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Extending the application of PAS 55/ ISO 55 000 to mineral asset management

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Synopsis

A mineral resource constitutes the principal underlying asset of a mining company, and must be exploited and managed in such a way that maximum value is derived from it. Various asset management frameworks applicable to physical assets are available. This paper focuses on the extension of an asset management approach, particularly the Publicly Available Specifications (PAS) 55 asset management framework and the International Organization for Standardization (ISO) 55000 series of standards, to mineral assets. It is concluded that PAS 55 and the ISO 55000 series of standards can be extended to manage mineral assets, resulting in an integrated approach to sustainably optimize value from the company's mineral assets. The benefits include improved returns on mineral assets, maximum mineral asset utilization, creation of an organizational culture focused on quality and continuous improvement, and assurance to stakeholders that the mineral assets are being efficiently managed over their entire life-cycle. In the context of this paper, a 'mineral resource' refers to both Resources and/or Reserves as classified by the SAMREC Code.

Keywords
mineral asset, mineral asset management, ISO 55000, PAS 55, mine planning, mining value chain.

Introduction

Mining involves the extraction of valuable mineral resources from the Earth's crust. A mineral resource is unique among natural resources in the sense that it is a wasting asset, which means that its value depreciates continuously with extraction. In addition, it is often impaired from time to time as commodity price changes (Macfarlane, 2011a). Since a mineral resource is a wasting asset there is a single opportunity available to optimize value from its extraction. Mine planning involves identifying a strategy to exploit the mineral resource in a way that maximizes value at an acceptable risk level throughout the life of mine (LOM). This optimum extraction strategy changes as economic conditions change, particularly commodity prices, as well as with improvements in orebody knowledge as mining progresses. It is the mineral deposit that competitively distinguishes two different mines and dictates the location of a mine; hence the adage 'the orebody dictates'. Therefore, a mineral resource is the primary tangible asset possessed by mining companies and must be managed in such a manner that maximizes its value at an acceptable risk level (Macfarlane, 2011a).

This recognition of mineral resources as the principal assets possessed by mining companies therefore requires the implementation of an asset management framework if optimum value is to be achieved from the resources. The Institute of Asset Management (IAM) is a professional body for companies involved in the acquisition, operation, and care of physical assets (Institute of Asset Management, 2016). In 2004 the Institute developed the Publicly Available Specification (PAS 55) for the optimized management of physical assets, which was further developed into an ISO standard; the ISO 5500X series of standards published in 2004. ISO 5500X refers to a series of standards consisting of ISO 55000, ISO 55001, and ISO 55002. ISO 55000 provides an overview, principles, and terminology of asset management, ISO 55001 outlines asset management requirements, and ISO 55002 outlines the guidelines on the application of ISO 55001 (Institute of Asset Management, 2015). In this paper the series is interchangeably referred to as ISO 55 000 or the ISO 5500X series of standards. These standards provide guidelines on asset management over the life-cycle of the asset. However, to date they have been mostly applied to those assets that can be presented on a balance sheet, and currently mineral

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assets are not recognized as such assets. In this paper we investigate the implications and usefulness of extending the application of the PAS 55/ISO 5500X series of standards to mineral asset management (MAM) in addition to other standards already adopted by mining companies such as ISO 14001, ISO 9000, and ISO 18000. Since the ISO 5500 series of standards were developed from PAS 55, most reference in this paper is to the PAS 55 standard.

Asset management

In financial accounting, an asset is generally regarded as a tangible or intangible economic resource owned by a business entity or an individual, the cost of which at the time of acquisition could be measured in monetary terms and can be presented on a company's balance sheet. The Institute of Asset Management (2015, p. 8) defines an asset as an 'item, thing or entity that has potential or accrual value to an organization' and asset management as 'the coordinated activity of an organization to realise value from assets'. For mining companies, assets can therefore be classified into two broad categories; the mineral resource to be extracted and those assets shown on a company's balance sheet used in the extraction process, including machinery and equipment.

IBM (2009, p. 2) defined asset management as 'systematic and coordinated activities and practices through which an organization optimally and sustainably manages its assets and asset systems, their associated performance, risks and expenditures over their life-cycles for the purpose of achieving its organizational strategic plan.' According to the Institute of Asset Management (2015), asset management for physical assets started around the 1980s and since then a number of approaches, standards, and models have been developed across the world. Among them is the IAM's PAS 55 standards which were published in 2004 and the ISO 5500X series of standards which were published in 2014 (Institute of Asset Management, 2015). PAS 55 provided the basis from which the ISO 5500X series of standards were developed, hence the focus in this paper on PAS 55.

What is PAS 55 asset management?

PAS 55 is the British Standard Institution's (BSI) Publicly Available Specification (PAS) for the optimized management of physical assets that provides good practices in life-cycle planning and cost/risk optimization of physical assets (Woodhouse, 2008). Adoption of the standard demonstrates competent governance of the company's critical assets. Woodhouse (2008) indicated that PAS 55 is internationally recognized and applicable to any sector of the economy where physical assets are a key or critical factor in achieving a company's business goals, and has proved to fully integrate strategic and operational plans. He also indicated that since its publication in 2004 there has been a significant increase in knowledge of asset management as a professional discipline and that it has been increasingly adopted by several sectors of the economy. Woodhouse (2008) also mentioned that organizations that have adopted PAS 55 have achieved as much as 30% reduction in the total cost of asset ownership, higher asset reliability, and many other business improvements. PAS 55 provides different levels at which asset units can be identified and managed as shown in Figure 1.

The BSI (2008) states that applying PAS 55 demonstrates a company's commitment to a high level of professionalism in whole life-cycle management of its physical assets, by assisting organizations to:

- Establish a system for optimum and sustainable physical asset management
- Implement, maintain, and improve their asset management systems
- Comply with asset management policies and strategies
- Seek certification/registration of their asset management system by an external organization, for example ISO certification.

Justification for adapting the PAS 55 asset management framework to mineral assets

The definitions of an asset given previously qualify mineral resources as assets. Fundamental to physical asset management is asset care in terms of maintenance and risk management and asset exploitation in terms of utilizing the asset to achieve corporate goals (Woodhouse, 2007). These fundamental aspects apply well to mineral resources, justifying the need for adopting an asset management framework for mineral assets to ensure their optimum care and exploitation. In MAM, asset care would translate to minimizing risks associated with the mining process using appropriate risk management systems that are already implemented in the mining industry. Asset exploitation would translate to the optimum extraction of the mineral asset from the ground.

Figure 1—Typical priorities and concerns evident when integrating and managing assets and asset systems (IBM, 2009)

Mineral resource management (MRM) is an integrated activity that identifies an optimal and sustainable extraction plan for the mineral resource to make the best out of the organization's investment against a set of constraints (Macfarlane, 2011a). This makes it necessary to adopt an asset management framework such as PAS 55, which is a checklist that assures shareholders that their interests and principal asset (mineral resource) are in good hands. PAS 55, because it constitutes an integrated approach, provides a framework for understanding how different functions of the organization fit together to maximize the mineral asset value along its life-cycle and is a demonstration of asset management competency.

PAS 55 recognizes that an asset has a life-cycle starting with creation followed by a period of usage, and ultimately disposal, which is typical of mineral assets (Woodhouse, 2011). Given that mineral resources are finite, they must be extracted in a sustainable manner that maximize the value realized from their extraction. The adaptation of an asset management framework such as PAS 55 to MAM enables this objective to be accomplished. Additionally, mining is a long-term business associated with high risks and uncertainties over the life of mine that necessitate the adoption of a proper asset management approach to optimize the mineral resource value and reduce risks along the mining value chain.

The tough economic, financial, and operational environment that the mining and metals industry is currently going through necessitates improvement in terms of MRM, and the recognition and treatment of mineral resources as principal assets possessed by mining companies. This therefore is a driver for the adoption of a sound asset management framework such as PAS 55 and ISO 55000 to ensure the survival and sustainability of the industry.

In line with the International Accounting Standards Board's (IASB) drive to recognize the mineral reserve as a financial asset that should be shown on a balance sheet, there is need to adopt an asset management framework to fulfil these IASB requirements. This implies that the mineral asset must be valued and reported according to international standards. The IASB extended International Financial Reporting Standard 6 for that purpose.

Mineral asset management framework

Given that the mineral resource is a wasting asset, the asset management approach must ensure the best care of the mineral asset over its life-cycle. Broadly, mine planning has two dimensions; the vertical and the horizontal. The vertical dimension is the mine planning levels, that is, the strategic, tactical, and operational planning levels, while the horizontal dimension is the mining value chain from exploration to mine closure. The PAS 55 framework shown in Figure 1 also divides asset management into these two dimensions, which can be translated to mineral asset management. By extending the framework in Figure 1 to MAM, the different levels of asset management can represent mine planning levels and the lowest level on the figure showing the asset life-cycle can represent the mining value chain.

Integration of the PASS 55 asset management levels with mine planning levels

Woodhouse (2011) mentioned the need to establish appropriate horizons for strategy, planning, and optimization over the asset's life-cycle. Figure 2 shows the integration of the PAS 55 levels with mine planning levels from strategic to operational planning.

Strategic planning

The Institute of Asset Management (2015) stated that strategic planning is the process of establishing asset management objectives. This is directional planning when the strategic purpose of the mineral asset is defined and it is decided whether it fits the company's overall portfolio of assets. Various options to deliver value are available and are analysed at this stage. Considering the given constraints, the optimum option in terms of mining method(s), designs, and operating level of a mineral asset is selected and the risk profile associated with each option is defined. The mining method(s) and optimum mine designs must be correctly matched to the mineral asset – 'the orebody dictates'. This is done at a pre-feasibility study level. The mineral asset's value, key value drivers, and what the asset is capable of delivering are also defined in terms of production rate and grade. These parameters are then evaluated in a discounted cash flow to determine the net present value (NPV) of the project. NPV is the main driver at this level.

Plans to use the asset(s) are drafted in terms of mineral asset utilization and analysis of constraints. Key considerations would be (Institute of Asset Management, 2015):

- Understanding the current mineral asset(s) condition, performance, utilization, and capability of the mineral asset portfolio to deliver value

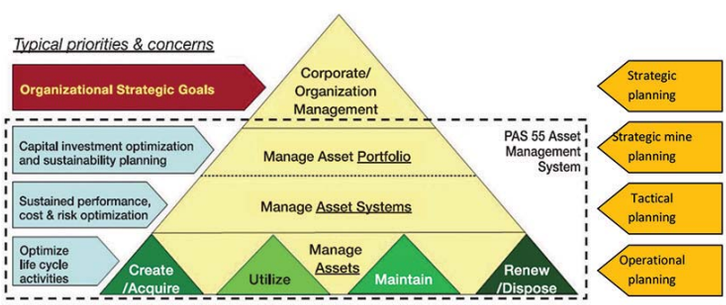

Figure 2—Levels of asset integration and management (adapted from IBM, 2009)

- Identifying and managing constraints that restrict the maximization of value from the extraction of mineral assets
- The need to acquire new mineral assets or enhance existing assets to maintain value.

For an operating mine, strategic planning focuses on continuous revision of long-term plans as economic and operating conditions change, in order to maintain an up-to-date plan that defines the future of the operation. Mining companies need to be responsive and adaptive to both internal and external changes (Harmony Gold, 2015). Different mining companies respond differently to these changes, but with the depressed commodity prices, most companies have focused on being low-cost producers in order to maximize profit margins. While some companies focus on cutting costs, others like Sibanye Gold are acquiring new assets and diversifying their asset portfolios for long-term competitiveness. This requires analysis of acquisition opportunities and compliant reporting, that is, Mineral Resources and Reserves should be reported in accordance with the SAMREC Code in the South African context.

Tactical planning

After the direction has been defined at strategic level, tactical planning now defines how the MAM objectives will be achieved. At a project level, tactical planning is done at the feasibility stage where detailed extraction strategies, production schedules, and profiles are defined on the options selected at the pre-feasibility stage. Risk assessment on the selected options is done and the flexibility, capability, and selectivity needs of the mineral asset are defined, all based on the grade variability within the mineral asset. Resources required to extract the mineral asset are also defined. Other aspects that should be considered at this level include selecting layouts for identified mineable areas and definition of the mine-to-mill process, for example, consideration of cyclic *versus* continuous haulage in coal mining.

For an operating mine, tactical planning focuses on three major areas:

1. The availability of mining areas to maintain required production profiles. This is done through controlling the critical path for access, infill development, ledging, and equipping of stoping areas
2. Efficient utilization of installed infrastructure capacities (for example loading and hauling equipment and plant)
3. Optimization of the production potential of the mineral asset over its life and the effective management of local constraints.

The tactical plan should ideally be updated quarterly and is a joint exercise between the MRM department and production personnel, with the MRM focusing on identifying the sequence of areas in terms of flexibility and grade mix and identifying areas that should not be mined, given the latest information available.

Operational planning

Key to PAS 55 asset management framework is effective management of assets over their life-cycles. Operational planning, also called short-term planning, is when the best option selected at the strategic mine planning stage and refined at a tactical level is implemented on the mineral asset. The objective is to ensure that the processing plant's demand is met (in terms of quantity and quality) while stewarding to the strategic and tactical plans. The aim is to break down the longer term company objectives into smaller, short-term targets. The focus is on the efficient utilization of physical assets and resources to deliver the mineral product at acceptable costs in order to remain productive and profitable.

The operational planning horizon progresses from a twelve- to eighteen-month annual plan through to daily plans and concentrates on the efficient allocation and utilization of physical assets and attainment of the required production profiles developed during tactical planning. The 1–2 year and 1–3 month rolling schedules include detailed considerations of stope preparation, ground support design, grade control, and drilling and blasting. The School of Mining Engineering (2016) at the University of the Witwatersrand relates operational planning to level 2 and level 3 delineation drilling. All aspects considered at this level require effective management to ensure effective utilization and delivery of the primary asset (the mineral reserve). Operational planning activities in terms of managing the mineral asset along its life-cycle broadly involve utilizing the mineral asset, maintaining the mineral asset, and finally renewing or disposing of the mineral asset at the end of the life of mine (LoM). These mineral asset life-cycle activities are discussed in the following section. Operational planning is driven by quality, safety, and profit. Plan compliance is also critical to avoid departing from annual budget targets.

Irrespective of the level, the planning process is the same, the only difference being the level of detail and accuracy required. An integrated and dynamic top-down and bottom-up mine planning approach must be implemented for effective MAM. Strategic goals should be cascaded down to operations and as more technical knowledge about the mineral asset is obtained from operations, feedback to the tactical and strategic levels should be given for optimum MAM.

Integration of the PASS 55 asset life-cycle with the mining value chain

Adopting a MAM framework implies that the mineral asset must be managed (planning, operating, optimization, and risk management) throughout its life-cycle of creation, utilization, maintenance, modification, and disposal. Figure 3 shows the integration of MAM activities with the mining value chain.

Creating/ acquiring the mineral asset

Aligning to the mining value chain, this level involves creating or acquiring the mineral asset when the mineral asset is explored or purchased. Feasibility studies on the mineral asset are done where mine plans and designs are generated that optimize the mineral asset value and reduce risks. Proper economic evaluations and valuation should be done to ensure that the right mineral asset(s) is acquired in the first place. Development/stripping and construction activities are done to ensure the mineral asset is ready to be operated. The level of orebody flexibility required must be defined and created to ensure maximum mineral asset utilization.

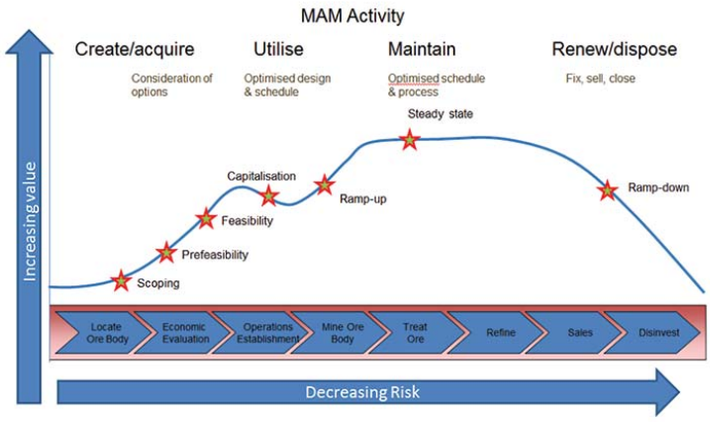

Figure 3—MAM activities and the mining value chain (School of Mining Engineering, 2016)

Utilizing the mineral asset

At this stage of the mineral asset life-cycle, the orebody is exploited. Flexibility should be created to ensure maximum utilization of the mineral asset and the mining methods, processes, cycles, and systems must be optimized to maximize production capacity. The mining system should be simulated to understand and manage constraints to maximize the rate of return. Optimum exploitation of the mineral asset can be achieved only if flexibility was created in the tactical planning stage. That flexibility should be maintained to ensure face length availability, hence maximizing the utilization of the mineral asset.

Maintaining the mineral asset

Maintenance of the mineral asset would involve ore reserve development to ensure the availability of mining areas, thereby maximizing the utilization of the mineral asset over its life. This will also ensure that the mineral asset continues to deliver its set production and economic targets. For maximum utilization and reliability of the orebody, control measures must be in place and applied, including real-time measuring and monitoring of processes to ensure proactive controls are put in place.

In physical asset management, reliability engineering is done, which is a systematic application of engineering principles and techniques throughout the asset life-cycle to ensure it has the ability to perform its required functions under given conditions (Institute of Asset Management, 2015). Extending this concept to mineral assets, mineral asset reliability would mean the ability of the mineral asset to deliver its planned production level under any given operational and economic constraints over its lifetime. Metrics such as 'mean time between failures' and 'mean time to repair' would equally be applied to mineral assets, for example, by measuring the mean time between encountering a geological structure and the mean time to mine around the structure respectively. The frequency of interruptions from geological structures and geotechnical constraints must be proactively understood to enable creation of adequate flexibility to maximize utilization of the mineral asset.

Creating flexibility in the mineral asset extraction plan is a way of preventive maintenance of a mineral asset that is applied to engineering maintenance of physical assets. Melvin and Benders (2012) mention that in general, reactive work often cost two to three times more than proactive work in maintenance of physical assets. The same applies to flexibility in mine plans; the benefits from a flexible mine plan outweigh the cost of creating flexibility. According to Kazakidis and Scoble (2003), flexibility does not only act as 'insurance' against uncertain production activities, but also to enable advantage to be taken of opportunities that may develop during the life-cycle of a mining operation. Sufficient flexibility can be achieved only if an acceptable level of front-end loading (FEL) was done during the asset acquisition stage.

As the mineral asset becomes exhausted through mining, flexibility also decreases. Maintaining flexibility and consequently sustainability may require investing in new technology to improve mineral recovery and/or processing efficiency, lowering the cut-off grade, and subsequently increasing the reserve base. Continuous exploration and application of modifying factors should be done to discover new mineral resources and continually convert resources into reserves. Recapitalization can also be done to replenish exhausted reserves, thereby extending the life of a mineral asset by exploring other areas within the mineral deposit.

Front-end loading in MAM

Since the mineral asset is the main input to the planning process and everything else is subordinate to it, a detailed knowledge of the asset is fundamental for effective MAM; in particular, the size, shape, spatial position, orientation, and geochemical characteristics of the orebody (School of Mining Engineering, 2016). This includes among other things knowledge of mineralogy, grade, density, rock jointing, mining rock mass rating, water quantity, and oxide/sulphide ratio. FEL ensures better understanding of the mineral asset in terms of geological structures such as potholes that affect the continuity of the orebody. Macfarlane (2011a) defined FEL as investing resources in project pre-planning to obtain detailed information and an acceptable level of orebody knowledge before the project implementation stage. The result is a comprehensive and integral mine plan that accurately accounts for risks and uncertainties through the LoM, thereby improving safety. Proper FEL is achieved if the MAM process is multidisciplinary.

As shown in Figure 3, value is created during the early stages of the project and can only be maintained or destroyed during execution. This shows the need for FEL early in the project life to maximize value from the mineral asset. Sufficient FEL lead to:

- Fewer surprises and changes to mine plans at the operational stage
- Less variance in short-term schedules (on-plan ramp-ups)
- Early identification of opportunities for creating flexibility in the mine plan
- Comprehensive and integral mine plans that accurately account for risks and uncertainties through the LoM, thereby improving health and safety
- A comprehensive mine plan and improvement in orebody capability and reliability.

Disposal of the mineral asset

As the mineral asset becomes depleted a point will be reached when the asset will deliver returns less than the cost of capital, and a decision should be made to either sell the mineral asset or close the mine. This process of deciding which mineral assets to dispose from a portfolio is done at a strategic planning level.

Implications of adopting a mineral asset management framework such as PAS 55

Enabling the benefits of a MAM system has several implications for MRM. Proper organizational systems must be in place for an effective implementation of MAM principles. The organizational structure must be well defined to facilitate the implementation of the asset management principles with clear direction, leadership, MAM roles and responsibilities (British Standards Institution, 2008). A multidisciplinary team for MAM must be established and MAM must be embedded in the duties of the MRM manager. The MRM department must be the custodian of MAM, coordinating inputs from various functions. The capabilities of other assets such as people, equipment, infrastructure, technology, and information, among others, must also be sound to ensure efficient practices and optimal exploitation of the mineral asset. This is because all these other assets are encompassed and governed by the overall MAM system. This implies that the mine planning processes, functions, and systems along the mining value chain must be integrated and people at all levels must be aware, competent, and committed to ensure an optimal end result. Adequate FEL is necessary to have sufficient knowledge of the mineral asset and information on its capacity, capital costs, risks, geological, geotechnical, and other orebody characteristics.

A successful MAM system also requires proper risk management systems to be in place and applied to manage the risks associated with the mineral asset to derive maximum benefits from an asset management framework. It is a requirement that an organization demonstrates ability to critically manage mineral assets risks. This implies that standards such as ISO 14000 and ISO 18000 must already be in place in the company. There is need for performance-accountable business focus within the organization, which implies that the strategic and life-of mine-plans must be transparent and auditable and be able to stand up to public scrutiny (Macfarlane, 2011a). Mineral resources/reserves reporting and valuation codes of practise should be complied with for good governance of the mineral asset. Appropriate measures of value should be used, for example economic value-add (EVA), and the value and performance of the mineral asset must be reported based on principles such as transparency, materiality, and competence.

Effective MAM requires optimization of mine plans and processes across the value chain. Value from the mineral asset is optimized when all key mine planning variables are optimized, including extraction rate, mining methods, and cut-off grade. Hall and Hall (2006) define an optimum mine plan as one:

- That best achieves the corporate goals taking into account the company's risk-reward profile
- With a good long-term performance
- That best achieves the desired measures of value such as maximum NPV, rate of return, and mine life and minimizes risks while satisfying the goals of other stakeholders, including governments and local communities.

Effective MAM requires short-term planning controls to be in place to avoid diverging from strategic mine plans and hence value erosion. Such controls include the following.

- *Dilution control*
  The contamination of ore with waste material or material below the cut-off grade must be controlled and minimized to ensure maximum recovery of the mineral asset. Sufficient test work must be done to understand the orebody continuity, boundaries, and grade variability. This will ensure that an optimum mining method (the one that minimizes dilution) is selected. This emphasizes the need for a competent and committed MAM team. Ebrahimi (2013) mentions the following effects of dilution on mineral asset value:
  - Decreases the head grade, thus decreasing cash flows and lowering NPV. In some cases, lower head grade means lower mill recovery
  - Increases mining and processing costs. Energy and resources are wasted in processing diluting material
  - Prolongs the processing of valuable material, thus delaying cash flows and impacting NPV because of the time value of money
  - Opportunity cost of processing diluting material.

  Dilution adversely affects short-term income and long-term mineral asset value. Although it is practically impossible to eliminate, it should be controlled to ensure maximum value is derived from the mineral asset(s). Effective dilution control is possible when efficient grade control methods are in place.
- *Grade control*
  Effective MAM requires understanding the grade distribution of the orebody so that waste and ore zones are clearly defined. This ensures that only valuable material is send to the mill for processing and also that a consistent and optimum mill grade is achieved for optimum recovery and profitability. Successful grade control is possible only when best-practise sampling is

done at the mine. Best-practise sampling involves selecting optimal sample spacing and sample collection points, and appropriate sample preparation and analysis.

Grade control is done to maximize value from the mineral asset by ensuring that only material with a contained value that is more than its mining and processing costs is mined. Grade control is also important in optimizing plant recovery. This is because the milling process is usually designed to be most efficient at a certain head grade, and when material with too high a grade is send to the plant, some of the value may be lost in the tailings, and on the other hand it is uneconomic to send low-grade material to the plant. When mining a mineral asset with significant grade variability, a blending strategy should be implemented to feed the mill with material of consistent head grade. Quality control and quality assurance standards must be practised from the resource model to the market. This can be done through efficient metal accounting and reconciliation to measure any ore losses and implement control measures to minimize such losses.

➤ *Metal accounting and reconciliation*

Accounting of the mineral asset must be done from its *in situ* phase to the final product. Therefore, there must be application of and compliance with metal accounting and reconciliation standards from the geological model to the product. This will ensure that the metal content is reconciled and accounted for across the full mining process together with the quantification, measuring, and accounting of losses. Macfarlane (2011b) mentions that 'metal accounting and reconciliation is an increasingly important governance issue in all mining operations, in that it is required, from a risk management perspective that the company is in control of its product throughout the mining value chain'. He further states that governance is no longer a boardroom issue but must be cascaded down to the tactical and operational planning levels. In that regard, the Australian Minerals Industry Research Association (AMIRA) code of practice and guidelines for metal accounting and reconciliation was developed. Therefore, for effective MAM, mining and metals companies should adopt the AMIRA code. Metal accounting and reconciliation involves estimating the metal along the value chain over a defined time period and a comparison of estimates and measurements along the value chain, and at different points in time (Macfarlane, 2011b). The three broad reconciliation points are between the resource model and the mine, between the mine and the mill, and between the mill and the market. The main objectives of metal accounting and reconciliation are to (Macfarlane, 2011b):

- Balance physical metal content along the value chain
- Ensure the mineral asset is eventually converted into a saleable product
- Identify losses of value along the value chain
- Investigate losses and implement future improvement strategies.

Best practice in metal accounting and reconciliation will ensure effective MAM through optimum metal recovery from the resource model to the product.

Possible ore losses along the mining value chain fall into two broad categories; apparent and real losses. Apparent losses occur due to errors or bias in sampling, assaying, and mineral resource estimation, whereas real losses include:

- Deterioration of mined ore, for example, as a result of oxidation
- Physical ore losses through theft, self-combustion, spillages (mainly at transfer points)
- Poor mining practices leading to ore being left in mining areas, for example, in the hangingwall or footwall.

Benefits of adopting a mineral asset management framework

Corporate governance is currently an issue of concern in the metals and mineral commodities sectors, particularly concerning the management and reporting of mineral resources/reserves. To ensure transparency and consistence in the management of mineral assets, it is necessary to prove to investors and various stakeholders that proper management systems are in place within the company. Adopting a MAM system such as PAS 55 in addition to the SAMREC Code will provide assurance to stakeholders and investors that an organization has an effective way of protecting investments and maximizing value from the mineral resource. It shows evidence and demonstration of sustainable good corporate governance and good practise to investors and other stakeholders, hence improving organizational reputation and ultimately improving shareholder value and marketability of mineral products. PAS 55 has demonstrated that mineral assets can be treated the same way other physical assets are being treated. Hence, due consideration should be given to the inclusion of the mineral assets in the financial statements.

Adopting a MAM system provides a platform for an organization to do a self-assessment and test its position in terms of identifying threats, gaps, and opportunities and then plan for improvement along the mining value chain. This enables the organization to model potential future scenarios and simulate how it can mitigate threats and capitalise on opportunities. A MAM system helps a mining company gain competitive advantage over other mining organizations by ensuring that its mineral assets. are effectively managed.

A PAS 55 asset management framework is also applicable for benchmarking, that is, comparing the organization's performance with other mining organizations and providing guidance for good practise. This helps to drive improvement, unlock more value from the mineral asset, and enhance the asset capability, which is achieved through good practise along the mining value chain.

Adopting a MAM framework like PAS 55 and ISO 55000 series of standards will result in integrated, controlled, dynamic, and systematic planning along the mining value chain. This will result in an optimized long-term mine plan which significantly improves the cash-flow profile of the organization and hence optimizes the return on investment. The strategic organizational planning and operational

planning that ensure that the principles of the total life-cycle planning, risk management, and sustainability are actually delivered within the day-to-day operation of the mine are evidently aligned with the fundamental PAS 55 framework. Therefore, adoption of PAS 55 will provide evidence of systematic, multifunctional, and optimized management of mineral assets that integrates short-term demands with sustainable long-term performance. This, for example, avoids the temptation for companies to focus only on short-term profitmaking strategies that erode long-term value. Such strategies include deferring long-term capital projects for short-term benefits, cutting development expenditure in underground mines, or deferring stripping in open pits.

An optimized mineral asset life-cycle also improves the health, safety, and environmental performance of an organization because the adoption of and compliance with a MAM framework will inherently involve identification and reduction of risks along the mining value chain. Adoption of the PAS 55/ ISO 5500X series of standards will ensures that all mineral-asset-related risks are actively managed to minimize adverse impacts on the performance of the business. PAS 55 and ISO 5500X are good yardsticks in mineral risk management, together with other ISO standards such as ISO 18000. A good MAM framework also facilitates and promotes adoption of and compliance with various other standards, regulatory and statutory codes, and practises which improves the overall business managements of an organization.

Conclusions

Even though mineral assets are currently not presented on companies' balance sheets, the same principles of asset management applicable to physical assets such as machinery and equipment can be applied to mineral assets. Mineral assets are the underlying assets that provide a mining company with a competitive edge against other mining organizations and therefore must be managed efficiently to derive optimum value from their extraction. The uniqueness of the mineral resource justifies the adoption of a sound asset management framework to unlock, optimize, and maintain the mineral asset value along the mining value chain. PAS 55 and ISO 5500X are such integrated frameworks that have proved useful in many asset-intensive sectors in which they have been adopted. Therefore, extending them to the management of mineral assets will optimize value from the finite mineral assets. This will provide a single and integrated way of managing mineral assets over their life-cycles and will allow compliance with other codes, such as AMIRA, SAMREC, and SAMVAL among others, which are key requirements of corporate governance.

Applying these standards to mineral assets provides assurance to the mining company and its stakeholders that the mineral assets are being managed in an optimum way. This will help mining companies gain competitive advantage through effective mineral asset management.

However, to ensure success and derive maximum benefits from the MAM framework there are several prerequisites. Organizational structures and systems must be aligned and integrated together with clearly defined roles and responsibilities of a committed and competent MAM team.

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