

Progress towards implementing a research agenda towards post-mining transitions

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Abstract

Mine closure does not have a great track record. While there are some important exceptions, too few mines have achieved effective closure, lease relinquishment and a positive legacy. Many of the reasons for this have been articulated through the Mine Closure Conference community. At the same time, there is a growing momentum towards thinking beyond closure and focusing on how to achieve better post-mining transitions by repurposing sites and delivering improved social and economic outcomes, and recognising the crucial role of First Nations people. Following the foundational stage of the Cooperative Research Centre for Transformations in Mining Economies, a research agenda was put forward focusing on four key aspects. The first of these is the need for deliberation on what post-mining transition means in different contexts. The second is the need to develop ways to incorporate a wider range of values into closure post-mine transition planning, to ensure future sustainability in livelihoods and environment. The third is the importance of integration and forecasting across a spectrum of biophysical, social and economic aspects of mine closure and transition. The fourth is to focus on elevating the scale for mine closure and transition planning, from the site to the regional scale and beyond. This paper summarises progress to date by the Cooperative Research Centre for Transformations in Mining Economies and adjacent work towards implementing this agenda.

Keywords: *beyond closure, mining, Indigenous, repurposing, just transition, regional development, post-mining land use*

1 Introduction

This paper presents highlights from a research agenda advanced by the Cooperative Research Centre for Transformations in Mining Economies (CRC TiME) (Measham et al. 2024), in addition to a summary of progress towards addressing that research agenda. This research agenda was developed in response to the track record of mine closure, with few examples of mines closing effectively and transformation to post-mining economic activities being effectively realised. This is of particular concern given that over 400 mines are expected to close worldwide in the next decade (Measham et al. 2024). This number is potentially an underestimate considering that there are signs of closure dates being brought forward for some mines, particularly those that produce commodities such as thermal coal that are affected by the earlier than expected retiring of coal fired power plants in some contexts (Feaster 2023; Latrobe City Council 2021). Even without mine closure dates being brought forward, there is a substantial number of mines that are expected to close in the decades ahead, emphasising the importance of effective closure and post-mining outcomes.

Rather than closing, many mines enter a state of care and maintenance, potentially due to low commodity prices or changing economic conditions. In theory, care and maintenance is a temporary state until maintenance is completed and/or commodity prices increase. In practice, many of the mines that enter care

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and maintenance remain in this state indefinitely. Often, these mines may be less viable in the first place, and equipment or infrastructure may degrade further over time – with the effect that the longer mines are in care and maintenance, the less likely it is that mining may resume. There are examples of the ‘temporary’ state of care and maintenance lasting over 50 years, regardless of the recovery of commodity prices during that timeframe. There is a growing concern that a substantial proportion of mines in care and maintenance will never re-open, or be rehabilitated (Lèbre et al. 2021; Pepper et al. 2021; Mills 2022). Conversely, it is possible that some mines currently in care and maintenance may become productive again due to changes in the global context, with decarbonisation leading to increasing demand for certain materials. Though it may not be a panacea, there is potential to extract additional commodities from waste streams at sites currently in care and maintenance, if technical and logistical challenges can be overcome (Measham et al. 2024).

One of the key reasons why mine closure has a poor track record is that closure costs are often underestimated. Gaining reliable data on the extent to which closure costs are underestimated can be difficult. Whether it is the way that companies provision for closure, or the basis that governments use for estimating financial assurance bonds, there is evidence that closure costs have been substantially underestimated and this has made closure more difficult to achieve (Dunow & Kalisch 2022; Purtill & Littleboy 2023; Measham et al. 2024).

In many places, mining has had substantial effects on First Nations peoples. While in recent years this is not necessarily deliberate in many circumstances, the impact is always felt. The exclusion of First Nations voices from analysis, data collection, decision-making and implementation processes relating to mine closure is a major concern and is a breach of their rights (Australian Human Rights Commission, 2010; Monosky & Keeling 2021). It is important also to recognise that the negative effects of poor closure are particularly experienced by Traditional Owners of mined lands (Horowitz et al. 2018). In some cases, preparedness for mine closure among Indigenous communities can be low and there is a substantial need to increase training in transferable skills and develop support services to ensure an equitable post-mining transition for First Nations communities (Rixen & Blangy 2016).

In many places, the effects of mining are felt disproportionately by Indigenous peoples. As rights holders, it is crucial to recognise the role of First Nations peoples in mine closure and post-mining transition. Yet, the inclusion of Indigenous aspirations, agency, knowledge and expertise into mine closure planning has not been consistent, and in many cases, First Nations voices have been excluded. It is critical for mining companies, governments and researchers to take time to build strong relationships with Indigenous peoples and to listen to their needs (Miller-Sabbioni et al. 2023).

CRC TiME was created in 2020 to address the multiple dimensions of mine closure and post-mining transformation. Three years into this initiative, CRC TiME reviewed the lessons from a portfolio of 22 foundational projects to distil lessons and identify a broader research agenda, discussed in Section 2.

2 Research agenda towards post-mining transitions

2.1 Need for deliberation on what post-mining transition means in different contexts

The first element of the research agenda is the need to define what post-mining transformation means in different contexts. It is important to note the distinction here between closure, for which there are essential concepts such as ‘safe, stable and non-polluting’ (Purtill et al. 2022). The language of closure is established in regulations and there is relative clarity around roles (Hamblin et al. 2022). Conversely, there is no agreed-upon language of what post-mining transformation is, or who is responsible for it (Beer et al. 2022; Hamblin et al. 2022). This lack of clarity on what post-mining transition means translates into confusion in mine closure planning and regional planning for communities affected by closure. A dialogue on what post-mining transformation means from diverse perspectives, along with a discussion of roles and responsibilities and how to coordinate with higher scales of governance, is needed before transformation can be progressed in order to engage with the priorities of diverse groups involved in the process (Reeves et al. 2022).

2.2 Developing ways to incorporate a wider range of values

The role of values is fundamental to achieving acceptable post-mining transitions, recognising the need to understand and respect the range of values in different contexts, incorporating multiple tangible and intangible aspects spanning social, cultural, economic dimensions (Measham et al. 2021; Maybee et al. 2023). The role of place is crucial, with the range of values varying within and between regions. To understand values we need strong relationships, particularly with Traditional Owners, and a commitment to deliberation. An essential consideration is that post-mining outcomes should be viewed as net-positive from multiple perspectives (i.e. the benefits outweigh the costs for diverse groups [Foran et al. 2022]). To position a region well for post-mining transformation, understanding and respecting diverse values should occur well in advance of closure timeframes. The need to include Indigenous people is mandatory through the United Nations Declaration on the Rights of Indigenous Peoples (United Nations 2011). Therefore, Indigenous-led and co-led projects are a crucial part of the research agenda put forward in this paper (Miller-Sabbioni et al. 2023).

2.3 Integration and forecasting

The engineering, technical and biophysical aspects of mine closure and post-mining transitions have been (and continue to be) extensively researched, to the effect that these aspects of mine closure and transition are relatively well understood in comparison to the social, cultural and economic aspects (Cote et al. 2022a). While there is substantial progress on the technical and biophysical aspects of mine closure and transformation, knowledge on these aspects tends to be siloed and fragmented. There are gaps in how the technical and biophysical components interact. Hydrology is an important example: despite advances in both surface water hydrology and groundwater hydrology, there remain gaps in understanding how surface water processes interact with groundwater processes. Similarly, research has improved our knowledge of ecological restoration, but less about how that restoration will behave in a changing climate. These gaps become more pronounced as scale increases from the site scale to the regional scale and beyond, as discussed in Section 2.4. Moreover, there is a need to better integrate the biophysical, technical and engineering aspects of mine closure with the social and economic aspects at the regional scale, rather than be siloed in respective fields (Bainton & Holcombe 2018; Vivoda et al. 2019).

2.4 Elevating the scale for mine closure and transition

The fourth element of the research agenda discussed here is the need to elevate attention from the site scale to the regional scale (Cote et al. 2022b). Building on the examples in the previous section, approaches to restoration at a site is limited unless it takes into consideration the circumstances and the ecology of the surrounding region. For water, the connectivity of water systems highlights the need to think beyond site boundaries. It is crucial to understand the linkages between surface and groundwater interactions at scale and the role of water bodies in post-mining economies (Cook et al. 2021). While individual mines may close, it is at the regional scale that social and economic effects are experienced. In locations where mines are large employers or generate indirect jobs in businesses that service the needs of mines or mine workers, the regional effects of mine closure can be significant (Fleming & Measham 2014). The role of the state here is an important consideration: by either encouraging or requiring a shift from site scale to regional scale for all biophysical as well as social and economic aspects included in mine closure governance.

3 Progress towards implementing research agenda

With 25 active projects at the time of writing, it is not feasible to detail all of CRC TiME's work to implement the agenda outlined in the previous section. Rather than an exhaustive listing we provide selected highlights of projects that illustrate how CRC TiME is implementing the agenda, as well as examples of the adjacent project work that is happening around CRC TiME. This adjacent work includes projects that were developed through the University of Queensland Closure Consortium – a related initiative that recently concluded.

The importance of rigorous deliberation in identifying post-mining transitions has been highlighted in the Shire of Coolgardie, where an unconventional approach driven by local government has enabled the Shire to

embrace new opportunities to diversify their economy and ‘future proof’ their community (Haslam McKenzie & Eyles 2024). At the regional scale progress towards developing deliberative processes on what post-mining transition means has advanced substantially in the Latrobe Valley where coal mine closure dates have been brought forward. A CRC TiME research project, focused on developing a shared vision for the future land use of mines in this region, has initiated a collaborative process combining local government, First Nations, mining companies, power station operators and community organisations. The first stage of this project is now complete, involving the co-development of post-mining land use scenarios using participatory multi-criteria analysis. The first stage focused on formulating and evaluating three post-mining land use scenarios considering:

- the degree to which the energy sector is concentrated in the Valley
- the degree to which regional transition is guided by social equity
- the degree to which transition is focused on circular economy, guided by principles of sustainable production and consumption.

Participants identified their preferences for what post-mining transition should focus on in Latrobe Valley, supplemented with a multi-criteria analysis. Importantly, rights holders and stakeholders reported changes in the way they work together (Foran et al. 2024). This project highlights that substantial progress is underway regarding deliberation on what post-mining transition means; however, this project was restricted to a single context. It will be important to learn from other examples of deliberation about post-mining transition in other contexts.

The *Collaborative planning for post-mining development in Latrobe Valley* project mentioned previously has also made progress towards the second area of the research agenda, namely, developing ways to incorporate a wider range of values. In developing deliberative processes, the project enabled a range of values to be brought into planning about post-mining land use in this region, including First Nations organisations, energy companies, local government, regional development bodies, community health and wellbeing organisations, labour agencies, educational institutions, industry peak bodies, state government agencies and water authorities (Foran et al. 2024). In a separate project, Reeves et al. (2022) engaged with a wide range of values and views on future land and water uses within the Latrobe Valley, drawing on a mixed methods approach combining interviews, focus groups and an online survey. The project highlighted the importance of creating wider community benefit through decisions regarding post-mining land use and water use (Reeves et al. 2022).

In addition, to improve the range of values that is included in discussions about closure and post-mining transformation, an Indigenous-led project is underway with a focus on training and skills development from the perspective of First Nations communities. A key focus of this project is to address the power asymmetry in closure planning, so that First Nations communities are empowered to participate more effectively in these processes (CRC TiME 2024b)

More broadly, research is underway to expand what is included in net present value (NPV) calculations using discounted cash flow (DCF) rates. That NPV DCF method has limited the range and type of values in mine planning, and been recognised as an important constraint that flows through to the ways mines are closed and the approach to post-mine planning (Lilford & Haque 2023). In broadening NPV calculations and the way we think about DCF, this project is engaging with a crucial mechanism by which a broader range of values (e.g. those of non-industry rightsholders and stakeholders) can be considered in mine closure and post-mining transformation (CRC TiME 2024a).

Progress towards integration is evidenced in the project titled *Mine pit lake assessments and management: a national Initiative* to support mine closure and regional opportunities. The project brings together a team with diverse disciplinary backgrounds to develop guidance based on scenario assessments, as well as strategies and toolkits to improve integration across organisational teams and inform decision-making about pit lakes. Importantly, the focus on integration is not restricted to the natural sciences, but also includes a broader range of backgrounds to better understand the aspirations and values of First Nations and regional communities as well as regulators (CRC TiME 2024c). With regard to forecasting, progress is being made in the area of ecological

forecasting through a project titled *Evaluation of an ecosystem forecasting system for rehabilitated arid landscapes* that develops a modelling system for rehabilitated arid landscapes in Western Australia.

Another example of progress towards integration is in the area of cumulative effects. The first stage of a project titled *A systematic approach to Regional cumulative effects assessment and management* to support transitions in mining economies has been completed. In this first stage of this project, a review of approaches to conducting cumulative effects assessment was completed. An important consideration was considering ways of integrating different knowledge types, particularly for bringing together western and Indigenous knowledge (Pope & Young 2024). In addition to the focus on knowledge integration, this project is particularly focused at the regional scale, and in this way it also contributes towards progressing the strategic issue of elevating scale from the site to region. Building on the first stage which has demonstrated different approaches to cumulative effects assessment, the next phase of the project will focus on building capacity to undertake regional scale cumulative effects assessments and developing tools to enable this type of assessment.

Another project that is progressing the agenda of elevating scale above the site level is focused on the economic trajectories of regions where mining occurs. A project titled *Identifying future economic development pathways for mining regions and increasing transition capacity* has developed a new framework to help identify resilience factors and transition capacity drivers (CRC TiME 2024d). The project has developed a novel approach to looking at diversification avenues and their regional employment effects. These regional impacts are particularly important for considering the potential changes in other sectors (e.g. through indirect employment) as regions experience post-mining economic transformation.

Recent work by Arratia-Solar et al. (2022) emphasises the importance of expanding the range of inputs into post-mining land use planning, particularly through consulting regional stakeholders on implementing post-mining land use options. Worden et al. (2024) developed a methodology to think about post-mining land use situated within a regional context, enabling stakeholders to consider options that are suited to larger geographic areas. Their method encourages thinking beyond common choices such as pastoral grazing and biodiversity conservation, to also include wind and solar energy, cropping, protected horticulture and tourism. In situations where biodiversity conservation is a preferred option, it is important to connect actions on the site to the surrounding region, such that biodiversity conservation contributes to broader connected ecological corridors (Worden et al. 2024). This research, conducted through the University of Queensland Mine Closure Consortium complements and extends the work conducted through CRC TiME.

Finally, it is important to recognise that there is a need to raise the level of awareness and understanding about mine closure and post-mining transition across all parties involved. Within mining companies, closure is well understood by closure teams, but less well understood by other parts of the business. More broadly, there is a need to increase the level of understanding among regulators, government, First Nations peoples, researchers, service providers and regional communities. For this reason, CRC TiME developed a course on Foundations of Mine Closure and Sustainable Transitions. Taking the form of a massive open online course, it is open to all, and the content is free for all to access. Fees only apply to those who wish to be assessed and receive recognition, to cover the cost of evaluation. There is strong overlap in the themes of the course and the agenda presented in this paper with the focus being thinking beyond mine closure.

4 Conclusion

This paper builds on previous work that highlights the importance of thinking beyond closure to focus on post-mining transitions. Specifically the paper demonstrates progress towards implementing a research agenda comprising four areas. With regard to the first area, namely deliberation on what post-mining means in different contexts, CRC TiME has made progress in particular locations including Coolgardie and Latrobe Valley. The experience from these locations will provide important lessons for other contexts. These projects also contribute toward progressing the second aspect of the research agenda in the form of incorporating a wider range of values and perspectives into planning and decision-making about closure and transitions. These insights are being complemented by additional projects which seek to embed a wider range of values into earlier planning and the project valuations, such as the NPV calculation using DCF rates. Broadening our

approach to these calculations is crucial if we want to embed a wider range of values into mine costing and planning. The third area of the research agenda focused on integration between the technical, biophysical and engineering dimensions of closure and transition, and how intersecting these with social and economic dimensions is making progress through projects; including a multi-staged approach to cumulative effects assessment. In addition, projects focused on particular aspects of mine closure, notably an integrated approach to pit lakes, further contributes to this agenda. Several of the projects listed above also contribute to implementing the fourth agenda, namely elevating scale from site to region. These projects are complemented by a focus on regional economic development and diversification, and related projects focused on contextualising post-mining land use planning within a regional context.

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