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"Sustainability is finding the next mine": The complicated relationships among legacies, sustainability, and EA

Morrissa Boerchers[a,*], A. John Sinclair[a], Robert B. Gibson[b], Norman M. Halden[c]

[a] Natural Resources Institute, University of Manitoba, Winnipeg, Manitoba R3T 2M6, Canada
[b] School of Environment, Resources and Sustainability, University of Waterloo, Waterloo, Ontario N2L 3G1, Canada
[c] Department of Geological Sciences, University of Manitoba, Winnipeg, Manitoba R3T 2N2, Canada

1. Introduction

Since the popularization of "sustainable development" in the late 1980's, the mining industry worldwide has initiated various efforts to integrate the concept into mining operations (Worrall et al., 2009). While mining can have positive sustainability effects (Hodge, 2004), the negative long-term effects can outweigh the positive short-term ones (Worrall et al., 2009; Roche et al., 2017; Li, 2015). Consequently, "mining" and "sustainability" still often seem to be contradictory (Gibson and Robinson, 2014). If mining is to be a sustainability-enhancing practice and lead toward greater and lasting regional well-being, then it seems sensible that the legacy effects of mining must be fully considered during environmental assessments (EA) and the inevitable tradeoffs weighed cautiously (Sandlos and Keeling, 2013). Instead, current EAs are often blind to tradeoffs and frequently do not ensure that mines are planned and operated to avoid negative mining legacy effects while also amplifying long term sustainability (Gibson, 2012; Johnston, 2014).

This paper identifies and confirms a set of legacy effects, introduced in an unpublished manuscript, which should be considered in EA. We start by establishing pertinent legacy effects and then introduce the methods and describe our case study for further testing these, Snow Lake, Manitoba. Next, we present findings related to the legacy effects and offer discussion on the use and suitability of EA in considering these effects. Finally, the concluding section summarizes ways forward through a legacy effects framework that applies next generation approaches to EA.

2. Context

2.1. Mining legacy effects

Mineral and metal resources are critical to modern-day living, but it is imperative that they be developed in a way that contributes positively to sustainability (Gibson and Robinson, 2014). Canada's history of nation building is closely linked to mining and other extractive industries, "so much so that resource development was once considered synonymous with public interest" (McAllister, 2004, 348). In many parts of Canada, mining and other geographically specific extractive industries attract the bulk of economic investment. Much the same is true of Australia, Brazil, and many other jurisdictions with colonial histories (Herbert et al., 2002; Furtado, 1963).

In an unpublished manuscript Gibson and Robinson (2014) outline a framework consisting of five key types of legacy effects (Fig. 1) associated with mining. While many of the legacy effects they describe have been documented in the literature, the focus here is on the suite of effects as captured in Fig. 1, rather than any one of the individual effects (e.g., new jobs or acid rock drainage) that often dominate any assessment of legacy. We adopt this framework to organize our discussion of mining legacy effects and to consider the importance of these effects to EA. Each of these five types of effects is discussed below.

2.1.1. Residual biophysical effects

Mining results in the movement of an incredible volume of material. Typically, only 2% of the desired ore mineral is found in the total rock excavated, leading to the adage that mining is primarily a waste management industry (Gibson and Klinck, 2005). The features associated with mining such as open pits, slag mounds, waste rock piles, and tailings ponds can cause biophysical issues (Sandlos and Keeling, 2013). Mining-related activities such as processing and smelting often generate toxic by-products from process chemicals such as cyanide, arsenic compounds and heavy metals (Bridge, 2004). Mine-generated tailings, plus spoil heaps and mineral stockpiles, require careful management lest they contaminate local water and soils through runoff of water with high concentrations of dissolved metals and other suspended solids. Recent tailings disasters (e.g., at Mount Polley in Canada and Fundão in Brazil) illustrate the threat of dam failure both during and after mine operations (Eisenhammer, 2015; Johnston, 2014).

Acid rock drainage (ARD also known as acid mine drainage) is a residual contamination problem that can also pose major biophysical risks (Bridge, 2004) and may be the biggest contamination issue facing the industry (MEND, 2014). Acids are created when sulfide minerals

* Corresponding author.
E-mail addresses: boerche3@myumanitoba.ca (M. Boerchers), john.sinclair@umanitoba.ca (A.J. Sinclair), rbgibson@uwaterloo.ca (R.B. Gibson), Nm.Halden@umanitoba.ca (N.M. Halden).

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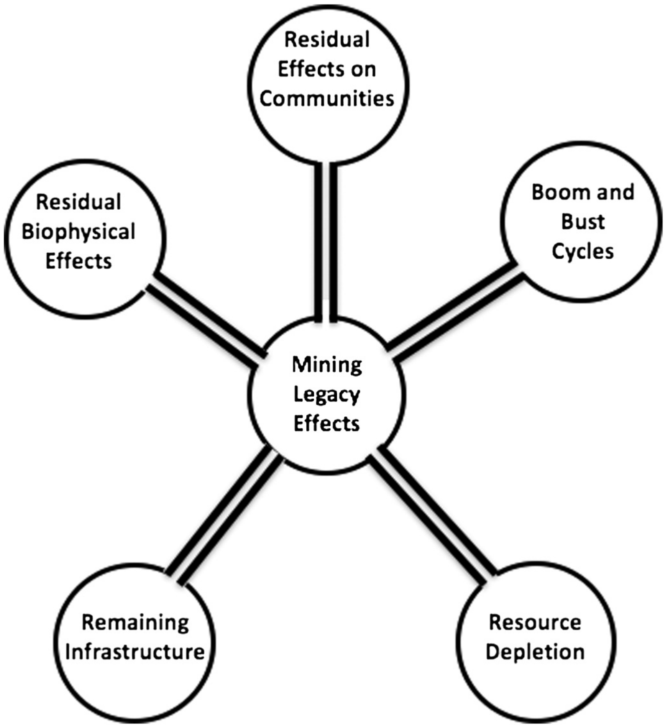

Fig. 1. Suite of legacy effects associated with mining.

(many metallic ores are found as sulfide minerals) oxidize to form sulfuric acid as they are exposed to oxygen and water (Bridge, 2004). Presently, there is no inexpensive technical fix or mitigation for ARD (Sandlos and Keeling, 2013). The effects of mining are also typically combined with the effects of ecosystem fragmentation due to mining projects plus their infrastructure, especially where that involves new roads and power transmission lines.

The legacy effects of one single mine also often contribute to the cumulative legacy effects of multiple mines, and/or other extractive industrial operations, power projects and infrastructure in the same region, watershed, or traditional territory of Indigenous people.

2.1.2. Residual effects on communities

The community benefits of mining are mostly economic through providing impetus and funds for improvements to community facilities, equipment, and services (Gibson and Robinson, 2014). New mining activities come with new opportunities for both direct employment and contract work. In Canada, the mining industry boasts the highest wages in the resource sector (HudBay Minerals Inc., 2015). Many mining companies provide local training and tout preferential local hiring and local purchasing practices to increase local community benefits and support (see for example Rio Tinto Alcan, 2015). Positive effects often diminish over time once the mine closes, investments are not being made in the community, and skilled individuals move to attain work elsewhere. Not all individuals however, are able to move to find work. This is especially true of some remote Indigenous populations.

In order to avoid the issues associated with mining dependent communities, many mining companies in Canada and around the world have employed a fly-in/fly-out (FIFO) model of operation for the last several decades (2001, 135; HudBay Minerals Inc., 2015). According to Storey (2001, 135), FIFO are mining operations where employees are flown in and provided lodging and food and “employees spend a fixed number of days working at the site, followed by a fixed number of days at home”. From one perspective, the FIFO model can reduce or eliminate the need for new resource dependent communities (e.g., Snap Lake Diamond Mine, Mary River Iron Mine) (Storey, 2010, 1163). The FIFO model is more complicated when a community already exists. FIFO typically reduces direct employment and typically reduces direct and indirect opportunities for nearby existing communities. Consequently, it reduces not just related income benefits during mine life but also opportunities to develop capacities and non-mining livelihoods that may serve after the mines close.

2.1.3. Boom and bust cycles

Global demand for a natural resource drives up development and production of the resource, leading to economic growth (boom) through the growth in jobs, increase in taxes and royalties, additional construction, etc. (Freudenburg and Gramling, 1998; Gibson and Robinson, 2014). A drop in demand or a glut of these natural resources in the market leads to lower mineral prices and an economic decline (bust) in the region as mines cut back or suspend operations and jobs, revenues, population and taxes drop (Putz et al., 2011). The bust can have negative implications for individuals and local businesses. Rapid economic growth can also lead to local price inflation and harmful economic dependencies on a single resource sector (Gibson and Robinson, 2014; Michael, 1995). This problem is exacerbated by the fact that many mining communities are geographically remote and therefore removed from most other viable economic opportunities. All aspects of community existence can become enveloped in the dominant sector so, for example, house prices in the community rise and fall with mineral prices. Economic benefits diminish in the later stages of the mine life and all mines eventually close, most after less than 20 years. Nearby communities associated with FIFO operations, as noted above, are provided fewer economic opportunities but are therefore less dependent and less likely to have severe bust effects when operation ends.

2.1.4. Remaining infrastructure

Roads, energy corridors, and other related infrastructure necessary for mining activities may connect remote communities as a spinoff effect (Gibson and Robinson, 2014; Pegg, 2006). This infrastructure is built with extraction in mind rather than community use during mining or use after the mine closes (for example see Ring of Fire transportation corridor discussion in Porter, 2015). Some see increased connection between remote areas and major centres as a positive as it allows for more easier access to various goods and services. Others see the increased connection as negative since it opens these areas up to more influence and destruction both culturally and ecologically (Reed and Miranda, 2007). Remaining infrastructure is also costly to maintain which may pose a burden to communities.

2.1.5. Resource depletion

Since mineral ore bodies are finite, mineral reserves offer a one-time opportunity for both the mining company and the community (Gibson, 2014). This opportunity has potential for great conflict between parties as short-term gains may lead to long-term loss and preclude future use of the resource (Gibson and Robinson, 2014). This has resulted in the development of tools such as impact benefit agreements, income sharing, and heritage funds to increase long term benefits of mining and use “mines as bridges” to more sustainable futures (Gibson and Robinson, 2014; Gibson, 2014; Prior et al., 2012).

2.2. Environmental assessment

To address the above challenges, environmental assessment (EA) has been growing in use, scope and ambition since its inception in the US *National Environmental Policy Act* of 1969 (Gibson et al., 2005). EA has been applied to mining development in Canada and worldwide (e.g., Franks et al., 2010; Noble and Bronson, 2005), though many prospecting activities are exempt from EA. Despite the evident shortcomings of EA processes in properly predicting and effectively managing the impacts associated with mining, it is still the main vehicle for assessing and planning mining proposals. EA has benefits for assessing mining in that it is applied worldwide, has many best practices