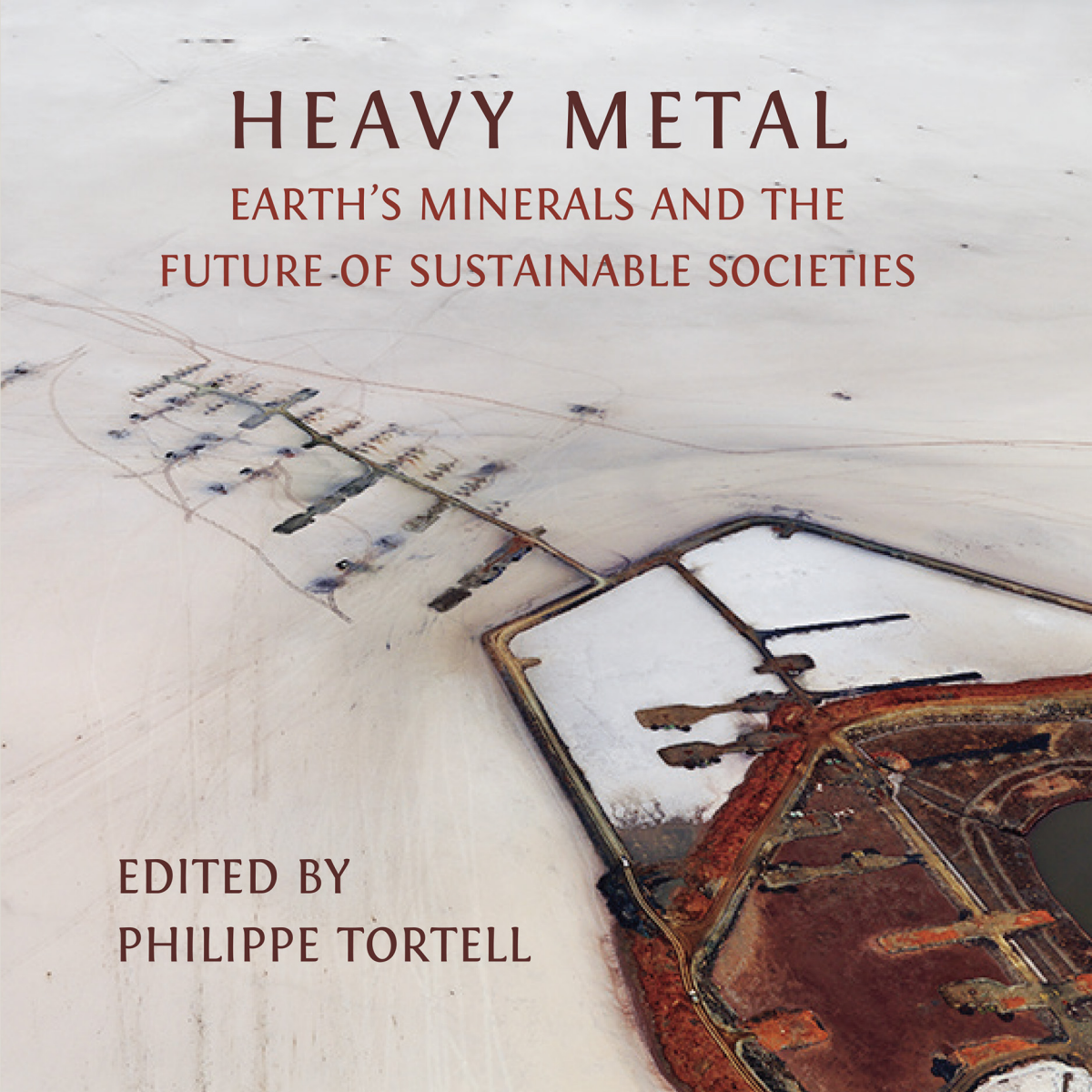
HEAVY METAL

EARTH'S MINERALS AND THE FUTURE OF SUSTAINABLE SOCIETIES



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Cover image: Edward Burtynsky, *Silver Lake Operations #15*, Lake Lefroy, Western Australia, 2007. Photo © Edward Burtynsky, all rights reserved.

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Introduction

Philippe Tortell

On the corner of Front and Bay Streets in downtown Toronto, two large office towers soar up from the pavement, the taller one with its forty-one floors, reaching nearly two hundred meters into the sky. In a city with many large skyscrapers, what you notice most about these particular buildings is the windows; more than fourteen thousand of them, each tinted with bronze-gold glass set into aluminum frames. On a sunny day, the golden windows reflect a shimmering and slightly distorted image of the bustling city below. At the time the buildings opened in 1979, an ounce of gold sold for about four hundred dollars, and the total quantity of gold in all the windows, close to two thousand five hundred ounces, was worth about one million dollars. At today's price (about two thousand dollars per ounce), the windows contain about five million dollars' worth of gold.

As a boy growing up in a small town near Toronto, I was fascinated by those golden buildings. Coming into the big city from the suburbs, it was the first thing I'd see when I emerged from Union Station—two gleaming pillars towering over the iconic Royal York Hotel. In my young imagination, the buildings represented untold riches; like a pot of gold at the end of a rainbow. In some ways, I wasn't so far off from the truth. The Royal Bank Plaza, as the buildings are known, hosts the headquarters of Canada's largest financial institution. It sits in the heart of the country's financial capital, where

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large fortunes have been won (and lost) in an economy built historically on natural resources—fur and pelts initially, and then agriculture, timber, fish and minerals. One of the early corporate clients leasing space in the building was Denison Mines Incorporated, a major producer of the uranium used in nuclear reactors. In the late 1970s, amidst a global energy crisis, the price of uranium skyrocketed, reaching nearly two hundred dollars per pound. With its large uranium mine near Elliot Lake, Ontario, Denison's profits were booming, just as its hundreds of employees settled into their new offices in the golden towers. One of those employees was my father.

My dad started working as an accountant with Denison Mines in 1979, the year the company headquarters moved into the Royal Bank Plaza. His arrival coincided with what turned out to be the peak of global uranium prices. Shortly after he joined the company, the price of uranium began to drop sharply. During the 1980s, growing environmental concerns—particularly in the wake of the 1986 Chernobyl disaster—led to a public backlash against nuclear energy, causing global demand for uranium to decrease steadily for the next two decades. The year I finished high school, in 1989, a pound of uranium was selling for about twenty dollars—less than 10% of its peak value just a decade earlier. By the early 1990s, the writing was on the wall; the company downsized significantly, and many people, including my father, were forced to look for other jobs. As the uranium mines closed, leaving behind more than a hundred million metric tons of radioactive waste rock, it seemed that my family's connection to the mining industry was over. But things didn't quite turn out that way. Though I didn't know it at the time, my life would intersect with minerals and mining a few more times over the subsequent decades.

By the time I was in university, my father had found a new job with a company that operated a copper and zinc mine in a small Turkish town on the Black Sea coast. The town's name, Çayeli, comes from the Turkish word for tea (*çay*), which is grown in large quantities on its mountainside slopes. As part of its waste management plan, the company, Çayeli Bakır İşletmeleri, was exploring a method to dispose of mine tailings in low-oxygen deep waters of the Black Sea, where high concentrations of hydrogen sulfide would bind up zinc and copper, capturing them in unreactive minerals that

would then sink to the seafloor. Such an approach, it was argued, was preferable to the storage of the mine waste on land, where the rocks would create acidic wastewater and release potentially high concentrations of metals into the environment. After my third year of university, on a visit to see my parents, I got a job in Çayeli, working alongside local scientists and a consulting team from Vancouver on an environmental impact assessment of the proposed waste disposal plan. In the end, I believe the plan went ahead, with somewhat mixed results. My role in the project was insignificant, but it connected me, once again, to the mining industry, and also in some small way to Vancouver—a city where I would settle less than a decade later.

Back in North America, I had decided to study oceanography, pursuing graduate school in the United States, and then, with great luck, landing a dream job as a professor at the University of British Columbia (UBC) in Vancouver. When I started that job, in 2002, I wasn't thinking much about mining. In the wake of the ill-fated Kyoto Protocol (a 1997 United Nations agreement to limit global greenhouse gas emissions),[11] the world was just beginning to reckon with the impending threat of global warming. Scientists around the world, including me, were more focused on understanding the impacts of rapidly increasing carbon dioxide (CO_2) concentrations on Earth's biophysical systems, than seeking actual solutions to the problem. Surely, we thought, the increasingly strident warnings from the Intergovernmental Panel on Climate Change (IPCC) would motivate global action to address the root causes of global warming. As it turns out, we were wrong.

Over the next two decades, the effects of climate change became ever more apparent, with rising global temperatures, increasing sea levels, melting glaciers and ice sheets, and more frequent extreme weather events. In the face of these mounting impacts, the world began, slowly, to move towards a broad (though not universal) consensus that we needed to mitigate the worst possible outcomes, shifting from fossil fuels to renewable, low-carbon energy and transportation. With the launch of the Tesla Roadster in 2008, electric vehicles became increasingly common (at least in Vancouver), while renewable energy began expanding more rapidly than fossil fuels

for the first time in history. By 2015, the fraction of new electricity generated from renewable sources surpassed 50% globally,[2] suggesting that the world was finally taking steps towards an energy transition. Maybe we were moving too slowly, but we were, at least, heading in the right direction. With determination and political will, it seemed that we had a fighting chance.

But there was a catch—all of those new renewable energy sources required a fundamentally non-renewable resource; minerals and metals needed for batteries, circuit boards, wiring and other components of the digital, carbon-neutral economy. Suddenly, it seemed, everyone was talking about cobalt, lithium, copper and nickel, not to mention rare-earth elements (REEs) like scandium and yttrium that few people had ever heard of before. China, in particular, was quick to anticipate potential future shortages of what came to be known as 'critical minerals', buying up a large share of global mineral resources, and investing in mineral processing facilities. Not to be outdone, other countries including the US, the United Kingdom, Japan, Australia and Canada, began launching their own critical mineral strategies, seeking to secure reliable long-term supplies of minerals to support their future green economies.

As metals became increasingly important in a globalized economy, the world began paying more attention to the true costs of renewable energy, with a spotlight on the potential environmental and social harms of mineral exploration and mining. In Canada, a country rich in mineral resources, another reckoning was also unfolding, as the nation began to examine the dark legacy of its colonial past. In 2015, the Truth and Reconciliation Commission of Canada released its final report, detailing more than a century of abuse perpetuated against the country's Indigenous peoples through forced cultural assimilation in a brutal system of Indian Residential Schools.[3] It wasn't just Indigenous cultures and languages that had been taken; even before the federal Indian Act of the late nineteenth century, Indigenous peoples across the country were displaced from their traditional lands, as the Canadian government sought to expand its control over the vast natural resources within its borders. Today, more than one hundred and fifty years after Canadian Confederation, the impacts of colonialism

continue to reverberate, and much of the nation's mineral wealth still lies on ancestral or unceded Indigenous lands.

It was in this context that my life, once again, intersected with the mineral resource industry. In 2019, I became Head of the University of British Columbia (UBC) Department of Earth, Ocean and Atmospheric Sciences, a group of about forty professors and many students and staff working to advance research and education across a wide range of Earth science disciplines. Early on, I came to appreciate the innovative work of my colleagues who were developing better approaches for mineral exploration and mining—from the discovery and characterization of new mineral deposits, to the design of lower impact mines and improved waste treatment methods. I also learned just how important Vancouver was to the global mining industry, as a worldwide hub for mineral exploration and geotechnical companies. But maybe the most important thing I learned was that the challenges of mining were not just scientific or technical in nature. Equally important were the legal, economic and political challenges—alongside the unresolved question of Indigenous rights and title, particularly in British Columbia, where the large majority of Indigenous lands were never ceded in treaties.

Beyond my own department, I began hearing about other mining-related research across UBC. The work was inspired and impressive, but much of it was running on parallel tracks, with relatively little cross-fertilization between academic silos. This seemed to me like a missed opportunity. And so, in 2022, as the world was beginning to emerge from the COVID-19 pandemic, I convened a group of experts from across UBC with deep knowledge of the global mineral resource sector. The group included some of my own colleagues in Earth sciences, but also others from mining engineering, law, economics, public policy and even the School of Music. It also included Indigenous leaders, and those in the mining industry with a practical working knowledge of the business. We called ourselves the Future Minerals Working Group,[4] and set out to understand what we might achieve together, combining our collective experiences

and perspectives to re-imagine the future of the mineral resource sector in Canada and beyond.

With some funding from UBC, the Future Minerals Working Group began meeting regularly, over lunch, to hash out ideas. At first, the conversations were a bit forced, with each person presenting their views in language that often felt foreign to others. But eventually, we converged on some critical themes that seemed particularly timely and important. Those themes—from the recognition of Indigenous land rights, to the development of lower impact mineral exploration, extraction and recycling methods—painted a broad picture of an industry in transition. It was an important story, but one that few people understood beyond a small group of insiders. And it was a story we felt compelled to share, not only with other academics, and industry and government experts, but also with the broader public. Otherwise, how would we, as a society, make responsible decisions about the resources supporting our carbon-neutral economic future? And so, as a group, with help from others around the world, we set out to build a new vision for the global mineral resource and mining sector.

As academics, we gravitated naturally towards research and education. We held seminars and panel discussions, wrote proposals and created a new UBC graduate course called *Heavy Metal*. But we also wanted to go further, seeking impact outside the ivory tower. We wrote op-eds, met with government officials, and looked for ways to connect directly with the public, hoping to make complex ideas both accessible and engaging. The book you now have before you represents an important part of that effort.

In putting this volume together, we sought to bring forward a wide range of perspectives, illuminating both the challenges and opportunities facing the future mineral resource sector. The collection begins with an essay by Allen Edzerza and Dave Porter, both Indigenous Elders, recounting the story of Indigenous resistance and land rights in the face of colonial resource extraction. Melanie Mackay's essay complements these ideas, presenting a long-term perspective on mining practices among British Columbia First Nations. Werner Antweiler, Sara Ghebremusse and Carol

Liao each consider the social, economic and legal contexts of mining in an increasingly interconnected world characterized by growing geopolitical rivalries. Writing from the perspective of an exploration geologist, Shaun Barker addresses the question of how and why large mineral deposits form on Earth, while John C. Wiltshire, Sara Russell, Anita Dey Nuttall and Mark Nuttall describe the potential new frontiers of mineral resource extraction on the seafloor, in outer space and in frozen polar regions. Lee A. Groat tells the story of lithium, an essential element for batteries, which has come to symbolize the future energy transition. Gordon Southam, Erik Eberhardt, Marcello M. Veiga and J. Alejandro Delgado-Jimenez discuss new approaches that could be used to access mineral resources—taking some inspiration from ancient practices and organisms. Allison Macfarlane tackles the complex question of community engagement and informed consent, while W. Scott Dunbar and Jocelyn Fraser present a disruptive vision for new business models in the global mining sector. Both Roger Beckie and Maria Holuszko discuss the enormous problem of mining and metal waste, while Nadja Kunz takes on the complex issue of water use and management—often a key flashpoint in the interaction of mining operations with local communities. The final essay in the book, by Naomi Klein, presents an alternative vision that challenges an economic growth imperative based on endless resource extraction.

Interspersed with the essays described above, a number of contributors explore minerals and mining through an artistic lens. The collection includes a series of stunning images and written reflections from the Canadian photographer Edward Burtynsky, whose camera captures the transformation of landscapes through large-scale resource extraction. The theme of transformation is also explored sonically, through the work of eight composers who have created the *Heavy Metal Suite*, each contributing a movement inspired by a metal produced in their country—copper from Chile, lithium from Australia, and platinum from South Africa, for example. In a series of short reflections, the composers provide insights into their creative process, and we include a link to the live premiere of the *Heavy Metal Suite*, which took place at the Vogue Theater in Vancouver on Earth Day (22 April), 2024. These creative interventions—both the photographs and musical scores—allow us to see minerals

and mining in a new light, and hear them with fresh ears, inviting us to imagine a different, and better, future.

I hope this collection, with its words, images and sounds, will help illuminate the complex challenges and opportunities ahead as we seek to supply the minerals needed for a sustainable future. To do this, we must better understand the role of metals and minerals in our daily lives, seeing more clearly the invisible resources that are buried underground or in the gadgets we carry in our pockets. The stakes could not be higher, and failure is not an option. And yet, I remain optimistic, even as we confront a rapidly changing climate and uncertainty about how and where we will find the minerals we need for a carbon-neutral economy. As I have engaged with these essays and authors over the past few months, I have learned that we already have many tools at our disposal, and also the collective capacity—if we choose to use it—to be innovative and creative, learning from past mistakes. Perhaps one day, in the not-so-distant future, we will see those golden buildings in Toronto not just as a cautionary tale of hubris, but also as a triumph of the human imagination.

Endnotes

1 *Kyoto Protocol to the United Nations Framework Convention on Climate Change, Dec. 11, 1997* (2303 U.N.T.S. 162), https://unfccc.int/resource/docs/convkp/kpeng.pdf

2 Victoria Masterson, '5 Milestones in Green Energy' (14 April 2021), *World Economic Forum*, https://www.weforum.org/agenda/2021/04/renewables-record-capacity-solar-wind-nuclear/

3 Truth and Reconciliation Commission of Canada, *Canada's Residential Schools: Summary of the Final Report of the Truth and Reconciliation Commission of Canada* (Montreal: McGill-Queen's University Press, 2015), https://ehprnh2mwo3.exactdn.com/wp-content/uploads/2021/01/Executive_Summary_English_Web.pdf

4 *UBC Future Minerals Initiative*, https://www.futureminerals.ubc.ca/