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Zombie Mines and the (Over)burden of History

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In humanity's relentless search for the industrial minerals that undergird our modern technology and economy, we have extensively and comprehensively ravaged natural landscapes. Sites like the Berkeley Pit in Montana or Western Australia's Kalgoorlie Super Pit exemplify the awesome scale of these transformations. Indeed, as an industry quip has it, mining is primarily a waste management business. Mineral solid waste accounts for the largest proportion of total global industrial waste production, and mining often generates toxic by-products ranging from heavy metals to process chemicals like cyanide. The effects of these wastes may persist long after mine closure and abandonment, requiring long-term care and maintenance.[1] Under pressure from governments and environmental groups in recent decades, the industry has begun to address these considerable and controversial legacies of extractive development.[2,3]

The mining industry often invokes the words reclamation, remediation, and restoration as a cornerstone of efforts to paint itself green. Industry and government promoters of mining as an ecologically sustainable enterprise are fond of producing before and after pictures of landscapes once devastated by mining, then healed through landscaping and revegetation to become productive recreational, agricultural, or even ecological reserves. In academic circles, geographers and historians have questioned the idea that mine closure inevitably leaves devastation in its wake, citing many examples where former mining communities have creatively restored landscapes to pay homage both to the industrial and ecological heritage of the local landscape.[4,5] In the popular arena, photographer Peter Goin and historian C. Elizabeth Raymond produced *Changing Mines in America* in 2004, a visual celebration of post-mining landscapes as significant cultural artifacts. On a global scale, the UK-based Eden Project produced *101 Things to Do with a Hole in the Ground* (2009), a lavishly illustrated and largely mining industry–funded coffee table book demonstrating the many ways mining landscapes have been converted from environmental liabilities to productive uses that include a wine cellar, a movie set, and a football stadium.[6,7] The message here is one of hope: that modern technology and no small dose of creativity can allow us to meet the raw material needs of industrial society without bringing ecological ruin to the landscape.

But such emphasis on the visual aesthetics of remediated landscapes obscures as much as it reveals about abandoned mines. As important as it may be to repair the uglier side of extensive, open-pit mining operations, in many cases it is the unseen (or more accurately, the unseeable) impacts of mining that pose the gravest long-term threat to ecological and human health. In many cases, mines produce chemical and radiological hazards that persist for long periods of time, even indefinitely, after their closure. Most of these toxins—substances such as uranium, arsenic, cadmium, lead, and other heavy metals—are released from the ore itself when rock is crushed and ground down into fine tailings to get at the target minerals. In other cases, the process of smelting may produce harmful substances (sulfur dioxide has been common historically). The infamous pollution around the Washoe Smelter in Montana and the moonscape created by the INCO nickel smelter in Sudbury, Ontario, exemplify the historically severe impacts on local animals and vegetation. Similarly, the use of toxic chemical reagents, particularly cyanide or mercury in gold ore processing, has in many cases created long-term pollution legacies at many former mine sites. Perhaps the most widespread water pollution problem associated with abandoned mines is acid rock drainage, a spontaneous chemical reaction that occurs when sulfide-bearing rock is oxidized, producing highly acidic mine water that upsets the pH balance and can be deleterious to aquatic life in local watersheds. Though mining has become one of the major forces through which humans physically transform the earth, it is these invisible chemical impacts that cause the most persistent and intractable environmental problems associated with abandoned mines.[8]

Through the past six years researching the history of mining impacts in northern Canada, we have come to think of abandoned mines as “zombies”—sites that continue to exert some sort of malevolent effect during their afterlife. Although technology may be able to mitigate or remove some of the persistent toxic threats of zombie mines, or prevent them from occurring at newer mines, many sites throughout the globe are haunted with toxic legacies that simply cannot be remediated. Among the estimated 500,000 abandoned mines in the United States, for example, there are many sites exhibiting acid rock drainage problems for which there is no easy technological fix.[9] According to newspaper reports, the inexorable rise of toxic ground water in the mine catacombs under Johannesburg pose a severe threat to the city, one for which no viable solution exists.[10,11] Even in the very remote areas of Canada north of the 60th parallel, reports have identified between 30 and 60 abandoned mines exhibiting zombie-like characteristics including radioactivity, heavy metal contamination, and acid mine drainage. Where these toxic sites can be remediated, the price tag is often enormous: a $555 million total clean-up bill for all sites, according to a 2002 report from Canada’s federal commissioner of the environment, an amount that has proven to be extremely low considering that the cleanup of one of these mines alone, the Giant Mine, is currently forecast at over one billion dollars.[12]

For all of these challenges, what is often forgotten in discussions of abandoned mines is that remediation and restoration programs may themselves pose new environmental risks and impacts. The treatment and management of zombie mines can be a tricky business, with some substances being very difficult, expensive, or impossible to treat at the site. If contaminated soil is scraped off a surface area, for example, where does the concentrated toxic material go? If stored at the site, what assurances do local communities have that the material is properly contained, potentially over very long periods of time? And if toxic material is removed from an abandoned mine, what assurance can be given that mobilizing the material will not introduce new risks, either at the original mine site, along the waste transportation chain, or at the waste disposal site where the material will be stored? Cleaning up and restoring an abandoned mine, seemingly an unalloyed good, may thus generate as many thorny environmental problems as actual mining itself.

In Canada, there is no better example to illustrate the environmental risks and public controversy over remediating zombie mines than the case of Giant Mine, adjacent to the city of Yellowknife, capital of the Northwest Territories. Operating from 1949 to 2004, this extensive underground and open-pit gold mining operation produced 7 million ounces of gold worth 2.7 billion dollars in 2002 Canadian currency. The company, Giant Yellowknife Mines, Ltd., extracted the lion’s share of this bounty from arsenopyrite rock formations, an ore type that requires roasting at high temperatures to extract the valuable yellow metal. One by-product of the roasting process is highly toxic arsenic trioxide, of which Giant Mine spewed 16,500 pounds per day into the local environment without any pollution control equipment from 1949 to 1951.

The spread of this material represented a particularly grave threat to workers and to adjacent Yellowknives Dene aboriginal communities, as arsenic dust accumulated in the snow they relied on for water during winter and berries that were collected through the summer and autumn. In April 1951 arsenic loading from the mine sickened an unknown number of Yellowknives Dene and killed a two-year-old Dene boy who drank contaminated water. In response, the mine company installed pollution-control equipment, gradually reducing the arsenic air pollution through the next three decades through technology and efficiency improvements. But this short-term technological fix produced longer-term problems: faced with mounting piles of collected arsenic dust, the company (with government sanction) decided to store it in mined out or specially constructed underground chambers, hoping that returning permafrost might lock up this toxic material forever. This may have been wishful thinking: survey work in the 1990s suggested permafrost coverage in the area around the mine was spotty. Regardless, the scraping of insulating soil layers on the surface of the mine and the circulation of heat from the lower workings of the mine prevented any potential return of even a partial permafrost layer. Today, 237,000 tons of highly toxic arsenic trioxide sits underground with no protective permafrost, enough toxic material to cause a major ecological and health catastrophe should it ever leak out through groundwater which, without pumping, will rise to flood the chambers.[13]

After company bankruptcy in 1999 and the final closure of the mine in 2004, the environmental liabilities of the site were left with the federal department of Aboriginal Affairs and Northern Development. Faced with an expensive and potentially devastating remediation challenge, the department proposed a novel, yet controversial, solution: leave the arsenic underground, while artificially restoring permafrost to re-freeze the rock chambers. According to the government, the frozen chambers will require maintenance (and pumping and treatment of the rising water table) "in perpetuity." The remediation plan also calls for the removal of contaminated soils (and containment within abandoned open pits); revegetation of tailings; removal of buildings; and the rehabilitation of a polluted creek running through the site.[14] But it's the word *perpetuity* that has critics in the community worried. As part of a public environmental assessment process scrutinizing the remediation, a local environmental NGO and the Yellowknives Dene First Nation consulted experts and held workshops on the questions of perpetual care and independent oversight of the project.[15] For these groups, the specter of living forever with the threat of toxic contamination entails an ethic of care and responsibility that raises complex issues of funding, management, and the communication of risk to future generations. In financial terms alone, the estimated $1 billion cleanup and perpetual maintenance costs will be a burden borne entirely by taxpayers (present and future).[17]

Giant Mine exemplifies the "undead" quality of many contaminated mine sites around the world, where local communities and environments must deal with the long-term threats posed by extractive industry wastes. Long after the miners are gone, their profits made, the scars and toxins from mining remain, haunting efforts at the restoration and healing of landscapes. Any serious discussion of the sustainability of mineral development and the place of industrial minerals in our modern society must grapple with the costs—financial and ecological—of zombie mines. Our research has shown how zombie mines not only stalk future generations and their use of the land, but also reproduce or reawaken historical conflicts over the negative experiences associated with previous mining, particularly for indigenous communities (who typically benefitted little from the wealth extracted in their territories).[17] The global trend towards accelerated mineral development and the renewed interest in abandoned mine sites for both remediation and redevelopment suggests the importance of attending to history in contemporary debates over the industry and its impacts.

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