IS MINERAL DEPLETION A THREAT TO SUSTAINABLE MINING?

by

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Abstract

For many people the term sustainable mining is an oxymoron. After all, mining entails the exploitation of non-renewable resources. Eventually these resources will be gone and mining will have to cease. As a result, many concerned individuals urge society to conserve non-renewable resources and where possible to use renewable resources instead.

Drawing on what we have learned from the debate over the long-run availability of mineral commodities over the past several decades, this paper describes two, very different mental models of mineral depletion. The first, known as the fixed stock paradigm, relies on physical measures of availability, and does indeed suggest that mining in the long run is inherently non-sustainable. Fortunately, for the mining industry and even more importantly for humanity as a whole, the fixed stock paradigm suffers from several serious shortcomings.

As a result, the second way of viewing depletion, known as the opportunity cost paradigm, is more useful and appropriate. It assesses resource availability by what society has to give up to produce another unit of a mineral commodity, for example, another a barrel of oil or ton of copper. While over time depletion tends to drive the opportunity cost of mineral production up, new technology and other forces can offset this upward pressure. Indeed, for many mineral commodities this has actually been the case over the past century, indicating that sustainable mining is possible.

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Introduction

Sustainable mining means different things to different people. To some it means mining carried out in a manner consistent with sustainable development. In particular, it is mining in a way that preserves the environment, protects indigenous cultures, and promotes the welfare of local communities. To others, sustainable mining implies the extraction of mineral resources from the earth in a manner that permits this activity—that is, extracting minerals resources from the earth—to continue indefinitely.

This paper focuses on this second definition and addresses the question: Is mineral depletion a threat to sustainable mining? For many, the answer is obvious. Indeed, they see the term sustainable mining, when defined in this manner, as an oxymoron. Since mining depends on non-renewable, depleting mineral resources, by its very nature it is unsustainable. Eventually the resources from which we produce copper, tin, nickel, and other mineral commodities will be exhausted.

Some may contend that this is not a pressing issue, that known stocks coupled with what we are likely to discover are sufficient for the foreseeable future. Still, fears about depletion, even if misplaced, can alter the way society behaves today for good or for bad. For example, concerns over the long-run availability of copper resources have led Gordon et al. (2006) to suggest that society will need to do more recycling, and where possible substitute more available resources for copper over the current century.²

² The International Copper Association, concerned that these conclusions might discourage copper consumption, sponsored a study by Tilton and Lagos (2007) to
Another example concerns lithium batteries, which many believe will be widely used over the coming decades to power hybrid and all electric automobiles. Fears that the needed lithium may simply not be available have led some (Bradbury 2008, Tahil 2007, and Tahil 2008) to recommend that society avoid developing better lithium batteries and instead invest in new battery technologies that rely on more abundant metals.³

So the question—is mineral depletion a threat to sustainable mining?—has implications and consequences not just for the distant future but for today and tomorrow as well. To address this question, this analysis draws on the on-going debate over the long-run availability of mineral commodities.⁴ In particular, it focuses on two very different ways or mental models of looking at depletion—the first is known as the fixed stock paradigm and the second as the opportunity cost paradigm—and it highlights their very different implications for sustainable mining.

The Fixed Stock Paradigm

The most common mental model used to assess the threat of mineral depletion is the fixed stock paradigm. It starts with the observation that the earth is finite. As a result, the supply of copper, oil, or any other mineral commodity must also be finite and hence a fixed stock. Demand, however, continues year after year, and so is a flow variable. This means that demand eventually must exhaust the available supply. When demand is

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³ For a different perspective on the long-run availability of lithium, see Yaksic and Tilton (forthcoming).
⁴ For more on this debate, see Tilton (2003).

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growing exponentially, as has been the case for many mineral commodities in the past, the end will arrive sooner rather than later given the well-known tyranny of exponential growth.

This, for example, is the view of depletion found in *Limits to Growth* (Meadows et al. 1972). Mineral scarcity due to depletion occurs suddenly and without warning. It is like a car that runs out of gas: one minute speeding down the highway, the next stalled on the berm.

Despite its logic and intuitive appeal, the fixed stock paradigm suffers from four critical shortcomings. First, many mineral commodities, especially the metals, are not destroyed when they are consumed. As a result, recycling and reuse are possible. Of course, recycling in some cases (such as the lead once used as an additive in gasoline) is prohibitively expensive, but this is a question of costs, not of physical availability.

Second, for other mineral commodities, including oil and other energy minerals, substitution can mitigate the threat of mineral depletion. Coal, natural gas, petroleum, nuclear, hydropower, wind, and solar energy can all be used to generate electric power. The mix of these resources used at any particular time reflects their costs. If depletion drives the costs of some up, their consumption will decline as society relies more on alternative energy sources.

Third, the fixed stock of many mineral commodities is huge. At current rates of consumption, for example, the copper and iron found in the earth’s crust would last 120 million years and 2.5 billion years respectively. These are very long periods of time. For comparison, the big bang occurred about 13 billion years ago, our solar system is about 5
billion old and already halfway through its expected life, and Homo sapiens evolved as a species only several hundred thousand years ago.

Fourth, and most important, long before the last barrel of oil or the last ton of zinc was hoisted from the earth’s crust, costs would rise dramatically. This would first curtail and then eventually eliminate demand. In short, the threat is not physical depletion, where we literally run out of mineral resources, but economic depletion, where the costs of producing and using mineral commodities rise to the point where they are no longer affordable.

The Opportunity Cost Paradigm

For these reasons, a more useful mental model for assessing the threat of depletion is the opportunity cost paradigm. The latter focuses on what society has to sacrifice or give up in order to produce another ton of coal or pound of nickel. Several measures are available for this purpose, including production costs and the value of mineral reserves in the ground. However, the most readily available and reliable is price. When the real price for a mineral commodity is rising over the long run, it is growing less available or more scarce.

The opportunity cost paradigm completely changes our perception of depletion. First, even in the absence of physical depletion, economic depletion may occur in the sense that mineral commodities become too expensive to use.

Second, if depletion does occur, it will occur gradually over time as the real prices of mineral commodities rise persistently, slowly eliminating their demand in one end use
after another. Depletion will not be a surprise. We will not wake up one day and find the cupboard bare or the car out of gas.

Third, and particularly important for the future of humans, mineral scarcity due to depletion is not inevitable, as the fixed stock paradigm implies. While the need to exploit lower grade, more remote, and more difficult to process deposits tends to drive the costs and prices of mineral commodities up over time, new technology can offset this upward pressure. In short, the long-run availability of mineral commodities is now determined by a race between the cost-increasing effects of depletion and the cost-decreasing effects of new technology.

Over the past century, this race has largely been won by new technology, as the long-run trends in real prices for most mineral commodities have either declined or remained the same.\(^5\) Of course, the past is not necessarily a good guide to the future, and we have no guarantee that such benevolent trends will continue indefinitely.

Fourth, population growth no longer necessarily reduces the long-run availability of mineral commodities. Every new baby is born with a brain as well as a mouth. While population growth tends to accelerate the consumption of mineral resources, which pushes costs and prices up, it also increases the human resources needed to generate the new technologies that reduce costs and prices. As a result, population growth can conceivably increase the long-run availability of mineral commodities, a possibility that a few scholars suggest is actually the case.\(^6\) It also raises the likelihood that poverty and discrimination (which prevent millions of people from developing their potential and so

\(^5\) See, for example, Barnett and Morse (1963), Krautkraemer (1998), Howie (2002), and Svedberg and Tilton (2006).

contributing back to society) may pose a greater challenge than population growth per se. In some countries, of course, population growth may impede development and contribute to poverty.

Fifth, the United States and other developed countries consume a disproportionately large share of the world’s resources compared to their populations. To many this seems unfair to the rest of the world, where billions of poor people struggle just to survive. Under the opportunity cost paradigm, however, the high levels of mineral consumption in the developed world need not necessarily increase resource scarcity. While this consumption tends to accelerate mineral depletion, the wealth that it creates in the developed world supports the technological efforts that push the cost and prices of mineral commodities down over time. It is not an accident that most of the new technologies increasing the availability of many mineral commodities over the past century have come from the developed countries. This raises the possibility that the poor may actually benefit from the apparent profligate use of mineral resources in the developed world, in the sense that today they have access to cheaper mineral commodities as a result than the developed countries did at comparable stages of development.

**Conclusions**

So the way one thinks about depletion matters. With the fixed stock paradigm, physical depletion is inevitable and mining is unsustainable. The end will come suddenly, and likely take us by surprise. Mineral consumption accelerates the day of reckoning.
Both population growth and the widespread use of mineral commodities in the developed world undermine the long-run availability of mineral commodities.

With the opportunity cost paradigm, if society can continue in the future as it has in the past to create new technologies that offset the cost-increasing effects of depletion, mining can be sustainable indefinitely. In this case, the primary production of steel, aluminum, copper, and other mineral commodities from extracted mineral ores will remain competitive with recycled materials and with substitute materials produced from renewable resources. In addition, the costs and prices of these products will not rise persistently over time, and consumers will not be forced to curtail their demand.

Thus, it is fortunate—both for the mining and for society as a whole—that the opportunity cost paradigm is the more useful and appropriate way of assessing the future threat of depletion to sustainable mining.

References


Mining and the associated minerals processing is not sustainable, because the resource it is based on is finite and because of the very large negative environmental impacts. However sustainability performance of the minerals industry can be improved in three main ways. Firstly, sustainability performance of the mineral industry could be improved by reducing mining through through reuse and recycling of minerals already mined, as this has a far lower negative impact than mining virgin material. Secondly, integrating sustainable concepts into mining and mineral processing should be carried out. These materials include precious and base metals, nonmetallic minerals, construction-grade stone, petroleum minerals, coal, and water. Economic geology is a...Å†‘ J.E. Tilton, 2010, "Is Mineral Depletion a threat to sustainable mining?", Society of Economic Geologists Newsletter, No. 82. Lindgren, W., 1933. Mineral Deposits. 930 pp. McGraw-Hill, New York. U.S. Geological Survey Circular 831, Principles of a Resource/Reserve Classification for Minerals (PDF format). Dill, H.G., 2010. Between 2000 and 2002, the Mining, Minerals and Sustainable Development (MMSD) project carried out research, analysis and consultation. This introduction describes what the project set out to do and the process that evolved to accomplish those goals. This page collates all the material previously available from www.iied.org/mmsd. All project documents, including the MMSD Working paper Series, final reports, regional reports, project bulletins and workshop notes are available for free download. Introduction. The mining and minerals industry has come under tremendous pressure to improve its soci To others, sustainable mining implies the extraction of mineral resources from the earth in a manner that permits this activity that is, extracting minerals resources from the earth to continue indefinitely. This paper focuses on this second definition and addresses the question: Is mineral depletion a threat to sustainable mining? For many, the answer is obvious. Indeed, they see the term sustainable mining, when defined in this manner, as an oxymoron. Since mining depends on non-renewable, depleting mineral resources, by its very nature it is unsustainable. Eventually the resources from whic