful substances such as dust, lead and mercury.<sup>342</sup> Child labour in general is being addressed by several organizations, and the latest estimates by ILO show that the number of child laborers fell by 11% globally over the past four years, while the number of children in hazardous work has decreased by 26%.<sup>343,344</sup>

### **Health and Safety Issues**

As in the case of LSM operations, health and safety is a major concern in ASM activities. ASM is often conducted under highly hazardous and uncontrolled working conditions. According to the ILO,<sup>345</sup> the major health risks associated with ASM are: exposure to dust, mercury and other chemicals; effects of noise and poor ventilation (heat, humidity, lack of oxygen); effects of overexertion, inadequate work space, and inappropriate equipment; and the transmission of communicable diseases including tuberculosis, influenza, cholera, yellow fever, etc.<sup>346</sup>

## 8 SER INITIATIVES

The electronic industry seeks to understand whether it can address SER issues at the mining level, or whether it can influence mining companies in terms of these issues. For decades, the mining industry, and its associated SER concerns have been—and continue to be—addressed. Numerous studies, initiatives, councils and programs related to these concerns have been undertaken or are on-going (Figure 18). The mining and metals industry has been undergoing intensive internal and external discussions with respect to social and environmental responsibility since the late 1990s. A key driver behind these discussions was a lack of progress from the sector in addressing environmental and social impacts of mining, metals production and use.



**Figure 18 Chronology of relevant non-state initiatives directly related to fostering sustainability in the mining sector.**<sup>347</sup>

Unlike the chemical sector (through Responsible Care<sup>®</sup>) and the forestry sector (through sustainable forest management programs like the Forest Stewardship Council), the mining and metals sector had not clearly addressed sustainable development in the past. This situation led to recognition, amongst other concerns, that the industry’s “social license to operate” and its

credibility was at risk, compounded by its inability to articulate and contribute to sustainable development for a broad base of stakeholders. This includes maintaining access to mineral rights, ensuring capital, providing product stewardship, securing government permits, and gaining the trust of communities and employees.

This section describes some SER initiatives that could be relevant for the electronic industry, beginning with a background to two major studies into the mining industry and their findings: the Mining, Minerals and Sustainable Development (MMSD) Project; and the Extractives Industry Review (EIR) Process, commissioned by the World Bank in response to stakeholder concerns. These two studies and their findings and recommendations were critical in the development of many of the main SER initiatives discussed in the following sections.

## **8.1 *SER Findings from the MMSD Project and the EIR Process***

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The Global Mining Initiative (GMI) was established in 1998 by a number of the more progressive companies in the sector (BHP, Anglo American, Noranda, WMC Resources, Phelps Dodge, Placer Dome, Rio Tinto, Newmont, Codelco) to initiate a discussion on issues around the reputation of the mining industry and the implications of sustainable development.<sup>348</sup> The GMI commissioned an extensive, independent two-year global research initiative known as the MMSD Project, led by the International Institute for Environment and Development, coordinated by the World Business Council for Sustainable Development (WBCSD), and performed by an independent research group, mostly funded by nine of the world's largest mining companies. A separate Assurance Group oversaw the work, which included diverse NGO and labor participants in addition to industry and government reviewers.

The MMSD Project addressed major themes for sustainability for the sector including: production and trade of minerals; land use; economic development; communities and mines; environmental impacts; life-cycle of minerals; artisanal and small-scale mining; and governance requirements. The final report, “Breaking New Ground”, published in 2002, was an authoritative study, unprecedented in its scope. Its conclusions are based on four regional processes, including Africa and Indonesia, over 175 commissioned studies, 23 global workshops and experts meetings, and a 7-week public review of preliminary conclusions.<sup>349</sup> The project also made significant efforts to remain independent, and as a result, it is widely accepted that this was accomplished.<sup>350</sup> The extensive recommendations that resulted from the study addressed the multi-faceted and complex social and environmental issues related to mining and metals. The study was followed by a global conference, the formation of the International Council of Mining and Metals (ICMM)<sup>351</sup> to take a lead role in promoting sustainable development within the sector, and included a declaration that outlined a number of initiatives designed to improve the sector's social and environment performance. In summary, the MMSD report found that there was a need for:<sup>352</sup>

- an industry protocol for sustainable development
- a commitment to address the negative legacy of the past
- supporting legalization of artisanal and small-scale mining

- integrated management of the full mineral chain
- more effective government management of mineral investment
- a more equitable international trade regime for minerals

Several of these recommendations are currently being implemented, in whole or in part, by various initiatives and programs as discussed in the following sections.

Another major study was The Extractives Industry Review (EIR) Process, which was an initiative of The World Bank Group (WBG) in response to concerns expressed by a diverse group of stakeholders around mining, particularly those from environmental and human rights organizations. The EIR began in July 2001, and was headed by Dr. Emil Salim, former Minister of the Environment for Indonesia. The EIR, like the MMSD, was a consultative process designed to engage all stakeholders—governments, NGOs, indigenous people, affected communities and community-based organizations, labor unions, industry, academia, and the World Bank. The main goal of the review was to determine whether extractive industries projects were compatible with the goals of sustainable development and poverty reduction.

The final report, “Striking a Better Balance”, made recommendations to the WBG including:<sup>353</sup>

- Pro-poor public and corporate governance (i.e., governance structures which address distribution of relative incomes to favor the poor) in particular, the need for revenue transparency as a condition for new investments, and not funding projects in areas without adequate governance
- More effective social and environmental policies, particularly for small-scale and artisanal mining, biological diversity, waste management, and project closure
- Respect for human rights, such that extractive industries projects that receive WBG financial support protect human rights, including recommendations regarding the use of security forces to protect project sites;
- That project proponents secure the free, prior and informed consent of potentially affected communities, affording such communities the opportunity to effectively engage in the decision-making processes that concern their lands, resources and livelihoods<sup>354</sup>

In a response to the EIR report written by Dr. Salim, the WBG agreed with many of the recommendations in its September 2004 published response, but made very few commitments. Dr. Salim, in a critique of the WBG response, called it “Business as Usual with Marginal Change.”<sup>355</sup>

## **8.2 Responsibility in SER Issues**

Based on the MMSD and EIR studies, as well as other literature, the following is a list of responsible parties:

- Governments – especially national governments—to provide governance, set rules and define frameworks for mining.

Effective governance in the mining sector is lacking in most developing countries.

*It is important to focus on capacity building throughout the sector. Government has a central and unavoidable role to play in improving governance for sustainable development through a national policy framework, regulation, and enforcement. But not all governments have the capacity to make the changes. Therefore it is especially important to focus on strengthening the capacity of national and local governments to design and enforce regulations.*<sup>356</sup>

State governments and their capacity for legitimate institutions, accountability and strong social and environmental policies play a large role in SER issues. Mineral resources are owned by the nation and are meant to contribute to economic development. The wealth provided by minerals should, in principle, be proportionately distributed within a country.<sup>357</sup> When the wealth distribution mechanism fails, often through corruption and the absence of management frameworks, the wealth goes to the powerful, giving rise to internal grievances, which can result in conflict. Therefore mineral development often does not contribute to poverty alleviation and broader economic development at the national level.<sup>358</sup> Land rights are also interlinked with regulations and government policy. The role of governments is illustrated for Canada with respect to changes in regulations and environmental assessment in recent years (Box 7), and shows that the political environment in which a company operates may be key to understanding how it acts. Although mining companies are often expected to resolve these governance issues, the MMSD study emphasizes that “companies should not have to assume the role of government at the local level”<sup>359</sup>

- Mining companies and the mining industry

For many mining companies, sustainability issues are still largely about “license to operate”, i.e. to maintain community and regulatory relations and access to the mineral in the ground. The MMSD report suggests that companies ensure that the mine project works constructively with government development programs so that the community can achieve sustainable development.

In relation to the role of mining companies and governments, Marius Kloppers, CEO of BHP Billiton states:<sup>360</sup>

*...sustainable development is about ensuring that our business remains viable and contributes lasting benefits to society. It is certainly not about philanthropy or soft marketing, but about maximizing value creation and gaining a strategic competitive advantage. We recognise that our bottom-line performance is dependent on ensuring access to resources and securing and maintaining a licence to grow. Therefore, maximising the bottom-line is about maintaining the same laser-like focus on social, environmental and ethical considerations as we do on operational and cost issues.*

*It will be interesting to see how countries in the developing world ensure they realise long-term benefits from the sustainable development of their vast natural resources... Smart countries will partner with companies that are committed to implementing these learnings.*

**Box 7-Governments Role in SER of Mining**

Governments play a key role in establishing laws and regulations for how a mine operates with respect to preventing and addressing social and environmental concerns. The Canadian Environmental Assessment Act is a regulation that requires a review panel for projects that may have significant or unknown adverse impacts on the environment, with mining projects often falling in this category. Under the Act, sustainability must be considered in assessing the impact and significance of projects. The following two cases highlight how regulations can affect the social and environmental performance of mining projects, as well as the “license to operate” for mining companies.

The Voisey’s Bay mining project in the province of Newfoundland and Labrador in eastern Canada has been heralded a success for the mining community on how corporate, Federal, Provincial and Aboriginal interests can reach compromise. Inco (now Vale-Inco) wanted to develop the Voisey’s Bay nickel-copper-cobalt deposit,<sup>361</sup> located within areas that are subject to land claims by two groups of Aboriginal people.<sup>362</sup> The two groups struggled to come to terms with the mine project, which among other issues, could threaten the migration of caribou central to their livelihood.<sup>363</sup>

The Terms of Reference for an environmental impact statement, imposed on Inco a “contribution to sustainability” test, such that Inco would ensure a long project life and avoid the negative ‘boom-and-bust’ consequences of mining in the region. Inco made a number of concessions in the negotiation process, including the decision to use a 6,000 t/d instead of a 20,000 t/d mill. This decision should extend project life and create the precedence for future community involvement.<sup>364</sup> Given that the regional authorities could not fully mitigate the ecological damage that would result in the development of the mine, Inco set forward on a strong plan of environmental stewardship that involves the engagement of local people and all levels of government. The rationale for their stewardship program is to ensure that even after the mine closes, the community and its environment will be healthy.<sup>365</sup> Although there are still some unresolved issues, the Voisey’s Bay mine is operating in an widely acceptable manner.

Northgate Minerals owns a copper and gold mine in western Canada in the province of British Columbia (Kemess South), which is being decommissioned, and was planning to extract metals from another section of the same geology (Kemess North). The Kemess North project involved a plan to dump mine tailings into Amazay Lake, which would effectively kill the lake ecosystem. The lake has sacred, cultural and environmental significance to the Tse Kay Neh. In reviewing the environmental impact assessment of the project, the review panel considered the following sustainability criteria: Environmental Stewardship; Economic Benefits and Costs; Social and Cultural Benefits and Costs; Fairness in the Distribution of Benefits and Costs; and Present versus Future Generations.<sup>366</sup> In September 2007, the review panel decided that any economic and social benefits from the project were outweighed by its long-term risks to the environment and by its social and cultural impacts on Aboriginal people.<sup>367</sup> It recommended to federal and provincial environment Ministers that the project not be permitted and this recommendation was approved by the Minister of the Environment on March 10, 2008.<sup>368</sup>

- Financial players, who fund mining projects and expect return on capital, or those like the World Bank, who provide financial assistance for development

MMSD suggested that international agencies, such as WBG, were in a unique position of influence and responsibility, particularly related to their ability to harmonize standards by which communities are treated, and to influence public and private-sector concerns with these standards.<sup>369</sup> An additional role of these agencies was seen as developing broadly applicable guidelines for integrated impact assessment for sustainable development in projects in which they are involved. Finally, it was suggested that they assist in the development of Community Sustainable Development Plans and continue to fund capacity-building initiatives for communities and state institutions.

The EIR revealed similar responsibilities, but also highlighted that while extractive industries investments can contribute to sustainable development, the WBG support for major mining companies versus small-scale mining initiatives was imbalanced. For example, during the period of 1990-2002, the IFC provided an average of \$100.8 million a year to multinational mining corporations, while in 2002 WBG support of small-scale mining initiatives appears to be \$610,100.<sup>370</sup>

- Community and local organizations, labor groups and other local stakeholders, NGOs

In recognition of the various perspectives related to mining development in communities, the MMSD report<sup>371</sup> discusses that international NGOs, in particular, need to further develop policies to provide guidance for community engagement, since the interests of communities may be different from development and environment advocacy groups.

- Manufacturers and other consumers

There is also a role and responsibility for SER issues by manufacturers that use metals and minerals:

*The most influential consumers of minerals are large manufacturing companies. In terms of sustainable development, the activities of the manufacturing industry are significant in several regards: the quantity of minerals used in a product, the manner in which the product is used, the source of the components or raw materials, and to whom the product is sold.*

*Decisions taken by leading manufacturing companies can be an important driver for change, as demonstrated in the forest products sector, though the same is yet to take place for mineral commodities. Due to the lack of interest[action] of large metals consumers, there is currently no mechanism to pass increased social and environmental costs on to the final consumers.*

*Most consumers of mineral products (with the possible exception of fabricators of raw metal products) feel remote from mining and minerals processing companies. This separation between production and consumption is often a physical one, but it is also due to the complexity of many manufactured products, which may contain small quantities of many mineral commodities combined with other materials and distributed in hundreds of components. This disconnect between the*

*producers and consumers of minerals poses serious challenges for the [mining] sector to move forward in a sustainable fashion.*<sup>372</sup>

The makeITfair campaign, which aims to raise consumer awareness of the social and environmental concerns related to mining of metals that are found in consumer electronics,<sup>373</sup> has contributed to making the SER connection and raising awareness about issues related to mining metals, electronics manufacturing, and consumer responsibility.

World Wildlife Fund-United Kingdom (WWF-UK) has also launched a campaign to inform consumers of the social and environmental performance of the luxury goods sector. It implicates this sector, particularly luxury brands, as responsible for the conditions under which the use of precious metals and minerals used in luxury goods are mined, in addition to its role and responsibility in other aspects of the supply chain such as sourcing, manufacture, marketing and distribution of products and services.<sup>374</sup> The report “Deeper Luxury: Quality and Style” was released in December 2007.

Other stakeholders may include individual consumers, and even the commodity exchanges, which act as middlemen into the system.

### **8.3 SER Initiatives in Mining and Metals**

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Several programs and initiatives related to SER issues in mining have arisen both as a result of the MMSD Initiative and the EIR Process and as independent responses to mining concerns. The types of initiatives and actions that attempt to address SER issues in mining can be broadly categorized as Mining or Metal Associations; Certification and Product Stewardship; NGO programs; and Governance approaches.

#### **8.3.1 Mining and Metals Associations**

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Almost all metals are represented by a commodity association. Two of the more prominent groups with respect to SER issues are covered here.

##### **International Council on Mining and Metals (ICMM)**

ICMM was established as an outcome of the Global Mining Initiative, formed by nine of the largest mining companies, which also partly funded the MMSD project. Currently, the ICMM consists of eighteen of the largest mining companies in the world. The number of mines and productive capacity of this group is very significant, accounting for a majority of production of many metals.

The ICMM Sustainable Development Framework includes 10 principles, public reporting of performance in line with the Global Reporting Initiatives (GRI's) Sustainability Reporting Guidelines (G3, 2006 Guidelines) and the Mining and Metals Sector Supplement (MMSS), and independent external assurance of compliance.<sup>375</sup> The GRI reporting supplement, part of the world's most widely used sustainability reporting framework, sets out principles and indicators that organizations can use to measure and report their economic, environmental, and social performance.<sup>376</sup>

ICMM is also comprised of associate members, including metal sector associations (e.g. Cobalt Development Association, International Aluminium Institute, International Copper Association, and the World Gold Council) and national mining bodies. The programs of ICMM can thus extend to companies other than its direct company members. The World Gold Council, for example, has formally committed to ICMM's principles.

The ICMM has a vision of a “viable mining, minerals and metals industry that is widely recognized as essential for modern living and a key contributor to sustainable development.”<sup>377</sup>

This is being addressed under their work program as follows:

1. Development of ICMM's mandatory sustainable development framework
2. Bringing the perspective and experience of the industry to global sustainable development forums
3. Facilitating materials stewardship (e.g. life cycle programs) and promoting regulations based on sound science.
4. Boosting the mining industry's socio-economic contribution to the countries and communities where ICMM companies operate.
5. Continuous improvement of industry's health and safety performance.
6. Enhancing the industry's environmental performance.

A recent ICMM report suggested the development of “engagement programs with downstream manufacturers, users and recyclers. ...a key mechanism for advancing materials stewardship along the value chain.”<sup>378</sup>

### **ITRI (formerly the International Tin Research Institute)**

ITRI is a UK-based trade association that supports the tin sector, and focuses on market analysis, sustainability and general industry promotion/communication for the sector. In 2005 the “Sustainability Project” was initiated, coordinated by the ITRI and financed by a \$5 per tonne environmental levy on member company sales. Planned actions include: a reserve-resource data set, recycling data, consumption statistics, life cycle assessment, and a characterization of the social and economic benefits of tin. The project also addresses requirements of the EU Chemicals Policy REACH and aims to provide better understanding of the fate and behavior of tin in the environment.<sup>379</sup> The status of the levy, encouraged across all producers, is not known. As of 2007, the Sustainability Project is seeking involvement across the supply chain of tin, so far engaging more than 90 companies in the tin industry.<sup>380</sup> In the past, producers have been fairly disconnected from downstream users and issues, and discussions of SER topics have been limited.<sup>381</sup>

### **8.3.2 Certification and Product Stewardship**

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#### **The Council for Responsible Jewellery Practices (CRJP)**

The CRJP has international scope and focuses on responsible supply chain practices for precious metals and gemstones.

*Our objective is to promote responsible ethical, social and environmental practices throughout the diamond and gold jewellery supply chain, from mine to retail.*<sup>382</sup>

The CRJP has membership from all phases of the diamond and gold supply chain, including the financial community. This council considers responsible, ethical, social and environmental practices throughout the diamond and gold jewelry supply chain – from mine to retail.<sup>383</sup> It is an initiative that is partially responsible for the launch of the Initiative for Responsible Mining Assurance (IRMA). In its final implementation, the CRJP will cover the key aspects of responsible business practices, including business ethics, human rights and labor standards, environmental performance and community standards for multiple phases of the supply chain.<sup>384</sup> Currently, it is in its very early stages of action. It has completed a Statement of Principles describing the fundamental ethical, social, human rights, and environmental standards necessary to maintain consumer confidence in the diamond and gold jewelry supply chain, and a Draft Code of Practices defining responsible ethical, social, human rights and environmental practices for organizations working in the Diamond and Gold jewelry supply chain.<sup>385</sup> At this point, this is a best-practice initiative rather than a certification scheme. The general outlook is that it has a high chance of succeeding in its mandate.

#### **Mining Certification Evaluation Project (MCEP)**

MCEP was the first major attempt to address the issue of a certification program specifically for mining. The main focus of the project was to assess the feasibility of third-party certification of the environmental and social performance of mining operations. using the Forest Stewardship Council certification scheme as a model, and to address governance issues in mining. Its mandate is describes as follows:

*The MCEP is a three-year research project investigating the feasibility of third-party certification of the environmental and social performance of mining operations. As a research activity, it has not attempted to create a working certification scheme, but is establishing a knowledge platform for broader international debate and future effort.*<sup>386</sup>

MCEP began as a working Group of seventeen people of various perspectives: mining companies, NGOs, government, academia, labor and other agencies. The main actors were Anglo American, BHP Billiton, MPI Mines, Newmont, Placer Dome, Rio Tinto, and WMC Resources; Minerals Council of Australia; WWF, Oxfam Australia and the Construction Forestry Mining and Energy Union; Government; and researchers from the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Centre for the Study of Health and Society at the University of Melbourne.<sup>387</sup>

The project began in 2002, with WWF-Australia being responsible for the overall management of the project and the MCEP Working Group being formed to direct and contribute to the work program.<sup>388</sup> MCEP used the ICMM Framework for developing criteria against which mine site environmental and social performance could be assessed. This project and its findings have been a foundation for the Initiative for Responsible Mining Assurance.

### **Initiative for Responsible Mining Assurance (IRMA)**

IRMA is a multi-sector effort, launched in Vancouver, Canada, in June 2006, “to develop and establish a voluntary system to independently verify compliance with environmental, human rights and social standards for mining operations.” Participants include mining companies (AngloGold-Ashanti, BHP Billiton, DeBeers Group, Newmont, Rio Tinto), jewelry (or jewellery) retailers (Tiffany & Co., Wal-Mart/Sam's Club), NGOs (Canadian Boreal Initiative, Center for Science in Public Participation, Conservation International, EARTHWORKS, Great Basin Resource Watch, Northern Land Council, Oxfam America, Pembina Institute, Renewable Resources Coalition, World Wildlife Fund) and trade associations (Council for Responsible Jewellery Practices, International Copper Association, International Council of Mining and Metals, Jewellers of America, the Nickel Institute), and individual participants. The initiative is meant to address social and environmental issues associated with mining operations, provide fair and equitable distribution of benefits to communities, and provide effective responses to potentially negative impacts to the environment, health, safety, and culture.<sup>389</sup>

IRMA had a one year mandate to establish an initial set of standards and verification system by July 2007, and is aiming to add to existing foundation of research, tools, and initiatives ranging from the Framework for Responsible Mining, to the ICMM Sustainable Development Framework, to the findings of the MMSD Project, to the Mining Certification Evaluation Project.

This is an ambitious undertaking and it is difficult to capture all metals mining and markets in one scheme. The multilateral process has been underway for several years. The next stage of results is anticipated for summer 2008, which may or may not provide a path for mine certification.

### **The Eden Project**

The Eden Project is an independent program in the UK, which completed a chain-of-custody certification in 2007 on a large copper purchase for construction of a new building roof. The Eden Project metals initiative:

*... is looking at the feasibility of recognizing and rewarding good practice along selected supply chains of metals and minerals. It aims to raise awareness of issues surrounding these supply chains and encourage a more integrated approach to metals and minerals stewardship schemes.<sup>390</sup>*

The initiative was an effort that included Rio Tinto. The aim was to track metals and minerals from the mine to the end product so that responsible behavior at all stages of the supply chain could be achieved. Currently, the Eden Project is exploring options by reviewing and compiling case studies on accredited supply chains to determine how they operate, identifying key challenges in supply chain management, and analyzing the various successes and limitations of

such schemes. The group acknowledged that supply chains can be long and complex for manufactured items like electronic products, which may include over twenty metals, each from different mines. The metals are likely to be in different components – manufactured in different factories – each with its own supply chain. Few supply chain stewardship schemes exist for products derived from metals and minerals (other than relatively simple examples like diamonds and gold for jewelry).

### **Kimberley Process Certification Scheme (KPCS)**

The KPCS started in Kimberley, South Africa, in May 2000 when diamond producing countries met to discuss ways to stop the trade in ‘conflict diamonds’ and ensure that diamond purchases were not funding violence and conflict. In December 2000, the UN General Assembly adopted a resolution supporting the creation of an international certification scheme for rough diamonds.<sup>391</sup>

In November 2002, negotiations between various stakeholders resulted in the KPCS which sets out the requirements for controlling rough diamond production and trade.<sup>392</sup>

*The Kimberley Process is an international initiative supported by governments, industry, NGOs and the UN to stem the flow of conflict diamonds – rough diamonds that are used by rebel movements to finance wars against legitimate governments. Its national certification schemes ensures that shipments of rough diamonds are free from conflict diamonds.*<sup>393</sup>

As of September 2007, the KP has 48 members, representing 74 countries. In November 2007, a plenary in Brussels further consolidated the Kimberley Process.<sup>394</sup> Although the certification is expected to work for diamonds, it does not help weak governments strengthen their institutions; as a result developing countries are challenged in actual implementation of the resolution’s recommendations.

### **The Green Lead Project**

The Green Lead project is a private sector project addressing issues related to the sustainability of the mining and use of lead.

*Green Lead™ builds on the principles set out in the sustainable development charter of the International Council on Mining and Metals (ICMM) and the lead risk reduction programs of the International Lead Management Center (ILMC).*<sup>395</sup>

The project has membership includes various Lead Zinc groups (ILZRO, ILZSG) and Lead groups (ILMC, LDAI); mining companies (BHP Billiton, Xstrata); NGOs (WWF Australia, Eco Futures); and International Council on Mining and Metals. The impacts of the life cycle of lead metal are being considered, starting in Australia, and include environmental, social and product stewardship issues. The project began in 2004 and to date has established some protocols. It has identified that it will achieve a contribution to sustainability by:<sup>396</sup>

- Identifying the environmental, health and social impacts associated with Lead and Lead Products.

- The Certification and Monitoring of Products and organizations that comply with the Green Lead Protocols.

The project attempts to extend product responsibility to all those involved in the life cycle, including suppliers, manufacturers, distributors, retailers, consumers, and recyclers.

### **Coltan Traceability**

Coltan (a mineral containing the metals niobium/columbium and tantalum) demand for electronics, particularly cell phones, resulted in an increase in illegal traffic of this mineral, which helped finance a 1998-2003 war and resulting humanitarian crisis in the central African country of the DRC that killed an estimated 5.4 million people<sup>397</sup> and created environmental concerns. As a result, the electronic industry responded by asking its manufacturers to not source coltan from the Congo. Recently, there has been interest in physically identifying coltan from the DRC. The DRC hopes to set up a scheme to certify coltan produced within its borders in 2009, in order to boost profits from legal exports. According to the Deputy Mines Minister of the DRC, Victor Kasongo:

*All the large companies are fighting for this. They'll be able to display a certificate to prove fair trade. You'll begin seeing many machines, many [products], that are certified.*<sup>398</sup>

Chemical tracing of coltan assumes that the areas producing coltan have unique mineral characteristics that will allow the ore to be traced to its origin. It also presumes the absence of mixing or sources along the supply chain, a consideration that may not be feasible. Whether this approach applies to tracing other metals had not been elaborated.

### **8.3.3 NGOs**

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#### **Communities and Small-Scale Mining (CASM)**

CASM began in March 2001, as a response to the EIR Process. The goal of CASM is:

*To reduce poverty by supporting integrated sustainable development of communities affected by or involved in artisanal and small-scale mining in developing countries.*<sup>399</sup>

CASM aims to improve the economic, social, and environmental performance of ASM activities, to provide better coordination between the various institutions working in this sector, and to address the complex social and environmental challenges facing small-scale mining communities.<sup>400</sup> CASM is attempting to establish productive relationships between local communities, large scale mining companies and government agencies in various regions, including Asia (e.g. China and Mongolia) and Africa (e.g. DRC and South Africa). CASM's work involves 35 other organizations in 25 countries across different regions, with potential benefits for thousands of people.<sup>401</sup> CASM donors include the UK's Department for International Development and The World Bank Group.<sup>402</sup> Other partners include: Natural Resources Canada; Trust funds from Austria, Denmark, Netherlands, and Switzerland; and the Global Mining Research Alliance.<sup>403</sup>

CASM-Africa is acting on ASM issues throughout Africa. In August 2007, it held a Donor Coordination meeting in the DRC, which was convened to try to address how to provide effective intervention in the DRC, to address the many problems occurring in this region. Some of the key players were mining companies such as Anvil Mining, Ashanti Goldfields Kilo, BHP Billiton, and DeBeers; international agencies such as ILO, World Bank, CASM, and USAID; and NGOs such as Global Witness, Human Rights Watch, Durban Process, and Pact.<sup>404</sup> Most of the work being done to address ASM issues is in the province of Katanga of the DRC, and a key issue that was identified was the need to not over-emphasize Katanga in aid and funding so as not to aggravate historical resentments between various regions of the DRC. The Kasai region was also identified as a key area to support due to the great potential for conflict in the future in the absence of intervention.<sup>405</sup> Some of the group was to meet in the fall of 2007 to move forward from the lessons learned at the Donor Meeting and to determine how to include additional stakeholders. There has been no update on the CASM site on whether this meeting took place or the outcome of it.

On February 4, 2008, an annual CASM-Africa workshop titled “Recognizing the role of Artisanal Small-Scale Mining in Community Development in Africa” was held in Cape Town, South Africa, with the support of Rio Tinto.<sup>406</sup> Issues that were relevant to South Africa included technology development and the role of women in ASM.

## **Pact**

Since its inception in 1971, Pact has had as its goal to empower local organizations in order to attain sustainable development. In 1992 Pact established itself as a nonprofit corporation.<sup>407</sup> Major project funds include two large grants, management programs addressing democracy and governance and HIV/AIDS, as well as projects to promote livelihoods, natural resource management, and peace building.<sup>408</sup> Their project work includes technical assistance and capacity building. Pact’s latest groundbreaking work is the development of:

*A new alliance with a set of mining companies, NGOs and donors in DR Congo to further social development aims in the country and to increase the capacity of these companies to operate as good corporate citizens. The alliance is centered in Katanga province where it is tackling such tough issues as artisanal mining, health care and education, human rights and security.*<sup>409</sup>

Pact is acting as a node for a multilateral effort to address the most crucial issues facing the DRC, which include governance, corruption, conflict, and ASM issues in the mining sector. Pact is working with CASM (funding provided by CASM), Anvil Mining, Katanga Mining Limited, Nikanor, Tenke Fungurume Mining, the DRC national government (funding through SAESSCAM, a World Bank funded training program that offers assistance for capacity and technical training and social development projects for ASM), and other NGOs. Most of the work being done to address ASM issues is in the province of Katanga. Some work has started with Ashanti Goldfields Kilo and Pact in the region of Ituri.<sup>410</sup>

Its efforts to improve the sustainability of ASM, and to provide sustainable livelihoods and community development, and its team-approach with CASM and mining companies, makes it a

very strong initiative, with possibilities of engaging with multinational companies interested in issues of ASM and development.

At the CASM donor meeting in the DRC, Karen Hayes, who is the Extractives Industry Program Director for Pact, said:

*...we need massive scale effort here. This is not about funding individual projects, it is about fundamental and large scale interventions at political level, in terms of resource management, for social transition, and with substantial resources.*

Pact works as a facilitator and mediator and seeks high quality partnerships, including government and business, to solve problems using a bottom-up approach.

### **Association for Responsible Mining (ARM)**

ARM started in 2003 as an independent, global-scale effort, and pioneer initiative, created as an international and multi-institutional organization to bring credibility, transparency and legitimacy to the development of a framework for responsible artisanal and small-scale mining.<sup>411</sup>

Its mandate is to meet the Millennium Development Goals and Declaration of Sustainable Development, with respect to: human rights; decent work; quality of life and sustainable human development for ASM communities; legality; environmental stewardship; gender equality; and fair trade.<sup>412</sup>

ARM began in 2004 and along with FLO (Fairtrade Labelling Organizations International) have signed a Memorandum of Understanding (Standard Zero for Fair Trade Artisanal Gold and Associated Silver and Platinum) to continue developing standards for Fair Trade artisanal gold and associated metals (silver and platinum).<sup>413</sup> Pilot projects are underway in Bolivia, Colombia, Peru and possibly Ecuador, with Green Gold Corporation (see below) being one of its first pilot projects.<sup>414</sup> ARM is conducting pilot projects to address complexity related to diverse types, sizes and levels of organization of ASM, and to determine how the standards perform in communities where different organizations are interlinked in the supply chain<sup>415</sup>.

ARM has two main objectives: 1) to create and accredit a viable, reliable and transparent certification process to address the global problem of unregulated artisanal mining; and 2) to focus on fair trade standards as they offer a market niche for small scale producers all over the world<sup>416</sup>.

### **Green Gold Corporation**

This is a regional project, based in western Colombia, considered as a pilot project of ARM. It focuses on artisanal mining of gold.

*The Green Gold Corporation contributes to the wellbeing of the communities of the biogeographic regions of Choco, through research and training processes, the promotion of alliances and productive systems and the sustainable use of natural resources.*<sup>417</sup>

The project involves various communities, ARM, IIAP (Institute of environmental research of the Pacific), and NOVIB (Dutch Development Agency). It was initiated as a response to the

devastation by large-scale mining on unique ecosystems and aims to create an equitable society with sustainable livelihoods.

To date, the project claims some successes, such as the first green gold jewelry collection made in May 2003, and the restoration of mining areas with local species, which has established alternative resources of income from cocoa, ginger, pharmaceutical plants, etc.<sup>418</sup> By 2010, the project hopes to be recognized by its efficiency and commitment to the socio-environmental management in the region, as a result of qualified human resources, a solid infrastructure and five ongoing projects.<sup>419</sup> Green Gold Corporation is a model for best practice for placer gold mining in the world of ASM but it has limited production capacity.<sup>420</sup>

### 8.3.4 Governance

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#### **Extractive Industries Transparency Initiative (EITI)**

The EITI is a response to the EIR Process recommendations. It addresses government corruption and supports improved governance in resource-rich countries through the verification and full publication of company payments and government revenues from oil, gas and mining.<sup>421</sup> The EITI:

*...aims to strengthen governance by improving transparency and accountability in the extractives sector. The EITI sets a global standard for companies to publish what they pay and for governments to disclose what they receive.*<sup>422</sup>

EITI is a joint effort by governments, companies, civil society groups, investors and international organizations and is led and managed by the UK Government and the Department for International Development (DFID). The EITI mandate is to ensure that revenues from extractive industries contribute to sustainable development and poverty reduction, reduce government corruption in resource-rich countries, and increase transparency regarding the payment of taxes and royalties by resource extraction companies, especially in countries plagued by the problems of bribery and corruption.<sup>423</sup>

Over 20 countries are in various stages of EITI implementation but none are yet compliant. To date, criteria have been established for implementing EITI in various countries and the EITI Secretariat is developing a guide for Business Managers on how to support the implementation of the EITI that should be available in the Spring of 2008.<sup>424</sup> The EITI sets out clear responsibilities for companies that support the EITI or who are operating in EITI implementing countries, and it requires that companies operating in the relevant sectors in countries implementing EITI have to disclose material payments to the government.<sup>425</sup> Ultimately, if this initiative is successful, it would address corruption and bribery and could promote sustainable development in developing countries by ensuring that funds from mining companies are used for local development. This is an important government-led global initiative by which to address concerns around government roles in mining, corruption, and resource benefits for sustainable development. It addresses government taxes, royalties, distribution to communities and citizens, and building of governance, institutions and infrastructure.

## 9 DISCUSSION AND RECOMMENDATIONS

The overall objective of this study was to help understand how aluminum, cobalt, copper, gold, palladium and tin are mined, recycled, purchased and where they are used in electronics products. Specifically, it considered whether EICC and GeSI members might influence SER issues at the mining level. To provide some context to the study, a review of current thinking on CSR in supply chain management was provided. The use, trade, mining and recycling of metals in the electronic industry were addressed and particular attention was placed on the current SER concerns and initiatives in connection with the selected metals.

The types and amounts of metals in electronics products vary from product to product, from brand to brand, and also change as technologies evolve. This, coupled with the absence of precise tracking of metal use across sectors, makes it challenging to provide an accurate estimate of the fraction of metal supply going specifically into electronics. By making certain assumptions, as detailed in this report, the electronic industry, with the term electronics being defined broadly, was estimated to use, as a fraction of global annual metal supply, a maximum of 36% of tin, 25% of cobalt, 15% of palladium, 9% of gold, 2% of copper, and 1% of aluminum.

The metals of interest in this report are commodities that are traded globally. The majority of trade is executed through direct contracts between sellers and buyers, with prices established in reference to those set on commodity exchanges. A small but important fraction is traded through commodity exchanges, such as the London Metal Exchange, where future pricing allows for management of risks associated with supply and demand. Cobalt is traded exclusively through direct buying, but nonetheless operates similarly as a commodity. Gold is both a commodity and an important international financial product, and its trade is more complex. The buyer-seller relationship often hinges on commercial conditions wherein neither party may be prepared to divulge details of their transactions.

Metals are 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. Each producer at each stage of production may mix different flows from different sources, depending on economics and availability. Because metals are elements, there is no inherent difference in properties from one unit of metal to the next. Given these patterns and the absence of tracking schemes, it is difficult to clearly follow the physical flows and trade of metals. Further investigation is needed to reveal a more quantitative understanding of specific metal quantities delivered through exchanges compared to those going through the direct market, particularly in the context of SER supply chain management. It is expected that volumes traded will vary from commodity to commodity, from year to year, and will depend on market influences like economic prognosis, investor behavior, supply disruptions, and shifts in manufacturing demand.

Globally, the annual supply of metal comes from mining, stored inventories (e.g., strategic stockpiles and gold bullion), and recycled production. Some metals, such as gold, are mined in more than 75 countries, whereas others, such as tin and palladium, have a more concentrated

geographic source. For some metals, such as cobalt, aluminum and copper, the loci of metal mining differ significantly from the loci of metal processing (including smelting and refining). Approximately 150 of the major mining companies control 83% of global mined value. Companies vary from large multinational corporations with dozens of sites, to state-owned firms that focus on production of one or a few metals from a country's mineral reserves, to intermediate-sized producers with only one or two mines. Additionally, there are artisanal and small-scale miners that operate manual and informal operations at a much smaller scale.

The global pool of supply of metals is changing, with more and more primary material being mined in developing countries, which tend to pose higher risk with respect to poor social and environmental conditions, and the absence of strong governance structures (See Figure 16). As of 2006, the biggest mining regions are as follows:

- Australia is the leading producer of aluminum ore (bauxite) (35%). As much as 20% of aluminum is produced by ASM, in China.
- The DRC is the leading producer of cobalt (41%) followed by Zambia (12%), and the fraction of mining from Central Africa is expected to grow.
- Chile is the leading primary copper producer (35%).
- Gold extraction is geographically distributed with South Africa, United States, Australia, and China producing an aggregate of 40% globally. ASM gold activities contribute to an estimated 20 to 25% of global production.
- Palladium is mined in Russia (44%) and South Africa (38%).
- Tin is mostly mined in South Asia, with China producing 41% and Indonesia 30% of global production. About 50% of tin is produced by small-scale miners.

In addition to primary metal production, metal scrap and refined recycled metal contribute substantially to the global metal commodity supply and international trade. Even though statistical information on recycling varies for the metals addressed in this study, the contribution of metals produced by recycling was found to be about 25 to 40%.

Recovery and recycling of metals from electronic products are low compared to other end-use products, such as automobiles and industrial equipment. A number of reasons are pertinent: there are very small amounts of metal in any given electronic product; many different metals are present in each product; some metals are much more valuable than others in the quantities present; electronic products are very diverse in type; and products are widely dispersed during their use. Together, these factors make for challenges in both the collection of metal from these products (estimated globally at less than 30%). Moreover, the efficiency of recycling of their metal content from such a complex feed ranges dramatically, from 25 to 95%, from worst informal-sector processor to best sophisticated operation.<sup>426</sup> Economic, environmental and resource incentives together driving efforts to increase the fraction of metals conserved in use, particularly for the valuable elements gold and palladium, by recycling metals from electronic products at end-of-life.

The general constraint to greater levels of metal recycling is not a lack of demand for recycled metal; rather it is the availability of old scrap that feeds recycling. In particular, the collection of old scrap from end-of-life products is constrained by the narrow margin between the costs of collection and processing and that of metal prices. As such, policies that focus on promoting purchasing of metal with recycled content are likely not contributing to societal environmental objectives in the sense that increased demand for recycled metal specifically does not lead to increased availability of recycled metal, nor does it affect the total quantities of recycled materials entering the total metal pool. In terms of recycling strategies, manufacturers and policy makers are advised to focus their efforts on helping to reduce costs and increase quantities of old scrap metal made available for recycling as a basis for a strong sustainability approach. Whitmore, for example, suggests that recycling is something that the primary mining industry should be considering:

*...there is definitely a logic and market for increased production of recycled materials (or even the use of current stockpiles ... there is, after all, enough gold stockpiled to meet demand for 17 years). About half of the world's lead is derived from recycled sources, as is a third of aluminium, steel and gold. Energy savings of up to 70% are available through recycling, not to mention the benefits from reduced toxic emissions, as well as to occupational health and safety. Yet, partly thanks to subsidies, companies search for new green field sites when so much useful metal lies in landfills (although some pilots on mining landfills are happening in the United States). ... [T]he mining industry should be looking towards switching its skills and knowledge towards investing in recycling.<sup>427</sup>*

However, the mining industry responds to such suggestions that raw material demand is rising much faster than end-of-life metal availability, and that much of society's metal is bound in long-term uses like buildings and infrastructure. Consequently, primary metal extraction (mining) continues to be critically necessary to supply the world's growing economy.

General aspects of trade and metal production are important to understanding the ability of the electronic industry to influence SER practices at the mining level. The Electronic Industry Citizenship Coalition is a supply chain initiative designed to address SER issues mainly in a manufacturing context and is being implemented by a range of companies in different positions within the supply chain to their first tier of suppliers, and in some cases to further tier suppliers. A review of the current literature on CSR and supply chain management revealed challenges in applying voluntary supply chain management initiatives, including deciding which SER issues are important or relevant, the number of codes of conduct that are being applied in the supply chain, and the issue of boundaries in the supply chain. In this context, it is important for EICC companies to determine whether the EICC manufacturing supplier initiative is appropriate for dealing with issues at the extractives level, particularly since voluntary codes of conduct specific to mining and metals sector operations, such as those of the ICMM, exist or are being developed.

Due to the nature of the trade and supply of metals, it is not reasonable to generalize responsibility for SER issues at the mine level to the electronic industry. The electronic industry is one of many end-users of metals, and is in many cases a minor user compared to other industries. There may be specific cases in which individual electronics companies should have a

better understanding of the supply relationship for specific products or metals, which can then facilitate influencing the social and environmental issues of metal production; however, the data and research in this study do not support generalization of SER for metal mining issues to the entire electronic industry. Instead, the MMSD report emphasizes “shared responsibility” of many stakeholders, including governments, mining companies, financial institutions, NGOs and manufacturers. In particular, it is important to understand the complexity of mining and not to underestimate the power and role of governments in the management of mineral resource extraction and effects.

The concept of “shared responsibility” across the metals life cycle is echoed by the ICMM member corporations. BHP Billiton, one of the largest miners in the world (and a significant producer of copper, cobalt and gold), has developed some of the more advanced stewardship programs in the metals industry. These include commitment to ‘work with those involved through the life cycles of our products and by-products to promote their responsible use and management.’<sup>428</sup> Rio Tinto, another very large mining company states that (emphasis added):

*There is a broad and growing recognition in the market place and in regulatory circles that producers should retain certain responsibilities for their products throughout their life cycles. While this is not well defined for the mining industry, there is recognition that a **primary responsibility** exists at company sites during production and that **some shared responsibility** exists beyond the “production gate”.*<sup>429</sup>

Even leading metal and mining companies, which engage in corporate responsibility initiatives and sector best practices such as the ICMM, can still face significant challenges, including criticisms and allegations of poor social and environmental performance from community and NGO groups. For example, Anglo American is a member of ICMM and adopts a full suite of CSR tools, yet both it, and its South African subsidiary Anglo Platinum, are being criticized by advocacy groups and NGOs.<sup>430</sup>

In terms of “shared responsibility”, it is important to point out other end-use sector perspectives. At its Roundtable on the Sustainability of Platinum Group Metals, the automotive industry stated that it:

*...cannot possibly assume a direct responsibility for [PGM] mining issues. Other participants felt that ... car manufacturers should require from their ... suppliers basic information about the identity of PGM producers and their sustainability performance.*<sup>431</sup>

Although the electronic industry cannot assume total responsibility for the social and environmental issues existing at the mines where its metals are sourced, there are areas where it might voluntarily influence more positive socio-environmental conditions related to its purchased materials. For this to occur, there is a significant barrier that must be overcome with respect to metal trade, tracking and tracing. Metal traded through commodity exchanges does not allow the buyer to distinguish source, either by tracking it forward to buyers, or tracing it back to suppliers. Metal traded through commercial contracts between seller and buyer may be more easily tracked, but will likely be constrained by commercial confidentiality and lack of tracking

or tracing mechanisms. In the general supply of metal, multiple sources and different grades of metals are commonly mixed and re-melted, including both primary and recycled sources; therefore, metal products (e.g. copper wire or sheet) are often not from a single source. This helps ensure efficient and economical supply from an industrial and financial perspective; however, line-of-sight tracking from the metal source is easily lost, as is the visibility of associated SER issues. Tracing the origins of metals from end-use back to source is even more challenging, since the metal is typically not physically identifiable to a mine or other source.

In contrast to the multi-tiered complexity of the electronic industry supply chain, the jewelry sector has a relatively simplified supply chain, making it somewhat easier to track metals from the mine through relationships with direct metal suppliers. Exclusive users of precious metals can benefit greatly from a positive perception of their products in terms of social and environmental issues. These factors facilitate the establishment of policies on ethical sourcing of raw materials. Two examples of such jewelry sourcing are:

- The boutique Scottish luxury ethical jeweler that sources its materials for private and commercial clients through certified fair trade sources, usually from small cooperatives in Colombia, Brazil and Africa.<sup>432</sup>
- Tiffany & Co. Jewelry, which sources silver and gold directly through a contract with Rio Tinto's Kennecott Utah Copper Corporation from the their Bingham Canyon mine. "Tiffany's preference for [Kennecott] metal stems from their desire to maintain chain of custody of the basic inputs to the jewellery-making process. This includes sourcing raw materials from suppliers who embrace socially and environmentally sustainable principles in their production processes."<sup>433</sup>

The supply chain of the jewelry sector has supported the establishment of these sourcing relationships, as well as the research into certification schemes, such as CRJP and IRMA for gold, silver and PGMs.

In seeking solutions to social and environmental issues related to metal mining, it should be noted that there is some distinction between choosing raw materials supply based on tracking versus tracing. If the electronic industry is interested in identifying and establishing sourcing priorities for (or against) preferred (or unethical) sourcing, then the issue becomes what course of action stakeholders might take. One option is a ban on undesirable metal. This would be an action based on negative social and environmental attributes to trace metal supply and discriminate against sources based regional political, social, or environmental concerns. Another option is regulating or assuring the mining and trading of supplied metal through such approaches as certification. This would be an action based on positive social and environmental attributes of mining such as choosing mining companies or regions with best practices and then tracking that metal from supply along the chain. If a source of metal is thought to be mined under very negative social and environmental conditions then a ban on that metal needs to consider several aspects:

1. For a ban to be effective, it must be implemented as part of a concerted international action plan that addresses fundamental regional structures and considers an environment that facilitates illegal exploitation of resources.<sup>434</sup>

Banning an undesirable or illegal activity may simply encourage shifts to alternative forms of illegal activity.

2. Banning creates hardships for people, either by depriving them of a livelihood or by increasing economic pressure that causes those who are exploiting the people to try to exert more control on resources, exacerbating the exploitation.

According to Collinson:

*Conflict trade is often a matter of mere survival for many among the poorest, even if it is also a source of vast profits for some*<sup>435</sup>

Le Billon further states that:

*Ending the consumption of conflict commodities may be as much a “problem” as a “solution” if it is to further increase the vulnerability of war victims.*<sup>436</sup>

3. In trying to ban a metal from regions of conflict, human rights abuses, or with sensitive ecosystems or environmental concerns, there is no guarantee that it will stop the poor social and environmental conditions, since other industries may continue sourcing from these regions.

According to Levin:

*Additionally, in a place where the emergency of the short term.... is sorely lived and where life is bare, the diminution of revenues from coltan sales would most probably encourage efforts in other destructive activities, e.g. poaching or logging, and impose further pressure on a very vulnerable society.*<sup>437</sup>

4. An industry ban on metal from a particular region does not guarantee that the metal is not still being sourced from that region.

This is illustrated through the case of Cuban nickel, which provides insight into the ability to circumvent traceability of metal flows.<sup>438</sup> For political and historical reasons, the United States has enforced a trade embargo against Cuba since 1962, including a ban on trade of mineral products from Cuba to the USA. Notably, Cuba is a major miner of nickel and cobalt (number six global producer in recent years); however, Cuban metal does find its way into the USA, thereby circumventing intended trade barriers. The number of steps and interactions in the global supply chain of these commodities, plus the fact that metal is not easily distinguishable by source, makes it difficult to ensure providence of commodity and therefore to actually enforce a barrier to trade. As such, Cuban metal is exported to Europe or Asia, where it may be blended and processed with other sources into specialty alloys, or it may be simply relabeled, before being imported into the USA.

There is also the case of coltan sourcing from the DRC earlier this decade. The following from the GeSI sponsored report is illustrative:

*Due to smuggling and the nature of the world market, however, it is almost impossible to guarantee that shipments of ore purchased on the ‘spot’ market are free of this ‘conflict coltan’.*<sup>439</sup>

*“... any tantalum purchased on the spot market can contain mixed ores. ...[T]here is no way to tell, chemically or geologically, where the ore originates. ... “Avoiding” illegal tantalum, and asking for verifications that, in fact, are virtually impossible to give, may convey the impression of an environmentally responsible corporate stance but will not withstand scrutiny.”*<sup>440</sup>

This issue is also highlighted by Levin in another report on coltan and the DRC:

*...regulating exports from the region would be incredibly tricky. Long-established smuggling networks in baby gorillas, ivory, diamonds and gold have proved their competence in defying international attempts to prevent such trades.*<sup>441</sup>

5. Imposing a ban on a mineral could be seen as abdicating responsibility from a corporate responsibility standpoint.

Levin states that:

*companies concerned with meeting their normative responsibilities are faced with a challenging dilemma. On the one hand, disengagement lays the regional coltan markets bare to competitors who are less vulnerable to exposure or consumer action in the face of unethical behaviour (e.g. China, C.I.S., India) ... It also reduces the immediate employment options of the Congolese who are accustomed to working in the trade. On the other hand, continued engagement with the region can be viewed as a complicit act of support for the foreign occupation ... and the humanitarian and environmental crises which ensue. It is essential that companies are transparent about this dilemma so that they do not feel swayed to make the most publicly comfortable rather than the most appropriate decision.*<sup>442</sup>

In the case of companies banning the use of coltan from the Congo, it remains to be seen whether there was any consequential positive impact on the social and environmental issues in the region. In the DRC, coltan was not the only resource that was fueling conflict. The sale of diamonds and other minerals have also contributed to funds that fuel the conflict. It is likely that recent changes to the political regime, changes in mining regulations, and on-the-ground NGO initiatives, such as the Durban Process,<sup>443</sup> CASM, implementation of KPCS in DRC, as well as an analysis of how EITI might help address ASM issues in the region<sup>444</sup> are contributing to some of the changes that are occurring with respect to the coltan certification schemes that are being developed.

6. Banning a metal from a particular region might not be feasible from a business perspective.

In the case of palladium, 82% is sourced from Russia and South Africa, both of which face serious social and environmental concerns. Almost 50% of cobalt is sourced from the DRC and Zambia. If the electronic industry were to ban metal from these regions, it might create problems with metal supply to the industry, or might shift end-users of these metals to that supply, given the limited pool from which cobalt can be sourced.

Despite all these difficulties in tracking and tracing metals, there are nonetheless large problems in metal mining that need to be addressed, and by making efforts to trace sources of metal in the

supply chain as far as possible, electronics companies may gain further insight and understanding into:

- social and environmental risks related to specific metals, companies, regions, etc. so that electronic industry can work to understand, focus on, and improve conditions in problematic regions or specific mines,
- key points in the supply chain that are common/shared by various members of the electronic industry, or other end-users, such that several stakeholders which could be engaged to strengthen efforts on existing initiatives or on influencing at certain key points in the supply chain

In the case of tin, which is the main component of solder, individual electronics companies may be able to trace the metal through the supply chain to particular solder manufacturers. This kind of investigation can provide an entry point for engagement on SER issues between the electronics companies, solder paste manufacturers, and tin producers, including participation with industry associations, such as ITRI.<sup>445</sup> A desirable route appears to be one of SER-focused partnerships between major parties that link sources to users.

If actions involve regulating the mining and trade of a metal, outcomes tend to be more positive, for example by providing fair and sustainable livelihoods for ASM workers, increasing regional security and prosperity and spin-off effects in development of infrastructure, agriculture and education. Additionally, sourcing based on positive attributes contributes to overall social and environmental performance for that metal, both the tracked source and the global pool of production for that metal. Moreover, positive schemes may more easily provide models of best practice that can be shared with other suppliers in the sector or region.

The manner in which metal regulation or certification is implemented is important. Under the Kimberley Certification scheme, the legalization of Angola's diamond industry was accompanied by forced displacement, child labor, and the abuse and killing of artisanal diamond diggers.<sup>446</sup> According to Le Billon, since the scheme only recognized the violence of "rebel movements aimed at undermining legitimate governments" the process "selected not only which, but also whose violences mattered."<sup>447</sup>

The concept of certification of minerals, a tracking approach, has gained popularity with the Kimberley Process Certification Scheme. Although there are positive outcomes of certification, such as the possibility of creating positive attributes and thus improving the SER practices for a global pool of a metal, it is important to understand its limitations.

*The effectiveness of the Kimberley Process in stopping the flow of conflict diamonds is still unknown. However, in Sierra Leone, other factors have come together to stop the war, and the diamonds produced there are still an important source of income for many of its citizens.*<sup>448</sup>

Certification could in fact create new social and environmental problems such as those related to the implementation of the Kimberley Process as discussed above, and may not be as broad a solution as it is believed<sup>449</sup>. For example, according to the MMSD study: "Sierra Leone does have a system of certification, but many gems are never seen by official eyes, and corrupt dealers

continue to buy the diamonds.”<sup>450</sup> A more recent study, “Dealing for Development”, discusses the ineffectiveness of KPCS in Sierra Leone based on research conducted after the KCPS was implemented in this country.<sup>451</sup> Additionally, providing incentives for mine certification schemes may favor larger companies who can afford the certification, and penalize ASM operations. The implications include the creation of a situation where producers who already have best practices are certified, while poor producers are not, such that there is no significant change to the social and environmental performance of metals going into the global pool. Another concern is that by putting attention on “conflict” or “blood” minerals in certification schemes, other social and environmental issues could be overlooked. For example, the mining industry has portrayed diamonds from the Canadian North as “clean” diamonds. However, diamond mining in these regions are still associated with other important social and environmental concerns such as being built in environmentally fragile ecosystems, having significant ecological footprints due to their location in northern regions, impacting on food sources for Aboriginal peoples through wildlife disruption, and disruption of cultural and social lives of Aboriginal peoples and the regional economy.<sup>452</sup> These issues are important to acknowledge in considering regulation and certification of metals, and help in creating a scheme that provides a true benefit to the social and environmental performance of that metal in the global pool and not just in a region.

If certification of metals were considered by the electronic industry, the following is noted for precious metals:

*Taking into consideration the characteristics of specific commodities and the structure of their trade on the international market, we could reason that a KPCS-like system would probably only work for resources with significant similarities to diamonds. This would mean commodities that: are highly valuable and easily portable – and therefore easily smuggled; are not produced in many countries; do not have a universal application; and where a linkage could be found between their trade and regional conflict ... Gold and platinum group metals would hence seem to be the best candidates.*<sup>453</sup>

Among the certification initiatives that were studied, ARM and CRJP are initiatives of most interest, as they appear to be strong, active and moving forward. These could be a positive step to establish a chain-of-custody for jewelry, including precious metals, diamonds and gemstones. Of interest to the EICC and GeSI members, gold is presently addressed by these initiatives, with opportunity for inclusion of silver, platinum and palladium metals in the future. Whether industrial uses of these metals, like electronics, can be included within the ARM or CRJP framework is not clear. As a mine site certification approach, IRMA is of interest should it yield tangible results in the near future.

The Eden Project is another initiative that is worth noting for its research into supply chain management and certification. It is of interest to the electronic industry in that the project managed to achieve chain-of-custody certification, albeit for a very different end-product type involving large lots of metal going to single large products (buildings).

If metals certification is accomplished in conjunction with programs that address sustainable livelihood alternatives to mining, as well as integration of illegal or informal mining and trade, it

would help both the SER issues and with sustainability and poverty alleviation related to ASM. Such programs need to include industry, governments, civil society organizations, and mining communities to address problems of poverty, corruption, political representation, violence, and environment, but are aligned with the MMSD recommendations for dealing with ASM issues. There are some implementation hurdles in these programs, such as the lack of feasible alternative livelihood options in some mining communities and their focus on artisanal mining, which can leave out industrial mining.<sup>454</sup>

An example of such a program is being led by Pact and CASM in Katanga, DRC. This country is plagued by conflict, weak governance issues, corruption, weak infrastructure, lack of capacity building, and extreme poverty. The coltan issue in the DRC in 2001, highlighted by NGO campaigns and addressed by electronic industry companies, resulted in promises of ethical sourcing of coltan, but alone has not solved the deeply-engrained and historical issues in the region, which have now led to further concerns of tin and cobalt sourcing from this region. The Pact-CASM work accomplished so far can claim some successes related to ASM issues, including helping to develop the country's social and economic resources, with efforts in food security, conflict resolution, and community-building.<sup>455</sup> There has also been socio-economic reintegration of laid-off mine workers. This type of on-the-ground, bottom-up approach may be preferable to top-down supply chain management, but poses very different challenges.

In terms of influencing mining practices, there may be some opportunities through partnerships with other large end-users of the metals of interest. In particular, the largest end-user of palladium is the automobile industry at 56%. The “Roundtable on Sustainable Platinum Group Metals”,<sup>456</sup> which includes representatives of the automobile industry, is actively addressing PGM supply and SER concerns, especially from Russia. The group notes that it may include the electronic industry in the future.

Based on this study's findings, there are opportunities for the GeSI and EICC members to influence social and environmental performance in mining and metals production. However, this will depend on a clearer understanding of specific metals used in components and electronic products. It is useful to make a distinction between tracing and tracking of materials though the supply chain. For metals, tracing from user to source is challenging, and the level effort needs to be assessed against the value of information gained. Tracking of materials, as-in chain-of-custody approaches, is emerging for metals and presents an opportunity for understanding the supply chain and stimulating SER improvement of metals production.

A better understanding of the roles of the various stakeholders involved in mineral extraction is needed. The extensive work done on mining and sustainable development in the last ten years, including the MMSD Project and the EIR Process, has resulted in many companies in the mining industry and metal associations being more proactive in dealing with SER issues in the metal life cycle. The many initiatives that are trying to address SER in mining reflect the beginning of this response, but it may take time before there is widespread evidence of more sustainable development of mining and metals production. It is noteworthy that leading mining companies have advanced with respect to social and especially environmental performance over the last decade. Additionally, ICMM and member firms, and metal commodity associations, have expressed desire for “shared responsibility” of metals management across the material life cycle.

Lastly, it should be emphasized that two general sustainability goals are to reduce the need for mineral mining in general, and to increase efficiency of resource and materials that are extracted. Towards these ends, it is clearly desirable both to enhance recovery of metals from EOL electronics products and to improve yields of metal recycled from electronic product scrap. These areas are already part of the scope of activity of electronic sector companies.

## **9.1 Recommendations**

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Based on this study, the following recommendations are made to the EICC and GeSI:

- The electronic industry should engage with appropriate existing SER initiatives and stakeholders, as identified in this study, possibly in partnership with other end-use sectors, to both strengthen efforts and reduce proliferation of overlapping initiatives.
- The electronic industry should continue to emphasize activities in management of end-of-life electronic products, including efforts to enhance materials efficiency after product use, and attention to recycling of metals.
- Individual electronic companies need to further characterize specific metal content and use in electronic products. This supports the tracking of metals used in electronics, helps in tracing sources of materials, and facilitates recycling.

## 10 ENDNOTES

<sup>1</sup> (Vogel, 2005)

<sup>2</sup> (Freeman & Velamuri, 2006)

<sup>3</sup> (TerraChoice, 2007)

<sup>4</sup> (Murray, 2000)

<sup>5</sup> (BSR, 2007, p. 04)

<sup>6</sup> (Carter & Jennings, 2004)

<sup>7</sup> (Worthington, Monder, Harvinder, & Shah., 2008)

<sup>8</sup> (WWF, 2007)

<sup>9</sup> (MakeITfair, 2007)

<sup>10</sup> (McIntyre, Smith, Henham, & Pretlove, 1998)

<sup>11</sup> (NOKIA, 2006)

<sup>12</sup> (Preuss, 2001)

<sup>13</sup> (Krueger, 2008, p. 119)

<sup>14</sup> (McRae, 2008)

<sup>15</sup> The first generation of LEED is an example of a buyer-driven scheme. The first generation of requirements were not coherent and did not address reasonable “green” expectations. The standards have been, and continue to be, redeveloped to better fit both the industrial reality and sustainability objectives.

<sup>16</sup> (McRae, 2008)

<sup>17</sup> The Forest Stewardship Council certification is such a program that understands the industry structure, and has sophisticated institutional buyer (e.g. Home Depot, Green Architects).

<sup>18</sup> In the case of the EICC code, the standards may not be appropriate to SER for the whole supply chain of metals, particularly the extraction of metals, but are actionable and coherent for the manufacturing supply chain.

<sup>19</sup> (Murphy & Poist., 2003, p. 123)

<sup>20</sup> (Maloni & Brown, 2006, p. 37)

<sup>21</sup> (Jorgensen, Pruzan-Jorgensen, Jungk, & Cramer, 2003)

<sup>22</sup> (Nimmo, 2008c)

<sup>23</sup> Adapted from TerraChoice (2007)

<sup>24</sup> (Roberts, 2003, p. 159)

<sup>25</sup> (Amaeshi, Osuji, & Nnodim, 2006)

<sup>26</sup> (Jorgensen et al., 2003, p. 33-35)

<sup>27</sup> (Boyd, Spekman, Kamauff, & Werhane., 2007)

<sup>28</sup> (Jorgensen et al., 2003)

<sup>29</sup> (BSR, 2007)

<sup>30</sup> Tailings are residual slurry of pulverized ore that is left over after minerals have been largely separated.

<sup>31</sup> (SVTC, 2002); and information provided by GeSI and EICC member companies, 2007.

<sup>32</sup> A personal computer assembly refers the core of the PC, the printed wire board populated with all active components, but excludes mechanical case, disk drive, power supply, cables and monitor.

<sup>33</sup> (Hageluken & Art, 2007)

<sup>34</sup> Adapted from NOKIA (2006)

<sup>35</sup> Al is the universal symbol for aluminum (also spelled aluminium) in the Periodic Table of Elements. Element symbols for the metals are used throughout this report.

<sup>36</sup> (Ericsson, 2008)

<sup>37</sup> (IAI, 2006)

<sup>38</sup> (IAI, 2006)

<sup>39</sup> (IC, 2008)

<sup>40</sup> (USGS, 2007)

<sup>41</sup> (ATSDR, 2004)

<sup>42</sup> (CDI, 2006, p. 46-47)

<sup>43</sup> (CDI, 2006)

<sup>44</sup> (CDI, 2006)

<sup>45</sup> (CDI, 2008b)

<sup>46</sup> (Umicore, 2008)

<sup>47</sup> (Umicore, 2008)

<sup>48</sup> (CDI, 2006)

<sup>49</sup> (CDI 2006)

<sup>50</sup> (ICSG, 2007)

<sup>51</sup> (ICSG, 2007)

<sup>52</sup> (Kane, 2008)

<sup>53</sup> (Milker, 2008)

<sup>54</sup> (WGC, 2008b)

<sup>55</sup> (WGC, 2008b)

<sup>56</sup> (WGC, 2008b)

<sup>57</sup> (Butterman & Amey\_III, 2005)

<sup>58</sup> (Goldavenue, 2008)

<sup>59</sup> (WGC, 2008c)

<sup>60</sup> (WGC, 2008b)

<sup>61</sup> (WGC, 2008b)

<sup>62</sup> (Folkerts-Landau, 2006)

<sup>63</sup> (PC, 2006)

<sup>64</sup> (GFMS, 2006)

- <sup>65</sup> (USGS, 2007)
- <sup>66</sup> (Nimmo, 2007)
- <sup>67</sup> (Roskill, 2007)
- <sup>68</sup> (ITRI, 2007)
- <sup>69</sup> Adapted from ITRI (2007)
- <sup>70</sup> (Folkerts-Landau, 2006)
- <sup>71</sup> These groups of metals include: Al, Cu, Ni, Zn, Pb, Au, Ag, PGM, Sn. Steel, most notably, operates within its own market somewhat independent of other metals. So-called “minor metals” including Co, Be and the rare earth metals operate in smaller non-exchange markets.
- <sup>72</sup> (IISD, 2008)
- <sup>73</sup> (LME, 2008)
- <sup>74</sup> There are exceptions. Radioactive commercial materials, like uranium, do occur in different atomic forms. Of interest to this study, recycled Sn can be sold as ‘low  $\alpha$ ’ with a reduced level of radioactivity and is used for soldering very sensitive electronic components (Nimmo, 2008c). These characteristics, plus the presence of specific impurities, may potentially facilitate “fingerprinting” of some sources.
- <sup>75</sup> (Ireton, 2008)
- <sup>76</sup> On this last point, see for example Weight (2008)
- <sup>77</sup> (Folkerts-Landau, 2006)
- <sup>78</sup> (LME, 2007)
- <sup>79</sup> (LME, 2007)
- <sup>80</sup> (Marketoracle, 2007)
- <sup>81</sup> See for example, data tables provided by JM (2008)
- <sup>82</sup> See for example BHP Billiton (2008)
- <sup>83</sup> (Magnowski, 2007)
- <sup>84</sup> (WGC, 2008e)
- <sup>85</sup> (LBMA, 2008)
- <sup>86</sup> (WGC, 2008e)
- <sup>87</sup> (LBMA, 2008)
- <sup>88</sup> (Leyland, 2005)
- <sup>89</sup> (GFMS, 2008b)
- <sup>90</sup> (Codelco, 2008)
- <sup>91</sup> (Codelco, 2006)
- <sup>92</sup> (Keith O’Brian, 2007-2008)
- <sup>93</sup> (Alibaba, 2008)
- <sup>94</sup> (LME, 2007)
- <sup>95</sup> (Formation, 2008)
- <sup>96</sup> (CRUMonitor, 2007)
- <sup>97</sup> (ITRI, 2008a)
- <sup>98</sup> (Bromby, 2008)
- <sup>99</sup> (Davis, 2007, p. 13)
- <sup>100</sup> (Counsell and Loraas, 2002) as cited in the Solomon et al (2006)
- <sup>101</sup> (MMSD, 2002, p. 63)
- <sup>102</sup> (Gilchrist, 1980), (Reuter, 2004)
- <sup>103</sup> (Ericsson, 2008)
- <sup>104</sup> (RMG, 2008)
- <sup>105</sup> Adapted from Pietersen (2007)
- <sup>106</sup> (PWC, 2007)
- <sup>107</sup> (MMSD, 2002, p. 63)
- <sup>108</sup> (Sindling, 2003), (Hinton et al., 2003)
- <sup>109</sup> (MMSD, 2002, p. 318)
- <sup>110</sup> (MMSD, 2002, p. 318)
- <sup>111</sup> (KPCS, 2007)
- <sup>112</sup> (MMSD, 2002, p. 318)
- <sup>113</sup> (Ericsson, 2008)
- <sup>114</sup> (Gardner, 2008)
- <sup>115</sup> (IHT, 2007)
- <sup>116</sup> (Reuters, 2007)
- <sup>117</sup> (Hetherington et al., 2008)
- <sup>118</sup> (Hetherington et al., 2008)
- <sup>119</sup> (CDI, 2008a)
- <sup>120</sup> (IC, 2008)
- <sup>121</sup> (Bream, 2007)
- <sup>122</sup> (Reinhard, 2007)
- <sup>123</sup> (CDI, 2006)
- <sup>124</sup> (CDI, 2006)
- <sup>125</sup> (Reinhard, 2007)
- <sup>126</sup> (Hetherington et al., 2008)
- <sup>127</sup> (ICSG, 2007)
- <sup>128</sup> (Graedel et al., 2002)
- <sup>129</sup> (Hetherington et al., 2008)
- <sup>130</sup> (Kettle, 2005)
- <sup>131</sup> (Hetherington et al., 2008).
- <sup>132</sup> (WGC, 2008d)
- <sup>133</sup> (McGregor, 2008)
- <sup>134</sup> (NMA, 2007)
- <sup>135</sup> (GFMS, 2008a)
- <sup>136</sup> (WGC, 2008b)

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- <sup>137</sup> (Ali, 2006)
- <sup>138</sup> (MMSD, 2002)
- <sup>139</sup> (Veiga, Maxson, & Hylander, 2005)
- <sup>140</sup> (Leyland, 2005)
- <sup>141</sup> (ILO, 1999)
- <sup>142</sup> (InfoMine, 2008)
- <sup>143</sup> (WGC, 2008f)
- <sup>144</sup> (GFMS, 2007) and (Hetherington et al., 2008)
- <sup>145</sup> (GFMS, 2007)
- <sup>146</sup> (R. B. Gordon, Bertram, & Graedel, 2006)
- <sup>147</sup> Adapted from Hetherington et al (2008).
- <sup>148</sup> (Kettle, 2007)
- <sup>149</sup> (Nimmo, 2008)
- <sup>150</sup> (Garrett, 2008)
- <sup>151</sup> (USGS, 2007b)
- <sup>152</sup> (ITRI, 2008c)
- <sup>153</sup> Numbers based on statistics provided in Garret (2008).
- <sup>154</sup> USGS (2008) estimates currently 200 t/year; Yunnan Tin JV forecasts 24,000 t/year for 2009.
- <sup>155</sup> (Pardomuan, 2007c)
- <sup>156</sup> (ITRI, 2008a)
- <sup>157</sup> Adapted from Hetherington et al (2008).
- <sup>158</sup> (Martchek, 2006)
- <sup>159</sup> (Ruhrberg, 2006)
- <sup>160</sup> (ICSG, 2007)
- <sup>161</sup> (Ruhrberg, 2006)
- <sup>162</sup> (NI, 2007)
- <sup>163</sup> On the variation of metal recycling by region and per capita income see IAI (2006)
- <sup>164</sup> (Atherton, 2006)
- <sup>165</sup> (Sempels, 2007)
- <sup>166</sup> (NI, 2007)
- <sup>167</sup> (Dubreuil & Young, 2004)
- <sup>168</sup> (ICSG, 2007)
- <sup>169</sup> (Hagelüken, Buchert, & Ryan, 2006)
- <sup>170</sup> (ICSG, 2007)
- <sup>171</sup> (IAI, 2006)
- <sup>172</sup> (Martchek, 2006)
- <sup>173</sup> (Martchek, 2006)
- <sup>174</sup> (Martchek, 2006)
- <sup>175</sup> (ICSG, 2008)
- <sup>176</sup> (Jolly, 2007)
- <sup>177</sup> (ICSG, 2007)
- <sup>178</sup> (ICSG, 2008)
- <sup>179</sup> (Nimmo, 2007)
- <sup>180</sup> (CDI, 2007)
- <sup>181</sup> (Shedd, 2007)
- <sup>182</sup> (WGC, 2008b)
- <sup>183</sup> (WGC, 2008b)
- <sup>184</sup> (GFMS, 2007)
- <sup>185</sup> (GFMS, 2007)
- <sup>186</sup> (CDI, 2007)
- <sup>187</sup> (Wang, 2006)
- <sup>188</sup> (Shedd, 2007)
- <sup>189</sup> (Jolly, 2007)
- <sup>190</sup> (Jolly, 2007)
- <sup>191</sup> (CDA, 2008)
- <sup>192</sup> (Jolly, 2007)
- <sup>193</sup> (Jolly, 2007)
- <sup>194</sup> (CDA, 2008)
- <sup>195</sup> (CDA, 2008)
- <sup>196</sup> (Jolly, 2007)
- <sup>197</sup> (IAI, 2006)
- <sup>198</sup> (WGC, 2008d)
- <sup>199</sup> (Amey, 2004)
- <sup>200</sup> (BHP Billiton, 2007a)
- <sup>201</sup> (WGC, 2008b)
- <sup>202</sup> (WGC, 2008d); (Amey, 2004)
- <sup>203</sup> (GFMS, 2006)
- <sup>204</sup> (Hagelüken et al., 2006)
- <sup>205</sup> (GFMS, 2007)
- <sup>206</sup> (USGS, 2007b)
- <sup>207</sup> (ITRI, 2008b)
- <sup>208</sup> (ITRI, 2008b)
- <sup>209</sup> (Nimmo, 2007)
- <sup>210</sup> (USGS, 2007a)
- <sup>211</sup> (USGS, 2007a)
- <sup>212</sup> (Nimmo, 2008a)
- <sup>213</sup> (NI, 2003)

- <sup>214</sup> (NI, 2003)
- <sup>215</sup> (NI, 2003)
- <sup>216</sup> (NI, 2003)
- <sup>217</sup> (NI, 2003)
- <sup>218</sup> (WO, 2008)
- <sup>219</sup> (Martchek & Bruggink, 2004)
- <sup>220</sup> (Martchek & Bruggink, 2004)
- <sup>221</sup> (Martchek & Bruggink, 2004)
- <sup>222</sup> (Martchek & Bruggink, 2004)
- <sup>223</sup> (Spatari, Bertram, Fuse, Graedel, & Rechberger, 2002)
- <sup>224</sup> (Spatari et al., 2002)
- <sup>225</sup> (ICSG, 2004)
- <sup>226</sup> (Amey, 2004)
- <sup>227</sup> (WGC, 2008a)
- <sup>228</sup> (Hageluku & Art, 2007)
- <sup>229</sup> (Atherton, 2006)
- <sup>230</sup> (Atherton, 2006)
- <sup>231</sup> (Dubal, 2007)
- <sup>232</sup> (Jolly, 2007, p. 07)
- <sup>233</sup> (Hageluku & Naka, 2008)
- <sup>234</sup> (Hageluku & Naka, 2008)
- <sup>235</sup> (Atherton, 2006)
- <sup>236</sup> Note that this argument of recycled supply and demand does not necessarily transfer to other materials. Unlike metals, recycled plastics exhibit different, usually inferior, properties compared to their virgin form. Users who shift from virgin to recycled plastics may therefore need to adjust their processes, products and quality expectations.
- <sup>237</sup> (Atherton, 2006)
- <sup>238</sup> (BE, 2008)
- <sup>239</sup> (Taylor, 2007)
- <sup>240</sup> Affiliation obtained from Verán (2007)
- <sup>241</sup> Affiliation obtained from Thuo (2006)
- <sup>242</sup> Duma Nkosi has been involved in various roles related to minerals and energy, such as chairperson of the Parliamentary Portfolio Committee on Minerals and Energy in 1997, Chair of the Assurance Group of the MMSD, and board member for the Board of the Minerals and Energy and Training Institute (MEETI). Retrieved Jun/03/2008 from [http://www.iied.org/mmsd/assu\\_pen.html#nkos](http://www.iied.org/mmsd/assu_pen.html#nkos).
- <sup>243</sup> (Whitmore, 2006, p. 311)
- <sup>244</sup> (Kloppers, 2007)
- <sup>245</sup> (Azapagic, 2004, p. 649)
- <sup>246</sup> (IAI, 2008)
- <sup>247</sup> (Innovest, 2006)
- <sup>248</sup> (RNZI, 2008)
- <sup>249</sup> (HI, 2008)
- <sup>250</sup> (Zhavoronkin, Masloboev, & Krause, 2005)
- <sup>251</sup> (BBC, 2007)
- <sup>252</sup> (BBC, 2007)
- <sup>253</sup> (BBC, 2007)
- <sup>254</sup> (Zhavoronkin et al., 2005, p. 30)
- <sup>255</sup> (BI, 2008)
- <sup>256</sup> (BI, 2008)
- <sup>257</sup> (ILO, 2008a)
- <sup>258</sup> (BI, 2008)
- <sup>259</sup> (Farrell, Sampat, Sarin, & Slack, 2004)
- <sup>260</sup> (Miranda et al., 2003)
- <sup>261</sup> (Farrell et al., 2004)
- <sup>262</sup> (UNEP/OCHA, 2000)
- <sup>263</sup> (Kingsley, 2004)
- <sup>264</sup> (McGregor, 2008) ; (USA, 1996)
- <sup>265</sup> (Veiga et al., 2005)
- <sup>266</sup> (NMA, 2007)
- <sup>267</sup> See the website of the China Gold Association at [www.cngold.org.cn](http://www.cngold.org.cn) (Retrieved Jun/04/2008)
- <sup>268</sup> (MLR, 2007)
- <sup>269</sup> (CIMG, 2008)
- <sup>270</sup> (CGG, 2008)
- <sup>271</sup> (Zijin, 2008)
- <sup>272</sup> (Capel, 2007)
- <sup>273</sup> (Capel, 2007)
- <sup>274</sup> (Pietersen, 2007)
- <sup>275</sup> (Pietersen, 2007)
- <sup>276</sup> (Azapagic, 2004, p. 647)
- <sup>277</sup> (Azapagic, 2004, p. 647)
- <sup>278</sup> (Azapagic, 2004, p. 649)
- <sup>279</sup> (Bream, 2007)
- <sup>280</sup> (MMSD, 2002, p. 204)
- <sup>281</sup> (Buchanan, 2008)
- <sup>282</sup> (Azapagic, 2004, p. 647)
- <sup>283</sup> (MM&P, 2004)
- <sup>284</sup> (Farrell et al., 2004)
- <sup>285</sup> (Farrell et al., 2004)

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- <sup>286</sup> (RT, 2004)
- <sup>287</sup> (GW, 2007, p. 12)
- <sup>288</sup> (GW, 2007, p. 12)
- <sup>289</sup> (BusinessWeek, 2005)
- <sup>290</sup> (PT-FI 2007)
- <sup>291</sup> (GW, 2007, p. 7)
- <sup>292</sup> (MMSD, 2002, p. 206)
- <sup>293</sup> (Gordon & Webber, 2003, p. 68)
- <sup>294</sup> (HI, 2008)
- <sup>295</sup> (PIPlinks, 2006)
- <sup>296</sup> (Gordon & Webber, 2003, p. 79)
- <sup>297</sup> (Gordon & Webber, 2003, p. 82)
- <sup>298</sup> (Gordon & Webber, 2003, p. 82)
- <sup>299</sup> (Gordon & Webber, 2003, p. 82)
- <sup>300</sup> (Gordon & Webber, 2003, p. 82)
- <sup>301</sup> (PIPlinks, 2006)
- <sup>302</sup> (BMF, 2008)
- <sup>303</sup> (Capel, 2007)
- <sup>304</sup> (Curtis, 2008)
- <sup>305</sup> (Geovic, 2006)
- <sup>306</sup> (Azapagic, 2004, p. 645)
- <sup>307</sup> (Koenig, 2007)
- <sup>308</sup> (Koenig, 2007)
- <sup>309</sup> (Petersen, 2007)
- <sup>310</sup> (Petersen, 2007)
- <sup>311</sup> (MMSD, 2002)
- <sup>312</sup> (WBG, 2003)
- <sup>313</sup> (MMSD, 2002)
- <sup>314</sup> (MMSD, 2002)
- <sup>315</sup> (MMSD, 2002)
- <sup>316</sup> (Hentschel, Hruschka, & Priester, 2002); (Crispin, 2003)
- <sup>317</sup> (Veiga et al., 2005)
- <sup>318</sup> (Veiga et al., 2005)
- <sup>319</sup> (Gyan-Baffour, 2003)
- <sup>320</sup> (Gyan-Baffour, 2003)
- <sup>321</sup> (Sindling, 2003)
- <sup>322</sup> (Gyan-Baffour, 2003)
- <sup>323</sup> (Aspinall, 2001)
- <sup>324</sup> (Sindling, 2003)
- <sup>325</sup> (Erman, 2007, p. 17)
- <sup>326</sup> (Erman, 2007, p. 17)
- <sup>327</sup> (Pardomuan, 2007b)
- <sup>328</sup> (MMSD, 2002)
- <sup>329</sup> (Gyan-Baffour, 2003)
- <sup>330</sup> (WBG, 2007)
- <sup>331</sup> (Kettle, 2007)
- <sup>332</sup> (Pardomuan, 2007a)
- <sup>333</sup> (ZJ, 2006)
- <sup>334</sup> (Kettle, 2007)
- <sup>335</sup> (ZJ, 2006)
- <sup>336</sup> (CRUMonitor, 2007)
- <sup>337</sup> (Nimmo, 2008a)
- <sup>338</sup> (Hinton, M.Veiga, & Beinhoff, 2003, p. 02)
- <sup>339</sup> (Hinton et al., 2003, p. 02)
- <sup>340</sup> (Hinton et al., 2003, p. 02)
- <sup>341</sup> (Hinton et al., 2003)
- <sup>342</sup> (ILO, 2008b)
- <sup>343</sup> (ILO, 2006)
- <sup>344</sup> (ILO, 2008b)
- <sup>345</sup> (ILO, 1999)
- <sup>346</sup> (WBG, 2007)
- <sup>347</sup> (Fonseca, 2008)
- <sup>348</sup> (McNeilly, 2000)
- <sup>349</sup> (MMSD, 2002)
- <sup>350</sup> For a different viewpoint on the MMSD study, see Whitmore (2006), FOE (2007) and Moody (2001). Note that Mines and Communities, an advocacy group for mine-affected communities, was formed at a London meeting by community activists and their supporters, in May 2001, partly as a response to the various industry initiatives (GMI, MMSD Project, and ICMM).
- <sup>351</sup> (Whitmore, 2006, p. 310)
- <sup>352</sup> (IIED/WBCSD, 2002). Details on these findings and actions can be found in Chapter 16 of (MMSD, 2002)
- <sup>353</sup> (Butler, 2005)
- <sup>354</sup> This recommendation has been the subject of debate with different views from various stakeholders such as mining companies, the World Bank, and NGOs. The No Dirty Gold campaign has released its “Golden Rules” which calls on mining companies to meet basic standards in their operations, including this recommendation. The Framework for Responsible Mining also deals with this issue extensively.
- <sup>355</sup> (Butler, 2005)
- <sup>356</sup> (MMSD, 2002, p. xxii-xxiii)

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- <sup>357</sup> (MMSD, 2002, chapter 8)  
<sup>358</sup> (MMSD, 2002, p. xvii-xviii)  
<sup>359</sup> (MMSD, 2002, p. 228)  
<sup>360</sup> (Kloppers, 2007)  
<sup>361</sup> (Vale, 2007)  
<sup>362</sup> (Vale, 2008)  
<sup>363</sup> (MMSD, 2002, p. 206)  
<sup>364</sup> (MMSD, 2002, p. 342)  
<sup>365</sup> (MMSD, 2002, p. 342)  
<sup>366</sup> (Jones et al, 2007)  
<sup>367</sup> (Jones et al, 2007)  
<sup>368</sup> (DFO, 2008)  
<sup>369</sup> (MMSD, 2002, p. 228)  
<sup>370</sup> (WBG, 2003, p. 25)  
<sup>371</sup> (MMSD, 2002, p. 228)  
<sup>372</sup> (MMSD, 2002, p. 71)  
<sup>373</sup> (MakeITfair, 2007)  
<sup>374</sup> (WWF, 2007)  
<sup>375</sup> (ICMM, 2007a)  
<sup>376</sup> (GRI, 2008)  
<sup>377</sup> (ICMM, 2007a)  
<sup>378</sup> (ICMM, 2007b)  
<sup>379</sup> (ITRI, 2005)  
<sup>380</sup> (ITRI, 2007)  
<sup>381</sup> (Nimmo, 2007)  
<sup>382</sup> (CRJP, 2007)  
<sup>383</sup> (CRJP, 2007)  
<sup>384</sup> (CRJP, 2007)  
<sup>385</sup> (CRJP, 2007)  
<sup>386</sup> (CSIRO, 2006)  
<sup>387</sup> (CSIRO, 2006)  
<sup>388</sup> (CSIRO, 2006)  
<sup>389</sup> (IRMA, 2008)  
<sup>390</sup> (TEP, 2007)  
<sup>391</sup> (TEP, 2007)  
<sup>392</sup> (TEP, 2007)  
<sup>393</sup> (TEP, 2007)  
<sup>394</sup> (TEP, 2007)  
<sup>395</sup> (GL, 2007)
- <sup>396</sup> (GL, 2007)  
<sup>397</sup> (Bavier, 2008)  
<sup>398</sup> (Bavier, 2008)  
<sup>399</sup> (CASM, 2008)  
<sup>400</sup> (CASM, 2008)  
<sup>401</sup> (CASM, 2008)  
<sup>402</sup> (CASM, 2008)  
<sup>403</sup> (CASM, 2008)  
<sup>404</sup> (CASM, 2007a)  
<sup>405</sup> (CASM, 2007a)  
<sup>406</sup> (Mutemeri, 2008)  
<sup>407</sup> (PACT, 2008b)  
<sup>408</sup> (PACT, 2008b)  
<sup>409</sup> (PACT, 2007)  
<sup>410</sup> (CASM, 2007b)  
<sup>411</sup> (ARM, 2008)  
<sup>412</sup> (ARM, 2008)  
<sup>413</sup> (ARM, 2008)  
<sup>414</sup> (ARM, 2008)  
<sup>415</sup> (Eschavarria, no date)  
<sup>416</sup> (ARM, 2008)  
<sup>417</sup> (GGC, 2007)  
<sup>418</sup> (GGC, 2007)  
<sup>419</sup> (GGC, 2007)  
<sup>420</sup> (Levin, 2008)  
<sup>421</sup> (EITI, 2007)  
<sup>422</sup> (EITI, 2007)  
<sup>423</sup> (EITI, 2007)  
<sup>424</sup> (EITI, 2007)  
<sup>425</sup> (EITI, 2007)  
<sup>426</sup> (Hageluken & Naka, 2008)  
<sup>427</sup> (Whitmore, 2006, p. 311)  
<sup>428</sup> (BHP Billiton, 2007b)  
<sup>429</sup> (RT, 2008)  
<sup>430</sup> For example see MakeITfair (2007)  
<sup>431</sup> (Pietersen, 2007)  
<sup>432</sup> (FB, 2008)  
<sup>433</sup> (RT, 2002)  
<sup>434</sup> (Hayes and Burge, 2003, p. 38)

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<sup>435</sup> Colinson, 2003 as cited in Le Billon (2006, p. 778-780)

<sup>436</sup> (Le Billon, 2006, p. 779)

<sup>437</sup> (Levin, 2003, p. 31)

<sup>438</sup> (Keith O'Brian, 2007-2008)

<sup>439</sup> (Hayes & Burge, 2003, p. 11)

<sup>440</sup> (Hayes & Burge, 2003, p. 36)

<sup>441</sup> (Levin, 2003, p. 31).

<sup>442</sup> (Levin, 2003, p. 30)

<sup>443</sup> See for example The Durban Process Campaign Report at [http://www.resourceglobal.co.uk/index.php?option=com\\_docman&task=cat\\_view&gid=34&I](http://www.resourceglobal.co.uk/index.php?option=com_docman&task=cat_view&gid=34&I). Retrieved Jun/14/2008.

<sup>444</sup> (Garrett, 2007)

<sup>445</sup> (Nimmo, 2008b)

<sup>446</sup> (Le Billon, 2006, p. 791)

<sup>447</sup> (Le Billon, 2006, p. 791)

<sup>448</sup> (MWC, 2006)

<sup>449</sup> There are various types of certification and the KPCS is a certificate of origin, not a certificate of ethical quality. (Levin, 2008). See also forthcoming report to be published by CASM prepared by Levin entitled "Certification and Artisanal and Small-scale Mining: an Emerging Opportunity for Sustainable Development FINAL PAPER 12th April 2008"

<sup>450</sup> (MMSD, 2002, p. 224)

<sup>451</sup> (Levin & Gberie, 2006)

<sup>452</sup> (MWC, 2006)

<sup>453</sup> (Schram, 2007, p. 38)

<sup>454</sup> (Le Billon, 2006, p. 787)

<sup>455</sup> (PACT, 2008a)

<sup>456</sup> (Pietersen, 2007)

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