Role of batteries and fuel cells in achieving Net Zero

Batteries for clean energy transition drive demand for deep sea mining

Introduction

The authors of the evidence in response to question eight are: Prof. Bramley J Murton (Professor of Marine Geoscience and lead scientist of the Deep-Sea Mineral Resources research team) and Dr Daniel Jones (marine biologist and Associate Head of the Ocean Bio-Geosciences Group). We run two research teams that represent the UK's foremost research leaders in seafloor mineral deposits and the potential environmental impacts of their exploitation. We work for the National Oceanography Centre (NOC), which is the UK's leading marine research institute. The NOC addresses research from the coast to the deep-sea, and spans disciplines from ocean physics, ocean climate modelling, biology, geosciences, and technology. The NOC manages the UK national research fleet and serves the UK marine science community through the National Marine Equipment Pool and the British Oceanographic Data Centre. The NOC makes the findings of its research available for public benefit including to inform public debate and decisions.

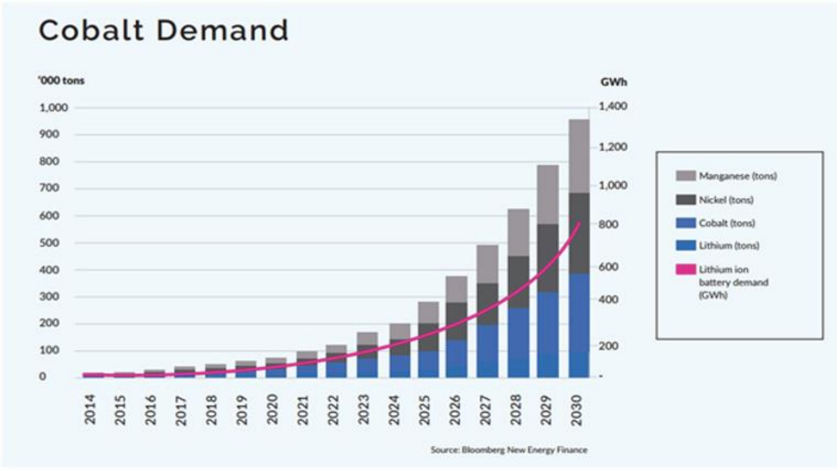
Summary

Batteries are needed to enable the transition to the low-carbon global energy economy that is needed in less than a decade, yet we are not prepared to meet the challenges. Not least of these is the supply of raw materials for the energy transition, and cobalt and lithium in particular are highlighted as major bottle-necks. In fact, if the supply of these metals is not addressed, there will be no energy transition. Here, we look at the supply, demand and shortage of cobalt, identify a vast and as yet untapped resource on the seafloor, discuss the potential environmental dangers involved, and identify potential solutions.

1. Meeting the need for cobalt for batteries from deep sea minerals

(i) the problem:

The UK has pledged to phase out new internal combustion engine domestic vehicles by 2030. There are currently 31.5 million cars on the UK roads. If we wanted to replace all these with electric vehicles (assuming they use the most resource-frugal next-generation batteries), we would need some 300,000 tonnes of cobalt. This is over three times the annual world cobalt production. Even if we only wanted to ensure all new domestic vehicles are electric, from 2030 as pledged, the UK would need to annually import the equivalent of the entire annual cobalt needs of all European industry. Not forgetting that the UK's ambitions are not alone, nor limited just to electric vehicles. Indeed, the entire green energy transition requires vastly more cobalt (as well as many other critical metals like lithium, rare-earths, and even copper) for grid upgrades, energy storage, renewable energy harvesting, and electrification in general, to power the energy transition (figures 1-3).



Cobalt price is expected to soar with the growth in demand for lithium ion batteries

Figure 1: Cobalt demand, grouped per generic usage: Source: Bloomberg New Energy Finances, (2018)

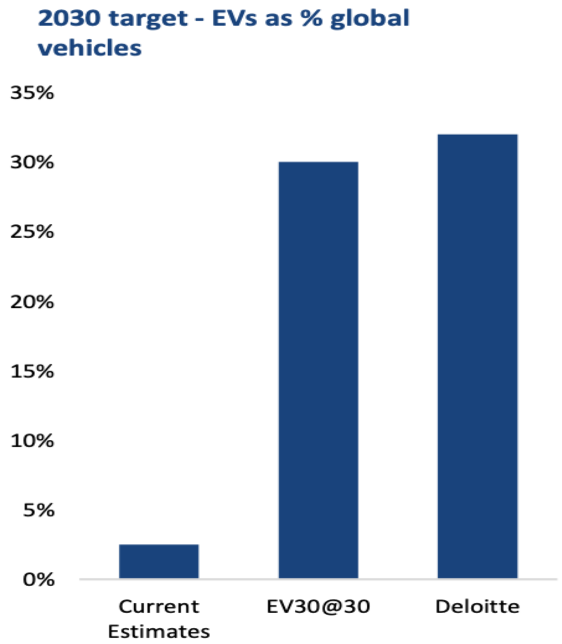


Figure 2: 2030 target growth in Electrical Vehicles (EVs) compared with current estimates, with implications for the raw materials required for their batteries. Source: McKinsey, EV30@30 and Deloitte.

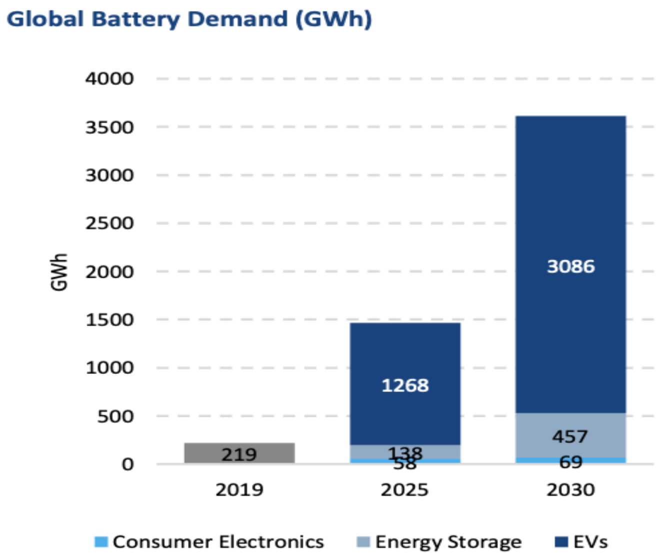


Figure 3: Battery demand based on governmental declarations and ambitions for the energy transition and the electrification of vehicles in particular. Source Deloitte, Fernley Securities, March 2021.

(ii) its significance:

Over the next few decades, global supply of raw materials must drastically change to accommodate not just the UK's transformation to a low carbon economy, but the whole World's. Although the Cobalt Institute (UK) predict that at current levels of demand, terrestrial sources of cobalt could last 100 years, this does not consider the exponential growth in demand as a result of the energy transition (figures 2 and 3). Nor does that resource potential recognise both the political instability and ethical issues surrounding the supply of cobalt from the politically unstable DRC (which dominates global mine production). Furthermore, terrestrial mining has its own detrimental footprint for both the environment and for the local population. While there are undoubtedly terrestrial cobalt resources yet to be discovered and exploited, it is generally considered that a new mine production facility takes at least a decade from initial exploration to the production of the first ore at the mine head.

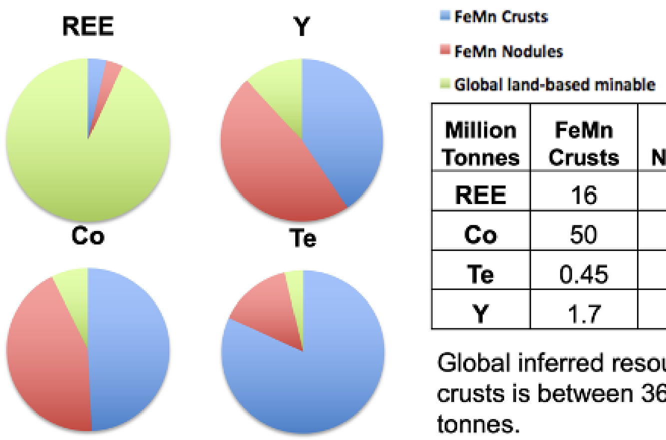
Put simply, unless new sources of cobalt (and other critical metals required to enable the energy transition) are found and bought on stream rapidly within a few (2-5) years, the UK and world together will be unable to reach anywhere near its carbon emissions pledges. We all know the IPPC predicted consequences of failing to reduce our CO_2 emissions on the global environment, economy, and toll on humanity.

(iii) the potential for mitigation:

Deep-ocean mineral deposits could make a significant contribution to future raw material supply. Growing metal demand and geopolitics are focusing increasing attention on their resource potential and economic importance. For example, the global inferred resource of marine manganese/iron-rich deposits is 36 to 200 billion metric tonnes, containing an estimated 94 million tonnes of cobalt, which is 12 times the total known land-based resource.

Seafloor FeMn deposits: a Resource Potential

Recent resource estimates[1] indicate marine FeMn deposits are major potential sources of Co Te and HREE. In particular, crusts excel as resources for Te, Co and Y.



Million Tonnes	FeMn Crusts	FeMn Nodules	Global land-based
REE	16	15	414
Co	50	44	7.5
Te	0.45	0.08	0.02
Y	1.7	2	0.5

Global inferred resource of marine FeMn crusts is between 36 and 200 billion metric tonnes.

Estimated resources of cobalt and other critical metals in deep-seafloor iron/manganese deposits. Source: World Ocean Review (2014)

For example, a single seamount (Tropic Seamount) studied by UK researchers at the National Oceanography Centre discovered deposits containing an estimated 30,000 tonnes of cobalt – enough to supply 10% of the UK domestic vehicle electrification. And the seamount is one of many in the Atlantic that are known to host these deposits. These deposits are readily accessible, and attracting industry attention.

Elsewhere, manganese/iron-rich nodules in the deep-sea are also of great interest, containing vast amounts of cobalt, nickel and other metals critical to batteries. The prime deposits are in the Pacific Ocean and a UK company (UK Seabed Resources – a subsidiary of Lockheed Martin) are one of many companies looking to exploit these over the next few decades.

There is great potential for the UK to migrate it offshore oil and gas technology to deep-sea minerals and mining, including the export of know-how, environmental monitoring, metal extraction, and value-added end-use.

Yet, extracting deep-sea mineral resources presents something of a societal conundrum. Mining will inevitably impact the natural environment (see below), yet many of the metals that these resources contain are the very ones vital to technologies that are integral to society developing a low-carbon future, meeting global sustainable development goals, and ensuring the long-term health of the planet.

2. The consequences if we get it wrong: the potential environmental impact of deep-sea mining

(i) the problem

Mining in the deep sea will cause impacts to the environment. It will affect the composition, structure, and functioning of the biological communities that live on the minerals themselves, as well as the wider marine environment and nearby habitats. Deep-sea mining is likely to be broad scale (>100 km^2 per year per operation for nodule mining) with major impacts caused by seabed mining vehicles and sediment plumes. The actions of mining vehicles will lead to habitat destruction and elimination of most living organisms within its direct path. Mining machinery will introduce noise and light pollution to the dark, quiet deep sea, impacting life at the seafloor, and in mid water, including marine mammals. Sediment plumes will be wide-reaching, likely travelling tens of km before settling on the seafloor. Sediment plumes will originate from mining equipment disturbing the seabed, as well as returned water plumes discharged in shallower ocean layers. Shallow-released particles can interact with important biological processes, organisms (e.g. plankton, birds, fish, marine mammals and turtles), and humans (via contamination of, or impact on, commercial fishing stocks).

(ii) its significance

The ecosystems of interest for mining, namely areas of active or inactive hydrothermal venting (SMS), seamounts (crusts) and abyssal plans (nodules), are very different and host different ecosystems. The communities associated with SMS and crusts can be highly productive, with dense marine life. In the case of active vents, these communities are unusual – gaining their nutrition from the chemicals released in venting. Less is known about inactive vents, although they appear to be diverse. Crusts are usually covered in diverse fauna, some of which are very large and old (e.g. corals) and may be disproportionally important for supply of new recruits. Pacific abyssal plains have low density but high diversity communities. While vent systems are better known, most deep-sea areas are poorly understood, with many unknown species. Deep-sea ecosystems are expected to be particularly sensitive to disturbance as a result of relative stability and low energy supplies.

Releasing sediment-laden water at depth could have far-reaching impacts. For example, seabed communities may be smothered, nutrients could be introduced to otherwise nutrient-poor systems, thermohaline circulation could be altered, toxic metals could be mobilized, and deep-sea fisheries may be contaminated in a similar way to those at shallower depths. Sediment plumes are likely to lead to high suspended sediment concentrations in the water column, with potential ramifications for midwater life. Suspended sediment will eventually settle over at least twice the area of the operation, and likely more. High sediment concentrations can physically damage organisms as sediments clog and damage digestive, filtering, and respiratory systems.

Existing information on the ecological effects of mining and potential recovery times is limited. Less than 20 experiments have been done starting in the 1970s. Revisits to old disturbance sites show little visible change to the disturbed tracks after several decades, very little recolonization of disturbed areas (even for microbes) and persisting biogeochemical changes affecting important ecosystem functions. Recovery from commercial-scale mining is likely to be even slower, as both the temporal and spatial scales of disturbance will be much larger than those of the experiments, and there will be cumulative impacts affecting the deep sea further complicating recovery (e.g. climate change). Recovery estimates are centuries or longer and some aspects may never recover. Regional-scale impacts could result in local extinctions and population declines, reducing biological connectivity and reproductive success.

(iii) the potential for mitigation

Deep-sea mining is thought inherently unsustainable and destructive, but impacts may be reduced with good management. Before robust management strategies can be designed fundamental research is needed to ascertain baseline conditions to better understand the communities that are at risk and further evaluation of how they are affected by mining. Environmental Impact Assessments should be done using this information to assess the risks of the project and sensitivities of the environment. These assessments should identify alternative project plans that may reduce or mitigate the impacts of the industry, helping to preserve unique and vulnerable communities. The risks of developments including mining are typically reduced by 1) avoidance; 2) minimisation; 3) restoration; or 4) offsetting. Mechanisms for avoiding impacts should include the establishment of marine protected areas, such as the network of Areas of Particular Environmental Interest in the Pacific. These should be supplemented with actions closer to the mined area, such as moving the project away from a vulnerable habitat and protecting additional sites close to the mined areas. Minimisation may include actions like introducing new technology to reduce sediment plumes. Restoration is complex and needs research to ensure that it has beneficial results but could include introducing new habitat into the deep sea to mimic that lost to mining. The last option, offsetting, is thought impractical for deep-sea mining owing to a range of biological, technical, financial and legal issues. Once a project's risks have been reduced as much as is practical, a decision can be made as to whether the economic, social, and political benefits of the project outweigh the costs. If the project is approved, then plans can be made for ongoing environmental monitoring to identify, measure and manage the impacts of the project throughout its life. If these negative effects become too severe, the project can be curtailed.

If we get it wrong, the results could have serious consequences. Impacts at the potential scale of deep-sea mining are rare in deep-ocean environments and may lead to effects that can be seen at regional scales, such as population reductions or even species extinctions. Owing to the isolation of deep-sea environments, these effects may not be felt for decades or even centuries after mining. At present, there isn't enough evidence on the potential impacts and their extent or the sensitivity, nature and connectivity of the receptor communities and species to accurately assess the potential consequences, particularly the most serious.

3. Conclusions

Deepsea minerals easily have the potential to meet the rapidly increasing gap between exponential demand growth and dwindling supply of critical metals (e.g.: cobalt) required to enable the energy transition (e.g.: through the use of batteries and electrification of road transport). Terrestrial supplies of cobalt are threatened by security of supply issues resulting from the dominance of the politically unstable DRC as the source of the mined ore, ethical and environmental practices in the DRC mines, the lag-time in finding and opening new mines, and the near monopoly position of China as the main source for the refined metal. In contrast, marine sources of cobalt can offer more secure supplies, with better regulation and environmental protection, and greater political stability. In the UK, opportunities arise for transforming existing offshore industrial sectors, such as oil and gas, to deep-sea mining. Such transformation can be of enormous economic benefit to the UK economically, strategically and trough the generation of new jobs. However, significant challenges remain for deep-sea mining in terms of environmental impact, protection, monitoring, restoration and social license. If we get this wrong, we will generate as yet unquantifiable environmental damage. Fail to do this, and we are almost certain to fail to achieve the energy transition with foreseen catastrophic consequences for the global climate.