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From start to finish – improving sustainable development aspects of life-of-mine practices

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In this article, we have reviewed historical and current life-of-mine (LOM) practices from a socioeconomic and environmental perspective. We describe what leading LOM practice aspires to be and discuss lessons learned to improve future LOM practice.

Historical practice

The last 30 years have seen a fundamental shift in the environmental and social expectations placed on extractive businesses. Mineral resources are often the property of the state and mining companies gain a temporary exploitation right, with government retaining the rights to economic 'rents'. As is common when goods are publicly owned and privately exploited, historically little thought was given to 'externalities'. Accordingly, poor LOM outcomes for affected communities and environments have frequently been the result. For instance, following mine closure, local communities commonly face high unemployment, loss of services and real estate value deflation. Local or even regional environments can also be exposed to risk when management of landforms such as tailings storage facilities and pit void water quality is reduced or stopped.

Evolving voluntary and leading practice

LOM practice evolved in the late 20th century, generally focusing on environmental aspects aligned to the then-new concept of ecological sustainable development. The vision that emerged was 'environmental stewardship', with the matching mine closure approach being 'rehabilitation'. Attempted rehabilitation to pre-mining landscapes became the default vision for regulators and responsible miners.

In the 21st century, a broader view of sustainable development became the policy foundation for resource extraction in Australia, inclusive of social and economic dimensions. Concepts such as multiple and sequential land use, with mining but a temporary land use, (Standing Council on Energy and Resources, 2013) and the conversion of natural resources into human and social capital are increasingly understood by mining companies. Other socioeconomic forces have also improved LOM practice. For instance, public scrutiny of LOM planning, progressive landform rehabilitation, long-term water management and stakeholder engagement have increased markedly in the past few decades.

Militating against improvement, commodity cycles, cost pressures, contracted business models and other factors still detract from the ability to put sustainability thinking into practice. There are disconnects between environmental studies, approval documentation and the actual resourcing for and application of satisfactory LOM planning in project feasibility planning. Due diligence and liability estimates for closure can be inadequate, with a growing history of companies on-selling mining properties with diminished resources but increased socio-environmental liabilities.

Lessons still to be learned

The mining industry continues with many practices that do not meet current, let alone previous stakeholder expectations (McCullough, 2016). While history tells us that learning from mistakes is the primary source of improvement, it is difficult to locate publications that describe failure. Consequently, how might mining social and environmental practitioners and regulators improve LOM policy and practice if there is no avenue for circumspection and no autopsies of suboptimal practice and regulation? The dramatic improvements in occupational health and safety performance at Australian mines in the past two decades came about through unrelenting forensic analysis of failure; the same approach is yet to occur for LOM learning.

Mine closure outcomes can be uncertain when regulatory closure requirements are unclear. This can be due to regulators not wishing to be overly prescriptive, or not having the working experience to advise proven rehabilitation and closure design methodologies. However, in the face of changing societal expectations, regulators must set clear mechanisms by which mined land relinquishment can be achieved.

Understandably, governments are risk-averse to resume responsibility for mined lands, influenced greatly by several instances of expensive completion liability being inherited by governments. An alternate approach to mine closure, not well-captured in current regulatory guidance and industry practice in Australia, is the use of specific endowment funds to provide for ongoing post-closure maintenance and remediation. This approach has worked well for uranium mines in Saskatchewan (Mackenzie, 2016). The dividends paid in perpetuity from such endowments provide for ongoing monitoring and maintenance activities at relinquished mine sites, including for contingent issues that may occur.

A major learning from historical mining projects has been that starting a mine with an end in mind leads to very different thinking during prefeasibility studies. This strategic approach requires that predevelopment investigations be rigorous, along with increased attention to social and environmental aspects generally. The approach also calls for detailed data and options analysis and fundamental decisions about the placement of infrastructure and temporary and final landforms to optimise operational outcomes and minimise the potential for legacy issues at closure. This knowledge needs to be updated and defined further during the operational phase, with geochemical and physical characterisation of wastes and pit walls, geotechnical studies and hydrological studies applied to mine design and catchment management. A focus on the end point, throughout the LOM, can prevent long-term impacts on surface and ground waters.

Emerging and future practice

Very few mines in Australia have actually closed successfully (Butler and Bentel, 2011). Closure is often deferred, with mines being placed under 'care and maintenance' – a sort of purgatory where many suboptimal operations linger for want of a clear regulatory exit point. Borne out of this reality, the new sustainability thinking in mining practice and the frequent reality of being unable to restore mined landscapes with the resources available, LOM thinking in Australia is starting to consider mine site 'regeneration' options.

Regeneration envisages ongoing social and economic value through closure with occupation of former mine sites by successor landowners (International Council on Mining and Metals, 2008). Regeneration may also involve lump sum transfer from an operating miner to a new land manager to finalise relinquishment and provide for post-closure monitoring and maintenance (Bocking et al, 2009). This approach has been the primary option for some time in much of Europe, Asia and North America, where population pressure means any consolidated land estate is extremely valuable. Although a lump sum transfer is harder to imagine in Australia's generally sparsely populated landscapes, there are exceptions, including well-populated mining areas such as the Hunter Valley in New South Wales, Ipswich in Queensland and the Latrobe Valley in Victoria. LOM design based on regeneration will include community involvement, or may involve decisions by beneficial land owners about post-mine land use.

A more current understanding of restoration ecology must also find its way into rehabilitation practice. Although leading practice methodologies developed in research institutions often find their way to mine sites, the overarching paradigm of restoration ecology has not. This is particularly so at landscape level, especially where major changes to physical geographies have occurred.

While relatively simple ideas such as trialling and progressive rehabilitation are slowly being demonstrated in practice, more conceptual ideas such as 'novel' ecosystems are less commonly considered. 'Novel' ecosystems may well be key to realising relinquishment for many former mine sites where physical and chemical change is so great that pre-mining biology is unable to re-establish using conventional rehabilitation approaches (Doley and Audet, 2013). A post-mining landform involving pit lakes is an extreme version, with a terrestrial environment modified into an aquatic one (McCullough and Van Etten, 2011). LOM planning aligned to such regional-scale development planning can be key to good closure outcomes (Murphy and Heyes, 2016).

Most importantly, a multidisciplinary approach to LOM planning at the start of the mine's life cycle and throughout significantly reduces risk and uncertainty. This results in fewer adverse social and environmental effects during operation and more effective long-term closure success. Several leading resources companies now advocate this approach and are beginning to embed it into their business planning procedures.

Conclusions

Given the myriad variables in mine site context, detailed prescription for LOM scenarios cannot be offered. However, it is possible to distil some key principles for good LOM planning, implementation and land use transition.

A major underlying principle is that miners are short-term custodians, typically occupying an area of land for periods measured in years or decades. Mining activity influence, however, can extend for decades beyond mine closure (Leblanc et al, 2000). Hence, the future of mined and otherwise affected lands should always be at the forefront of mine planning and operation. Approached in this way and with proper planning, societal benefit from mining can extend beyond closure, with mined lands continuing to be an asset. There is increasing realisation of this on a site-specific basis, with the key drivers typically being maintenance of local employment, municipal services and a local economy (Mauric et al, 2012). With the loss of employment and the economic multiplier effect of a dominant enterprise, the transition to a post-mining situation must consider and plan for the creation, diversity and resilience of a new economy.

Another critical principle for LOM design is the need for comprehensive and in-depth understanding of landscape processes including geology, geochemistry of wastes and hydrological and hydrogeological context. Production of a reliable mine material 'balance sheet', ie ore, tailings, soil and waste rock, and scheduling for predicted LOM treatment is critical to mitigating long-term environmental impacts.

Minimising the geographic and ecological footprint during operations is crucial, and the key to this is progressive rehabilitation. Progressive rehabilitation designed into LOM planning minimises the long-term disturbance of ecological, soil, water, air and social amenity. Progressive rehabilitation costs should be captured at a sufficient level of detail to underpin a publicly available and peer reviewable assessment. This includes post-closure landforms being designed and costed for post-closure stability. Planning should include contingent cost estimates for closing mines prematurely, as well as modelled costs of closure at the end of the projected reserve life.

Post-mining land use discussions early in mine life will expectedly change with continually evolving community and stakeholder expectations. Engaging with affected parties early, often and transparently on the LOM vision will lead to political support for mining through to closure transition. Regeneration, involving the development of socioeconomic options for post-mining land use, is important in this regard. Regulatory frameworks need to encourage regular stakeholder engagement and review, with a focus on risk reduction and opportunity creation. Safe, stable, non-polluting and sustainable landforms are the minimum acceptable outcome, with the maintenance of post-mining commercial and social opportunity the aspiration. Practical concepts and procedures for understanding and mapping LOM requirements are increasingly available.

There are no valid reasons for contemporary miners to be unaware of responsible LOM planning and execution; it is the application and regulation that are often lagging. Indeed, LOM competence is now an essential contributor to miners' ability to gain a social licence to operate and to secure development consents in the first place.

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