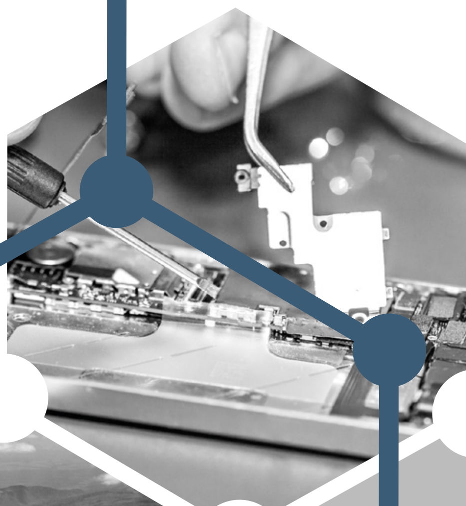
# MATERIAL CHANGE

A STUDY OF RISKS AND OPPORTUNITIES FOR COLLECTIVE ACTION IN THE MATERIALS SUPPLY CHAINS OF THE AUTOMOTIVE AND ELECTRONICS INDUSTRIES



drive sustainability

RESPONSIBLE MINERALS INITIATIVE

THE DRAGONFLY INITIATIVE
SUSTAINABLE BUSINESS. THE 360° PERSPECTIVE

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# FOREWORD

Environmental, social and governance issues associated with corporate supply chains and the sourcing of materials used in the manufacture of industrial and consumer products are subject to increasing scrutiny.

Regulators, investors, consumers and environmental and human rights groups are appealing to companies to publicly disclose the results of supplier due diligence and commit to engaging business partners in efforts to address negative impacts associated with their activities and improve operating practices. Navigating the path towards achieving that end however, is not simple.

The supply chains of businesses today are highly complex. They extend to multiple tiers and to thousands of suppliers. In the manufacture of their products, businesses source parts, components, and modules containing many materials from hundreds of countries across the globe, and from a wide range of environmental, social and political contexts. To meet the challenge of conducting due diligence, appropriately monitor performance and enable improvements at the operations of their suppliers, companies today need tailored information on the environmental, social and governance risks in their supply chains. Furthermore, to identify and prioritise opportunities to collaborate with their peers to effect positive change, analytical comparisons across many materials, industries, countries and issues considerably aid sound strategic decision making. One of the biggest obstacles to setting and implementing strategies for responsible sourcing, however, is the constrained access to and limited public availability of reliable current data and analysis on the environmental and social dimensions of material production and processing.

*Material Change* presents findings from studies carried out by Drive Sustainability (DS) and the Responsible Minerals Initiative (RMI) on the responsible sourcing of materials in the automotive and electronics industries. It includes results from these studies but is not comprehensive in its coverage of the studies' areas of research, nor are the results conclusive. Rather, this report is an early milestone in the continuing programmes of both DS and the RMI.

This report gathers, analyses and presents publicly available information on materials commonly used in the automotive and electronics industries. It aims to positively contribute to discussions on responsible sourcing among industry peers and stakeholders by enabling industry wide comparisons of the materials' and main producing countries' environmental, social and governance issues and their importance in the manufacturing of consumer and industrial automotive and electronic products.

The report does not attempt to evaluate the net contribution of materials to society or to weigh the costs and benefits of natural resource development. There are both adverse and positive outcomes associated with industrial activity. Rather, the goal of DS and the RMI is to raise awareness of potential risks and the opportunities for collective action to catalyse systemic improvements throughout the supply chains of both industries.

The scope of the study is intentionally broad. Instead of narrowing the analysis to a few materials and researching their supply chains in detail, *Material Change* presents a general industry level assessment of many materials with the goal of challenging the reader to broaden their view of multifaceted and interconnected manufacturing supply chains. Similarly general in presentation are the environmental and social information and economic and governance indicators for countries identified as top producers of the materials.

The report uses publicly available information. Despite the very considerable research efforts of industry associations and research institutes, there are gaps in contemporary information on environmental, social and governance issues associated with the production of many materials and on their supply, demand and use. DS and the RMI will continue to explore ways in which the two organisations and their members can contribute to improving the availability of reliable information and to incorporate that information into future reports as it becomes available.

From material to material, and from company to company, supply change risks can vary significantly, as do the opportunities for members of the two industries to catalyse change. The corporate policies of individual companies and management practices at sites and facilities are very often the primary factors determining the sound management of potential impacts associated with business activities and associated reputation risks.

DS and the RMI acknowledge that companies have a responsibility to conduct due diligence on their supply chains in accordance with internationally recognised standards and that decisions on supply chains and material sourcing are a matter for the management of individual businesses. *Material Change* is not a replacement for company due diligence, and the information presented in this report should not be interpreted as representing specific risks to any one individual company or as being irreversibly present in a particular material supply chain.

DS and the RMI recognise that collaborative action among businesses, across industries, and with governments and civil society is a powerful tool to address some of the serious social and environmental problems affecting workers and communities in countries where many of the materials in this report originate. *Material Change* aims to be a starting point from which to stimulate an exchange of information on where collective actions by industry groups or trade associations might be best focused to maximize positive social, environmental and governance impacts.

Modern car

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# 1 DRIVE SUSTAINABILITY AND THE RESPONSIBLE MINERALS INITIATIVE

## 1.1 Drive Sustainability

**Drive Sustainability** (DS) is a partnership of ten major automotive brands - manufacturers of commercial and passenger vehicles (**BMW Group**, **Daimler AG**, **Ford**, **Honda**, **Jaguar Land Rover**, **Scania CV AB**, **Toyota Motor Europe**, **Volkswagen Group**, **Volvo Cars** and **Volvo Group**) convened to take action for greater sustainability throughout the automotive supply chain.

The Partnership, facilitated by CSR Europe, seeks to positively influence the automotive supply chain by promoting a common approach within the industry and by supporting the integration of sustainability into procurement processes.

DS has a set of common guidelines - the Guiding Principles – that outline expectations for suppliers on key responsibility issues including, but not limited to, business ethics, working conditions, human rights and environmental matters. Based on these guidelines, DS has developed a number of tools and resources, including a self assessment questionnaire, training services, and local networks.

In 2017 DS announced the establishment of its Raw Materials Observatory. This process aims to develop a common approach to understanding and assessing impacts, risks, and opportunities for positive action within the material supply chains of the automotive industry.

DS has been working to improve the sustainability of the automotive supply chain for the past five years, and this new study represents the next step in its commitment to ensuring that the highest standards of business ethics, good working conditions and respect for the environment and human rights are upheld in its members' supply chains. The collaborative approach taken by this study complements individual activities of each member company, with the common goal of increasing overall sustainability in the automotive sector worldwide.

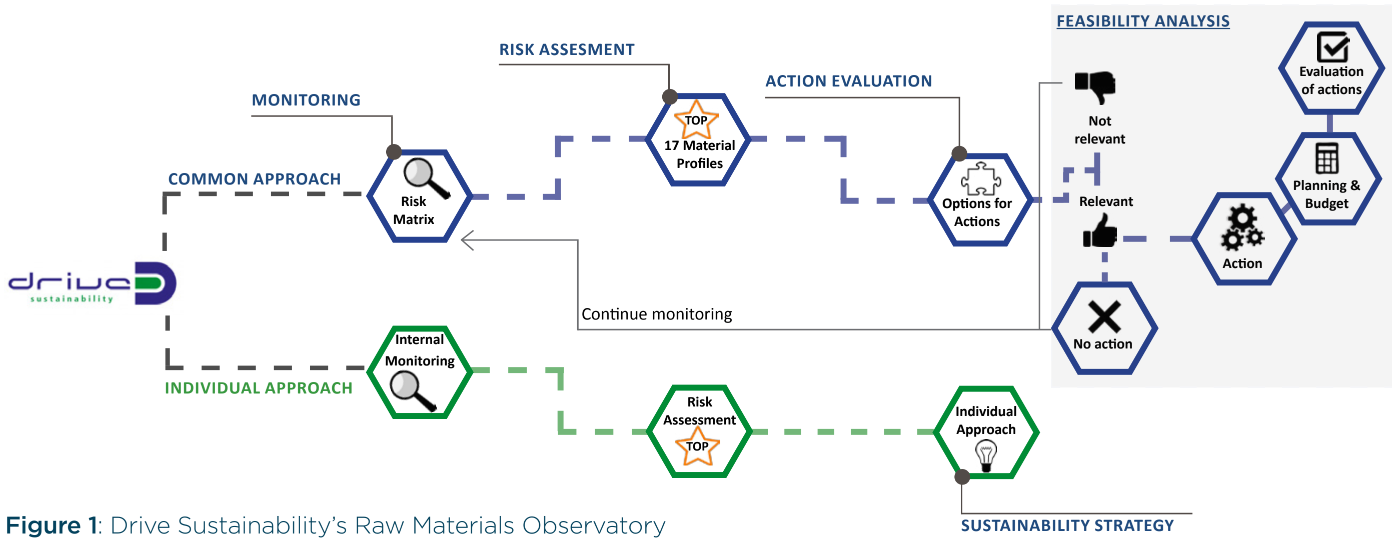



**Figure 1**: Drive Sustainability's Raw Materials Observatory

## 1.2 The Responsible Minerals Initiative

Today, more than 360 companies from over ten different industries participate in the Responsible Minerals Initiative (The RMI, formerly the Conflict Free Sourcing Initiative (CFSI)), to support responsible sourcing of minerals globally.

Founded in 2008 by members of the Responsible Business Alliance (RBA) and the Global e-Sustainability Initiative (GeSI), the RMI serves as a collaborative, multi-industry platform that encourages and improves regulatory compliance and company due diligence through the development and broad application of tools, resources and guidance documents.

Realising the opportunity and responsibility to include key materials in sourcing strategies, the RMI promotes the understanding of the salient social and environmental impacts of extracting and processing the materials that feed into industry supply chains, and contributes to mitigating these impacts. The RMI leverages direct and indirect partnerships and uses international standards (e.g., Organisation for Economic Co-operation and Development (OECD) Guidelines for Multinational Enterprises, and the United Nations (UN) Guiding Principles on Business and Human Rights) as guideposts.

The RMI creates the enabling conditions for its member companies to identify, assess and mitigate salient risks in their material supply chains. Its range of tools includes the Risk Readiness Assessment, a self-assessment tool for companies to assess and communicate their risk management practices, and supply chain surveying tools, such as the Conflict Minerals Reporting Template and Cobalt Reporting Template.

The RMI also assists member companies with due diligence and supply chain assurance, via operating an independent third-party audit program for smelters/refiners of 3TG, which is being built upon for cobalt. By contributing to peer learning via publication of guidance documents and white papers, and by influencing international dialogue, the RMI is fostering a platform for continuous improvement and education of companies and their supply chain partners.

The RMI is developing a sensing and prioritisation process to assist member companies to understand such demands for responsibly sourced materials, to prioritise efforts to meet it, and to manage associated commercial risks. This study forms part of that sensing research, providing baseline data that will help to inform prioritisation for the RMI, as well as may be used by the RMI member companies for their own due diligence and prioritisation.


**Figure 2**: RMI approach to identify & prioritise salient risks

Iron mine, Cerro Bolivar, Venezuela

# 2 HOW TO USE THE REPORT

*Material Change* is intended as a resource to inform discussions on responsible sourcing by enabling general, industry wide comparisons across 37 materials commonly used in automotive and electronics products. This report should not be used as a substitute for a company's due diligence on any particular material, commodity, supply chain or supplier.

*Material Change* includes several assessments and ratings of materials through heat maps and charts, and information presented in profiles of a selection of 18 of the materials studied. The reader should not assume that these industry level assessments and ratings apply to all companies or operations active in the production of the materials. Many companies have in place management systems that adhere to industry best practices wherever they operate, and many operate in jurisdictions that have stringent environmental and social regulatory requirements that are actively enforced. The corporate policies of individual companies and management practices at sites and facilities are very often the primary factor determining the sound management of potential impacts associated with business activities and associated reputation risks. The intention of DS and the RMI is for the information in this report to spur further enquiry into material supply chains and encourage the widespread adoption of good practices and commitments to continual improvement.

*Material Change* intentionally uses data and analyses that are comparable across the many materials and supply chains studied. Accessing data sets that allow cross-material comparison has proved difficult, however, and we note in this report the areas where data is missing and the implications for the results of the study. The ratings given in this report for some of the criteria therefore should be considered indicative, rather than conclusive. Credible information is generated and made available by industry associations and research institutions for several materials and commodities and, although not always incorporated into this report, should be consulted when designing and deploying corporate supply chain strategies and due diligence.

*Material Change* aims to support the reader by:

- Providing a broad comparative industry-level assessment of materials in the supply chain of automotive and electronics products that can help in the design of appropriately comprehensive and inclusive corporate due diligence policies.
- Identifying potential hot spot issues associated with materials and top producing countries in the supply chains of the two industries. While the supply chains of many companies will not be at risk from association with the impacts covered in this report, a raised awareness of the possibility of these issues being present will encourage further investigation and better informed due diligence efforts, if only to rule out exposure to risk.
- Stimulating discussion with industry peers, groups and associations to prioritise actions in responsible sourcing strategies and focus on where individual company engagement and collective action can best catalyse positive change.

It is important that the reader uses the results presented in this report only when the methodology used to choose the assessment criteria and determine ratings is understood. The methodological approach and criteria are introduced in the body of the report, and the report's appendices provide descriptions in further detail. Furthermore, several of the core sources used in *Material Change* are identified in the report and should be reviewed and referred to alongside the presentation of results.

This report:

1 Presents analyses of materials commonly used in the manufacture of automobiles and electronic products using two sets of criteria that establish 1) a material's importance to industry, and 2) its associated environmental, social and governance issues.

2 Provides graphical representations of generalised ratings of the materials.

3 Summarises in material profiles material specific analyses and provides additional information on some of the major producer countries for materials selected by DS and RMI members.

Section 3 describes the study's methodology. Materials were selected by DS and the RMI members for the study through a process described in Section 3.1. In Section 3.2, the groups' choice of criteria to analyse the materials is presented. Two sets of criteria are applied to each of the materials.

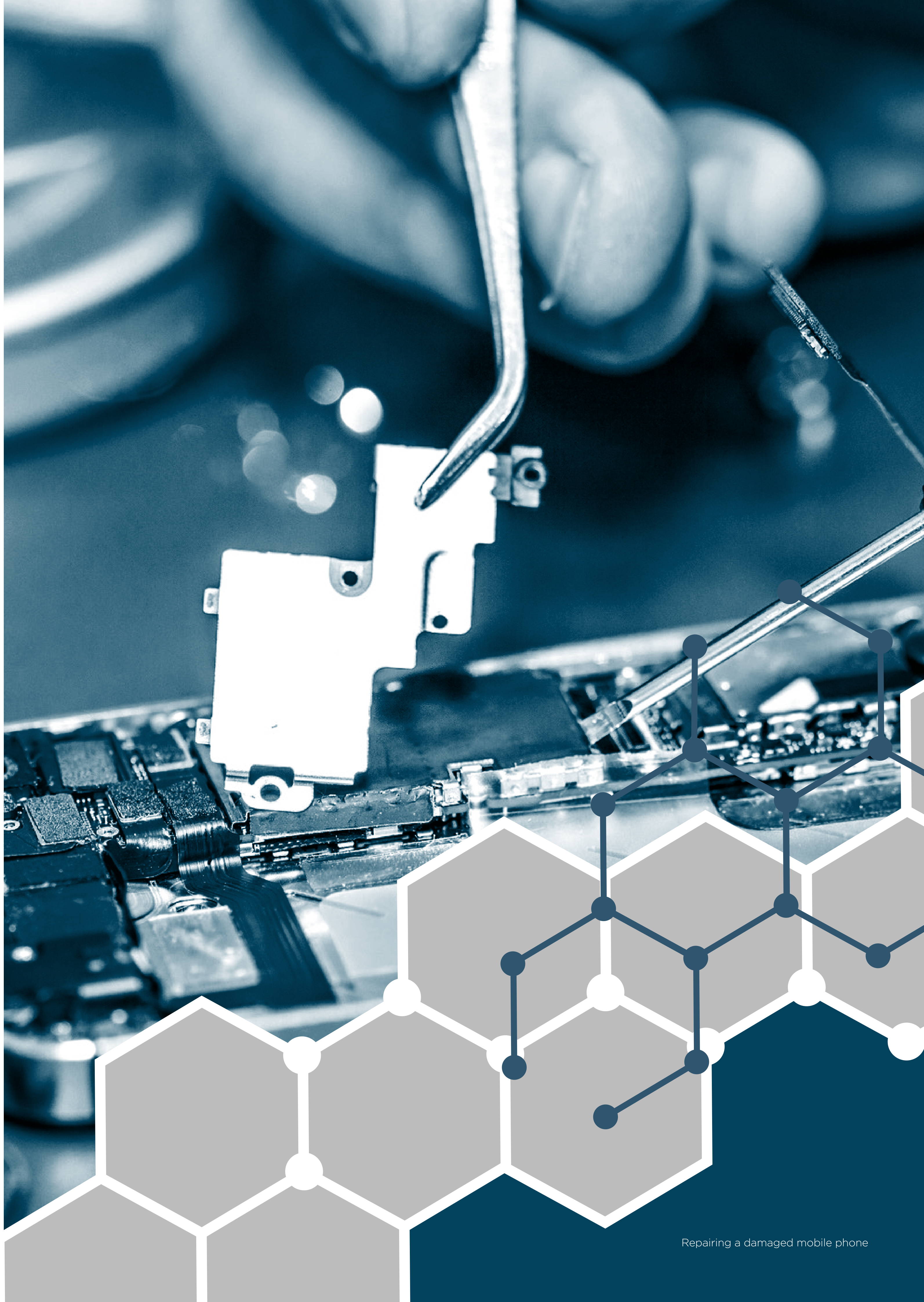
The first set of criteria identify the most important materials for the two industries' and the second set the environmental, social and governance issues associated with the production of materials - from source to factory gate. The criteria have been developed to give a general industry-level view of the issues associated with the 37 materials. For several materials there is an absence of comprehensive data sets that would enable painting a more rounded picture of the supply chains studied; this has been noted and is further discussed, along with other methodological design features of the study in section 3.3. Section 3.4 describes the approach taken to assess possible opportunities for collective action by the members of DS and the RMI.

In Section 5, results are presented in three formats. First, two heat maps are introduced that show the 37 materials and rating for each against the two sets of criteria. The heat maps provide an overview of all 37 materials studied and allow the reader to discern hotspots of importance and potential environmental, social and governance risks and impacts associated with a material. Rather than definitive and objective levels of risk, hotspots should be seen as areas for further enquiry by individual companies beginning due diligence on their specific supply chains.

Second, a series of illustrative bar charts present the 37 materials by level of industry consumption for each of the two industries on one axis and their strength of association with a selection of 8 of the 11 environmental, social and governance issues covered in this report on a second.

Third, profiles of 18 materials summarise the risk and impact ratings for each material, as well as the social, development, and economic indicators associated with the material's top producer countries. The 18 materials were selected based on RMI and Drive's institutional priorities as identified in consultation with each organization's respective membership.

The appendices to this report include lists of the materials studied, (Appendix A) and a guide to the assessment criteria (Appendix B and C).



Repairing a damaged mobile phone

# 3 STUDY METHODOLOGY

Sulfur and iron polluted river at Sao Domingos abandoned mine

## In this section the approach followed when selecting materials and formulating the criteria is explained.

The methodology is designed to arrive at an industry level appreciation of environmental, social and governance issues associated with the 37 materials studied.

It is acknowledged that many companies have begun and are advancing in their journey to understand the issues and risks in their supply chain and might already have completed in-depth studies on the social and environmental aspects of their material sourcing, such as materiality assessments and life cycle analyses. The potential to widen the scope of the research into each material and its associated environmental, social and governance issues, is vast. This report should, therefore, not be considered as comprehensive or complete but as a source of information that individual companies and others interested in the responsible sourcing of materials can use to design and undertake investigations into specific supply chains from their own point of view.

## 3.1 The materials

Rubber tree, Sri Lanka

The study started with an initial screening of 50, which was then narrowed to 37 materials commonly found in automotive and electronics products. The automotive and electronics industries offer a diverse range of products for consumers and for industrial applications.

To anchor the research and the collection of data, two "illustrative products" have been chosen, one for each industry. A smartphone has been chosen as an illustrative product for the electronics sector, and a generic passenger vehicle for the automotive sector, blending composition data from a number of vehicle types.

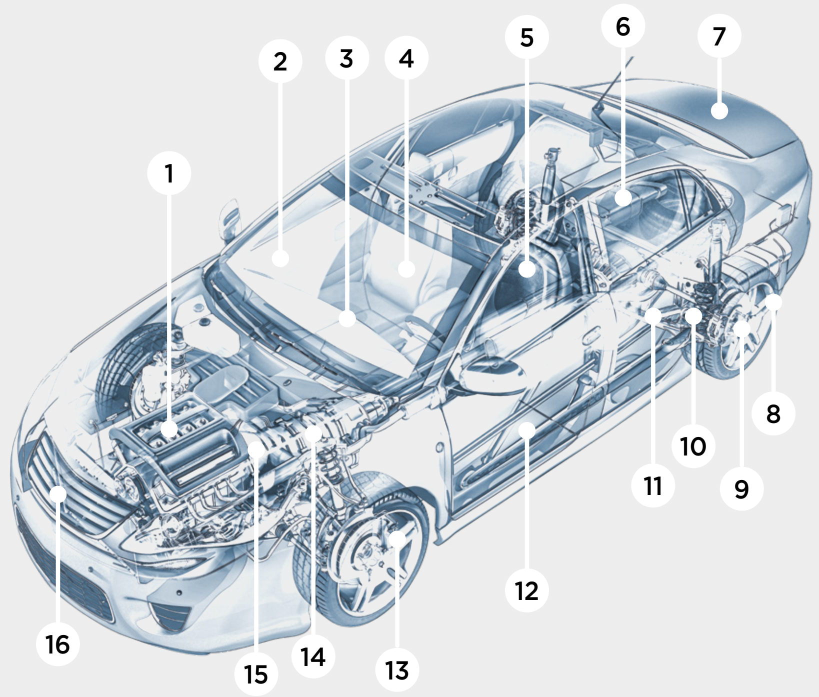
Figures 3 and 4 provide a generalised representation of these two products and materials used in some of their key components and applications. These illustrations indicate common applications of 18 materials profiled in section 5 of this report in two generic products. Applications may vary for specific products and other types of vehicles, and in some instances these materials may be substituted. The material profiles in section five also refer to these two generic products.

Many electronic applications are also found in vehicles. To avoid duplication, information on materials found in electronic applications in automobiles have not been repeated in Figure 3, which lists instead and applications and their materials additional to those found in electronics.



Figure 3

# Selected* materials in a passenger vehicle




### Selected materials and applications

**1 Engine**
Aluminium
Nickel *(turbocharger)*
Tungsten *(crankshaft)*

**2 Microphone / Speaker**
Rare earth elements
Nickel
Iron
Cobalt

**3 LED Display**
Rare earth elements

**4 Windscreen / Windows**
Glass

**5 Interiors**
Leather
Plastics

**6 Catalytic converter**
Palladium
Plastics
Rare earth elements

**7 Paint / Pearlescent finish**
Mica
Cobalt

**8 Tyres**
Rubber
Cobalt

**9 Wheels**
Graphite *(bearings)*
Steel / Iron
Tungsten *(bearings, ball joints)*

**10 Suspension**
Steel / Iron

**11 Chassis**
Aluminium
Steel / Iron
Tungsten

**12 Body panels**
Steel / Iron

**13 Brakes**
Graphite
Steel / Iron
Tungsten

**14 Transmission**
Nickel
Steel / Iron

**15 Clutch**
Graphite

**16 Radiator**
Copper

### Applications found in electric/hybrid cars

**Lithium-ion battery**
Cobalt
Graphite
Lithium
Nickel
Rare earth elements
Zinc*
(Tin**)

### Materials in applications found throughout a passenger vehicle

**Capacitors**
*Found in systems for brakes, power steering, transmission, electric motors etc.*
Mica
Palladium
Tantalum

**Electric motors**
*Found in starter motor, alternator, windscreen wipers, air conditioning etc.*
Graphite
Rare earth elements

**Plating**
*Found on engine parts, brake parts, chassis, trims, air conditioning etc.*
Nickel
Zinc

**Printed circuit boards**
*Found in systems for braking, engine control systems, safety and security systems, GPS navigation and entertainment etc.*
Aluminium
Copper
Gold
Nickel

**Solder**
Tin

**Circuitry**
Copper
Gold
Palladium

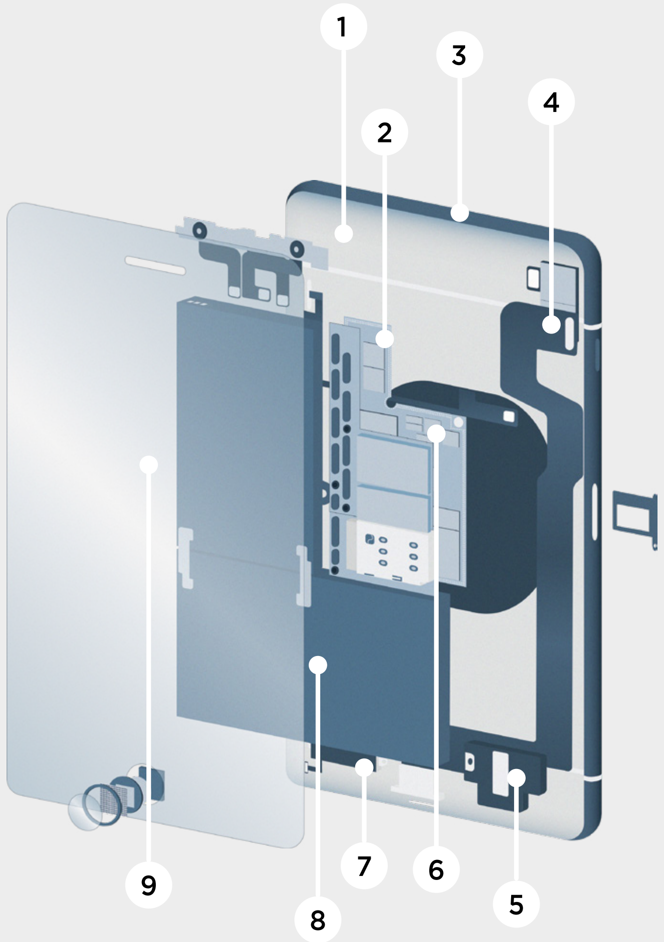
The materials included in this illustration are restricted to the 18 materials profiled in section 5.3 of this report.
Applications may vary for specific products and other types of vehicles, and in some instances these materials may be substituted.

* Used to manufacture zinc air fuel cells and nickel-zinc batteries, as alternatives to lithium-ion batteries.

** Tin is an important material in lead-acid batteries, but not in batteries used in hybrid/electric vehicles.

Figure 4

# Selected* materials in a smartphone




## Selected materials and applications

1 **Casing**
Aluminium

2 **Printed circuit board**
Aluminium
Copper
Gold
Nickel

3 **Paint / Pearlescent finish**
Mica

4 **Circuitry**
Copper
Gold
Palladium

5 **Microphone / Speaker**
Copper
Iron
Nickel
Rare earth elements

6 **Capacitors**
Palladium
Tantalum

7 **Vibration unit**
Rare earth elements
Tungsten

8 **Battery**
Cobalt
Graphite
Lithium
Nickel

9 **Display screen**
Glass
Rare earth elements
Tin

## Materials in applications found throughout a smartphone

**Insulation**
Mica

**Solder**
Tin

The materials included in this illustration are restricted to the 18 materials profiled in section 5.3 of this report.
Applications may vary for specific products and other types of vehicles, and in some instances these materials may be substituted.





The materials assessed in this study were identified by the Original Equipment Manufacturer (OEM) members of DS. Each DS member provided a list and a ranking of the materials their company considered priorities for their responsible sourcing strategies. Drawing on these individual contributions, a consolidated list was created of 50 materials that were identified most often by the members as priorities. An early screening of available data revealed that it would be difficult to collect comparative information on individual rare earth elements (REEs), resulting in the exclusion of some and the treatment of the remainder as a single group under one material. Five REEs (Erbium, Europium, Holmium, Thulium, Ytterbium) were excluded from the study due to lack of data on their use and functionality in automotive supply chains. Data for nine other REEs (Cerium, Dysprosium, Gadolinium, Lanthanum, Neodymium, Praseodymium, Samarium, Terbium and Yttrium) were consolidated as available data is largely aggregated at the level of this group of elements, and information on the environmental, social and governance aspects of their recovery indicates similar characteristics for many of the REEs.

The RMI provided a shortlist of materials to be included in this study based on its sensing process. The RMI's sensing process aims to establish, through a series of filters based on historical and forecasted data, which materials the RMI prioritise for further research and possible action through working groups formed by its members. The selection of shortlisted materials for this study was based on a 2008 study on Social and Environmental Responsibility in Metals Supply to the Electronics Industry[3] as well as ten filters focusing on supply chain criteria and key social, governance and environmental risks associated with the minerals' sources.

The materials selected from these two processes were combined to form the final list of 37 materials covered by this study and these are shown in Box 1.

While the majority of these materials are derived from mined minerals and subsoil resources, they are not exclusively so. The non-mined materials included in this study are leather and natural rubber.

Furthermore, not all the materials studied are "raw materials" in the strict definition of the word, as many undergo significant transformation before they reach the factory gate. For example, aluminium begins its journey as bauxite ore before it is chemically processed into alumina and smelted into aluminium metal. Rolling mills then process the aluminium into sheet material for manufacturing plants. Similarly, iron ore is combined with carbon, limestone, and oxygen in furnaces to make steel, and silica sand is dredged from river beds and harvested from beaches to be processed into glass. Also included are plastics, for which the main feedstock raw material is hydrocarbon (gas and oil) that is 'cracked' to create the material's basic molecular architecture. The terms "mineral" and "raw material" are avoided where possible, therefore, and reference is made simply to "material" throughout.

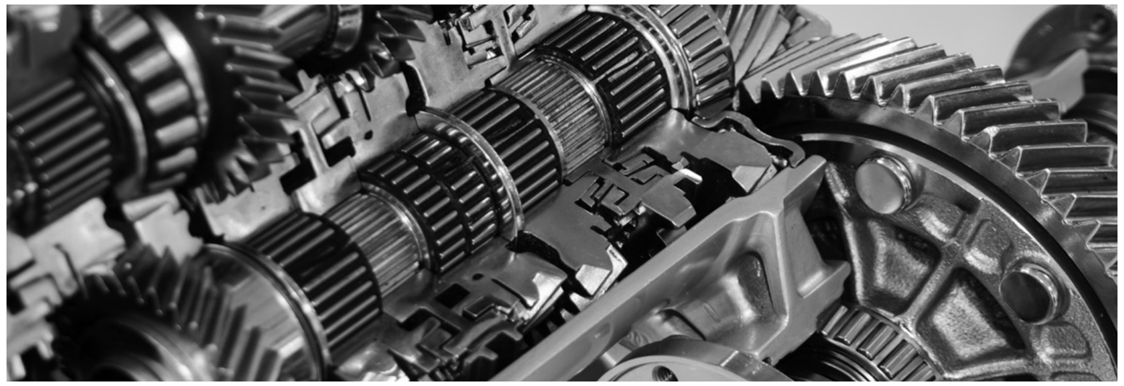
Box 1

**37 selected materials found in automotive and electronics products**

| | |
|---|---|
| Antimony | Molybdenum |
| Aluminium / Bauxite | Nickel |
| Beryllium | Niobium |
| Bismuth | Palladium |
| Chrome & Chromium | Plastics |
| Cobalt | Platinum |
| Copper | Rare Earth Elements |
| Gallium | Rhodium |
| Germanium | Ruthenium |
| Glass (silica sand) | Rubber (natural) |
| Gold | Silver |
| Graphite (natural) | Steel / Iron |
| Indium | Tantalum |
| Lead | Tin |
| Leather | Titanium |
| Lithium | Tungsten |
| Magnesium | Vanadium |
| Manganese | Zinc |
| Mica | |

3.Social and Environmental Responsibility in Metals Supply to the Electronics Industry, prepared for the Electronic Industry Citizenship Coalition and the Global e-Sustainability Initiative by GHGm, 20 June 2008.

## 3.2 The assessment criteria



Automotive Transmission

### DS and the RMI members formulated the criteria used in this study to be broadly applicable to the selected materials and to gather and analyse data and generate information on environmental, social and governance issues that is salient for the industry as a whole.

These criteria are indicative of the areas of concern of many OEM companies and their stakeholders in both industries. It is acknowledged, however, that different criteria and indicators might provide a richer and more accurate picture of specific risks and environmental, social and governance impacts in particular material supply chains, industry sectors or countries.

As a general overview of the materials, the report is intended to serve as a point of departure for businesses to examine specific materials, or supply chain issues, in greater depth rather than as a definitive evaluation of risk or impacts. DS and the RMI recognise that the corporate policies of individual companies and management practices at sites and facilities are very often the primary factor determining the sound management of adverse impacts. This level of operational performance is not covered in this study and should always be the subject of company due diligence.

16 criteria organised into two broad categories were applied to each of the materials:

**1** Importance to Industry

(Criteria 1 – 5) These five criteria indicate the degree to which the automotive or electronics industry relies on a material to manufacture its products, the supply vulnerability of that material and the potential influence of the industry sector on a material's supply chain by virtue of its proportional consumption of global production.

**2** Environmental, Social and Governance Issues

(Criteria 6 – 16) These eleven criteria indicate the extent to which production of a material is associated with adverse environmental, social or governance impacts that affect upstream communities and wider society and present a risk to corporate reputation.



**Table 1:** The assessment criteria

Table 1 lists the 16 criteria and corresponding indicators against which each of the materials were assessed, while Appendix B provides a full guide to each of the criteria, and the indicators and measures used for rating materials[4].

| Criterion | Indicator |
|---|---|
| **Importance to Industry** | |
| 1. Industry consumption | Percentage (%) of total global consumption that can be attributed to the automotive or electronics industry, indicating the influence of the industry sector in the material's supply chain and an implied responsibility to act to remedy adverse impacts. |
| 2. Function criticality | The degree to which the material performs a purpose that cannot be fulfilled by an alternative, potentially more sustainable substitute without compromise to the quality or functionality of the product. |
| 3. Residual end-of-life waste[5] | Percentage (%) of material not recycled from end-of-life (EOL) post-consumer waste in the two industries. EOL recycling can be a favourable alternative to mining new materials, particularly for materials that are scarce or with predicted high rates of depletion. |
| 4. Virgin material consumption[6] | Percentage (%) of total material input into production that is newly mined, extracted or produced. This criterion can be used to measure the circular use of materials at an industry level by how much of the total material input into the production system comes from virgin sources as opposed to recycled post-consumer scrap. |
| 5. Estimated rate of depletion | The rate at which a material is becoming unavailable from mining indicating where improved recycling rates are most urgent. Very few raw materials can be considered truly physically scarce. The availability of a mineral is determined by the cost of extraction, technological capacity, and by geopolitical and environmental factors. |
| **Association with Environmental, Social and Governance Issues** | |
| **Criterion** | **Indicator** |
| 6. Artisanal and small-scale mining (ASM) | Percentage (%) of global material production reportedly attributable to ASM. Although much has been achieved in recent years in improving the capacity and management practices at ASM operations, ASM is often strongly associated with serious environmental and human rights impacts. |
| 7. Child labour and forced labour | Prevalence of child labour and/or forced labour associated with the global production of the material. |
| 8. Countries with weak rule of law | The material's strength of association with producer countries that have weak rule of law. |
| 9. Countries experiencing corruption | The material's strength of association with producer countries' perceived levels of corruption. |
| 10. Countries experiencing high-intensity conflict | The degree to which key producing countries of each material are associated with the highest intensity (political) inter or intra- state conflict. It should be noted that this criterion does not measure whether the production of the material is itself directly linked with conflict, but whether it is produced in a country that is associated with state conflict. |
| 11. High CO2 emissions[7] | Relative level of CO2 emissions within the group of materials studied associated with the production or processing stages of material's life cycle. The criterion excludes emissions associated with the use of the final product. |
| 12. Incidences of conflict with Indigenous Peoples | Evidence of incidences of Indigenous Peoples in conflict with, or mobilising against, material producers over land-use and resource rights. |
| 13. Incidences of overlap with areas of conservation importance | Evidence of coincidence of production sites with designated protected and other recognised areas of importance for conservation of biodiversity and natural landmarks. It should be noted that although the body of information on the overlap of production activities (especially mining) and areas of conservation importance continues to grow, data that are commodity specific and comparable across the materials in this study are unavailable. |
| 14. Potential for acid discharge to the environment | Likelihood of the material being found in acidic sulphide ores, creating risk of acid-mine drainage (AMD.) and/or association with acids used in mineral processing. |
| 15. Potential for harm from hazardous materials and chemicals | The degree to which the material is connected with a heightened, inherent, threat, such as hazardous pollutants that present serious health and safety challenges for workers and surrounding communities. |
| 16. Preconditions for radioactive materials in ores and tailings | Likelihood of the material being found in ores containing naturally occurring radioactive material (NORM) or is associated with Technologically Enhanced Naturally Occurring Radioactive Material (TENORM). |

4.To achieve a comprehensive comparison of the 37 materials' ratings the criteria have been formulated to allow scores from 'low' to 'very high'. To achieve this consistency across the ratings the formulations of some criteria are sometimes less intuitive than other possible options. For example, to measure the circular use of a material the total material input into the production system from virgin sources is measured, rather than the more common measure of the percentage of recycled post-consumer material used in the process.
5.This is the inverse of what is more commonly expressed as the end of life recycling rate (EOL-RR.)
6.This is the inverse of what is more commonly expressed as the end of life-recycling input rate (EOL-RIR.)
7. This criterion measures the association of the materials' production with climate change, the popular measure for which is greenhouse gas emissions, which in turn is commonly expressed as carbon dioxide equivalent emissions (CO2e). It has not been possible to access data on carbon intensity or CO2e for a great many of the materials, even though private information (such as from Life Cycle Analysis studies) does exist. CO2e data is available for whole industries (e.g. mining and quarrying activities in the EU Member States), but this is not broken down by material. This criterion focuses on CO2, therefore, rather than CO2e because of the lack of comparable, material specific, global data sets.

# 3.3 Considerations in the choice and formulation of the criteria

*Material Change* assesses materials at a general industry-wide level and the criteria have been chosen and formulated for that purpose. Noted in this section are some of the factors considered in the design of the criteria.

The research team endeavoured to choose criteria applicable to, and comparable between, both mined and non-mined materials as some of the studied materials are not extracted from the earth but are agricultural and silviculture products. Indicators for these criteria have been selected based on the availability of comparative data across as many of the 37 materials as possible. Criterion five, "estimated depletion rate", and criterion six, "artisanal and small-scale mining" are applied only to mined materials.

Risks associated with poor corporate governance, such as commercial corruption, illegal practices and operations and connection to organised criminal networks, are not assessed here as such issues are specific to the behaviour of individual entities and no credible data source was identified that assesses these aspects comparatively at the country level or for specific materials.

Similarly, while the significance of localised impacts on communities is recognised, such as gender based violence and discrimination, loss of livelihoods due to resettlement and interactions with private security at mine sites or processing facilities, criteria for these issues have not been included as no data source was identified that enables a material level or industry wide assessment.

Although highly relevant from the perspective of responsible sourcing, animal welfare was not considered in the comparative analysis of natural leather. Such a criterion is inapplicable to any other material assessed, and therefore could not be incorporated into the methodology.

Life cycle analyses (LCAs) are a particularly useful tool to better understand and compare the environmental footprint of a product, component or production process, and one that many companies already use in the development of their responsible sourcing strategies. Few comprehensive LCAs are publicly available for the materials in this study and an insufficient number to allow a comparative analysis across all 37 studied. Furthermore, it has not been possible within the mandate and resource constraints of this study to commission LCAs on all of the materials.

Also not addressed in this report is the highly topical issue of single-use plastics. The environmental and health impacts of single use plastics arise from the large quantities of used materials released continuously as waste. Most plastics employed in automotive and electronics products have a much longer life cycle, and therefore do not have the same associated risks as single-use plastics. The ratings given to plastics in this study reflect that difference.





# 3.4 Assessing opportunities for collective action

For 18 materials selected by DS and the RMI to correspond with their institutional priorities, the study identified, reviewed and rated opportunities for collective action to address adverse environmental and social impacts or to advance positive change in communities affected by material production.

Identified opportunities included: joining existing industry initiatives to promote best practice standards, principles frameworks and certification schemes, or starting new ones; engaging upstream companies, communities and other stakeholders to improve conditions in resource-producing areas; participation in materials stewardship and lifecycle management programmes; and promoting collective action where no initiative exists. DS and the RMI acknowledge that some of the most compelling opportunities to catalyse positive change might be found where there is little or no current activity, but where there might well be other businesses, civil society and government agencies eager to collaborate.

The study assessed the scope for engagement that these opportunities offer for DS and the RMI members, both collectively and individually. The assessment considered the relevance of the opportunities to the two industries' supply chains, and the value that an engagement by its members could add compared with other industry sectors or groups; the potential scale of impact that could be attributed to the initiative, including the geographic range of impacts, the range of materials targeted, and the potential benefits, both in terms of the number of people reached, and the intensity of need that the initiative seeks to address; the possibility for DS and the RMI members to participate or support the initiative; and, the level and nature of resources that members would be expected to contribute to the success of the initiative.

While it is acknowledged that many of the most supported and well established initiatives globally cover a broad range of materials, with a tight thematic focus, this study seeks to focus on targeted, material specific initiatives, many of which have been recently developed, thereby offering an opportunity for timely leadership by industry members .

The results of this research on opportunities for collaborative action serve to directly inform DS and the RMI's early and continuing discussions with their members on future plans for engagement in different material supply chains and have not been included in this document. DS and the RMI will continue to inform stakeholders of actions taken collectively to support material-specific initiatives through their websites and other regular communication channels.

# 4 STUDY LIMITATIONS

*Material Change* is general and broad in scope. The research uses parameters and criteria chosen to enable reliability and consistency across the data. While more than 400 references have been reviewed for this study, the information gathered should not be considered exhaustive.

The choice of information sources is informed by data quality and contemporaneity. Several data sets and reports - although relevant - have therefore not been included in this study. Where possible, the analysis has been restricted to data that have been generated, gathered and published within the last five years, and from at least one of the following sources:

- A peer-reviewed academic journal.
- A published report by a reputable NGO, think tank, research institute or industry association.
- A media article by a named author.
- Government agencies or institutions.

In some areas it is clear that there has been little research and it has not been possible to gather complete data sets for all the analytical criteria applied to each material. Where data sets are incomplete, an average value is used.

Data sets collected for each of the materials are considered 'complete' when data conforming to the above parameters are present for each of the 16 criteria against which the material is analysed. Most materials have complete data sets or are missing data for only one or two criteria out of the possible 16. It has not always been possible to find data relevant to a criterion for all materials within a single data source. In such instances, assessments are based on data gathered from multiple sources, each of which conforms where possible to the above parameters for data reliability.

Some materials are recovered as a by-product of other ores - for example, cobalt is nearly always a by-product of copper or nickel, indium is very often a by-product of zinc, and sometimes copper; and gallium is a by-product of aluminium and, less often, zinc. In these cases, we have relied in part or entirely on information on the primary material recovered with which the by-product is associated.

The materials heat maps in section 5.1 give details on where data are missing for each material and criterion, and Appendix A gives an overview of data completeness by material and industry.

**Table 2**: Completeness of material data sets

| Industry | Materials with complete data | Missing data for 1-2 criteria | Missing data for 3-5 criteria | Missing data for 6-10 criteria |
|---|---|---|---|---|
| Automotive | 14 | 14 | 5 | 4 |
| Electronics | 15 | 12 | 6 | 4 |

This study forms part of wider processes for sensing and prioritisation for DS and the RMI members, and the data presented here will be augmented as these processes advance. As more data becomes available, ratings can both increase and decrease.

# 5 STUDY RESULTS

In this section, results of the study are presented in three formats.

**1** First, two 'heat maps' (Figures 5 and 6) show the 37 materials and the ratings for each against the 16 criteria organised by the two categories: importance to industry and environmental, social and governance issues. The two heat maps enable an overview of all 37 materials and allow the reader to discern hotspots of importance and potential environmental, social and governance (ESG) issues associated with a material. It should be noted that a hot spot does not necessarily imply a prevalence of a frequency of an ESG issue associated with a material. Rather it draws attention to the presence of an issue and the need for further enquiry.

**2** Second, a series of bar charts present the materials' ratings against an aggregation of the 11 ESG issues (Figures 7 and 8) and a selection of 8 of the 11 ESG issues covered in this report (Figures 9 to 24).

**3** Third, summarised information on 18 of the studied materials is presented in individual material profiles.

These heat maps, charts and material profiles can be used to begin the process of identifying risks and impacts in materials supply chains and to look for potential opportunities for collective actions to address environmental and social issues. They should not be seen as a replacement for any individual company's due diligence, and it is not suggested that the 18 materials covered by the profiles should be considered a priority for any individual company's sourcing strategy. Rather, taken together these form a starting point for companies that are at the early stages of developing or reviewing the sources of their materials and might wish to join in industry-wide efforts on responsible sourcing.

## 5.1 The materials heat maps

The following two heat maps (Figures 5 and 6) show the 37 materials and the ratings for each against the 16 criteria used in this study.

Ratings assigned to criteria for each of the materials are given a colour code and are presented in Table 3.

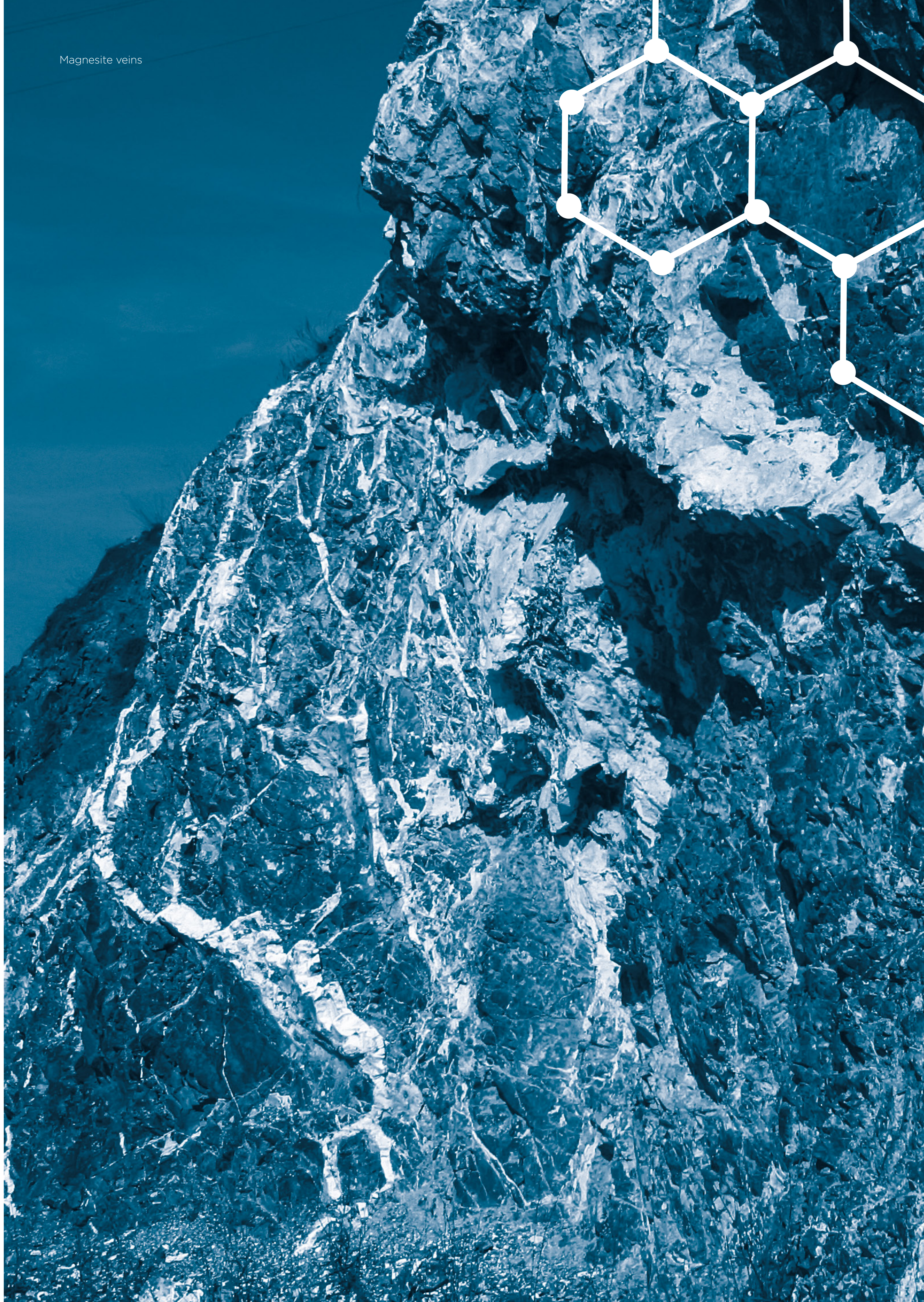
**Table 3:** Key to materials' ratings

| Rating | Colour |
|---|---|
| Very High / Very Strong | |
| High / Strong | |
| Moderate | |
| Low / Weak | |
| Missing Data | MD |
| Non Applicable | N/A |

Colour-coding the materials against each of the criteria allows for a heat map and an awareness of the materials' importance to industry and quick identification of issues hotspots, either by thematic area or by material. Table 1 and Appendix B provide guidance to the criteria and should be read when using the heat maps. Where sufficient detailed information is available the materials have been rated on their association with ESG issues by the four levels from 'weak' to 'very strong', but this has not been possible for all of the criteria. For three of the criteria 'Incidences of overlap with areas of conservation importance', 'Potential for acid discharge to the environment' and 'Preconditions for radioactive materials in ore and tailings') only two possible simplified ratings are used, 'yes' or 'no'.

In the following heat maps, a 'hotspot' draws attention to a potential issue associated with the production of a material, but does not imply a definitive measure of risk or impact. The application of a "hotspot" for an individual company is possible only when the company has fully scoped the materials it uses, in what quantity, and from which source and origin. The corporate policies of companies and management practices at sites and facilities are very often the primary factor determining the sound management of adverse impacts. This level of operational performance is not covered in this study and should always be the subject of company due diligence.




Magnesite veins

# Materials heat map

## Materials heat map key

| Not Applicable | Missing Data | Low | Moderate | High | Very high |
|---|---|---|---|---|---|
| N/A | MD | | | | |

| Mineral /Material | Importance to Industry | | | | | | | | | | Mineral /Material |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Industry consumption | | Function criticality | | Residual end-of-life waste | | Virgin material consumption | | Estimated rate of depletion | | |
| | Automotive | Electronic | Automotive | Electronic | Automotive | Electronic | Automotive | Electronic | Automotive | Electronic | |
| Aluminium / Bauxite | High | Moderate | Moderate | Moderate | Low | Low | Moderate | Moderate | Low | Low | Aluminium / Bauxite |
| Antimony | High | High | High | High | High | High | Moderate | Moderate | Very high | Very high | Antimony |
| Beryllium | High | High | Very high | Very high | High | Very high | Very high | Very high | Low | Low | Beryllium |
| Bismuth | Low | High | Moderate | Moderate | Very high | Very high | High | High | Moderate | Moderate | Bismuth |
| Chrome & Chromium | High | MD | Very high | Very high | MD | Low | Moderate | Moderate | MD | MD | Chrome & Chromium |
| Cobalt | High | High | Moderate | Moderate | High | High | Low | Low | Low | Low | Cobalt |
| Copper | High | High | Very high | Very high | Low | Low | Moderate | Moderate | Moderate | Moderate | Copper |
| Gallium | Low | High | High | High | Very high | Very high | Very high | Very high | Low | Low | Gallium |
| Germanium | Moderate | High | Very high | Very high | Very high | Very high | High | High | Low | Low | Germanium |
| Glass (silica sand) | High | Low | Very high | Very high | Low | MD | Very high | Very high | MD | MD | Glass (silica sand) |
| Gold | Low | Moderate | Low | Low | Moderate | Moderate | Moderate | Moderate | Moderate | Moderate | Gold |
| Graphite (natural) | Moderate | Low | High | High | Very high | Very high | High | High | High | High | Graphite (natural) |
| Indium | MD | Very high | Very high | Very high | Very high | Very high | Very high | Very high | Low | Low | Indium |
| Lead | Very high | Low | Low | Low | Low | Low | Low | Low | Moderate | Moderate | Lead |
| Leather* | High | N/A | Very high | N/A | Very high | N/A | MD | N/A | N/A | N/A | Leather* |
| Lithium | High | High | Moderate | Moderate | Very high | High | Very high | Very high | Low | Low | Lithium |
| Magnesium | High | High | Very high | Very high | MD | Moderate | High | High | Low | Low | Magnesium |
| Manganese | High | Low | Very high | Very high | Low | Low | Moderate | Moderate | Low | Low | Manganese |
| Mica | MD | MD | Moderate | Moderate | Very high | High | MD | MD | MD | MD | Mica |
| Molybdenum | High | Low | Very high | Very high | High | High | Moderate | Moderate | Very high | Very high | Molybdenum |
| Nickel | Moderate | High | High | High | Low | Low | Low | Low | Moderate | Moderate | Nickel |
| Niobium | High | Low | Moderate | Moderate | MD | High | Very high | Very high | Low | Low | Niobium |
| Palladium | Very high | High | Very high | Low | High | High | High | High | Low | Low | Palladium |
| Plastics | Moderate | Moderate | MD | MD | MD | High | MD | MD | MD | MD | Plastics |
| Platinum | Very high | Low | High | High | Moderate | High | Moderate | Moderate | Low | Low | Platinum |
| Rare earth elements** | Moderate | Very high | Very high | Very high | Very high | Very high | High | High | Low | Low | Rare earth elements** |
| Rhodium | Very high | Moderate | Very high | Very high | Low | High | High | High | Low | Low | Rhodium |
| Rubber (natural)* | Very high | N/A | Very high | N/A | Low | N/A | High | N/A | N/A | N/A | Rubber (natural)* |
| Ruthenium | Moderate | Very high | MD | MD | MD | High | Moderate | Moderate | Low | Low | Ruthenium |
| Silver | Moderate | High | Moderate | Moderate | High | High | Low | Low | Moderate | Moderate | Silver |
| Steel / Iron | Moderate | Low | High | High | Low | Low | Moderate | Moderate | Moderate | Moderate | Steel / Iron |
| Tantalum | MD | Very high | Very high | Moderate | Very high | Very high | High | High | Low | Low | Tantalum |
| Tin | Moderate | Very high | Very high | Very high | High | High | Low | Low | Moderate | Moderate | Tin |
| Titanium | Low | Low | High | High | Very high | Very high | Moderate | Moderate | Low | Low | Titanium |
| Tungsten | High | Moderate | Moderate | Moderate | High | High | Low | Low | Moderate | Moderate | Tungsten |
| Vanadium | MD | N/A | Low | N/A | Very high | N/A | Low | N/A | Low | N/A | Vanadium |
| Zinc | Moderate | High | Low | Low | Moderate | High | Low | Low | Very high | Very high | Zinc |

**Figure 5**

**Leather and rubber are sometimes found in the accessories of electronics products, such as watch straps or smartphone cases and covers and 1% of rubber is consumed by electronics industry globally across all product ranges.. The electronics industry's consumption of leather and rubber is tiny and they do not perform a critical functions for any electronics product and they are therefore rated as non 'applicable' for their importance to the electronics industry.*

***Praseodymium, Cerium, Dysprosium, Gadolinium, Neodymium, Samarium, Terbium, Yttrium*

The "hotspots" in this heat map draw attention to potential issues associated with the production of a material, but do not imply a definitive measure of risk or impact.

# Materials heat map

## Materials heat map key

| Not Applicable | Missing Data | No / Weak | Moderate | Strong | Yes / Very Strong |
|---|---|---|---|---|---|
| N/A | MD | | | | |

**Association with Environmental, Social and Governance Issues**

| Mineral /Material | Artisanal and small-scale mining (ASM) | Child labour and forced labour | Countries with weak rule of law | Countries experiencing corruption | Countries experiencing high-intensity conflict | High CO2 emissions | Incidences of conflict with Indigenous Peoples | Incidences of overlap with areas of conservation importance | Potential of acid discharge to the environment | Potential for harm from hazardous materials and chemicals | Preconditions for radioactive materials in ore/tailings | Mineral /Material |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aluminium / Bauxite | No / Weak | No / Weak | Strong | Strong | Moderate | Strong | Strong | Yes / Very Strong | No / Weak | Moderate | Yes / Very Strong | Aluminium / Bauxite |
| Antimony | No / Weak | No / Weak | Yes / Very Strong | Yes / Very Strong | No / Weak | MD | Moderate | MD | Yes / Very Strong | Moderate | No / Weak | Antimony |
| Beryllium | No / Weak | No / Weak | Moderate | Moderate | No / Weak | MD | MD | MD | Yes / Very Strong | Moderate | No / Weak | Beryllium |
| Bismuth | No / Weak | No / Weak | Strong | Yes / Very Strong | Moderate | MD | MD | Yes / Very Strong | Yes / Very Strong | No / Weak | No / Weak | Bismuth |
| Chrome & Chromium | Moderate | No / Weak | Strong | Strong | Moderate | MD | Strong | MD | No / Weak | Yes / Very Strong | No / Weak | Chrome & Chromium |
| Cobalt | Strong | Yes / Very Strong | Yes / Very Strong | Yes / Very Strong | Yes / Very Strong | Moderate | Moderate | Yes / Very Strong | Yes / Very Strong | Strong | No / Weak | Cobalt |
| Copper | No / Weak | No / Weak | Moderate | Moderate | Moderate | Moderate | Yes / Very Strong | Yes / Very Strong | Yes / Very Strong | Yes / Very Strong | Yes / Very Strong | Copper |
| Gallium | No / Weak | No / Weak | MD | MD | MD | Moderate | Strong | Yes / Very Strong | Yes / Very Strong | Moderate | Yes / Very Strong | Gallium |
| Germanium | MD | No / Weak | Strong | Strong | No / Weak | MD | MD | MD | Yes / Very Strong | MD | MD | Germanium |
| Glass (silica sand) | No / Weak | No / Weak | Moderate | Moderate | No / Weak | No / Weak | Moderate | MD | No / Weak | No / Weak | MD | Glass (silica sand) |
| Gold | Moderate | Strong | Strong | Strong | No / Weak | Yes / Very Strong | Yes / Very Strong | Yes / Very Strong | Yes / Very Strong | Yes / Very Strong | Yes / Very Strong | Gold |
| Graphite (natural) | MD | No / Weak | Strong | Strong | Moderate | MD | Moderate | MD | No / Weak | Moderate | No / Weak | Graphite (natural) |
| Indium | No / Weak | No / Weak | Moderate | Strong | No / Weak | Moderate | Strong | Yes / Very Strong | Yes / Very Strong | Strong | Yes / Very Strong | Indium |
| Lead | No / Weak | No / Weak | Strong | Strong | Moderate | Moderate | Strong | Yes / Very Strong | Yes / Very Strong | Yes / Very Strong | No / Weak | Lead |
| Leather | N/A | Moderate | Strong | Strong | Moderate | Moderate | Moderate | MD | N/A | Yes / Very Strong | N/A | Leather |
| Lithium | No / Weak | No / Weak | Moderate | Moderate | No / Weak | No / Weak | Yes / Very Strong | No / Weak | No / Weak | No / Weak | No / Weak | Lithium |
| Magnesium | MD | No / Weak | Strong | Strong | Moderate | Strong | MD | No / Weak | Yes / Very Strong | No / Weak | No / Weak | Magnesium |
| Manganese | Moderate | No / Weak | Strong | Strong | Moderate | MD | Moderate | No / Weak | Yes / Very Strong | Strong | No / Weak | Manganese |
| Mica | Strong | Yes / Very Strong | Strong | Strong | No / Weak | MD | Moderate | No / Weak | No / Weak | Moderate | No / Weak | Mica |
| Molybdenum | Moderate | No / Weak | Strong | Strong | Moderate | MD | MD | MD | Yes / Very Strong | Strong | Yes / Very Strong | Molybdenum |
| Nickel | No / Weak | No / Weak | Strong | Strong | Strong | Strong | Yes / Very Strong | Yes / Very Strong | Yes / Very Strong | Yes / Very Strong | No / Weak | Nickel |
| Niobium | MD | No / Weak | Moderate | Strong | Yes / Very Strong | MD | Moderate | No / Weak | Yes / Very Strong | No / Weak | Yes / Very Strong | Niobium |
| Palladium | No / Weak | No / Weak | Strong | Strong | No / Weak | Yes / Very Strong | MD | No / Weak | Yes / Very Strong | Moderate | No / Weak | Palladium |
| Plastics | MD | No / Weak | Strong | Strong | No / Weak | MD | MD | MD | N/A | MD | MD | Plastics |
| Platinum | No / Weak | No / Weak | Strong | Strong | No / Weak | Yes / Very Strong | Moderate | No / Weak | Yes / Very Strong | Moderate | No / Weak | Platinum |
| Rare earth elements** | MD | No / Weak | Strong | Strong | No / Weak | MD | Moderate | No / Weak | No / Weak | Moderate | Yes / Very Strong | Rare earth elements** |
| Rhodium | No / Weak | No / Weak | MD | MD | MD | MD | MD | No / Weak | Yes / Very Strong | Moderate | No / Weak | Rhodium |
| Rubber (natural) | N/A | Yes / Very Strong | Strong | Strong | No / Weak | Moderate | Yes / Very Strong | Yes / Very Strong | N/A | Moderate | N/A | Rubber (natural) |
| Ruthenium | No / Weak | No / Weak | MD | MD | MD | MD | MD | No / Weak | Yes / Very Strong | Moderate | No / Weak | Ruthenium |
| Silver | Moderate | No / Weak | Strong | Yes / Very Strong | Strong | Strong | Yes / Very Strong | Yes / Very Strong | Yes / Very Strong | Strong | Yes / Very Strong | Silver |
| Steel / Iron | No / Weak | No / Weak | Strong | Strong | No / Weak | Strong | Strong | Yes / Very Strong | No / Weak | No / Weak | Yes / Very Strong | Steel / Iron |
| Tantalum | Yes / Very Strong | Yes / Very Strong | Yes / Very Strong | Yes / Very Strong | Yes / Very Strong | MD | MD | Yes / Very Strong | Yes / Very Strong | No / Weak | Yes / Very Strong | Tantalum |
| Tin | Yes / Very Strong | Strong | Yes / Very Strong | Strong | Strong | MD | Moderate | Yes / Very Strong | Yes / Very Strong | No / Weak | Yes / Very Strong | Tin |
| Titanium | MD | No / Weak | Strong | Strong | No / Weak | Strong | Strong | No / Weak | No / Weak | No / Weak | Yes / Very Strong | Titanium |
| Tungsten | Moderate | No / Weak | Strong | Strong | No / Weak | MD | Moderate | No / Weak | No / Weak | No / Weak | No / Weak | Tungsten |
| Vanadium | MD | No / Weak | Strong | Yes / Very Strong | Moderate | MD | MD | MD | Yes / Very Strong | MD | MD | Vanadium |
| Zinc | No / Weak | No / Weak | Strong | Strong | Moderate | Moderate | Strong | Yes / Very Strong | Yes / Very Strong | Yes / Very Strong | Yes / Very Strong | Zinc |

**Figure 6**

***Praseodymium, Cerium, Dysprosium, Gadolinium, Neodymium, Samarium, Terbium, Yttrium*

The "hotspots" in this heat map draw attention to potential issues associated with the production of a material, but do not imply a definitive measure of risk or impact.

## 5.2 Materials' ratings

### To allocate effort and resources where the greatest positive outcome is possible, it is necessary to prioritise.

To help companies take a first-step in their own prioritisation processes, the illustrations in this section display the 37 materials according to the level of consumption by the two industry sectors and their strength of association with environmental, social and governance (ESG) issues using illustrative bar charts. The availability of information and the conclusions drawn on consumption by material for each industry varies considerably and for that reason the material's have been clustered into four bands of consumption level - low to very high, the methodology for which is explained in Appendix B.

Industry consumption is only one of the criteria used in this study to better understand the material's importance to industry and it should not be applied exclusively in decisions on material sourcing.

Higher consumption of a material implies a greater imperative for an industry to take a collective action to catalyse positive change for producing countries, communities and stakeholders and to minimise exposure to reputation and compliance risk downstream.

The bar charts in this section present the materials' ratings against an aggregation of the 11 ESG issues (Figures 7 and 8) and a selection of 8 of the 11 ESG issues covered in this report (Figures 9 to 24). The three ESG issues for which an association with a material is a simple 'yes' or 'no' are not included in this section as comparing them in this format would add little analytical value; these issues are included in the ESG heat map and material profiles, however.

## Environmental, social and governance aggregated risk rating

Figures 7 and 8 compare the two industries' consumption plotted against an aggregation of the 11 ESG criteria presented in the heat maps in section 5.1. Each of the ESG criteria carries an equal weight in the aggregated rating and, where there is missing data for one or more criteria, the rating has been adjusted to ensure fair comparison. These two figures give a very general idea of how many and how strongly associated are the materials with the ESG issues in this report.





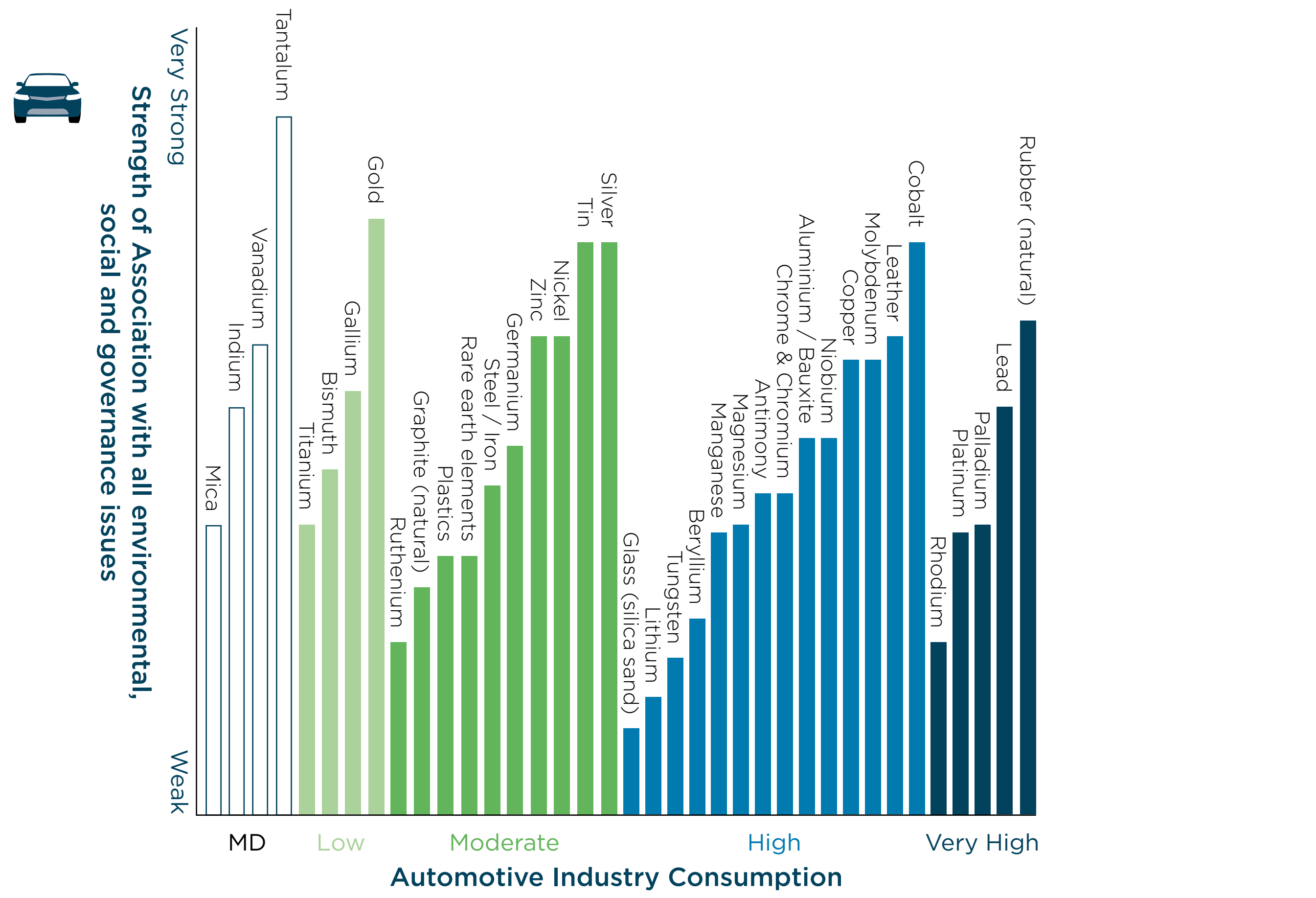



**Figure 7**: Ratings of materials by industry % of total global consumption and association with all ESG issues

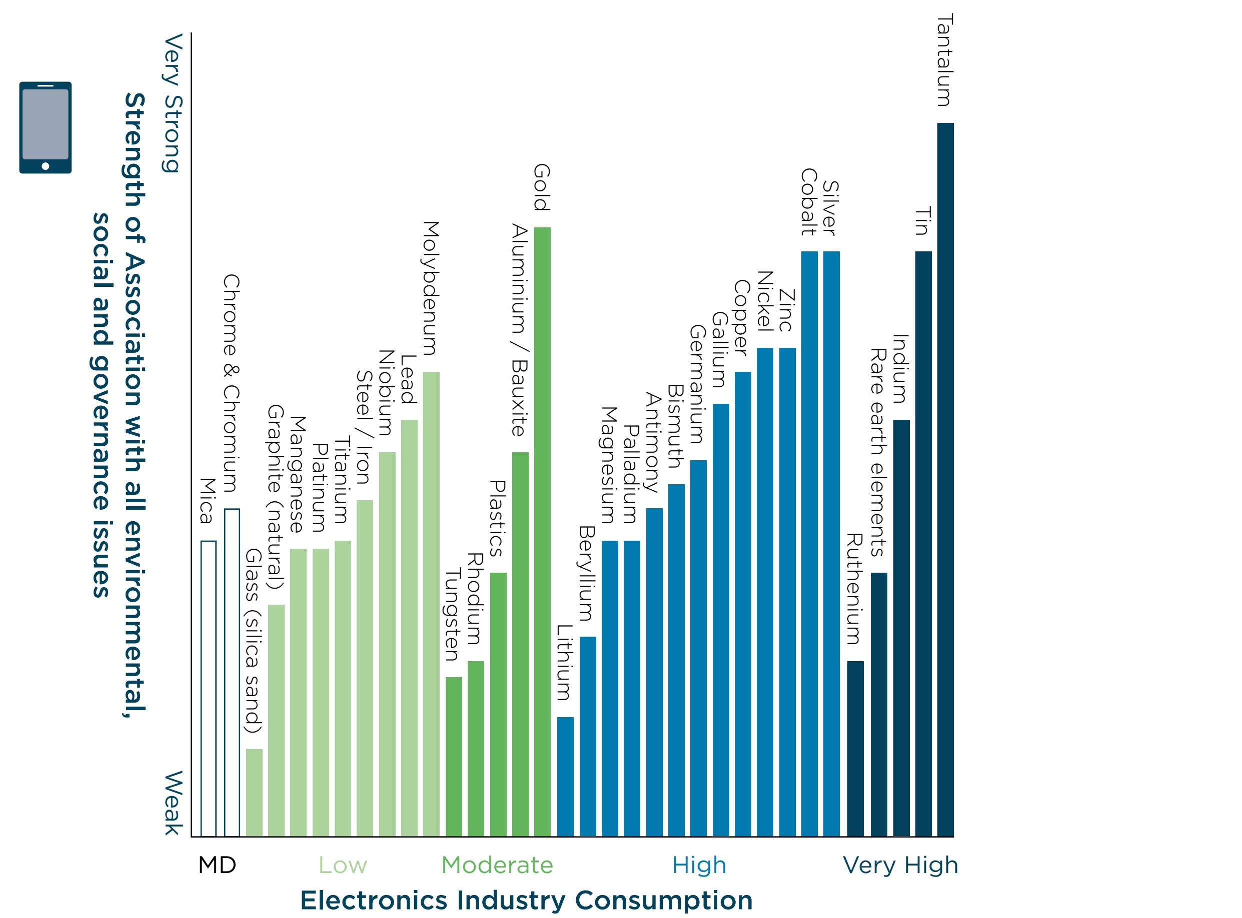



**Figure 8**: Ratings of materials by industry % of total global consumption and association with all ESG issues

# Association with Artisanal and Small-Scale Mining (ASM)

Figures 9 and 10 compare the two industries' consumption and association of the 37 materials with artisanal and small-scale mining (ASM). Although much has been achieved in recent years in improving the capacity and management practices at ASM operations, ASM is often strongly associated with serious environmental and human rights impacts.

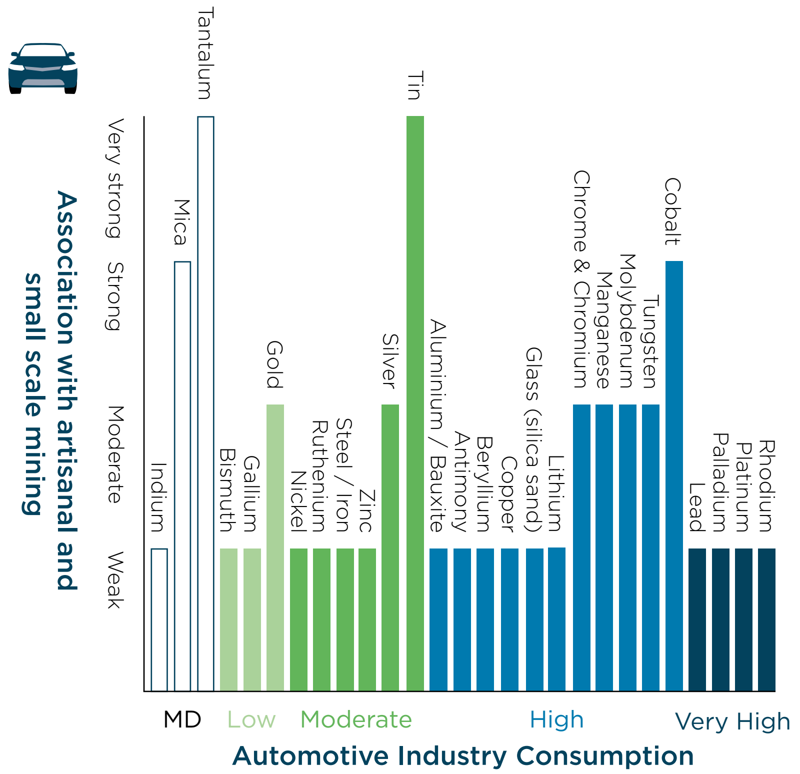



**Figure 9:** Ratings of materials' association with ASM and by automotive industry % of total global consumption

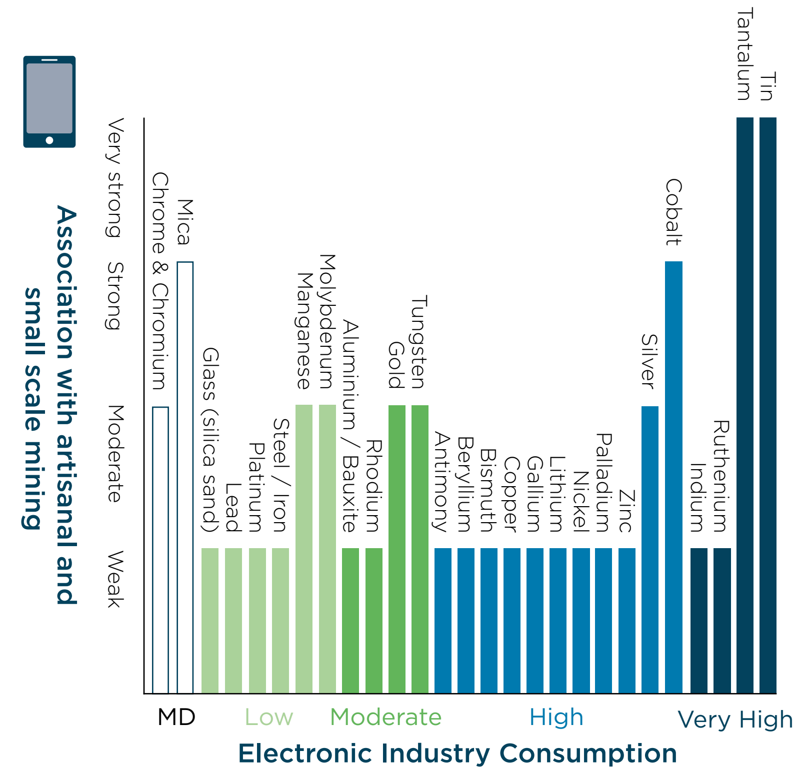



**Figure 10:** Ratings of materials' association with ASM and by electronics industry % of total global consumption



# Association with child labour and forced labour

Figures 11 and 12 compare the two industries' consumption and association of the 37 materials with child labour and forced labour. The US State Department and the Bureau of International Labor Affair's (ILAB) maintains a database of goods that it has reason to believe involve child labour or forced labour in violation of international standards.

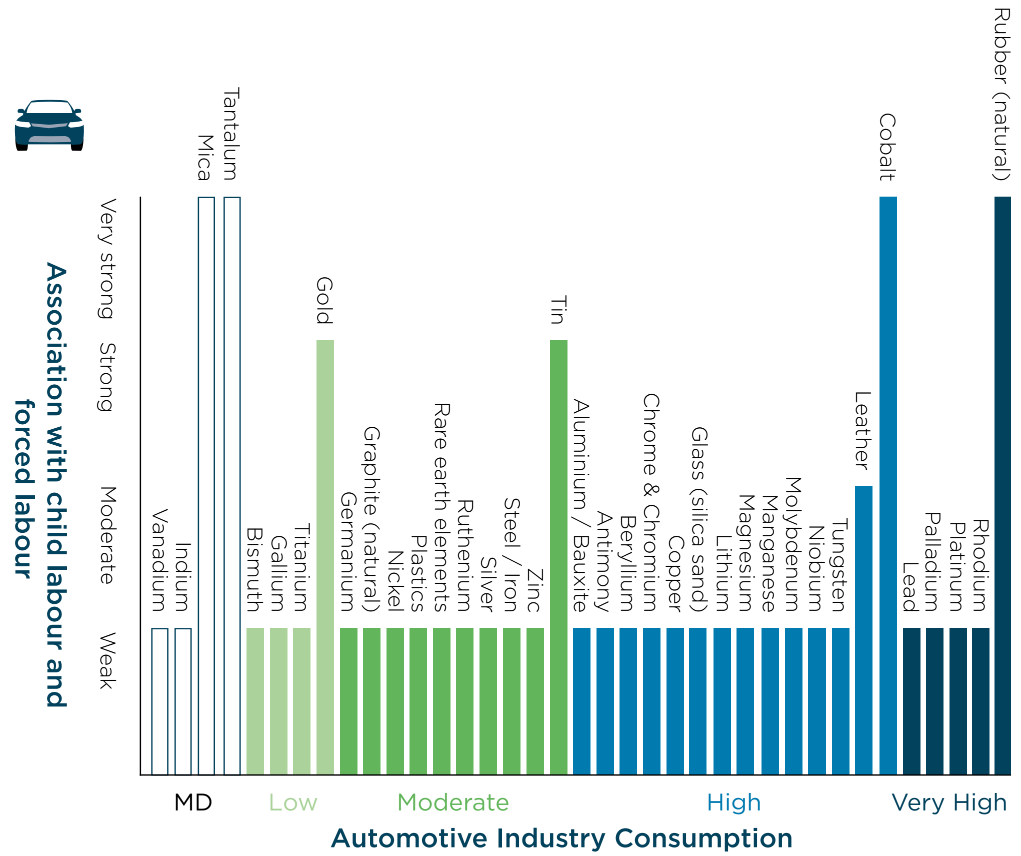



**Figure 11:** Ratings of materials' association with child labour and forced labour and by automotive industry % of total global consumption

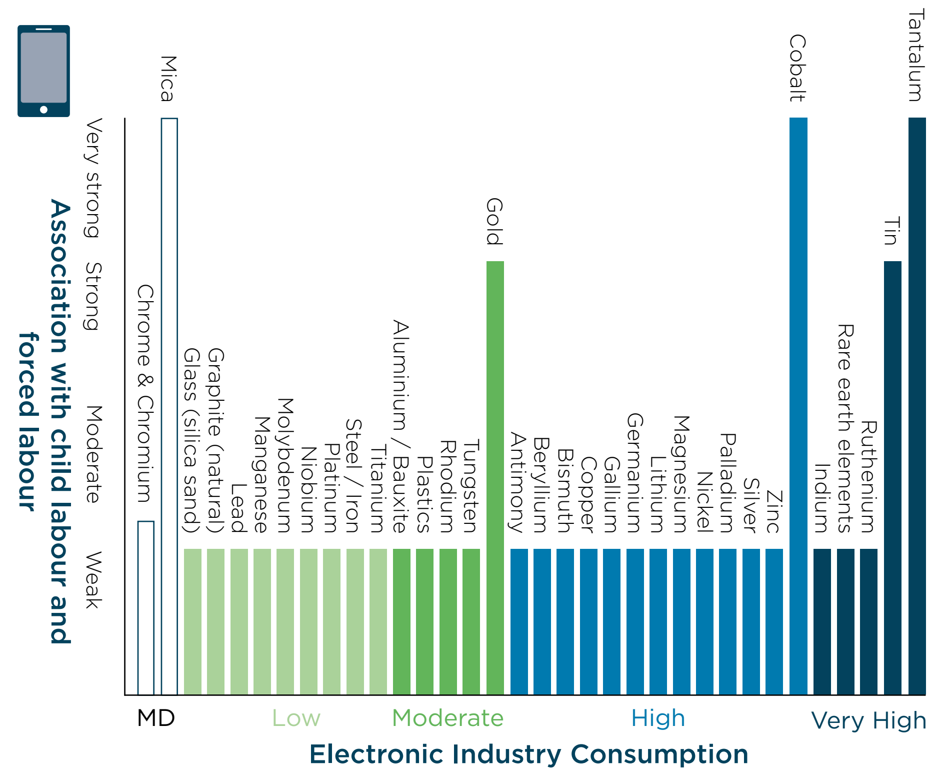



**Figure 12:** Ratings of materials' association with child labour and forced labour and by electronics industry % of total global consumption

# Association with countries with weak rule of law

Figures 13 and 14 compare the two industries' consumption and association of the 37 materials with producer countries with weak rule of law. The Worldwide Governance Indicator (WGI) for Rule of Law is the primary source of information. The WGI Rule of Law indicator captures "perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence".

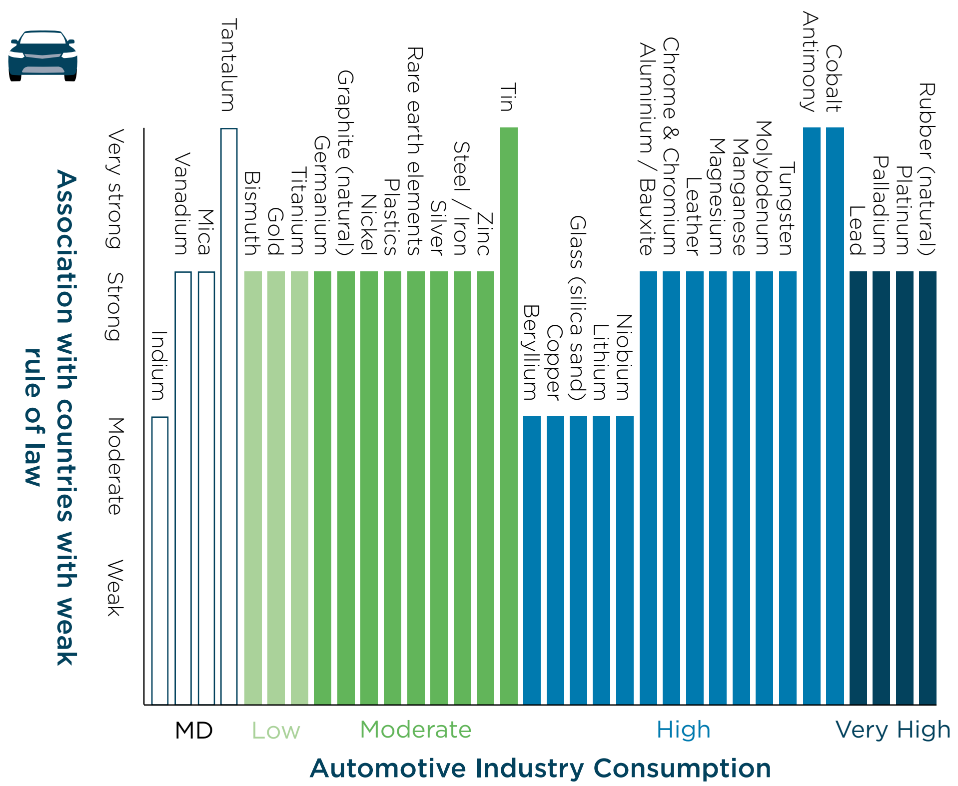



**Figure 13:** Ratings of materials' association with countries associated with weak rule of law and by automotive industry % of total global consumption

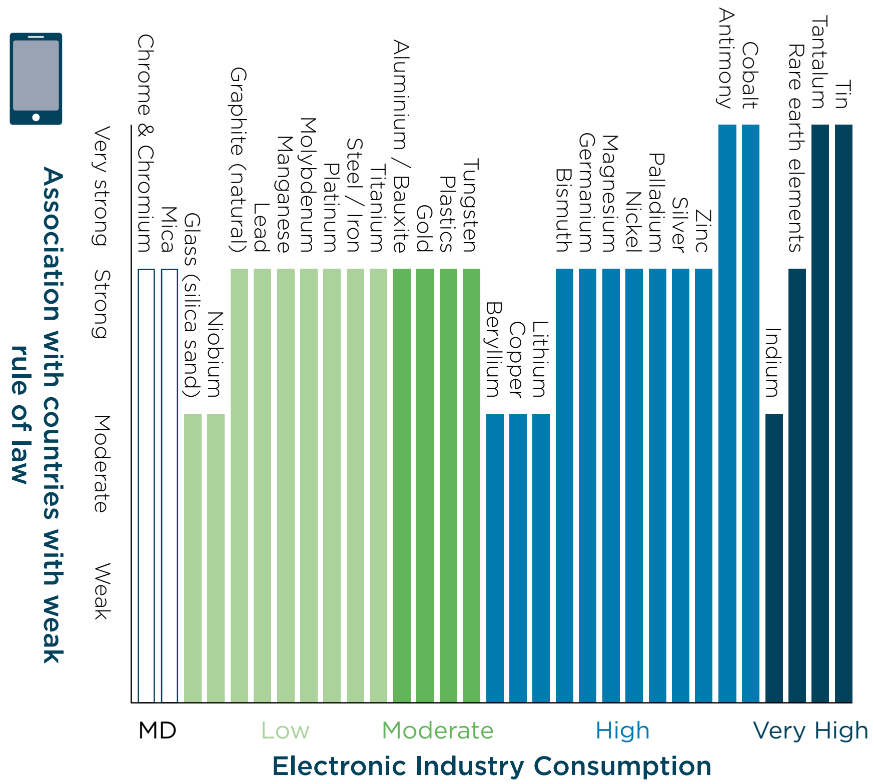



**Figure 14:** Ratings of materials' association with countries associated with weak rule of law and by electronics industry % of total global consumption



# Association with countries experiencing corruption

Figures 15 and 16 compare the two industries' consumption and association of the 37 materials with countries experiencing corruption. The Worldwide Governance Indicator (WGI) for Control of Corruption is the primary source of information. WGI captures 'perceptions' of corruption in a country and the rating indicates the levels of perceived corruption in the materials' top five producer countries.

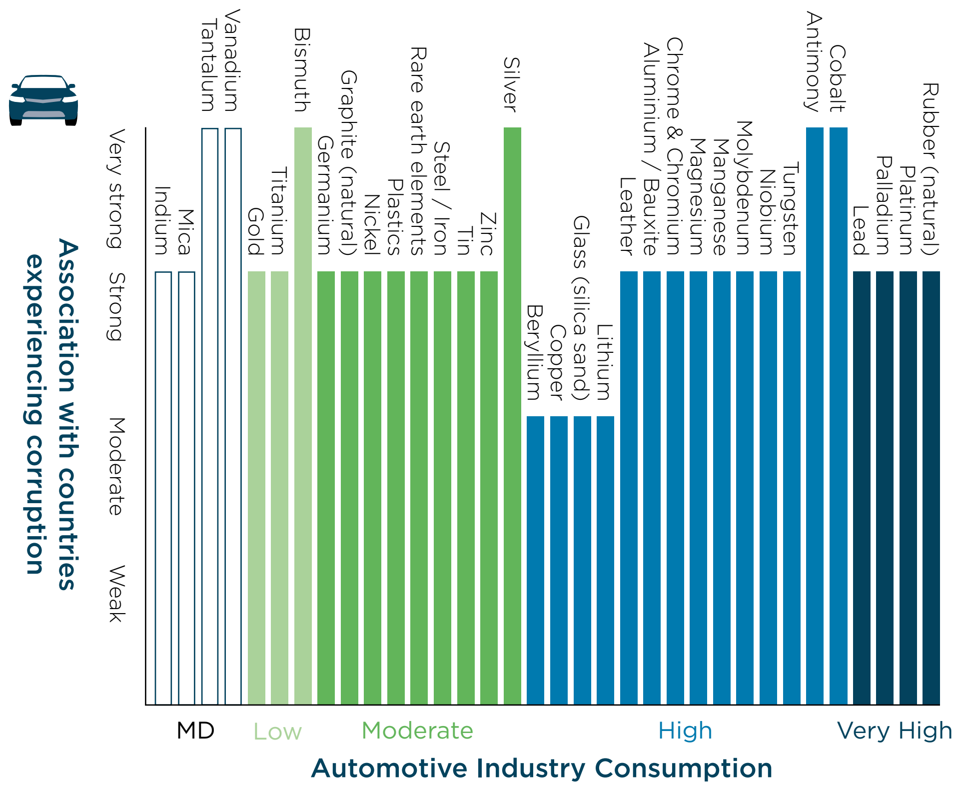



**Figure 15:** Ratings of materials' association with countries experiencing corruption and by automotive industry % of total global consumption

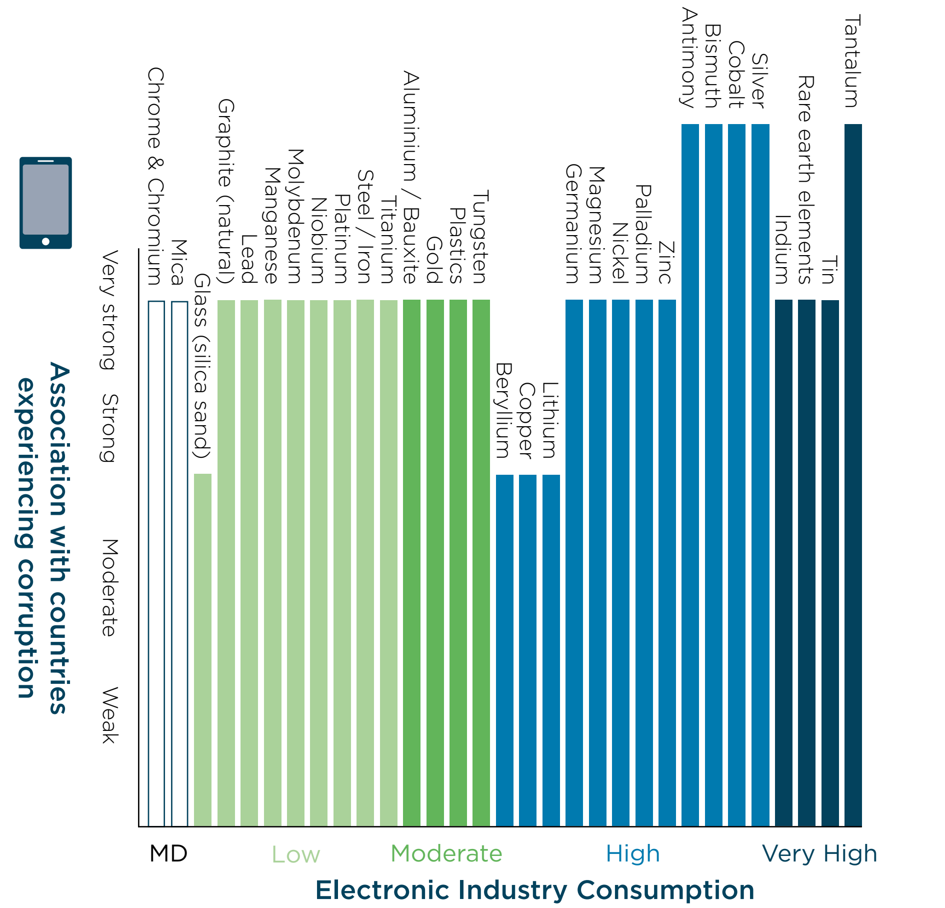



**Figure 16:** Ratings of materials' association with countries experiencing corruption and by electronics industry % of total global consumption

# Association with countries experiencing high-intensity conflict

Figures 17 and 18 compare the industry consumption of the two industries against the 37 materials with countries associated with high-intensity (political) inter or intra- state conflict (i.e.'limited war' or 'war') according to the Heidelberg Institute for International Conflict (HIIK) Research's Conflict Barometer.

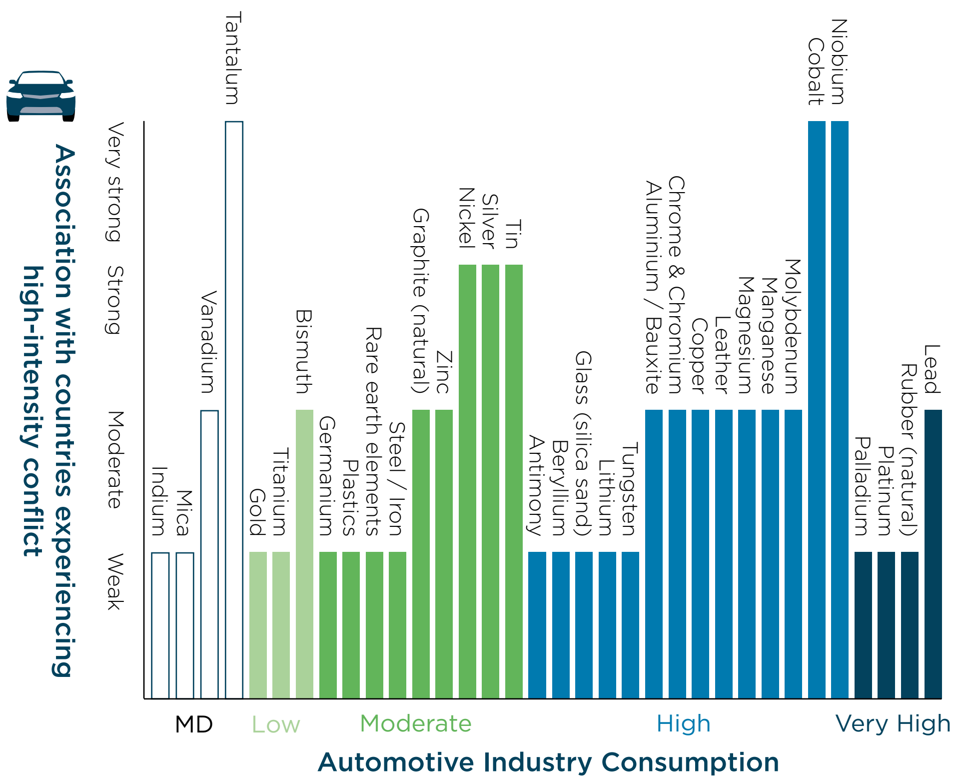



**Figure 17:** Ratings of materials' association with countries experiencing high-intensity conflict and by automotive industry % of total global consumption

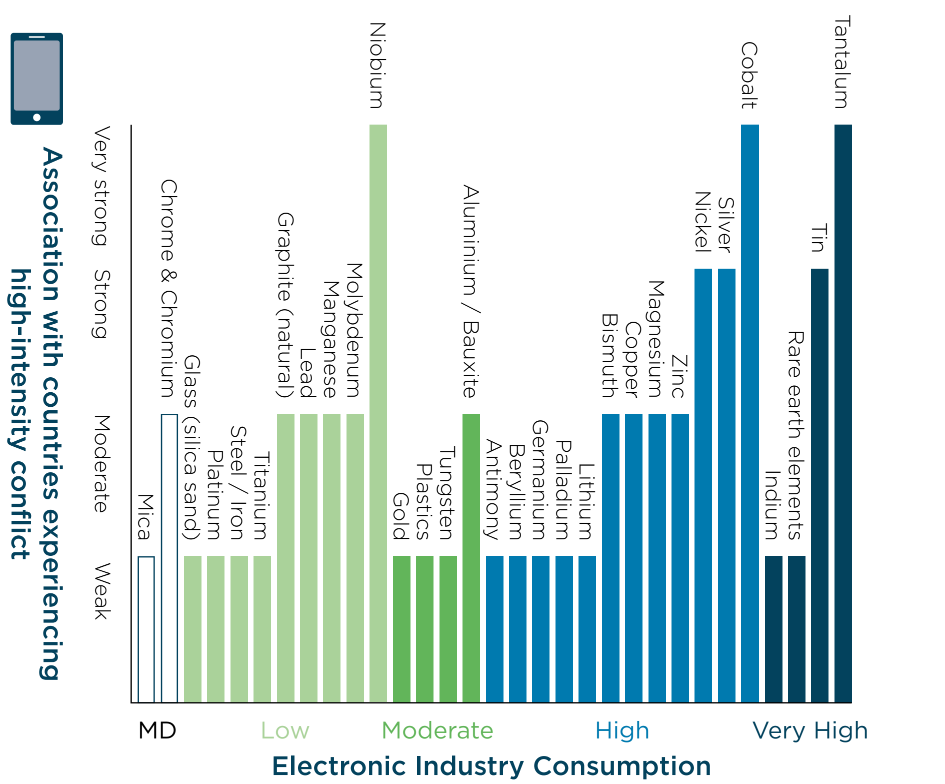



**Figure 18:** Ratings of materials' association with countries experiencing high-intensity conflict and by electronics industry % of total global consumption



# Association with high CO2 emissions

Figures 19 and 20 compare the two industries' consumption and association of the 37 materials with (relatively) high CO2 emissions. It is ranked according to the amount (kilograms) of CO2 emissions per kilogram of material. The production of most mined materials is associated with high levels of greenhouse gas emissions because of the energy intensity of extraction and processing.

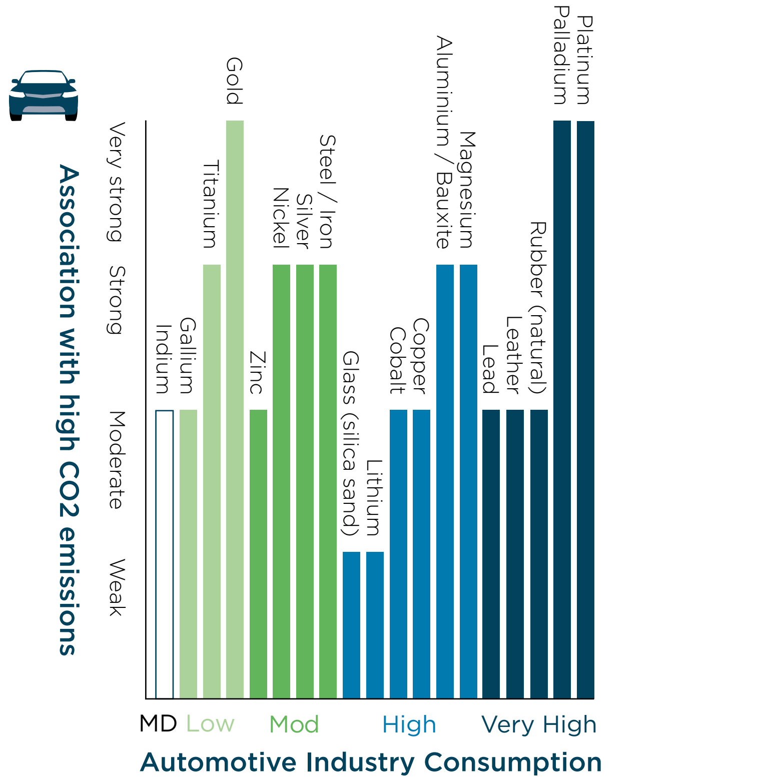



**Figure 19:** Ratings of materials' association with high CO2 emissions and by automotive industry % of total global consumption

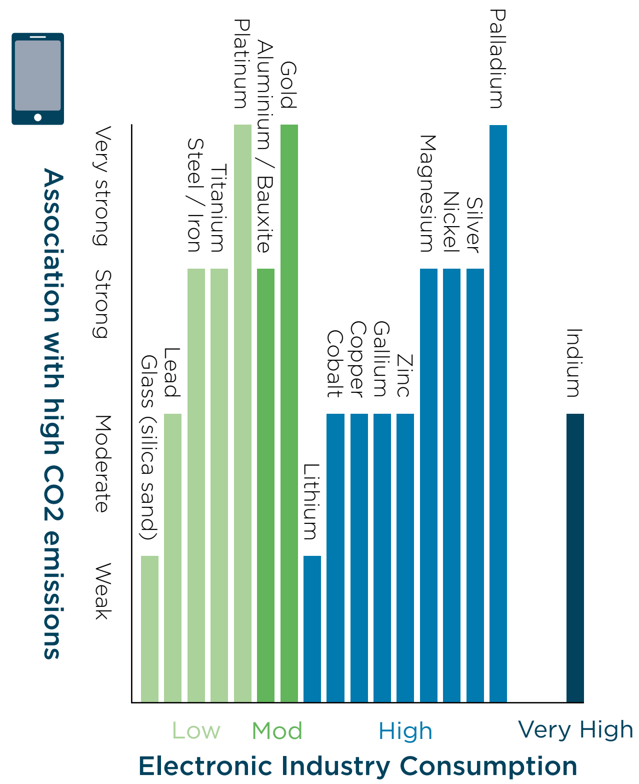



**Figure 20:** Ratings of materials' association with high CO2 emissions and by electronics industry % of total global consumption

# Association with incidences of conflict with Indigenous Peoples

Figures 21 and 22 compare the two industries' consumption and association of the 37 materials with incidences of conflict with Indigenous Peoples. A broad definition of "conflict" is used that encompasses protracted disputes, public grievance over rights and resources, protest or demonstration and incidences of violence between producer companies and Indigenous Peoples' groups or representatives. This criterion rates the material by relative number of recorded incidences, but does not indicate prevalence in the industry.

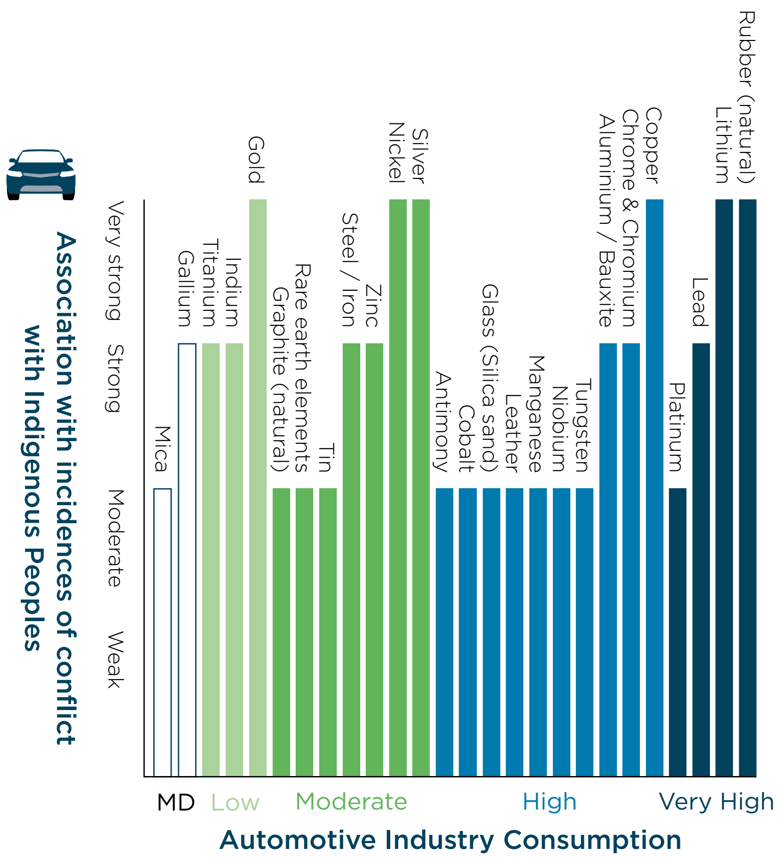



**Figure 21:** Ratings of materials' association with incidences of conflict with Indigenous Peoples and by automotive industry % of total global consumption

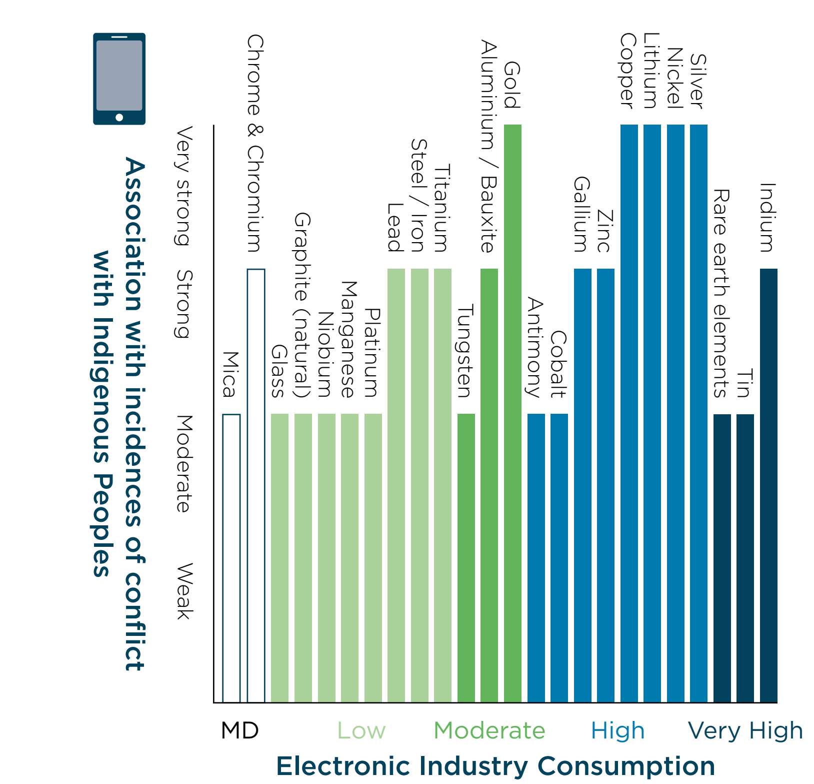



**Figure 22:** Ratings of materials' association with incidences of conflict with Indigenous Peoples and by electronics industry % of total global consumption



# Association with the potential for harm from hazardous materials or chemicals

Figures 23 and 24 compare the two industries' consumption and association of the 37 materials with the potential for (human) harm from hazardous materials or chemicals. Rather than an indication of industry prevalence, it highlights the importance of having in place the management measures to address the potential of exposure to hazardous materials or chemicals.

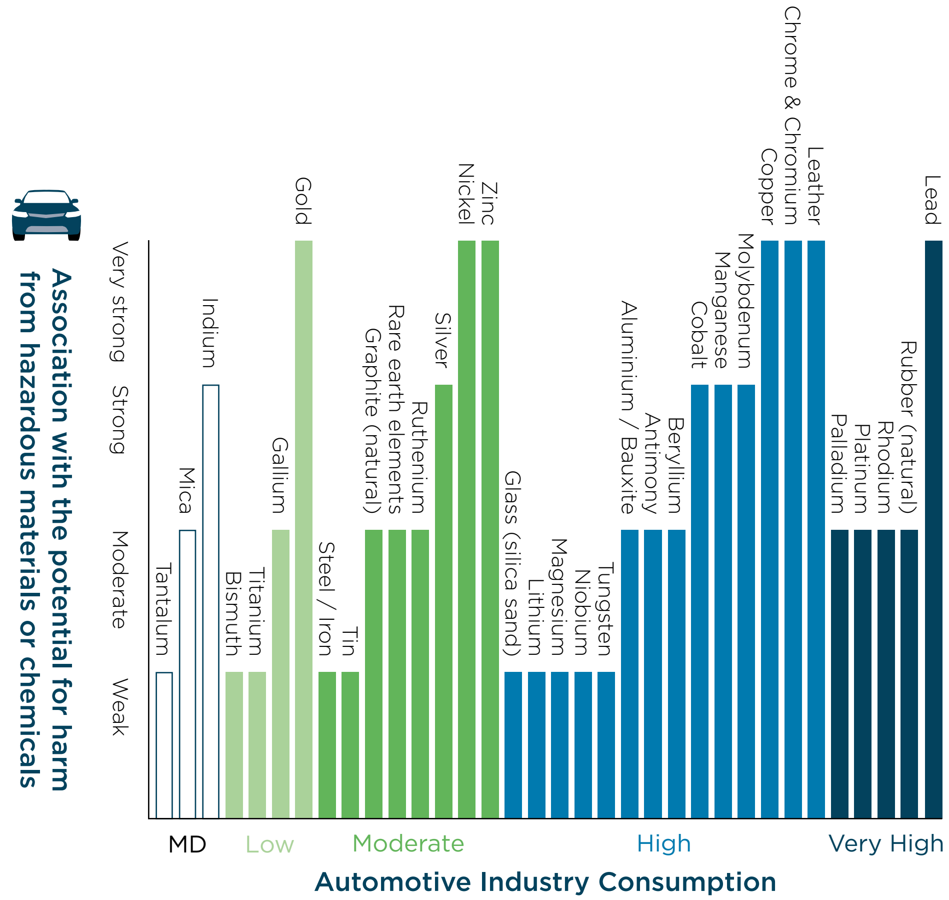



**Figure 23:** Ratings of materials' association with potential for harm from hazardous materials or chemicals and by automotive industry % of total global consumption

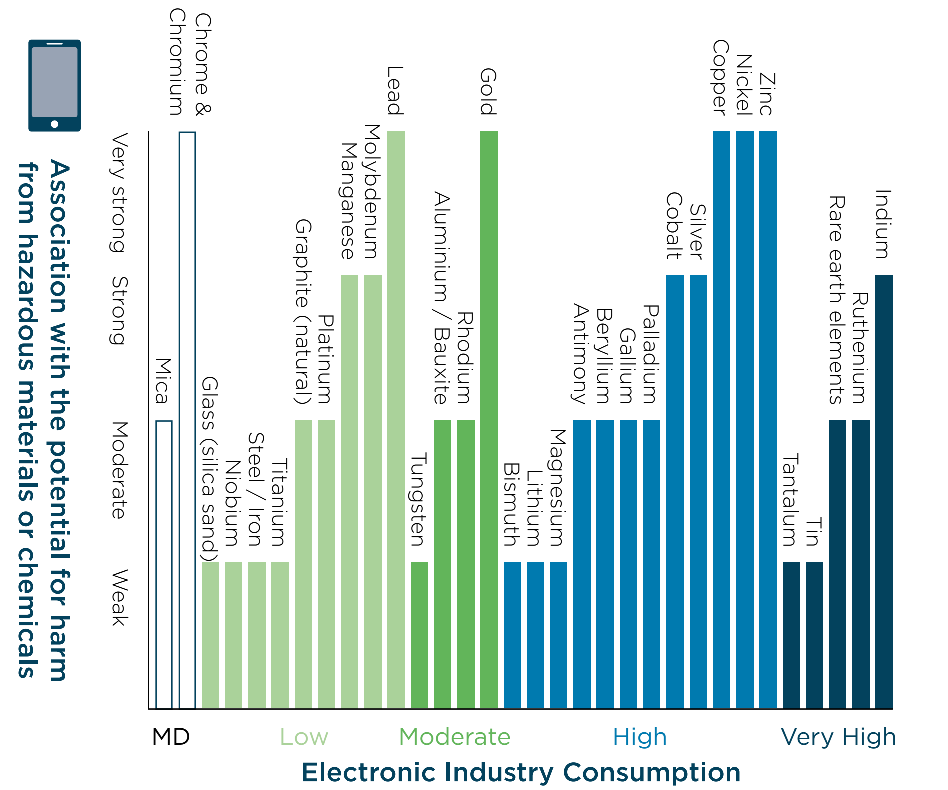



**Figure 24:** Ratings of materials' association with potential for harm from hazardous materials or chemicals and by electronics industry % of total global consumption

# 5.3 Material profiles

## This section presents profiles of 18 materials (Box 2) selected by DS and the RMI.

Each profile presents a summary and overview of environmental, social and governance (ESG) issues and information on top producer countries associated with the 18 materials' supply chains. The materials were selected based on RMI and Drive's institutional priorities as identified in consultation with each organization's respective membership. The profiles are intended as a resource to help inform prioritisation decisions for positive action, rather than as tools for sourcing decisions. They are not intended to encourage or dissuade the reader from any particular sourcing option for the material and do not replace the reader's own knowledge and appraisal of impacts, risks and opportunities for engagement in their company's specific supply chains. As the responsible sourcing programmes of DS and the RMI continue, it is anticipated that the number of material profiles and the depth and breadth of the information they include will grow and be made available in future publications.

| Materials | Box 2 |
|---|---|
| Aluminium / Bauxite | |
| Cobalt | |
| Copper | |
| Glass (silica sand) | |
| Gold | |
| Graphite (natural) | |
| Leather | |
| Lithium | |
| Mica | |
| Nickel | |
| Palladium | |
| Rare Earth Elements | |
| Rubber (natural) | |
| Steel / Iron | |
| Tantalum | |
| Tin | |
| Tungsten | |
| Zinc | |





## Each profile is organised by the following seven sections:

**1**

### Material uses

This section summarises information on the material's uses for some common applications in the automotive and electronics industries, and notes which other materials profiled by this study are also found in those same applications. Where multiple materials feature in the same application this may indicate an opportunity for engagement with supply chain partners and for collective action at the component level, thereby addressing multiple material supply chains simultaneously.

**2**

### Material significance

This section presents four indicators for the importance of the material to the two industries. Two of these (industry consumption and function criticality) are criteria used in the heat maps. The other two provide information on the material's content in the illustrative products chosen for the study and notes which other industries are also significant consumers of the material. The information presented is general and there will be significant variations across the broadly diverse product ranges of both industries.

**3**

### Supply significance

This section includes indicators for the factors influencing the supply of the material. As well as three indicators used in the materials heat maps (residual end-of-life waste, consumption of virgin material and estimated rate of depletion), two indicators on EU and USA dependency on imported material are included to illustrate possible constraints on supply from international trade relations with producer countries.

**4**

### Strength of association with environmental, social and governance issues

This section indicates the strength of association of the material with the 11 ESG issues considered within the study. Different indicators are used for each issue and are described in Appendix B. Where a sliding scale is inappropriate, the material's association with an issue is rated as either 'yes' or 'no'.

**5**

### Top producer country information

This section presents details of the top five countries where the material in its raw form is mined or produced, together with country-specific economic and governance indicators. For some materials more than five countries are listed. This occurs when multiple countries produce the similar proportion of global production or if they produce a comparatively large proportion of global production. Countries not in the top five are not listed unless they have high production potential and are expected to become a key future supplier. For example, Bolivia is not currently a top five producer of lithium but is expected to become an important producer in the future due to the size of its lithium resources, estimated by the USGS to contain approximately nine million tonnes of identified lithium resource. This section is intended to offer a quick snapshot of country-level data rather than provide information that can be used to replace a comprehensive country risk assessment.

**6**

### Examples of environmental, social and governance issues

This section aims to illustrate through brief examples some of the ESG impacts on communities and countries that can be associated with the material's production. The information is drawn from various sources including peer reviewed papers, industry reports and media articles, the references for which are listed in section 5.4. This section is strictly illustrative and should not be considered generally representative of companies' performance or production practices in the industry.

**7**

### Supplementary notes

This section records a number notable aspects specific to the production of the material that, due to the general level of analysis of the report, are not incorporated or might not be evident in the presentation of the results. These are important to consider when completing detailed due diligence on the material's sources. As more information becomes available from industry and the research sectors, it is anticipated that this section will grow in future versions of this and other reports from DS and the RMI.

# Material profile: Aluminium / Bauxite

*Lightweight and structurally strong*

*This profile is intended as a general introduction to environmental, social and governance issues associated with the production of aluminium. It should not be considered to be comprehensive or be regarded as legal advice. It is not a replacement for company due diligence and the information should not be interpreted as representing specific risks to any one individual company or irreversibly present in a particular material supply chain.*

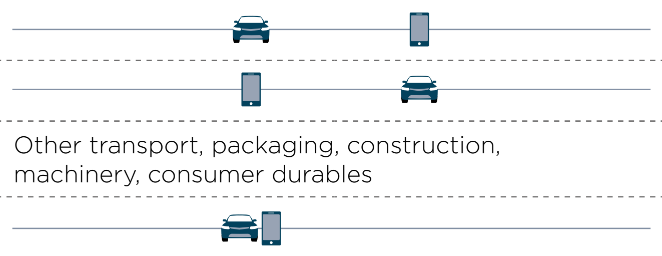
*Please see **www.thedragonflyinitiative.com/material-change-report** for the methodology and a guide to the criteria and indicators used to generate the information in this profile.*

| Material uses | Passenger vehicle | Smartphone |
|---|---|---|
| Applications of aluminium: | Chassis, engine, printed circuit board | Printed circuit board, casing |
| Other profiled materials in these applications: | (chassis, engine:) steel | (printed circuit board:) copper, nickel, gold |

## Material significance

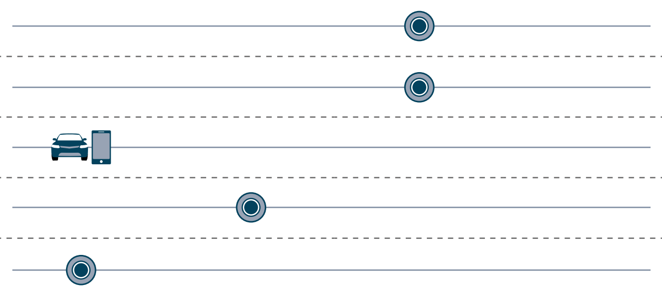
Low | Mod | High | V. High

- % content in a passenger vehicle and smartphone:
- Industry consumption:
- Other top consuming industries: Other transport, packaging, construction, machinery, consumer durables
- Function criticality:



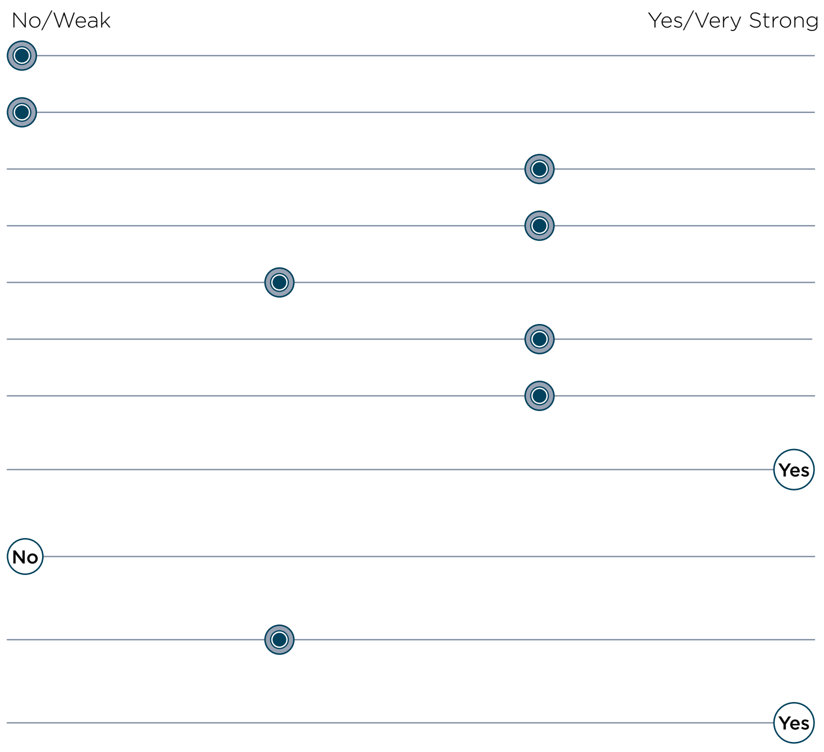
## Supply significance

- EU dependency on imported material:
- US dependency on imported material:
- Residual end of life waste:
- Virgin material consumption:
- Estimated rate of depletion:



## Association with environmental, social and governance issues

- Artisanal and small-scale mining
- Child labour and forced labour
- Countries with weak rule of law
- Countries experiencing corruption
- Countries experiencing high-intensity conflict
- High CO2 emissions
- Incidences of conflict with Indigenous Peoples
- Incidences of overlap with areas of conservation importance
- Potential for acid discharge to the environment
- Potential for harm from hazardous materials and chemicals
- Preconditions for radioactive materials in ores and tailings




## Top producer country information

| | Australia | China | Brazil | India | Guinea |
|---|---|---|---|---|---|
| % Global Mined Production (Bauxite) | 31 | 25 | 13 | 10 | 8 |
| % Global Production (Alumina) | 18 | 50 | 9 | 5 | 0 |
| % Global Reserves | 22 | 4 | 9 | 2 | 26 |
| % Mining Sector Contribution to GDP | 3.8 | 0.5 | 1.3 | 0.3 | 9.5 |
| Human Development Index | 0.939 V. HIGH | 0.738 HIGH | 0.754 HIGH | 0.624 MEDIUM | 0.414 LOW |
| Rule of Law | STRONG | WEAK | MODERATE | MODERATE | V. WEAK |
| Experience of Corruption | LOW | HIGH | HIGH | HIGH | V. HIGH |
| Experience of State Conflict (Heidelberg Conflict Barometer) | LOW (Dispute) | MODERATE (Violent Crisis) | HIGH (Limited War) | MODERATE (Violent Crisis) | MODERATE (Violent Crisis) |

## Examples of environmental, social and governance issues

This section aims to illustrate through brief examples some of the environmental, social and governance impacts on communities and countries that are publicly reported to be associated with the material's production. The information is drawn from various sources including peer reviewed papers, industry reports and media articles, the references for which are listed in section 5.4. The examples are from the material's top producer countries. This section is strictly illustrative and should not be considered generally representative of companies' performance or production practices in the industry.

**Conflict with Indigenous Peoples**
The Wik and WikWaya peoples have been in dispute with the government of Queensland Australia, for the recognition of their native title rights and the associated right to control bauxite mining activities on their lands (Doyle et al., 2015). In 2015 the Wik peoples presented a case against the Queensland Government, in opposition to the announcement of the developer being approved to mine the region's rich bauxite deposits. The case was withdrawn in 2016 (Anderson, 2016; Kim, 2015). Another mining multinational which operates in the region has had an agreement with the Wik people since 2001, which aims to increase economic participation in bauxite mining.

Bauxite mining has also reportedly led to deforestation and an increase of air and water pollution (Doyle et al., 2015). In some areas of Brazil bauxite mining has been associated with extensive deforestation and the forced migration of indigenous populations. Additionally, some mining has reportedly impacted on urban communities, lowering water quality and consequently fish stocks and medicinal plant crops (EJA, 2017).

Some extraction of bauxite in India has been associated with environmental impacts (Tatapi et al., 2016). Several conflicts between indigenous groups and mine developers have been reported in India including a much publicised bauxite project in Odisha (formerly and still commonly known as Orissa), which was proposed in a location considered to be sacred. Orissa state is rich in bauxite ores and is also home to large areas of forests and a tribal population, which has attracted the support of international activists and groups protecting Indigenous Peoples rights. In 1992, the Orissa mining corporation was licensed to lease the bauxite mining sites to private national and international companies and establish joint ventures with the government. The bauxite mines are mainly located in tribal regions (EJA, 2017).

**Potential for harm from hazardous materials and chemicals**
Some Alumina production sites in China have been cited as impacting human health following illegal polluting discharge and the improper treatment of toxic "red mud" waste, a by-product from the bauxite refining process. This toxic run off has reportedly been observed seeping into local water sources used for crop irrigation; leading to lower crop yields near aluminium plants in Hunan. The demand for Chinese aluminium depends mainly on growth in the automobile, electricity and real estate sectors (Yao, 2015).

**Key**

**MD** = Missing Data
***** = Where multiple sources have been considered and/or where deductions/estimations/assumptions have been generalised from existing data.

A national mining company operates several mines – and an aluminium plant – on the port of Kamsar, Guinea. Dynamite explosions from these mines have reportedly resulted in the collapse of houses in the locality. Agricultural yields have also been lower and the pollution of water sources has been alleged. Communities have also reported respiratory and stomach problems from dust and air pollution caused by the transport of bauxite, (EJA, 2017). In 2017 protests and riots broke out in the city of Boké following power outages, the death of a driver involved in an incident with a vehicle transporting bauxite and the perceived failure of mining to raise living standards (EJA, 2017).

**Aluminium and livelihoods**
In 2014 mining accounted for 8.7% of Australia's GDP and the mineral sector employed approximately 173,000 people. Australia accounted for 32% of the world's mined bauxite in 2014. Western Australia remained Australia's leading bauxite producing State, accounting for 58.3% of the country's total and Queensland accounted for 33.4% (USGS, 2014).

In 2013 metals accounted for 16.4% of the value of mineral production in India, with bauxite accounting for 1.6 % of this. Employment in the mining industry was estimated to be 50 million in 2013 with 5% of those individuals employed in the production of bauxite (Indian Bureau of Mines, 2014).

## Supplementary notes

This section records notable aspects specific to the production of the material that due to the general level of analysis of the report are not incorporated or might not be evident in the presentation of the results. These are important to consider when completing detailed due diligence on the material's sources.

**High CO2**
Although the primary reference used to rate Aluminium's association with (relatively) high CO2 emissions indicates a rating of 'moderate', the rating has been adjusted to strong. This adjustment is considered appropriate for a 'hotspot' analysis of this kind as aluminium production is recognised by many authoritative sources to be a significant emitter of CO2 (IPCC, 2014). One reason for the apparent differences in conclusions is the range of C02 emissions in the industry, which depend on the energy type used for electrolysis in primary smelting: coal (which is still a common source of energy generation in China) or natural gas or hydro-generated power, for example. Emissions are significantly reduced for recycled aluminium (through re-melting/refining). A more detailed analysis than is made here would show a range in the ratings from 'low' for recycled aluminium to 'very high', depending on the source of energy generation.

**Potential for harm from hazardous materials and chemicals**
Bauxite residue, or "red mud" is a toxic by-product of the Bayer process, by which 95% of aluminium is refined globally. The environmental impacts of bauxite residue are highly significant but are not considered in the analysis of materials. The potential for harm from hazardous materials criterion considers chemical inputs into the refining process, but not chemical outputs from the process. It should be noted that this limitation applies to tailings and other by-products for all other materials in this study. It is mentioned specifically for aluminium because the scale of the environmental impacts associated with bauxite residue can be particularly significant.

# Material profile: Cobalt

*Hard-wearing at high temperatures, low thermal and electrical conductivity.*

*This profile is intended as a general introduction to environmental, social and governance aspects associated with the production of cobalt. It should not be considered to be comprehensive or be regarded as legal advice. It is not a replacement for company due diligence, and the information should not be interpreted as representing specific risks to any one individual company or irreversibly present in a particular material supply chain.*

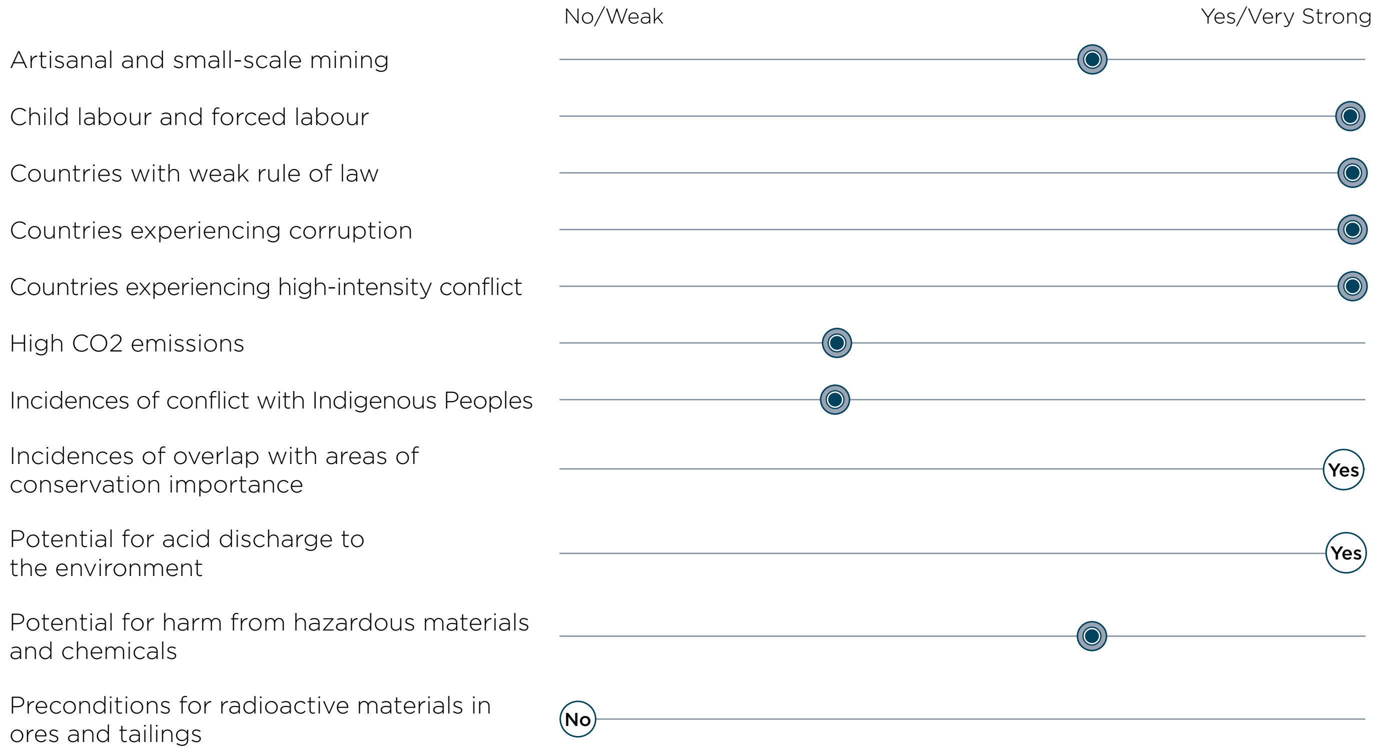
*Please see **www.thedragonflyinitiative.com/material-change-report** for the methodology and a guide to the criteria and indicators used to generate the information in this profile.*

| Material uses | Passenger vehicle | Smartphone |
|---|---|---|
| Applications of cobalt: | Battery *(lithium-ion)* | Battery *(lithium-ion)* |
| Other profiled materials in this application: | (lithium-ion battery:) graphite, lithium, nickel | |

| Material significance | Low | Mod | High | V. High |
|---|---|---|---|---|
| % content in a passenger vehicle and smartphone: | Passenger vehicle* | | Smartphone* | |
| Industry consumption: | | | Passenger vehicle*, Smartphone | |
| Other top consuming industries: | Industrial catalysts, medical, superalloys, inks and pigments | | | |
| Function criticality: | | Passenger vehicle, Smartphone | | |

| Supply significance | Low | Mod | High | V. High |
|---|---|---|---|---|
| EU dependency on imported material: | | | ● | |
| US dependency on imported material: | | | | ● |
| Residual end of life waste: | | | Passenger vehicle, Smartphone | |
| Virgin material consumption: | ● | | | |
| Estimated rate of depletion: | ● | | | |

## Association with environmental, social and governance issues






## Top producer country information

| | DRC | China | Canada | Russia | Australia | Zambia |
|---|---|---|---|---|---|---|
| % Global Mined Production | 54 | 6 | 6 | 5 | 4 | 4 |
| % Global Reserves | 49 | 1 | 4 | 4 | 14 | 4 |
| % Mining Sector Contribution to GDP | 14.4 | 0.5 | 0.5 | 0.9 | 3.8 | 10.1 |
| Human Development Index | 0.435 LOW | 0.738 HIGH | 0.920 V. HIGH | 0.804 V. HIGH | 0.939 V. HIGH | 0.579 MEDIUM |
| Rule of Law | V. WEAK | WEAK | STRONG | V. WEAK | STRONG | WEAK |
| Experience of Corruption | V. HIGH | HIGH | LOW | V. HIGH | LOW | HIGH |
| Experience of State Conflict (Heidelberg Conflict Barometer) | V. HIGH (WAR) | MODERATE (violent crisis) | LOW (Dispute) | MODERATE (violent crisis) | LOW (Dispute) | V. LOW (No Conflict) |

## Examples of environmental, social and governance issues

This section aims to illustrate through brief examples some of the environmental, social and governance impacts on communities and countries that are publicly reported to be associated with the material's production. The information is drawn from various sources including peer reviewed papers, industry reports and media articles, the references for which are listed in section 5.4. The examples are from the material's top producer countries. This section is strictly illustrative and should not be considered generally representative of companies' performance or production practices in the industry.

**Artisanal and small scale mining; Child labour and forced labour**
90% of all mining labour in the copper and cobalt belt in the DRC is artisanal and small-scale Faber et al. 2017. ASM is associated with child labour (and some commentators estimate that 2.53% of children aged 17 or under work in the mining sector in the copper-cobalt belt (Faber et al., 2017). Several human rights campaigners are calling on the government to take action to tighten and actively enforce international conventions in a country where the state is generally perceived as failing to adequately protect human rights and the environment (SOMO, 2016).

**High CO2 emissions**
Nearly 50% of global cobalt production is refined in China, where some operations have caused environmental concerns related to high CO2 emissions from energy generation. These concerns have prompted the suspension of production and a country-wide implementation of more stringent policies and procedures, particularly regarding emissions (Zou, 2016).

**Potential for harm from hazardous materials or chemicals**
Norilsk, a mining town located near the Arctic Circle, Russia, has been associated with pollution from mineral processing. A nickel plant in the town, that produces cobalt as a by-product, continues to present alleged contamination concerns with spills in 2016 affecting local indigenous communities and their livelihoods (IWGIA, 2016).

Occupational health and safety issues, such as respiratory and dermatological issues, have been reported in the DRC allegedly due to exposure to cobalt particles (Amnesty International, 2016). Furthermore, mining communities are reportedly exposed to dangerous levels of contaminated dust and water and are vulnerable to forced relocation to resource-poor areas.

**Potential for acid discharge to the environment**
Some copper and cobalt mining waste has been associated with acid mine drainage in Zambia. Large areas within currently active mining region of the Copperbelt are reportedly contaminated with both cobalt, copper and other toxic metal residues that present risks to public health. Mining discharge is also allegedly compromising water quality in some regions and affecting local aquatic systems (Lindahl, 2014).

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Please always credit the Responsible Minerals Initiative, Drive Sustainability and The Dragonfly Initiative for the work they have done compiling and analysing this information.

# Supplementary notes

This section records notable aspects specific to the production of the material that due to the general level of analysis of the report are not incorporated or might not be evident in the presentation of the results. These are important to consider when completing detailed due diligence on the material's sources.

**Association with Conflict Mineral Legislation**
Cobalt is not a designated conflict mineral according to Section 1502 of the Dodd-Frank Wall Street Reform and Consumer Act of 2010. Large amounts of cobalt are produced in the DRC however, which is a country covered by "Dodd-Frank".

**EOL waste and recycling rates**
The recycling and recovery of cobalt from end-of-life batteries are reported to be promising, but rates depend significantly on the availability of technology, which is currently not widespread. Recent research shows that new recycling strategies are being implemented to increase the recovery of valuable materials, especially cobalt, from batteries.

**Function criticality**
Increasing frequency of industry articles imply that a breakthrough in dependency on cobalt is forthcoming. Researchers at Northwestern University's McCormick School of Engineering, backed by the US Department of Energy, have developed a lithium battery which replaces cobalt with iron. This does not appear to be reflected in the price of lithium, however, which indicates increasing near-term scarcity.

**EU dependency on imported material**
The 2017 list of Critical Raw Materials for the EU states that the import reliance rate for cobalt is 32%. It lists Finland (66%) and Russia (31%) as the main sources of EU supply. This study would like to highlight that the cobalt from Finland will most likely have its origins in the Democratic Republic of the Congo, however. Therefore, the EU dependency on cobalt from outside its borders is likely to be higher than recorded using the EU CRM approach. Therefore the rating has been adjusted from 'moderate' to 'high' to reflect this trading relationship.

**Artisanal and small scale mining; Child labour and forced labour**
The majority of cobalt is produced as a by-product of formal industrial-scale nickel and copper mining operations, not by ASM. The relative high rating for these two criteria for cobalt is because cobalt is listed by the US State department as being associated with child or forced labour in the DRC, where the vast majority of cobalt is mined.

**Potential for acid discharge**
The majority of cobalt is produced as a by-product of formal industrial-scale nickel and copper mining operations; cobalt is extracted further downstream in the transformation process. Because of the strong relationship between copper and cobalt mining, and because the potential for acid discharge from copper mining is associated with acid discharge, cobalt has also been rated as 'yes'.

**Key**

**MD** = Missing Data
* = Where multiple sources have been considered and/or where deductions/estimations/assumptions have been generalised from existing data.

# Material profile: Copper

*High conductivity, high ductility, medium strength, and good resistance to corrosion.*

*This profile is intended as a general introduction to environmental, social and governance aspects associated with the production of copper. It should not be considered to be comprehensive or be regarded as legal advice. It is not a replacement for company due diligence, and the information should not be interpreted as representing specific risks to any one individual company or irreversibly present in a particular material supply chain.*

*Please see* ***www.thedragonflyinitiative.com/material-change-report*** *for the methodology and a guide to the criteria and indicators used to generate the information in this profile.*

| Material uses | Passenger vehicle | Smartphone |
|---|---|---|
| Applications of copper: | Circuitry, printed circuit board, radiator | Circuitry, printed circuit board |
| Other profiled materials in these applications: | (printed circuit board:) gold, nickel, aluminium, | |

| Material significance | Low | Mod | High | V. High |
|---|---|---|---|---|
| % content in a passenger vehicle and smartphone: | Passenger vehicle | | Smartphone | |
| Industry consumption: | | | Passenger vehicle, Smartphone | |
| Other top consuming industries: | Construction, other transport, consumer durables, industrial machinery | | | |
| Function criticality: | | | | Passenger vehicle, Smartphone |
| **Supply significance** | | | | |
| EU dependency on imported material: | | | | ● |
| US dependency on imported material: | | ● | | |
| Residual end of life waste: | Passenger vehicle, Smartphone* | | | |
| Virgin material consumption: | | ● | | |
| Estimated rate of depletion: | | ● | | |

## Association with environmental, social and governance issues

Artisanal and small-scale mining

Child labour and forced labour

Countries with weak rule of law

Countries experiencing corruption

Countries experiencing high-intensity conflict

High CO2 emissions

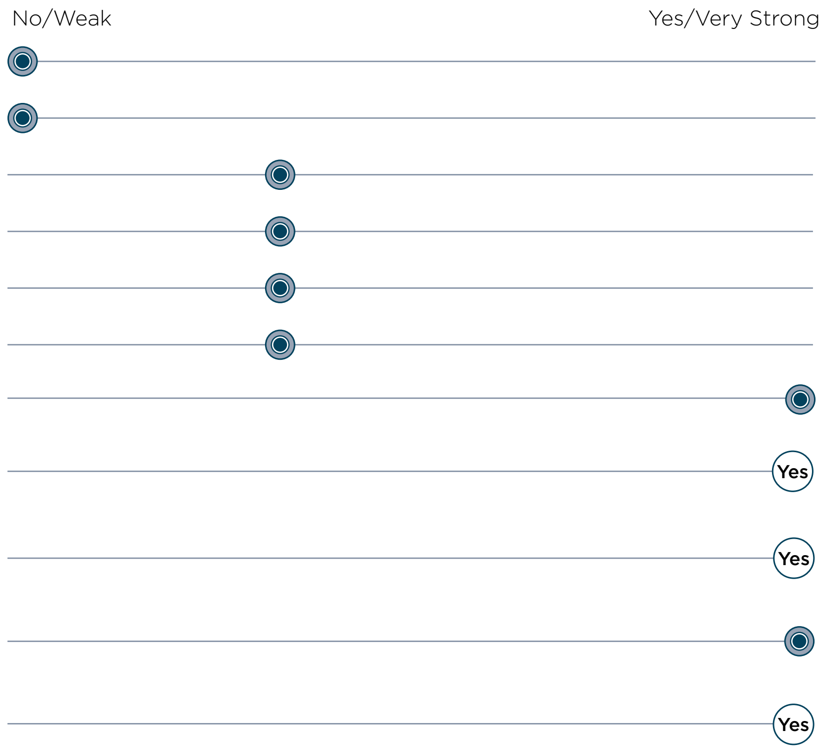
Incidences of conflict with Indigenous Peoples

Incidences of overlap with areas of conservation importance

Potential for acid discharge to the environment

Potential for harm from hazardous materials and chemicals

Preconditions for radioactive materials in ores and tailings






## Top producer country information

| | Chile | Peru | China | USA | DRC | Australia |
|---|---|---|---|---|---|---|
| % Global Mined Production | 28 | 12 | 9 | 7 | 5 | 5 |
| % Global Reserves | 29 | 11 | 4 | 5 | 5 | 12 |
| % Mining Sector Contribution to GDP | 11.6 | 5.4 | 0.5 | 0.1 | 14.4 | 3.8 |
| Human Development Index | 0.847 V. HIGH | 0.740 HIGH | 0.738 HIGH | 0.920 V. HIGH | 0.435 LOW | 0.939 V. HIGH |
| Rule of Law | STRONG | WEAK | WEAK | STRONG | V. WEAK | STRONG |
| Experience of Corruption | LOW | HIGH | HIGH | LOW | V. HIGH | LOW |
| Experience of State Conflict (Heidelberg Conflict Barometer) | MODERATE (Violent Crisis) | MODERATE (Violent Crisis) | MODERATE (Violent Crisis) | MODERATE (Violent Crisis) | V. HIGH (War) | LOW (Dispute) |

## Examples of environmental, social and governance issues

This section aims to illustrate through brief examples some of the environmental, social and governance impacts on communities and countries that are publicly reported to be associated with the material's production. The information is drawn from various sources including peer reviewed papers, industry reports and media articles, the references for which are listed in section 5.4. The examples are from the material's top producer countries. This section is strictly illustrative and should not be considered generally representative of companies' performance or production practices in the industry.

**Potential for acid discharge to the environment; Potential for harm from hazardous materials and chemicals**

Some copper mining in Chile is associated with impacts to ecosystems and communities. Concerns have been raised about the demands on water from copper projects in one of the world's most arid regions – the Atacama Desert. Contaminants and sulfuric acid in groundwater samples have also reportedly been observed at mine sites. Operations in Antofagasta have received complaints regarding alleged black dusk from the transportation of exported copper concentrates and the city reports the highest incidences of cancer in Chile (EJA, 2017). Several copper smelters in Chile have also been given environmental warnings.

In Jiangxi Province, China, communities downstream from copper mines have allegedly experienced pollution and high levels of occurrences of cancer have been reported. In 2013 the Ministry of Environmental Protection expressed concern over this reported toxic chemical pollution and its subsequent effects on human health and the environment, noting that there have been "serious cases of health and social problems, like the emergence of cancer, in villages in individual regions". Following nationwide concerns surrounding mining operations, including copper, the Chinese government confirmed plans to raise domestic environmental standards (Zou, 2016).

**Artisanal and small scale mining**

Some copper deposits in the DRC occur alongside cobalt and 90% of miners living in the mining communities of the copper-cobalt belt work in artisanal mining (Faber et al., 2017). Working conditions are poor and miners face considerable health risks including the inhalation of heavy metal dusts (SOMO, 2016).

**Conflict with Indigenous Peoples**

Mining related conflict, including conflict reportedly relating to copper, at large scale operations is a cause of social unrest (Defensoria del Pueblo, 2017). Additionally, the deaths of mining protesters because of police attacks have been reported as recently as November 2016 (Global Witness, 2016). At the core of these conflicts is the fear that mining will deplete and pollute water sources, a concern that some affirm is not without foundation (mining is one of the main contributors to the pollution of waterways in Peru (Monge, 2016)). Conflicts are also observed in response to a proposed copper mine in Arequipa. These protests led to the declaration of a "State of Emergency" (Hill, 2015). Low copper prices have also affected mining in Peru, with several investments on standby (EJA, 2017). In 2014, Peru's copper mine output accounted for about 7.5% of world production (USGS, 2014c).

Historical mining activity from uranium-rich copper deposits in Arizona, USA has led to elevated levels of radioactivity recorded in surface soil and groundwater (EPA, 2016). Changes in political leadership in the US could result in the amendment of legislation and enable a new proposed copper project, set to be one of the largest in the world, to come to fruition in the state. Community members including Native American and environmental groups, have called for continued review of the project following concerns of potential environmental impacts (Flitter, 2016).

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**Copper and livelihoods**
Copper mining plays an important role in Chile's economy, accounting for 11% of GDP in 2014 (USGS, 2014a). However, strikes, and the threat of strikes, over pay and benefits were prominent characteristics of the Chilean mining sector in 2016-17 (Sanderson et al., 2017). In 2013 the DRC's mining and mineral processing sector accounted for an estimated 20.9% of GDP, with copper alone contributing 13.5% of GDP. In 2014, the mining of minerals including copper, manganese, and tourmaline was reported to employ nearly 5,200 miners (USGS, 2014b).

## Supplementary notes

This section records notable aspects specific to the production of the material that due to the general level of analysis of the report are not incorporated or might not be evident in the presentation of the results. These are important to consider when completing detailed due diligence on the material's sources.

**Association with Conflict Mineral Legislation**
Copper is not a designated conflict mineral according to Section 1502 of the Dodd-Frank Wall Street Reform and Consumer Act of 2010. Some copper is produced in the DRC, a country which is covered by "Dodd-Frank" and is produced in sufficient volume to feature in the top producer country table.

**Key**

**MD** = Missing Data
* = Where multiple sources have been considered and/or where deductions/estimations/assumptions have been generalised from existing data.

# Material profile: Glass

*Silica sand is integral to glass making due to low impurities, high durability and heat and chemical resistance. The most important characteristic of glass is its transparency, variable viscosity and water resistance.*

*This profile is intended as a general introduction to environmental, social and governance issues associated with the production of glass. It should not be considered to be comprehensive or be regarded as legal advice. It is not a replacement for company due diligence, and the information should not be interpreted as representing specific risks to any one individual company or irreversibly present in a particular material supply chain.*

*Please see **www.thedragonflyinitiative.com/material-change-report** for the methodology and a guide to the criteria and indicators used to generate the information in this profile.*

| Material uses | Passenger vehicle | Smartphone |
|---|---|---|
| Applications of glass: | Windscreen, windows, display screen | Display screen |
| Other profiled materials in these applications: | (display screen:) rare earth elements, tin | |

| Material significance | Low | Mod | High | V. High |
|---|---|---|---|---|
| % content in a passenger vehicle and smartphone: | | | | |
| Industry consumption: | | | | |
| Other top consuming industries: | Construction, other transport | | | |
| Function criticality: | | | | |

| Supply significance | |
|---|---|
| EU dependency on imported material: | |
| US dependency on imported material: | |
| Residual end of life waste (smartphone[MD]): | |
| Virgin material consumption: | |
| Estimated rate of depletion: | **MD** |

## Association with environmental, social and governance issues

| | No/Weak … Yes/Very Strong |
|---|---|
| Artisanal and small-scale mining | |
| Child labour and forced labour | |
| Countries with weak rule of law | |
| Countries experiencing corruption | |
| Countries experiencing high-intensity conflict | |
| High CO2 emissions | |
| Incidences of conflict with Indigenous Peoples | |
| Incidences of overlap with areas of conservation importance | **MD** |
| Potential for acid discharge to the environment | No |
| Potential for harm from hazardous materials and chemicals | |
| Preconditions for radioactive materials in ores and tailings | **MD** |

## Top producer country information (Silica Sand)

| | USA | Italy | France | Turkey | Germany |
|---|---|---|---|---|---|
| % Global Mined Production | 51 | 8 | 5 | 4 | 4 |
| % Global Reserves | Large* | Large | Large | Large | Large |
| % Mining sector contribution to GDP | 0.1 | <0.1 | <0.1 | 0.2 | <0.1 |
| Human Development Index | 0.920 V. HIGH | 0.887 V. HIGH | 0.897 V. HIGH | 0.767 HIGH | 0.926 V. HIGH |
| Rule of Law | STRONG | MODERATE | STRONG | WEAK | STRONG |
| Experience of Corruption | LOW | MODERATE | LOW | HIGH | LOW |
| Experience of State Conflict (Heidelberg Conflict Barometer) | MODERATE (Violent Crisis) | V. LOW (No Conflict) | LOW (Dispute) | HIGH (Limited War) | MODERATE (Violent Crisis) |

*As designated by USGS (2017). Also, quartz-rich sand and sandstone, the main sources of industrial silica sand, occur throughout the world and in most countries, but extraction of these resources may be uneconomic in some locations due to distribution, environmental restrictions or quality requirements (USGS, 2017).

## Examples of environmental, social and governance issues

This section aims to illustrate through brief examples some of the environmental, social and governance impacts on communities and countries that are publicly reported to be associated with the material's production. The information is drawn from various sources including peer reviewed papers, industry reports and media articles, the references for which are listed in section 5.4. The examples are from the material's top producer countries. This section is strictly illustrative and should not be considered generally representative of companies' performance or production practices in the industry.

**Incidences of overlap with areas of conservation importance**
In Cambodia, marine sand mining reportedly disturbs organisms and habitat on the sea bed and has led to lower biomass and a change in species composition (UNEP, 2014). However, the Cambodian government permanently banned the export of sand in July 2017 (BBC, 2017).

The Asian construction boom is reportedly fuelling a large illicit trade in sand (The Economist, 2017). Sand mining in India has allegedly eroded river banks, causing bridges to collapse and disruption to riparian ecosystems (Beiser, 2017).

Intensive sand-mining in Indonesia has been bolstered by the demand for sand by Singapore's construction industry, where land is being artificially reclaimed from the sea. Since 2005 Indonesia has lost over 20 islands due to a combination of rising sea levels and erosion, thought to be driven by coastal sand-mining (Beiser, 2017).

The shoreline north of Monterey, USA is eroding at a rate of eight acres per year, faster than elsewhere in the state. This erosion is alleged to be related to sand mining. Despite the closure of most operations in the 1980s due to erosion, the Monterey operation has continued (Beiser, 2017). The operation is scheduled to close in 2020 (Rogers, 2017).

## Supplementary notes

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**Incidences of overlap with areas of conservation importance**
Although the availability of data is insufficient to make a comparative rating for the material, and in particular the proximity designated areas such as national parks or other protected areas, it is noted that there are multiple reported incidences of the threats of sand mining to ecosystems and species valued locally and internationally. Globally, sand is being extracted at a rate far greater than it is naturally replenished. The depletion of existing reserves is reported to be contributing to widespread environmental damage, particularly where it is removed by dredging from sea beds or coastal areas (UNEP, 2014).

**Estimated rate of depletion**
While the inability to access data on the depletion rate of sand made it impossible to rank the material, it is worth noting that sand is formed by erosive processes over thousands of years (John, 2009), and some commentators argue that sands are now being extracted at a rate far greater than their renewal.

**Key**

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# Material profile: Gold

*High thermal and electrical conductivity and very high resistance to corrosion, allowing technical performance to remain unchanged over time.*

*This profile is intended as a general introduction to environmental, social and governance issues associated with the production of gold. It should not be considered to be comprehensive or be regarded as legal advice. It is not a replacement for company due diligence, and the information should not be interpreted as representing specific risks to any one individual company or irreversibly present in a particular material supply chain.*

*Please see **www.thedragonflyinitiative.com/material-change-report** for the methodology and a guide to the criteria and indicators used to generate the information in this profile.*

| Material uses | Passenger vehicle | Smartphone |
|---|---|---|
| Applications of gold: | Circuitry, printed circuit board | Circuitry, printed circuit board |
| Other profiled materials in these applications: | (printed circuit board:) copper, nickel, aluminium | |

## Material significance

Low | Mod | High | V. High

% content in a passenger vehicle and smartphone: *

Industry consumption:

Other top consuming industries: Jewellery, official coins and medals, investment, dentistry

Function criticality:

## Supply significance

EU dependency on imported material:

US dependency on imported material: **MD**

Residual end of life waste: *

Virgin material consumption:

Estimated rate of depletion:

## Association with environmental, social and governance issues

No/Weak | Yes/Very Strong

Artisanal and small-scale mining

Child labour and forced labour

Countries with weak rule of law

Countries experiencing corruption

Countries experiencing high-intensity conflict

High CO2 emissions

Incidences of conflict with Indigenous Peoples

Incidences of overlap with areas of conservation importance: Yes

Potential for acid discharge to the environment: Yes

Potential for harm from hazardous materials and chemicals

Preconditions for radioactive materials in ores and tailings: Yes



## Top producer country information

| | China | Australia | Russia | USA | South Africa | Canada | Peru |
|---|---|---|---|---|---|---|---|
| % Global Mined Production | 15 | 9 | 8 | 7 | 5 | 5 | 5 |
| % Global Reserves | 4 | 17 | 14 | 5 | 11 | 4 | 4 |
| % Mining Sector Contribution to GDP | 0.5 | 3.8 | 0.9 | 0.1 | 0.2 | 0.5 | 5.4 |
| Human Development Index | 0.738 HIGH | 0.939 V. HIGH | 0.804 V. HIGH | 0.920 V. HIGH | 0.666 MEDIUM | 0.920 V. HIGH | 0.740 HIGH |
| Rule of Law | WEAK | STRONG | V. WEAK | STRONG | MODERATE | STRONG | WEAK |
| Experience of Corruption | HIGH | LOW | V. HIGH | LOW | MODERATE | LOW | HIGH |
| Experience of State Conflict (Heidelberg Conflict Barometer) | MODERATE (Violent Crisis) | LOW (Dispute) | MODERATE (Violent Crisis) | MODERATE (Violent Crisis) | MODERATE (Violent Crisis) | LOW (Non Violent Crisis) | MODERATE (Violent Crisis) |

## Examples of environmental, social and governance issues

This section aims to illustrate through brief examples some of the environmental, social and governance impacts on communities and countries that are publicly reported to be associated with the material's production. The information is drawn from various sources including peer reviewed papers, industry reports and media articles, the references for which are listed in section 5.4. The examples are from the material's top producer countries. This section is strictly illustrative and should not be considered generally representative of companies' performance or production practices in the industry.

**Potential for harm from hazardous materials or chemicals**
A large gold refiner was reported to be the single biggest mercury polluter in Australia, Mexico, US, Europe, Japan and Canada in 2014. Workers at the nearby mine allegedly suffered from sore throats, nausea and eye irritation because of the plants' toxic emissions, however the Department for Health disputes these claims (Sunday Times, 2012).

Some of China's gold-mining sector is reported to be a source of mercury emissions and high concentrations of heavy metal contamination. This contamination has reportedly resulted in ecological concerns in the gold-mining region of Shaanxi (Li et al., 2014). Some incidents of ongoing community conflict with gold-mining interests in the Autonomous Region of Tibet have been reported due to alleged negative environmental impacts (EJA, 2017). In 2014, the output of gold in China was 486 tonnes, an increase of 14% compared with 2013, and China's production of gold ranked first in the world (USGS, 2014b). Class action against gold mining companies to compensate mine workers for alleged occupational health issues has resulted in mining companies preparing a multi-billion-dollar settlement with as many as 100 thousand former workers who report that they suffer from debilitating lung diseases (Stoddard, 2018).

**Conflict with Indigenous Peoples**
In 2013 the grassroots aboriginal movement "Idle No More" protested gold mining projects in Canada. The movement cut off access to a gold, copper and zinc mine in northern Manitoba for several hours, in 2013, due to demands surrounding ownership stakes in the $790 million project (Gordon and Martell, 2013).

In Peru, there are disputed land use claims from indigenous communities bordering mining concessions (Global Witness, 2016).

**Artisanal and small scale mining**
Some alluvial gold mining (AGE) in Colombia is associated with organised criminal groups and the trade of narcotics. The UNODC, together with Colombian Ministries, reported that in the departments of Caquetá, Putumayo and Nariño, over 80% of the detected AGE activities are found in territories affected by coca crops. It is also reported that small scale gold mining is one of the main drivers of deforestation in Colombia, with vegetation loss mainly concentrated in Chocó, one of the most biodiverse areas in the world. Mercury pollution and subsequent health issues in the region have also been reported (UNODC, 2016). In 2017, six contractors inspecting at an illegal gold mine were killed by an explosion (Bocanegra and Cobb, 2017).

**Key**
**MD** = Missing Data
* = Where multiple sources have been considered and/or where deductions/estimations/assumptions have been generalised from existing data.

Some informal ASM gold mining in Peru is reported to be associated with human rights concerns such as child and forced labour, sexual exploitation and trafficking (US Department of Labor, 2017). ASM gold mining in Peru is also allegedly associated with environmental degradation and deforestation as well as mercury usage which can lead to serious health risks and contamination of food sources (Global Initiative Against Transnational Organised Crime, 2016).

Some informal gold mining in South Africa has reportedly been linked to organised crime, lower levels of occupational health and safety and an increase in respiratory disease (Chamber of Mines, 2017).

**Gold and livelihoods**
In 2014, mining and fuel accounted for 12% of Peru's GDP with a total of 42,025 mining concessions covering 14.6% of the country's land. In December 2014, the recorded number of mine holders was 11,705, of which 2,452 were small-scale miners, 8,000 were artisanal miners, and 1,253 were large- and medium-scale miners. In 2014, Peru accounted for approximately 4.7% of the world's gold production (USGS, 2014d).

In 2014, South Africa's mineral industry accounted for 7.5% of GDP and employed 495,592 workers. In 2014, gold mining accounted for 24% of the mineral industry's total employment. Between 2004 and 2013 South Africa's share of world gold production decreased to about 5% from 14%. This is primarily attributable to difficult geologic conditions and high ore haulage costs (USGS, 2014e).

In 2014, Canada's mining accounted for 4% of GDP and employed 376,455 people (USGS, 2014a). Australia's gold industry employed 22,439 people in 2012 (Satchwell, 2013).

In 2013 mineral production contributed to 7.8% of GDP in Colombia. According to the country's 2010 census, of 14,000 surveyed mining enterprises, 98% were categorised as small or medium scale (72% of these were small scale) and 63% operated without a mining license (USGS, 2014c).

## Supplementary notes

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**Association with Conflict Mineral Legislation**
Gold is a designated conflict mineral according to Section 1502 of the Dodd-Frank Wall Street Reform and Consumer Act of 2010. Small amounts of gold are produced in countries covered by "Dodd-Frank" such as Uganda and Tanzania, however not in sufficient volume to feature in the top producer country table.

# Material profile: Graphite (natural)

*Good electrical and thermal conductivity, high chemical stability and highly resistant to corrosion.*

*This profile is intended as a general introduction to environmental, social and governance issues associated with the production of graphite. It should not be considered to be comprehensive or be regarded as legal advice. It is not a replacement for company due diligence, and the information should not be interpreted as representing specific risks to any one individual company or irreversibly present in a particular material supply chain.*

*Please see* ***www.thedragonflyinitiative.com/material-change-report*** *for the methodology and a guide to the criteria and indicators used to generate the information in this profile.*

| Material uses | Passenger vehicle | Smartphone |
|---|---|---|
| Applications of graphite: | Battery *(lithium-ion)*, brakes, clutch, electric motors, wheels *(bearings)* | Battery (lithium-ion) |
| Other profiled materials in these applications: | (lithium-ion battery:) cobalt, lithium, nickel | |

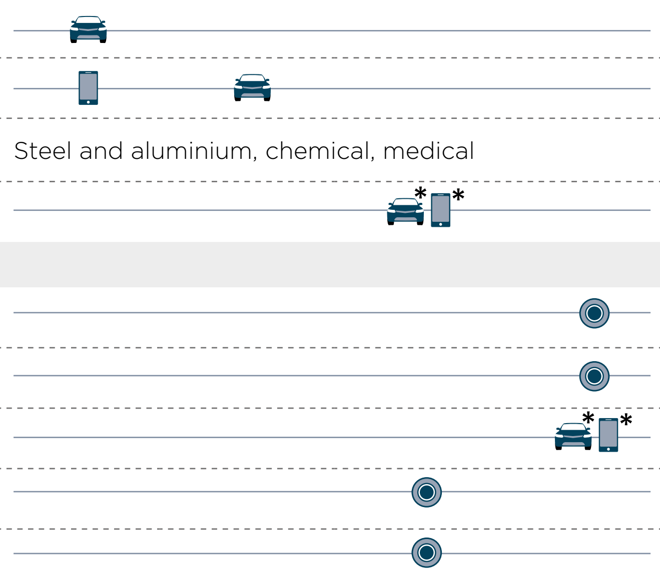
## Material significance

Low | Mod | High | V. High

- % content in a passenger vehicle (smartphone[N/A]):
- Industry consumption:
- Other top consuming industries: Steel and aluminium, chemical, medical
- Function criticality:

## Supply significance

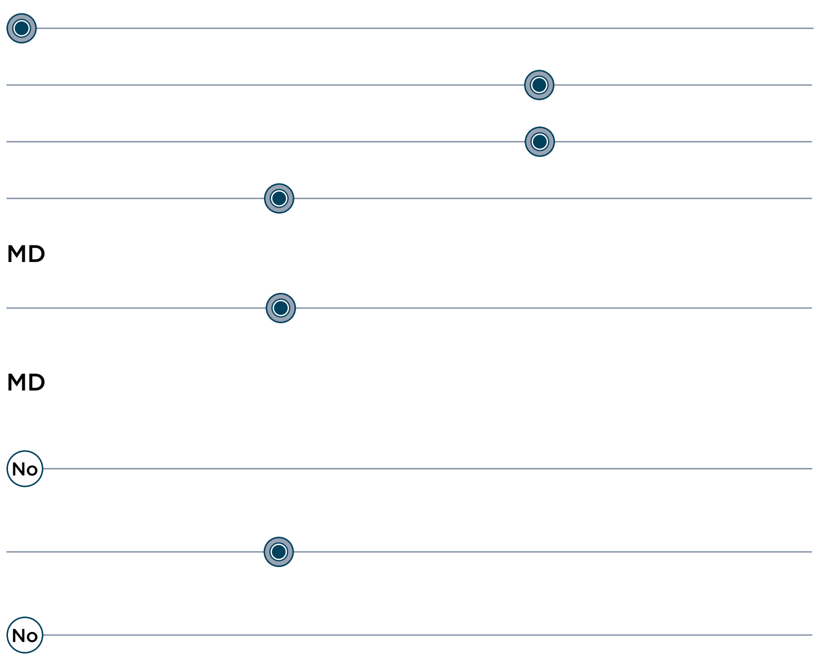
- EU dependency on imported material:
- US dependency on imported material:
- Residual end of life waste:
- Virgin material consumption:
- Estimated rate of depletion:



## Association with environmental, social and governance issues

No/Weak — Yes/Very Strong

- Artisanal and small-scale mining: MD
- Child labour and forced labour
- Countries with weak rule of law
- Countries experiencing corruption
- Countries experiencing high-intensity conflict
- High CO2 emissions: MD
- Incidences of conflict with Indigenous Peoples
- Incidences of overlap with areas of conservation importance: MD
- Potential for acid discharge to the environment: No
- Potential for harm from hazardous materials and chemicals
- Preconditions for radioactive materials in ores and tailings: No





## Top producer country information

| | China | India | Brazil | Turkey | N. Korea |
|---|---|---|---|---|---|
| % Global Mined Production (not currently specific to flake graphite – TBC) | 65 | 14 | 6 | 3 | 3 |
| % Global Reserves | 22 | 3 | 29 | 36 | – |
| % Mining Sector Contribution to GDP | 0.5 | 0.3 | 1.3 | 0.2 | <0.1 |
| Human Development Index | 0.738 HIGH | 0.624 MEDIUM | 0.754 HIGH | 0.767 HIGH | 0.901 V. HIGH |
| Rule of Law | WEAK | MODERATE | MODERATE | WEAK | V. WEAK |
| Experience of Corruption | HIGH | HIGH | HIGH | MODERATE | V. HIGH |
| Experience of State Conflict (Heidelberg Conflict Barometer) | MODERATE (Violent Crisis) | MODERATE (Violent Crisis) | HIGH (Limited War) | HIGH (Limited War) | MODERATE (Violent Crisis) |

## Examples of environmental, social and governance issues

This section aims to illustrate through brief examples some of the environmental, social and governance impacts on communities and countries that are publicly reported to be associated with the material's production. The information is drawn from various sources including peer reviewed papers, industry reports and media articles, the references for which are listed in section 5.4. The examples are from the material's top producer countries. This section is strictly illustrative and should not be considered generally representative of companies' performance or production practices in the industry.

**Potential for harm from hazardous materials or chemicals**
Pollution from some graphite mining in China has resulted in reports of dust and "graphite rain", which is lowering local air and water quality (World Economic Forum, 2015). Communities in the locality of these sites have reported instances of soot covering their homes, damaged crops and polluted drinking water (Whoriskey, 2016). Additionally, concerns have been raised regarding the alleged disposal of wastewater (Lazenby, 2014). In 2014 China's natural graphite production was estimated to be 780,000 tonnes. China was the world's leading consumer of graphite, accounting for 50% of global consumption (USGS, 2014).

Major challenges have been identified in some aspects of the Indian graphite mining industry, including problems related to land usage for new mines amidst legal, environmental and social concerns. Issues of fraud due to a lack of transparent policies fuelling corrupt practices (Salwan, 2014) have also been alleged. Additionally, residents living around plants have reported black dust deposits and emissions, which, they say, can be smelled within a 500-700m radius of the plant. Residents are looking to the National Green Tribunal to intervene in the issue (Times of India, 2017; Centre for Science and the Environment, 2015). In 2013, industrial minerals, including graphite accounted for 15.1% of total mined production in India.

**Child labour and forced labour**
North Korea's mining industry has been in decline since the early 1990s, due to decades of neglect and lack of funds for infrastructure development to support mining activities. Despite the UN introducing a full ban for several minerals including iron ore, copper and nickel in 2016, graphite was not originally listed. This ban was extended in 2017 to cover all mining sectors. However, there have been reports that Kim Jong-Un's regime has grown increasingly inventive in circumventing sanctions (Cunningham, 2017). Mining in North Korea is associated with forced labour (HRW, 2016).

## Supplementary notes

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**Function criticality**
While 'function criticality' is rated as 'high, implying that there are currently few substitutes for graphite when used in the automotive and electronics industries, it should be noted that there are reports of several pilot stage projects that are underway to explore viable alternate options for the material.

**EOL Recycling Rates**
At present, recycling of graphite from scrap is very limited and only occurs for a few applications. A lack of economic incentives combined with technical challenges has stalled the market for recycled graphite and there is little to no information available on the global quantities and values of recycled graphite.

**Key**

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# Material profile: Leather

*High tensile strength, high resistance to puncture and high absorption.*

*This profile is intended as a general introduction to environmental, social and governance issues associated with the production of leather. It should not be considered to be comprehensive or be regarded as legal advice. It is not a replacement for company due diligence, and the information should not be interpreted as representing specific risks to any one individual company or irreversibly present in a particular material supply chain.*

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| Material uses | Passenger vehicle | Smartphone |
|---|---|---|
| Applications of leather: | Interiors | N/A *(accessories)* |
| Other profiled materials in this application: | None | |

| Material significance | Low | Mod | High | V. High |
|---|---|---|---|---|
| % content in a passenger vehicle (smartphone[N/A]): | Passenger vehicle | | | |
| Industry consumption (smartphone[N/A]): | | | Passenger vehicle | |
| Other top consuming industries: | Fashion and accessories, furniture. | | | |
| Function criticality (smartphone[N/A]): | | | | Passenger vehicle |

| Supply significance | |
|---|---|
| EU dependency on imported material: | **MD** |
| US dependency on imported material: | **MD** |
| Residual end of life waste (smartphone[N/A]): | V. High (passenger vehicle) |
| Virgin material consumption: | **MD** |
| Estimated rate of depletion: | N/A |

## Association with environmental, social and governance issues

| | No/Weak … Yes/Very Strong |
|---|---|
| Artisanal and small-scale mining | N/A |
| Child labour and forced labour | |
| Countries with weak rule of law | |
| Countries experiencing corruption | |
| Countries experiencing high-intensity conflict | |
| High CO2 emissions | |
| Incidences of conflict with Indigenous Peoples | |
| Incidences of overlap with areas of conservation importance | **MD** |
| Potential for acid discharge to the environment | N/A |
| Potential for harm from hazardous materials and chemicals | |
| Preconditions for radioactive materials in ores and tailings | N/A |



## Top producer country information

| | China | Brazil | Russia | S.Korea | Italy | India |
|---|---|---|---|---|---|---|
| % Global Production (light bovine leather) | 17 | 14 | 9 | 7 | 7 | 5 |
| % Global Apparent Availability *(= Production + imports - Exports)* | 37 | <1 | <1 | 7 | <1 | 3 |
| % Leather sector contribution to GDP | **MD** | **MD** | **MD** | **MD** | **MD** | **MD** |
| Human Development Index | 0.738 HIGH | 0.754 HIGH | 0.804 V. HIGH | 0.901 V. HIGH | 0.887 V. HIGH | 0.624 MED |
| Rule of Law | WEAK | MODERATE | V. WEAK | STRONG | MODERATE | MODERATE |
| Experience of Corruption | HIGH | HIGH | V. HIGH | V. HIGH | MODERATE | HIGH |
| Experience of State Conflict (Heidelberg Conflict Barometer) | MODERATE (Violent Crisis) | HIGH (Limited War) | MODERATE (Violent Crisis) | MODERATE (Violent Crisis) | LOW (No Conflict) | MODERATE (Violent Crisis) |

## Examples of environmental, social and governance issues

This section aims to illustrate through brief examples some of the environmental, social and governance impacts on communities and countries that are publicly reported to be associated with the material's production. The information is drawn from various sources including peer reviewed papers, industry reports and media articles, the references for which are listed in section 5.4. The examples are from the material's top producer countries. This section is strictly illustrative and should not be considered generally representative of companies' performance or production practices in the industry.

**Potential for harm from hazardous materials and chemicals**
In Icoaraci, Brazil, over 130 thousand people were reportedly exposed to pollutants, including chromium, from the leather industry. This has allegedly affected respiratory health and increased the chance of lung, nasal and sinus cancer in those exposed (EJA, 2017).

There have been reports of odours, waste and pollution from residents who live near tanneries. In some areas of China. There have also been reports of land disputes particularly in relation to a factory in the Guangxi Zhuang Autonomous Region. Some of China's leather industry is also associated with lower occupational health and safety (Gombault et al., 2013).

Groundwater in the areas where some tanneries are located in India has reportedly decreased in quality due to pollution from tannery waste (Ramesh and Thirumangai, 2014).

**Child labour and forced labour**
Within the unorganised sector and SMEs, workers health and safety is lower. Some of India's leather industry is allegedly associated with child labour in both the tanneries and slaughterhouses and issues of bonded labour have also been reported (Gombault et al., 2013).

Brazil reportedly struggles with some forced and child labour issues and deforestation related to the leather industry (Gombault et al., 2013).

**Leather and livelihoods**
In 2012 the industry accounted for 3% of employment and 3.5% of industry output in China (Lu and Dickson, 2015). China's export trade of low-skill and labour-intensive goods such as toys and leather goods accounted for less than 10% in 2013 (Wei and Balasubramanyam, 2015). In 2013 Brazil's leather sector employed over 50 thousand workers (APLF, 2013). In 2015, the textile industry accounted for 7% of China's GDP (Business Wire, 2016).

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## Supplementary notes

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**Function criticality**
Leather used for interiors in cars can be substituted with other materials. Furthermore, synthetic and 'grown' leather are available and reportedly match high standards for quality. Nevertheless, the demand from auto consumers for natural leather is high, especially for luxury vehicles, and drives the choice for this material for many automotive manufacturers. For this reason leather's importance for function criticality is rated as 'very high'.

**Leather supply chain and environmental, social and governance issues**
It is noted that leather sourced by the automotive industry typically originates in Northern Europe, where strict regulatory control minimises the environmental and social impacts of production.

Leather is produced in different phases, starting with the slaughter of the animal and basic processing and preparation of the hide. This commonly takes place in the countries where the animals are reared for the food industry. During following phases hides are processed to meet the quality specifications of the 'end user' industries, including the automotive industry. For the automotive industry, these advanced processing phases are mostly located in Northern Europe.

While it is relatively easy to track the origin of leather to the facilities of suppliers processing leather in Europe, it is less straight forward to track the journey of the animal hides from the first phases in the country where the animals are reared and slaughtered. However, in keeping with the overall methodology of the study the impacts associated with leather production worldwide are included. Asian leather production is more highly associated with adverse environmental and social impacts than northern European production, so manufacturers consuming only northern European leather may experience commensurately lower association with environmental and social risks than those indicated by this study.

**CO2 emissions**
Currently, there is no single methodology and no international agreement on methods for calculating the carbon footprint of leather. Emissions occur at all stages of the production process from farm to slaughterhouse to tanneries to manufacturing and distribution, including transportation. The allocation of carbon emissions at each stage of the process varies according to other products associated with the raw material, however. Most studies on CO2 emissions from leather production conclude that the 'raw material extraction' contributes the most CO2 emissions. Whether to include the carbon footprint of cattle farming in methodologies to calculate the total emissions of leather is the subject of continuing discussions in the industry and within regulatory agencies. So too is whether such methodologies should include the transformation of forested land for the purposes of rearing livestock and the related net-emissions of CO2. The association of leather with CO2 emissions is rated as 'moderate' in order to alert the reader to potential risk of association with this important issue.

**Animal Welfare**
Although highly relevant from a corporate responsibility perspective, animal welfare was not considered in the analysis of natural leather as it is inapplicable to any other material assessed, and therefore was not incorporated into the methodology that aims to make a comparative analysis across the materials.

**Key**

**MD** = Missing Data
* = Where multiple sources have been considered and/or where deductions/estimations/assumptions have been generalised from existing data.

# Material profile: Lithium

*Light weight, high energy-storage density.*

*This profile is intended as a general introduction to environmental, social and governance issues associated with the production of Lithium. It should not be considered to be comprehensive or be regarded as legal advice. It is not a replacement for company due diligence, and the information should not be interpreted as representing specific risks to any one individual company or irreversibly present in a particular material supply chain.*

*Please see* ***www.thedragonflyinitiative.com/material-change-report*** *for the methodology and a guide to the criteria and indicators used to generate the information in this profile.*

| Material uses | Passenger vehicle | Smartphone |
|---|---|---|
| Applications of lithium: | Battery *(lithium-ion)* | Battery *(lithium-ion)* |
| Other profiled materials in this application: | (lithium-ion battery:) cobalt, graphite, nickel | |

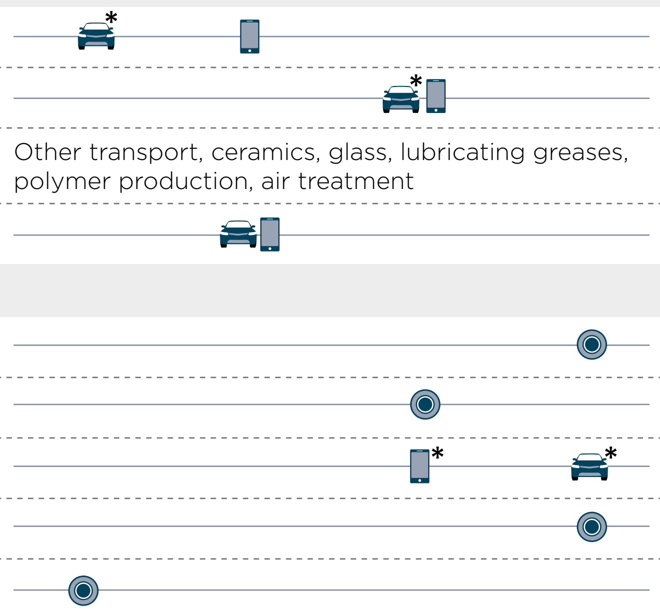
## Material significance

Low | Mod | High | V. High

- % content in a passenger vehicle and smartphone:
- Industry consumption:
- Other top consuming industries: Other transport, ceramics, glass, lubricating greases, polymer production, air treatment
- Function criticality:

## Supply significance

- EU dependency on imported material:
- US dependency on imported material:
- Residual end of life waste:
- Virgin material consumption:
- Estimated rate of depletion:



## Association with environmental, social and governance issues

No/Weak | Yes/Very Strong

- Artisanal and small-scale mining
- Child labour and forced labour
- Countries with weak rule of law
- Countries experiencing corruption
- Countries experiencing high-intensity conflict
- High CO2 emissions
- Incidences of conflict with Indigenous Peoples
- Incidences of overlap with areas of conservation importance
- Potential for acid discharge to the environment
- Potential for harm from hazardous materials and chemicals
- Preconditions for radioactive materials in ores and tailings




## Top producer country information

| | Australia | Chile | Argentina | China | Bolivia |
|---|---|---|---|---|---|
| % Global Mined Production | 41 | 34 | 16 | 6 | just starting* |
| % Global Reserves | 4 | 19 | 5 | 8 | 22 |
| % Mining Sector Contribution to GDP | 3.8 | 11.6 | 0.3 | 0.5 | 4.2 |
| Human Development Index | 0.939 V. HIGH | 0.847 V. HIGH | 0.827 V. HIGH | 0.738 HIGH | 0.674 MED |
| Rule of Law | STRONG | STRONG | WEAK | WEAK | V. WEAK |
| Experience of Corruption | LOW | LOW | HIGH | HIGH | HIGH |
| Experience of State Conflict (Heidelberg Conflict Barometer) | LOW (Dispute) | MODERATE (Violent Crisis) | LOW (Dispute) | MODERATE (Violent Crisis) | MODERATE (Violent Crisis) |

**Bolivia has only just started exporting lithium in small quantities, however it has been included here because it holds one of the world's largest lithium reserves, representing a critical future supply.*

## Examples of environmental, social and governance issues

This section aims to illustrate through brief examples some of the environmental, social and governance impacts on communities and countries that are publicly reported to be associated with the material's production. The information is drawn from various sources including peer reviewed papers, industry reports and media articles, the references for which are listed in section 5.4. The examples are from the material's top producer countries. This section is strictly illustrative and should not be considered generally representative of companies' performance or production practices in the industry.

**Conflict with Indigenous Peoples**

In Argentina's Salar de Hombre Muerto, local Indigenous Peoples communities claim that lithium operations have decreased the water quality in streams used for humans, livestock and crop irrigation (FOE, 2013). The mining operations have also reportedly exacerbated water shortages. Additionally, the province lacks a formal process for negotiations between indigenous communities and mining companies (Whoriskey, 2016).

Bolivia currently makes up the smallest portion of The Lithium Triangle, but it is thought to have the largest undeveloped lithium brine reserves in the world: Salar de Uyuni. The USGS estimates that this salt flat contains approximately 9 million tonnes of identified lithium resource (Leni, 2017). However, the lithium-rich Salar de Uyuni is located near to the San Cristóbal Mine, which has allegedly caused an "environmental and social disaster that affects all of Southwest Potosí" – in part due to its reported use of 50,000 litres of water per day since it opened in 2007 (FOE, 2013).

The salt flats in Chile, where lithium reserves are located, are arid territories where access to water is key for the local communities and their livelihoods, as well as the local flora and fauna. In Atacama, mining reportedly consumes, contaminates and diverts scarce water resources away from local communities and the extraction of lithium has allegedly caused some water-related conflicts with different communities (FOE, 2013).

**Lithium and livelihoods**

Preliminary data indicates that Argentina exported 11,300 tonnes of lithium carbonate in 2014 to China (4,800 tonnes) the United States (3,300 tonnes), and Japan (1,400 tonnes). Although there are no exact figures to measure the existent reserves, studies suggest that Argentina has the potential to reach a global leading position on the production of this mineral (Deloitte, 2016).

**Key**

**MD** = Missing Data

***** = Where multiple sources have been considered and/or where deductions/estimations/assumptions have been generalised from existing data.

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Please always credit the Responsible Minerals Initiative, Drive Sustainability and The Dragonfly Initiative for the work they have done compiling and analysing this information.

# Supplementary notes

This section records notable aspects specific to the production of the material that due to the general level of analysis of the report are not incorporated or might not be evident in the presentation of the results. These might be important to consider when completing detailed due diligence on the material's sources.

**Association with Conflict Mineral Legislation**
Lithium is not a designated conflict mineral according to Section 1502 of the Dodd-Frank Wall Street Reform and Consumer Act of 2010. Small amounts of lithium are produced in Zambia, a country which is covered by "Dodd-Frank", however not in sufficient volume to feature in the top producer country table.

**EOL – recycling rate (electronics)**
Lithium EOL recycling has been given a low rating (<1%) but there is evidence that recycling rates might increase. For example, the UK has seen a high level of consumer battery recycling. For example, the UK has seen a high level of consumer battery recycling (a target of 45% collection of consumer batteries was set for 2017. Statistics from the National Packaging Waste Database (NPWD) of the U.K's Environment Agency indicate that the target was only narrowly missed, with a recorded rate of 44.89% of batteries collected for recycling in 2017). A major European recycling unit has patented a hydrometallurgical recycling process, which has a higher material recycling efficiency, and aims to recover 100% of metal content (NPWD, 2017).

# Material profile: Mica

*Pearlescent, lightweight, unique electrical and thermal insulating and mechanical properties.*

*This profile is intended as a general introduction to environmental, social and governance issues associated with the production of mica. It should not be considered to be comprehensive or be regarded as legal advice. It is not a replacement for company due diligence, and the information should not be interpreted as representing specific risks to any one individual company or irreversibly present in a particular material supply chain.*

*Please see **www.thedragonflyinitiative.com/material-change-report** for the methodology and a guide to the criteria and indicators used to generate the information in this profile.*

| Material uses | Passenger vehicle | Smartphone |
|---|---|---|
| Applications of mica: | Paint/Pearlescent finish *(scrap and flake mica)* | Capacitors *(muscovite sheet mica)*, insulation |
| Other profiled materials in these applications: | None | |

| Material significance | Low | Mod | High | V. High |
|---|---|---|---|---|
| % content in a passenger vehicle (smartphone[N/A]): | | | | |
| Industry consumption: | **MD*** | | | |
| Other top consuming industries: | Construction, paint, plastics, cosmetics | | | |
| Function criticality: | | | | |
| **Supply significance** | | | | |
| EU dependency on imported material: | **MD** | | | |
| US dependency on imported material: | | | | |
| Residual end of life waste: | | | | |
| Virgin material consumption: | **MD** | | | |
| Estimated rate of depletion: | **MD** | | | |

**There is lack of data on the use of synthetic versus natural mica by the auto and electronics industries. While mica appears in some components, it is not included in all. For example, only approximately 3% of capacitors are believed to include mica and these are found primarily in large form electronics as opposed to consumer goods.*

## Association with environmental, social and governance issues

| | No/Weak | Yes/Very Strong |
|---|---|---|
| Artisanal and small-scale mining | | |
| Child labour and forced labour | | |
| Countries with weak rule of law | | |
| Countries experiencing corruption | | |
| Countries experiencing high-intensity conflict | | |
| High CO2 emissions | **MD** | |
| Incidences of conflict with Indigenous Peoples | | |
| Incidences of overlap with areas of conservation importance | No | |
| Potential for acid discharge to the environment | No | |
| Potential for harm from hazardous materials and chemicals | | |
| Preconditions for radioactive materials in ores and tailings | No | |



## Top producer country information

### Sheet Mica

| | India+ | Russia |
|---|---|---|
| % Global Mined Production | 48 | 45 |
| % Global Reserves | Very Large | Moderate |
| % Mining Sector Contribution to GDP | 0.3 | 0.9 |
| Human Development Index | 0.624 MEDIUM | 0.804 V. HIGH |
| Rule of Law | MODERATE | V. WEAK |
| Experience of Corruption | HIGH | V. HIGH |
| Experience of State Conflict (Heidelberg Conflict Barometer) | MODERATE (Violent Crisis) | MODERATE (Violent Crisis) |

### Scrap and Flake Mica

| | China | Russia | Finland | USA |
|---|---|---|---|---|
| % Global Mined Production | 69 | 9 | 5 | 3 |
| % Global Reserves | Large** | Large | Large | Large |
| % Mining Sector Contribution to GDP | 0.5 | 0.9 | 0.3 | 0.1 |
| Human Development Index | 0.738 HIGH | 0.804 V. HIGH | 0.895 V. HIGH | 0.920 V. HIGH |
| Rule of Law | WEAK | V. WEAK | STRONG | STRONG |
| Experience of Corruption | HIGH | V. HIGH | LOW | LOW |
| Experience of State Conflict (Heidelberg Conflict Barometer) | MODERATE (Violent Crisis) | MODERATE (Violent Crisis) | V. LOW (No Conflict) | MODERATE (Violent Crisis) |

*+ Research indicates that India is a top producer of premium quality sheet mica used in electronic applications, while it does not produce a significant proportion of global scrap and flake mica, according to official production figures. Nonetheless, India has become associated with lower-grade mica that is better suited to grinding for use in paint and cosmetics because there is a large informal mining sector that recovers lower-grade remnants from inactive mines.*

*** As designated by USGS 2017: Scrap and flake mica resources are considered more than adequate to meet world demand in the foreseeable future*

## Examples of environmental, social and governance issues

This section aims to illustrate through brief examples some of the environmental, social and governance impacts on communities and countries that are publicly reported to be associated with the material's production. The information is drawn from various sources including peer reviewed papers, industry reports and media articles, the references for which are listed in section 5.4. The examples are from the material's top producer countries. This section is strictly illustrative and should not be considered generally representative of companies' performance or production practices in the industry.

**ASM; Child labour and forced labour**
The Indian states of Jharkhand and Bihar are home to the world's largest mica mining area, and account for an estimated 25% of the world's total production. It is reported that around 90% of mica mined in these states is mined illegally (SOMO, 2016). Mica mining in this area of India is reported to be associated with child labour issues, with 20 thousand child labourers estimated to be involved. The mining of mica, in some areas of India, is reported to have low health and safety standards, with some sites at risk of mine collapse, as well as fatal accidents reported in illegal mines. At least six people died in the years 2014 and 2015 and it is alleged that not all accidents are reported to the police due to the illegality of the mining. Miners working in these unregulated environments are also exposed to dust which may lead to silicosis following long term exposure (SOMO, 2016). In 2017, following the publication of reports disclosing child labour, government officials announced plans to formalise the mica industry (Dash, 2017). It is estimated that mica accounted for less than 1% of total mineral production in India in 2013 and less than 1% of India's formal mining sector employed in the production of mica in 2017 (USGS, 2017).

## Supplementary notes

This section records a number notable aspects specific to the production of the material that due to the general level of analysis of the report are not incorporated or might not be evident in the presentation of the results. These are important to consider when completing detailed due diligence on the material's sources.

**Missing data**
It has proven difficult to gather industry-level data on mica for several of the criteria. Few studies have been completed on the supply and demand for mica and its relationship with the automotive and electronics industry. According to research carried out by the RMI through their membership, mica is only used in about 3% of electronic capacitors. However, small quantities of mica appear in many components in automotive and electronic products. The RMI research identified over 70 components across the two industries that might contain mica. In summary, mica can be found in: electronic systems, sound systems and displays, climate control systems, lighting systems, hardware, paint and a variety of connecting sealing applications. It is problematic to judge the significance of the consumption by the two industries, although the information available suggests that the automotive and electronics industries are not large users of the material.

Data on EU dependency is absent, as is the recycling rates and end of life waste associated with mica. The estimated depletion rate too is currently unknown as world resources have not been formally evaluated.

There is also lack of data on the use of synthetic versus natural mica by the automotive and electronics industries.

**Potential for acid discharge to the environment:**
In some cases acid is used when recovering mica when the target ore needs to be separated from more valuable ore, such as beryllium.

**Key**

**MD** = Missing Data
***** = Where multiple sources have been considered and/or where deductions/estimations/assumptions have been generalised from existing data.

# Material profile: Nickel

*Strong at high and low temperatures, high resistance to corrosion and magnetic.*

*This profile is intended as a general introduction to environmental, social and governance issues associated with the production of nickel. It should not be considered to be comprehensive or be regarded as legal advice. It is not a replacement for company due diligence, and the information should not be interpreted as representing specific risks to any one individual company or irreversibly present in a particular material supply chain.*

*Please see* ***www.thedragonflyinitiative.com/material-change-report*** *for the methodology and a guide to the criteria and indicators used to generate the information in this profile.*

| Material uses | Passenger vehicle | Smartphone |
|---|---|---|
| Applications of nickel: | Engine *(turbocharger)*, microphone/speaker, plating, printed circuit board, transmission | Printed circuit board |
| Other profiled materials in these applications: | (printed circuit board:) copper, gold, aluminium. (plating:) zinc | |

| Material significance | Low | Mod | High | V. High |
|---|---|---|---|---|
| % content in a passenger vehicle and smartphone: | | * | | |
| Industry consumption: | | | | |
| Other top consuming industries: | Steel manufacture, coins, superalloys | | | |
| Function criticality: | | | | |

| Supply significance | |
|---|---|
| EU dependency on imported material: | |
| US dependency on imported material: | |
| Residual end of life waste: | * |
| Virgin material consumption: | |
| Estimated rate of depletion: | |

## Association with environmental, social and governance issues

| | No/Weak | Yes/Very Strong |
|---|---|---|
| Artisanal and small-scale mining | | |
| Child labour and forced labour | | |
| Countries with weak rule of law | | |
| Countries experiencing corruption | | |
| Countries experiencing high-intensity conflict | | |
| High CO2 emissions | | |
| Incidences of conflict with Indigenous Peoples | | |
| Incidences of overlap with areas of conservation importance | | Yes |
| Potential for acid discharge to the environment | | Yes |
| Potential for harm from hazardous materials and chemicals | | |
| Preconditions for radioactive materials in ores and tailings | No | |



## Top producer country information

| | Philippines | Russia | Canada | New Caledonia | Australia |
|---|---|---|---|---|---|
| % Global Mined Production | 22 | 11 | 11 | 11 | 9 |
| % Global Reserves | 6 | 10 | 4 | 9 | 24 |
| % Mining Sector Contribution to GDP | 1.2 | 0.9 | 0.5 | MD | 3.8 |
| Human Development Index | 0.682 MEDIUM | 0.804 V. HIGH | 0.920 V. HIGH | MD | 0.939 V. HIGH |
| Rule of Law | WEAK | V. WEAK | STRONG | MD | STRONG |
| Experience of Corruption | HIGH | V. HIGH | LOW | MD | LOW |
| Experience of State Conflict (Heidelberg Conflict Barometer) | V. HIGH (War) | MODERATE (Violent Crisis) | LOW (Non Violent Crisis) | V. LOW (No Conflict) | LOW (Dispute) |

** New Caledonia is a sui generis of France with an upcoming referendum on independence in 2018. Data is not available from this study's sources for New Caledonia independently of France.*

## Examples of environmental, social and governance issues

This section aims to illustrate through brief examples some of the environmental, social and governance impacts on communities and countries that are publicly reported to be associated with the material's production. The information is drawn from various sources including peer reviewed papers, industry reports and media articles, the references for which are listed in section 5.4. The examples are from the material's top producer countries. This section is strictly illustrative and should not be considered generally representative of companies' performance or production practices in the industry.

**Incidences of overlap with areas of conservation importance**
The Goro mine in New Caledonia was temporarily closed in 2013 after mine effluent was discovered to be leaking into a lagoon designated as a UN World Heritage Site.
A similar spill was reported at the same plant in 2014, the fifth significant leakage in five years (USGS, 2013). The plant is now under review due to falling nickel prices. New Caledonia's nickel accounts for about 25% of the world's total resources. Its economy remains heavily dependent upon nickel and its by-product, cobalt, with the total value of nickel exports accounting for 10% of GDP in 2014. In the same year total employment in nickel mining and smelting was 6,308, of which 2,541 people were employed in mining, 1,595 employed as mining contractors, and 2,172 employed in nickel smelting (USGS, 2015).

**Conflict with Indigenous Peoples; Water/soil pollution**
A nationwide mine audit led to the closure of seventeen of the Philippine's nickel mines in 2017, as well as a ban on new open-pit explorations, due to reported environmental compliance concerns (Cruz, 2017). The Philippines is alleged to be one of the most dangerous places in the world for anti-mining activists, especially indigenous activists, with high incidences of conflict associated with mining projects reported (Global Witness, 2016). In 2014, the mining and quarrying sector accounted for 5% of the Philippines' GDP, compared to 1% in 2013. One of the main mineral commodities produced in the Philippines is nickel, accounting for 1.1% of GDP. The Philippines produced 21% of the world's nickel in 2014 (USGS, 2014).

**Potential for acid discharge and for harm from hazardous materials and chemicals**
Norilsk, Russia one of the world's biggest nickel-producing areas, has been reported to be in the 'Top 10 Toxic Threats' worldwide. Some mining and smelting operations are reported to have caused pollution, particularly sulfur dioxide emissions that are associated with acid rain and heavy-metal contamination in water systems. About 130 thousand residents have allegedly been exposed to particulates and phenols from air and soil pollution. This has caused increased levels of reported respiratory diseases and cancers of the lungs and digestive system, which children are especially vulnerable to (Blacksmith Institute, 2013). Despite closure of one of the factories in 2016, concerns have been raised about other plants in Norilsk taking on operations (Luhn, 2016). In 2015, Russia was the second largest country in terms of mining and refined nickel production, with Norilsk Nickel accounting for 92% of Russia's refined nickel production (KPMG, 2016).

**Key**
**MD** = Missing Data
***** = Where multiple sources have been considered and/or where deductions/estimations/assumptions have been generalised from existing data.

# Material profile: Palladium

*Resistant to high temperatures and corrosion, also a superior catalytic material (absorbs hydrogen gas).*

*This profile is intended as a general introduction to environmental, social and governance issues associated with the production of palladium. It should not be considered to be comprehensive or be regarded as legal advice. It is not a replacement for company due diligence, and the information should not be interpreted as representing specific risks to any one individual company or irreversibly present in a particular material supply chain.*

*Please see* ***www.thedragonflyinitiative.com/material-change-report*** *for the methodology and a guide to the criteria and indicators used to generate the information in this profile.*

| Material uses | Passenger vehicle | Smartphone |
|---|---|---|
| Applications of palladium: | Catalytic converter, capacitors, circuitry | Capacitors, circuitry |
| Other profiled materials in these applications: | (catalytic converter:) rare earth elements | |

| Material significance | Low | Mod | High | V. High |
|---|---|---|---|---|
| % content in a passenger vehicle and smartphone: | | | | |
| Industry consumption: | | | | |
| Other top consuming industries: | Jewellery, chemical, dentistry | | | |
| Function criticality: | | | | * |

| Supply significance | |
|---|---|
| EU dependency on imported material: | |
| US dependency on imported material: | |
| Residual end of life waste: | |
| Virgin material consumption: | |
| Estimated rate of depletion: | |

## Association with environmental, social and governance issues

| | No/Weak … Yes/Very Strong |
|---|---|
| Artisanal and small-scale mining | |
| Child labour and forced labour | |
| Countries with weak rule of law | |
| Countries experiencing corruption | |
| Countries experiencing high-intensity conflict | |
| High CO2 emissions | |
| Incidences of conflict with Indigenous Peoples | **MD** |
| Incidences of overlap with areas of conservation importance | No |
| Potential for acid discharge to the environment | Yes |
| Potential for harm from hazardous materials and chemicals | |
| Preconditions for radioactive materials in ores and tailings | No |

## Top producer country information

| | Russia | South Africa | Canada | USA | Zimbabwe |
|---|---|---|---|---|---|
| % Global Mined Production | 39 | 35 | 11 | 6 | 5 |
| % Global Reserves | 2 | 94 | <1 | 1 | 2 |
| % Mining Sector Contribution to GDP | 0.9 | 0.2 | 0.5 | 0.1 | 3.3 |
| Human Development Index | 0.804 V. HIGH | 0.666 MEDIUM | 0.920 V. HIGH | 0.920 V. HIGH | 0.516 LOW |
| Rule of Law | V. WEAK | MODERATE | STRONG | STRONG | V. WEAK |
| Experience of Corruption | V. HIGH | MODERATE | LOW | LOW | V. HIGH |
| Experience of State Conflict (Heidelberg Conflict Barometer) | MODERATE (Violent Crisis) | MODERATE (Violent Crisis) | LOW (Non Violent Crisis) | MODERATE (Violent Crisis) | MODERATE (Violent Crisis) |

## Examples of environmental, social and governance issues

This section aims to illustrate through brief examples some of the environmental, social and governance impacts on communities and countries that are publicly reported to be associated with the material's production. The information is drawn from various sources including peer reviewed papers, industry reports and media articles, the references for which are listed in section 5.4. The examples are from the material's top producer countries. This section is strictly illustrative and should not be considered generally representative of companies' performance or production practices in the industry.

**Potential for acid discharge and for harm from hazardous materials and chemicals**
Some environmental degradation has been observed around Russian Platinum Group Metals (PGM) production sites, with the city of Norilsk reported as one of the most contaminated places on Earth (Blacksmith Institute, 2013). PGM emissions and the occurrence of elevated PGM concentrations have raised concerns regarding their effects on the local population and the environment (Rauch and Fatoki, 2015). International relations with Russia have resulted in alleged concerns surrounding the potential impact of threatened economic sanctions upon commodity prices. This was particularly evident in 2014 when events regarding Ukraine led to an increase in Palladium prices (Rosenfeld, 2014).

South Africa's PGM reserves are in the Bushveld Igneous Complex (BIC) in the Northern part of the country and elevated PGM concentrations have been reported, alongside concerns about exposure to the local population and environmental degradation (Rauch and Fatoki, 2015). In 2014, South Africa accounted for 30% of the world's mined palladium and 23% of refined palladium. In 2014 PGM mining also accounted for 38% of the mineral industry's employment (USGS, 2014).

**Key**

**MD** = Missing Data
***** = Where multiple sources have been considered and/or where deductions/estimations/assumptions have been generalised from existing data.



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# Material profile: Rare earth elements (REEs)

Cerium, Dysprosium, Gadolinium, Germanium, Lanthanum, Neodymium, Praseodymium, Samarium, Terbium, Yttrium

*Unique electrical, magnetic, spectroscopic and thermal properties specific to each element.*

*This profile is intended as a general introduction to environmental, social and governance issues associated with the production of REEs. It should not be considered to be comprehensive or be regarded as legal advice. It is not a replacement for company due diligence, and the information should not be interpreted as representing specific risks to any one individual company or irreversibly present in a particular material supply chain.*

*Please see **www.thedragonflyinitiative.com/material-change-report** for the methodology and a guide to the criteria and indicators used to generate the information in this profile.*

***Note:** the below rankings indicate the modal values across all REEs analysed.*

| Material uses | Passenger vehicle | Smartphone |
|---|---|---|
| Applications of REEs: | Batteries, catalytic converters, permanent magnets, LED displays | Vibration unit, microphone/speakers, display screen |
| Other profiled materials in these applications: | (batteries:) nickel (catalytic converter:) palladium | (display screen:) glass, tin (microphone/speakers:) iron |

| Material significance | Low | Mod | High | V. High |
|---|---|---|---|---|
| % content in a passenger vehicle and smartphone: | Passenger vehicle, Smartphone | | | |
| Industry consumption: | | Passenger vehicle | | Smartphone |
| Other top consuming industries: | Glass, ceramics | | | |
| Function criticality: | | | | Passenger vehicle, Smartphone |
| **Supply significance** | | | | |
| EU dependency on imported material: | | | | ● |
| US dependency on imported material: | | | | ● |
| Residual end of life waste: | | | | Passenger vehicle, Smartphone |
| Virgin material consumption: | | | ● | |
| Estimated rate of depletion: | ● | | | |

## Association with environmental, social and governance issues

| | No/Weak | | | Yes/Very Strong |
|---|---|---|---|---|
| Artisanal and small-scale mining | MD | | | |
| Child labour and forced labour | ● | | | |
| Countries with weak rule of law | | | ● | |
| Countries experiencing corruption | | | ● | |
| Countries experiencing high-intensity conflict | ● | | | |
| High CO2 emissions | MD | | | |
| Incidences of conflict with Indigenous Peoples | | ● | | |
| Incidences of overlap with areas of conservation importance | No | | | |
| Potential for acid discharge to the environment | No | | | |
| Potential for harm from hazardous materials and chemicals | | ● | | |
| Preconditions for radioactive materials in ores and tailings | | | | Yes |



## Top producer country information

| | China | Australia | Russia | India | Brazil |
|---|---|---|---|---|---|
| % Global Mined Production | 83 | 11 | 2 | 1 | <1 |
| % Global Reserves | 37 | 3 | 15 | 6 | 18 |
| % Mining Sector Contribution to GDP | 0.5 | 3.8 | 0.9 | 0.3 | 1.3 |
| Human Development Index | 0.738 HIGH | 0.939 V. HIGH | 0.804 V. HIGH | 0.624 MEDIUM | 0.754 HIGH |
| Rule of Law | WEAK | STRONG | V. WEAK | MODERATE | MODERATE |
| Experience of Corruption | HIGH | LOW | V. HIGH | HIGH | HIGH |
| Experience of State Conflict (Heidelberg Conflict Barometer) | MODERATE (Violent Crisis) | LOW (Dispute) | MODERATE (Violent Crisis) | MODERATE (Violent Crisis) | HIGH (Limited War) |

## Examples of environmental, social and governance issues

This section aims to illustrate through brief examples some of the environmental, social and governance impacts on communities and countries that are publicly reported to be associated with the material's production. The information is drawn from various sources including peer reviewed papers, industry reports and media articles, the references for which are listed in section 5.4. The examples are from the material's top producer countries. This section is strictly illustrative and should not be considered generally representative of companies' performance or production practices in the industry.

**Potential for harm from hazardous materials and chemicals**
In Baotou, located in the Autonomous Region of Inner Mongolia, rare earth mining has reportedly led to toxic lake legacies and soil and air pollution. This alleged pollution has led to an increase in public health concerns, including respiratory illness, skin diseases and cancer (Maughan, 2015; UNPO, 2015).

**Preconditions for radioactive materials in ores and waste**
REEs are found in the beach sand minerals, significantly monazite, of the Chavara region, India (Akshay, 2016). Due to monazite containing high concentrations of thorium; monazite mining is highly restricted due to radiation risks. However, a satellite imaging initiative has identified potential illegal mining of beach sands in the Tamil Nadu region, raising environmental and health concerns as well as highlighting the scale of illicit trade (EJA, 2017).

## Supplementary notes

This section records notable aspects specific to the production of the material that due to the general level of analysis of the report are not incorporated or might not be evident in the presentation of the results. These are important to consider when completing detailed due diligence on the material's sources.

**EOL-RIR (virgin material input)**
The EOL-RIR for the majority of REEs is <1 %. However, EOL-RIR rates for Yttrium (31%) and Terbium (22%) must be noted. REEs are often incorporated as small components in complex items, or as part of complex materials. Because of this, recycling REEs can be difficult, and can require complicated, energy-intensive processes (Schüler et al., 2011). Nevertheless, as for many metals, new scrap generated during the manufacture of alloys are an important secondary source, mainly in a closed loop (30% of magnet alloys end up in scraps during manufacture) (Higgins, 2016).

**Key**

**MD** = Missing Data
***** = Where multiple sources have been considered and/or where deductions/estimations/assumptions have been generalised from existing data.

# Material profile: Rubber (natural)

*High tensile strength, hard wearing and renewable.*

*This profile is intended as a general introduction to environmental, social and governance issues associated with the production of rubber. It should not be considered to be comprehensive or be regarded as legal advice. It is not a replacement for company due diligence, and the information should not be interpreted as representing specific risks to any one individual company or irreversibly present in a particular material supply chain.*

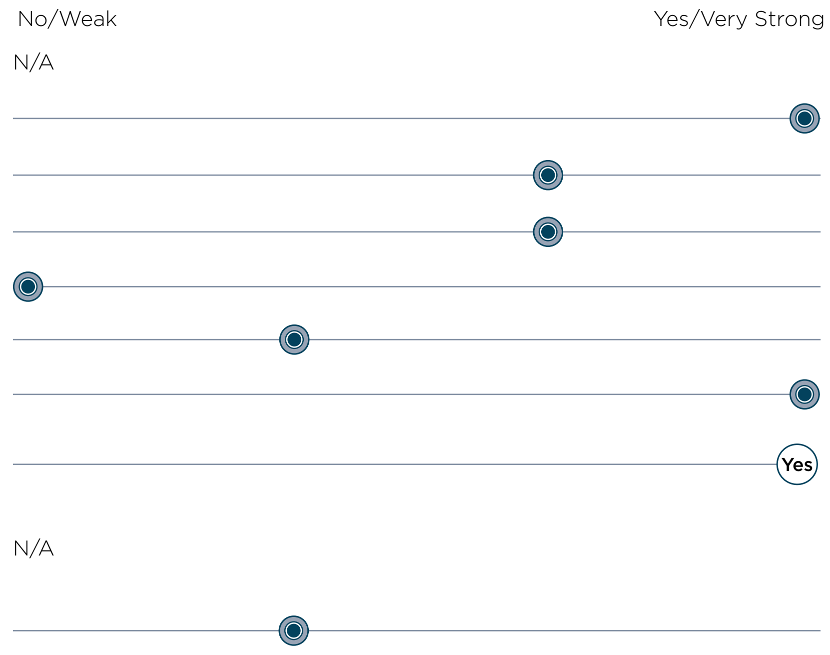
*Please see* ***www.thedragonflyinitiative.com/material-change-report*** *for the methodology and a guide to the criteria and indicators used to generate the information in this profile.*

| Material uses | Passenger vehicle | Smartphone |
|---|---|---|
| Applications of rubber: | Tyres | N/A *(accessories)* |
| Other profiled materials in these applications: | (display screen:) silica sand (see glass) | |

| Material significance | Low | Mod | High | V. High |
|---|---|---|---|---|
| % content in a passenger vehicle (smartphone[N/A]): | ● | | | |
| Industry consumption (smartphone[N/A]): | | | | ● |
| Other top consuming industries: | Latex, footwear, adhesives | | | |
| Function criticality (smartphone[N/A]): | | | | ● |
| **Supply significance** | | | | |
| EU dependency on imported material: | | | | ● |
| US dependency on imported material: | **MD** | | | |
| Residual end of life waste (smartphone[N/A]): | ● | | | |
| Virgin material consumption: | | | ● | |
| Estimated rate of depletion: | N/A (renewable) | | | |

*While synthetic rubber is widely employed in tyre manufacture, tyres still require a proportion of natural rubber. This proportion varies greatly according to required end use and performance of tyre.*

## Association with environmental, social and governance issues




| Issue | No/Weak – Yes/Very Strong |
|---|---|
| Artisanal and small-scale mining | N/A |
| Child labour and forced labour | |
| Countries with weak rule of law | |
| Countries experiencing corruption | |
| Countries experiencing high-intensity conflict | |
| High CO2 emissions | |
| Incidences of conflict with Indigenous Peoples | |
| Incidences of overlap with areas of conservation importance | Yes |
| Potential for acid discharge to the environment | N/A |
| Potential for harm from hazardous materials and chemicals | |
| Preconditions for radioactive materials in ores and tailings | N/A |



## Top producer country information

| | Thailand | Indonesia | Vietnam | India | China |
|---|---|---|---|---|---|
| % Global Production | 34 | 24 | 7 | 7 | 6 |
| % Rubber Sector Contribution to GDP | **MD** | **MD** | **MD** | **MD** | **MD** |
| Human Development Index | 0.740 HIGH | 0.689 MEDIUM | 0.683 MEDIUM | 0.624 MEDIUM | 0.738 HIGH |
| Rule of Law | MODERATE | WEAK | MODERATE | MODERATE | WEAK |
| Experience of Corruption | HIGH | HIGH | HIGH | HIGH | HIGH |
| Experience of State Conflict (Heidelberg Conflict Barometer) | MODERATE (Violent Crisis) | MODERATE (Violent Crisis) | MODERATE (Violent Crisis) | MODERATE (Violent Crisis) | MODERATE (Violent Crisis) |

## Examples of environmental, social and governance issues

This section aims to illustrate through brief examples some of the environmental, social and governance impacts on communities and countries that are publicly reported to be associated with the material's production. The information is drawn from various sources including peer reviewed papers, industry reports and media articles, the references for which are listed in section 5.4. The examples are from the material's top producer countries. This section is strictly illustrative and should not be considered generally representative of companies' performance or production practices in the industry.

**Conflict with Indigenous Peoples; Incidences of overlap with areas of conservation importance**
The rapid expansion of Cambodia's natural rubber industry is reported to have resulted in illegal deforestation and land rights issues. Alleged, high levels of corruption have prompted concerns that large scale projects will benefit local elites whilst further damaging the surrounding forest ecosystems. In the North-Eastern province of Ratanakiri, land – comprising of primary rainforest – has been allocated to Vietnamese investors to develop rubber plantations. The area is also home to Cambodia's Indigenous Peoples who depend on the forest for their livelihood. In most of the cases, Indigenous Peoples have reportedly not been consulted nor informed about these projects (EJA, 2017).

In the Southwest of China the rapid expansion of the rubber sector has allegedly led to the replacement of natural forests by monoculture plantations, resulting in a loss of biodiversity and encroachment into species habitats (Zhuang-Fang et al., 2014). In 2017, tighter environmental regulations, including measures to regulate air pollution were introduced, following the closure of a refinery in response to environmental checks after the Ministry of Environmental Protection detected odour (Meng, 2017).

Some rubber plantations in Thailand are reported to be associated with deforestation, environmental degradation, soil erosion and lower levels of biodiversity. Air, water and odour pollution were also allegedly observed in the production process. Additionally, increases of musculoskeletal issues including lower back pain were reported in rubber tappers in Thailand (Udom et al., 2016).

**Child labour and forced labour**
Child labour has been reported in some of the Indonesian rubber sector, with children reportedly exposed to hazards and working in isolated environments. A study by IPEC reported that 59% of children working in rubber plantations were under 15 years old (ILO, 2017).

**Rubber and livelihoods**
Natural rubber production in Thailand involves over 6 million people from various sectors: farmers, entrepreneurs, labourers and government agencies (Association of Natural Rubber Producing Countries, 2017).

Low rubber prices have impacted the incomes and livelihoods of smallholders and tappers which has prompted many to convert to more profitable crops, however there are some concerns that smallholders who do not have these resources may be forced to sell their land (Fair Rubber Association, 2016). Approximately 80% of Indonesia's rubber output is produced by smallholder farmers and around 85 % of production is exported (Indonesian Investments, 2016).

China is the world's largest producer of natural rubber, and its consumption in 2016 jumped by 4.6% year on year to 4.896 million tons, of which 77.9% was used for radial tyres (Arunwarakorn et al., 2017; Business Wire, 2017).

**Key**
**MD** = Missing Data
***** = Where multiple sources have been considered and/or where deductions/estimations/assumptions have been generalised from existing data.

## Supplementary notes

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**Rubber consumption (electronics industry)**
Although the volumes of rubber consumed by the electronics industry is tiny compared with the automotive industry, and for that reason has been noted as being not applicable for this analysis, it is interesting to note that.... household appliances, including electronic items, use 1% of global natural rubber (European Commission, 2017).

**Function criticality**
While natural rubber can be substituted with synthetic rubber - and is more likely to be substituted in passenger vehicles than larger commercial vehicles - the European Commission has raised concerns about synthetic tyres as these are produced from oil. They state that "given the current oil prices and the fact that this is not a renewable source this should not be considered as a sustainable alternative to natural rubber" (European Commission, 2017).

# Material profile: Steel / Iron

*High strength and durability against weather, heat, applied force and hard wear.*

*This profile is intended as a general introduction to environmental, social and governance issues associated with the production of steel. It should not be considered to be comprehensive or be regarded as legal advice. It is not a replacement for company due diligence, and the information should not be interpreted as representing specific risks to any one individual company or irreversibly present in a particular material supply chain.*

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| Material uses | Passenger vehicle | Smartphone |
|---|---|---|
| Applications of steel: | Body panels, brakes, chassis, engine, suspension, transmission, wheels | Vibration unit, microphone / speaker |
| Other profiled materials in these applications: | (steel alloys:) aluminium, copper, manganese, nickel | |

| Material significance | Low | Mod | High | V. High |
|---|---|---|---|---|
| % content in a passenger vehicle and smartphone: | | | Smartphone | Passenger vehicle |
| Industry consumption: | Smartphone | Passenger vehicle | | |
| Other top consuming industries: | Construction, other transport, consumer durables, machinery | | | |
| Function criticality: | | | Passenger vehicle, Smartphone | |
| **Supply significance** | | | | |
| EU dependency on imported material: | | | ● | |
| US dependency on imported material: | ● | | | |
| Residual end of life waste: | Passenger vehicle, Smartphone | | | |
| Virgin material consumption: | | ● | | |
| Estimated rate of depletion: | | ● | | |

## Association with environmental, social and governance issues




## Top producer country information
### Iron Ore

| | Australia | China | Brazil | India | Russia |
|---|---|---|---|---|---|
| % Global Mined Production (iron content of ore) | 35 | 16 | 19 | 7 | 4 |
| % Global Reserves (iron content of ore) | 28 | 8 | 15 | 7 | 17 |
| % Mining Sector Contribution to GDP | 3.8 | 0.5 | 1.3 | 0.3 | 0.9 |
| Human Development Index | 0.939 V. HIGH | 0.738 HIGH | 0.754 HIGH | 0.624 MEDIUM | 0.804 V. HIGH |
| Rule of Law | STRONG | WEAK | MODERATE | MODERATE | V. WEAK |
| Experience of Corruption | LOW | HIGH | HIGH | HIGH | V. HIGH |
| Experience of State Conflict (Heidelberg Conflict Barometer) | LOW (Dispute) | MODERATE (Violent Crisis) | HIGH (Limited War) | MODERATE (Violent Crisis) | MODERATE (Violent Crisis) |

### Raw Steel

| | China | Japan | India | USA | Russia |
|---|---|---|---|---|---|
| % Global Production | 50 | 7 | 5 | 5 | 4 |
| Human Development Index | 0.738 HIGH | 0.903 V. HIGH | 0.624 MEDIUM | 0.920 V. HIGH | 0.804 V. HIGH |
| Weak Rule of Law | HIGH | LOW | MODERATE | LOW | V. HIGH |
| Experience of Corruption | HIGH | LOW | HIGH | LOW | V. HIGH |
| Experience of State Conflict (Heidelberg Conflict Barometer) | MODERATE (Violent Crisis) | LOW (Non Violent Crisis) | MODERATE (Violent Crisis) | MODERATE (Violent Crisis) | MODERATE (Violent Crisis) |

**Key**

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Please always credit the Responsible Minerals Initiative, Drive Sustainability and The Dragonfly Initiative for the work they have done compiling and analysing this information.

## Examples of environmental, social and governance issues

This section aims to illustrate through brief examples some of the environmental, social and governance impacts on communities and countries that are publicly reported to be associated with the material's production. The information is drawn from various sources including peer reviewed papers, industry reports and media articles, the references for which are listed in section 5.4. The examples are from the material's top producer countries. This section is strictly illustrative and should not be considered generally representative of companies' performance or production practices in the industry.

**Conflict with Indigenous Peoples; Incidences of overlap with areas of conservation importance.**
Some social issues have been reported for iron ore mining in Australia. In July 2017, the Federal Court awarded exclusive rights and interests to 2,700 square kilometres of land in the ore-rich Pilbara to the Yinjibarndi people. This title covers an area North of Karijini National Park, which overlaps with a pre-existing mining concession. This decision paves way for the Yindjibarndi people to seek compensation (Powell and Kagi, 2017). Furthermore, concerns have been raised surrounding the high level of water use by the steel and iron industry, during refining, in Australia (Mudd and Yellishetty, 2011).

**Potential for harm from hazardous materials and chemicals and for acid discharge; High CO2 emissions**
Communities in Piquia de Baixo, located in the vicinity of five pig-iron plants, have reported pollution and dust in the environment and inside their homes. A report by the International Federation of Human Rights found that 77% of households in the community had experienced acute health issues such as asthma, skin problems and diarrhea (Phillips, 2015). Associated illegal logging has also been reported in the Pantanal of Mato Grosso do Sul, which has the third largest reserve of iron ore in Brazil (EJA, 2017).

Handan, situated in the Hebei Province of China, accounts for 10% of global steel output. It is thought to be one of the most polluted cities in the world. Environmental problems are alleged to have occurred in Handan, including a toxic chemical leak which turned the Zhuozhang River brown, resulting in increased fish mortality rates. Air pollution has reportedly affected local communities and studies have concluded that the direct CO2 emissions of China's iron and steel industry account for 15% of China's total emissions (Gu et al., 2015).

India's iron and steel industry has been linked with water pollution with effluents from refining. Water pollution levels in Urla, Raipur, have been reported as higher than the limits set by water quality standards. This has the potential to impact on human health. In 2013 metals accounted for 16.4% of the total value of mineral production in India with iron ore accounting for 76.2% of this. Of the 50 million people employed in the mining industry in 2013, 29% were employed in the production of iron ore (USGS, 2013).

Magnitogorsk, home to Magnitogorsk Iron and Steel Works is the third most polluted city in Russia. Benzo(a)pyrene, a carcinogen linked to lung cancer, has been recorded as an air pollutant in Magnitogorsk. Levels of benzo(a)pyrene in the city measure at 23 times the allowed concentration. Millions of cubic metres of industrial waste water, from refining, are also reportedly pumped into the Ural River each year leading to the pollution of water sources by heavy particles and nitrites (Luhn, 2016).

**Steel / iron and livelihoods**
Iron ore is the mainstay of the Brazilian mineral market accounting for approximately 80% of the country's minerals export (KPMG, 2015).

In 2014 Australia accounted for more than 20% of the world's production of iron ore and mining accounted for 8.7% of its GDP (USGS, 2015).

China's mineral industry is expected to achieve steady economic growth in 2015 and beyond, those with serious excess capacity – including steel – will likely slow (USGS, 2014).

In Russia, the value of metallurgy and finished metals production was 6.4% of the GDP. Mineral products made up 70.5% of the total value of Russia's exports (with ferrous metals accounting for 4.1% of this) (USGS, 2014).

## Supplementary notes

**Association with countries experiencing high-intensity conflict**
Steel's association with countries experiencing high-intensity conflict is rated 'low'. This rating combines the separate scores for 'raw steel' and 'iron ore'. Iron ore assessed separately would be rated as having a 'moderate' association with countries experiencing high-intensity conflict, a rating that is higher than 'raw steel' in most part due to the importance of Brazil for iron ore and pig iron production. Brazil is ranked as having a high-intensity conflict - Level 4 - by the Heidelberg Barometer: experiencing 'limited war'.

# Material profile: Tantalum

*Very hard-wearing, easily fabricated and highly conductive of heat and electricity.*

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| Material uses | Passenger vehicle | Smartphone |
|---|---|---|
| Applications of tantalum: | Electronics capacitors | Electronics capacitors |
| Other profiled materials in these applications: | None | |

| Material significance | Low | Mod | High | V. High |
|---|---|---|---|---|
| % content in a passenger vehicle and smartphone: | | | | |
| Industry consumption (passenger vehicle[MD]): | | | | |
| Other top consuming industries: | Medical, superalloys, chemical | | | |
| Function criticality: | | | | |
| **Supply significance** | | | | |
| EU dependency on imported material: | | | | |
| US dependency on imported material: | | | | |
| Residual end of life waste: | | | | |
| Virgin material consumption: | | | | |
| Estimated rate of depletion: | | | | |

## Association with environmental, social and governance issues

| | No/Weak | Yes/Very Strong |
|---|---|---|
| Artisanal and small-scale mining | | |
| Child labour and forced labour | | |
| Countries with weak rule of law | | |
| Countries experiencing corruption | | |
| Countries experiencing high-intensity conflict | | |
| High CO2 emissions | MD | |
| Incidences of conflict with Indigenous Peoples | MD | |
| Incidences of overlap with areas of conservation importance | | Yes |
| Potential for acid discharge to the environment | | Yes |
| Potential for harm from hazardous materials and chemicals | | |
| Preconditions for radioactive materials in ores and tailings | | Yes |



## Top producer country information

| | DRC | Rwanda | Brazil | China | Australia |
|---|---|---|---|---|---|
| % Global Mined Production | 41 | 27 | 10 | 5 | N/A |
| % Global Reserves | N/A | N/A | 36 | N/A | 69 |
| % Mining Sector Contribution to GDP | 14.4 | 0.2 | 1.3 | 0.5 | 3.8 |
| Human Development Index | 0.435 LOW | 0.498 LOW | 0.754 HIGH | 0.738 HIGH | 0.939 V. HIGH |
| Rule of Law | V. WEAK | MODERATE | MODERATE | WEAK | STRONG |
| Experience of Corruption | V. HIGH | MODERATE | HIGH | HIGH | LOW |
| Experience of State Conflict (Heidelberg Conflict Barometer) | V. HIGH (War) | LOW (Non Violent Crisis) | HIGH (Limited War) | MODERATE (Violent Crisis) | LOW (Dispute) |

## Examples of environmental, social and governance issues

This section aims to illustrate through brief examples some of the environmental, social and governance impacts on communities and countries that are publicly reported to be associated with the material's production. The information is drawn from various sources including peer reviewed papers, industry reports and media articles, the references for which are listed in section 5.4. The examples are from the material's top producer countries. This section is strictly illustrative and should not be considered generally representative of companies' performance or production practices in the industry.

**Artisanal and small-scale mining**
In 2012 over 50% of tantalum mined in the DRC was recorded as coming from artisanal and small scale mining (ASM) sources (Polinares, 2012.) Artisanal mining continues to be linked with child labour (US Department of Labor) and wide-ranging social and environmental issues including occupational disease and accidents, gender-based violence, water pollution and deforestation (EJA, 2018.) Artisanal mining camps are also linked to the continued depletion of the Eastern Mountain Gorilla due to illegal hunting of bushmeat for miners' consumption (IUCN Red List, 2017-3).

Tantalum mining in Rwanda is associated with ASM production and fraudulence in the representation of mineral provenance, a red flag according to the OECD Due Diligence guidance on sourcing conflict minerals (OECD, 2013). This is based on recurrent reports of cross-border smuggling. Investigations also showed the mining sector to be lacking in compliance with regards to payment of taxes, fees and royalties. (iTSCi, 2013).

Tantalum production in the Brazilian Amazon region has been linked with the FARC which has been reportedly involved in the illicit trade of coltan and other minerals across the borders between Columbia, Venezuela and Brazil (Global Observatory of Transnational Criminal Networks, 2016).

## Supplementary notes

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**Association with Conflict Mineral Legislation**
Tantalum is a designated conflict mineral according to Section 1502 of the Dodd-Frank Wall Street Reform and Consumer Act of 2010. Large amounts of tantalum are produced in the DRC and Rwanda, which are countries covered by "Dodd-Frank".

**Key**

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# Material profile: Tin

*Highly malleable, ductile and corrosion-resistant with a low melting point.*

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| Material uses | Passenger vehicle | Smartphone |
|---|---|---|
| Applications of tin: | Solder | Display screen, Solder |
| Other profiled materials in these applications: | (display screen:) glass, rare earth elements<br>(solder:) copper, silver (see Zinc) | |

| Material significance | Low | Mod | High | V. High |
|---|---|---|---|---|
| % content in a passenger vehicle and smartphone: | | | | |
| Industry consumption: | | | | |
| Other top consuming industries: | Glass, packaging, chemical | | | |
| Function criticality: | | | | |

| Supply significance | |
|---|---|
| EU dependency on imported material: | |
| US dependency on imported material: | |
| Residual end of life waste: | |
| Virgin material consumption: | |
| Estimated rate of depletion: | |

## Association with environmental, social and governance issues

| | No/Weak … Yes/Very Strong |
|---|---|
| Artisanal and small-scale mining | |
| Child labour and forced labour | |
| Countries with weak rule of law | |
| Countries experiencing corruption | |
| Countries experiencing high-intensity conflict | |
| High CO2 emissions | MD |
| Incidences of conflict with Indigenous Peoples | |
| Incidences of overlap with areas of conservation importance | Yes |
| Potential for acid discharge to the environment | Yes |
| Potential for harm from hazardous materials and chemicals | |
| Preconditions for radioactive materials in ores and tailings | Yes |



## Top producer country information

| | China | Indonesia | Myanmar | Brazil | Bolivia | Peru |
|---|---|---|---|---|---|---|
| % Global Mined Production | 36 | 20 | 12 | 9 | 7 | 6 |
| % Global Reserves | 23 | 17 | 2 | 15 | 9 | 2 |
| % Mining Sector Contribution to GDP | 0.5 | 0.5 | 0.3 | 1.3 | 4.2 | 5.4 |
| Human Development Index | 0.738 HIGH | 0.689 MEDIUM | 0.556 MEDIUM | 0.754 HIGH | 0.674 MEDIUM | 0.740 HIGH |
| Rule of Law | WEAK | WEAK | V. WEAK | MODERATE | V. WEAK | WEAK |
| Experience of Corruption | HIGH | HIGH | HIGH | HIGH | HIGH | HIGH |
| Experience of State Conflict (Heidelberg Conflict Barometer) | MODERATE (Violent Crisis) | MODERATE (Violent Crisis) | V. HIGH (War) | HIGH (Limited War) | MODERATE (Violent Crisis) | MODERATE (Violent Crisis) |

## Examples of environmental, social and governance issues

This section aims to illustrate through brief examples some of the environmental, social and governance impacts on communities and countries that are publicly reported to be associated with the material's production. The information is drawn from various sources including peer reviewed papers, industry reports and media articles, the references for which are listed in section 5.4. The examples are from the material's top producer countries. This section is strictly illustrative and should not be considered generally representative of companies' performance or production practices in the industry.

**Artisanal and small scale mining; Child labour and forced labour**
Some artisanal and small-scale tin mining (ASM) in Bolivia is allegedly associated with child labour in situations determined as hazardous by national law (US Department of Labor, 2016).

The islands of Bangka and Belitung, which produce 90% of Indonesia's tin, have reportedly experienced widespread environmental degradation. Some tin mining in Indonesia is also associated with informal ASM, which can be linked to poor workplace health and safety, and higher levels of respiratory disease and mosquito-borne diseases (Hodal, 2012). Some tin mining in Indonesia continues to be linked with child labour, in situations determined as hazardous by national law (US Department of Labor, 2016). Indonesia accounted for 27% of the world's tin production in 2014, and the country was the world's leading exporter of tin metal. Exports from Indonesia, however, decreased to their lowest level since at least 2006 owing to the combined effects of Indonesia's export restrictions and decreasing global tin prices (USGS, 2014b).

**Environmental issues and compliance**
In 2016 some of China's tin operations were asked to stop production following inspections that deemed them to be falling short of environmental compliance standards (Stanway. 2016). Most operations have since carried out maintenance and re-opened (ITRI, 2016).

**Governance issues**
2016 saw a rapid growth in tin mining in Wa Province, Myanmar controlled by an insurgent army. This growth is allegedly due to Wa Province – which accounts for the large share of Myanmar's tin production – becoming a key source for global electronics manufacturers (Verisk Maplecroft, 2017). The trade of tin from Wa Province is linked to alleged narcotics trafficking (Lee and Schectman, 2016). In 2014, Myanmar's production of tin ores and concentrates increased by 289%. This increase was mainly fuelled by increased demand from the Chinese electronics industry after Indonesia implemented tighter restrictions on tin exports. Myanmar was the top supplier of tin ore to China in 2014 (USGS, 2014a).

**Key**

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## Supplementary notes

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**Association with Conflict Mineral Legislation**
Tin is a designated conflict mineral according to Section 1502 of the Dodd-Frank Wall Street Reform and Consumer Act of 2010. Relatively small amounts of tin are produced in countries covered by "Dodd-Frank" such as the DRC and Rwanda, however not in sufficient volume to feature in the top producer country table.

**Function criticality**
Solder is recognised as a key application within electronics and tin is the primary material used for solder, and so highly relevant for both industries. According to the sources referenced in this study, tin is widely substitutable in many key applications. The source is comparative across many materials and concludes that it is technically feasible to substitute tin. Epoxy resins have been identified as a substitute for solder, primarily where there is no need for electrical conductivity in the end-use item. The European Commission's Critical Raw Material study (2017), while recognising that there is a slow up take in the substitution of tin, also states that the electronics industry is decreasing the quantities of tin used on a per product basis. Industry associations assert that tin is, in practice, irreplaceable for use in solder, however. Despite extensive work on 'solderless technologies,' advances have been slow and alternatives are not in widespread use. The 'function critically' rating has therefore been set at "very high" in recognition that the practical applications of substitutes for tin in solder, or for solderless technologies, are not currently widespread and their adoption seems unlikely in the near future.

# Material profile: Tungsten

*Highest melting point of all metals, high thermal and electrical conductivity, high chemical stability.*

*This profile is intended as a general introduction to environmental, social and governance issues associated with the production of tungsten. It should not be considered to be comprehensive or be regarded as legal advice. It is not a replacement for company due diligence, and the information should not be interpreted as representing specific risks to any one individual company or irreversibly present in a particular material supply chain.*

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| Material uses | Passenger vehicle | Smartphone |
|---|---|---|
| Applications of tungsten: | Tungsten carbide, a composite material, is used for cutting and drilling tools, and in small quantities in brakes; chassis; engine (crankshaft); wheels (ball joints and bearings) | Vibration motor; tungsten carbide is used for cutting and drilling applied to manufacture electronics |
| Other profiled materials in these applications: | (tungsten carbide in brakes, engine, wheels:) cobalt | |

| Material significance | Low | Mod | High | V. High |
|---|---|---|---|---|
| % content in a smartphone (passenger vehicle^MD): | | | Smartphone* | |
| Industry consumption: | | Smartphone | Passenger vehicle | |
| Other top consuming industries: | Steel manufacture, industrial engineering, mining, construction, energy, aerospace, lighting, chemical | | | |
| Function criticality: | | Passenger vehicle, Smartphone | | |

| Supply significance | Low | Mod | High | V. High |
|---|---|---|---|---|
| EU dependency on imported material: | | ● | | |
| US dependency on imported material: | | ● | | |
| Residual end of life waste: | | | Passenger vehicle*, Smartphone* | |
| Virgin material consumption: | ● | | | |
| Estimated rate of depletion: | | ● | | |

## Association with environmental, social and governance issues

No/Weak — Yes/Very Strong

- Artisanal and small-scale mining
- Child labour and forced labour
- Countries with weak rule of law
- Countries experiencing corruption
- Countries experiencing high-intensity conflict
- High CO2 emissions: **MD**
- Incidences of conflict with Indigenous Peoples
- Incidences of overlap with areas of conservation importance: No
- Potential for acid discharge to the environment: No
- Potential for harm from hazardous materials and chemicals
- Preconditions for radioactive materials in ores and tailings: No



## Top producer country information

| | China | Vietnam | Russia | Bolivia | Austria |
|---|---|---|---|---|---|
| % Global Mined Production | 82 | 7 | 3 | 2 | 1 |
| % Global Reserves | 61 | 3 | 3 | **MD** | <1 |
| % Mining Sector Contribution to GDP | 0.5 | 0.2 | 0.9 | 4.2 | 0.0 |
| Human Development Index | 0.738 HIGH | 0.682 MEDIUM | 0.804 V. HIGH | 0.674 MEDIUM | 0.893 V. HIGH |
| Rule of Law | WEAK | MODERATE | V. WEAK | V. WEAK | STRONG |
| Experience of Corruption | HIGH | HIGH | V. HIGH | HIGH | LOW |
| Experience of State Conflict (Heidelberg Conflict Barometer) | MODERATE (Violent Crisis) | MODERATE (Violent Crisis) | MODERATE (Violent Crisis) | MODERATE (Violent Crisis) | V. LOW (No Conflict) |

## Supplementary notes

This section records notable aspects specific to the production of the material that due to the general level of analysis of the report are not incorporated or might not be evident in the presentation of the results. These are important to consider when completing detailed due diligence on the material's sources.

**Association with Conflict Mineral Legislation**
Tungsten is a designated conflict mineral according to Section 1502 of the Dodd-Frank Wall Street Reform and Consumer Act of 2010. Small amounts of tungsten are produced in Rwanda, (USGS, 2017), a country that is covered by "Dodd-Frank", however not in sufficient volume to feature in the top producer country table.

**Material uses and Industry consumption**
The industry consumption rating for tungsten in automotive and electronics products includes the use of tungsten carbide in cutting and drilling tools, which is by far the most important use of the material in these industries. Tungsten is also used in the applications mentioned in this profile, but only in small amounts.

**US dependency on imported material**
This study's analysis is based on the USGS critical minerals research for 2016. It is noted that the USGS critical minerals list for 2017, which was published after the completion of the analysis for this report, recorded a significant leap in US reliance for tungsten and would be rated in this profile as 'High' if incorporated.

**Function criticality**
While the criticality of tungsten used in the illustrative products is rated as moderate, it should be noted that the criticality of tungsten carbide in cutting and drilling tools is likely to be 'very high', as there are no realistic alternates to the alloy currently and such tools are considered indispensable to both industries.

**Key**

**MD** = Missing Data
***** = Where multiple sources have been considered and/or where deductions/estimations/assumptions have been generalised from existing data.

# Material profile: Zinc

*Very high storage density, high stability.*

*This profile is intended as a general introduction to environmental, social and governance issues associated with the production of zinc. It should not be considered to be comprehensive or be regarded as legal advice. It is not a replacement for company due diligence, and the information should not be interpreted as representing specific risks to any one individual company or irreversibly present in a particular material supply chain.*

*Please see **www.thedragonflyinitiative.com/material-change-report** for the methodology and a guide to the criteria and indicators used to generate the information in this profile.*

| Material uses | Passenger vehicle | Smartphone |
|---|---|---|
| Applications of Zinc: | Batteries; Plating | Plating |
| Other profiled materials in these applications: | (batteries:) nickel; graphite<br>(plating:) nickel | |

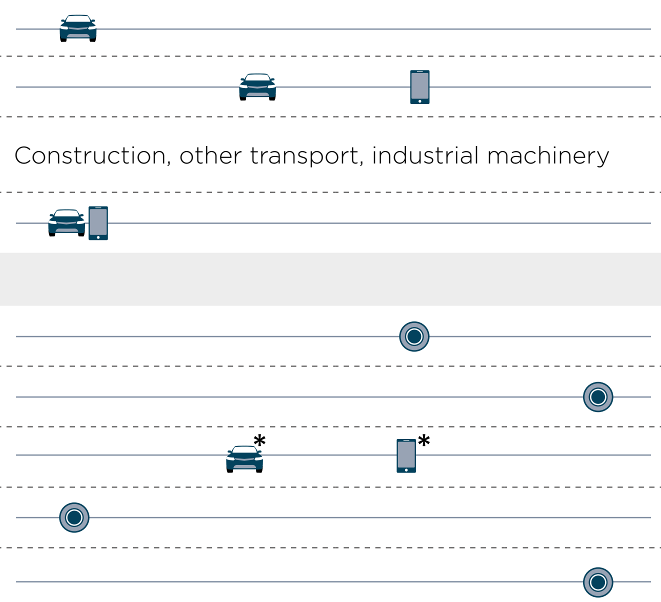
## Material significance

Low | Mod | High | V. High

- % content in a passenger vehicle (smartphone[N/A]):
- Industry consumption:
- Other top consuming industries: Construction, other transport, industrial machinery
- Function criticality:

## Supply significance

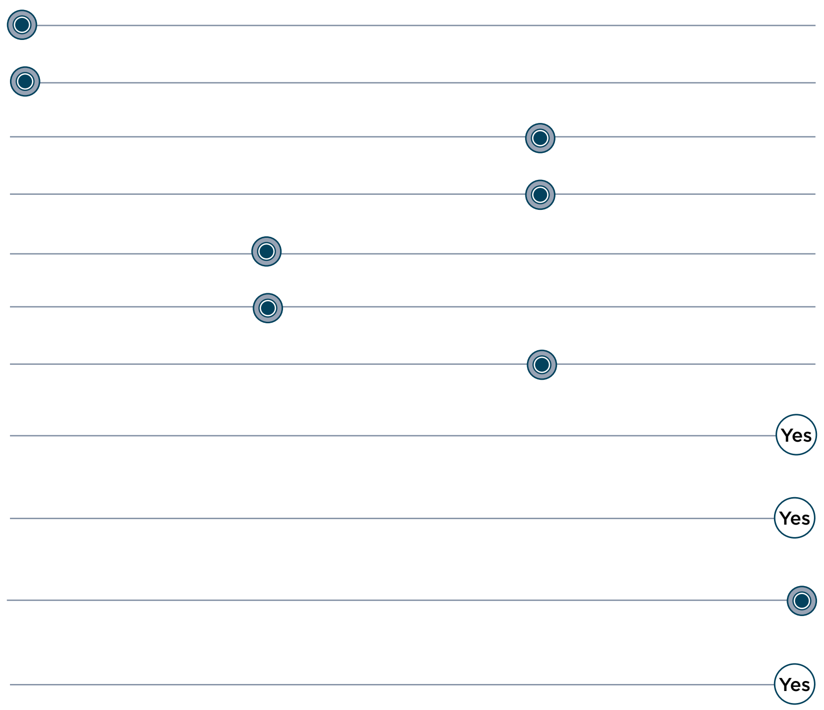
- EU dependency on imported material:
- US dependency on imported material:
- Residual end of life waste:
- Virgin material consumption:
- Estimated rate of depletion:



## Association with environmental, social and governance issues

No/Weak — Yes/Very Strong

- Artisanal and small-scale mining
- Child labour and forced labour
- Countries with weak rule of law
- Countries experiencing corruption
- Countries experiencing high-intensity conflict
- High CO2 emissions
- Incidences of conflict with Indigenous Peoples
- Incidences of overlap with areas of conservation importance
- Potential for acid discharge to the environment
- Potential for harm from hazardous materials and chemicals
- Preconditions for radioactive materials in ores and tailings




## Top producer country information

| | China | Peru | Australia | USA | Mexico |
|---|---|---|---|---|---|
| % Global Mined Production | 38 | 11 | 7 | 7 | 6 |
| % Global Reserves | 18 | 11 | 29 | 5 | 8 |
| % Mining Sector Contribution to GDP | 0.5 | 5.4 | 3.8 | 0.1 | 0.6 |
| Human Development Index | 0.738 HIGH | 0.740 HIGH | 0.939 V. HIGH | 0.920 V. HIGH | 0.762 HIGH |
| Rule of Law | WEAK | WEAK | STRONG | STRONG | WEAK |
| Experience of Corruption | HIGH | HIGH | LOW | LOW | V. HIGH |
| Experience of State Conflict (Heidelberg Conflict Barometer) | MODERATE (Violent Crisis) | MODERATE (Violent Crisis) | LOW (Dispute) | MODERATE (Violent Crisis) | V. HIGH (War) |

## Examples of environmental, social and governance issues

This section aims to illustrate through brief examples some of the environmental, social and governance impacts on communities and countries that are publicly reported to be associated with the material's production. The information is drawn from various sources including peer reviewed papers, industry reports and media articles, the references for which are listed in section 5.4. The examples are from the material's top producer countries. This section is strictly illustrative and should not be considered generally representative of companies' performance or production practices in the industry.

**Potential for harm from hazardous materials and chemicals and for acid discharge into the environment**
China is one of the largest producers and consumers of lead and zinc in the world. In some areas of China it has been reported that a large amount of lead, zinc, and related elements, such as cadmium, have been released into the environment due to mineral processing activities. This has allegedly caused pollution to surrounding water resources, soils, and crops. In some areas, this pollution is reported as being hazardous to human health (Li et al, 2014).

**Conflict with Indigenous Peoples**
Mining related conflict, including conflict reportedly relating to zinc, at large scale operations is a cause of social unrest (Defensoria del Pueblo, 2017). In November 2017, production was disrupted at one of Peru's largest silver, lead and zinc mines due to disputes over alleged land use and opposition from the Andean Oyon people (Topf, 2017).

**Key**

**MD** = Missing Data
* = Where multiple sources have been considered and/or where deductions/estimations/assumptions have been generalised from existing data.



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**Tungsten**
Dodd–Frank Wall Street Reform and Consumer Protection Act (2010) Section 1502. (Accessed at: http://legcounsel.house.gov/Comps/Dodd-Frank%20Wall%20Street%20Reform%20and%20Consumer%20Protection%20Act.pdf ).

USGS, (2017) Tungsten Commodity Summary. US Geological Society.

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Defensoría del Pueblo (2017) Reporte de Conflictos Sociales, No. 166, December 2017 (Accessed January 2018 at http://www.defensoria.gob.pe/conflictos-sociales/ home.php).

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# APPENDICES

**Appendix A:** Materials analysed in this study and completeness of data sets

**Shaded =** complete data set (16 criteria)

| Material | Automotive data set: criteria complete (max 16) | Electronics data set: criteria complete (max 16) |
|---|---|---|
| Aluminium / Bauxite | 16 | 16 |
| Antimony | 14 | 14 |
| Beryllium | 14 | 14 |
| Bismuth | 15 | 15 |
| Chrome & Chromium | 12 | 12 |
| Cobalt | 16 | 16 |
| Copper | 16 | 16 |
| Gallium | 12 | 12 |
| Germanium | 6 | 6 |
| Gold | 15 | 16 |
| Graphite (natural) | 14 | 14 |
| Indium | 15 | 15 |
| Lead | 16 | 16 |
| Leather | 12 | 11 |
| Lithium | 16 | 16 |
| Magnesium | 13 | 13 |
| Manganese | 15 | 15 |
| Mica | 12 | 12 |
| Molybdenum | 13 | 13 |
| Nickel | 16 | 16 |
| Niobium | 13 | 13 |
| Palladium | 15 | 15 |
| Platinum | 16 | 16 |
| Plastics | 6 | 6 |
| Rare earth elements (REEs)[9] | 14 | 14 |
| Rhodium | 12 | 12 |
| Ruthenium | 9 | 9 |
| Rubber (natural) | 13 (complete data set as 3 criteria are n/a) | 13 (complete data set as 3 criteria are n/a) |
| Silica sand | 14 | 14 |
| Silver | 16 | 16 |
| Steel / Iron | 16 | 16 |
| Tantalum | 13 | 13 |
| Tin | 14 | 14 |
| Titanium | 15 | 15 |
| Tungsten | 15 | 14 |
| Vanadium | 8 | 8 |
| Zinc | 16 | 16 |

9. The overall score for REEs is an average taken across the available individual REE scores. As a result, the data completeness is higher for the combined REEs.

## The following guide explains the criteria and indicators used in this study and gives details for some of the data sources.

**Appendix B:** Guide to the assessment criteria and rating system for materials

### Importance to industry

**Industry consumption**

% of total global consumption by automotive or electronics industry.

Low: less than 5%

Moderate: from 5% to 10%

High: from 10% to 30%

Very high: more than 30%

This criterion measures the percentage (%) of total global consumption of the material that can be attributed to the automotive or electronics industry. For the automotive industry the ratings is based on consumption of the industry as a whole; there is little available data that enables segmentation, such as for passenger vehicles specifically. For the electronics industry, the rating uses information for the consumption of consumer electronics, as this is the strongest data set available. These data help industry understand the potential influence of their sector within a supply chain. Where an industry is a major consumer of a material, it also indicates a greater responsibility to take action in the supply chain and an opportunity to collaborate with like minded business partners to improve practices and avoid or reduce impacts associated with production in the material's supply chain. The availability of information and the conclusions drawn on consumption by material for each industry varies considerably and for that reason we have distinguished four bands of consumption level from low (less than 5%) to very high (more than 30%).

*Primary sources: USGS Mineral Yearbooks & Fact Sheets; EU Commission; Dupont et al, (2016) Antimony Recovery from End-of-Life Products and Industrial Process Residues: A Critical Review, Journal of Sustainable Metallurgy, 2, pp.79-103; individual mineral trade associations; Deloitte (2015) Study on Data for a Raw Material System Analysis: Roadmap and Test of the Fully Operational MSA for Raw Materials Final Report; European Commission (2016) The Raw Materials Scoreboard; European Commission (2015) Critical Raw Materials Substitution Profiles September 2013 Revised May 2015.*

*Material specific sources: Curtolo, D.C., Friedrich, S. and Friedrich, B. (2017) High Purity Germanium, a Review on Principle Theories and Technical Production Methodologies. Journal of Crystallization Process and Technology; Debanshu Bhattacharya (2015) Modern Niobium Microalloyed Steels for the Automotive Industry. Microalloying 2015 & Offshore Engineering Steels 2015 pp 71-83; Deloitte (2015) September 2015 Iron and steel industry report; UK Government (2017) Future capacities and capabilities of the UK steel industry.*





### Importance to industry cont.

**Function criticality**

Substitutability Score - a score of 1-100 where 1 = substitutable and 100 = not substitutable without unacceptable compromise to performance quality.

Low: score lower than 41

Moderate: score from 41 to 54

High: score from 54 to 68

Very high: score more than 68

This criterion describes the degree to which the material performs a purpose that cannot be fulfilled by an alternative, potentially more sustainable substitute without compromise to the quality or functionality of the product. If there is no likely viable substitute, the material is considered critical to functionality. These data help industry to identify how critical the material is to their product's functionality, and whether opportunities exist to substitute it with anotherless harmful, more sustainably produced or more abundant material. This information is particularly useful if the material is associated with many adverse impacts or if supply is scarce. Where available data relevant to the specific functions performed by the material in automotive and electronic applications have been considered. It is noted that while some materials achieve a low score for their general substitutability across their common end uses, when their substitutability is considered for use in a specific application they might score higher.

Please note that while the study referenced for this criterion states that substitution is technically feasible, none of the metals assessed for the study have substitutes that provide exemplary performance across all major applications. The study concludes that substitution in the face of metal scarcity is therefore not a general panacea.

*Primary sources: Graedel, T.E., et al (2015) "On the materials basis of modern society," 112(20) PNAS; Tercero Espinoza, L. A., et al (2015) "Substitution of Critical Raw Materials," CRM_InnoNet; USGS Mineral Commodity Summaries (2017).*

**Residual end-of-life waste**

% end-of-life post-consumer waste that is not recycled

Low: less than 50% waste (more than 50% recycled)

Moderate: from 50% to 65% waste

High: from 65% to 99% waste

Very high: more than 99% waste (less than 1 % recycled)

This criterion represents the percentage (%) of the material not recycled from end-of-life (EOL) from post-consumer waste from the two industries' products. It should be noted that there is an absence of conclusive, comparative data sources for residual end-of-life waste, and that the ratings against this criterion provide an indication only for residual EOL waste for the materials. End-of-life (EOL) recycling can be a favourable alternative to mining virgin materials, particularly for materials that are scarce or with predicted high rates of depletion. A high rating (i.e. low end of life recycling rates) for this criterion indicates that there is either an absence of economic incentive or a lack of appropriate, or accessible, recycling technology. These data can help industry identify whether there is a potential to increase recycling from their own products, thereby increasing circularity within their production economies.

*Primary sources: Buchert, M., et al (2012) "Recycling critical raw materials from waste electronic equipment," Oko Institute.V.; European Commission (2017) Critical raw materials and the circular economy; European Commission (2017) Study on the review of the list of Critical Raw Materials Critical Raw Materials Factsheets; European Commission (2016) The raw materials scoreboard; European Commission (2016) Lithium ion battery value chain and related opportunities for Europe. Authors: Natalia Lebedeva, Franco Di Persio, Lois Boon-Brett; Dupont et al, (2016) Antimony Recovery from End-of-Life Products and Industrial Process Residues: A Critical Review, Journal of Sustainable Metallurgy, 2, pp.79-103.*

*Material specific sources: Hageluken (2012) Recycling the Platinum Group Metals: A European Perspective, The Platinum Metals Review individual mineral trade associations; Soo et al (2017) Comparative Study of End-of-Life Vehicle Recycling in Australia and Belgium; Lin et al (2016) Characterization of spent nickel-metal hydride batteries and a preliminary economic evaluation of the recovery processes.*

## Importance to industry cont.

**Virgin material consumption**
input to production that is newly mined, extracted or produced

Low: less than 70% newly mined (more than 30% from recycled material)

Moderate: from 70% to 90% newly mined

High: from 90% to 99% newly mined

Very high: more than 99% newly mined (less than 1% of from recycled material)

This criterion describes the material input that is not derived from recycled material and which is therefore assumed to be newly mined, extracted or produced. This criterion can be used to measure the circular use of materials by how much (%) of the total material input into the production system comes from virgin sources as opposed to recycled scrap. It is important to note that the criterion draws on the European Commission's Critical Raw Metals (CRM) report. The CRM report calculates at the industry level the EOL-Recycling Input Rate using the values from primary material input, recycled end of life material, scrap used in fabrication (new and old scrap) and scrap used in production (new and old scrap). Although several critical raw materials (CRMs) have high recycling potential, the consumption of EOL recycled material is low, and therefore the use of virgin material is generally high. This can be explained by several factors: sorting and recycling technologies for many CRMs are not yet available at competitive costs; it is impossible to recover materials which are in-use dissipated; many CRM EOL resources are currently found in long-life hard assets, which implies delays between manufacturing and scrapping and the recycling input rate; demand for many CRMs is growing in several industry sectors and the availability of EOL material is largely insufficient to meet demand.

*Primary sources: Mathieux, F, et al, (2017) "Critical raw materials and the circular economy" Science for Policy report for the Joint Research Centre, Luxembourg: Publications Office of the European Union.*

**Estimated rate of depletion**

Low: unavailable in more than 1000 years from 2050.

High: unavailable in between 100 and 1000 years from 2050

Very high: unavailable in under 100 years from 2050

This criterion is only applicable to mined materials. It describes the estimated rate at which the material is likely to become unavailable from mining. These data help industry to better understand where improving recycling rates and promoting a circular economy is most urgent and could have the most immediate impact. It is noted that very few raw materials can be considered truly physically scarce. The availability of a mineral is determined by the cost of extraction, technological capacity, and by geopolitical and environmental factors. This geological reality is reflected in the very long depletion horizons of many of the materials.

These ratings taken from Theo Henken's study are based on the corrected UNEP data on the Extractable Global Resources (EGR) and recent extraction data from USGS. Theo Henkens calculated the potential depletion period for every metal after 2050. By deducting the expected total extracted quantity of the metal between 2010 and 2050 from the EGR (and neglecting thus far extracted amounts) he estimates for each metal the remaining available geological stock by 2050. Yearly extraction is calculated with the assumption of an annual growth of the extraction with 3% between 2010 and 2050. The depletion periods given are after 2050. It is assumed that the extraction increases annually by 3 % until 2050 where after it stabilises.

Further information specifically on material reserves can be found via the USGS commodity profiles at: https://minerals.usgs.gov/minerals/pubs/commodity/

*Primary sources: Henckens, M.L.C.M., (2016) "Managing raw materials scarcity," Optima Grafische Communicatie, Rotterdam, The Netherlands; UNEP (2011) Recycling rates of metals: A status report; USGS Mineral Commodity Summaries (2017, 2016).*





## Importance to industry cont.

**Artisanal & small-scale mining (ASM) %**

Weak: under 5% of Global production

Moderate: from 5% to 15%

Strong: from 15% to 25%

Very strong: more than 25%

This criterion describes the percentage (%) of global production reportedly attributable to artisanal and small-scale mining (ASM). In general, the greater the proportion of production from ASM, the more likely it is that the material could be associated with serious environmental and human rights impacts. This study acknowledges that much has been achieved in recent years to improve the capacity of ASM operators and to develop best practice frameworks for responsible ASM, such as Fairtrade, Fairmined, the Swiss Better Gold Association the Better Sourcing Programme and the Impact Facility for Sustainable Mining Communities. It is also acknowledged that some minerals may become associated with these issues at subsequent stages of the supply chain, such as recycling post-consumer waste, or 'urban mining.' The prevalence of unregulated ASM remains so great that for this industry level analysis it remains an appropriate indicator for a large proportion of the associated issues mentioned. ASM ratings are only provided for mined materials. It is recognised, however, that while leather and rubber production falls outside the technical definition of ASM, these materials can be associated with smallholder production. There is generally a lack of current and comprehensive data sets on ASM, and therefore sources more than five years old have been included. These should be updated as more data becomes available. The upcoming DELVE database may provide a good future source of data on ASM (pending 2018).

There is no accepted universal definition of ASM. However, for the purpose of this report, we define ASM as follows: "ASM comprises all types of mining operations, non-mechanised or mechanised, that do not represent conventional industrial mining enterprises. Artisanal mining involves only individuals or families and is purely manual. Small-scale mining, however, is more extensive and usually more mechanized. ASM takes place mostly in rural areas where operations may be formal or informal. These operations can be described as low technology and labour intensive mineral extraction |and processing activities, which exploit commodities

*Primary sources: BGR (2015; The mining sector in Africa and the conflict minerals issue. Presentation by Nathalie Sterbik UNICRI (2015;) IIED (2002) Artisanal and Small Scale Mining (Chapter 13); Wagner M., Franken G., Martin N., Melcher, F., Vasters, J. (2007): Zertifizierte Handelsketten im Bereich mineralischer Rohstoffe: Projektstudie. Bundesanstalt für Geowissenschaften und Rohstoffe, Hannover; individual mineral trade associations.*

*Material specific sources: Brill (2012) Change in Democratic Mongolia: Social Relations, Health, Mobile Pastoralism, and Mining (p252); Responsible Mica Initiative (accessed 2017) http://www.responsible-mica-initiative.com/the-mica-issue.html; Somo/Terres des Hommes (2016) Beauty and a beast; UNICRI (2015) Promoting an international strategy to combat illicit trafficking in precious metals; Hein (2014) Artisanal mining in Burkina Faso: A historical overview of iron ore extraction, processing and production in the Dem region.*

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## Association with environmental, social and governance (ESG) issues

**Child labour and forced labour**

Weak: under 5% of global production

Moderate: from 5% to 10% of global production

Strong: from 10% to 30% of global production

Very strong: more than 30% of global production

This criterion rates the material according to whether its global is associated with child labour and/or forced labour as per the US State Department country profiles or in the Bureau of International Labour Affair's (ILAB) list of goods and their source countries, where the Bureau has reason to believe child labour or forced labour in violation of international standards is involved. The ILAB lists these materials by "Exploitation Type". The readily available data on child labour and forced labour were insufficiently detailed to distinguish relative levels of strength of association for the materials.

*Primary sources: US Department of Labour, Findings on the Worst Forms of Child Labour: The List of Goods Produced by Child Labour or Forced Labour (accessed online). Note that coverage of forced labour in this report is not restricted to forced child labour but covers forced labour of workers overall.*

*This study notes that the ILO do not have up-to-dateresources on child and forced labour. The last comparative publication was published in 2005 and more recent publications are both too geographically specific and too specific to certain materials (e.g. "Child Labour in Tin Mining in Indonesia).*

**Countries with weak rule of law**

Weak: top 5 producer countries associated with very strong rule of law

Moderate: top 5 producer countries associated with strong rule of law

Strong: top 5 producer countries associated with moderate rule of law

Very strong: top 5 producer countries associated with weak rule of law.

This criterion measures the material's strength of association with producer countries that have weak rule of law. The Worldwide Governance Indicator (WGI) for Rule of Law is the primary source of information. The WGI describes its Rule of Law indicator as "capturing perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence". It should be noted that the WGI's indicator captures 'perceptions' of the rule of law in a country and are aggregate measures constructed by averaging together data from multiple underlying sources. The rating for this criterion is determined by multiplying the % of global production of each of the top five producer countries of the material with points attributed to four levels of rule of law determined by the relative position of each country in the WGI Rule of Law indicator ranking.

- Very strong rule of law – country falls into the top quartile of the WGI Rule of Law indicator ranking
- Strong rule of law – country falls into the third quartile of the WGI Rule of Law indicator ranking.
- Moderate rule of law – country falls into the second of the WGI Rule of Law indicator ranking.
- Weak rule of law – country falls into the bottom quartile of the WGI Rule of Law indicator ranking.

*Primary sources: World Bank, Worldwide Governance Indicators, http://info.worldbank.org/governance/wgi/#home*





## Association with environmental, social and governance (ESG) issues cont.

**Countries experiencing corruption**

Weak: top 5 producer countries associated with low levels of corruption

Moderate: top 5 producer countries associated moderate levels of corruption

Strong: top 5 producer countries associated with high levels of corruption

Very strong: top 5 producer countries associated with very high levels of corruption

This criterion measures the material's strength of association with producer countries' perceived levels of corruption. The Worldwide Governance Indicator (WGI) for Control of Corruption is the primary source of information. The WGI describes its Control of Corruption indicator as "capturing perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests". It should be noted that the WGI's indicator captures 'perceptions' of corruption in a country and are aggregate measures constructed by averaging together data from multiple underlying sources The rating for this criterion is determined by multiplying the % of global production of each of the top five producer countries of the material with points attributed to four levels of control of corruption determined by the relative position of each country in the WGI Control of Corruption indicator ranking.

- Low levels of corruption – country falls into the top quartile of the WGI Control of Corruption indicator ranking.
- Moderate levels of corruption – country falls into the third quartile of the WGI Control of Corruption indicator ranking.
- High levels of corruption – country falls into the second quartile of the WGI Control of Corruption indicator ranking.
- Very high levels of corruption – country falls into the bottom quartile of the WGI Control of Corruption indicator ranking.

*Primary sources: World Bank, Worldwide Governance Indicators, http://info.worldbank.org/governance/wgi/#home*

**Countries experiencing high-intensity state conflict**

Weak: less than 5% of materials come from countries that have an "intensity of conflict" ranking of 4 to 5 on the HIIK index.

Moderate: between 5% and 20% of materials come from countries that have an "intensity of conflict" ranking of 4 to 5 on the HIIK index.

Strong: between 20% to 50% of materials come from countries that have an "intensity of conflict" ranking of 4 to 5 on the HIIK index.

Very strong: more than 50% of materials come from countries that have an "intensity of conflict" ranking of 4 to 5 on the HIIK index.

This criterion identifies whether the key producing countries of each material are associated with high-intensity (political) inter or intra- state conflict (i.e. 'limited war' or 'war'). It measures the strength of association of a material with countries experiencing conflict. This is determined in accordance to whether the top five producer countries feature on the Heidelberg Institute for International Conflict (HIIK) Research's 2017 Conflict Barometer as experiencing violent conflict. According to the Heidelberg approach, a political conflict is a perceived incompatibility of intentions between individuals or social groups. The given rating indicates the percentage of the material being produced in countries associated with conflict according to the HIIK barometer. It should be noted that this criterion does not illustrate/measure the direct association between each material and conflict.

## Association with environmental, social and governance (ESG) issues cont.

| | |
|---|---|
| **High CO2 emissions**<br>Low: 0-1 kilograms of CO2 per kilogram of material<br>Moderate: 1-10 kilograms of CO2 per kilogram of material<br>High: 10-100 kilograms of CO2 per kilogram of material<br>Very high: 100 + kilograms of CO2 per kilogram of material | This criterion describes the relative level of CO2 emissions within the group of materials studied associated with the production or processing stages of the material's life cycle. The criterion excludes emissions associated with the use of the final product. Materials are ranked according to the amount (kilograms) of CO2 emissions per kilogram of material produced. It has not been possible to access data on carbon intensity or CO2e for many of the materials. Even though private information (such as from Life Cycle Analysis studies) does exist on CO2e, it is not widely available publicly and nor does it enable comparisons across multiple materials. The production of most mined materials is associated with high levels of greenhouse gas emissions because of the energy intensity of extraction and processing. The mining sector uses approximately 11% of the world's total energy and requires constant and reliable energy access for its operations.<br>*Primary sources: Gutowswki, Tmothy. G., et al. (2013) The energy required to produce materials: constraints on energy-intensity improvements, parameters of demand, Rankin, J. "Energy use in metal production," presentation in High Temperature Processing Symposium 2012; Norgate and Rankin; IPCC, (2014) Norgate (2011) Minerals, Metals and Sustainability: Meeting Future Material Needs citing - (Norgate, T E and Rankin, W J, 2000. Life cycle assessment of copper and nickel production; Norgate, T E and Rankin, W J, 2001. Greenhouse gas emissions from aluminium production – a life cycle approach. Greenhouse Gases in the Metallurgical Industries: Policies, Abatement and Treatment; Norgate, T E and Rankin, W J, 2002. An environmental assessment of lead and zinc production processes).*<br>*Additional (material specific) sources: Han Hao et al. (2017) Emissions: GHG Emissions from the Production of Lithium-Ion Batteries for Electric Vehicles in China; Sheila Devasahayam, Kim Dowling, Manoj K. Mahapatra (2016) Sustainability in the Mineral and Energy Sectors; Sampath P.Dayaratne Kennedy D.Gunawardana (2015)Carbon footprint reduction: a critical study of rubber production in small and medium scale enterprises in Sri Lanka; Carbon Footprint Calculation from Cradle to Grave: A Case Study of Rubber Manufacturing Process in Sri Lanka (2015); Jawjit et al (2010) Greenhouse Gas Emissions from Rubber Industry in Thailand; SETIS/ European Commission Energy Efficiency and CO2 Reduction in the iron and steel industry; Nilsson et al (2017) A Review of the Carbon Footprint of Cu and Zn; MIT (2013) One order of steel; hold the greenhouse gases.* |





## Association with environmental, social and governance (ESG) issues cont.

| | |
|---|---|
| **Incidences of conflict with Indigenous Peoples**<br>Weak: no recorded incidences of conflict with Indigenous Peoples or their territories<br>Moderate: one recorded incident.<br>Strong: between 1 and 3 recorded incidences.<br>Very strong: more than 3 incidences of conflict with Indigenous Peoples | This criterion describes the material's association with incidences of Indigenous Peoples in conflict with, or mobilising against material producers over land-use and resource rights. A broad definition of "conflict" is used that encompasses protracted disputes, public grievance over rights and resources, protest or demonstration and incidences of violence between producer companies and Indigenous Peoples' groups or representatives.<br>*Primary sources: International Work Group for Indigenous Affairs, (2017;) Environmental Justice Atlas, (2017).* |
| **Incidences of overlap with areas of conservation importance**<br>No: no overlap of production sites with areas of conservation importance<br>Yes: production sites are in or near areas of conservation importance | This criterion indicates where there is evidence of coincidence of material production sites with designated protected areas and other recognised areas of importance for conservation and natural landmarks. This study recognizes that production sites and facilities can operate without resulting in long-term adverse impacts to biodiversity and natural features when managed appropriately. Furthermore, compensation instruments, such as biodiversity offsets, can be acceptable in some cases to achieve 'no net loss' of biodiversity. Nevertheless, this criterion implies there is a need for a special level of care on the part of the operator and a focus for company due diligence. It should be noted that although the body of information on the overlap of production activities (especially mining) and important conservation areas continues to grow, there is a paucity of analyses that are specific to the production sites of, and compare many of the materials in this study. The readily available data on the overlap of production sites and important biodiversity areas were insufficiently detailed to distinguish multiple relative levels of strength of association for the materials. For this criterion only two possible ratings are used, therefore, 'yes' or 'no'.<br>*Primary sources: Environmental Justice Atlas (2017;) IBAT for Business, https://www.ibatforbusiness.org/, 2018; WWF-Sight, wwf.sight.org, 2018; Kobayashi, H., Watando, H., and Kakimoto, M., (2014) "A global extent site-level analysis of land cover and protected area overlap with mining activities as an indicator of biodiversity pressure," Journal of Cleaner Production, 84, pp459-468*<br>*Additional sources: Alvarez-Berríos and Aide (2015) Global demand for gold is another threat for tropical forests. Environ. Res.;SOMO (2016) Cobalt Blues - Environmental pollution and human rights violations; The DIG Study (2016) Leather and its toxic effects.* |

## Association with environmental, social and governance (ESG) issues cont.

**Potential for acid discharge to the environment**

No: No or very low potential for acid discharge to the environment

Yes: Potential for acid discharge to the environment

This criterion identifies whether the material is associated with the potential of acid discharge into the environment. This is assessed according to whether the material is likely to be found in acidic sulfide ores, heightening the possibility of acid-mine drainage (AMD), as well as the use of acid (leachates) during the recovery of the material (leaching). The impacts from uncontrolled acid discharge to the environment can be severe. Unmanaged acidic discharge from mines creates further contamination impacts by leaching metals (such as copper and nickel) into local soil and water systems, which is exacerbated during communition (crushing and grinding of ore and rock). The likelihood of acid discharge is highly dependent on the management practices and systems being implemented at operating sites and facilities. It should be noted that with good management practices the risk of acid discharge to the environment can be dramatically reduced.

*Primary sources: Management of Sulfide-Bearing Waste, a Challenge for the Mining Industry Björn Öhlander,Terrence Chatwin and Lena Alakangas (2012), EPA (2017), Current Approaches for Mitigating Acid https://www.researchgate.net/publication/236460293_Current_Approaches_for_Mitigating_Acid_Mine_Drainage [accessed May 11 2018].*

*Additional sources: USGS Mineral Commodity Summaries (2017, 2016); Mining Watch Canada (2012) Environmental and Health Effects of Chromium; Wang et al (2015) Magnesium Contamination in Soil at a Magnesite Mining Region of Liaoning Province, China. UNEP (2014) Sand, rarer than one thinks; Iyer et al (2017) Unsafe Chromium and its Environmental Health Effects of Orissa Chromite; Ren et al (2015) Analysis of the Metals in Soil-Water Interface in a Manganese Mine; Pinsino et al (2012) Manganese A New Emerging Contaminant in the Environment; EPA (2012) Rare Earth Elements: A Review of Production,. Processing, Recycling, and. Associated Environmental Issues. Robert J. Weber. Superfund and Technology Liaison. U.S. EPA Office of Research and Development. Mining – EAUC; Gleekia and Sahu (2016) Impacts of iron ore mining on water quality – a comparative study of India and Liberia; Fei et al (2017) Health and ecological risk assessment of heavy metals pollution in an antimony mining region a case study from South China; Wang et al (2015) Magnesium Contamination in Soil at a Magnesite Mining Region of Liaoning Province, China.*





## Association with environmental, social and governance (ESG) issues cont.

**Potential for harm from hazardous materials and chemicals**

Weak: no reported threats

Moderate: association with minor threats to health, such as dust and dermatological irritants

Strong: association with arsenic, cyanide and toxic heavy metals (identified as concerns by Pure Earth but not regarded as comparatively prevalent)

Very strong: association with lead,chromium, cadmium and mercury (identified as the highest concern by Pure Earth)

This criterion indicates the degree to which the material is connected with a heightened, inherent threat, such as hazardous pollutants that present serious health and safety challenges for workers and surrounding communities. This criterion draws on the materials and chemicals identified by Pure Earth as the highest concern due to their disability adjusted life year (DALY) impact. DALY has been widely used since 1990s for evaluating global and/or regional burden of diseases. DALYs for a disease or health condition are calculated as the sum of the Years of Life Lost (YLL) due to premature mortality in the population and the Years Lost due to Disability (YLD) for people living with the health condition or its consequences (WHO 2018). This criterion also includes a rating to capture the potential of exposure to dust and dermatological irritants; these materials are associated with occupational health and safety issues, including, but not limited to, the inhalation of metallic and mineral dusts which can directly cause, or exacerbate a variety of respiratory illnesses such as silicosis, TB, pneumoconiosis and bronchitis. The criterion also accounts for the impacts of chemicals used in leather and natural rubber processing on workers' health. This criterion does not measure the prevalence of incidents but notes that there are multiple reports associated with the material hazardous materials and/or chemicals. It highlights that appropriate management measures need to be in place to address the potential of exposure to these hazardous materials or chemicals.

*Primary sources: multiple, including Pure Earth (2016) World's Worst Pollution Problems and Pure Earth (2016) Industrial Mining and Ore Processing accessed online via http://www.worstpolluted.org/projects_reports/display/134. World Health Organisation (2018) Metrics: Disability-Adjusted Life Year (DALY) Quantifying the Burden of Disease from mortality and morbidity Chen, W., et al (2012) "Respiratory Diseases Among Dust Exposed Workers," Department of Occupational and Environmental Health, School of Public Health, Tongji Medical College in Huazhong University of Science & Technology, China.; Utembe et al (2015)Hazards identified and the need for health risk assessment in the South African mining industry; Rim et al(2013) Toxicological Evaluations of Rare Earth's and Their Health Impacts to Workers: A Literature Review; Wesdock, James C. MD, MPH Arnold, Ian M. F. MD, MSc, DOHS (2014) Occupational and Environmental Health in the Aluminium Industry Key Points for Health Practitioners; Fei et al (2017) Health and ecological risk assessment of heavy metals pollution in an antimony mining region a case study from South China; SOMO (2016) Cobalt Blues - Environmental pollution and human rights violations; Taylor et al (2014)Environmental arsenic, cadmium and lead dust emissions from metal mine operations. Implications for environmental management, monitoring and human health; ILO (2014) Wages and Working Hours in the Textiles, Clothing, Leather Industry; SOMO (2016) Hell bent for Leather; The DIG Study (2016) Leather and its toxic effects; Wei and Balasubramanyam (2015) A Comparative Analysis of China and India's Manufacturing Sector*

*Additional references: Chatham-Stephens, Kevin, et al. "Burden of disease from toxic waste sites in India, Indonesia, and the Philippines in 2010." Environmental health perspectives 121.7 (2013): 791, Ericson, Bret, et al. "Cost Effectiveness of Environmental Lead Risk Mitigation in Low and MiddleIncome Countries." GeoHealth 2.2 (2018): 87-101, Ericson, Bret, et al. "The global burden of lead toxicity attributable to informal used lead-acid battery sites." Annals of global health 82.5 (2016): 686-699.*

*This study notes that while the ILO have an Encyclopedia for OHS, the sources are prior to 2011, which exceeds the 5-year limit that is applied to this study.*

## Association with environmental, social and governance (ESG) issues cont.

**Preconditions for radioactive materials in ores and tailings**

No: the raw material is not usually found together with NORM in the same geological deposits or associated with TENORM.

Yes: the raw material can be found together with NORM in the same geological deposits or is associated with TENORM.

This criterion indicates the likelihood of the material being found in ores containing naturally occurring radioactive material (NORM) or if it is associated with Technologically Enhanced Naturally Occurring Radioactive Material (TENORM). The EPA define NORM as "materials which may contain any of the primordial radionuclides or radioactive elements as they occur in nature, such as radium, uranium, thorium, potassium, and their radioactive decay products, such as radium and radon, that are undisturbed as a result of human activities." TENORM is defined as "naturally occurring radioactive materials that have been concentrated or exposed to the accessible environment as a result of human activities such as manufacturing, mineral extraction, or water processing." "Technologically enhanced" means that the radiological, physical, and chemical properties of the radioactive material have been concentrated or further altered by having been processed, or beneficiated, or disturbed in a way that increases the potential for human and/or environmental exposures" (EPA). Though an important indicator of a serious public issues, when properly managed the risks associated with radioactive waste at mine sites can be dramatically reduced. We also note the risk of radioactivity in mining waste is dependent on the scale of operation and processing methods used. The readily available data on pre-conditions for radioactive waste were insufficiently detailed to distinguish relative levels of strength of association. For this criterion only two possible ratings are used, therefore, 'No' or 'Yes'.

*Primary sources: Naturally Occurring Radioactive Material (NORM VI) Symposium, IAEA, 2010; World Nuclear.; US Environmental Protection Agency (accessed online 2017) TENORM: Gold, Silver, Zircon and Titanium Mining Wastes; Peter Dolega, Stefanie Degreif, Matthias Buchert, Doris SchülerOeko-Institut e.V (2016) European Policy Briefing Outlining Environmental Challenges in the Non-Fuel Mining Sector. Min et al (2013); EPA (2017) TENORM: Gold, Silver, Zircon and Titanium Mining Wastes (accessed 2017) ; https://www.epa.gov/radiation/tenorm-bauxite-and-alumina-production-wastes (accessed 2018)*





## **Appendix C:** Guide to the producer country and additional material criteria and indicators used in the material profiles

### Additional material criteria and indicators

**% content in illustrative product**

Low: up to 5%

Moderate: 5% to 15%

High: 15% to 25%

Very high: more than 25%

This criterion measures the material's estimated proportion (%) of the total weight of an industry illustrative product for both the automotive and electronics industries. This data gives a rough indication of the potential influence of the industry in a specific supply chain.

Primary sources: American Chemistry Council (2016;) USGS, (2011;2013;) Fairphone, (2017.)

**Dependency - EU import reliance rate**

Score of 0-100%, where 0 = no reliance in imports, and 100% = total reliance on imports.

Low: less than 25%

Moderate: from 25% to 50%

High: from 50% to 75%

Very high: more than 75%

This criterion is not used in the comparative rating of the material, and so does not appear in the 'heat-maps' or charts. It is included in the material profiles, however. The criterion describes the degree to which the EU relies on imports of the material from sources outside the EU. These data alert industry to the possibility that future supply of the material may depend on strategic trade relations and therefore might imply that the surety of its supply is vulnerable. The 'Import reliance rate' -a parameter used to balance the risks linked to the global supply mix and the actual EU sourcing mix (domestic production plus imports) - takes into account global supply and actual EU sourcing in the calculation of Supply Risk, and it is calculated as follows: EU net imports / (EU net imports + EU domestic production). The indicator does not account for a circular life cycle (e.g. input of recycled materials).

*Primary sources: European Commission, (2017) Communication From The Commission To The European Parliament, The Council, The European Economic And Social Committee And The Committee Of The Regions on the 2017 List of the Critical Raw Materials for the EU*

**Dependency - US import reliance rate**

Score of 0-100%, where 0 = no reliance in imports, and 100 = total reliance on imports.

Low: less than 25%

Moderate: from 25% to 50%

High: from 50% to 75%

Very high: more than 75%

This criterion is not used in the comparative rating of the materials, and so does not appear in the 'heat maps' or bar charts. It is included in the material profiles, however. The criterion describes the degree to which the US relies on imports of the material from sources outside the US. These data alert industry to the possibility that future supply of the material may depend on strategic trade relations and therefore might imply that the surety of its supply is vulnerable. The USGS National Minerals Information Center tracks how much the United States relies on other countries for minerals critical to the economy and national security. The indicator does not account for a circular life cycle (e.g. input of recycled materials).

*Primary sources USGS (2017): https://minerals.usgs.gov/minerals/pubs/mcs/2017/mcs2017.pdf (p8) https://www.usgs.gov/news/interior-releases-2018-s-final-list-35-minerals-deemed-critical-us-national-security-and*

## Top producer country information

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| **Global mined production**<br>% global production originating from the country | Percentage of global production originating from the country, as calculated by the United States Geological Survey (USGS).<br>*Source: USGS 2017 Commodity Summaries* |
| **Global reserves**<br>% estimates global reserves located within the country | Percentage of global reserves located in the country, as estimated by USGS.<br>*Source: USGS 2017 Commodity Summaries* |
| **Mining sector contribution to GDP**<br>% of country GDP, attributable to mining | Percentage of gross domestic product (GDP) attributable to mineral rents, where "mineral" excludes coal, oil and gas. Mineral rents are the difference between the value of production for a stock of minerals at world prices and their total costs of production. Minerals included in the calculation are tin, gold, lead, zinc, iron, copper, nickel, silver, bauxite, and phosphate. From the World Development Indicator 'Contribution of natural resources to gross domestic product.'<br>*Source: World Development Indicators, 2014* |
| **Rule of Law**<br>Very strong rule of law – country falls into the top quartile of the WGI Rule of Law indicator ranking<br>Strong rule of law – country falls into the third quartile of the WGI Rule of Law indicator ranking.<br>Moderate rule of law – country falls into the second of the WGI Rule of Law indicator ranking.<br>Weak rule of law – country falls into the bottom quartile of the WGI Rule of Law indicator ranking. | The Worldwide Governance Indicator (WGI) for Rule of Law is the primary source of information. The WGI describes its Rule of Law indicator as "capturing perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence". It should be noted that the WGI's indicator captures 'perceptions' of the rule of law in a country and are aggregate measures constructed by averaging together data from multiple underlying sources. The rating for this criterion is determined by the relative position of each country in the WGI Rule of Law indicator ranking. |
| **Experience of Corruption**<br>Low levels of corruption – country falls into the top quartile of the WGI Control of Corruption indicator ranking.<br>Moderate levels of corruption – country falls into the third quartile of the WGI Control of Corruption indicator ranking.<br>High levels of corruption – country falls into the second quartile of the WGI Control of Corruption indicator ranking.<br>Very high levels of corruption – country falls into the bottom quartile of the WGI Control of Corruption indicator ranking. | The Worldwide Governance Indicator (WGI) for Control of Corruption is the primary source of information. The WGI describes its Control of Corruption indicator as "capturing perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests". It should be noted that the WGI's indicator captures 'perceptions' of corruption in a country and are aggregate measures constructed by averaging together data from multiple underlying sources The rating is determined by the relative position of each country in the WGI Control of Corruption indicator ranking. |





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| **Heidelberg conflict barometer**<br>Levels of political conflict:<br>Dispute (1)<br>Non-violent crisis (2)<br>Violent crisis (3)<br>Limited war (4)<br>War (5) | The Heidelberg conflict barometer is the work of the Heidelberg Institute for International Conflict Research (HIIK). HIIK adopt the concept of political conflict, which is a positional difference between at least two assertive and directly involved actors regarding values relevant to a society and which is carried out using observable and interrelated conflict measures that lie outside established regulatory procedures and threaten core state functions, the international order, or hold the prospect of doing so. The HIIK methodology distinguishes between five levels of conflict intensity: dispute, non-violent crisis, violent crisis, limited war, and war. The violent crises levels are considered medium intensity conflicts, while wars and limited wars are high intensity conflicts.<br>It should be noted that this criterion does not illustrate/ measure the direct association between each material and conflict. |
| **Human development Index (HDI)**<br>Score of 0, where 0 = no human development and 1 = highest potential human development. | The Human Development Index (HDI) is an index of potential human development, assuming no inequality. It is a composite index combining life expectancy, education and per capita income indicators, which are used to rate countries into four tiers of human development. A country scores higher HDI when the lifespan is higher, the education level is higher, and the GDP per capita is higher. Norway currently has the highest HDI value at 0.949 while Central African Republic has the lowest, at 0.352.<br>*Source: UNDP Human Development Report 2016* |
| **Conflict mineral legislation** | This criterion is not used in the comparative rating of the material, and so does not appear in the 'heatmaps' or charts. It is included in the material profiles, however. The criterion association with the foremost act of conflict minerals legislation worldwide, Section 1502 of the US Dodd-Frank Act. The Dodd-Frank Act names specific materials, as well as producer countries. Both materials and countries if associated with conflict minerals legislation are therefore included for this indicator. This study recognises that resource conflict, worldwide, manifests much more broadly than the forms addressed by the Dodd-Frank legislation, however.<br>*Primary sources: Section 1502 Dodd-Frank Act, 2012. http://www.cftc.gov/LawRegulation/DoddFrankAct/index.htm* |

**The Dragonfly Initiative** is a full service advisory firm established to support businesses in the raw materials value chain. Our multi-disciplinary team gives us a 360° vision of what matters to commercial and not-for-profit enterprises from mine to market. We are sustainable business and risk management experts, with a strong track record in change management, corporate communications, and programme implementation. We work with mining companies large and small, refiners, manufacturers, OEM, jewellers, retailers, and consumer-facing brands worldwide to build and implement corporate strategies that create value through ensuring compliance with prevailing industry standards; identification of new product lines and markets; communications support to capture social responsibility commitments; efficiencies through the application of cloud software geared specifically to our client's needs; and, a unique focus on managing impact finance and philanthropic funds to invest in projects in mining communities worldwide.

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