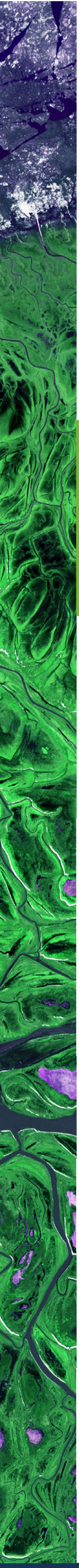

The Transition Institute 1.5
The ambition for an actual transition

EXPLANATORY NOTE

#2 - June 2022

The return of the mineral resources issue

Damien GOETZ[1]

[1]Centre of Geosciences, Mines Paris - PSL, Fontainebleau, France

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Like hydrocarbons and coal, mineral resources are the result of a concentration process that develops over a long geological timescale, and that therefore should be considered as non-renewable at the scale of humanity. Due to climate change, we are having to undertake an energy and ecological transition that involves a radical shift in our mindset. The question of the finitude of mineral resources was raised in the work done by the Club of Rome and the Meadows report in 1972. It was then rapidly forgotten as mineral resource prices generally decreased as a result of technological progress and the discovery of new exploitation sites. At the same time, the focus moved to fossil fuel. Twenty years ago, we were asking ourselves how long we had until oil, gas and coal supplies ran out. Today, the high level of CO2 emissions generated by fossil fuels means that we are looking for ways to limit the volume of known fossil fuels that we can burn, and how to develop alternative energies that emit much lower quantities of greenhouse gases.

These alternative energies (wind, solar, geothermal, etc.) and their implementation (electrochemical storage, increased share of electricity in the energy mix) require metals: copper and aluminum for electricity conduction; silicon and silver for classic photovoltaic, and indium, selenium, or cadmium and tellurium for thin-film solar panels; copper and sometimes rare earths for windings or permanent magnets in wind turbine generators and electric mobility engines; lithium, cobalt, nickel and magnesium for cathodes in Li-Ion batteries, and graphite for the anodes in these batteries.

These new needs have highlighted the question of the depletion of finite mineral resources, and therefore the long-term availability of these metals so essential to the transition. The simplest approaches to determine the depletion timeline of a substance, which consist in looking at known reserves or resources, are now outdated: they are systematically invalidated due to the dynamic aspect of these indicators. O. Vidal, at ISTerre in Grenoble, and E. Hache at IFPEN, have recently developed approaches based on global evolution scenarios (economic growth, energy consumption growth, rate of penetration of different technologies, etc.), combined with models

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featuring renewed resources. Their simulations can precisely identify the time horizons after which the global production capacity of a substance will no longer be able to satisfy demand due to the scarcity and depletion of reserves. They can also be used to evaluate different parameters on these horizons (e.g. recycling rate, substitution rate).

The new needs of the transition also raise new questions. Firstly, while 20th-century metallurgy primarily involved ferrous metals and base metals (copper, zinc, lead, nickel, etc.), modern metallurgy employs almost all of the natural elements. Yet the mining industry's capacity to respond to evolving demand depends on the specific features of markets for different substances. A new demand will be harder to meet if the quantity demanded represents a major share of the current global market (this is the case for lithium and cobalt, but not copper and nickel, for which the quantities demanded are still low compared to current markets). The market will have a real response capacity if the substance constitutes the main metal in the exploited reserves (e.g. copper, lithium and nickel), compared to substances exploited as sub-products of another metal (e.g. cobalt, silver, minor metals like indium and gallium), or substances exploited by "family" (e.g. rare earths and platinoids). Lastly, trace metals could rapidly constitute a block, since their low-volume markets can only significantly evolve at the cost of a very high production of the main substance (e.g. to double the global production of gallium, which is about 400 t/year would mean doubling bauxite production, which is 400 Mt/year).

This then raises the question of the speed of the transition. Some studies consider that to move from the current vehicle fleet to a 100% electric fleet would require a 3,000% growth rate in the lithium market! Yet the time constants of the mining and metal industries are such that the speed of production of a given substance is limited by the development capacity of production centers. Transition scenarios should therefore integrate realistic hypotheses, in the short term and mid term (about 20 years), of evolutions in the production capacities of the different types of market.

Lastly, with demographic growth and rising average living standards per inhabitant at global scale, the pressure on mineral resources continues to grow, and we need to do everything we can to avoid the loss of materials.

It is true that we do not consume mineral resources. The copper industry does not actually alter the copper atom. But this atom can for example move from an ore deposit to a motor winding for the electric window on a car, and then, if the motor is not dismantled before the car chassis is recycled, it might be diluted in low-quality secondary steel, which might then end up as a concrete-encased reinforcement. Our copper atom will not therefore have disappeared, but it will be very difficult to access. In growth markets, recycling alone will never be enough to meet demand. Nevertheless, everything needs to be done to take metal recycling rates to as high a level as possible and limit the pressure on primary resources. This involves limiting dispersive uses and increasing collection, which involve organizing recycling chains and developing technologies to improve the quality of separation between different types of product. To achieve this will require developing more effective metallurgical systems to process the components that alloy numerous metals, sometimes in very low quantities. Recyclability aspects will need to be integrated right from the object design phase. All of which requires constantly seeking material efficiency and better usage of the properties of metals.

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CONTACT

the-transition-institute.minesparis.psl.eu

tti.5@minesparis.psl.eu

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