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Mining the periodic table

By some counts, 50 of the 94 naturally occurring elements on the periodic table will be useful or even essential in a transition to a low-carbon economy. Many of the 50 are recent additions to what could be called the 'useful list' of elements that started with basics, such as gold, copper and iron, thousands of years ago. It seems that today, we have a need for every one of the 94 naturally occurring elements. We are mining the periodic table. There are several distinctive features of many recent additions to the useful list: Scarcity; complexity of extraction and a rapid (in historic terms) rise in market demand. In many cases, rapid rise in demand has been met by a concentration of supply. For example, the Democratic Republic of Congo dominates the supply of Cobalt. It is South Africa and China that dominate supplies of Platinum Group Elements and Rare Earth Elements respectively. A rapid rise in market demand also means that almost all supply is primary (mined rather than recycled) and there is a need to develop and scale up extraction technology. Add to these factors, that many of the new additions to the useful list occur as companion metals to more common elements such as copper, nickel and uranium and it is no wonder that many are deemed 'critical materials'. A critical material is one for which there is a high risk of a supply disruption, and where the impact of such a disruption would be great. The European Union includes 43 elements in its list of critical materials, many of them associated with low carbon technologies or high tech consumer products. Criticality of a material usually implies an imbalance of power in the global marketplace and a heightened risk of resource-focused international conflict.

The criticality of a material can be cured by diversifying supply. In other words, by opening new mines and processing facilities in new regions. Those who find ways to diversify supply, pave the way for a low carbon future and contribute to the de-escalation of factors that could lead to international conflict. The research communities, industries and governments of

India and Australia have shown great leadership in this regard. Furthermore, Indian, Australian, Japanese and United States Foreign Ministers have formed the 'Quad Foreign Ministers' group, to advance shared security and trade interests, including those concerning critical materials. Indian-Australian cooperation is also evident in the Critical Minerals Consortium (CMC), which I cofounded with Associate Professor Mohan Yellishetty earlier this year. The CMC is dedicated to advancing research in the field of critical minerals. Associate Professor Yellishetty was raised and first educated in India, and is now at Monash University in Australia. He is recognised as a global leader in sustainable mining. As a member of the Indian academic diaspora, he maintains strong ties with India, particularly through IIT, and is leading efforts to initiate Indian-Australian research around mining and minerals.

The range of research and development that is required into critical minerals spans the full value chain, from exploration, through mining, minerals processing to refining. There are also new challenges in strategic mine planning. The externality with the most impact on any mining project is the future market demand and price for the mined commodity. Investment decisions made today will rely on price and demand forecasts that reach decades into the future. When planning a mine for a conventional primary mineral, such as copper, iron ore or coal, there is a long history of market development that provides some comfort: Patterns of technology development, supply and demand are established and change relatively slowly. For many critical minerals, no such history exists. The only thing that can be predicted is – unpredictability. For critical minerals, there is a need to fully adopt methods for planning in conditions of great uncertainty: Scenario planning, real options, stochastic optimisation and more. Planners have had decades to train these techniques on conventional minerals projects. Now, with a long list of critical elements, minerals, materials, the time to use these techniques has truly come.