Centre for Social Responsibility in Mining
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Mining regions in transition – a global scan

Report for the Social Aspects of Mine Closure Research Consortium

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Graphical representations including the research steps (Figure 1), RESET analytical framework (Figure 10) and the Table 5 icons were designed by Darren Sprott, Design Solutions Australia.

Companion reports on this research

Multiple reports on *Mining regions in transition- a global scan* are available on the Social Aspects of Mine Closure Research Consortium webpage (https://www.mineclosure.net/). In addition to this report there is a succinct web version you can scroll through on the project details page, a narrated PowerPoint to view and a technical report with more details of methods and data.

Citation

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Cover image

A graphical representation of our RESET (Regional Economic, Social and Environmental Transition) analytical framework. See Section 4: Capacity of regions to transition. (Credit: Darren Sprott).

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Ranked in the world's top 50[1], The University of Queensland (UQ) is one of Australia's leading research and teaching institutions. UQ strives for excellence through the creation, preservation, transfer and application of knowledge. For more than a century, we have educated and worked with outstanding people to deliver knowledge leadership for a better world.

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The Sustainable Minerals Institute (SMI) is a world-leading research institute committed to developing knowledge-based solutions to the sustainability challenges of the global resource industry, and to training the next generation of industry and community leaders. The Institute is transdisciplinary, and our work is impartial and rigorous. Our research integrates the expertise of production, environmental and social science specialists to deliver responsible resource development.

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The Centre for Social Responsibility in Mining (CSRM) focuses on the social, cultural, economic and political challenges that occur when change is brought about by mineral resource extraction. The Centre contributes to industry change through independent research, teaching and by convening and participating in multi-stakeholder dialogue processes. Our team consists of geographers, anthropologists, sociologists, political scientists, economists, development and natural resource specialists.

[1] QS World University Rankings and Performance Ranking of Scientific Papers for World Universities, 2018.

List of symbols and abbreviations

Abbreviation	Definition
>	Greater than
≥	Greater than or equal to
<	Less than
%	Per cent
$/km^2$	Per square kilometre
Bt	Billion tonnes
GADM	Database of General Administrative Areas
GHM	Global Human Modification
HDI	Human Development Index
JORC	Joint Ore Reserves Committee
km	Kilometres
MCI	Mining Contribution Index
MRITs	Mining regions in transition
Mt	Million tonnes
R&Rs	Reserves and resources
RESET	Regional Economic, Social and Environmental Transition
RGI	Resource Governance Index
t	Tonnes
WGI	Worldwide Governance Index

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Executive summary

This global scan examines the capacity of mining regions to transition to a post-mining future. The study highlights the complex patterns of human-nature interactions and considers the influence of key contextual factors on transition capacity. Three tiers of mining regions are identified based on this analysis: least constrained capacity, constrained capacity and most constrained capacity.

Method

The study draws upon public sources of geo-locatable data using three steps:

1. Defining and locating the world's mining regions
2. Defining and characterising a sub-group of regions where important mining assets are approaching the end of their economic lives
3. Analysing the comparative capacity of these regions to successfully transition to post-mining alternatives according to contextual factors that influence transition capacity.

Results

The analysis identified 554 administrative regions that have at least three mines within 50km of each other. These 'mining regions' are spread across 79 countries; more than half being in major mining countries, such as the USA, Australia, India, China, Canada and Russia.

We report patterns, trends and contextual factors for these regions and identify variations in the number of mines, the total reserves and resources (R&Rs), the proportion of closed and operating mines, mine sizes, mining methods and commodities.

Forty-six regions meet our criteria for 'mining regions in transition' (MRITs). These criteria are: (i) a minimum tonnage of R&Rs, (ii) a minimum proportion of closed mines and (iii) more than the average number of mines reportedly closing within 10 years (noting that many factors can change the timing of closure).

Location and characteristics of 46 mining regions in transition

Our analysis shows that:

- The number of mines in each MRIT ranges from three (in Brazil's Paracatu, Mexico's Eduardo Neri and the USA's San Juan) to 56 (in South Africa's Northern Cape Province).
- R&Rs of MRITs total 102.7Bt, accounting for around 9% of the R&Rs of all mining regions.
- More than 200 mines (33%) are reported to be already closed and about 170 others (27%) are reported to be closing within the next decade.
- Forty-nine per cent of mines are open pit and 5 MRITs (11%) have only open-pit mines.
- In 40 MRITs, more than half the mines extract the same primary commodity. Gold is the prevailing commodity in 22 regions (48%). Coal and copper are the dominant commodities in seven regions (15%), followed by iron ore in five regions (11%).

Regional capacity to transition

Using to the RESET framework (Regional Economic, Social and Environmental Transition), the study identified three tiers of regional capacity among these MRITs. Factors supporting preventive, proactive and precautionary management of the transition are evident in 12 MRITs, which also show declining mining activity. The combined factors indicate that these regions will face fewer constraints to transition than other MRITs Seven other MRITs were found to be poorly equipped to handle the transition due to existing constraints.

Tier 1 encompasses the 12 regions with the strongest capacity for transition. These regions have high human development and robust governance scores. Gold is the prevailing commodity in seven of these regions and the others extract primarily iron ore, copper, silver and coal. Open-pit mining is the most common mining method in two-thirds of Tier 1 regions. All are rural with low population densities of <10 inhabitants/ km^2. Fort Smith Region, in the Northwest Territories, Canada, is a typical Tier 1 MRIT. This region is profiled in Section 4.2.1.

In **Tier 2**, there are 27 regions with combinations of favourable and constraining contextual factors. All regions have high or very high human development scores. Environmental constraints feature in all Tier 2 regions, with water risks particularly evident. Apurímac in Peru and Leonora in Australia are examples of Tier 2 MRITs. These two regions are discussed in Section 4.2.2.

Tier 3 regions are the most constrained MRITs. These seven regions are in less developed countries that have national economies dependent on mining. They lack commodity diversity, have less satisfactory governance scores and have a significant proportion of mines closed or scheduled to close within 10 years. Moreover, all are in environmentally fragile locations. In this tier of regions, all but one (Haut-Katanga, in Democratic Republic of Congo) have above the median percentage of large mines. Gauteng, in South Africa, epitomises many of the challenges for Tier 3 MRITs. This region is profiled in Section 4.2.3.

The implications of this research outlined in Section 5 can be used to inform management practices, policy development and community planning to enhance the transition to closure and post-mining. Section 6 provides recommendations that flow from the study findings about the comparative capacity of regions to transition.

1. Introduction

This study determines the location of the world's mining regions. It identifies those regions facing the potential closure of important mines and profiles their relative capacity to transition to post-mining alternatives. We call this progression the transition to closure, which incorporates staged planning processes for the end of mining production, environmental rehabilitation and decommissioning of mining assets, plus the activities associated with creating post-mining futures. These stages are influenced by a multitude of factors – both mining-related and regional characteristics – that extend beyond the control of a single mine, company or government authority (Svobodova et al., 2020). Greater understanding of these factors requires the same attention that is given to economic, engineering and geological life-of-mine considerations (Everingham & Mackenzie, 2019).

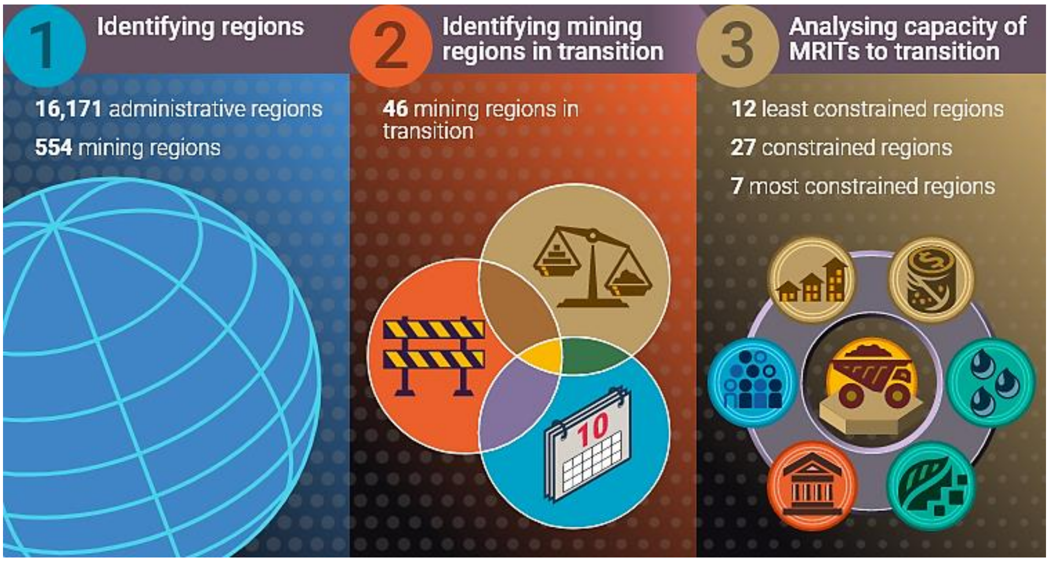
Our source for all mining-related data is the Joint Ore Reserves Committee reports (JORC, 2012) as presented in the S&P Market Intelligence Database. This commercial database compiles public data released by mine owners and is one of the largest, most comprehensive and up-to-date global sources of data on extractive industry sites (Valenta et al., 2019). Although not legally enforceable, JORC reporting in the S&P database provides standardised information about measurable contextual factors of interest to government and shareholders. Several of these factors attest to the diversity and comparative capacity of mining regions in transition. Other contextual and regional data draw upon public sources that are geo-locatable.

Undertaking a global scan of this type is challenging since current reporting practices do not provide readily comparable, comprehensive performance data (Boiral & Henri, 2017). We use a mix of specific indicators and aggregate indexes to address these limitations (following Lèbre et al., 2020; and Owen et al., 2020). The steps we follow are reported in sections 2, 3 and 4 of the report.

1.1 Research steps and report structure

A key aim of the study is to articulate clear, consistent approaches to defining mining regions. The study establishes a rationale for the selection of jurisdictions and mines, locates and characterises 'mining regions in transition' then determines key factors that influence the regions' capacity to transition (Figure 1). Subsequent sections report each of these steps in turn.

Figure 1: Main steps of the research to narrow focus and allow progressively greater insight



The report has seven sections outlined below:

- Section 2 provides our working definition of mining regions and describes the global sample used in the study.
- Section 3 focuses on MRITs; that is, regions with closed mines (typically sites where operations have stopped and there has been a formal closure process) or where important regional assets are approaching the end of their economic lives.
- Section 4 sets out criteria for defining a region's capacity to smoothly and effectively transition to post-mining alternatives. Based on these criteria, three 'tiers' of regions are identified that correspond to progressively greater constraints.
- Section 5 discusses the implications of these findings for different stakeholders.

Recommendations for various parties, based on the study findings, are made in Section 6 and the report's conclusions are presented in Section 7.

Succinct accounts of this research on the web and in a PowerPoint are available here. A separate technical report provides further detail of the methods used and auxiliary data for readers wishing to expand on the summary accounts in this report.

Image credit: Darren Sprott, Design Solutions Australia

2. Defining and locating the world's mining regions

A study of mining regions and their capacity to transition to closure requires an understanding of the sub-national context. The scholarly and grey literature abound with definitions of 'a region' (for examples, see Appendix: Defining regions). These works explain differences in capacity and performance – whether related to economic prosperity, labour markets, demographic make-up or social wellbeing. Many of the characteristics highlighted are relevant to locating global mining regions; however, in some cases, the spatial boundaries are ill-defined.

Informed by this background work, our study adopted a definition of mining regions that takes into account the economic, political, social and environmental complexity of mining regions. The definition is: '**geographical regions that are administered by a single government entity, and where at least three operating and/or closed mines within 50km of each other form a dense mine cluster**'. By overlaying administrative regions with mine clusters, we identified a set of 554 mining regions.

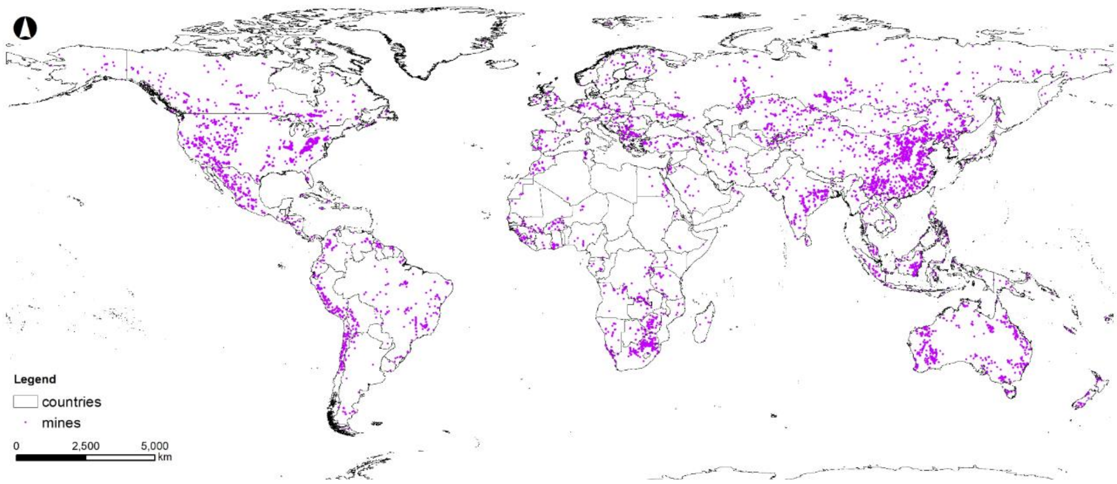
Section 2 describes the geographic distribution of this global set of mining regions and characterises mining in the region in terms of the reserves and resources (R&Rs), commodities extracted, mining method, mine sizes, and proportion of closed and operating mines.

2.1 Methodology

Global mining sites

Mining regions were identified by sequentially analysing the location and density of mines (cluster distribution) within global administrative regions using data from the S&P Global Market Intelligence database.[2] To systematically locate key mineral production sites, we removed mines in the preproduction stage, those without status information and those without XY coordinates listed in the database. This initial selection process led to a sample of 8,555 mines from a total 35,610 mines. Each is geo-located at a point using its XY coordinates (Figure 2).

Figure 2: Global distribution of 8,555 mines selected for identification of mining regions in transition



Mine clusters

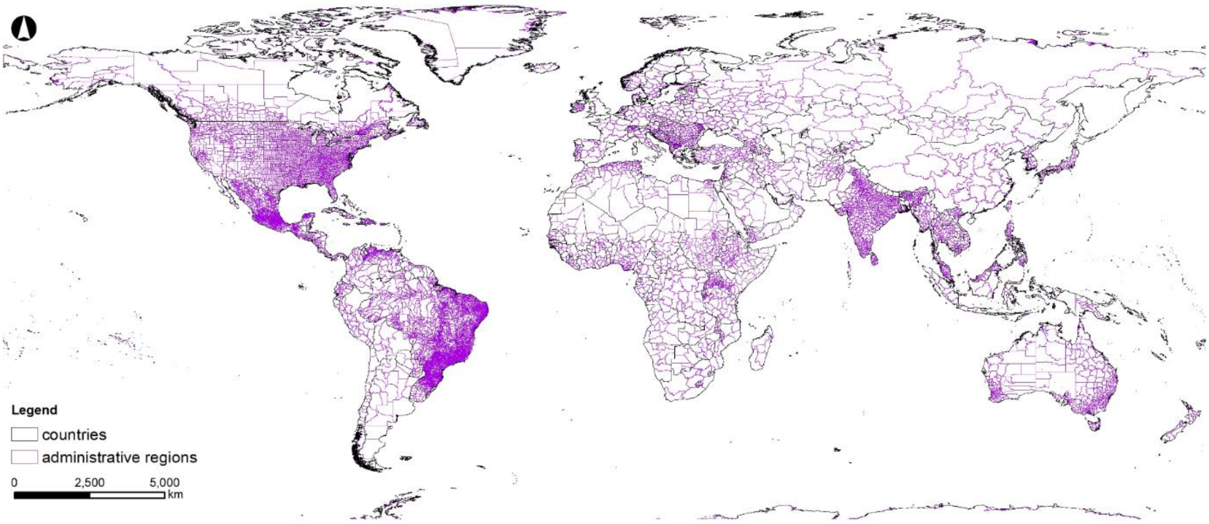
Spatial clustering determined the density and intensity of mining activities within regions. To identify mine clusters, we measured the distance between mines using the 'Near function' in ArcGIS. A 50km distance was adopted as a threshold value for higher density of mines within regions, and 7,234 mines were located within this threshold.

[2] The S&P Global Market Intelligence database relies on public disclosure, which results in some skewing and limitations of data. For instance, historical and mine size data may be incomplete. Artisanal and small-scale mining or some state-owned projects and other unreported mining activities are typically not covered by this database. Projections about mine stages and closure may prove inaccurate. In addition, there are gaps in data, e.g. only 50% of entries include information about closure dates.

Boundaries of administrative regions

To identify administrative regions and their geographical boundaries, we used a dataset of global administrative areas, known as GADM.[3] The dataset provides boundaries of 386,735 administrative jurisdictions at multiple levels and with variable sizes. The administrative levels are reported in a sequence of non-overlapping geographic areas and vary on a country basis from national, state/ province, regional to local levels. Sub-country or sub-province levels were adopted as an administrative region assumed to have consistent regulation and functional governance. This selection procedure identified the sample of 16,171 administrative regions with clearly defined boundaries (Figure 3).

Figure 3: Administrative regions as identified in the GADM dataset of global administrative areas.



Locations of global mining regions

To identify mining regions, we selected administrative jurisdictions with a higher density of mines; that is, those with ≥3 mines within 50km of each other. The analysis identified that 15,044 have no mines in 50 km clusters, 573 others have only one or two mines in this proximity and 554 have ≥3 mines (Table 1). Only 13 regions have clusters of more than 70 mines.

Table 1: Number of mines within 50km distance of each other across administrative regions. (Mining regions are those in the shaded columns).

Number of mines within 50km of others	0	1-2	3-20	20-70	70-212
Number of administrative regions with that number of mines close together	15,044	573	491	50	13

[3] The Database of Global Administrative Areas is a high-resolution database of the location of country administrative areas, that aims to cover all countries, at all levels, and at any time period. It is maintained by the American Association for the Advancement of Science (AAAS) https://www.aaas.org/programs/scientific-responsibility-human-rights-law/global-administrative-areas and located at https://gadm.org/index.html. Note that the number of administrative regions in a country varies significantly.

2.2 554 global mining regions and their characteristics

This section describes the global set of 554 mining regions presenting the patterns, trends and contextual factors evident among them.

Geographic distribution

Mining regions are located in 79 countries around the world (Figure 4). More than half of them (57%) are in countries covering vast territorial areas. The USA alone accounts for one-quarter of all mining regions, but these regions only occupy 6% of the country's administrative jurisdictions. Other countries with more than 25 mining regions include Australia, India, China, Canada and Russia, each accounting for more than 4% of global mining regions. Between 7% and 94% of the administrative jurisdictions in these countries are mining regions (Figure 5).

Figure 4: Global distribution of mining regions

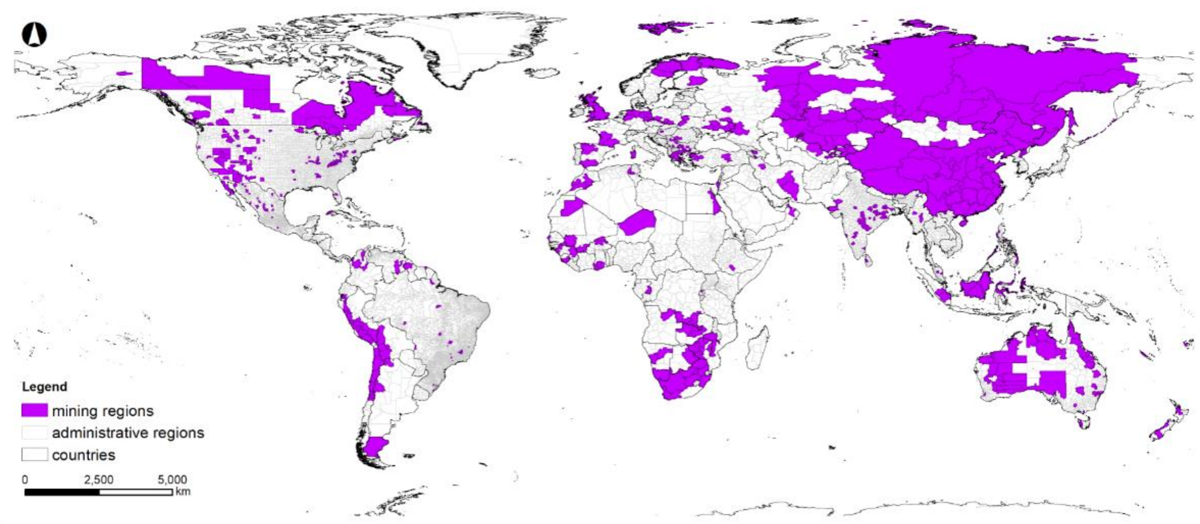
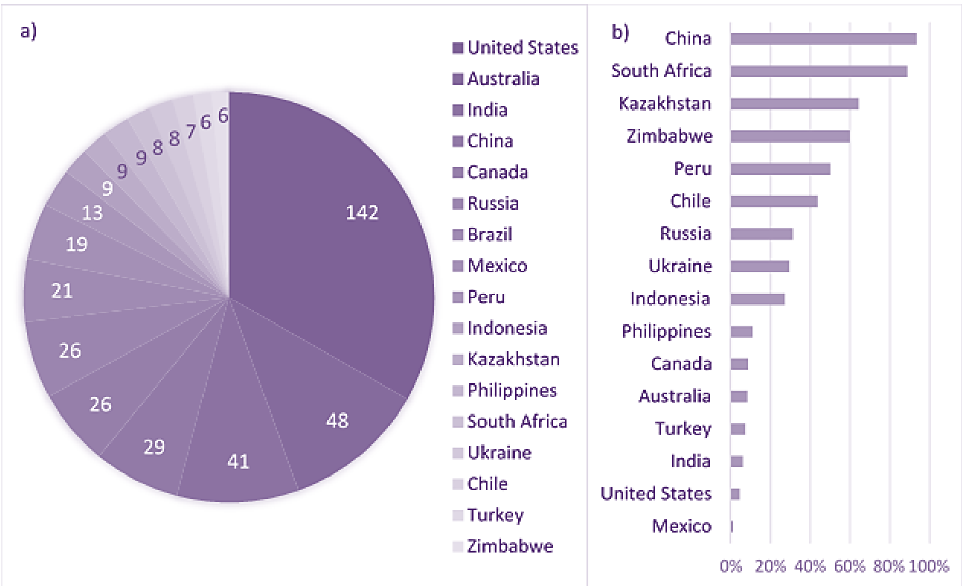


Figure 5: Countries with >5 mining regions (a) ranked by number of mining regions per country; (b) ranked by percentage of administrative regions that are mining regions.



Number of mines per region

While the average number of operating or closed mines per mining region is 13, seven mining regions contain more than 100 mines each. They are located in China (4), Russia (1), Ukraine (1) and South Africa (1). One Chinese region, Shanxi, reports 213 mines, 47% of which have more than 1Mt in R&Rs. In contrast, 117 mining regions in 37 countries contain only three mines. This represents 21% of the global set of mining regions.

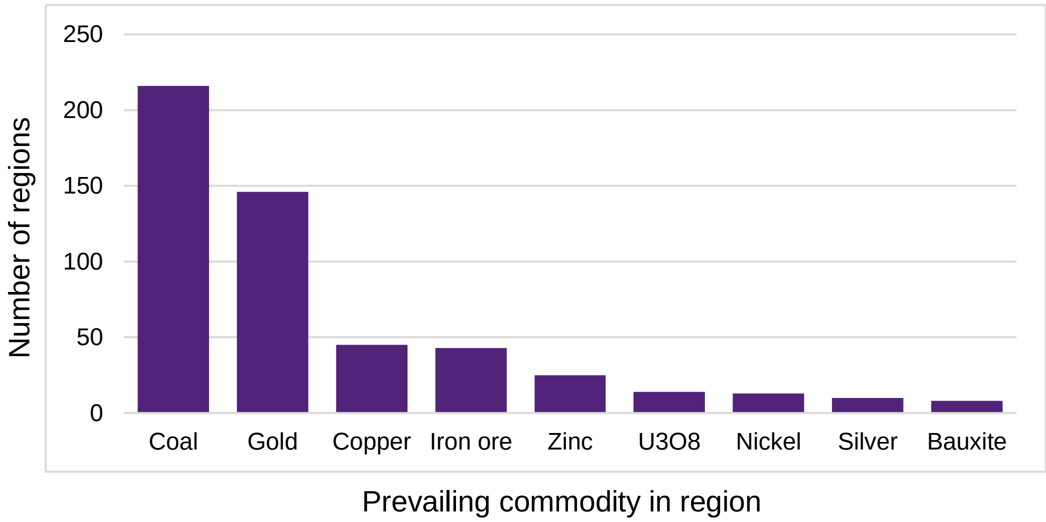
Intensity of mining in the region

Similar variation was identified in the R&R data, with 11% of mining regions having <1Mt of R&Rs. In general, tonnage per region is relatively high, with 25% having R&Rs of ≥1000Mt. In 60% of mining regions, there are more than 100Mt of R&Rs in either one large mine or several smaller ones. Large mines (i.e. R&Rs ≥100Mt) account for all mines in eight mining regions (3 in India, 2 in Australia, 1 each in Poland, Ukraine and Guinea) and ≥50% in another 58 mining regions.

Commodities

Coal and gold are the most common commodities extracted in the sample of mining regions. Coal extraction prevails in 39% of regions and gold in 26% of regions. Other common commodities are copper (8.1% of regions) and iron ore (7.8% of regions) (Figure 6). In 42% of the regions, a single commodity is mined, meaning the regions are specialised in the extraction of that one commodity. Where there are several commodities extracted in a region, the most common secondary commodities are gold (12% of regions) and zinc (9% of regions).

Figure 6: Primary commodity extracted in global mining regions



Mine type

Open-pit mining is the prevailing extraction method in 316 mining regions (57%), while underground mining is the most common method in 133 mining regions (24%).

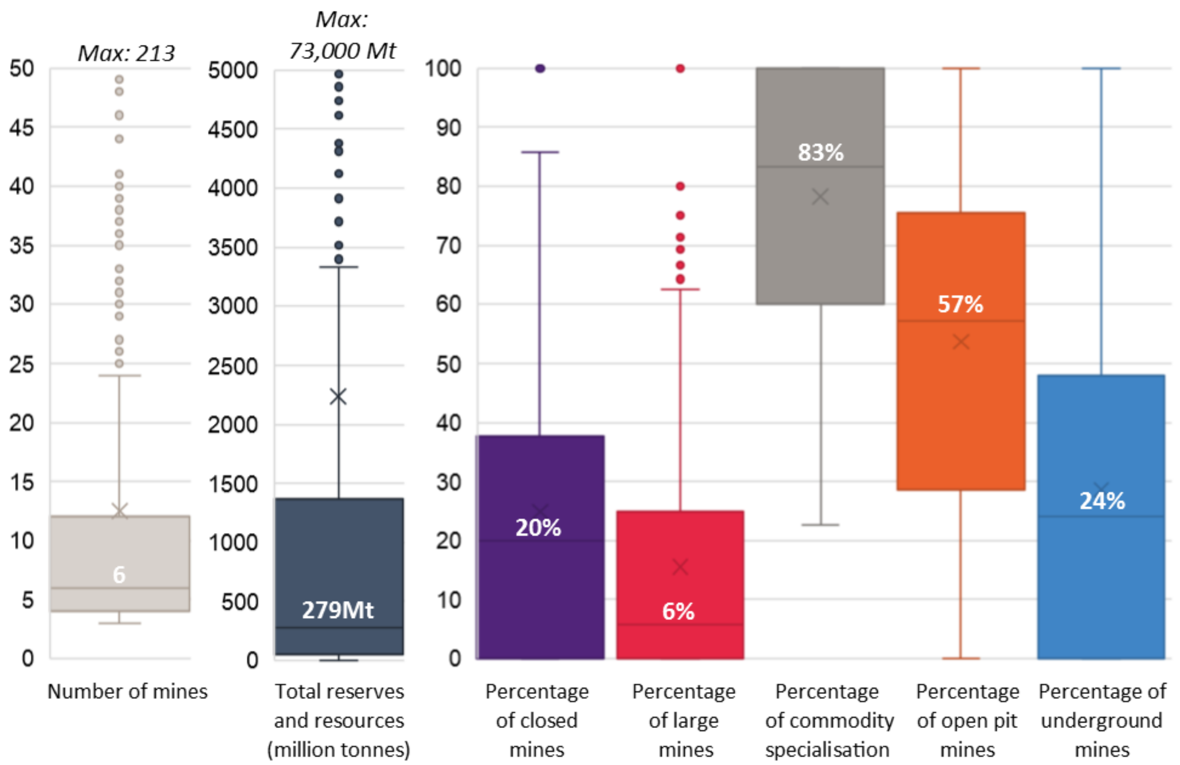
Global trends in mining regions

Characteristics of global mining regions are summarised in Table 2 and Figure 7.

Table 2: Global patterns observed in data on 554 mining regions.

	Range	Median (Middle) value
Number of mines	3-213	6
Total reserves and resources (Mt)	0-72,634	279
Percentage of large mines (≥100Mt)	0-100	6
Percentage of mines extracting prevailing commodity	23-100	83
Percentage of mines with prevailing mine type	29-100	67
Percentage of open-pit mines	0-100	57
Percentage of underground mines	0-100	24

Figure 7: Global trends observed in 554 mining regions visualised using box plot diagrams.[4] Median values are provided near the corresponding median line of the plots. Maximum values falling outside the scale are specified above the plot.



[4] Box plot diagrams present data through their quartiles. The height of the box indicates the spread and distortion in the data. The lines extending from the boxes (whiskers) indicate variability outside the upper and lower quartiles (i.e. range of the data) and individual points show outliers. Lines across the plot indicate median (middle) values.

3. Identifying and characterising mining regions in transition

Not all the 554 global mining regions can be regarded as being in transition. Many mines in these regions are in early or mid-production and, therefore, have less intense focus on closure compared with regions where older mines are approaching the end of their economic lives (ICMM, 2019). In addition, there are 13 mining regions (2.3%) that already have completed their closure transitions; that is, all their mines have closed. Seven of these regions are in the USA, and one each in Australia, Canada, France, the Philippines, Czech Republic and Surinam.

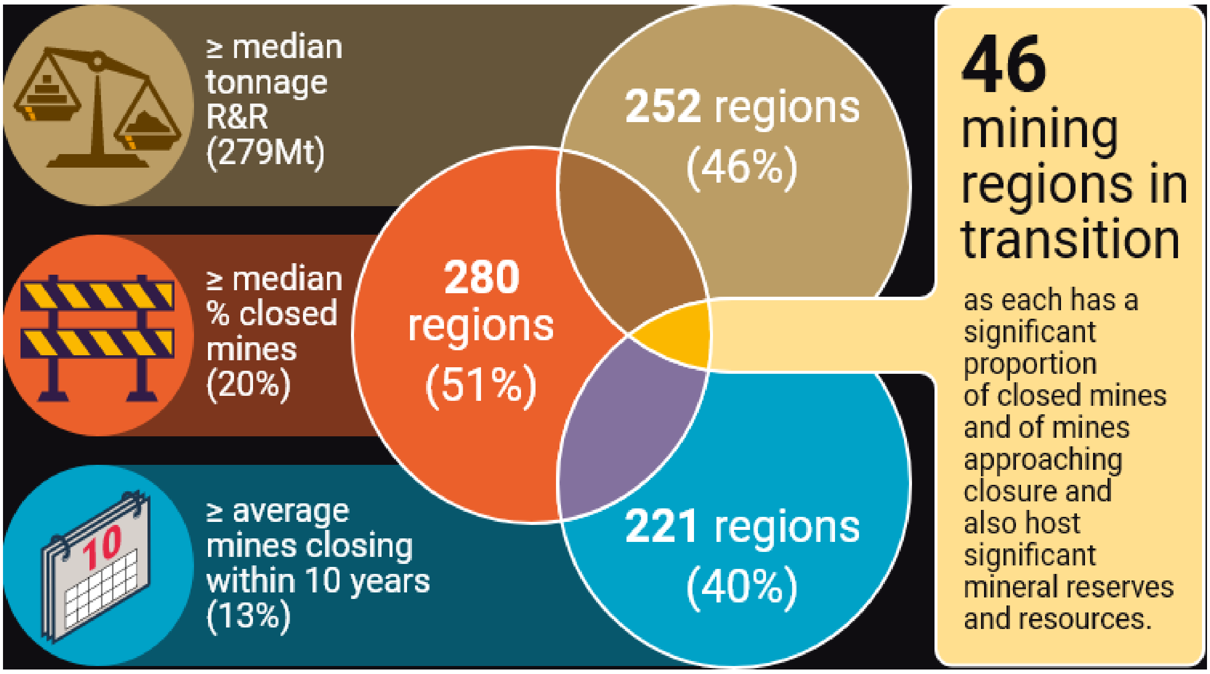
This study defines MRITs as '**mining regions that have a significant proportion of closed mines and of mines approaching closure, and that also host significant mineral reserves and resources**'.

3.1 Methodology

Three criteria were used to identify MRITs from the sample of mining regions:

1. Regions where the percentage of closed mines is equal to or above the median value of the 554 mining regions, the median value being 20% of closed mines in the region. A significant proportion of closed mines is indicative of a mature mining region where a regional transition to closure is plausibly under way.
2. Regions where the percentage of mines with projected closure dates within the next 10 years is equal to or above the average value of the 554 mining regions, the average value being 13%. This criterion indicates that preparations for mine closure are progressing and that there are more closures to come. When a significant proportion of mines are reaching closure across a region, governance actors need to implement transition planning at the regional level.
3. Regions with high R&Rs indicate the intensity of mining and mining sector significance and hence we applied a threshold of >278.9Mt or R&Rs above the regional median value. These regions have larger mine footprints and potentially face greater adverse impacts than small and marginal mining regions. Consequently, they are likely to require more resources and technical capability to manage their transition.

Figure 8: Combination of three factors to define mining regions in transition.



Note: R&R = Reserves and resources

Figure 8 represents the relationship between the three criteria outlined above. Forty-six mining regions (8% of the sample) meet all three criteria (see the central overlap area in the figure). We define these regions as MRITs. Table 3 presents the threshold values for each criterion and compares the MRIT thresholds with those for all mining regions.

Table 3: Characteristics of 46 mining regions in transition in comparison with all 554 mining regions. Shaded cells show the threshold values applied to select MRITs.

	Intensity of mining (Mt of reserves and resources/ R&R)		**% Closed mines**		**% Closing in 10 years**	
	MRITs	All mining regions	MRITs	All mining regions	MRITs	All mining regions
minimum	296	0.04	20	0	13	0
maximum	26,919	72,634	75	100	75	100
average	2,234	2,239	36	25	29	13
median	776	279	33	20	25	0

3.2 Locating and describing 46 MRITs

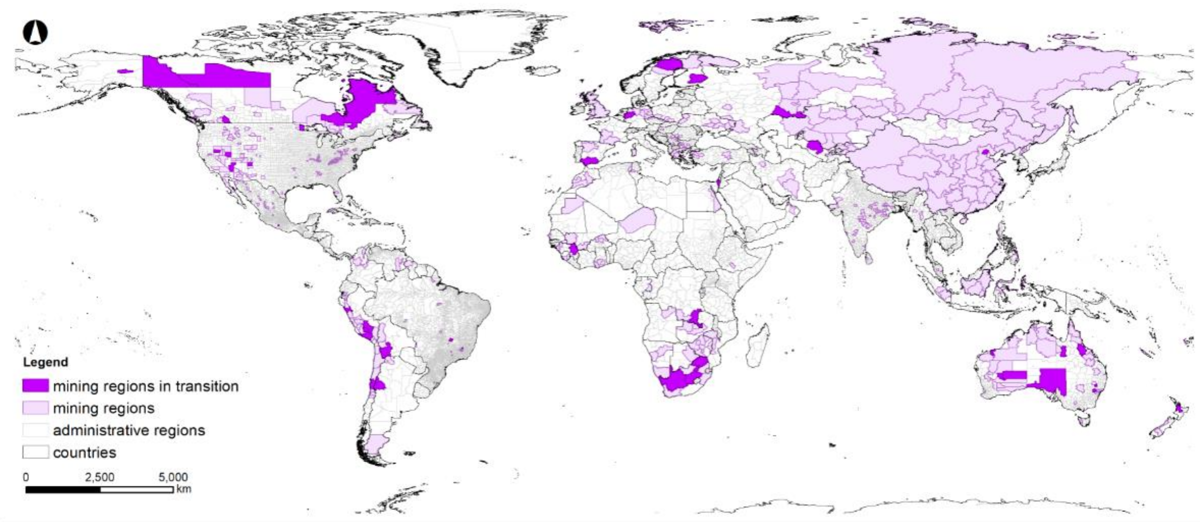
Section 3.2 characterises and presents the global distribution of the 46 MRITs. As indicated in Table 3, these regions have diverse characteristics, which are explored here.

Global distribution

MRITs are not spread evenly across the globe since 21% are in Latin America, where Peru, alone, has 8%. Another 19% are in Australia, 15% in Canada, 13% in the USA and 8% in South Africa (see Figure 9). Few MRITs are in Africa outside of South Africa or in Asia, other than China, even though there are many mining regions in these countries. For instance, India has 41 mining regions, none of which are in transition. Other Asian countries, including Indonesia, the Philippines, Vietnam, Myanmar and Cambodia, all have multiple mining regions that are not yet transitioning to closure. Similarly, in Africa, there are several countries with mining industries that have not yet reported when specific mines might close.[5]

Nine of Australia's 48 mining regions, seven of the 142 mining regions in the USA, five of the 26 mining regions in Canada and only one of the 26 mining regions in Russia are classified as 'in transition'. Where only a small proportion of a country's mining will end, there may be fewer national repercussions than where a larger proportion of mining regions must make the transition. For instance, in Uzbekistan, the only mining region faces closure and, in South Africa, four of the eight mining regions are in transition. Peru has the same number of regions (four) facing closure. However, Peru has a total of 13 mining regions so may be less dramatically affected than Uzbekistan or South Africa, since two-thirds of its mining regions are likely to continue producing. In neighbouring Brazil, effects are even more diluted, with only one of the 21 mining regions transitioning to closure. Mexico has a similar outlook, with only one of its 19 mining regions in transition. In fact, the Latin American countries in general, despite some long-life mines in Chile for example, bear many of the characteristics of less mature mining regions rather than MRITs.

Figure 9: Global distribution of 46 mining regions in transition



[5] These African countries include Burkina Faso, Botswana, Ghana, Namibia, Rwanda, Senegal, Sierra Leone, Zambia and Zimbabwe.

Number of mines

There are 641 mines across the MRITs. The number of mines in each MRIT ranges from three – in Brazil (Paracatu), Mexico (Eduardo Neri) and the USA (San Juan) – to 56 in South Africa's Northern Cape Province. South African MRITs, for example, have more than 188 mines in total and more than 30 mines in each region. The challenge of managing transition is potentially greater in MRITs with such significant mine numbers.

Closed and closing mines

More than 200 (33%) of the mines in MRITs are already closed and about 170 (27%) others are reported to be closing within the next decade (although many factors can change this). MRITs with the highest percentage of closed mines are the Gunnedah region in Australia (75% of mines are closed), Nordrhein-Westfalen in Germany (73% closed) and Port Hedland in Australia (71% closed).

Across the MRIT set, the proportion of mines with anticipated closure dates within 10 years ranges from 13% to 75%. On average, 27% of mines in MRITs report closure dates within a decade. In 17 MRITs, more than 30% of mines will be closing within the same period. MRITs with highest percentages of mines expected to close within a decade are the San Juan province in Argentina (75% of mines closing), Itabira in Brazil (60%), and Kankan in Guinea (57%).

Intensity of mining in the region

MRITs total 102.7Bt of R&Rs, which represents 9% of the total R&Rs reported in the 554 mining regions. Of the 46 MRITs, 17 (37%) have more than 1Bt of R&Rs each. Two MRITs (Limpopo in South Africa and the Unincorporated region in South Australia) have more than 10Bt of R&Rs each.

Commodity and mining method

Among MRITs, 22 regions (48%) have ≥75% of their mining targeting the same commodity and in eight regions, all mines extract a single commodity. Of these specialised regions, the St Louis region in Minnesota is exclusively focused on iron ore and four others are predominantly coal. Gold is the exclusive focus in the remaining three regions.

In MRITs, 315 mines (i.e. 49% of mines in MRITs) are open pit and five MRITs have open-pit mining as the only mine type. These five regions are: Mid-Western New South Wales, Laverton and Gunnedah in Australia, Itabira in Brazil, and Eduardo Neri in Mexico.

Mapping and visualising summary characteristics of MRITs

The global distribution and characteristics of all 46 MRITs are represented on satellite images of the Earth available here (scroll down through Step 2). The 3D representation of the regions uses Google Earth as an entry platform, allowing users to explore the high-level details of the regions and their landscapes from various angles. This is the first searchable repository to provide a scan of global mining regions in transition.

4. Capacity of regions to transition

Despite important differences between the regions, for example in local and regional economies, social composition, locations and natural environment, it is possible to identify common constraining and enabling factors that will influence transition outcomes. These relate to both the mining practices that prevail in the region and a combination of development-related regional factors. Understanding the transition capacity of individual regions was the focus of step three. We defined regional capacity to transition as '**the dynamic, multidimensional capability of a region to harness or adapt regional assets, while cultivating new competencies that enable the region to survive and prosper even as mining activity changes'**. By profiling comparative capacity to transition, the study identifies contextual factors, both across and within the regions that enable or constrain closure options.

4.1 Methodology

We formulated an analytical framework – RESET (Regional Economic, Social and Environmental Transition) – to guide our work. RESET incorporates socio-economic, environmental and governance dimensions – key pillars of sustainability (Figure 10). We added a demographic dimension to capture remoteness from population centres, which is another contextual factor that influences capacity to transition. Many factors could be used to assess these dimensions (Uhlmann et al., 2014). We selected six high-level factors based on the availability of public data sources that have enough international coverage to permit a global scan.

Figure 10: RESET, an analytical framework to diagnose capacity of mining regions to transition. The RESET framework consists of four dimensions and six data sources.

We applied thresholds stipulated in the data sources as the basis for understanding variations and comparing differences across the MRITs (Table 4). Categorising the 46 MRITs based on these thresholds and different configurations of contextual factors, yielded three categories or **tiers** that have different transition capacities (summarised in Table 4).

Table 4: Dimensions, contextual factors, data sources and thresholds of transition capacity

Dimension	Contextual factors influencing transition capacity	Data sources	Thresholds: Original scores	Thresholds: Our rating	Tier 1 Total number of regions =12	Tier 2 Total number of regions =27	Tier 3 Total number of regions =7
 Socio-economic	Level of development	UNDP's Human Development Index (HDI)	0 – 0.549 (Low) 0.55-0.699 (Medium)	Less developed	0	0	7
			0.7 – 0.799 (High) 0.8 – 1 (Very high)	Developed	12	27	0
	Dependence on Mining	ICMM's Mining Contribution Index (MCI)	80+ (Very high) 60-79 (High)	Dependent	3	25	7
			40-59 (Medium) 20-39 (Low) 0-19 (Very low)	Less dependent	9	2	0
 Environment	Risks to regulation, quality and quantity of water	Aqueduct Water Risk Atlas – composite water risks at catchment level	0-1 (Low) 1-2 (Low-medium)	Low risk	12	7	1
			2-3 (Medium-high) 3-4 (High) 4-5 (Extremely high)	High risk	0	20	6
	Extent of modification of natural environment	Cumulative Global Human Modification (GHM)	0-0.1 (Low)	Low modification	12	6	1
			0.1-0.4 (Moderate) 0.4-0.7 (High) 0.7-1 (Very high)	High modification	0	21	6
 Governance	Quality of national governance and regulation	Composite Worldwide Governance Indicators (WGI)	<23.85 (Very low) 23.9-41.37 (Low) 41.38-60.29 (Medium)	Less satisfactory	0	11	7
			60.34-70.99 (High) >71 (Very high)	Satisfactory	12	16	0
 Demography	Remoteness	2015 residential population density from CIESIN	<10/km^2 (Very low) 11-150/km^2 (Low)	Rural	12	24	6
			>150/km^2 (Medium-high)	Urban	0	3	1

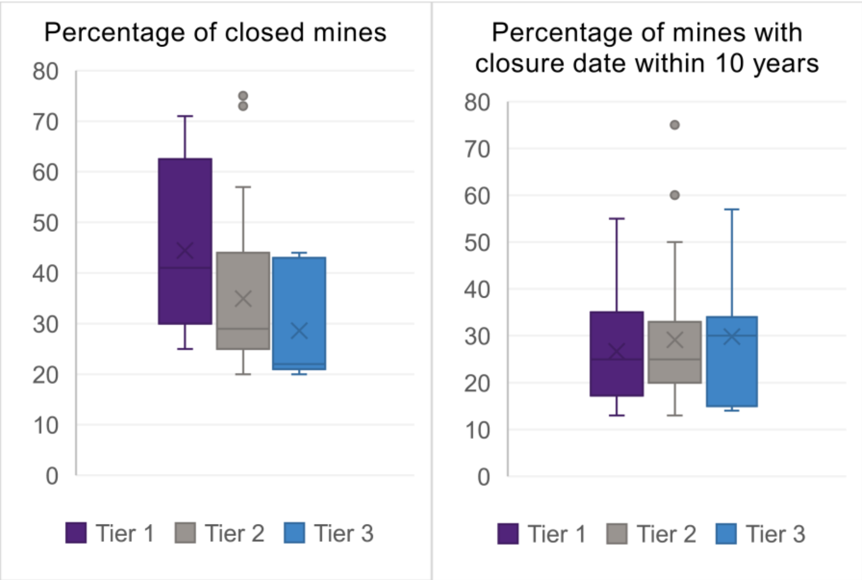
4.2 Spectrum of capacity of regions to transition

Factors supporting preventive, proactive and precautionary management of the transition are evident in 12 MRITs, which also show declining mining activity. The combined factors indicate that these regions will face fewer constraints to transition than other MRITs. The remaining 34 regions face varying degrees of constraints and challenges, seven of them (15%) being quite poorly equipped to handle the transition.

The 12 regions with the least constrained capacity for closure transition (Tier 1 regions) are in Canada (5 regions), the USA (3 regions), Australia (3 regions) and Sweden (1). These regions share high human development and generally robust governance procedures and practices, and are in sparsely populated regions with largely untouched environments.

In contrast, the seven regions with most constrained capacity to transition (Tier 3 regions) are located primarily in Africa (4 in South Africa and 1 each in Democratic Republic of Congo and Guinea) and one is in South America (Bolivia). Such regions share lower HDI and a weak governance framework that is unlikely to deliver any closure transition benefits to the wider society. All these regions are in less developed countries with national economies dependent on mining. They lack commodity diversity and have a significant proportion of mines closed or scheduled to close within 10 years (Figure 11).

Figure 11: Percent of closed and closing mines across three tiers of MRITs

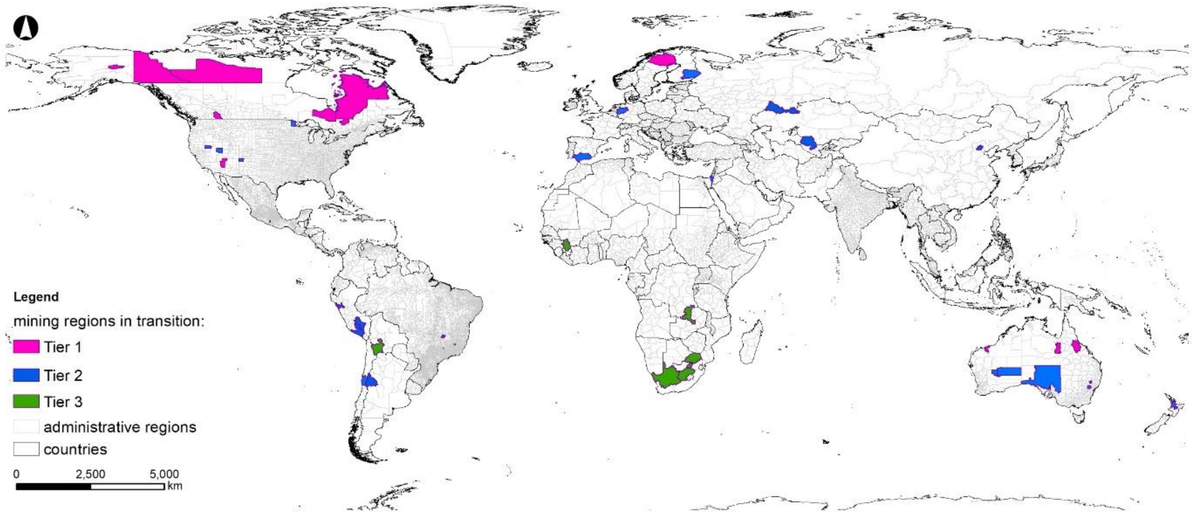


In Tier 3, all but two regions (Northern Cape Province and Limpopo in South Africa) are facing substantial mine closures within a decade: more than twice the minimum percentage for the MRIT sample (which is 13%). In addition, they all have varying environmental constraints that inhibit transition and post-mining options. For example, apart from Kankan in Guinea, there are high levels of modification of the natural environment and there are high water risks.

The intermediate category, Tier 2 regions, account for more than half the world's MRITs (58% or 27 of the 46 regions). They have dispersed locations, with more than half of them in Australia, USA and Europe (15) and a substantial number in Latin America (9). These regions have a combination of enabling and challenging contextual factors and, tellingly, their capacity to transition is constrained by environmental factors, though the type and level of the challenge varies. Even with high human development and other favourable factors, regions with high dependence on mining, a relatively low population density and environmental challenges will benefit from pre-closure capacity building in advance. This strategic work will require significant cooperation, planning and resourcing at the regional level.

The location and categorisation of the MRITs are shown in Figure 12.

Figure 12: Global distribution of MRITs in three tiers of capacity to transition.



The following subsections describe the configuration of factors influencing the transition capacity of the three tiers of MRITs.

4.2.1 Tier 1 regions

Tier 1 comprises regions with the strongest capacity to transition; that is, regions that have contextual factors and available assets to facilitate closure adaptation. Among these contextual factors are high **human development** and generally robust **governance** procedures and practices.

The number of mines in these regions ranges from five (in Fairbanks, USA) to 24 (in Ontario, Canada). An additional favourable contextual factor for nine regions is their moderate **dependence on mining** (which is in the range of 40-60% in the Mining Contribution Index (MCI)). Even the three mining-dependent Australian regions, with a MCI rating above 60%, have favourable transition conditions. For example, between 2016 and 2018, the MCI registers a decreasing Australian dependence on mining, suggesting that mining is becoming less important for its economy.

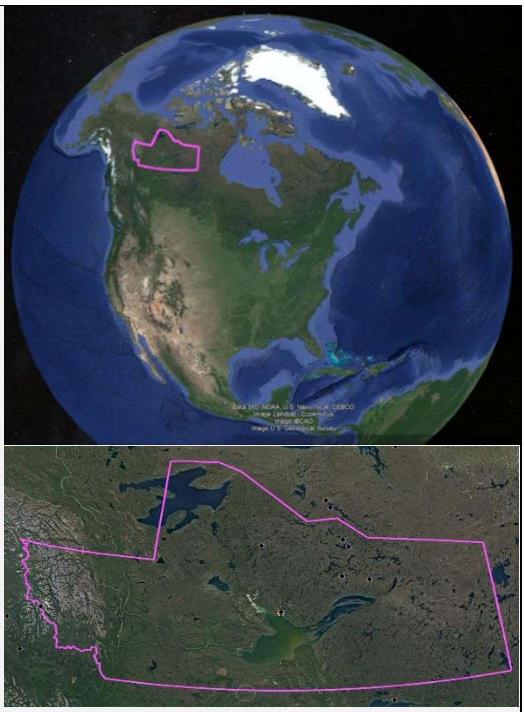
Gold is the most common commodity mined in seven Tier 1 regions; the remaining five extract primarily iron ore, copper, silver and coal. The percentage of mines producing the **prevailing commodity** ranges from 33% (Mohave County, USA, where four of the 12 mines produce silver) to 100% (Fairbanks, where all five mines focus on producing gold). In all, two-thirds of regions in this Tier have more than 70% of their mines producing the prevailing commodity.

In two-thirds of Tier 1 regions, open-pit mining is the most common **mining method**, utilised at more than half the mines; from 53% in Nord-du-Québec (Canada) to 81% in Cloncurry (Australia). Even where underground or placer mining prevails, open pit is frequently the secondary method. Canadian regions, for example, employ placer mining in 18% of operations in Valle de l'Or and 25% of mines in Cochrane. All regions in this tier have at least one **large mine**. Three regions (East Kootenay and Cochrane in Canada and Norrbotter in Sweden) have two or more large mines.

Box 4.1 Example of a tier 1 region: Fort Smith, North West Territories, Canada

Fort Smith, North West Territories, Canada

Fort Smith is one of the 26 mining regions in Canada, a country with established industrial scale mining and very high human development. It is ranked in the top 20% of global jurisdictions for governance quality. Like most Tier 1 regions, Fort Smith is sparsely populated – with less than one inhabitant per km^2 on average. It has low water risks and modifications to its natural environment have been very low. It does, however, face constraints on future options including climate. The region has 11 mines: seven have closed and another two are reported to be closing within 10 years. As these contextual factors indicate, mining dependence is decreasing. While Fort Smith has substantial favourable factors, its remoteness, low population density and the prevalence of open-pit mining indicate that careful planning is needed to ensure prosperity and the wellbeing of residents post-mining.



On average, Tier 1 regions have a higher percentage (45%) of closed mines than the other two tiers but a slightly lower percentage of mines closing within a decade (28%). However, the challenge ahead is not insignificant. At 55% (6 mines), Valle de l'Or has the highest percentage of mines scheduled to close within 10 years. Five more regions have a significant percentage (≥25%) of mines scheduled to close within that period: Cloncurry (Queensland, Australia), Nord-du-Québec (Quebec, Canada), Cochrane (Ontario, Canada), Yukon (Canada) and Mohave County in the USA.

4.2.2 Tier 2 regions

Tier 2 regions have a combination of favourable and constraining contextual factors. All the regions have high or very high **human development** scores.

There is no definite trend in mining dependency across these regions. Almost half (48%) are economically **dependent on mining** (all the Australian and Peruvian regions; Coquimbo, Chile; Orenburg, Russia; and Navoi, Uzbekistan). Another 44% are moderately dependent. The remaining four regions include Nordrhein-Westfalen (Germany) and Andalucía (Spain) and have a low dependence on mining (meaning a MCI below 40%). Changes in the MCI from 2016 to 2018 suggest that nine Tier 2 regions (including La Libertad, Apurímac and Arequipa in Peru) are becoming more dependent on mining, while the other 18 regions are becoming less dependent.

Twelve Tier 2 regions have two or more **large mines** (with R&Rs higher than 100Mt). In most Tier 2 regions (74%), open-pit mining is the most common **extraction method**, with underground mining the prevailing method in only five regions (19%). These regions are: Lake Macquarie (Australia), Nordrhein-Westfalen (Germany), Beijing (China), La Libertad (Peru) and Arequipa (Peru).[6] The average percentage of closed mines is 35%, which is lower than the Tier 1 average of 45%, but the average percentage of mines closing within 10 years is slightly higher than the Tier 1 average (30%). Regions with a significant percentage scheduled to close within this timeframe include San Juan, Argentina where 75% of mines are expected to close within 10 years; Itabira in Brazil (60%) and White Pine in Nevada, USA (50%).

[6] No mining method data is available for 2 regions – Cusco and Eastern Finland – in the S&P database.

Coal and gold are the most common **prevailing commodities**. The prevailing commodity is mined exclusively in seven Tier 2 regions including three in Australia, two in the USA and one each in Mexico and Argentina. A further seven Tier 2 regions have ≥75% of their mining targeting the same commodity. In the Unincorporated region in South Australia, only 29% of mines extract the prevailing commodity, gold, so it potentially produces more diverse commodities.

More than half (52%) the Tier 2 regions are **rural with medium population densities** (>10 but <150 inhabitants/km^2). Three regions in this tier have more than 50 inhabitants/km^2. These are the Latin American regions of Itabira (Brazil), Eduardo Neri (Mexico) and La Libertad (Peru). More than a third of the regions have low population densities and two regions – the Unincorporated region in South Australia and Laverton, Western Australia – have extremely low population densities (0.009 inhabitants/km^2). Only three Tier 2 regions – Lake Macquarie, NSW (Australia), Nordrhein-Westfalen (Germany) and Beijing (China) – are considered predominantly urbanised, with population densities exceeding 150 inhabitants/km^2.

Environmental challenges feature in all Tier 2 regions but the type and level of challenge varies: from low to high human modification of land and low-medium to high overall water risk. The three regions with the highest **human modification of the landscape** are the Nordrhein-Westfalen coal region in Germany, the Lake Macquarie coal region in Australia and the Beijing iron ore region in China. Landscape modification in these regions is largely attributed to urbanisation. Mining in these regions predominantly uses underground methods, which usually have less impact on the landscape than open-pit mining. The Tier 2 regions with the lowest landscape modification are White Pine and Pershing (USA), and Leonora, the Unincorporated region in South Australia and Laverton (Australia). These five are all gold-producing regions in which open pit is the prevailing mining method.

In general, Tier 2 regions have significant **water risks** with most having a rating above the medium risk threshold. Only one region (La Libertad, Peru) has an extremely high overall water risk while six regions (Apurímac in Peru, Arequipa in Peru, Navoi in Uzbekistan, Beijing in China, HaDarom in Israel and Coquimbo in Chile) have a high overall water risk. Thirteen regions have a medium-to-high water risk. No Tier 2 region has a low water risk. The correlation between overall water risk and human modification across regions is not strong. Four outliers are Beijing region in China (high water risk, high GHM), Gunnedah region in NSW, Australia (medium-high water risk, medium GHM), Lake Macquarie, also in NSW, Australia (medium-high water risk, high GHM) and Nordrhein-Westfalen in Germany (medium-high water risk, high GHM).

Governance capacity is another differentiating factor across the Tier 2 regions. Sixteen of the 27 regions have sound governance, while the remaining regions have less satisfactory governance. The Navoi region in Uzbekistan has the poorest governance rating, followed by Orenburg in Russia. Waikato in New Zealand has the highest governance rating of Tier 2 regions.

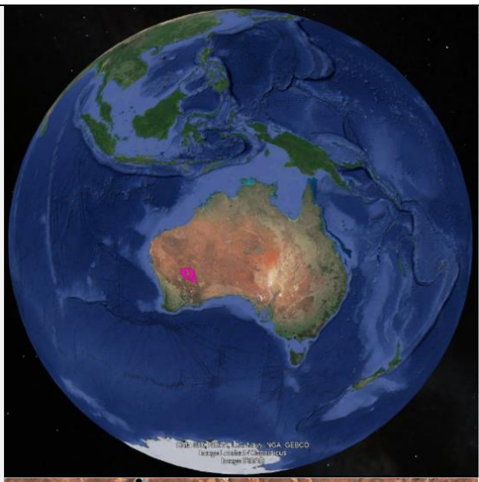
Box 4.2: Example of a tier 2 region: Leonora in Australia

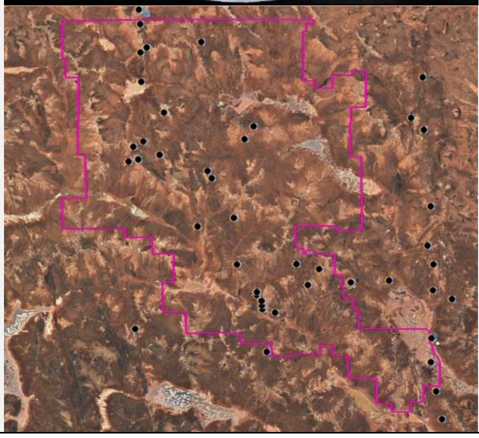
Leonora, Western Australia

The Leonora gold mining region in Australia has the most mines of any Tier 2 region. All its 29 mines are closely clustered and 80% of them use open-pit extraction methods. Although eight mines have already closed, the prospect of another 10 closing in the next decade suggests a more intense closure transition is looming.

Like Fort Smith in Canada, this region has contextual factors favouring the region's capacity to transition. For example, it is located in a country with very high human development and a robust governance context. The rural region also has minimal modification to its natural environment.

These favourable factors, however, are balanced by a number of constraining factors. These include its sparse population density, regional water risks and mining dependence of more than 50%, although dependence on mining in Western Australia (the relevant administrative jurisdiction) is decreasing.



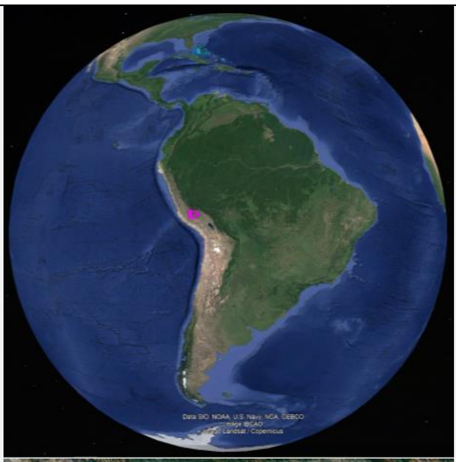


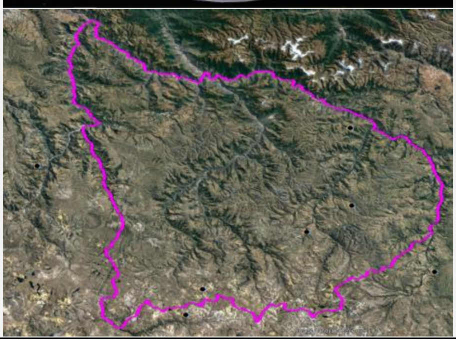
Box 4.3: Example of a tier 2 region: Apurímac in Peru

Apurímac, Peru

The Apurímac region is in Peru, another country with relatively high human development. This gold-mining region too, is located in a mining-dependent country, and its mines are all densely clustered, though there are only four of them.

However, the similarities end there. In Peru, dependence on mining is increasing and other factors temper the region's capacity to transition. These less favourable factors include the high water risks and moderate modification to the environment, most likely linked to surrounding agricultural activity. This predominantly agrarian region has a medium density population of 19 inhabitants/km^2. In addition, a less satisfactory governance context (by both WGI and RGI measures) detracts from Apurímac's transition capacity.





4.2.3 Tier 3 regions

Tier 3 regions are the most constrained MRITs. The regions have challenging **socio-economic factors**, with Bolivia and the Democratic Republic of Congo having noticeably lower HDI scores than other countries. This means that MRITs in these countries (Potosa and Haut-Katanga respectively) may lack a healthy, skilled workforce for post-mining activities, their income and livelihoods are likely to be fragile, and they lack the resources and infrastructure to sustain future development. The challenge is compounded for these two regions as well as for Kankan in Guinea, since the trend there is for increasing **dependence** on mining.

All Tier 3 regions are in jurisdictions with **less satisfactory governance**. Regions with the lowest governance scores are Kankan (Guinea), Potosa (Bolivia) and Haut-Katanga (Democratic Republic of Congo). The Democratic Republic of Congo and Guinea are particularly constrained in this respect, with their governance scores being in the lowest 20% of countries. The other four Tier 3 regions are in South Africa, which has a governance score slightly below the satisfactory threshold.

Gold is the **prevailing commodity** in three Tier 3 regions while others extract primarily copper, zinc, platinum and diamonds. The proportion of mines in the regions producing the prevailing commodity ranges from 50% (Free State, South Africa) to 90% (Gauteng, South Africa).

Tier 3 regions have considerably more **large mines** than regions in the other two tiers (an average of 7 compared with 2). Limpopo in South Africa hosts 20 large mines. South Africa is home to other regions with high numbers of large mines. As a country with considerable barriers to mining development, the Democratic Republic of Congo has only one large mine, though it does have extensive artisanal mining that will present challenges in any mine closure transition.

The average **number of mines** in Tier 3 regions is also much higher than in the other two tiers (33 compared with 10 each). The South African regions are again notable, having between 35 and 56 mines – the highest of any MRIT.

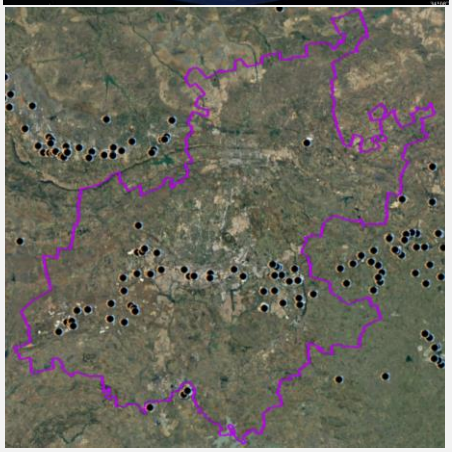
Five regions have a significant percentage of mines **scheduled to close within 10 years**; more than twice the minimum percentage for the MRIT set. Two of these are the South African regions of Free State (34%) and Gauteng (31%). The other regions are Potosa (Bolivia) (28%), Haut-Katanga (Democratic Republic of Congo) (34%) and Kankan (Guinea) (57%).

All Tier 3 regions face high **environmental challenges**. Human modification of the landscape in these regions is generally above the moderate threshold, apart from the Northern Cape region in South Africa. Human modification levels are generally aligned with population density from most modified in the urban region of Gauteng to less modified in the most sparsely populated Northern Cape of South Africa. These disparate results within South Africa highlight the value of regional as opposed to national data. Overall water risks are generally medium-to-high, apart from Potosa in Bolivia, which has a low-to-medium water risk. The separate water risk component measures indicate that there may be higher specific water risks. For example, the Northern Cape region rates extremely high on water quality risks and high on water quantity risks.

Box 4.4: Example of a tier 3 region: Gauteng in South Africa

Gauteng, South Africa

Gauteng, with both Johannesburg and Pretoria in the region, is the only predominantly urbanised Tier 3 region with an average population density of 740 inhabitants/km^2. In other respects, though, this South African region epitomises many of the challenges confronting Tier 3 regions. These challenges include lower human development, dependence on mining (65%) and an absence of high-quality governance to regulate the transition.



Gauteng has 49 closely clustered mines, nine of which are large mines, and 44 that extract gold. More than half its mines use open-pit mining methods. Twenty-one mines are already closed and a further 15 will reportedly close within 10 years. As well, the mining cluster extends over regional boundaries. The region needs additional capacity given its lower human development and environmental fragility (a moderately modified natural environment and water risks), which is most likely linked to its high-density population and urbanisation.

This region contrasts with the sparsely populated Northern Cape region, where, however, the collaborative Northern Cape Shared Value project aims to create alternatives during operations that might continue post-mining.

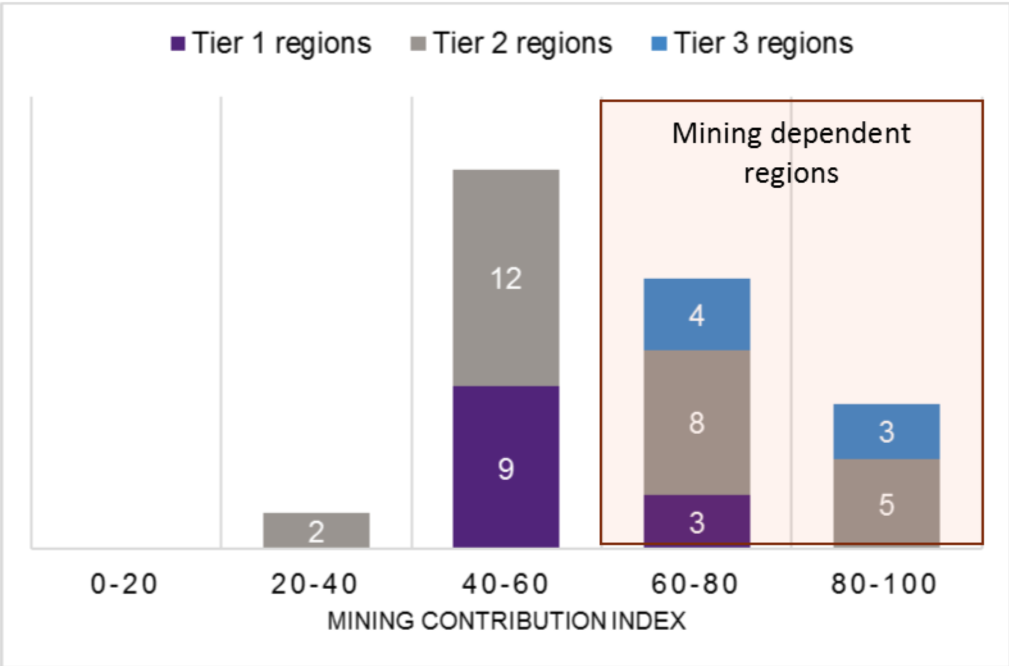
4.3 Comparative capacity of regions to transition

As Section 4.2 demonstrates, the configuration of a region's socio-economic, environmental, governance and demographic factors influences its capacity to transition to closure. In Section 4.3 we highlight key differentiating factors between the three tiers. Our analysis and designation of tiers does not imply some regions will automatically succeed and others fail. Rather, it identifies relative capacity of regions and regions that may warrant more strategic and policy attention and support through the transition.

Socio-economic

In this research, the closure transition is largely an issue for developed countries with high human development at a national level. A small proportion of the MRITs are in less developed countries. Dependence on mining of these countries varies (Figure 13).

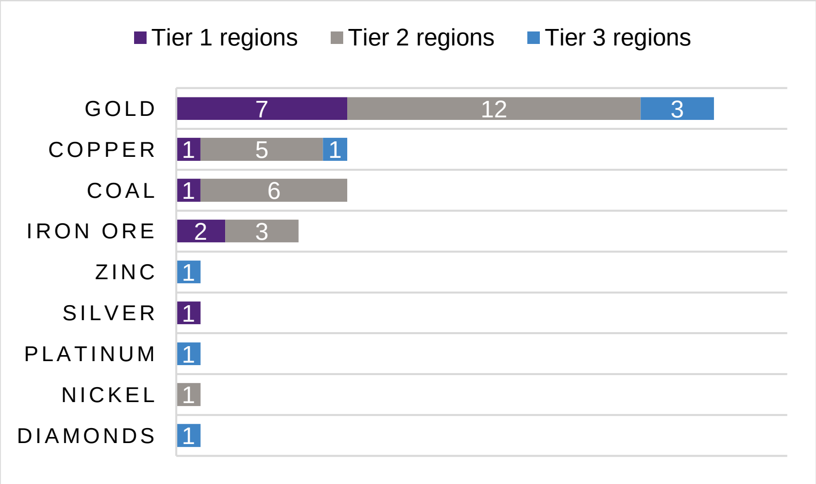
Figure 13: Relative dependence of MRITs in three tiers



All Tier 3 regions are dependent on mining compared with about half the Tier 2 regions. Tier 1 regions are the least dependent of the MRITs, with three quarters of them outside the dependence threshold, and rated as moderately dependent. As the regions were selected for the extent of their mining activity, it is not surprising that low dependence on mining is only associated with two MRITs.

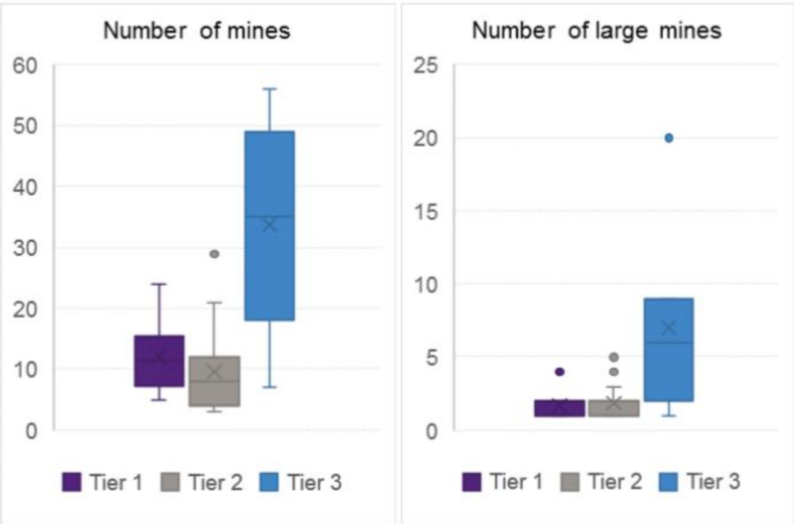
Regions with mines producing the same commodity will face bigger socio-economic challenges associated with mine closure than those with more diversified mining and economic bases (especially if closure is early or unplanned). Where mining dominates the local economy, the loss of the principal economic engine exposes the region's narrow economic base. In such regions, the loss of mining employment accompanying the transition to closure has ripple effects. There is substantial reduction in the flow of income through local economies which affects retail, food services, and other connected sectors, as well as social services. In 22 regions, gold-mining prevails and this lack of diversity combines with other socio-economic and environmental, governance and demographic factors to shape transition capacity of those regions (Figure 14).

Figure 14: Prevailing commodities of MRITs in three tiers of transition capacity



Tier 3 regions have significantly more mines and more large mines than tiers 1 and 2 (Figure 15). The number of mines, their size and location also influence transition capacity. Regions with many mines are more likely to be dependent on mining and have less economic diversity than regions with fewer mines. More significant economic impacts are expected from the closure of large mines compared with small mines due to greater employment displacement and the flow-on effects to procurement of local goods and services and indirect impacts to other local businesses. Heavy clustering means that there is greater potential for cumulative socio-economic and environmental impacts from multiple mine closures within the same timeframe, the mitigation of which requires significant co-operation, planning and resourcing at the regional level (Porter et al., 2013).

Figure 15: Number of mines and number of large mines in three tiers of capacity of MRITs



Environmental factors

Many environmental factors will influence the prospects and wellbeing of MRIT residents. Globally, MRITs are spread across different climatic, vegetation and land-use zones and across heterogeneous landscapes. The resultant diversity underscores the importance of granular data and the consideration of specific regional contexts.

Mining and rehabilitation practices are important considerations in closure planning and the mining method influences the level of rehabilitation required prior to closure and relinquishment. Open-pit mines are more challenging to rehabilitate than underground mines due to the existence of final voids, the size and extent of waste dumps that require recontouring and revegetation, and the potential for acid mine drainage. In this respect, Tier 2 regions have the highest average percentage of open-pit mines, but Tier 3 regions have the highest absolute number of open-pit mines (Figure 16).

Figure 16: Number and percent of open-pit mines in three tiers of capacity of MRITs

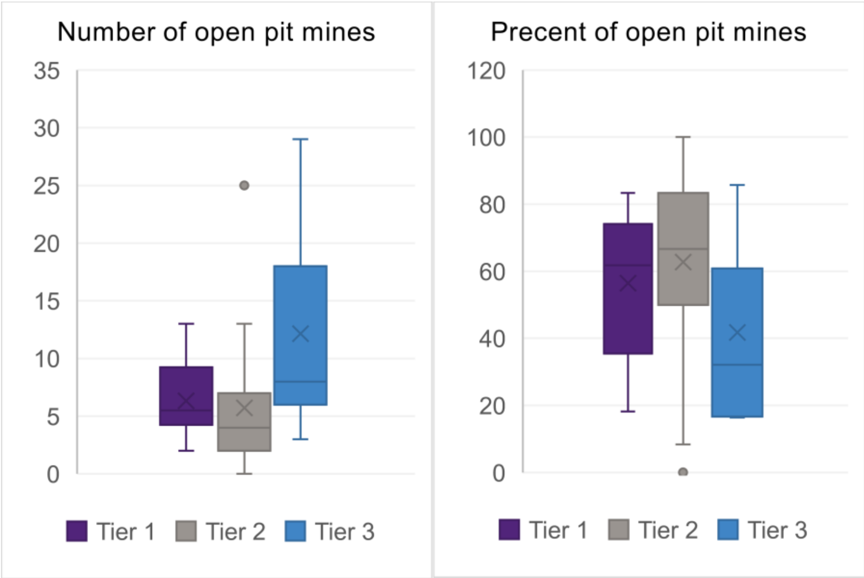
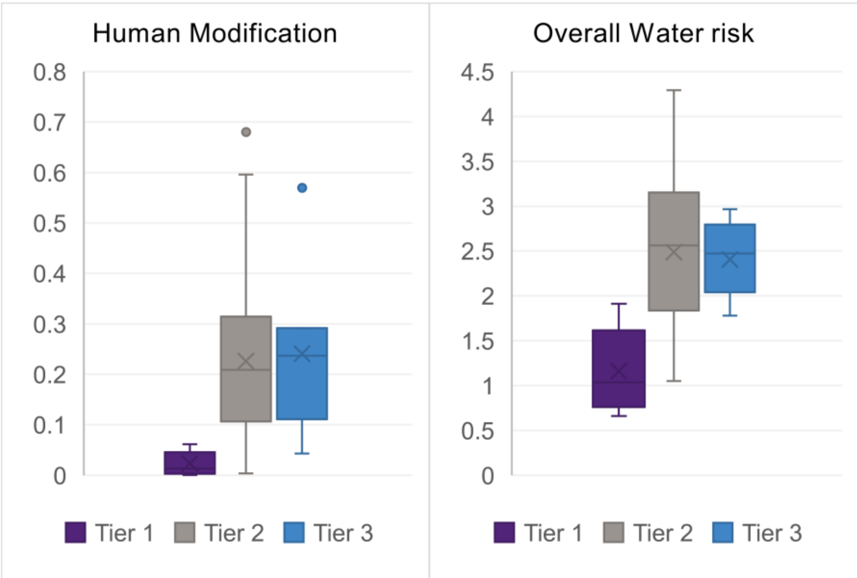


Image credit: private collection

Tier 2 and Tier 3 regions also have significantly higher water risks compared with Tier 1 regions (Figure 17). With greater changes to the landscape, water quantity and water quality in these categories of regions, there are greater closure challenges and longer-term constraints on transition options. Water impacts will limit post-mining land use, particularly in terms of regional biodiversity, ecosystem services and local livelihoods. Preventive and mitigating action and further investigation are required in these circumstances. While strip mining (e.g. in open-cut coal mining) is conducive to progressive rehabilitation, open-pit mining of metal orebodies is not, as the entire pit needs to remain open for mining to occur. Remediating these pits, in particular, will take significant planning, resourcing and time to complete.

Figure 17: Overall water risks and human modification in three tiers of capacity of MRITs



The number and size of mines also influence other environmental assets available for the closure transition. Larger mines generate more waste and surface disruption, which may increase negative impacts. These consequences of mining interact with features such as landforms, vegetation, drainage patterns, soil types and climatic zones. The average percentage of large mines in the 554 mining regions is 16%. Sixty per cent of MRITs (27 regions) have above this global average.

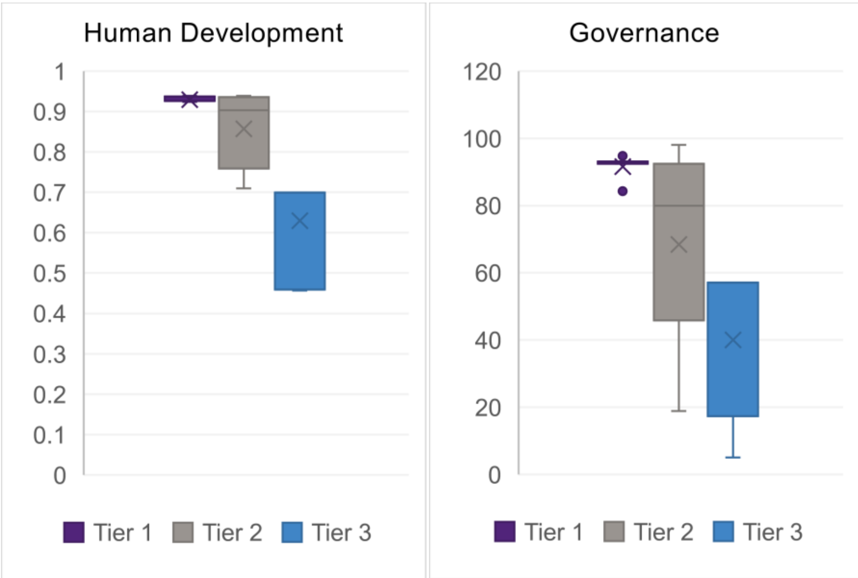
Extent of modification of natural environment

Risks to regulation, quality and quantity of water

Quality of governance

Governance is a critical factor for regions, as post-mining transitions require rigorous systems to be in place, strategic planning to be undertaken well in advance of closure, and substantial resources to be available. In Tier 1 regions, the combination of high human development and generally robust governance procedures and practices enhances their potential to harness suitable planning, human and financial resources for regional transitions (Figure 18). Nevertheless, these favourable contextual factors may be subject to regional policy and priorities and to distribution idiosyncrasies in each context. Planners will need to pay close attention to equity issues, including ensuring benefits and opportunities are widespread and are not limited to a specific sector nor small, elite groups (Wilson et al., 2018). Similarly, closure options and post-mining wellbeing of residents of regions in other tiers will be influenced by the interaction of contextual factors with existing regulations.

Figure 18: Human development and governance in three tiers of capacity of MRITs

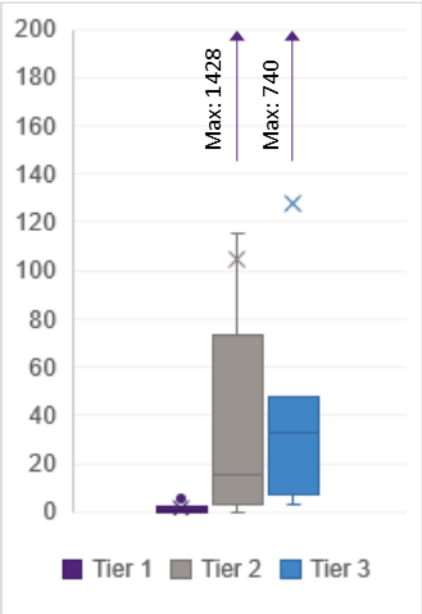


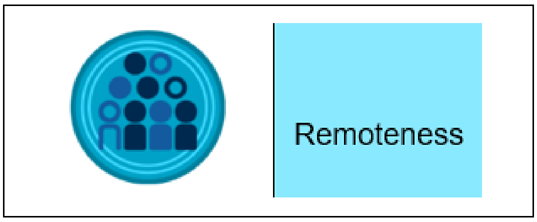
	Level of development		Quality of national governance and regulation

Demographic factors

Demographic factors that influence closure transition options include regional populations, settlement patterns and social interaction. In this regard, the final contextual factor considered in our analysis is remoteness in terms of population density. In general, urbanised regions have greater capacity to transition to, through and beyond mine closure compared with remote regions that have low population densities. There are more options and resources available to regions with higher and more densely settled populations, or those closer to sizeable urban centres and enabling infrastructure. The diversification of the local economy will influence the available alternatives. On the other hand, the impacts on unemployment may not be as great as in densely populated areas where a more substantial population is seeking employment. In addition, closure transitions in urban areas attract more media and political scrutiny than rural regions, putting regulators and proponents under pressure to deliver beneficial post-closure outcomes. Only five of the MRITs are predominantly urbanised – with population densities of at least 150 residents/km^2. Three of these regions are in Tier 2 and one in each of the other tiers. On average, population density is highest in Tier 3 regions and lowest in Tier 1 regions (Figure 19).

Figure 19: Population density (people per square kilometre) in three tiers of capacity of MRITs





4.4 Identifying transition strategies for each tier

By demonstrating the regional capacity to transition, the scan provides a context for determining priority action areas in all tiers of regions. It encourages regional closure planners to recognise and work within local parameters using local assets.

The designated tiers do not imply that some regions will automatically succeed, and others fail. Rather, they imply that different priorities will sustain the transition across regions and that effective transition planning needs to be sensitive to the regional context. The following paragraphs highlight transition considerations for each tier.

Tier 3 regions, the study suggests, will need considerable support with their closure transitions. As Section 5 notes, global efforts and resources could assist with their transition journeys and this support could come in the form of closure-specific training for decision-makers in all sectors.

Even though **Tier 2 regions** have high human development and other favourable transition factors, they also face a number of constraining factors. Regions with high water risks associated with closed and closing mines face socio-environmental challenges which constrain their post-mining options. Those with high dependence on mining, a relatively low population density and environmental challenges will benefit considerably from advance pre-closure institutional capacity building. Significant cooperation, planning and resourcing will be required at the regional level to manage the closure transition in Tier 2 regions.

Although **Tier 1 regions** are the least constrained of the three tiers, significant regional scale planning and institutional capacity building is required to manage closure transitions. In addition, the data source constraints of this study – largely national-scale data – can mask regional and intraregional transition challenges. For instance, strong national governance scores do not always correspond to robust resource governance – especially where mining regulation is a sub-national responsibility. Similarly, high human development in a nation masks regional disadvantage and recognition of diversity and marginalised groups. Hence, in these regions, priority attention should be given to regional disadvantage and to strengthening resource governance and governance institutions at all levels.

Together, the comparisons highlight a message of the report – that context matters and there is not a cookie-cutter approach that can be applied globally. Region-specific studies and a full appreciation of specific contexts underpins successful closure transitions. These may tackle the challenges in finding reliable, geo-locatable and globally comprehensive sources of info and provide valuable granular detail (and local knowledge) of specific regional contexts.

Image credit: Google Earth

5. Implications (for companies, regulators and others)

Mining companies, regulators, civil society organisations and researchers all play a role in transition processes and outcomes. This section highlights key implications of the study for MRITs.

The global scan, centred on three tiers of regional capacity, reveals both the importance and obscuring effect of national level indicators. National level governance indicators are useful in clarifying the broad effect of the State in regulating mining activities, as are indicators on human development. In the case of the latter, national-level human development indicators can be misleading when describing regional conditions. This is clearly demonstrated by the differences between Tier 1 and Tier 2, where the effect of differential investments in schooling, health and other common infrastructure is muted by composite national measures.

Responsible environmental rehabilitation is essential for all tiers of regions. Solutions are needed for open-pit voids and waste facilities that are stable and non-polluting, and which offer a future productive alternative.

For Tier 3 regions in predominantly less developed nations, the human development implications are naturally more acute. Industry's opportunity to demonstrate a commitment and progress against the United Nations' Sustainable Development Goals is constrained in these contexts. In the regions where economic dependency is notably high, the future challenges of mine closure should not be ignored, even early in establishing a national mining industry. Results suggest that Tier 3 regions, in particular, would be a welcome target for further support by United Nations and World Bank agencies with respect to how States manage the burden of overseeing closure activities without jeopardising future foreign investment. Similarly, these are regions warranting collaborative initiatives – by all operators, or by multiple sectors including local and regional governments and other industries.

The results suggest that 'closure' scheduling could be a serious challenge in mining regions. The capacity of regions to carry multiple closures in the same period is a major question given the number of MRITs that have a significant portion of large mining developments projected to close within a 10-year window. Staging of closure is often a unilateral, company decision based on numerous external factors that may not align with other regional trends and prospects. This is an example of mine-closure-related issues that require collaboration of multiple regional stakeholders to achieve optimal results (Everingham et al., 2020).

Public discourse about mine closure has, until recently, focused on environmental factors, even when the discourse is notionally about the social aspects of closure (Unger et al., 2020). The *just transition* discourse – while currently centred on coal – raises the bar substantially by introducing consideration of employment and quality of life post-mining. Given the role of other commodities (such as copper and iron ore) in the production of low carbon energy technologies, it is likely that both states and industry will be pressured to invest more deliberately in post-transition initiatives (Svobodova et al., 2020; Lèbre et al., 2019).

This high-level strategic analysis of the potential for smooth regional transitions to closure informs management practices, policy development and community planning. It will provide a valuable basis for dialogue about region-specific transition initiatives such as those being investigated by ICMM in Witbank (South Africa) and the Bowen Basin in Queensland, Australia.

6. Recommendations

Understanding how transition is influenced by, or can influence, different categories of stakeholders is an important step in determining future actions (Everingham et al., 2020). Four groups of stakeholders can all take action and contribute to ensuring mining regions do not lose capacity and diminish their human, social, institutional and cultural assets as a result of mining or mine closure (Cheshire et al., 2011). Actions worthy of consideration include:

Mining companies

- Commodity-specific action is appropriate with coal and gold miners taking a lead. They should clarify the off-site risks and likely trajectories through the final years of mining, rehabilitation and beyond, that are specific to their commodity and common contexts.
- For a smooth transition to relinquishment, long-term, off-site, environmental and socio-economic factors need to be understood and considered in any post-mining plans (Worden, 2020). These plans should align with regional plans.
- Final voids are a priority in all contexts. Similarly, waste dumps, particularly tailings facilities, are not simply engineering or environmental concerns but can pose socio-political risks.
- Risk assessments and management systems need to reflect a whole-of-mine-life perspective with enough weight given to the socio-cultural risks of closure.

Regulators

- Long-established mining countries (e.g. Australia, Canada, USA, South Africa and Peru) should take a lead in ensuring appropriate regulation and monitoring of the closure transition journey. Nevertheless, the capacity to transition is most constrained in less developed regions and these therefore warrant attention and support in regulating all stages of the mining lifecycle.
- Advance planning and capacity building should be used to build resilience for the closure transition. For instance, predicting gaps that will appear as mining scales down allows for mitigating measures to be put in place.
- Closure-specific regulation beyond financial assurance and environmental rehabilitation has not been adopted in many jurisdictions to date but is urgently needed (Kung et al., 2020).
- Regulators should ensure there are no disincentives to economic diversification and consider encouraging local business development in non-mining fields and new industries to boost the resilience of regional economies in the face of industry downturns and closure.

Other industries and civil society organisations

- Local businesses should avoid overreliance on one market (the mining industry). They should consciously diversify both their product and customer base to build resilience into their business and the regional economy.
- Maintaining the vibrancy of community and institutional life during mining protects against social voids that can occur when mining companies exit. These social voids can match any landscape void. Various industries and organisations should identify common interests and work together towards a future vision that recognises the considerable value of collaborative action, and the opportunities to harness a range of assets (Everingham et al., 2018).
- Local industry, commerce and institutions can adopt a positive, forward-looking focus on opportunities and assets if they consider factors outlined in this report. At the same time, they should not overlook differential effects and vulnerable groups nor the risks to the regional economy or population that constrain closure options.

- Agile companies and organisations exhibiting innovation and adaptability are most likely to prove resilient to the changes accompanying mine closure and provide a basis for post-mining renewal.

Researchers

Four features of our assessment method point to research opportunities that extend this global scan of regional transition capacity:

- There is value in capturing relevant contextual factors in a limited number of indicators but the demonstrated relevance of context suggests some intuitively relevant factors also warrant investigation.[7]
- Our examination of high-level ESG factors with potential to cushion impacts on closure transitions, should be complemented by examining specific policy settings, environmental practices and economic programs that may serve this purpose.
- This snapshot in time should be supplemented by consideration of trends over time and historical experiences that potentially shape closure options.
- Our three-tier system has limited sensitivity to the degree of difference in various factors given the generalisations and dichotomous analysis adopted in this study. Finer gradations across the spectrum would be instructive.[8]

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[7] For example, access to goods and services is generally considered to be important for improving regional wellbeing. Access to populated centres potentially includes neighbouring regions that give access to a wider choice of goods and services, expanded education and employment opportunities, and more specialised health and social services. Hence transport infrastructure and inter-regional distances and spatial relationships are factors worthy of consideration.

[8] We adopted two mutually exclusive options to describe results on most measures such as the rural/urban distinction based on population density; developed/ less developed (based on HDI); dependent/less dependent (based on MCI); environmentally fragile/ less fragile etc. This was even the case where the source data is not continuous but identifies multiple categories rather than just two categories.

7. Conclusion

All regional communities experience economic change at one or more points in their lifetime and these changes have the potential for adverse future impacts. This report offers a forward-looking, regional overview that assesses the capacity of the world's mining regions to meet holistic objectives and challenges when geological, market and/or policy pressures cause mining to decline or cease altogether. The findings are indicative, rather than conclusive, and will vary depending on company decisions and factors, including commodity prices as well on specific regional contexts.

The study focused on four dimensions of a sustainable transition – environmental, socio-economic, governance and demographic. It examined data about six contextual factors likely to function as enablers or constraints on a region's capacity to transition: level of development, dependence on mining, environmental fragility (both in terms of modification of the natural environment and water risks), quality of governance and remoteness. It highlights the strengths and capacity-building opportunities for three tiers of regions using the RESET analytical framework (Figure 10). Three configurations of regional factors found in these MRITs imply that different priorities will sustain the transition across regions and that effective transition planning needs to be sensitive to the regional context.

Appreciating similarities and differences between MRITs increases understanding of their capacity to reinvent themselves and change development trajectories after mining declines or ceases. The study illustrates that regions appearing to have strong transition capacity can share similarities with more constrained regions and that apparently similar regions may have disparate transition experiences. This serves as a caution to assumptions that selected case studies provide a 'cookie cutter' formula for transitioning successfully. Even when we can catalogue a range of the MRIT characteristics and assets with some accuracy, we still lack knowledge of how the characteristics interact – with each other, with the context and with exogenous factors. These combinations and interactions lie at the heart of a region's strategic options and capacity to transition.

Understanding mining regions in transition is challenging, both conceptually and methodologically. The improved, evidence-based understanding developed in this study provides a foundation for managing the mine closure transition with agility and transformative partnerships.

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Appendix: Defining regions

Table 5: Summary of literature defining regions

Body of literature	Regions defined by	Key assumptions	Sample literature
Economics	High degree of economic, social and cultural interaction between governments, businesses and people[1]	Functionally networked regions with supply chain, labour, logistics and services links and exchanges are generally based around centres (such as relatively large towns and cities) and have distinctive economic productivity and performance.	Productivity Commission (Australia) (2017) Stimson et al. (2011).
Regional development	Structure of the economy	The economic structure of the region including the share of individual sectors in the economy; employment; and production and changes in individual sectors are the main determinants of regional prosperity	Hola & Nowobilski (2018) Dong et al. (2018)
Geography	Location and topography	Size, location, and topography influence accessibility of various assets and explain differences between the performance, wellbeing and opportunities of regions.	Regional Australia Institute (2017)
Regional studies	Settlement patterns and population density	Whether a region is predominantly rural and close to an urban centre, predominantly rural and remote, intermediate or predominantly urban largely accounts for differences between regions.	Brezzi et al. (OECD) (2011) Wolfe (2014)
Planning	Land use and land tenure patterns[1]	The prevailing land use and land tenure patterns and their dynamics largely explain the character, socio-economic outcomes and prospects of a region	Hogeun et al. (2019) Rega et al. (2020) Shaw et al. (2020)
Policy and governance	Administrative boundaries	Uniform policies and administration provide coherent functioning and performance of a region as a basis for comparison and generalisation	Lomba et al. (2020) Endl et al. (2020)
Demography	Population structure[1]	Population patterns, trends and characteristics including inequalities are dynamic and both shape and respond to the changing performance and wellbeing of regions.	Segers et al (2020) Baum et al. (2010)

Environmental Science	Landscapes, climates and vegetation (biomes, ecoregions, catchments)	Natural endowments of a region such as its climate, soil, water, landscape and plant and animal life and their vulnerability explain how they function, adapt and interact.	Hersperger et al. (2020) Hogeun et al. (2019)
Multidisciplinary	Combination of interacting characteristics	A region is a complex configuration of economic, social, environmental and governance characteristics	Landry et al (2020) Wellmann et al (2020)

[1] The boundaries of regions in many of these usages are ill-defined or not comparable. They need to be examined in conjunction with a geo-locatable area.

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