

Influence of social and environmental factors on mine rehabilitation in Australia and Brazil

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Abstract

Mine rehabilitation laws in Australia and Brazil share similar goals and challenges. However, both countries have a distinct social and environmental context that has led to differences in the regulatory focus in each jurisdiction. Brazil has a clear focus on public reporting and oversight of tailings dam management that reflects both the recent history of dam failures with significant consequences. Although such incidents have led to improved guidance on tailings management in Brazil and internationally, there remains an opportunity for improved public reporting practices to be implemented in Australia to match the level of reporting and transparency in Brazil. In comparison, regulatory reforms in Queensland provide arguably some of the best legislation governing progressive rehabilitation and closure of mines in Australia. These reforms have been driven by a range of factors including several mining companies defaulting on their responsibilities, leaving the sites abandoned and liabilities to rest with the State. Requirements for greater progressive rehabilitation could be strengthened in Brazil and be aligned with environmental approvals as in Queensland. Both countries also share challenges balancing regulation between the federal and state governments. In Brazil, the National Mining Agency (known as the Agência Nacional de Mineração) is responsible for issuing mining permits, assessing compliance with mining regulatory standards, and collating information and data about the mining sector at the national level. While a consistent national approach is advantageous, it may limit local or regional resolution. As an example, environmental licences and mine rehabilitation plans, which are essential documents at the start of the mining process, are issued by State environmental agencies. Each of the 26 States (plus Brasilia) can have specific rules that can make it difficult for the National Mining Agency to manage these aspects. In Australia, regulation, management and reporting on mine rehabilitation is undertaken at the State and territory level. This has led to wide variation in regulatory processes and inconsistent reporting across the country. This paper summarises the rehabilitation laws in Queensland, Australia and Brazil. It describes their strengths and weaknesses and considers some of the social and environmental factors that have influenced the regulatory system used to manage and report on rehabilitation. The paper also identifies the learnings from each jurisdiction that can be applied to identify opportunities for improvement in both countries.

Keywords: *mine rehabilitation, regulation, Australia, Brazil*

1 Introduction

Australia and Brazil both have vast natural resources, including large reserves of coal, metal ores, and non-metallic minerals. Mining represents a significant part of the economy in both countries. Mineral extraction

activities accounted for about 2.4% of Brazil's Gross Domestic Product (GDP) (ANM 2022) and 9% of the GDP in Australia (OECD 2023) in 2019. Brazil and Australia cover large areas that include wide variation in climate and geology. Key mining areas in Brazil include Minas Gerais, Pará, Bahia and Goiás states. Mining is widespread in Australia with over 350 operating mines located in all states of Australia and the Northern Territory (Geoscience Australia 2023). Australia has the largest reserves of iron ore in the world with 28% of the world's share followed by Brazil with 19.6% of the world's share and both also have significant copper and gold reserves (OECD 2022). Australia also has the largest proven gold reserves with an estimated of 10,000 metric tonnes, equivalent to 20% of the total gold available in the world compared with Brazil that has 3.4% of total world reserves (DISER 2020).

Rehabilitation requires the land to be returned to a stable state, the achievement of which is influenced by environmental and social factors. Australia and Brazil encompass a range of geographic and climatic regions. Brazil has a humid tropical and subtropical climate except for a drier area in the Northeast. It includes the Amazon rainforest with mountainous terrain with high rainfall during summer rains. Brazil has large areas of rainforest with slopes that can be affected by landslides in some locations. Much of Australia is relatively dry and arid though there are areas of tropical rainforest in north Australia and sub-tropical areas to the south. Australia is relatively flat and has low seismicity (Williams 2023). The mining areas in Queensland, Australia and in Brazil are often located in remote areas that occur on indigenous lands which can challenge the rights of indigenous peoples and create social tension around land use (Ferrante & Fearnside 2020).

2 Review methodology

This review provides a comparative analysis of the influence of social and environmental factors on the regulation of mine rehabilitation and closure in Brazil and Queensland, Australia. The review evaluates the strengths and weaknesses of mining and rehabilitation law in Brazil and Queensland Australia. It discusses differences between the federal or commonwealth level laws used for regulating mine closure at the state (and territory) level in both countries. The review also considers what influence of social and environmental factors have had on their development and application. The analysis of laws in Australia focusses on the state of Queensland as it is a key mining region and arguably has one of the more robust regulatory frameworks for progressive mine rehabilitation in Australia. A recent analysis of the regulatory frameworks for mine rehabilitation in Queensland, Victoria and Western Australia found Queensland's regulation was the most legislatively detailed, independently administered, legally forceful and transparent (Hamblin et al, 2022). Although there is a focus on the state of Queensland to represent the Australian context, it is acknowledged that there are differences in the social and environmental factors that may influence the regulatory frameworks between Queensland the Australian States and territories.

The review considers the published literature and draws on the expertise and knowledge of staff from the federal government agency National Mining Agency in Brazil (Agência Nacional de Mineração) and the Office of the Queensland Mine Rehabilitation Commissioner in Australia. This paper reflects a collaborative partnership between the two groups to share information regarding mine rehabilitation practices.

3 Regulation of mining and rehabilitation in Brazil

The legislation regarding mine closure and rehabilitation in Brazil is managed by the Federal Government through the Ministry of Mines and Energy and the National Mining Agency in Brazil. The Ministry of Mines and Energy is responsible for defining and implementing mining laws and the National Mining Agency is responsible for regulating, supervising and establishing operational rules for the sector throughout Brazil. All laws that deal with mineral resources in Brazil are managed by the Federal Government including the administration of processes related to the issuance of permits for the different modalities involved in mineral activity, from mineral exportation through to the closure, decommissioning and rehabilitation of mines.

The key legislation governing mining in Brazil is the Decree-Law nº 227/67 and its regulations, also called the Mining Code (Government of Brazil 1967). In addition, mining is the only economic activity in which

mandatory environmental recovery is included in its major legislation, the Federal Constitution of the Republic (Government of Brazil 1988). A requirement of the Federal Constitution is that:

“Anyone who exploits mineral resources is obliged to recover the degraded environment, in accordance with the technical solution required by the competent public body, as provided by law (art. 225)”.

Under these laws, mineral resources are assets of the Federal Government. The Federal Government of Brazil is responsible for laws that deal with mineral resources and their management. This includes issuing of permits to start exploration, and for the closure, decommissioning and rehabilitation of mines. Although mining is the only economic activity that is regulated in the environment chapter of the Brazilian Federal Constitution, the regulation and application of environmental laws are the responsibility of the states (and sometimes municipalities). This can lead to a mismatch between the responsibilities of agencies that regulate mining and the environment (Lima et al. 2006).

In Brazil, there are four different "types" of mining permits issued by the Federal Government. These permits include the Survey Authorization/Mining Permission (Autorização de Pesquisa/Concessão de Lavra), Licensing Regime (Regime de Licenciamento), Artisanal Mining Permission (Lavra Garimpeira) and the Extraction Regime (Registro de Extração). The Survey Permit (Autorização de Pesquisa/Concessão de Lavra) allows for the issue of a mineral mining permit (Portaria de Lavra). This permission authorises up to 2,000 hectares of mining area for metallic mineral substances, fertilising mineral substances, coal, diamonds, bituminous and pyrobituminous rocks, peat and rock salt; 1,000 hectares for rocks for coating and 50 hectares for mineral substances related to direct use in civil construction, mineral water, sand, feldspar (when suitable for use in the transformation industry), gems (except diamond) and decorative stones. In areas located in the Legal Amazon defined in art. 2 of Law nº 5.173/66 (Government of Brazil, 1966), the maximum extension limit established for mineral substances is substantially larger at 10,000 hectares. An approval has four steps before mining activity can commence as shown in Figure 1.

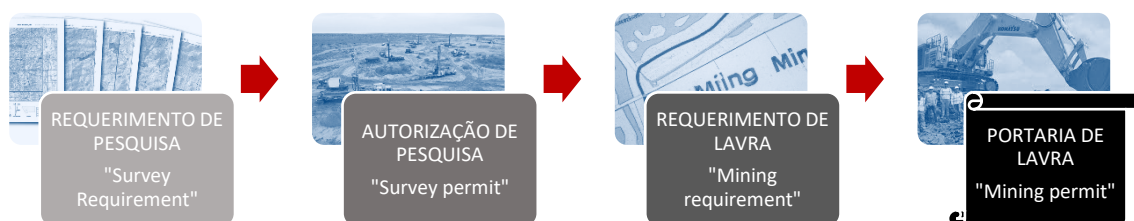


Figure 1 Flowchart with the stages to obtain a mining permit from the Federal Government in Brazil

The initial stage is the Survey Requirement which includes a description of the area, geographical and survey works plan, a budget and schedule. Following this, a Survey Permit is issued, with a duration of 2 years (with possible extension) to carry out a mineral survey. In this second stage, the company will quantify the mineral substance of interest and must start work within 60 days from issue of the permit. A report describing the resource, called the Final Survey Report (Relatório Final de Pesquisa) is submitted and reviewed by the National Mining Agency. Where the economic viability is verified an exploration permit may be granted. The third stage refers to the Mining Requirement (Requerimento de Lavra) and requires an Economic Use Plan (Plano de Aproveitamento Econômico). At this stage, both mineral and environmental permits are required.

The last stage in the process takes place with the approval of the Economic Use Plan, and subsequent issuance of the Mining Permit (Portaria de Lavra), a document issued by the Minister of Mines and Energy or by the Regional Manager (depending on the mineral substance). The validity of this permission is linked to the useful life of the mine declared in the Economic Use Plan. It is with this mineral permission that the interested party requests the Environmental Agency for the Environmental Operation Licence (Licença de Operação), and after issuing the two permissions (mineral and environmental) the company is authorised to

start mining work. The other three regimes allowed for mining activity in Brazil refer to more precarious titles and generally apply to smaller areas and mineral substances of lower value.

The Licensing Regime (Regime de Licenciamento) is a simplified mineral exploration process, where the interested party registers a licence with the National Mining Agency, which must be issued by the municipality where the area is located. It is provided exclusively to the owner of the land or to whoever obtains express authorisation from it. In this regime, the maximum area of each permit is 50 hectares.

The Extraction Regime (Regime de Extração) is exclusive to public administration bodies of the Federation, States and Municipalities. Minerals obtained under this regime are for exclusive use in works directly carried out by public bodies and may have a maximum area of 5 hectares. These permits are valid for a specified period, generally linked to the duration of the work being carried out.

Artisanal and small-scale mining have a slightly different process and require Artisanal Mining Permission (Permissão de Lavra Garimpeira). Gold, diamond, cassiterite, columbite, tantalite and wolframite, exclusively in alluvial, eluvial and colluvial forms, are considered to be minable and permitted to be extracted under this regime. It applies to a maximum area of 50 hectares for individuals, 1,000 hectares in other regions for Cooperatives, 10,000 hectares in the legal Amazon and has a maximum period of 5 years, renewable at the discretion of the National Mining Agency. The Artisanal Mining Permission does not apply to indigenous lands and when it occurs on borders with other countries.

Mine closure and rehabilitation requirements are described in Resolution No. 68/2021 published by the National Mining Agency in Brazil. This provides rules for the planning of Mine Closure, to be prepared by all mining companies in the country, whether those in the initial mining application phase or those that are already in operation.

3.1 Interaction between state and federal laws in Brazil

In Brazil, the Ministry of the Environment and Climate Change defines the laws that must be followed by the states. However, the requirements and analysis of environmental permits are, for the most part, carried out by the states, which can legislate and define their specific rights. In general, environmental licences follow a flow as shown in Figure 2, defined by Law nº 6.938/81 (Government of Brazil 1981), which established the National Environmental Policy (Política Nacional do Meio Ambiente). In the initial stage, a Term of Reference is established between the Agencies, environmental entities and the interested parties to carry out studies of the environmental impacts from the activity. With the terms of reference defined, the Environmental Impact Assessment (EIA) and the Environmental Impact Report (EIR) commence, which consist of environmental assessment (physical, biological and socioeconomic aspects); analysis of the environmental impacts of the project and its alternatives, measures to mitigate negative impacts (prediction of environmental programs planned to be implemented in order to reduce damage to the environment); follow-up and monitoring program, indicating the quality standards to be adopted as parameters.

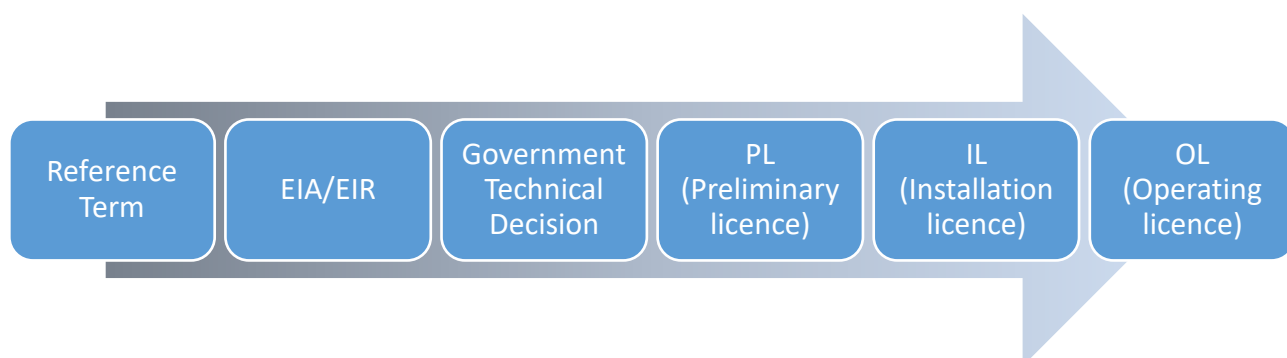


Figure 2 Procedural stages for obtaining environmental permits in Brazil

After preparing the EIA/EIR, interested parties present the documentation to the environmental entity or agency for assessment. Public hearings can be held, with the participation of stakeholders, so that the public is notified of the project and provided an opportunity to provide feedback. Such input may or may not be considered for the final decision by the Environmental Agency in issuing the permit.

When deemed appropriate by the Environmental Agency, interested parties receive a Preliminary Licence (Licença Prévia). This establishes the requirements and conditions to be met in the next stages of the project, observing municipal, state or federal land use plans. The Economic Use Plan, Degraded Area Recovery Plan (Plano de Recuperação de áreas Degradadas) and the EIA/EIR are technical documents required to obtain the Preliminary Environmental Licence. Once the Preliminary Licence has been received, interested parties must obtain the Installation Licence (Licença de Instalação), which authorizes the project and associated land clearing. The Mining Application is approved by the National Mining Agency with the environmental Installation Licence granted by the State Environmental Agency.

Once all the previous licensing steps have been completed, the Environmental Agency authorises the operation of the enterprise or activity with the issuance of the environmental Operation Licence (Licença de Operação) where mining can commence. Furthermore, there are some specific restrictions that may prevent the mining activity. This is the case of Natural Conservation Units defined in specific laws, where mining activity is totally restricted, or allowed with restrictions. In Brazil, Law nº 9985/2000 (Government of Brazil 2000), which created the National System of Nature Conservation Units (Sistema Nacional de Unidades de Conservação da Natureza), defines two different types of units, those of full protection and those of sustainable use, according to the degree of environmental importance and preservation of biodiversity. In Integral Protection Units, which are National Parks, Ecological Stations, Biological Reserves, Natural Monuments and Wildlife Refuges, places with a high degree of preservation and thriving biodiversity, a mining activity is not allowed in any way, with only the indirect use of natural resources by indigenous communities for subsistence and for scientific research purposes being allowed. In the Sustainable Use Units, mining activity is permitted with severe restrictions, since the main objective of these areas is the compatibility between nature conservation and the sustainable use of its natural resources. Environmental Protection Areas, National Forests, Extractive Reserves, among others, are classified as Sustainable Use Conservation Units, where mining activity is only permitted if it is compatible with the Unit's Management Plan (Plano de Manejo), defined by the competent Environmental Agency.

3.2 Social and environmental aspects of mining in Brazil

Mining operations in Brazil sometimes occur in areas with steep slopes and high rainfall making them prone to instability. Mining operations in Brazil have resulted in significant environmental accidents with social consequences. The collapse of the “Fundão” dam in the municipality of Mariana/MG in 2015 resulted in millions of cubic metres of iron ore tailings flowing along more than 600 km of the Doce River, reaching the Atlantic Ocean. This incident left a trail of destruction and affected several ecosystems and riverside communities, which is considered the biggest environmental accident in the history of Brazil.

The other, which took place in 2019 in the city of Brumadinho/MG, where the B1 dam collapsed at the “Córrego do Feijão” mine, did not cause as great an environmental impact as the first, but caused an irrecoverable social impact. This resulted in the loss of more than two hundred lives of mining employees, who were having lunch in a restaurant downstream of the dam, and who did not have time to escape, being buried alive by millions of cubic metres of iron ore tailings.

Another issue that has been causing social problems in Brazil, is mining on indigenous lands. It is defined in the Federal Constitution (Government of Brazil 1988) that:

“Mining and surveys for mineral resources in indigenous lands can only be carried out with authorization from the National Congress, after hearing the affected communities.” (art. 223)

Despite this requirement, there are cases in which mining activities permitted on indigenous lands have not been adequately regulated. Most of these indigenous areas are found in the Legal Amazon area, in places with rich biodiversity and fragile ecosystems. These areas are also rich in valuable minerals such as gold, diamonds, precious stones and rare earth elements, among other ores of high economic value. Lack of regulation for mining in indigenous lands has been causing serious conflicts, since they are usually areas of difficult access and, consequently, difficult to control by the state. This favours the invasion of these protected lands by miners and large companies, who exploit these minerals outside the requirements of the law and consent of indigenous peoples, invariably leaving serious environmental liabilities, such as large areas deforested and contaminated, mainly with mercury (Veiga & Hinton 2002).

4 Regulation of mining and rehabilitation in Queensland, Australia

Mining has occurred in Queensland for over 150 years. In this time many operations have been abandoned. There are approximately 120 significant abandoned mines with a combined disturbance area of about 10,300 hectares (Queensland Government, 2019). In Australia, minerals are owned and regulated by states and territories (OECD 2023). Each state and territory have their own legislative frameworks for the granting of rights, the provision of permits, licences or leases and titles for exploration. A review of regulatory frameworks for mine closure in three key mining jurisdictions (Western Australia, Queensland and New South Wales) reported that of these three states, Queensland's regulatory system is the most legislatively detailed, independently administered, legally forceful and transparent (Hamblin et al. 2022). The laws in Queensland are reviewed here to give an indication of broader trends across Australia.

The pathway to obtain approvals for a mining project in Queensland includes following the steps. Firstly, an exploration permit is required for prospecting, geophysical surveys, drilling, sampling and testing of materials. A mineral development licence (MDL) is then needed to define and evaluate the development potential of the resource. An MDL can be granted for an exploration permit where there is a significant mineral occurrence of possible economic potential (Queensland Government, 2023). A mining lease is required for large scale mining operations. In Queensland, the *Mineral Resources Act 1989* establishes the mineral resources tenure for mining licences and describes the requirements for surrendering, transferring and forfeiting a mining lease.

An Environmental Authority (EA) is required under the *Environmental Protection Act 1994* (EP Act) for environmentally relevant environmental activities. An EA for a project must be granted before a mining lease can be approved. The level of environmental risk and scale of the mining project affects the type of EA required. For example, these can include a standard application for an EA, a variation application, or a site-specific application. Small scale mining projects including some artisanal mines are required to follow a code that describes standard requirements.

A major mining project would require an Environmental Impact Statement (EIS) to be prepared. This process is used to assess the environment in the area of the project and potential environmental, economic and social impacts of the project (Figure 3). The proponent must propose actions to avoid, minimise, and mitigate potential impacts. In some instances, an offset may be required to compensate for unavoidable impacts on significant environmental matters. In Queensland, an EIS may be assessed under the EP Act, administered by the Department of Environment and Science (DES) or under the *State Development and Public Works Organisation Act 1971* (SDPWO Act), administered by the Coordinator-General, Department of State Development, Manufacturing, Infrastructure and Planning. Major projects are assessed by the Coordinator-General where they are declared a 'coordinated project'.

In Queensland, the *Mineral and Energy Resources (Financial Provisioning) Act 2018* established the Financial Provisioning Scheme (FPS), which requires mining permit holders to pay financial assurance, in the form of a contribution to a financial provisioning fund or provide a surety (depending on the assessed risk of the operator and mine). The amount of money that is required to be paid into the fund depends on the liability or the Estimated Rehabilitation Cost (ERC) for the site. The ERC reflects the costs that the state would

reasonably be expected to incur to make the site safe, stable and non-polluting if a site were to close prematurely. An EA holder is also required to demonstrate rehabilitated mine lands can sustain a post-mining use.

The EP Act requires mine sites to progressively rehabilitate sites prior to closure and relinquishment of mined land. These changes require mining companies to submit a Progressive Rehabilitation and Closure (PRC) plan which includes a schedule that describes specific rehabilitation milestones and criteria to assess performance. Permit holders must meet progressive rehabilitation milestones and criteria. Under the new regulations, mining permit holders are required to comply with their progressive rehabilitation schedule and are liable for non-compliance with their rehabilitation requirements creating a much more robust regulatory framework for mine closure. There are criminal offence sanctions for contravening a condition of a PRC plan schedule, as well as the capacity of a court to order the EA holder to pay the costs of the administering authority in responding to any environmental harm caused by the contravention (Hamblin et al. 2022). The recent strengthening of laws in 2018 is expected to reduce abandonment and provide the State with financial resources to remediate land should this occur.

Prior to the introduction of PRC plans, rehabilitation requirements were stipulated in EAs. Rehabilitation conditions in EAs tended to vary widely, in part because approvals range in their age and requirements for rehabilitation having improved over time. Rehabilitation requirements were typically described in a rehabilitation plan or closure plan and in some instances these were not required to be submitted to the administering authority until a period prior to closure (for example 5 years prior to closure). These earlier rehabilitation plans often did not include clear progressive milestones or robust criteria that could be used to assess the performance of rehabilitation. The use of a plan to regulate rehabilitation rather than specific conditions in a permit, made it difficult to assess compliance or take enforcement actions. This also meant that some operators may not have defined or implemented a rehabilitation plan until closure was imminent.

4.1 Interaction between state and federal laws in Queensland

The primary piece of legislation relating to environmental management at the Commonwealth (i.e. federal) level is the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). An action (such as mining) that is expected to have an impact on a matter of national environmental significance would require approval from the Commonwealth Environment Minister in addition to state level approval. The legislation outlines 'triggers' for assessment of an action under Commonwealth legislation. Examples relevant to mining can include potential impacts to water resources or protected areas, habitat or threatened species. Where a project or 'action' triggers the EPBC Act, a Commonwealth approval is needed before a project can proceed. Both the Commonwealth and the Coordinator-General can impose conditions on an environmental approval, however, the EA is issued by DES. Likewise, responsibility for compliance and enforcement largely rests with DES.

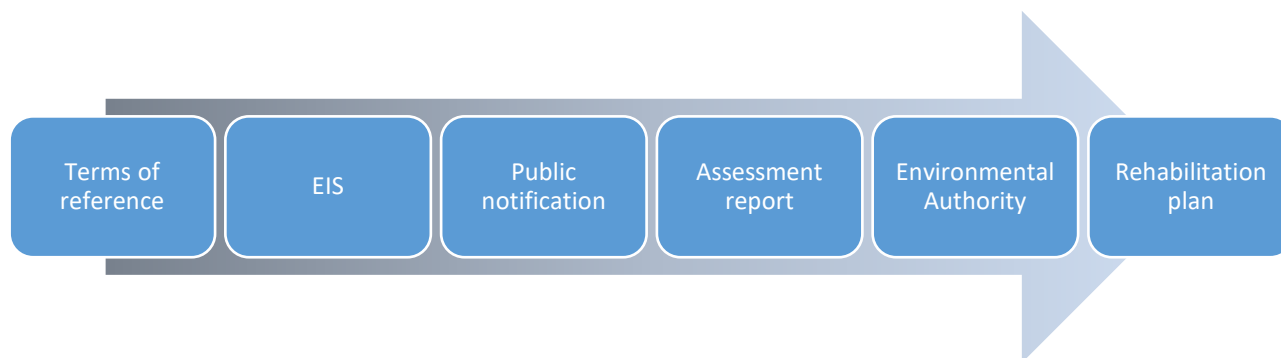


Figure 3 Stages for obtaining a mining permit in Queensland, Australia

4.2 Social and environmental aspects of mining in Queensland

While there have not been catastrophic tailings dam failures in Queensland, incidents have occurred elsewhere in Australia such as the 2018 failure of the tailings dam at Cadia Valley in New South Wales. This was reportedly due to two magnitude 2.7 earthquakes; however, the failure did not threaten human safety around the dam (The Guardian., 2018). Most mining projects in Queensland occur in remote regional areas away from major population centres such as in the Northwest Minerals province in Queensland, located in relatively flat and dry lands with low seismic risks. Mining projects can also have a range of positive and negative impacts on communities. Mining communities in resource areas in Queensland depend on mining for employment and can represent a large contribution to regional economic development.

Major mining projects require community consultation under the *Strong and Sustainable Resource Communities Act 2017* (Hamblin et al. 2022). Community consultation is also a key component of the PRC plan and is intended to ensure that anyone impacted by proposed rehabilitation and closure activities at the site has an opportunity to provide input to the planning process (DES 2021). The *Native Title Act 1993* requires mine operators to make Indigenous land use agreements about how land and waters will be used and managed. Such measures are important but do not guarantee social acceptance. An example occurs in Western Cape York, Queensland where bauxite mining impacts on local Indigenous communities in a variety of ways. In this area, mining has caused concerns about biocultural, community health and livelihood impacts from the loss of access to traditional lands and resources, and the ability to ‘care for country’ (Annandale et al. 2021).

5 Comparisons across Brazil and Australia

Unlike most countries, where mineral and environmental activity is regulated by the state or its territories, Brazil has a “regulatory mismatch” where the mineral permit is issued by a federal agency, but the environmental permits are issued by the states or municipalities, which have autonomy to define the procedures and criteria for each case. It is very difficult for the National Mining Agency of Brazil, to communicate at the federal level with the environmental agencies of the 26 states of the federation to define standardised procedures and processes. If standard procedures were put in place, mineral and environmental permits could be processed in a more consistent way.

This makes governance and management over the progress of mining processes fragmented, since each state can define how its environmental licencing systems will work. This can cause delays and takes years for a company to be able to obtain licences to operate within the law. Furthermore, the socio-economic inequalities that exist in Brazil can make these processes even more difficult.

Wealthier states or those with a greater tradition in mineral activity, generally have more structured environmental agencies, with professionals in sufficient quantity and quality to meet the demand for environmental licensing of mining activities with quality and efficiency. On the other hand, less developed states and with less tradition in mining activities, usually have poorly structured environmental agencies, without qualified professionals for an adequate analysis of requests for environmental permissions for mining, which in addition to a greater delay in the analysis and issuance of the permissions, poses the risk of developing activities in an inappropriate way.

Until 2021, the National Mining Agency of Brazil required a very basic Mine Closure Plan (Plano de Fechamento de Mina – PFM) from mining companies, inserted only as a subtopic of the Economic Use Plan that focusses on mineral production and operational safety. In this way, issues related to the closure and rehabilitation of mines were almost completely neglected by the National Mining Agency, since the environmental agencies were exclusively assigned the obligation to accompany, monitor and validate the actions of closure and rehabilitation of mines, which in most cases were not (and still are not) carried out properly.

The only issue that made the National Mining Agency of Brazil move to improve its governance of environmental issues, were the tragic accidents that occurred with mining dams in 2015 and 2019 with the collapse of the “Fundão” and the Brumadinho dams. These events, added to the great pressure from society, justice bodies, public ministries, internal control bodies and political agents, forced the Brazilian government and the National Mining Agency of Brazil to develop strict laws and regulations based on world’s best practices, to raise the safety actions of tailings dams in Brazil to a level that today is a world reference. The National Mining Agency of Brazil developed a tailings dam reporting systems called ‘Sistema Integrado de Gestão de Barragens de Mineração’ or Integrated Mining Dam Management System ([SIGBM Público | ANM - Agência Nacional de Mineral](#)). Industry is required to submit a dam inspection statement every 15 days and a statement of stability to an on-line data portal. This provides a basis for accurate and standardised reporting on tailings risk at the national level. However, tragic accidents and very serious social and environmental consequences had to occur before due attention was given to this issue. Another aspect of the Fundão rupture was that the impacts expected across state boundaries. Where the environmental impacts of a mine extend across a state border, it triggers a Federal response in Brazil.

Regarding the issue of mine rehabilitation and closure planning and also the management of abandoned mines, Brazil is still walking at a slow and modest pace. It is a topic that has not yet caused any serious impact on society and the environment, which could draw attention of the “lawmakers”. However, the reality is that there are probably thousands of abandoned mines in Brazil, and here we put “probably”, because there is no official survey on the number of abandoned mines in the country. A study carried out in just one state, in Minas Gerais, identified more than 500 mines between paralysed and abandoned (FEAM 2022). The potential total number that would be found in a national survey is concerning. This high number of abandoned mines is a direct reflection of the lack of governance by government bodies, whether federal or state, mining or environmental, in the proper establishment of rules for mine closure and post-closure relinquishment. As a result, cases of mine abandonment are frequent in Brazil. The cause of abandonment likely reflects the limited control by the state and lack of severe punishments for companies which in turn increases the environmental and social risks of abandoned mines (Veiga and Hinton 2002; Perlatti et al. 2021; da Silva Borges Barbosa et al. 2022).

The regulatory reforms recently introduced in Queensland have improved financial assurance and introduced more robust progressive rehabilitation requirements. The drivers for these changes include the reported widening gap between disturbance and rehabilitation. A paper by (Cooper 2019) highlighted a 2016 review by Queensland Treasury found the State had an estimated rehabilitation cost of \$8.7 billion but held around \$6.9 billion in financial assurance. Other catalysts for legislative change include a number of mines defaulting and becoming abandoned. Purtill et al. (2022) highlighted an examples the Minister for Environment and Heritage Protection and Minister for National Parks and the Great Barrier Reef, Steven Miles cited the disclaiming of high risk mine sites such as Texas Silver, Collinwood Tin and Mt Chalmers when introducing the Environmental Protection (Chain of Responsibility) Amendment Bill 2016 (Qld). This likely reflects broader social awareness of the issues at that time.

6 Conclusion

Both Australia and Brazil have a long tradition of mining with established regulatory systems for the approval and management of the social and environment impacts of mining. The legal systems in both jurisdictions share a similar process for approving major mining projects requiring an environmental approval before mining can commence. Mine closure planning and progressive rehabilitation are integrated into regulatory approval processes in Queensland and Brazil. Queensland’s Progressive Rehabilitation and Closure plan provides a model for regulating, monitoring and compliance. The regulatory process for mining in Brazil is weighted towards the initial approvals for mines and consideration of mine rehabilitation in Brazil could be strengthened. There is also a mismatch between the application of laws between the federal and state levels of governance that can create gaps in the implementation of the laws in Brazil. This can reduce the technical scrutiny on mine rehabilitation plans and limit capacity to enforce compliance with them. A positive aspect

of the regulatory system in Brazil is that where environmental impacts of a mine extend across a state border, a Federal regulatory response is triggered. This was demonstrated by the Fundão rupture. This is different to the approach in Australia, where transboundary pollution would trigger two or more State-regulatory responses, and not a Federal one unless it triggered Commonwealth legislation. Federal oversight to manage cross-boundary matters is likely to provide greater consistency.

Measures are being taken to improve mine rehabilitation and closure practices in Brazil. In April 2021, the National Mining Agency published Resolution No. 68/2021 (ANM 2021) which provides rules for the planning of Mine Closure, to be prepared by all mining companies in the country, whether those in the initial mining application or those that are already in operation. Although still modest and not very detailed, it is considered a positive first step for the country to advance in this matter. Recent tailings dam failures and the resultant social and environmental impacts have also led Brazil to strengthen the public reporting of the risks associated with tailings dam structures. Ongoing improvement to develop and implement leading world practices is a commitment of the National Mining Agency in Brazil.

While regulatory reform has brought about more robust legislation to govern mine rehabilitation in Queensland there remains some gaps. An example is the public reporting on tailings dam risk. Although many tailings dams in Queensland are located in relatively flat and dry lands with low seismic risks there are some high-risk tailings dams. The collapse of Brazil's Brumadinho iron ore tailings dam in 2019 prompted self audits of tailings dam risk in Australia. From this audit, a small number of dams were identified as high-risk including Rio Tinto's Andoom and Torro mines at Weipa and two dams inside Mount Isa Mines operated by Glencore (Maguire 2019). Although there has been a tailings dam failure at Cadia in New South Wales and reports of high-risk structures in Queensland, there is a lack of public facing reporting of risk, let alone near real time. The National Mining Agency in Brazil have developed excellent public reporting on tailings dams in response to the tragic dam failures that have occurred there. Queensland would benefit from adopting a similar regime of reporting and public disclosure of mine structure risks and rehabilitation. Queensland has the only known public reporting of progressive rehabilitation in Australia, though some jurisdictions are known to be developing such systems. Ultimately, greater transparent reporting is likely to drive improvement in practices.

Improved engagement with traditional owners and working towards closure of mines with a long-term benefit to surrounding indigenous communities remains a goal for both countries. Interactions between institutions and governments such as National Mining Agency in Brazil and the Office of the Queensland Mine Rehabilitation Commissioner provides a basis to improve mine rehabilitation practices.

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References

- ANM, 2021, Resolução nº 68/21, Dispõe sobre as regras referentes ao Plano de Fechamento de Mina – PFM, Agência Nacional de Mineração, Government of Brasil, Brasília, Brasil.
- ANM, 2022, Anuário Mineral Brasileiro - Principais Substâncias Metálicas 2022 (Ano Base 2021) - PRÉVIA. Agência Nacional de Mineração, Available at: <https://www.gov.br/anm/pt-br/centrais-de-conteudo/publicacoes/serie-estatisticas-e-economia-mineral/anuario-mineral/anuario-mineral-brasileiro>.
- Annandale, M, Meadows, J & Erskine, P 2021, 'Indigenous forest livelihoods and bauxite mining: A case-study from northern Australia', *Journal of Environmental Management*, 294 (May), p. 113014. doi: 10.1016/j.jenvman.2021.113014.
- Cooper, S. 2019, 'Maximising post-mining land use: Queensland Government reforms', in *Mine Closure 2019: 13th International Conference on Mine Closure*. Australian Centre for Geomechanics, pp. 969–982. Available at: https://papers.acg.uwa.edu.au/p/1915_76_Cooper/ (Accessed: 27 May 2022).
- DES 2021, Guideline - Progressive rehabilitation and closure plans (PRC plans). Department of Environment and Science, Queensland Government. Available at: https://environment.des.qld.gov.au/__data/assets/pdf_file/0026/95444/rs-gl-prc-plan.pdf.

- DISER 2020, Resources and Energy Quarterly. Resources, Department of Industry Science Energy and Resources.
- Ferrante, L. & Fearnside, PM, 2020, 'Brazil threatens Indigenous lands', *Science*, 368(6490), pp. 481–482. doi: 10.1126/science.abb6327.
- Fundação Estadual do Meio Ambiente (FEAM) 2022, Government of Minas Gerais State, 'Cadastro de Minas Paralisadas e Abandonadas no Estado de Minas Gerais', p. 30.
- Geoscience Australia 2023, Australian mineral facts, Earth sciences for Australia's future. Available at: <https://www.ga.gov.au/education/classroom-resources/minerals-energy/australian-mineral-facts>.
- Government of Brazil 1966, Lei nº 5.173/66, Plano de Valorização Econômica da Amazônia, 1966, Brasília, Brasil.
- Government of Brazil 1967, Código de Mineração. Brasília, Brasil.
- Government of Brazil 1981, Lei nº 6.938/81, Política Nacional do Meio Ambiente, 1981, Brasília, Brasil.
- Government of Brazil 1988, Constituição da República Federativa do Brasil. Brasília, Brasil.
- Government of Brazil 2000, Lei nº 9985/2000, Sistema Nacional de Unidades de Conservação da Natureza (SNUC), 2000, Brasília, Brasil.
- Hamblin, L, Gardner, A and Haigh, Y 2022, Mapping the Regulatory Framework of Mine Closure. Perth, Australia: CRC TiME Limited.
- Lima, HM, de Flores, JC, do C, and Costa, F L 2006, 'Plano de recuperação de áreas degradadas versus plano de fechamento de mina: um estudo comparativo', *Rem: Revista Escola de Minas*, 59(4), pp. 397–402. doi: 10.1590/s0370-44672006000400008.
- Maguire, K 2019, Tailings dams failure risks range from high to extreme in audits by Australian mining giants, ABC Rural. Available at: <https://www.abc.net.au/news/rural/2019-06-20/tailings-dam-audit-finds-high-failure-risks-across-australia/11223510>.
- OECD 2022, Recent performance of the mining sector in Brazil, Regulatory Governance in the Mining Sector in Brazil. doi: <https://doi.org/10.1787/63d60aa8-en>.
- OECD 2023, Mining regulation in Australia, Mining regulation in selected countries. Available at: <https://www.oecd-ilibrary.org/sites/b12ca2a9-en/index.html?itemId=/content/component/b12ca2a9-en>.
- Perlatti, F, Martins, EP, Oliveira, DP, Ruiz, F, Asensio, V, Rezende, CF, Otero, XL & Ferreira, TO, 2021, 'Copper release from waste rocks in an abandoned mine (NE, Brazil) and its impacts on ecosystem environmental quality', *Chemosphere*, 262. doi: 10.1016/j.chemosphere.2020.127843.
- Purtill, J, Gagen, EJ, and Hamilton, B, 2022, 'A Brief History of Mine Rehabilitation Reforms in Queensland', *Environmental and Planning Law Journal*, 39(1), pp. 64–78.
- Queensland Government 2023, Mineral and coal authorities, Business Queensland. Available at: <https://www.business.qld.gov.au/industries/mining-energy-water/resources/minerals-coal/authorities-permits/applying/authorities/development-licence>.
- Queensland Government 2019, Abandoned mines management policy. Department of Natural Resources, Mines and Energy. Available at: https://www.resources.qld.gov.au/__data/assets/pdf_file/0008/1454939/policy-abandoned-mines.pdf.
- da Silva Borges Barbosa, V., Mota de Lima, H. and Fonseca, B. M. (2022) 'Assessing risks of abandoned urban mines in the UNESCO World Heritage City of Ouro Preto, Brazil', *Applied Geography*, 139(December 2021). doi: 10.1016/j.apgeog.2022.102648.
- The Guardian 2018, Dam wall collapse at Newcrest-owned Cadia goldmine forces shutdown, Australian Associated Press. Available at: <https://www.theguardian.com/australia-news/2018/mar/11/dam-wall-collapse-at-newcrest-owned-cadia-goldmine-forces-shutdown> (Accessed: 14 June 2023).
- Veiga, MM, & Hinton, JJ, 2002, 'Abandoned artisanal gold mines in the Brazilian Amazon: A legacy of mercury pollution', *Natural Resources Forum*, 26(1), pp. 15–26. doi: 10.1111/1477-8947.00003.
- Williams, DJ, 2023, A systematic and systemic review of mined landform stability and its impact on transitioning for regional benefits. CRC TiME Limited. Available at: <https://crctime.com.au/research/projects/project3e/>.