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INTRODUCTION

Introduction

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Metals demand is increasing with the global population growing and millions of people improving their standard of living and rising out of poverty every year. On top of these two factors, which have always been driving the need for metals, the urgent necessity to combat the alarmingly high levels of carbon dioxide gas (CO_2) in the atmosphere creates additional demand, demand for the traditional metals and minerals, whether iron and steel, copper and aluminium or phosphate and potash, but also a large number of new and exotic elements. The cellphone as an illustration of almost the entire periodic table is well-known and ubiquitous.

Some geologists claim that mankind has had a much more profound effect on the surface of the Earth than the ice ages, but in a much shorter time period. Mankind has become a geological force. Human impact is so forceful that it is suggested that we are now in a new geological era, called the *Anthropocene* following the Holocene.[1]

Sufficient supply, at affordable prices, of fossil-free energy and clean water are two key issues for the coming decades. To deliver all the metals and minerals to make it possible to solve these two fundamental problems will require a joint effort by all parties involved in the mining sector: industry, governments, academia and trade unions and other civil society organisations.[2] The huge volumes of metals and minerals necessary to cover future needs have caused a growing concern for the availability of "non-renewable" resources for the coming generations. It is hence important to once and for all clarify for the long term: most metals and minerals are available on earth in huge quantities. All metals are elements, which are not destroyed when mined and used. They can be recycled and in practice reused almost infinitely. The key issue today and into the future is not "will there be enough metals and minerals" but: How can the elements needed be extracted in sufficient quantities without causing irreversible harm to humans and the environment?

With the increased use of a wide range of elements, serious problems could (and most probably will) nevertheless develop. They must all be carefully considered: How to deal with potential toxicity and carcinogenicity? Will accessibility and price affect wealth distribution and equality in societies? Which are the local socio-economic effects where the mines are built? Is there a need for revised legislation and regulations? How much exploration must be undertaken to secure necessary resources? and many others.

There are studies and reports of future material demands for energy storage, renewable energy production, electric vehicles and fossil-free steel production and many other sectors and usages.[3] In spite of the urgency to start tackling both the major issue about future supply and all the "minor" problems there is, to my knowledge at least, no comprehensive studies to estimate total, global demand for metals and mineral towards 2050. The problems arising when attempting to create a global picture are certainly huge.[4] Nobody can forecast how the green energy will be produced in the coming decades, hence to estimate the amounts of metals and minerals needed is even more difficult.[5] This is a serious weakness and hampers necessary discussion about the future supply of metals and minerals. In spite of these huge uncertainties, it will be necessary to estimate the demand of metals and minerals, both the traditional ones produced in large quantities, such as iron and steel, aluminium and copper and the fertiliser elements potassium and phosphorous, which are all fundamental pillars of all societies and the new ones needed in much smaller quantities but still critical for the green

[1] For a detailed discussion about the Anthropocene please see Hamilton 2017.

[2] The recently completed EU Horizon 2020 project *Strategic dialogue for sustainable raw materials for Europe* outlines a number of pathways forward to deal with the problems created by increasing demand for metals and minerals. On a local and national level, the Swedish CSO *Georange* presents, in an attempt to take a "critical but pro-mining" stance, meeting places where urgent issues, such as access to land and jobs vs the environment can be discussed in a constructive and collaborative spirit.

[3] The World Bank report from June 2017 is but one example of such studies.

[4] Another EU Horizon 2020 project MinFuture tries to move away from monitoring individual, isolated flows to monitoring systems at company, national, regional (e.g. EU) and global levels.

[5] J-P Birat 2018 develops fascinating aspects of technolgical change in the steel industry.

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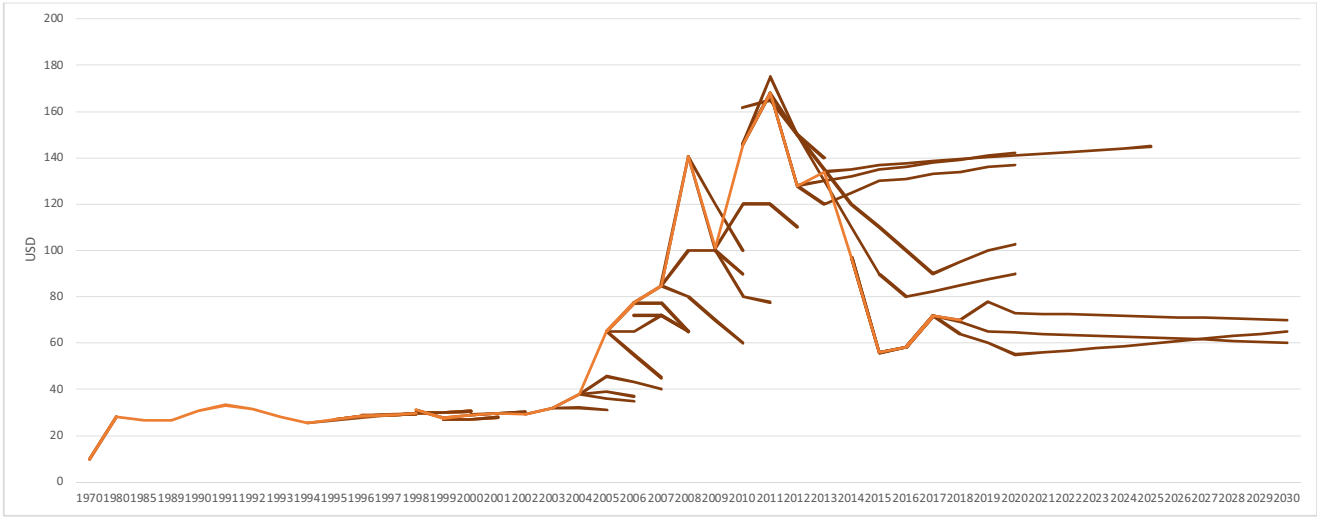

Fig. 1 Iron ore price (62%, cfr China) and forecasts (USD/t). Source: World Bank

energy production, such as cobalt, lithium, platinum group metals, rare earth elements and graphite.

The mining industry has up to now managed to satisfy the growing global demand.[6] Over the twentieth century, the industry has even done so at decreasing or flat metal prices. Mine production has continuously become more effective and less costly. The lowering of production costs has been made possible by new technologies, exploration finding new deposits and other innovations. These factors have so far offset the cost-increasing factors such as rising real wages, mineral depletion and more stringent government regulations in order to internalise externalities, for example environmental degradation and health and safety issues. However, a lot still remains to do: remediation of old sins and prevention of continued environmental degradation, in particular the threats of climate change. Efforts must be accelerated.

Historic evidence shows that production has managed to meet demands, due to technical innovations and reduced costs of production. There is of course a risk that this will not be the case in the future. There is however no doubt that the key to a future sustainable availability of metals and minerals is research and development aimed at finding and producing more, wasting less and using less. New technology and new ways of prioritising, governing and organising mining in order to secure access to all the metals and minerals needed are the only available methods to increase availability. The supply of metals to raise the low-income economies and their populations out of poverty will require huge amounts of metals and minerals. A stable supply of metals and minerals is a key issue to create equality and peace in the world.

On top of, or perhaps rather beside, the lurking ecosystem disasters, there are further "normal" mega problems: trade wars, migration, biodiversity, the rise of China as an economic, political and military power house, local and regional opposition to industrial activities (not-in-my-backyard syndrome) and availability and prices of (fossil free) energy which are all affecting the supply and demand of minerals and metals.

To understand, let alone to forecast development trends, has always been difficult. In today's world, it is almost impossible—but still necessary. The main factor in discussing the future is —even if this situation is acknowledged and actively avoided—the situation today. The influence of what is happening right now is so strong simply because it is known and to a lesser extent that it is the starting point for the trajectory of the future. Actual historic iron ore price and forecasts, made at various points in time, in Fig. 1 demonstrate this fact eloquently.

It was against this background that the traditional mining seminar at the Centre for Energy, Petroleum and Mineral Law and Policy (CEPMLP) at the University of Dundee in Scotland was revived in 2017. On April 5–6, the XVth mining seminar "What trends in regulating the mining sector? Sharing insights from research and practice" was held. The seminar was co-organised by Luleå University of Technology, the German Geological Survey (Bundesanstalt für Geowissenschafte und Rohstoffe), and Mineral Economics.

The cooperation between CEPMLP and Mineral Economics (at that time Raw Materials Report) goes a long way back. Between 1995 and 2010, we jointly published this journal under the name *Journal of Mineral Policy, Business and Environment*. In the same period, the first mining seminars were also held at the Centre in Dundee. During the days of the so-called "super cycle", the seminar became an annual flag-ship event bringing together practitioners from industry and government with academics and consultants for almost a full week loaded with debate and networking at the university

[6] These two paragraphs build largely on Tilton et al. 2018.

campus and visiting some of the picturesque castles and small whisky distilleries around Dundee. In 2017, the program of the seminar, as usual, created and supported an informal and participatory atmosphere with lively discussions when delegates did not agree on an analysis presented or conclusions reached. It is my sincere hope that the tradition can survive.

Eight of the papers presented are included in this special issue of Mineral Economics. They cover a range of legal and economic aspects of mining, and they all contribute to facilitate the continued development of a sustainable mining industry from a supportive but critical starting point. Some of the papers have been updated and rewritten in light of the discussions held in Dundee and all have been carefully scrutinised by knowledgeable reviewers.

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