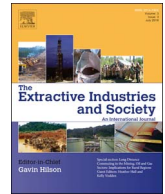




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Rare earth elements: Development, sustainability and policy issues

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ABSTRACT

Rare earth elements are essential to modern life as we know it. With their exceptional magnetic and conductive properties, they enable the hardware of contemporary life to be faster, lighter, and stronger. Since the 2010 crisis precipitated in part by China's then *de facto* monopoly over rare earth production, diverse actors across the globe have pursued multiple and sometimes conflicting measures to transform the industry. These include efforts to open new mines, lower prices, mitigate social and environmental harms, curtail black market activity, identify substitutable elements, and achieve national-level supply security. These diverse efforts intersect with broader geopolitical, historical, and cultural struggles around the world. The outcomes of these efforts vary, though arguably few have generated intended results. Several years after the global (re)awakening to the importance of rare earth elements and the hazards associated with their production, the relationship between its industries and society, broadly defined, remains troubled in practice, poorly-conceived in policy, and under-examined in the social science literature. This special issue convenes emergent social science research into some of the development, sustainability, and historical issues surrounding rare earth elements in different times, places and sectors across the globe.

1. Introduction

Rare earth elements are essential to modern life as we know it. With their exceptional magnetic and conductive properties, they enable the hardware of contemporary life to be faster, lighter, and stronger. Since the 2010 crisis precipitated in part by China's then *de facto* monopoly over rare earth production, diverse actors across the globe have pursued multiple and sometimes conflicting measures to transform the industry. These include efforts to open new mines, lower prices, mitigate social and environmental harms, curtail black market activity, identify substitutable elements, and achieve national-level supply security. These diverse efforts intersect with broader geopolitical, historical, and cultural struggles in different sites across the globe, directly and indirectly enlisting rare earth mining in issues as diverse as the ongoing US-led occupation of Afghanistan to the defense of Indigenous land use rights in the Brazilian Amazon. The outcomes of these efforts vary, though arguably few have generated intended results. Several years after the global (re)awakening to the importance of rare earth elements and the hazards associated with their production, the relationship between its industries and society, broadly defined, remains troubled in practice, poorly-conceived in policy, and under-examined in the social science literature.

This special issue convenes emergent social science research into some of the development, sustainability, and policy issues surrounding rare earth elements in different times, places and sectors across the

globe. The importance of these elements transcends sectors and disciplines. The complexity of their geological incidence, historical geographies of production, social importance, and contemporary applications also defies a unified global analysis of rare earth industries and society.

This is due to the importance of rare earth elements to many critical technologies. Because they are critical to the technologies of global communications, transportation, medicine, energy generation, surveillance and militarism, questions surrounding access and applications are geopolitically charged. The quest for rare earth elements has been entangled in the defining territorial struggles of the past century, because control over these elements has frequently been understood as control over one's development destiny. Furthermore, rare earth mining and processing continues to be done in an environmentally destructive way, which generates conflict in current and prospective mining sites.

Conventional theories on global resource geopolitics would explain the complex political lives of rare earth elements as a result of scarcity, which, when combined with mere accidents of geology, would be sufficient to explain efforts to mine them in socially and environmentally sensitive places. This logic contends that prospectors look for rare earths in remote places such as North Korea, Afghanistan, Greenland, and colonial Africa simply because there are no other options. This logic absolves us of our responsibility to critically analyze the problematic *status quo* of rare earth elements.

This logic does not withstand basic empirical inquiry into the

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contemporary political economy of rare earth elements. Rare earths are not rare, so the tendency for them to be invoked as causes for conflict in scholarship, policy discourse and popular culture says more about our antiquated resource assumptions than about the objective reality of rare earth elements on Earth. Most of these elements are as abundant as copper or lead. Annual global demand has yet to surpass annual supply, which fluctuates between the relatively modest 120,000–140,000 t. Despite the political intrigue that capitalizes on the myth of rarity, the global rare earth economy has in fact been characterized by oversupply and insufficient demand. By any measure—geological, economic, or political—rare earth elements are not rare.

Instead, what is rare about these elements are the places where it is politically acceptable to mine and process them in a cost-effective manner. Rare earth elements tend to coincide with other elements that are harmful to human health when dug out of the ground and pulverized into fine dusts: heavy metals, arsenic, and fluorite, among others. Add to this the acids needed to separate elements from their parent material, and the result is a large volume of waste that is expensive to effectively control. This has led to a preference for mining in sites where local populations have limited power of refusal or cannot hold the mining industry accountable. Environmental violations resulting from irresponsible waste management practices have plagued the sector, and generated justifiable resistance in communities neighboring proposed mining sites.

Not only are rare earths abundant in the Earth's crust and in the global market, much less controversial methods for maintaining a steady global supply are readily available. These are flex mining and recycling. Flex mining refers to the practice of reprocessing the tailings from other mines or industrial production activities for rare earth elements (Knapp, 2016). Efforts are underway to extract high purity rare earth oxides from a niobium mine in Brazil, and from coal ash in the United States. Rare earth elements are also abundant in phosphorus, silver, and lead mines in different parts of the world. Reprocessing existing mine wastes for rare earths and other useable elements would fix multiple problems at once. The accumulated wastes in aging infrastructure from 20th century mining operations, some of which were never built to effectively contain toxic waste, present a persistent and growing problem for the local and national contexts in which they are located. Opening new mines is risky and costly. It poses economic risk for investors, it poses political risks for local and national governments backing potentially controversial projects, and even the most carefully-managed operation poses environmental health and safety risks for neighboring communities. Reprocessing existing mine wastes would reduce the overall footprint of former mining operations. This would facilitate local environmental remediation efforts while also negating the need to open new mines. The outlook for flex mining is promising but unproven on an industrial scale.

A similar situation characterizes recycling. Annually, less than 1% of rare earth elements consumed are recycled, meaning that we are accumulating untapped stockpiles in our electronic waste. Although it is, admittedly, challenging to implement a recycling program that requires the collection of items as diverse as smart phones and rockets, it is hardly impossible. Meanwhile, scientific breakthroughs in recycling methods are largely ignored in policy due to a lack of political will. This state-of-affairs allows the faulty logic of scarcity to prevail, which supports the misguided quest to open up new mines around the world. The notion that opening new mines is the best or only reasonable way to acquire rare earth elements is antiquated. It is a markedly 20th century mentality, which grew out of the colonial extractivist regimes of the preceding four centuries. Our technology has changed such that for the first time in known history, flex mining, reclamation, and recycling can feasibly replace mining as primary sources for critical minerals. But investors, policy-makers, and the market have been slow to adapt, confirming that the past and present of rare earth industries are inseparable from their social context.

In a context of geological abundance and amidst exciting

technological potential, efforts to mine rare earths in remote, conflict-prone, or sensitive locations continue. North Korea, Greenland, Afghanistan, Madagascar, and the Amazon Rainforest are just a few of the places that have made headlines in recent years as the next 'jackpot' in a global quest to find the next source of these 'critical' materials. The fact that we have the technology and the lucky geology to produce rare earth elements in a sustainable and conflict-free manner; yet, we are overwhelmingly failing to do so, indicates that the contemporary geography of rare earth prospecting and production is driven by secondary interests which are sometimes only marginally related to rare earth elements.

Understanding these interests is important to building a more efficient, sustainable, and just rare earth economy. To move away from the violent political economy of rare earth elements requires a measure of global coordination that pessimistic commentators say is not possible. Pessimism is easy because it demands nothing. By doing nothing and discouraging others, pessimists are proven correct when change fails to happen. Alarmism is similar. It may take slightly more energy to rearrange a partial understanding of the global rare earth economy into yet another variation of 'the China threat' to generate alarm, but the intellectual demands are equally as light. Neither pessimism nor alarmism require an in-depth understanding of the historical and contemporary complexities of the rare earth sector, while both preclude the hard work of formulating and coordinating collaborative solutions.

A constructive approach to the contemporary rare earth problem is to examine specific aspects of related development, sustainability, and policy issues. There are two ways to do this. The first is to look at in-depth case studies from specific times, places, and sectors in order to clarify the complexity, bit by bit. The second is to examine the ways in which the persistent confusion is useful for political, geopolitical, and economic agendas. The articles in the special issue address the first, and this introduction approaches the second.

This introduction to the special section of *Extractive Industries and Society* proceeds as follows. The second section presents a broad overview of some of the scientific, public, and popular literatures on rare earth elements since the 2010 crisis. The third section presents one illustrative example of problematic relationship between rare earths and geopolitics. The final section introduces the articles in this collection.

2. The 2010 crisis and subsequent publications

In late 2010, the world awoke to its dependence on China for 97% of the global supply of rare earth elements. Although production had migrated from the West to China in a gradual process over the latter two decades of the 20th century, it had been largely ignored outside of the sector. For nearly a decade, no one complained about the concentration of this dirty and dangerous industry in China's hinterlands, until rare earth elements featured in a geopolitical dispute between Japan and China over the Diaoyu/Senkaku Islands. The Japanese coast guard detained a Chinese fisherman who strayed too close to the islands, which was interpreted in Eastern China through the lens of WWII atrocities. Frustrated with what they viewed as Beijing's slow response, a handful of port workers and officials decided to take matters into their own hands by reminding Japan of its economic dependence on China. They held up shipments of rare earth oxides bound for Japan, which temporarily disrupted some of the flow of these commodities from China to Japan. This was, by and large, an inconsequential event that blew up into a market panic and a political crisis after the New York Times ran stories suggesting that China had embargoed rare earth shipments to Japan (Bradsher, 2010; Bradsher and Tabuchi, 2010).

Although it was not the first story published on China's rare earth sector (Bradsher, 2009a,b; Hilsum, 2009) this story brought a rude awakening to global dependence on China for critical materials. The market responded with a panic: prices for some elements increased by as much as two thousand percent. In the unfocused and frantic moments that followed, several inaccurate conclusions were drawn on the

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