Deep-Sea Mining: a Manageable Necessity or a Curse?

Fernando J.A.S. Barriga[1]

Abstract

The dependence of modern societies upon critical raw materials (nearly all metals) is overwhelming. Some believe that demand is growing faster than offer, not only because of geological availability but also for political and economic reasons.

For these reasons it is imperative to consider new sources for raw materials. The seafloor stands as a likely candidate. We must create readiness now to be prepared when the need comes.

One of the greatest fears is the environmental cost involved in mining the deep seafloor. However, the mining industry no longer deserves its partially not favorable reputation. We need both the resources and the environment. And NIMBY (Not In My Back Yard) will not help.

Keywords: Seafloor mining, recycling, circular economy, Mar Mineral exhibition

Resumo

A dependência das sociedades modernas sobre matérias-primas críticas (quase todas metais) é esmagadora. Alguns acreditam que a procura está a crescer mais rapidamente do que a oferta, não apenas em função da disponibilidade geológica, mas também por razões políticas e económicas.

Por estas razões, é imperativo considerar novas fontes de matérias-primas. O fundo do mar é um candidato provável. Devemos criar prontidão agora para estarmos preparados quando a necessidade vier.

Um dos maiores receios é o custo ambiental envolvido na mineração do fundo do mar. No entanto, a indústria mineira não merece a sua reputação por vezes não favorável. Precisamos dos recursos e do ambiente. E NIMBY (não no meu quintal) não vai ajudar

Palavras-chave: Mineração do fundo do mar, reciclagem, economia circular, Exposição Mar Mineral

[1] Fac Ciencias Univ Lisboa.Instituto Dom Luiz (IDL. FCUL, Edificio C6, Campo Grande, 1749-016 Lisboa, Portugal. f.barriga@fc.ul.pt

Introduction

Population growth and rising standards of living are placing new, extremely high levels on the demand of many mineral resources. These circumstances, and newly available technological developments, produced renewed interest in deep-sea mining. However, environmental concerns, with variable degrees of justification, are raising opposition to the concept. The forecast for the behavior of consumption versus availability of many raw materials, nearly all critical metals, arguably show that consumption will grow much faster than resource discovery onshore. Finding new sources of raw materials seems inescapable. The deep seafloor stands out as a likely candidate. There is great need of public support to the concept, and this can only be achieved through a global effort involving not only science, industry, and governance but also information of the public at large. Modern mining, properly implemented, is no more problematic than other large scale industrial operations, including agriculture and fisheries, as described further in this text. The supply of mineral resources, onshore or offshore, must be footprint-free, or nearly so, and it is essential that the public understands this. The "Not in my Back Yard" (NIMBY) attitude has a price, often a heavy environmental price.

Sea Floor Mining and the Ecosystem

Marine mining has already started, decades ago, for diamonds, currently up to depths in excess of 200 metres. Although the industry recognizes there is a footprint, it considers the footprint quite minor, because the area mined is small: in Namibia, where offshore diamond mining is now 70% of the country's total, only 3% of the concession of 3,700 sq. miles (9600 km^2) have been mined. As plans to mine deep-sea massive sulphide deposits and polymetallic nodules progress, the environmental concerns grow. Some of these concerns are as follows:

- The deep-sea ecosystems are composed of long-lived species, with low rates of reproduction. The environment may not recover from mining on a human time scale;
- The dynamics of tailings plume dispersion must be defined, tailings must be returned to the seafloor with the least possible effect on the ecosystem;

- Protected, non-mining areas must be created adjacent to mining areas;
- Mining must involve scientists, industry and governance. Research must focus on the ecosystem and on new technology; knowledge must flow and be incorporated in the production process. Governance must create adequate rules, and enforce them;
- New consumption habits must be fostered;
- There must be ample investment for the above tasks, scientists must sail and have access to state of the art tools.

(after Ana Colaço, in interview for Mar Mineral exhibition, MUHNAC, Lisboa).

The Circular Economy

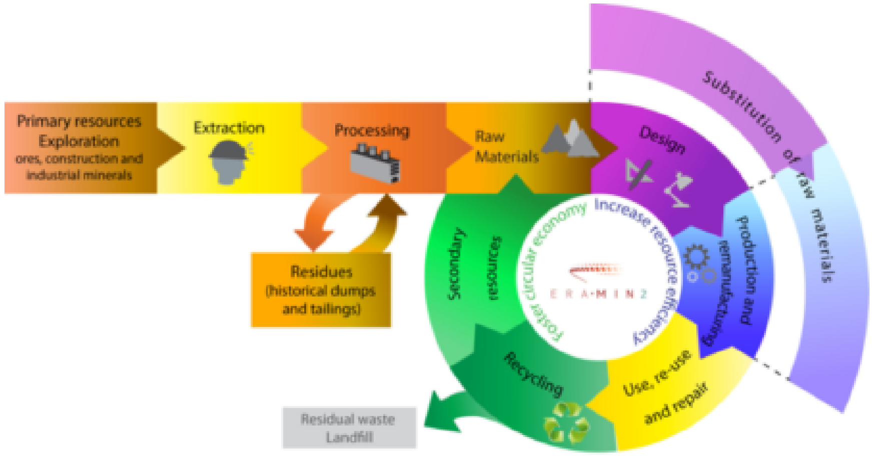

Figure 1. The circular economy (D. Carrilho, FCT (Portugal). In www.era-min.eu, retrieved January 201.

Partly because of its name, many people and organizations think that the circular economy will soon render the exploitation of primary resources obsolete. However, a truly circular economy, in this sense, will not be possible for a long time yet, because (a) losses are inevitable; (b) consumption will continue to grow for many decades. Using the name "Circular Economy" conveys the false notion that we can do without primary production. A more appropriate designation would be "Feedback Economy".

There can be no doubt that recycling, secondary resources, and the like are important (see Figure 1). However, their ability to replace the exploitation of primary resources in a planet with a population expected to grow to about 10 billion people by 2050 is implausible (United Nations Department of Economic and Social Affairs, Population Division. July 2015. Retrieved 30 May 2017). Rare Earth Elements (REE) are a good example as, in many applications (e.g. phosphor layers for flat screen for computers, TV's and smartphones) the REE concentrations are significantly lower than in natural REE ores. The economic and energy costs of recycling REE from these devices is clearly unfavourable, rendering it next to unfeasible.

Green Mining, Blue Mining

Mining no longer needs to be the culprit. The modern technological development and economic terms have allowed use of the term "green mining", on land-based mining operations. Countries like Finland and Canada, and organisations such as the MIT in the USA are pioneering the concept. Modern mining is no worse, on the contrary, than other essential industries, including fisheries and agriculture, both with a heavy load of problems. Agriculture claims about 50,000 km^2 of new arable land per year, due to topsoil loss, largely a result of agriculture. Many years ago, the Worldwatch Institute called this "… the quiet crisis in world economy" (LR Brown, EC Wolf, 1984, Worldwatch paper 60, September 1984). Recently, a senior UN official reinforced this view warning that we may have "…only 60 years of farming left if soil degradation continues" (C Arsenaut, 2017, Reuters, in Scientific American). Clearly new farming methods, less soil-destructive, must be developed and brought to generalized use. Mining is not the only industry that has to preserve the environment.

With an appropriate set of rules and their proper enforcement, mining can be "green". Many rules apply to onshore green mining, but the first is universal: Illegal and unregulated mining operations must be shut down. Figure 2 (Google Earth image retrieved 2018) shows the effect of nearly 30 years of large scale mining, limited to the mine itself, and the tailings impoundment, surrounded by a landscape identical to the pre-mining situation.

If responsible mining onshore is "green mining" the offshore counterpart can be called "blue mining". We need to be able to de-

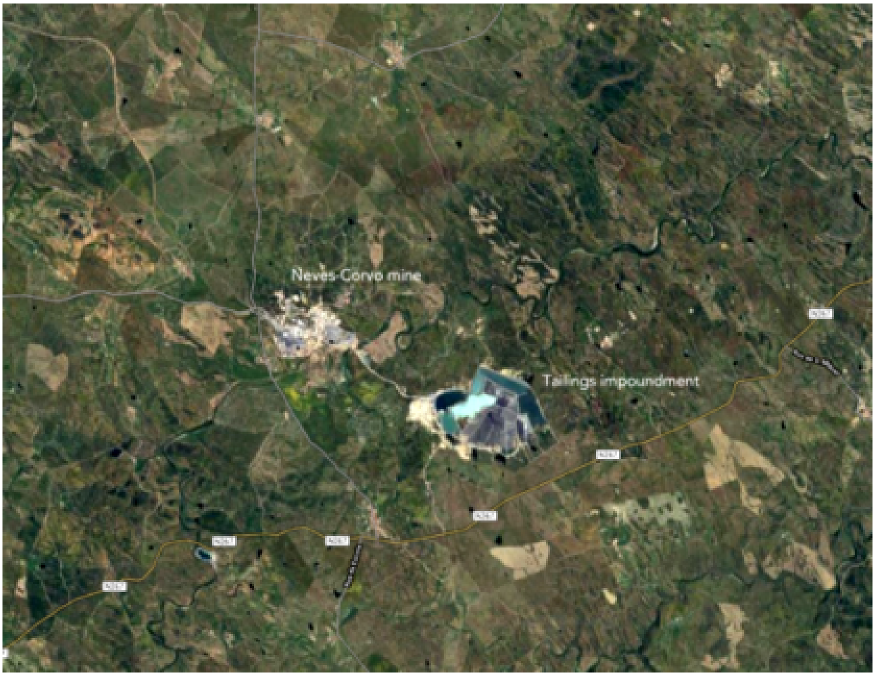

Figure 2. Google Earth image of the Neves-Corvo area in Southern Portugal. Distance between mine and impoundment about 3 km.

scribe examples of blue mining, to persuade the general public that the deep seafloor ecosystems will survive seafloor mining. A powerful statement comes from the Clarion-Clipperton Zone (CCZ). The potential area for mining in the CCZ is 12.5 million km^2. The existing concessions, mined for 20 years, will extract nodules in about 4000 km^2 of each concession, or about 0.5% of the CCZ potential area.

The Norwegian Example

Norway went through a nationwide effort, since the 1960's, to implement the offshore oil industry (http://www.norskpetroleum.no/en/ retrieved January 2018). This included a lot of apt exploration, but far more than that. Proper and careful relations with foreign oil companies, establishment of a legal framework, creation of Statoil, and a great education effort, with two main components: training young geologists, geophysicists, engineers and lawyers, and developing among the general public the notion that an oil industry could be properly established, with minimal environmental cost and great economic advantage. Fifty years later it is clear that the Norwegian oil industry is a success. The importance of education is well expressed in a simple statement: "… common causes of social conflict in the [mining] industry include insufficient consultation, lack of public participation, lack of education, environmental concerns and opposing expectancies of social and economic prospects."http://www.vttresearch.com/Documents/impact/Helena_Wessmann_Intl_Innovation.pdf, retrieved 2017).

Norway recently began working on a similar effort for offshore seafloor massive sulphide (sms) deposits. Little is known yet, but chances are Norway will become a leader in the trade.

Mar Mineral, Science and Riches on the Deep Seafloor

To help informing the public about seafloor mining issues we have assembled a museum exhibition, in Museu Nacional de História Natural e da Ciência (MUHNAC) in Lisbon. The exhibition, in 400 m^2, consists of panels with titles, short texts and graphics; 3D objects and specimens (all originals: there are no replicas). Ten video presentations (six of which produced originally for the exhibition) are an important part of the set. The exhibition is assembled on a grey concrete background, which emphasizes the ambiance. Dominant colours vary too (white – dark blue – brown).

The exhibition begins with a display of the diversity of industrial products (including many everyday products) that require mined resources; in a second area some achievements on the study of the deep seafloor are shown, with emphasis on mineral resources.

Exhibits include hydrothermal vent field samples, from the North Atlantic, the Arctic and the Pacific; carbonate conduits related with mud volcanoes and gas hydrates; a brief explanation concerning the deep biosphere; and exhibits of polymetallic nodules (about 250, on sediment, both from the Clarion-Clipperton Zone of the Equatorial Pacific) and ferromanganese crusts collected by EMEPC in the North Atlantic. The third main area consists of a display of technologies of access, surveying and sampling the seafloor, including an authentic

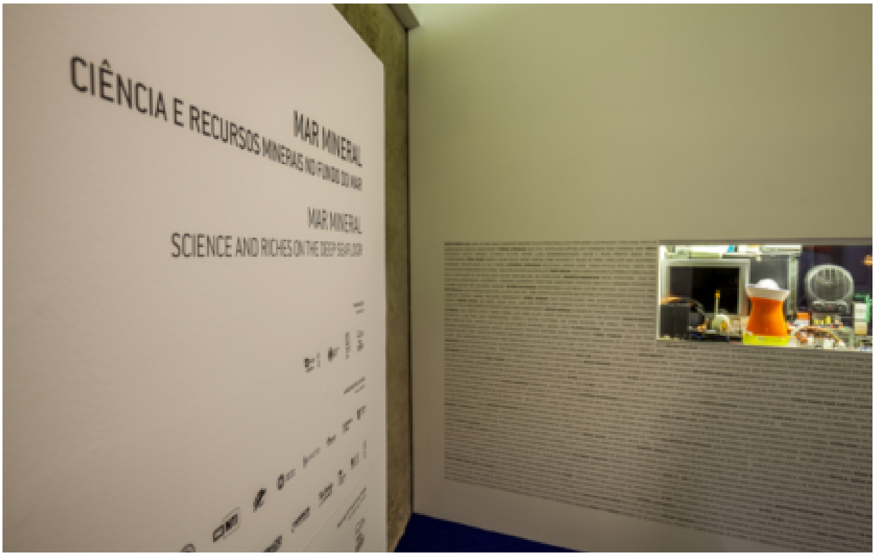

Figure 3. Mar Mineral starts by showing our extreme dependence on mineral resources. Photo Gonçalo Barriga

Figure 4. General aspect of area B, illustrating the main mineral resources already discovered on the seafloor.

AUV (Infante) made in Portugal by ISR/IST and a 3D model of the concept of seafloor mining; representations of relatively detailed exhibits on extraction solutions, vertical transport systems and ecosystem preservation; a striking presentation of the sea and seafloor under Portuguese jurisdiction, produced by EMEPC;

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Figure 5. Left, the Infante AUV, made in Portugal by ISR/IST; Centre, a lightbox describes the ROV Luso (tethered), can work down to 6000 metres. Back, map with a representation of the "Portuguese Sea" and main exploration areas for mineral resources (both EMEPC).

A fourth section recalls that some types of seafloor mineral deposits, namely massive sulphide deposits, have equivalents generated hundreds of million years ago on the floors of ancient oceans, and are now exposed on land, where they can be exploited and studied, contributing to our knowledge of the modern examples. Emphasis is placed on the Iberian Pyrite Belt of South Portugal and Southwest Spain, one of the most important provinces of ancient volcanogenic massive sulphide provinces. A series of invited conferences completes the exhibition.

Acknowledgements

This article is dedicated, as is the Mar Mineral exhibition, to the memory of Mário Ruivo, a tireless defender of the Ocean, the ecosystems and the environment at large. However, Mário was also capable of agreeing with the point of view conveyed here: deep seafloor mining yes, if properly done, respecting the environment. Hence the dedication.

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Figure 6. Area D of the Mar Mineral exhibition, dedicated to ancient seafloor massive sulphide deposits, with emphasis on the Iberian Pyrite Belt.

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