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Approaches to responsible sourcing in mineral supply chains

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ABSTRACT

Over the last decade, 'responsible sourcing' has become a topic of broad interest. Policymakers, consumers and companies refer to 'responsible sourcing' as a way to address sustainability risks in globalized mineral supply chains, but the term is used to refer to a wide range of sustainability objectives pursued by a variety of approaches. To address the need for a definition and structuring of the topic, a review was performed of the existing literature and of company policies on 'responsible sourcing' of minerals. The study develops a framework for responsible sourcing, here defined as 'the management of social, environmental and/or economic sustainability in the supply chain through production data'. We propose that 'responsible sourcing' should be used as an umbrella term encompassing all sourcing designed to be 'socially responsible', 'green' or 'sustainable'. Two approaches to managing responsible sourcing of minerals were identified: supply chain due diligence and sourcing via sustainability schemes. This study maps the sustainability requirements of such schemes and uses these to categorize them as socially responsible sourcing, sustainable sourcing or green sourcing. It also identifies the extent in the supply chain to which the schemes provide assurance or certification and how far traceability extends. The study provides a framework for future research and a springboard for further development of approaches to responsible sourcing that can be used by both companies and academics.

1. Introduction

The globalization of supply chains brings benefits, but also risks with regards to social and environmental sustainability, particularly when raw materials or products originate from countries with regulatory concerns. Policymakers, consumers and companies are seeking new ways to address sustainability risks in these globalized supply chains. A number of governmental and private sector initiatives have emerged to address these issues in upstream supply chains, while companies are exploring how best to respond to growing demands to take responsibility for their supply chains. One approach taken by companies to address these issues is termed 'responsible sourcing'.

One milestone in the area of responsible sourcing was the endorsement of the United Nations Guiding Principles on Business and Human Rights (UNGPs) in 2011. These principles provide a benchmark for companies on how to respect human rights, not only within their own business, but also to exercise wider 'human rights due diligence' – a process to identify, prevent, address, and account for their impact on human rights throughout their supply chains (United Nations, 2011). Also relevant in this context is the United Nations Global Compact, adopted in 2005, which encourages companies to implement sustainability goals and apply sustainable practices throughout the supply chain, including environmental, social and governance goals (United Nations Global Compact, 2018).

Though the term 'responsible sourcing' was first introduced in the food and clothing industries (Young and Osmani, 2013), one of the main focuses of attention is currently responsible sourcing of minerals, particularly so-called 'conflict minerals' (tin, tantalum, tungsten and gold, in short '3 TG'). After the formal end of the second Congolese war, violence and human rights abuses in Eastern Congo continued and media and NGOs reported on the role in the conflict of minerals in widespread use in our electronics and cars. Under international pressure, policies were developed to address this issue of conflict minerals. In 2010 the United States passed the Dodd Frank Act, Section 1502 of which is aimed at stopping army and rebel groups in the Democratic Republic of the Congo (DRC) from using profits from trade in 'conflict minerals' to fund their violent operations (SEC, 2012). The European Union recently passed Regulation 2017/821, designed to stem the trade in 3 TG as 'conflict minerals', that will come into force in 2021. This EU legislation is only obligatory for companies importing minerals or metals in the form of mineral ores, concentrates or processed metals (European Commission, 2018a, b).

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Besides the problems of 3 TG mining, NGO reports in the past few years have also highlighted the serious environmental pollution and human rights violations associated with cobalt mining (SOMO, 2016). In response, manufacturers are now starting to pro-actively search for ways to achieve 'responsible' import of cobalt.

Although when it comes to responsible sourcing of minerals much of the attention is directed towards the raw materials themselves, there are also concerns about other aspects of the supply chain, such as poor working conditions in factories (Danwatch, 2013). A number of sustainability schemes consequently seek to address human rights violations and environmental pollution in other parts and aspects of the mineral supply chain beyond mining.

The term 'responsible sourcing' can thus relate to a range of sustainability objectives and can address sustainability concerns in various links in the supply chain. There exist, furthermore, a range of approaches to responsible sourcing that differ in terms of both their objective and method. The issue is compounded by a number of related terms being used in the literature in connection with responsible sourcing. The word 'responsible' is sometimes replaced by' sustainable', 'ethical', 'green' or 'conflict-free', for example, while 'purchasing' and 'procurement' may be used rather than 'sourcing'. According to the International Council on Mining and Metals (ICMM), there is no internationally accepted definition of responsible sourcing (ICMM, 2015). It has been demonstrated that lack of a broadly accepted definition could be a significant barrier to implementation of the concept by procurement managers (Young and Osmani, 2013).

Against this background, the objective of this study is to structure the field of research on responsible sourcing and to review approaches to responsible sourcing of minerals, in particular. Although in a circular economy responsible sourcing includes the sourcing of secondary (recycled) materials, the focus in the literature and in the approaches reviewed was on primary raw materials. The scope of this study is therefore responsible sourcing in the mineral supply chain from mining to end-product, excluding the supply chain after product manufacture.

2. Materials and methods

2.1. Scientific literature review

A twofold research methodology was adopted, consisting of a systematic review of the academic literature on 'responsible sourcing' and an analytical review of corporate approaches to the issue, as evidenced in company (sustainability) reports and other literature. The literature review, conducted to analyse definitions and descriptions of the term, was confined mainly to the academic literature, but also included two non-academic sources: a guide to responsible sourcing by the International Council on Mining and Metals (ICMM, 2015) and a guide by the International Chamber of Commerce (ICC, 2008). The term "responsible sourcing" was queried in the title and abstract/topic of (English) articles in three databases: Web of Science (an online subscription-based scientific citation indexing service), Scopus (a bibliographic database containing abstracts and citations for academic journal articles) and the online library of Leiden University (comprising several databases). The queries covered all years of publication. Discounting duplicates, these searches together generated 56 articles containing the term "responsible sourcing" in the title or abstract/description. For some articles, only the abstract was used for the present review.

In only 8 of the 56 articles was the term "responsible sourcing" used in relation to minerals and metals, with the topics of the other articles as follows: construction (21), paper supply chain (6), supply chain management (6), clothing (4), food (2), seafood (salmon) (2), retail (2), coffee (1), banking (1), governance (1), marketing (1) and materials (1). To ensure all articles linked to minerals and metals were found, additional queries were made in Web of Science using the terms, "sourcing of minerals" and "mineral supply chain" as search topic. This yielded only one additional relevant article containing the term "responsible sourcing". This article was added to the selection, resulting in 57 articles, of which 9 are linked to minerals.[1] Additionally, literature was reviewed to analyse how the term "responsible sourcing" can be linked to the term "sustainable supply chain management". In Scopus, the term "sustainable supply chain management" generated 224 results. These were sorted by citation and the 17 articles with more than 100 citations were reviewed.

The articles linking "responsible sourcing" to minerals/metals were all published in recent years, between 2014 and 2017. Those relating to other subjects were published between 2004 and 2017, apart from one article on ethical banking from 1995. Responsible sourcing in connection with clothing first appears in 2011, in connection with seafood (salmon) in 2017. In 2011 there was a peak in articles on responsible sourcing relating to construction, which may be associated with a Dutch government programme for sustainable construction launched in 2008, which stated that by 2012, 25% of construction materials were to derive from schemes recognised as 'responsible sourcing' (Glass and Dainty, 2011).

2.2. Company reports and sustainability schemes

Secondly, company reports and several additional publications were reviewed to identify, and subsequently analyse, corporate 'responsible sourcing' strategies. In Europe, the main industries using steel and non-ferrous metals are construction, automotive, mechanical and electrical engineering, aerospace and medical devices (European Commission, 2018a, b). According to NGOs, the industries most prone to use of 'conflict minerals' are electronics and communications, aerospace, automotive, jewelry and industrial products (Ernst and Young, 2012). To examine the 'responsible sourcing' strategies of downstream companies in these sectors, ten of the world's largest manufacturers were selected from the sectors sourcing 3 TG ('conflict minerals'), which include electronics (Samsung, Apple, Hewlett Packard, Siemens, Dell), automotive (Daimler, Toyota, BMW) and aerospace (Boeing, Airbus) (Fortune, 2017). Larger companies have relevant publications available online. Additionally, five companies were selected that mainly use other minerals, with little or no 3 TG, viz. manufacturers of steel and aluminium products (Arcelor Mittal, Ardagh Group, Tata Steel, Norsk Hydro, Novelis). These companies were selected by means of a simple Google search for steel and aluminium industries. Relevant reports about sustainability, 'conflict minerals' and responsible sourcing published by the companies themselves were then selected and analysed.[2]

Having identified corporate approaches to 'responsible sourcing', a follow-up literature search was conducted to find additional information on how these are implemented by the companies concerned. To this end, the three aforementioned databases were searched using the terms "mineral", "certification", "due diligence" and combinations thereof in the title or abstract. This resulted in 50 articles relating to certification and/or due diligence. The issue of how these approaches are implemented by individual companies is discussed in Section 3.2.

3. Results

3.1. Defining responsible sourcing

Though there is no internationally accepted definition of 'responsible sourcing' (ICMM, 2015), in the review of literature and company reports three definitions were found. More than one-third of the selected articles are linked to the construction sector, and these use the definition of the British Standards Institution (BSI), which has

[1] A list of of the articles can be found in the Supplementary Information

[2] A list with references to the reports can be found in the Supplementary Information

Table 1
'Responsible sourcing' versus 'responsible procurement'.

Type	Objective	Approach
Responsible sourcing	Managing the sustainability (social, environmental and/or economic) of the supply chain	Via production data
Responsible procurement	Managing the sustainability (social, environmental and/or economic) of suppliers	Via supplier monitoring and supplier development

developed a responsible sourcing sector certification scheme standard for construction products (BS 8902:2009). The BSI defines responsible sourcing as "the management of sustainable development in the provision or procurement of a product" (BRE Global, 2016). There is a second definition linked to the construction sector: that of Upstill-Goddard et al. (2015) who define responsible sourcing as "the management of sustainability issues associated with materials in the construction supply-chain, often from an ethical perspective". These definitions have in common that they refer to management of sustainability and to a specific material or product. Young (2015), too, argues that the scope of responsible sourcing of metals is materials supply. Based on the analysis of existing definitions, we define responsible sourcing as "the management of social, environmental and/or economic sustainability in the supply chain through production data" (Table 1). 'Production data' refers to information on the production location and production process of the material and may be provided either by the suppliers or through a sustainability scheme.

Some of the formal literature and company reports link responsible sourcing to some form of supervision of a company's direct suppliers, via 'supplier monitoring' and 'supplier development', for example.

In its 'Guide to Responsible Sourcing' the International Chamber of Commerce (ICC) defines the term as follows: "responsible sourcing, also referred to as supply chain responsibility, is a voluntary commitment by companies to take into account social and environmental considerations when managing their relationships with suppliers" (ICC, 2008). The focus here is thus on suppliers, with the Guide describing how to assess and select suppliers and track supplier compliance (ICC, 2008).

Approaches focusing on supplier monitoring are also linked to the term 'procurement', e.g. "responsible sourcing is demonstrated typically through an organisation's procurement policy, via its purchasing decisions and practices" (Glass et al., 2012). Though practices of responsible procurement and responsible sourcing overlap, the former focus more on monitoring relations with suppliers, the latter more on production data. 'Responsible procurement' can therefore be defined as 'management of the social, environmental and/or economic sustainability of suppliers through supplier information' (Table 1). As the scope of this article is 'responsible sourcing', 'responsible procurement' and related practices have been excluded.

In the academic articles reviewed there is considerable variation in the intended scope of the terms 'responsible' and 'sourcing'. In 32 of the 58 articles this scope was identified, in the article itself or via cited references, and analysed. The same was done with the company reports reviewed.

3.2. Scope of the term 'responsible'

'Sustainability' is today used in multiple senses, to refer to a variety of desirable characteristics[3], mainly socially and environmentally related but also economic, alone or in combination. This is also the case in the articles reviewed.

3.2.1. Social aspects: 'socially responsible sourcing'

In 35% of the articles, 'responsible sourcing' was linked specifically to the social aspect of sustainability. These articles were concerned with the following issues: minerals, coffee, clothing and supply chain management. The following terms relating to social aspects were identified: human rights, conflict minerals, working conditions, child labour, forced labour, health and safety, and community. In our review of the literature and company reports we found that responsible sourcing in relation to minerals focuses mainly on the sourcing of so-called 'conflict minerals' and on human rights. Airiki et al. (2015) conclude that the company representatives interviewed for their research are strongly motivated to address the issue of conflict minerals, which they aim to achieve through 'responsible sourcing' methods.

As this type of 'responsible sourcing' revolves around human rights issues, it is sometimes also referred to as 'ethical sourcing'. Here, we shall refer to responsible sourcing that focuses on social aspects as 'socially responsible sourcing'.

3.2.2. Environmental aspects: 'green sourcing'

Examples of 'responsible sourcing' giving sole consideration to environmental aspects were virtually absent in the literature analysed, as these issues generally come under the heading 'sustainable supply chain management' or 'green procurement' (Seuring and Müller, 2008). Only one of the studies reviewed linked responsible sourcing exclusively to environmental aspects (Ghodeswar and Kumar, 2014), but this was also categorized as 'green procurement' (see Section 3.1.3). Forms of 'responsible sourcing' focusing solely on environmental aspects we would refer to as 'green sourcing'. Methods have been developed for gold mining without use of toxic cyanide or mercury, with the resultant product referred to as 'green gold' (ABC news, 2018). Factoring in this kind of information could be used in the future to achieve 'green sourcing' of minerals.

3.2.3. Environmental, social and economic sustainability aspects: 'sustainable sourcing'

The third type of 'responsible sourcing' addresses two or more aspects of the 'triple bottom line' of sustainability: environmental, social and economic requirements. Of the articles reviewed, 65% address both social and environmental issues and in some cases economic requirements, too. For example, Glass et al. (2012) argue that responsible sourcing should address a range of environmental, economic and social considerations, while the ICMM Guide states that" responsible sourcing is about sustainable procurement and the responsible supply of minerals and metals. Both should have agreed-upon environmental and social performance standards or criteria" (ICMM, 2015). An example of an economic aspect relevant to responsible sourcing is the condition that companies should provide transparency with respect to economic contributions such as taxes (Wall et al., 2017a) or that companies should have taken measures to avoid corruption-related dealings and/or provide proof of payment (Kickler and Franken, 2017). Here, we shall refer to responsible sourcing that focuses on social and environmental and possibly economic requirements as 'sustainable sourcing'.

3.3. Scope of the term 'sourcing'

In the literature, the term 'responsible sourcing' may refer only to suppliers at the beginning of the product supply chain or to suppliers all the way down the chain.[4]

[3] An overview of the 'sustainability characteristics' can be found in the Supplementary Information.

[4] An overview of the scope of the term 'sourcing' can be found in the Supplementary Information.

Fig. 1. Responsible sourcing by the end-user company from mining.
Icons are from FlatIcon (2019), numbers of companies in the supply chain from Philips (2019).

3.3.1. Sourcing scope 'a': upstream supply chain

Some authors explicitly link the term 'responsible sourcing' to the initial links in the supply chain, often referred to as the upstream supply chain. For example, Zorzini et al. (2015) argue that "socially responsible sourcing (SRS), which focuses on the upstream management of the supply chain, is an important aspect of the broader sustainable supply chain management (SSCM) agenda" (Zorzini et al., 2015). In the context of minerals, the OECD defines the upstream supply chain as "the supply chain from the mine to refiners" (OECD, 2016). The supply chain from the smelter onwards is then considered 'downstream' (Young, 2015). In the literature the term 'origin' or 'provenance' may also be used in this context. For example, Young (2015) writes that "[responsible sourcing] manages information associated with source (origin) and production of raw materials". In 45% of the formal literature explicitly describing its features, 'responsible sourcing' is linked (only) to the upstream part of the supply chain (or 'origin').

Fig. 1 illustrates responsible sourcing of minerals by the end-user company from the upstream part of the supply chain (mining). The numbers of companies in the supply chain is based on the estimations by Philips for the supply chain of conflict minerals (2019).

3.3.2. Sourcing scope 'b': entire supply chain

In 55% of the formal literature in which its features are explicitly described, responsible sourcing is linked to the entire supply chain, e.g. "supply chains including the ultimate sources" (Wall et al., 2017a). Verney et al. (2011) state that the aim of responsible sourcing is to "improve the implementation and traceability of sustainability objectives throughout the project supply-chain", and the ICMM (2015) Guide likewise refers to the entire mineral supply chain: "the importance of responsible resourcing is growing as organisations increasingly take the evaluation of environmental and social performance beyond their own operations and integrate it into supply chain and purchasing decisions" (ICMM, 2015). While the supply chain varies according to the mineral involved, its links can consistently be categorized as 'mining and exploration', 'processing (refining and smelting)', 'manufacturing (fabrication)', 'retail' and 'trading'. Various schemes for managing the sustainability of some or all of the links in such chains have been developed and are discussed in Section 3.2. Fig. 2 illustrates responsible sourcing of minerals by the end-user company from mining, processing and manufacturing (linked to the entire supply chain).

3.4. Linking 'responsible' and 'sourcing'

Our literature review shows that the notion of 'responsible sourcing' is used in a variety of ways. In this article we propose that the following should be adopted as a definition: 'the management of social, environmental and/or economic sustainability in the supply chain through production data', i.e. information on the production location and production process of the material concerned. In tandem with this definition, subsidiary terms can be added to indicate more specific sustainability features. It can be considered an umbrella term for socially responsible sourcing, green sourcing and, broadest of all, sustainable sourcing. In terms of the supply chain, it can refer to management of the upstream part only or to the entire chain.

3.5. Responsible sourcing of minerals: management approaches

A variety of approaches can be adopted to implement responsible sourcing of minerals. The reviewed company reports reference mainly two. The first is 'supply chain due diligence', which is cited in the reports of all the companies with 3 TG in their supply chain as part of their responsible sourcing policies (e.g. Apple, Airbus, BMW, Boeing, Dell, HP). In this due diligence approach 'supply chain mapping' plays an important role. Secondly, companies reference compliance with sustainability schemes as a means to the same end. Finally, they refer to the need for traceability or a 'chain of custody' (e.g. Airbus, 2017), which is accomplished through supply chain due diligence and/or compliance with specific sustainability schemes. The approach of ensuring that direct suppliers meet sustainability criteria (e.g. through a supplier code of conduct) was also identified in some company reports, but is categorized here under responsible procurement and therefore ignored.

3.5.1. Due diligence

Responsible sourcing of minerals is linked by several authors to "supply chain due diligence". The term 'due diligence' is used in a variety of contexts. In law it means the care exercised by a reasonable person to avoid harm to other persons or their property, while in business it can be defined as research and analysis of a company or organization in preparation for a business transaction.[5] The OECD (2016) describes due diligence as "an on-going, pro-active and reactive process through which companies can ensure that they respect human rights and do not contribute to conflict". This guidance is currently the leading approach for companies seeking to source their minerals 'conflict-free', and is part of the European Legislation on 'conflict minerals'. The OECD (2016) provides a five-step framework, of which one is to identify and assess risks in the supply chain, followed by a step to mitigate them. The risks are based on so-called 'red flags' for locations, suppliers or circumstances (OECD, 2016). The due diligence approach in the context of minerals focuses on the upstream supply chain – mining and refining – and on social requirements and human rights. As such it is therefore to be categorized as 'socially responsible sourcing'.

A risk-based approach has as a disadvantage that the guidance provided must identify specific risks with respect to specific issues (thereby excluding environmental risks, for example) and specific geographic areas (conflict and high-risk). The OECD due diligence guidance currently applies to tin, tantalum, tungsten and gold (3 TG),

[5] https://www.merriam-webster.com/dictionary/due%20diligence

Fig. 2. Responsible sourcing by the end-user company from mining, processing and manufacturing. Icons are from FlatIcon (2019), numbers of companies in the supply chain from Philips (2019).

but it is noted that supplements on other minerals may be added to the guidance in the future (OECD, 2016). At the latest OECD Forum on Responsible Mineral Supply Chains, there were discussions on adding cobalt and mica (OECD, 2018).

It is not only in OECD countries that the principle of due diligence has been adopted for mineral supply chains. In May 2016 the Chinese Chamber of Commerce of Metals, Minerals and Chemicals published Chinese Due Diligence guidelines for responsible mineral supply chains (CCCMC, 2016). This is an important step, considering the importance of Chinese companies downstream in the supply chain, for example with respect to coltan, where Chinese companies are dominant downstream (Bleischwitz et al., 2012). Instruments like the OECD guidance confirm that due diligence is no longer only a means of identifying risks to the own company, but also a way to identify risks to third parties affected by company activities, in particular those relating to human rights (Martin-Ortega, 2013).

Certain difficulties have been identified by companies using this approach, particularly when it comes to accurate identification of smelters in the supply chain. It is common for a mineral supply chain to encompass a spectrum of nine suppliers or more (Young, 2015). When a company identifies a supplier not meeting responsible sourcing criteria, it may be difficult for them to exert pressure on that supplier or find a new one, particularly if the company is small or medium-sized, implying that the leverage is upstream in the supply chain (Hofmann et al., 2015). In the past few years, some of the (bigger) companies have started to publish a list of their suppliers beyond the first tier, which could create more transparency. As Cisco (2015) argues, “improving transparency in the supply chain is critical to helping us address some of our most significant sustainability issues” (as cited in Kashmanian, 2017).

3.5.2. Sustainability schemes

Responsible sourcing is about managing sustainability in the supply chain on the basis of ‘production data’, i.e. information on the production location and production process (rather than on suppliers). That information can be provided by so-called ‘sustainability schemes’ based on standards and certification covering any number of sustainability aspects and links in the supply chain.

3.5.2.1. Sustainability schemes - sustainability requirements. Over the past decade numerous ‘sustainability schemes’ and ‘sustainable mining’ initiatives have been developed, differing in their requirements and the type of responsible sourcing to which they apply. Table 2 lists the main sustainability schemes together with their requirements: social, environmental and economic. Only schemes with requirements with respect to mining (rather than products) are included. Two schemes are aimed primarily at providing ‘conflict-free’ minerals: the Kimberley Process Sustainability scheme and the Responsible Minerals Assurance Process. These two initiatives, together with the International Tin Supply Chain Initiative and the Regional Certification Mechanism, set no environmental requirements.

3.5.2.2. Sustainability schemes - steps in the supply chain covered. Some of the sustainability schemes, like the Initiative for Responsible Mining Assurance (IRMA, 2018) and Development Diamonds Standards (Development Diamonds Standards, 2018), are concerned only with sustainable mining, while others certify or monitor other links in the supply chain, too. The Aluminium Stewardship Initiative Performance Standard, for example, covers bauxite mining, alumina refining, smelting, casting, semi-fabrication, material conversion, manufacturing and sales of products (Aluminium Stewardship Initiative, 2014). It is a performance standard with general criteria for all the companies in the supply chain and specific criteria for mining (e.g. on mine rehabilitation), refining and smelting (e.g. on storage of bauxite residue). The Fairmined Standard applies to mining, processing, trading, refining, manufacturing and consumer products, but its sustainability requirements apply only to (artisanal and small-scale) mining. The Responsible Jewellery Council has one standard with requirements for every link in the supply chain, plus a specific set of requirements for responsible mining. Fair Stone has separate sustainability standards for quarries and processing factories, while Xertifix has one standard for both.

Table 3 summarizes the type of responsible sourcing featured in the sustainability schemes as well as the extent of supply chain coverage.

Ali and Mori jr. (2016) concluded that the characteristics of sustainability schemes that make them successful can be summarized under the following headings: transparency, stakeholder participation, monitoring and evaluation mechanisms, interoperability, local development, sanctions and non-compliance, standards and training and capacity building.

3.5.3. Chain of custody

To ensure certified minerals reach the end-user without being mixed in the supply chain with non-certified or illegal minerals, some sustainability schemes have developed a ‘chain of custody’ model to support traceability. In legal contexts a chain of custody refers to the chronological documentation, or ‘paper trail’, recording the sequence, custody, control, transfer, analysis and disposition of physical or electronic evidence (EDRM, 2017). In addition to requiring traceability of materials, some sustainability schemes, such as the Kimberley Process Certification Scheme, also require concrete administration of financial proceeds. This traceability of payments creates greater transparency in the supply chain and contributes to better governance of natural resources in conflict regions (Dam-de Jong, 2015). For example, the Extractive Industries Transparency Initiative (EITI) aims specifically to enhance transparency by requiring (governments and) companies to

Table 2
Overview of sustainability schemes for minerals with their sustainability requirements marked with an x. Sources: Kickler and Franken (2017); Bettercoal (2017), Development Diamonds Standard (2018), Fair Stone (2010), International Conference of the Great Lakes Region (2018), International Tin Supply Chain initiative (2017) Kimberley Process (2018); Responsible Jewellery Council (2013), Responsible Minerals Initiative (2017), Responsible Mining Index (2018); Responsible Minerals Assurance Programme (2018), Responsible Steel (2018a, 2018b), XertifiX (2018).

Mineral/commodity	Name	Organisation	Type	Social requirements	Environmental requirements	Economic requirements
Diamonds	Kimberley Process Certification Scheme	Kimberley Process	Certification	X (Conflict-free)		
3 TG	Responsible Minerals Assurance Process (former Conflict-Free Smelter Programme)	Responsible Minerals Initiative	Assurance	X (Conflict-free)		
3T	International Tin Supply Chain Initiative	International Tin Research Institute	Traceability initiative	X		X
3 TG	Regional Certification Mechanism	International Conference on the Great Lakes Region	Certification	X		X
Diamonds	Development Diamonds Standards (Maendeleo Diamond Standards)	Diamond Development Initiative International	Programme/Standard	X	X	X
All mineral resources	Standard for Responsible Mining	Initiative for Responsible Mining Assurance	Standard	X	X	X
All mineral resources	Responsible Mining Index	Responsible Mining Index	Index	X	X	X
3T	Certified Trading Chains Programme	Bundesanstalt für Geowissenschaften und Rohstoffe	Certification	X	X	X
Coal	Bettercoal Code	Bettercoal Initiative	Standard	X	X	X
Aluminium	Aluminium Stewardship Initiative	Aluminium Stewardship Initiative	Standard	X	X	X
Steel	Responsible Steel Stewardship	Australian Steel Stewardship Forum	Standard	X	X	X
Diamonds, gold and platinum group metals	RJC Certification	Responsible Jewellery Council	Certification	X	X	X
Gold	Fairmined Standard	Alliance for Responsible Mining with Fairtrade Foundation	Standard	X	X	X
Natural stone	Fair Stone	Fair Stone e.V.	Standard	X	X	X
Natural stone	XertifiX Criteria	XertifiX e.V.	Standard/ Certification	X	X	X

Table 3
Requirements and steps in the supply chain covered by the sustainability schemes.

	Social requirements	Social, environmental and economic requirements
Upstream	• Kimberley Process Certification Scheme • Responsible Minerals Assurance Process • International Tin Supply Chain Initiative • Regional Certification Mechanism	• Development Diamonds standards • Standard for Responsible Mining • Responsible Mining Index • Certified Trading Chains Programme • Bettercoal Code
Supply Chain	**Socially responsible sourcing**	**Sustainable sourcing (upstream)** • Aluminium Stewardship Initiative • Fairmined standard • Fair Stone • XertifiX • Responsible Steel Stewardship • Responsible Jewellery Council **Sustainable sourcing (supply chain)**

report on their payments.

There are four different 'chain of custody' models in use: the identity preservation model, the physical segregation model, the mass balance model and the book and claim approach (ISEAL, 2016).

With the identify preservation model, a certified product from a certified site is separated from other sources, while with the physical segregation model, certified products also stay segregated from non-certified sources, but products from different locations may be mixed. Particularly in conflict areas, high-risk areas and areas with artisanal and small-scale mining (such as the African Great Lakes Region), sustainability schemes work with a physical segregation model to trace the mineral from the mining site to the smelter, thus ensuring certified and non-certified minerals are not mixed. Tools to ensure physical traceability include tracking systems such as a label with a scan code (also called 'bagging and tagging').

With the mass balance model, certified and non-certified minerals may be mixed, but their respective volumes must be documented and assured in the value chain. The Responsible Minerals Initiative assures conflict-free minerals at the smelter level, for example. Some smelters consider that their position in the supply chain shoulders them with a disproportionate burden and responsibility, however, and hold that other actors, both upstream and downstream, should bear greater responsibility (STRADE, 2018). While there are currently assured 'conflict-free' smelters for 3 TG, for other minerals it is unlikely that all supplies to the smelter can be verified unless a mass balance approach is adopted to ensure smelters process only responsibly sourced minerals (STRADE, 2018).

Finally, with the book and claim approach, also called 'credit trading', sustainability certificates or credits are issued at the beginning of the supply chain. These can be bought by market participants at the end of the supply chain, through a certificate or trading platform. There is no physical traceability of the material in the supply chain and it is not known whether the end product contains any certified product (ISEAL, 2016).

Furthermore, blockchain technology is emerging as a tool for supply chain traceability (RCS Global and ICMM, 2017). Though the blockchain technology is generally associated with cryptocurrencies like bitcoin, researchers see its potential in resource governance, too (Chapron, 2017), as it would enable secure traceability of certifications and other information in the supply chain. A blockchain can be seen as an online/distributed ledger, providing proof that a recorded piece of information (data, document, transaction, certificate, etc.) existed at a particular time (Ecomatters, 2018). Information that can be logged (using a mobile phone, for example) includes the mineral volume or weight, photographs, relevant times and dates. Once logged in the blockchain, the information cannot be changed (Investor Intel, 2017). The difficulty with using a blockchain for mineral traceability is that there is a need to verify the physical transaction. One option is to have it verified by a trustworthy sustainability scheme, which would need to have been rolled out at the locations concerned. Verification of the transactions could be done using a mass balance approach, by tracing the amounts of certified materials recorded in the ledger by each company.

The type of blockchain being piloted here and there in sustainability schemes is usually a private, as opposed to public, blockchain. A public blockchain network, which anyone can join to make a transaction, has two main drawbacks: it requires a substantial amount of computational power, while its openness supports only a weak notion of security (IBM, 2017). In a private blockchain, access and transactions can be controlled by multiple stakeholders, access is restricted and therefore more secure, and transactions can be made transparent to outside parties.

Fig. 3 provides an overview of the sustainability schemes, aligned with the certified or assured companies in the supply chain. The arrows illustrate which steps are covered by a chain of custody model.

It is worth noting that a focus on traceability may detract from the sustainability agenda. According to Hilson (2014), for example, the 'ethical minerals' agenda, with its preoccupation with traceability, may overshadow certain other sustainability objectives like fair trade and empowerment of small producers.

3.5.4. Synopsis

Several management approaches to responsible sourcing can be identified, Companies can adopt supply chain 'due diligence' to proactively manage their supply chains, which is particularly useful for identifying and managing specific risks like sourcing from mines operated by armed groups ('conflict minerals'). To manage these risks, companies can source their materials via 'sustainability schemes'. While supply chain due diligence and supply chain mapping can in principle be used for sustainable, socially responsible and green sourcing, analysis of company reports shows that the current focus is mainly on the sourcing of 'conflict-free' minerals, i.e. on socially responsible sourcing. At present, most companies have adopted management approaches because of legislative requirements (generally with respect to conflict-free sourcing), but given evolving consumer and investor demand for responsible sourcing, companies would be wise to implement a flexible compliance programme in order to meet additional responsible sourcing requirements and anticipate shifting markets for their products (Sarfaty, 2015).

4. Discussion

The topic of responsible sourcing of minerals is relatively new and only nine articles were found that are specifically linked to the subject. These were published between 2014 and 2017, five of which in 2017, indicating growing interest in the topic.

In company documents as well as the literature, the main focus of responsible sourcing of minerals is on the conflict minerals tin, tantalum, tungsten and gold (3 TG), which can be explained by the

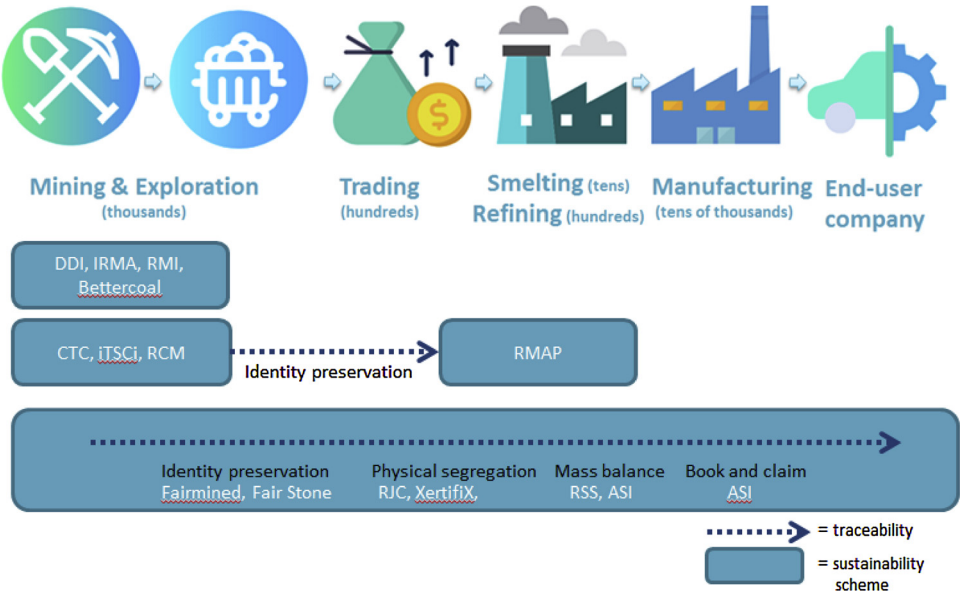

Fig. 3. Sustainability schemes: coverage of mining (left), smelting (centre) or entire supply chain (left to right) and chain of custody model.
Sources: Kickler and Franken, Aluminium Stewardship Initiative (ASI), Initiative for Responsible Mining Assurance (IRMA), Development Diamonds Standards, Regional Certification Mechanism (RCM), Certified Trading Chains (CTC), (Responsible Mining Index (RMI), 2018), Responsible Minerals Assurance Programme (RMAP), (Responsible Steel Stewardship (RSS), Responsible Jewellery Council (RJC), Philips and FlatIcon.

legislative requirements laid down in Section 1502 of the Dodd-Frank Act and European Union Regulation 2017/821. Though the focus has been primarily on 3 TG, there are developments that indicate a growing interest in (voluntary) responsible sourcing of other minerals, too. The OECD has announced, for example, that they may add supplements to their Due Diligence guidance covering other minerals. In the latest discussions at the OECD's Forum on Responsible Mineral Supply Chains, inclusion of cobalt and mica was debated (OECD, 2018). Several companies already include cobalt in their responsible sourcing policies. In addition, the development of sustainability schemes for other minerals shows that interest in responsible sourcing extends beyond just 'conflict minerals'. For example, the analysis of the Responsible Mining Index is not based on specific minerals, but on specific companies. Also, many sustainability schemes include environmental, economic as well as social requirements.

The development of sustainability schemes and the emerging literature on responsible sourcing indicate that attention is moving from addressing responsibility issues at mines only to include the entire supply chain, i.e. including processing and manufacturing, too. At a policy level this is also the trend. The United Nations Global Compact, for instance, encourages companies to adopt sustainability goals and apply sustainable practices throughout the supply chain, setting environmental, social and economic goals. The evolving consumer and investor demand for responsible sourcing could expand the types of companies involved as well as the types of products and markets.

A lack of transparency in mineral supply chains makes responsible sourcing difficult, for example because downstream companies cannot identify their suppliers (up to the smelter). There are certain developments underway, however, that could improve transparency. Some of the (bigger) companies have started to publish a list of their suppliers beyond the first tier, while some sustainability schemes require transparency in payments and traceability from beginning to end of the supply chain, through a 'chain of custody' certification, for example. Lastly, several sustainability schemes have piloted blockchain technology in an effort to improve supply chain transparency and traceability.

These developments will affect approaches to responsible sourcing and put companies downstream in the supply chain in a better position to influence companies upstream.

5. Conclusions

This study aimed to create a better understanding of responsible sourcing of minerals. It defined responsible sourcing as 'the management of social, environmental and/or economic sustainability in the supply chain through production data'. While this is rooted in existing definitions, it adds a brief indication of how responsible sourcing works: 'through production data'. This 'how' distinguishes the term from responsible procurement, which in this study we define as 'the management of social, environmental and/or economic sustainability of suppliers through supplier information'.

Though most of the articles and company reports using the term 'responsible sourcing' do not explicitly define it, they do cite a range of sustainability requirements regarded as intrinsic to the notion. We propose that responsible sourcing should be used as an umbrella term encompassing socially responsible sourcing (social aspects), green sourcing (environmental aspects) and sustainable sourcing (social, environmental and economic aspects).

Although the term itself is not often clearly defined, a range of approaches to it are cited and described in the literature and, particularly, in company documents. This study identified two main approaches to the responsible sourcing of minerals: supply chain 'due diligence' and sourcing via 'sustainability schemes'. These approaches are closely linked, with the latter being used in pursuit of the former. Together, these approaches can in principle enable companies to cover their complex supply chains from beginning to end. Due diligence aims to manage supply chains by mitigating risks, while sourcing via sustainability schemes seeks to guarantee that certain sustainability requirements are met in the production phase.

There are numerous sustainability schemes in place for different types of minerals, but they can all be described in terms of three key characteristics. The first is the breadth of the sustainability requirements, ranging from 'conflict-free' minerals to an extensive set of environmental, social and economic requirements. The second is whether the scheme focuses solely on certification or assurance with respect to mining, or whether processing and manufacturing are also included. The third defining characteristic is a scheme's traceability: whether it includes traceability (or a 'chain of custody' model) and, if so, whether this takes in the entire supply chain or only the trajectory from mine to smelter. This study mapped the sustainability requirements of these schemes and used these to categorize them as socially responsible sourcing, sustainable sourcing or green sourcing. It also identified the extent in the supply chain to which there is assurance or certification and how far traceability extends.

There are only a limited number of studies that have examined the meaning of the term 'responsible sourcing' of minerals. This study fills

the gap by looking both at the theoretical meaning and the practical implementation of this notion. In the process, descriptions of responsible sourcing in other fields were also analysed. Our study thus provides a useful reference point and a springboard for future research on responsible sourcing and approaches to achieving it.

Disclaimer

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Appendix A. Supplementary data

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