

Placing the South African *mining sector* in the context of a circular economy transition

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The intention of this short think piece on the circular economy in mining, is to initiate discussion on the sector opportunities for South Africa. These opportunities are framed within the context of the current challenges facing the South African mining sector.

The mining and metals industry has a significant role to play in a circular economy as it provides the primary materials for consumer-use. Many South African mines already adopt elements of a circular economy with the potential to grow their initiatives to a larger scale for a subsequent meaningful impact on the economy.

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Introduction

South Africa is richly endowed with mineral resources. The Minerals-Energy-Complex is an important feature of the South African economy – not only in the provision of minerals and metals into the domestic market, but also the global economy. It is a resource intensive sector, both in the provision of resources, but also as a major consumer of resources such as energy, water and chemicals. However, the contribution of the mining sector to the development of the country is gradually diminishing due to declining productivity; increasing operating costs; fluctuating exchange rates and commodity prices; declining ore grades; increasing mining depth; and health, safety, social and environmental challenges¹.

The circular economy is positioned as a framework from which to grow prosperity, jobs, and resilience while reducing greenhouse gas (GHG) emissions, waste, and pollution. However, the circular economy has traditionally been seen as a threat to the mining sector, based on a philosophy of reducing primary resource extraction in favour of the collection and reprocessing of secondary resources or “wastes”². Early concepts of the circular economy placed mining outside of the circular economy (Fig. 1), however recent studies show that the circular economy has a lot to offer the mining sector through sustainable resource use.

The CSIR recognises the role of the mining sector in South Africa’s transition to a more circular economy. Firstly, in the role that the sector plays in providing minerals and metals into downstream economic sectors such as manufacturing, human settlements and mobility. Secondly, the circular economy creates an opportunity for the mining sector to become more competitive and innovative through the adoption of circular economy principles by designing out waste, closing

resource loops; and regenerating natural systems: ^{3,4,5}

- **Design out waste**, e.g., redesign mining processes and value chains to be more resource efficient
- **Keep materials in use**, e.g., reduce, reuse and recycle various waste streams, including end-of-life equipment
- **Regenerate natural systems**, e.g., renewable energy, restoring mining landscapes

The circular economy also has the potential to unlock new growth areas for the South African mining sector. Transitioning to a low-carbon future, as called for in the National Development Plan (NDP, 2030), will require more and different minerals and metals, not less⁶. And despite growing innovation in closing resource-loops, primary demand for minerals and metals is unlikely to be fulfilled by secondary resource supplies alone, given the limitations in the quantity, quality and accessibility of waste materials⁷. Urban mining also provides an opportunity for mining houses to diversify their access to minerals and metals, at higher grades and lower costs.

Globally, 50% of climate impacts, 90% of water stress, and 90% of biodiversity loss is a result of resource extraction and processing⁸. Changing the way we produce and consume resources is critical to addressing a number of global societal threats. The COVID-19 pandemic has also highlighted the need for more resilient and sustainable supply chains, including those for minerals and metals, which are facing their own set of challenges.

The reliance of the South African economy on minerals and metals raises the questions: Is resource scarcity and resource security the driver behind South Africa’s circular economy transition, as seen in many countries? And is there an understanding of the resources needed to achieve South Africa’s development objectives as outlined in the NDP?

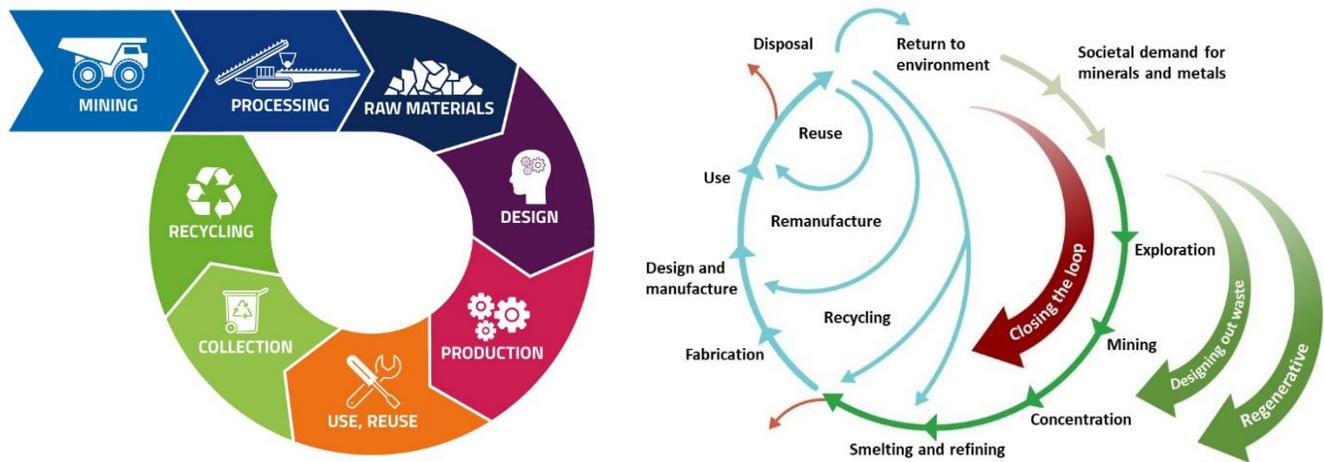


Figure 1. Integrating the main life cycle stages for minerals and metals into the circular economy (adapted from EIT, 2018; ICMM⁵)

The current state of mining in South Africa

The mining sector has always played a pivotal role in the South African economy with national gross domestic product (GDP) contributions in excess of 20% in the 1970s⁹. Over the years, the GDP contribution has steadily declined, with current contributions reported to be at 8%¹⁰. In 2020, mining directly contributed R371.9 billion to the GDP, a decrease from R376.4 billion in 2019¹¹. The sector employed 452,866 people in 2020, a decline from 462,039 in 2019¹¹.

South Africa has the world's largest resources of platinum group metals (PGM), manganese, chromium, and gold¹². Other economically important resources include coal, iron ore and diamonds. In 2019, mineral resource exports alone accounted for 39% of the GDP while imports accounted for 15%. Mineral exports included PGMs, iron-ore, coal, gold, manganese, petroleum (when overproduction occurs), and chromium. Imports primarily comprised petroleum and bauxite¹³.

South Africa has a rich policy landscape governing the mining sector. The Department of Mineral Resources and Energy (DMRE) promotes and administers the regulations of the mining and minerals sector. Their goal is to promote economic growth, social prosperity and environmental sustainability through the mineral resources and energy sectors¹⁴. The sector is regulated by the Mineral and Petroleum Resources Development Act (2002) (as amended). The Mining Charter is a regulatory instrument that details specific measurable targets for the industry and aims to facilitate transformation, sustainable development, and growth of the industry¹⁵. Regarding environmental management, Regulation 5 of the 2015 Financial Provisioning Regulations published under Government Notice R1147 requires every mining company to set aside rehabilitation funds that can be used for the management, remediation and rehabilitation of all environmental impacts arising from mining activities. The regulation falls under the National Environmental Management Act (107 of 1998) administered by the Department of Forestry, Fisheries and Environment (DFFE). While the circular economy is not yet recognized in South African mining policy, the mining sector's existing policy framework can serve the sector as it transitions to a more circular model.

However, legislation alone is not enough to ensure the transition to a low-carbon, sustainable and inclusive mining sector. The mining sector faces a number of growing challenges. Amongst the adverse socio-economic and environmental impacts is its contribution to climate change, over-exploitation of resources, pollution, and a rapidly growing carbon footprint³. A recent material flow analysis for South Africa shows that our economy is dominated by the extraction of resources supporting export markets with little local stock building; large throughputs of gaseous, liquid and solid wastes; and very little productive return of resources back into the South African economy¹⁶. While other countries benefit from our minerals and metals, South Africa is left with the legacy of growing volumes of mining waste, and associated soil and water pollution.

Reducing carbon emissions is a key environmental challenge facing South Africa. Coal-generated electricity is the primary energy source for mining companies¹⁷. Coal mining and associated power utilities play a dominant role in the generation of GHG emissions. South Africa is ranked as the 12th largest contributor to global GHG emissions, accounting for 1% of global emissions¹⁸, with 15% of South Africa's GHG emissions originating from the mining sector¹⁹. Apart from environmental consequences, the country faces the risk of lack of investment if we lag in our transition to carbon-neutrality. This could in turn have a direct impact on employment rates in the mining sector. These issues are further complicated by a sector now chasing complex ore bodies, mined at greater depths, with aging infrastructure, resulting in increasing operating costs, and severe health and safety concerns²⁰. There is an increased demand for access to reliable energy, better quality of resources, and transitioning to carbon neutrality²¹. Development and implementation of policies and incentives to promote circularity in the mining sector is required to stimulate economic growth and create alternative employment opportunities.

The South African mining sector in a circular economy

The following section explores the circular economy in the context of the mining sector – as a driver of a circular economy transition, but also as an opportunity for the sector.

1. Resource scarcity and security as driver

For many countries, resource scarcity and security has been the driver to a circular economy transition. These countries face limited access to the primary resources needed to support their development. The European Union, for example, has tracked this in terms of Critical Raw Materials (CRM) since 2008²². CRMs are those raw materials that have high economic importance, high supply shortage risk, and are difficult to substitute²³. It is currently unclear as to whether South Africa has an understanding of the resources needed to achieve its development objectives, including the remaining years of economically viable mineral resources, and the local and global demand for these resources. This information is considered critical to mitigating the risks to South Africa's development.

Another factor affecting South Africa's mining sector, is the transition by other countries to a circular economy. If the European Union, for example, were to shift to a fully circular economy, the demand for South Africa's resources is expected to decline, with a resultant impact on local GDP. This would further exacerbate the unemployment rate in the country, but could present an opportunity for greater local beneficiation.

2. Circular economy opportunities in the mining sector

Transitioning to a circular economy also provides opportunities for the mining sector, aligned with the three circular economy principles –

Design out waste and pollution

New and emerging technologies are being explored for increased precision and efficiency in ore extraction, with minimal energy usage; reduced water and capital intensity; and less waste production. For example, coarse particle recovery, bulk sorting, ultrafine recovery, and *in situ* mining²⁴. Efficient extraction involves a more complete extraction of the ore, extending the life of mining operations, and increasing the range of mineral recovery. This reduces the need to open new greenfield mines (minimising the environmental footprint) and provides diversified opportunities for economic return.

Reducing dependence on fresh water in mining operations can contribute positively to ecological systems. Possible innovative technologies for water recovery and recycling include dry processing; evaporation management; novel leaching; and dry stacking. This will also eliminate the need for wet tailings storage facilities and instead create stable, dry, and sustainable land. Substitution of raw materials, where possible, could potentially minimise the overall production of waste, reduce health and environmental impacts, and reduce carbon emissions from excessive mining operations, for example, the use of thiosulphate leaching as an alternative to cyanide in gold processing.

Keep products and materials in use

Closing resource loops is focused on keeping resources circulating within the economy through reuse, repair, refurbishment and recycling. While there is still much to be done here, this concept is already adopted by some South African

mines at a site-level. Opportunities include the re-purposing of waste rock; making bricks from clay-rich tailings; zero-waste-to-landfill strategies; using scrap metal in combination with primary concentrates to produce metals; producing fly ash geopolymers; secondary smelting of electronic scrap to recover valuable metals such as gold, silver, copper and palladium; and optimising the recovery of co-products, e.g., a nickel mining company can increase the recovery of co-products such as PGM, cobalt and copper⁵. Additionally, re-mining of tailings has the potential to revive economic opportunities for mining companies.

Given the growing stress on South Africa's water resources, further compounded by changing climates, closing the loop on wastewater, and the recovery of potable water from e.g. acid mine drainage, create immediate opportunities for mines.

Regenerate natural systems

The impact of coal-powered electricity generation remains a crucial issue that needs to be urgently addressed if the country is to achieve its low-carbon goals. The transition to renewable energy, through a green industrialisation strategy, is critical to a circular economy transition. This could be utilised to power mining haulage fleets, machinery, and equipment, amongst other uses. The integration of renewable energy such as solar, wind, hydrogen (green energy) to power mining operations will reduce energy consumption, costs and carbon footprint. For example, Gold Field's Westonaria mine plans to move towards 20% solar powered operations by 2022 to partially mitigate the impacts of Eskom's unreliable supply²⁵.

Green hydrogen mining has huge economic potential for South Africa, which would consequently result in increasing demands for PGMs (platinum is used as a catalyst in fuel cells)²⁶. The advent of hydrogen mining may lead to the adoption of fuel cell technologies in the country, used in electric vehicles (EVs). Mining companies such as Anglo American and Impala Platinum have already adopted the use of fuel cell electric vehicles (FCEV) at South African operations. The production of green hydrogen requires renewable energy (solar and wind power), both of which are vast in South Africa. This creates opportunities to decarbonize the South African economy while creating new markets through the export of green energy²⁶.

While the concept of a circular economy is relatively new to the South African mining sector, it is clear that many of the underlying principles are already being applied in the sector, although perhaps not yet at the scale for meaningful impact. These initiatives, however, have mainly been driven from a waste management and eco-efficiency context and not from a circular economy context. And while reducing, re-using, and recycling materials are highly feasible to adopt, the 'high impact' principles of regeneration of natural systems and designing out waste require large investments, often making them difficult and slow to adopt⁴.

The benefits of a circular mining sector

According to ACEA⁴, the adoption of circular economy principles may benefit the mining sector, by:

- Reducing operating costs and increasing efficiency, through optimised use of resources;
- Increasing access to capital by meeting investor requirements on climate change and social issues;
- Staying ahead of regulatory requirements, by adopting comprehensive sustainable measures;
- Adapting to the global shift in consumer demand for environmentally-friendly products, and hence the changing demand for materials supplied by the sector; and
- Mitigating growing internal and external reporting pressure from global mining institutions.

Several opportunities discussed in the previous sections either have been or are in the process of being implemented at some South African mines. This suggests that these initiatives are not unrealistic in a South African context. A significant overall positive impact could be achieved if a larger proportion of mines, or even better, the mining sector, were to adopt these practices.

The fact that minerals and metals are finite resources is undeniable. This raises many questions with regards to South Africa's future security: What are the implications to our economy, and to society, if our resources were depleted or inaccessible? If South Africa's global trading partners were to adopt more circular models of their own, where does that leave South Africa as a major exporter of raw materials? These questions lend themselves to the need for South Africa to diversify its economic activities while decoupling economic development from primary resource consumption. One such intervention would be to add value to raw materials through greater local beneficiation. Apart from beneficiation, the potential for other downstream (and upstream) interventions across the mining value chain need to be assessed if the country is to meaningfully benefit from its resources in the long-term²⁷.

Embedding the mining sector in South Africa's transition to a more circular economy, has the potential to create new jobs, while also reskilling and upskilling existing mine employees. This would consequently increase the demand for training facilities and change management specialists, thereby further enhancing the country's socio-economic position.

Placing the mining sector within the circular economy also creates synergies with other sectors. Young²⁸ for example, suggests that there could be significant socio-economic value through partnerships between mining companies and more circular sectors, such as automotive and technology companies.

Conclusion

Although South Africa is richly endowed in mineral resources (now), future socio-economic development may be jeopardized by continuing with a traditional, resource-intensive, linear, take-make-dispose approach. Government and industry must understand the role of the mining sector within a resource-secure growth path. The current challenges facing the mining industry need to be addressed, including, national objectives of a just transition to a low-carbon economy. The circular economy provides us with a model to address some of these challenges.

Considering emerging technological innovation, there is a need to understand what South Africa's critical raw materials are, and if resource scarcity is a driver for South Africa to transition to a more circular economy. South Africa is well positioned to take advantage of these circular opportunities. Many mining companies have already adopted some of the principles of a circular economy, implying that there is potential to scale their application to achieve meaningful impact. If strategically addressed, the circular economy should not be considered a threat, but rather a model with potential to unlock new opportunities for the mining sector. Global investment into the mining sector could accelerate the drive towards economic growth, carbon neutrality and social well-being through the circular economy. Further studies will provide a means to explore the circular economy opportunities for the South African mining sector in more detail.

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