MiReBooks

+ MIXED REALITY CONTENT

MIXED REALITY HANDBOOKS FOR MINING ENGINEERS

VOLUME 1

PART I _ SUSTAINABILITY IN MINING
PART II _ MINE PLANNING

Carsten Drebenstedt, Susanne Feiel, Peter Moser (Eds.)

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MIXED REALITY HANDBOOKS FOR MINING ENGINEERS

VOLUME 1

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PART I
SUSTAINABILITY IN MINING

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MINE PLANNING

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Context of MiReBooks

The MiRe Books series (Mixed Reality Handbooks for Mining Education) aims to contribute to higher education programmes in mining by presenting the content in a new way using modern, digital media, especially mixed reality with elements of virtual reality (VR) and augmented reality (AR). Using a terminal device, the reader can view the multimedia contents of the book series at any location – from home, on the road or in the classroom – e.g. as 3D models, motion simulations and videos from different perspectives, also in 360° format. Conventional drawings and photos can thus be better accessed and complement the transfer of knowledge.

The book series is aimed at students as well as experts and the public interested in raw material topics. With the integration of digital elements into textbooks and reference books, new opportunities arise for knowledge development and transfer as well as for increasing transparency with regard to complex processes: e.g. how does the machine/process really work, what interventions are associated with raw material extraction, and what does the post-mining landscape look like?

The impetus for the book series came at the suggestion of Montanuniversität Leoben based on a project funded by EIT Raw Materials in the period 2017 to 2020. A consortium of universities and companies built the platform for depositing and accessing the digital content and provided the first content. Special thanks therefore go to the funding institution and the partners Montanuniversität Leoben, TU Graz, TU Bergakademie Freiberg, Lulea University of Technology, RWTH Aachen, Tallinn University of Technology, Università degli Studi di Trento, VTT Technical Research Centre of Finland Ltd, Epiroc Ropck Drills AB, KGHM Cuprum and Luossavaara-Kiirunavaara AB; furthermore, to the University of New South Wales and VA Erzberg GmbH.

After completion of the project, books on the various relevant mining topics are now being published in loose succession. The digital content is constantly being expanded. The first volumes are on 'Mining and Sustainability' and 'Economic Geology and Mine Planning'. Other planned volumes will be dedicated to e.g. surface and underground mining technologies, safety and environmental protection, and rock mechanics, as well as to mine closure and post-mining landscapes.

Pedagogical teaching philosophy

The MiReBooks project is a direct response in tackling the European Union's revised 'Digital Education Action Plan' (2021-2027), in which two strategic priorities have been identified: firstly, 'Fostering the development of a high-performing digital education ecosystem' and secondly, 'Enhancing digital skills and competences for the digital transformation'[1]. This goes together well with the necessity that future workers within the mining industry will need more digital skills due to the shift to new technologies such as remote-controlled operational systems and autonomous drones and vehicles (EY, 2019)[2].

Furthermore, utilising digital aspects within traditionally based education bridges the gap between university curriculum goals and student digital natives.

Funded by the European Institute of Innovation and Technology (EIT) and by the Raw Materials Knowledge and Innovation Community (KIC)[3] and co-funded by Montanuniversität Lebeon, MiReBooks was a cross-border project that developed a series of virtual and augmented reality-based (Mixed Reality, MR) interactive mining handbooks which are to be used as a new digital standard for higher mining education throughout Europe.

The MiReBook series has been set out using state-of-the-art pedagogical frameworks complete with a transparent teaching and learning pathway. The content of the book series was developed by various experts in their respective fields. Utilising the latest knowledge and combining this with innovative technology, the learning experience of the students will tackle all three components of each identified competence i.e. Knowledge, Skills and Ability.

The goal behind the books is to offer the blend of technical knowledge combined with state-of-the-art digital application to support and deepen the students' understanding of the material and, ergo, to optimise their competences in the respective fields.

Didactics

Each book in the series comes complete with a learning pathway which sets out the specific learning goals according to Bloom's Taxonomy[4]. Educators are then able to ascertain the assessment which they are able to provide based on the level required by the participating students, e.g. Bachelor or Master etc.

Furthermore, each book offers competence checks. These provide the students with the opportunity to self-evaluate their comprehension of the material which they have completed without the need for supervision. Asynchronous support is also given to educators and students in the form of a fully functional and up-to-date MiReBooks platform. Here additional material and links are provided to videos, articles and support.

One significant edition offered via the platform for educators is an extensive guide called 'new methods in mining education – mirebooks handbook' (➡ Online Resource 0.1). This explains in depth the didactics, use and application of teaching 4.0 and will guide you through the characteristics of Mixed Reality technologies with practical input on how to take the first steps towards your own MR teaching concept.

ONLINE RESOURCE 0.1 NEW METHODS IN MINING EDUCATION – MIREBOOKS HANDBOOK

References:

1 https://education.ec.europa.eu/focus-topics/digital-education/action-plan

2 EY. 2014. The Future of Work: the Changing Skills Landscape for Miners: A Report for the Minerals Council of Australia. Ernst & Young, Australia. Retrieved from: https://minerals.org.au/sites/default/files/190214%20The%20Future%20of%20Work%20the%20Changing%20Skills%20Landscape%20for%20Miners.pdf

3 https://eitrawmaterials.eu

4 https://bloomstaxonomy.net/

The importance of raw material extraction for society

'Everything comes from mining' was once a proud saying of workers in the raw material supply chain. It is no coincidence that the early epochs of human history were named after the dominant materials: Stone Age, Bronze Age and Iron Age. Today as well, materials dominate the development of society, making the manufacturing of aeroplanes, computers and solar cells possible. However, it is no longer just individual chemical elements, such as carbon or uranium as energy carriers, but complex alloys and a multitude of elements which enable technology to function – in a mobile phone there are about 60 different ones.

Before materials become products, the raw materials must be provided. If these are mineral and energy raw materials, they are extracted from the earth's crust in a process called mining. According to their use, geo-raw materials are divided into construction raw materials, energy raw materials, metals and industrial minerals. Today, we need them for all of our basic needs: housing, food, mobility, communication ...

The trend in the demand for geo-raw materials is clear: as world population grows and the standard of living rises, so does the consumption of raw materials. Whereas 100 years ago a household made do with about 180 items, today that figure is already about 10.000 in Europe!

Construction raw materials (sand, gravel, clay, limestone ...) with a share of approx. 50% and energy raw materials (coal, oil, natural gas ...) with a share of approx. 40% make up the lion's share of raw material extraction. Only 10% is accounted for by the multitude of metals (base metals, non-ferrous metals, precious metals ...) and industrial minerals (salt, gypsum, kaolinite, bentonite, graphite, fluorite, baryte ...). In the case of metals, the mining of the base metals iron (approx. 1.540 million t/a), aluminium (approx. 63 million t/a) and copper (approx. 21 million t/a) dominates. Some metals, such as lithium (approx. 200.000 t/a) and rare earths (200.000 t/a), have only gained in importance during recent decades and, despite their small quantity, have enormous significance for technology development: e.g. in the energy sector (WMD, 2021).

World mining production in 2019, excluding construction raw materials, amounts to approx. 18 billion t per year and has roughly doubled since 1984 (WMD, 2021). In relation to the world population, this is an average of approx. 2,5 t per person per year. In Europe it is about 6 t per year. The most effective way to reverse the trend seems to be to abandon fossil fuels, which are dominated by about 7,7 billion t/a of coal and about the same amount of natural oil and natural gas together. At the same time, climate-damaging emissions will also decrease. However, the demand for raw materials for alternative energy supply systems will then increase. The study 'Metals for Clean Energy: Pathways to solving Europe's raw materials challenge' (KU LEUVEN, 2022) illustrates the challenges in Europe alone for the ambitious approach of meeting the Paris climate targets of 2015. According to this study, the annual demand for metals (excluding steel) will grow from the current approx. 20 million tonnes to up to 75 million tonnes by 2050. By far the largest share is accounted for by aluminium and copper, whose availability must increase by 40% and 50% respectively. Cobalt with 403%, dysprosium with 433% and lithium with 2.109% are at the top of the demand increases.

The crux of the matter is that metals such as copper – which are needed for e-mobility and wind turbines, for example – only occur in low concentrations in the ore. With a copper content of 1% in the ore, for 1 t of pure copper almost 100 t of finely-ground waste rock is produced, which is flushed into special tailings, plus about the same amount of overburden, which is mainly deposited in external dumps. Thus, for an annual production of 20 million tonnes of copper per year, about 4 billion t of rock have to be mined, processed and deposited! These enormous amounts of mining do not appear in the statistics, but must be taken into account when considering the environmental impacts (environmental accounting).

The United Nations' Sustainable Development Goals (SDGs), officially known as 'Transforming our world: the 2030 Agenda for Sustainable Development' is a set of 17 Global Goals to end poverty, protect the planet, and ensure prosperity for all. There are estimations that the need for mineral raw materials including mineral fuels and non-energy raw materials should at least double to reach these UN goals.

Maybe a circular economy will find the balance between demand, supply and use; but such an economy is at the very beginning of its development. It will show a way to reduce the extraction of raw materials and to protect the environment and resources by considering the responsible use of geo raw materials and energy. Solutions are long-lasting products that are used more intensively (e.g. shared), will be repaired, and only as a last consideration will be recycled. Not all raw materials can be recovered during recycling: e.g. the raw materials gypsum and clay used for cement production from the product concrete. In the case of glass and the base metals, this has been possible on a large scale for decades. However, due to the growing demand for raw materials, the often long time of products in use – e.g. steel bridges – and the losses during recycling, the extraction of primary raw materials will continue to be necessary for the foreseeable future. For raw materials that have only recently become important, it will take decades before they are even available for recycling.

Highly selective raw material extraction and adapted processing can increase the yield of valuable materials from deposits and reduce raw material losses. This requires good planning and adapted techniques and technology. The use of by-products from deposits as well as the residues from treatment and processing also increases raw material efficiency. Residue piles of the past are already being mined again thanks to new technologies and increased prices.

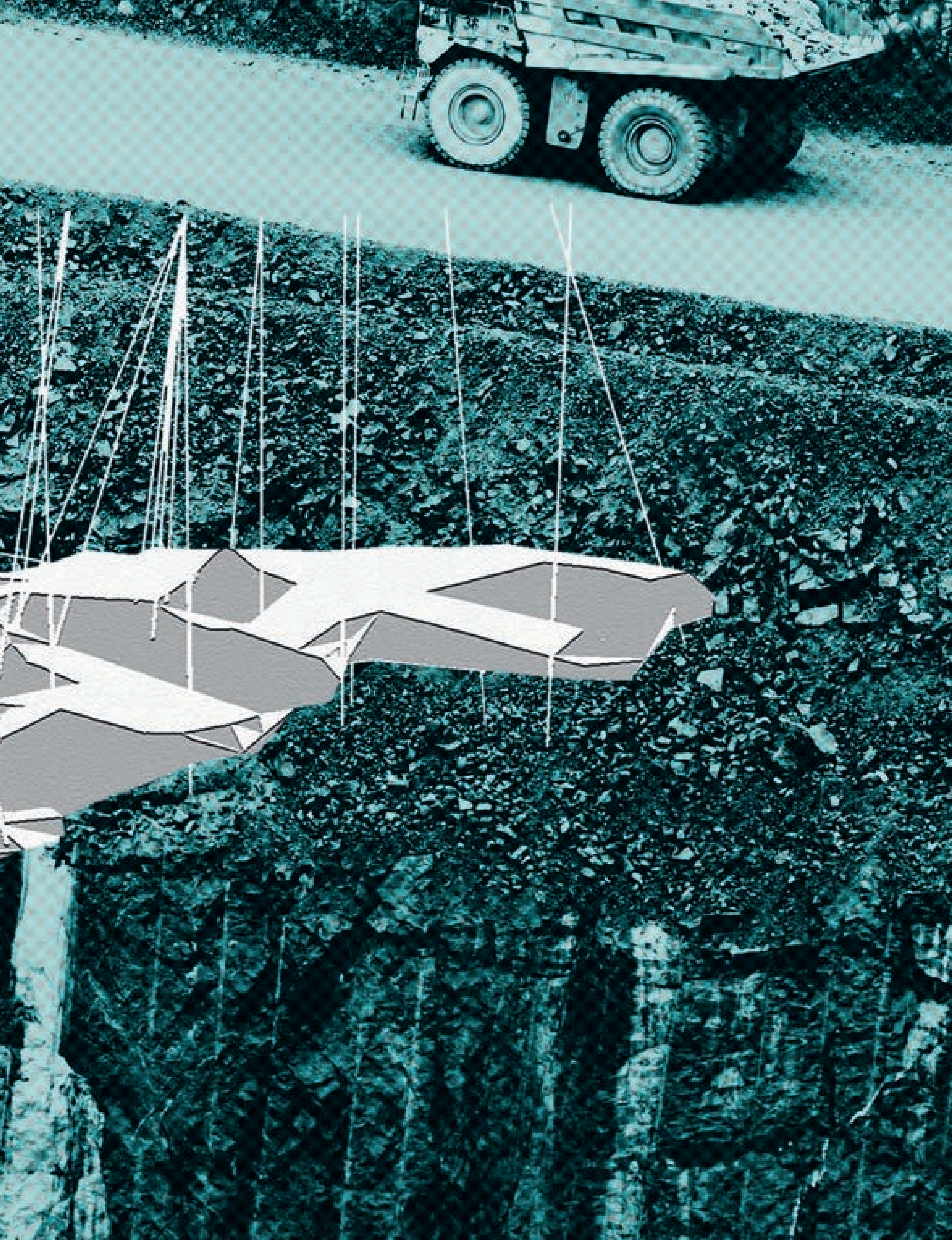
Deeper layers of the earth's crust, smaller deposits, the seabed and outer space also need to be further investigated scientifically as future sources of raw materials, but also for the impacts the extraction of such deposits may cause.

We hope that with the MiRe Books series we will contribute to the positive development of mining in the fast-changing environment of the 21st century, and we wish our readers not just an entertaining and exciting experience with the materials, but also one which they will be able to use as much as possible in their day-to-day lives in mining.

Units

**ONLINE RESOURCE 0.2
LINK TO INTERNATIONAL
SYSTEM OF UNITS**

The International System of Units (SI) is used in all tables and calculations of this book. Furthermore, according to ISO 80.000 and the International System of Quantities (ISQ) a comma ',' is used throughout this book as a decimal separator and as the thousands separator a point '.'



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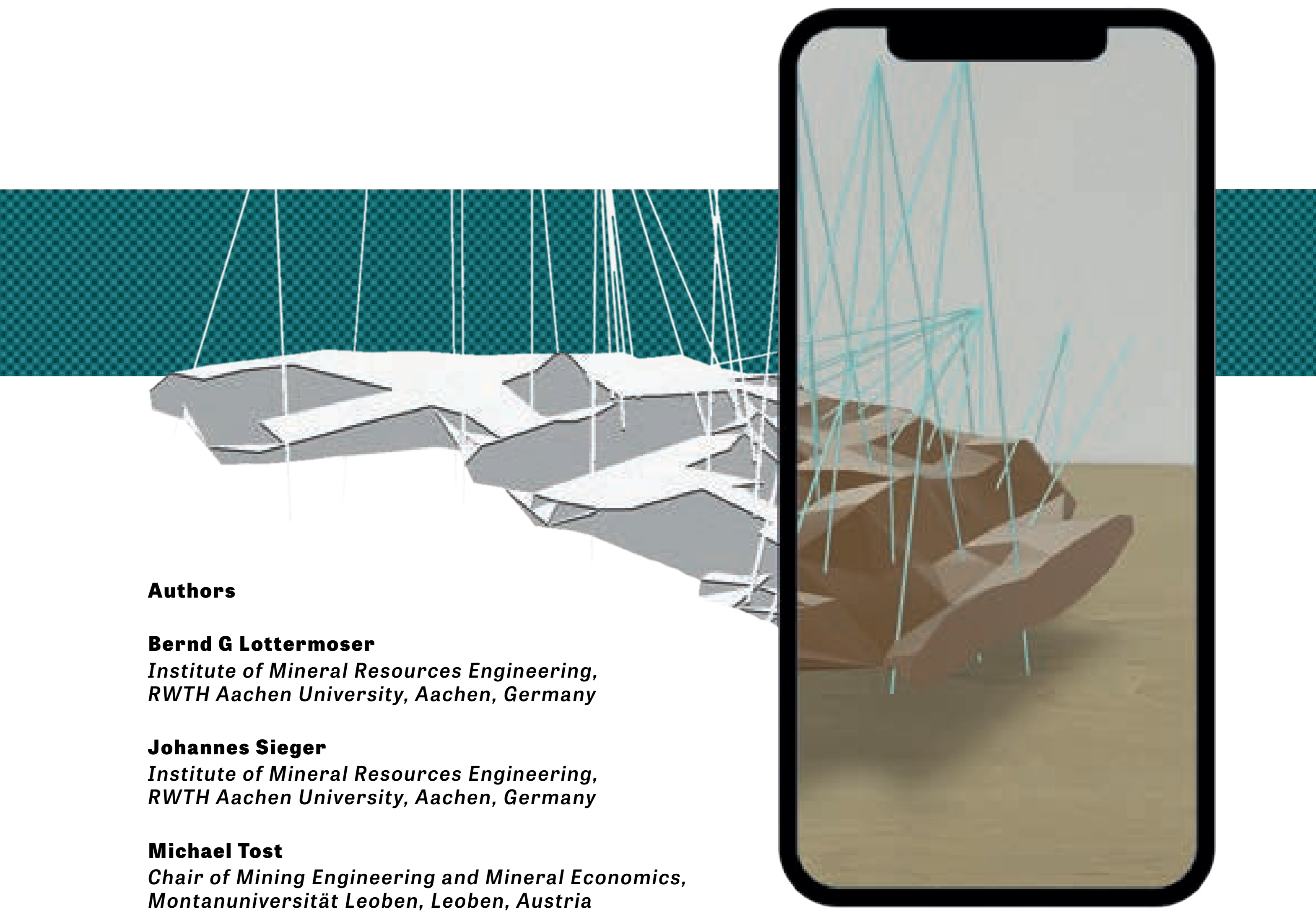

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Learning outcomes of Part I

Upon successful completion of the contents of Part I of this book, participants will be able to:

1 Explain in depth that modern mining requires more than just technical solutions for the extraction of mineral resources

2 Critically appraise the fundamental terminology, concepts, principles and theories used in describing sustainability in mining, including the concepts of Social License to Operate (SLO), Corporate Social Responsibility (CSR), Environmental, Social and Governance (ESG), Sustainability and Sustainable Development (SD), and Sustainable Development Goals (SDGs)

3 Critically reflect and explain that mining must address economic, environmental and social expectations with global sustainability-related trends relevant to individual mining operations and associated impacts/implications for the mining sector

4 Design, evaluate and methodically expand their own learning processes by using the provided digital learning contents, covering aspects of mining and sustainability.

Key concepts of sustainability and their significance to mining

Acronym	Definition	Significance
Sustainability or Sustainable Development (SD)	The two terms are commonly used interchangeably. However, sustainability is a concept and sustainable development is a societal goal or process, whereby the needs of the present are met without compromising the ability of future generations to meet their own needs.	Evidently, the application of traditional SD principles to mining is fundamentally difficult because mining removes limited resources. In a linear economy, conventional strategies to assess the sustainability of mining operations measure and monitor their social, environmental and economic performance. This data is used to determine and report on whether a mining operation is sustainable over the life cycle of the mine. By contrast, in a circular economy, the assessment of sustainability in mining should not focus on the life cycle of the mine but consider the long-term circularity and life cycle of the mined mineral.
Social License to Operate (SLO) or License to Operate (LTO)	The informal social contract covering the acceptance of a mine or company by its employees, the community, the public and external stakeholders.	An SLO needs to be earned during the entire life of mine cycle (prior to, during and post mining). Particular attention must be paid to the choice of the verb 'earn'. The SLO must be 'earned'. You cannot simply obtain, receive, get or acquire the SLO.
Corporate Social Responsibility (CSR)	A management concept whereby mining companies voluntarily integrate social and environmental concerns into their operations.	CSR requires practices and actions which map, assess, improve and report on the performance of a mining company on societal, environmental and economic issues.
Environmental, Social and Governance (ESG)	An approach to judge and evaluate a mining company based on environmental, social and governance criteria to determine the level of sustainability which it has achieved.	The ESG performance of corporations can be measured and assessed using a set of standards and indices.
Sustainable Development Goals (SDGs)	A collection of 17 interlinked global goals articulated by the United Nations and designed to achieve a better and more sustainable future for all.	Mining is intrinsically linked with the SDGs and can contribute to all of them.
Sustainable mining, or sustainable mineral resource development	It requires the implementation of practices that lead to environmental and social advances over traditional methods of resource development, which focus purely on economic benefits.	Methods and systems are required which will minimise negative environmental and social impacts, maintain the health and safety of mine workers, and consider the interests of all stakeholders and affected communities.

List of acronyms in Part I

4DS	4-degree scenario
AOD	Aerosol optical depth
ASM	Artisanal small-scale mining
B2DS	Beyond 2-degree scenarios
BII	Biodiversity Intactness Index
CapEx	Capital expenditures
CED	Cumulative energy demand
CEEC	Coalition for Eco Efficient Comminution
CFC	Chlorofluorocarbon
CRM	Critical raw materials
CSR	Corporate Social Responsibility
DLR	Deutsches Zentrum für Luft- und Raumfahrt (German Aerospace Centre)
E/MSY	Extinctions per million species-years
EITI	Extraction Industry Transparency Initiative
ESG	Environmental, Social and Governance
FCEV	Fuel cell electric vehicle
FDI	Foreign direct investments
FPIC	Free, prior and informed consent
GDP	Gross domestic product
GHG	Greenhouse gas
GMI	Global Mining Initiative
GRI	Global Reporting Initiative
GWP	Global warming potential
HFO	Heavy fuel oil
ICMM	International Council on Mining and Metals
IEA	International Energy Agency
IIED	International Institute for Environment and Development
ILO	International Labour Organisation
IPCC	In-pit crushing and conveying
IRENA	International Renewable Energy Agency
IRMA	Initiative for Responsible Mining Assurance
ISF	Institute for Sustainable Futures
KPI	Key performance indicator
LOM	Life of mine
LPRM	Local procurement reporting mechanism
LSM	Large-scale mining
LTIFR	Lost time injury frequency rate
LTO	License to operate
MMSD	Mining, Minerals and Sustainable Development
NFRD	Non-financial reporting directive
NGO	Non-governmental organisation
OECD	Organisation for Economic Cooperation and Development
OEM	Original equipment manufacturer
OHS	Occupational health and safety
OP	Open pit
OpEx	Operating expenses
PPA	Power purchase agreement
REE	Rare earth elements
REmap	Renewable energy roadmap
RSBN	Responsible Sourcing Blockchain Network
SD	Sustainable Development
SDG	Sustainable Development Goals
SEG	Society of Economic Geologists
SLO	Social License to Operate
SR	Stripping ratio
UG	Underground
UN	United Nations
UNDP	United Nations Development Programme
UTS	University of Technology Sydney
WBCSD	World Business Council for Sustainable Development
WBG	World Bank Group
WCED	World Commission on Environment and Development

Introduction to mining and sustainability

CHAPTER 1

1.1. Mining and the sustainability challenge

Mining is intrinsically linked to human development. Since the industrial revolution, the mining sector has been a major driver of economic growth. Today, minerals primary resource extraction is an economic driver in 81 countries. Those countries account for a quarter of the global GDP and 50 per cent of the world's population, of which almost 70 per cent live in extreme poverty (United Nations Environment Programme, 2021).

While the mining sector has great potential to lead economic growth and lessen poverty, mining itself is also often associated with financial, economic, governance, social and environmental concerns (Carvalho, 2017). In fact, the mining sector and society have a long-standing, uneasy relationship. On one hand, mining products are vital and essential parts of modern societies. Mining provides the base of industrial supply chains and delivers social development for societies. On the other hand, societies around the world are not fond of the 'holes in the ground,' and they are shifting their attention to address fundamental issues around social justice (e.g. the transparency of the industry and its wealth generation) as well as environmental protection (e.g. pollution issues, environmental footprints, greenhouse gas emissions). Hence, mining is at the core of public scrutiny and active in a field of tension involving a multitude of stakeholders that have diverse and sometimes diverging interests. Few industrial activities generate more controversy, and the mining sector faces pressure from governments, investors and society.

In future, mining and trading of mineral products will continue to have a prominent role in the global economy, inasmuch as the demand for minerals and materials will continue to increase. A recent World Bank Group report concludes that production of minerals, such as graphite, lithium and cobalt, could increase nearly 500% by 2050 to meet growing demand for clean energy technologies (➡ Video Resource 1.1). Critical raw materials (like rare earth elements) are required for sustainable development and the transition from fossil fuel to renewable energy sources. The question therefore arises as to how a growing world population can be supplied with mineral and energy resources over the long term in a sustainable manner. Providing resources for future generations economically by using environmentally sound and socially accepted practices has become and will remain a major global challenge (➡ Video Resource 1.1).

AUTHOR OF THIS CHAPTER
➡ Bernd G Lottermoser

STATEMENT

'There has always been a great difference of opinion among people about mining. Some praise it highly, the others reproach it fiercely.'

GEORGIUS AGRICOLA *(1556), German scholar, mineralogist and metallurgist*

VIDEO RESOURCE 1.1 MINING AND THE SUSTAINABILITY CHALLENGE FROM DIFFERENT PERSPECTIVES

This global challenge can only be solved through very important strategies and changes, especially in the way the mining sector engages with society and its stakeholders, integrates social and environmental concerns into its operations, and discloses its activities and reports on its sustainability practices. Thus, the core concept of sustainability, *'meeting present needs without compromising the needs of future generations',* is increasingly being incorporated into modern mine development and the life-of-mine cycle (➡ Video Resource 1.1).

COMPETENCE CHECK
How relevant is mining today?

1.2. Mining and its engagement with stakeholders

Documenting the mining sector's engagement with society at large and with individual stakeholder groups has a deep-rooted tradition in Europe. In the 16th century, Georgius Agricola (1494-1555) published his ground-breaking work 'De Re Metallica'. With this bestseller, Agricola is internationally recognised as 'the father of mining, mineralogy and metallurgy'. In addition, he became one of the first, if not the first, to document the controversy of earning **the social license to operate (SLO)** from local communities, as there are different views about the status of mining: 'There has always been a great difference of opinion among people about mining. Some praise it highly; the others reproach it fiercely' (Agricola, 1556).

The SLO is the acceptance of a mine or mining company by its employees, local community, the general public and an extended stakeholder network, including financial institutions, non-governmental organisations (NGOs) as well as local, state and national government agencies (Komnitsas, 2020). Similarly, the SLO concept is applied to other industries, including the oil and gas sector (Meehan, 2016). Today, all stakeholders are demanding stronger engagement, disclosure and transparency, to the extent that the social license is basically as important as the actual mining license itself, without which mining companies will find it impossible to operate.

COMPETENCE CHECK
Why is social acceptance relevant for mining?

ONLINE RESOURCE 1.1
ONLINE RESOURCES OF THE EXTRACTIVE INDUSTRIES TRANSPARENCY INITIATIVE (EITI)

In fact, modern societies nowadays even expect transparency in order to promote the open and accountable management of oil, gas and mineral resources. Here, the Extraction Industry Transparency Initiative (EITI) has been instrumental in articulating an international standard on how information is disclosed along the extractive industry value chain. Along this value chain, it encompasses aspects such as how extraction rights are awarded, how revenues make their way through government, or how they benefit the public (➡ Video Resource 1.2 and ➡ Online Resource 1.1).

VIDEO RESOURCE 1.2
EXTRACTION INDUSTRY TRANSPARENCY INITIATIVE: WHAT IS THE EXTRACTIVE INDUSTRIES TRANSPARENCY INITIATIVE?

Nowadays, society's expectations of mining practices have never been higher, and communities and stakeholders have found their voice. Community expectations, stakeholder perceptions, and most importantly trust can be shattered in an instant, such as the failure of a tailings dam. Society's expectations require transparency and disclosure from the mining sector. In the old days, this meant publicising through printed newspapers, posters, pamphlets and newsletters. Today, even a simple static homepage on the internet is no longer adequate. In the fast pace of information tidal waves, in which we all live today (with internet and online networks allowing constant engagement and unlimited access to information), it is no longer sufficient to just make statements and let them stand on their own. Instead, society and stakeholders expect a conversation.

For the mining sector, the SLO is an essential foundation for its activities and at the core of its **sustainability.** Today, the only way to be economically viable for a mining operation is to earn the SLO from all stakeholders and to operate in a socially responsible manner. For example, opposition to mines and failure to earn an SLO from local communities for mine development can stall (➡ Video Resource 1.3) or even prevent a project's viability (➡ Video Resource 1.4).

These days, social media and their digital networks have been accepted as communication and sharing tools by society, organisations and corporations. Also, some major mining corporations have embraced social media wholeheartedly (➡ Online Resource 1.2). Other companies and organisations see social media as a double-edged sword and shun social media completely. The main advantages of social media are, however, that they promote knowledge sharing and a conversation. Through social media channels, the mining sector is able to provide information, to respond directly to comments, and to create an open, productive dialogue. However, one should not forget in that dialogue: mining occurs because of society's hunger for resources. This fact is often lost in the conversation. Regardless, stakeholders need to be engaged and informed about planned or active mining operations so that mining corporations can earn a level of acceptance or approval by the local communities and stakeholders (i.e., the SLO). Thus, rapidly evolving communication technologies and societal expectations have led to a broad change in the way modern mining companies engage with society.

VIDEO RESOURCE 1.3
AL JAZEERA ENGLISH: ECUADOR: SMALL TOWN COMMUNITY PROTEST TO RESIST LICENSED MINING

VIDEO RESOURCE 1.4
EURONEWS: RIO TINTO ANNOUNCES PUSHBACK IN NEW LITHIUM MINE PROJECT IN SERBIA

ONLINE RESOURCE 1.2
SOCIAL MEDIA PLATFORMS OF SELECTED MINING COMPANIES

1.3. Mining and its sustainability performance

Modern mining companies have recognised their **Corporate Social Responsibility** (CSR). They have taken on the sustainability challenge and are making sustainability a core element of their business strategies and at their actual operations. Once such concepts have been adopted, a company's performance needs to be assessed by measuring parameters that should be quantifiable. Thus, the **Environmental, Social and Governance** (ESG) performance of a company can be assessed by evaluating the activities of an operation. In Europe, large companies are legally obligated by the Non-Financial Reporting Directive (NFRD – Directive 2014/95/EU) to disclose non-financial information on how they deal with social and environmental issues (Koundouri et al., 2022). Moreover, an increasing number of companies are voluntarily issuing sustainability reports as investors are putting more emphasis on the sustainability and the ESG ratings of the companies in their investment decisions. Also, investment firms use ESG ratings from companies as a guide for screening stocks for inclusion in ESG and sustainable investment portfolios and funds. However, the rating of companies according to ESG criteria remains a challenge. In 2022, for example, Tesla, the automotive company which stands out for its focus on environmentally conscious transportation, was removed from the S&P 500 index, which is dedicated to companies excelling at ESG criteria, whereas oil companies remained on the list. Clearly, concerns have been raised about the quality of the ready-made ESG ratings provided by some consultancies and ratings companies. Sustainability analysis is complex, and all ESG ratings should be based on measurable, quantifiable parameters.

An evaluation of the **social performance** of a mining company can be made by reporting on its engagement with society and its work force. Key metrics for social sustainability in mining may relate to training and education, health and safety, labour practices, social innovations and reporting. An evaluation of its **economic performance** can be made by reporting on its influence on the national economy and its own business activities. Key metrics for economic sustainability in mining may relate to investments in fixed assets, investments in research and development, pending claims, commodity production, operational excellence, economic benefits to others and operational profits. An evaluation of **environmental performance** can be made by measuring and monitoring environmental media (e.g. soil, water, air, sediment), biodiversity and also its improvement in various environmental metrics (e.g. the increased use of renewable energy sources on site). Quite often, the key metrics for environmental sustainability in mining relate to land disturbance and pollution reduction, water management, waste reduction, protection of biodiversity, greenhouse gas emissions, efficiencies in energy use and mine site rehabilitation (Lottermoser, 2017).

COMPETENCE CHECK
Why should mining companies meet ESG criteria?

These social, economic and environmental metrics can then be used to report on a mining operation's ESG performance and sustainability. Public reporting on sustainability in the form of documents or websites has in fact become a well-entrenched practice in the mining sector (➡ Online Resource 1.3). However, there is also criticism of some sustainability reports, as the documentation is sometimes vague, incomplete or lacking in quality and transparency. In fact, a presentation on ESG performance can even be deceptive, as companies may use their communication strategies to convince the public or individuals that their activities and products are environmentally friendly, even when they are not (➡ 'greenwashing,' Video Resource 1.5). Until ESG performance can be independently verified, the quality and transparency of ESG ratings, which are used to label or even rate companies, operations or products as 'green' or 'ESG' compliant, will continue to be met with much criticism and greater scrutiny.

ONLINE RESOURCE 1.3 SUSTAINABILITY REPORTS OF SELECTED MINING COMPANIES

VIDEO RESOURCE 1.5 BBC: WHAT IS GREENWASHING?

1.4. Scope of Part I

Part I of this mixed reality book focuses on sustainability principles and challenges in industrial surface and underground mining, where sophisticated machinery is employed. Unorganised, artisanal small-scale mining (ASM), which does not make use of sophisticated machinery, has not been considered in this book. The book has thereby been organised into four chapters. **Chapter 1** sets the scene as an introduction. It introduces some sustainability concepts and activities in the mining sector and presents the scope of the book. **Chapter 2** provides an insight into the social license to operate (SLO) as well as the efforts required to ensure public acceptance throughout the mine's life-cycle. This chapter documents the initial definition of SLO and the development of further SLO concepts. This is followed by discussions of how SLO and SD are linked. The chapter concludes with information on how the SLO debate is pursued from a European perspective. **Chapter 3** covers the history and fundamentals of sustainability definitions, concepts and goals, whereby it also explains how sustainability is linked to mining. The chapter demonstrates that sustainable mining is conducted by improving social, economic and environmental outcomes. Furthermore, this chapter introduces sustainability-related trends that are affecting the mining industry, and it subsequently outlines the implications of these trends for the mining industry. After that, the Sustainable Development Goals (SDGs) of the United Nations are documented and it is shown in some detail how mining can contribute to the individual SDGs. Finally, **Chapter 4** concludes the book with a description on how the mining sector may contribute to the development of circular economies.

ONLINE RESOURCE 1.4
ONLINE DIGITAL RESOURCES ON MINING AND SUSTAINABILITY

CHAPTER

2

Social license to operate

AUTHOR OF THIS CHAPTER
➡ Michael Tost

STATEMENT

'You don't get your social license by going to a government ministry and making an application or simply paying a fee… It requires far more than money to truly become part of the communities in which you operate.'

PIERRE LASSONDE (2003), former President of Newmont Mining Corporation

VIDEO RESOURCE 2.1 CANADA SCIENCE AND TECHNOLOGY MUSEUM: SOCIAL LICENSE TO OPERATE – JIM COONEY

2.1. Introduction to social license to operate

In the mid to late 1990s, the mining industry was in crisis. Globalisation had led many international mining companies to explore and start mining operations in ever more – and often developing – countries. Environmental accidents such as the tailings dam failure at BHP's Ok Tedi mine and civil unrest, e.g. related to Rio Tinto's Bougainville Copper operations, were an unfortunate part of this development, increasing the risk profiles of these companies. Growing connectivity, which resulted from the communications revolution that started in the mid-1990s, also meant that previously remote mining locations in distant parts of the world were becoming connected to international civil society organisations, academic institutions and the media. No longer would the relationship of a mining project to local communities in remote parts of the developing world be out of sight for the rest of the world. This trend, combined with a period of low commodity prices – as was the case at the time – resulted in a perfect storm: investors and the public in developed countries became increasingly reluctant to support mining companies.

It was in this context that a group of mining company executives came together at the World Economic Forum to discuss the situation. They concluded that the mining industry needed a change, and they initiated the Global Mining Initiative (GMI), with the Mining, Minerals and Sustainable Development (MMSD) project, in order to understand what Sustainable Development (SD) meant for the industry (IIED, 2002).

In March 1997, as part of this broader journey, Canadian mining company Placer Dome executive Jim Cooney used the term 'social license' in a presentation at a World Bank conference for the first time (➡ Video Resource 2.1). He used it to describe the challenge that mining companies face in building relationships with local communities around their projects. Cooney argued that, especially in developing countries, the legal license for operating a mine must be complemented with a 'social license', responding to the need '*to engage with local communities that were directly affected, as well with their institutional supporters around the world, to seek their approval for the establishment of a mine in their vicinity*'.

The concept was quickly taken up and adopted in Canada and other parts of the world. Similar to SD, it resulted in a broad range of definitions and practices. This chapter describes some of the (academic) developments and definitions concerning the Social License to Operate (SLO), provides an overview of the relationship between SLO and SD, and lastly presents in detail the SLO model, as well as guidelines and tools developed in the scope of the European Horizon 2020 project MIREU.

2.2 What is a social license to operate?

Based on Cooney's initial definition, SLO quickly turned into a global concept, describing company-community relationships not just in mining, but also in other high-impact industries such as agriculture and forestry (e.g. de Jong, 2016), bioenergy (e.g. Edwards and Lacey, 2014) or tourism (e.g. Bickford et al., 2017). Over time and similarly to SD, a broad range of definitions and descriptions has emerged, with a commonality being that all agree that a formal government permit is indeed not enough. There is, however, ambiguity as to how precisely SLO unfolds and how it considers different institutional and cultural contexts. There is also a debate as to whether SLO is even the appropriate term, since there is no actual license granted by the community; the argument is sometimes made that social acceptance or social performance (preferred by the industry) would be better terms. Three concepts are further discussed below.

Concept 1: Thomson and Boutilier (2011)

Canadians Thomson and Boutilier (2011) define SLO as '*a community's perceptions of the acceptability of a company and its local operations*'. Based on observations at a Bolivian mine over a 15-year timeframe, they identified four levels of SLO, which they described in a model (Figure 2.1). They also claimed that these levels were inversely related to the level of socio-political risk, meaning that lower SLO indicates higher risk.

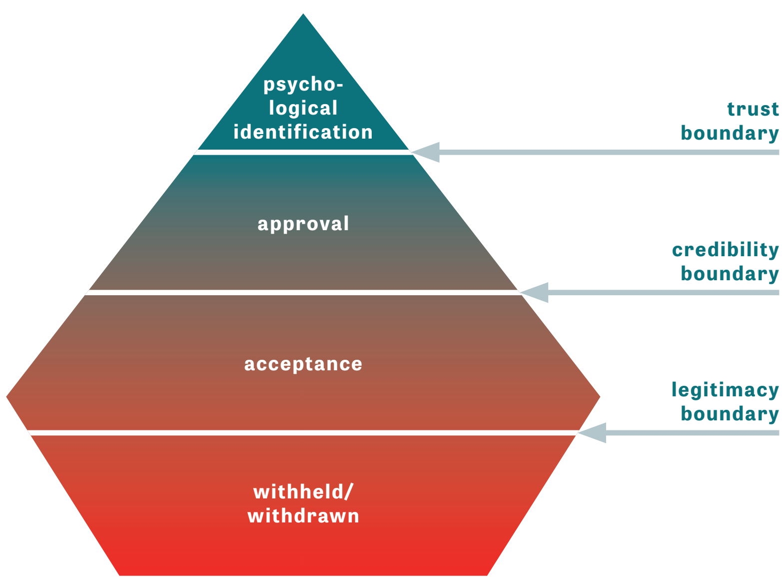

Figure 2.1 The pyramid model of SLO (after Thomson and Boutilier, 2011). © Society for Mining, Metallurgy & Exploration (SME). Used with permission from SME

Thomson and Boutilier describe the lowest level as having the SLO withheld or withdrawn. This implies that the project is in danger of restricted access to essential resources (e.g. financing, legal licenses, raw materials, labour, markets or public infrastructure). The next level of SLO is acceptance of the project. In Figure 2.1, this level covers the greatest area in order to indicate that it is the most common level of SLO that is granted. If the company establishes its credibility, the social license rises to the level of approval. Over time, if trust is established, the social license could rise to the level of psychological identification. Between the levels there are three boundaries – legitimacy, credibility and trust.

The authors found that the levels of SLO (withheld/withdrawn, acceptance, approval, psychological identification) are influenced by the following four factors:

1. Economic legitimacy ('*The perception that the project/company offers a benefit to the perceiver*')
2. Socio-political legitimacy ('*The perception that the project/company contributes to the well-being of the region, respects the local way of life, meets expectations about its role in society, and acts according to stakeholders' views of fairness*')
3. Interactional trust ('*The perception that the company and its management listens, responds, keeps promises, engages in mutual dialogue, and exhibits reciprocity in its interactions*')
4. Institutionalised trust ('*The perception that relations between the stakeholders' institutions (e.g. the community's representative organisations) and the project/company are based on an enduring regard for each other's interests').*

Thomson and Boutilier also go beyond the traditional definition of community: rather than talking about geographic community, they talk about stakeholder networks (with stakeholders being all persons with an interest in a company or project).

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