Revisiting Abiotic Depletion Potential (ADP) to assess the risk of depletion of Magnesium

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Context:

Due to resource dissipation, virgin raw materials will always be required. Then, circular economy thinking should integrate the mining industry and not oppose it. Resource depletion comes, therefore, as a concern, since mineral resources are not renewable.

Abiotic Depletion Potential (ADP):

Resource depletion accounts for the scarcity of the resource and hence the limitations in its availability to current and future generations [4]. As an attempt to access the risk of resource depletion within Life Cycle Assessment (LCA), Guinée & Heijungs (1995) [3] proposed the Abiotic Depletion Potential (ADP) method. It is a characterization factor derived by dividing the extraction rate (DRi) of a given raw material by the squared assumed stock of a resource (Ri), according to the following equation. The result is normalized by antimony data, chosen arbitrarily as a reference element.

$$ADP_i = \frac{DR_i / (R_i)^2}{DR_{ref} / (R_{ref})^2}$$

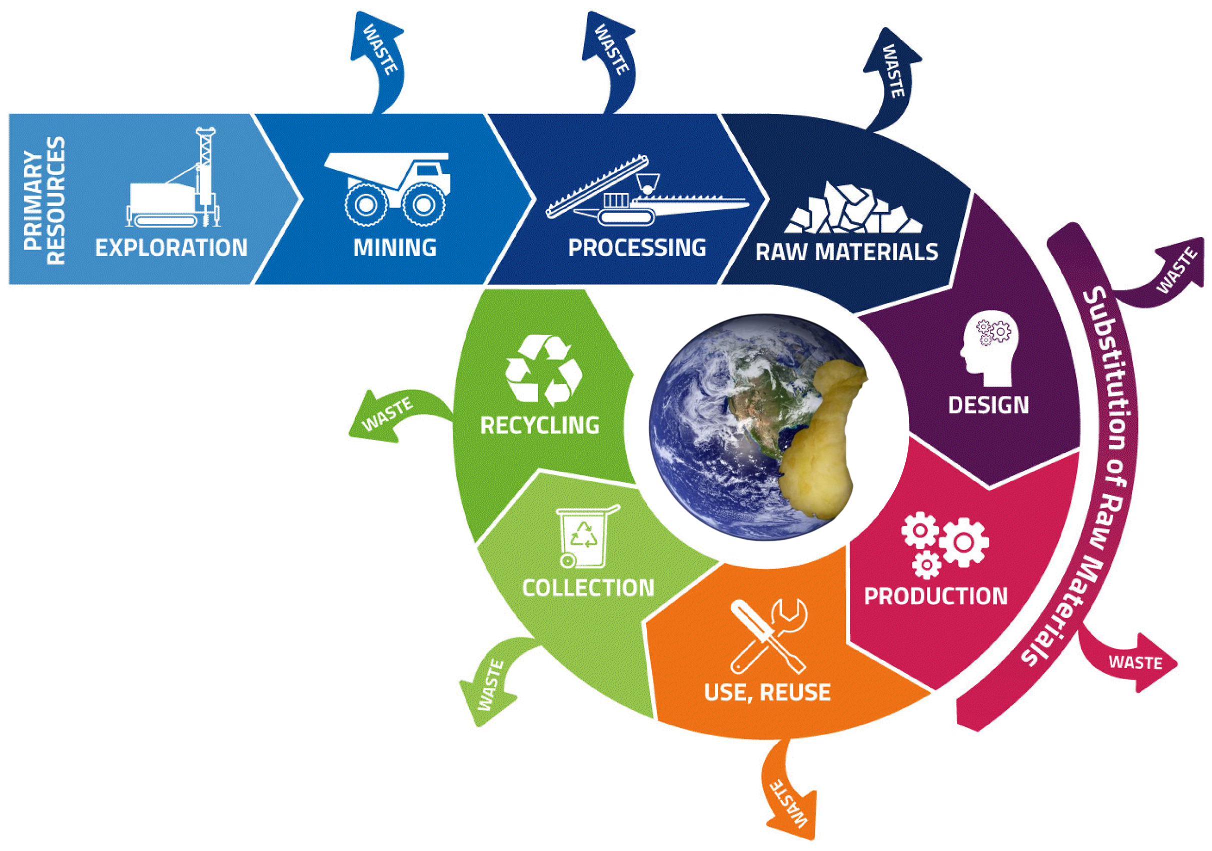

Fig. 1: Representation of a product life cycle, Source: EIT Raw Materials

Discussion:

Is There a Fixed Stock?

The determination of the stock of a given resource has been challenging and the origin of the main mistakes while assessing ADP. Guinée & Heijungs (1995) [3] proposed the "Ultimate Reserves", which accounts for all the amount of an element in the Earth's crust. This approach accounts for every mineral specie wherever in the crust, regardless the technical or economic conditions to recover and process it. Stocks are intimately related to functionality and availability; therefore, it seems not so meaningful to account for all the amount of an element, but for the fraction that is functional, recoverable and able to be processed. The concepts of mineral resource and reserve could nor serve to calculate ADP since they are a snapshot of the current context and ADP envisions a long term, being crustal content the only base reliable and stable enough. Then, some criteria must be adopted to consider availability in a very long run, which seems to be the biggest challenge.

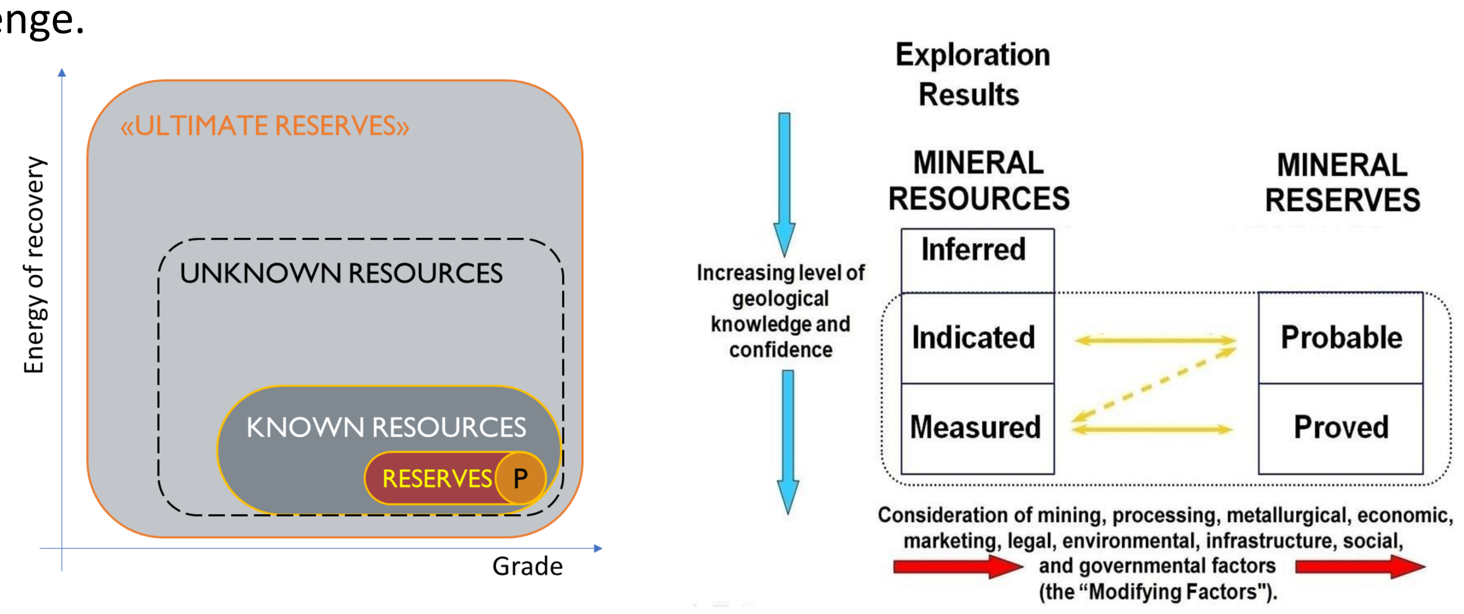

Fig. 2: Differentiation between the mineral stocks classifications [2]

Anthropogenic Stocks

With the increasing stimulus to build an industry more aligned with circular economy principles, recycling is being fostered in many industries. Then, it is important to consider the anthropogenic stocks in the calculation of ADP. However, the estimate of these stocks requires individual studies and the main uses of a given element in the Technosphere and the respective dissipation and production rates must be considered. Occupation-in-use must also be considered [1]. Additionally, if the anthropogenic stocks represent a neglectable part of the total stocks, it will not make any difference in the calculation.

ADP: A Dedicated Practice

ADP has been used in approaches that encompass a wide batch of elements and most of the times the same criteria (e.g., crustal depth) are applied to very distinct elements. This practice leads to imprecise assumptions, since it is not geologically reasonable because different elements may have distinct origins and behaviors in the Geosphere. The generalisation is also not economically supported, since elements may also have different values, not being able to afford the same extraction/processing costs. It is inconceivable to expect companies to dig as deep for limestone as they do for gold, due to the discrepant added values between these commodities. In the same way, it is unimaginable to find bauxite as deep as we find copper, given the differences in the geogenesis of these mineralisations.

Magnesium, Magnesia, Magnesite

As ADP requires a dedicated approach, studies should include a good comprehension of the element and its uses in the Technosphere. Magnesium is a very abundant element on Earth, but the high dissipative character of its main use, refractories, raises the concern with depletion. The refractory industry uses magnesia (MgO) as an important aggregate produced mainly from the calcination of magnesite (MgCO3), a CO2-intensive process. Magnesia can be also obtained from seawater and brines (common sources for Magnesium metal) and from Mg-bearing minerals as well, with very energy-intensive processes. A better understanding of the magnesium industries will allow a more meaningful ADP assessment with more assertive assumptions.

$$MgCO_{3(s)} \xrightarrow{\Delta} MgO_{(s)} + CO_{2(g)}$$

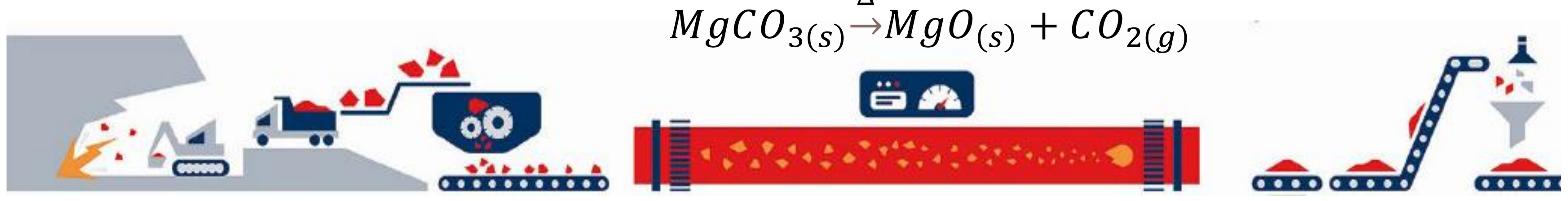

Fig. 3: Representation of magnesia production from magnesite

Conclusions:

- ADP must be applied in dedicated studies, considering the singularities of each element in the stocks and in the Technosphere;
- The estimate of the stocks seems to be the most challenging point when coming to ADP, because it lies in estimating variable factors in a very long-term;
- Anthropogenic Stocks may be included in the calculation if they are relevant when compared to the total stocks and if the dissipation rates of the main uses and the "Occupation-in-use" are considered;
- ADP is more like a matter of supply than an environmental impact.

References:

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Beneficiaries