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The application of a novel geometallurgical template model to characterise the Namakwa Sands heavy mineral deposit, West Coast of South Africa

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ABSTRACT

Geometallurgy offers significant value to the minerals industry and as a result, Namakwa Sands, a South African heavy mineral sands operation, has implemented a systematic geometallurgical strategy that is integrated with its existing mineral resource management processes. This paper reports on the advanced ore characterisation of the Namakwa Sands deposit, and aims to define the constituent ore types in terms of bulk geochemistry and mineralogy, including the mineral characteristics that could possibly affect recovery. A novel geometallurgical template model was developed at Namakwa Sands to study and quantify the penalties that deleterious mineral characteristics could potentially impose on the recovery of the ore minerals. In addition to enhanced mineral resource definition, this geometallurgical template model allows mineral resource scoring and ranking based on potential mineral recoveries. The generic structure of the geometallurgical template model makes it potentially viable for general application in the mineral sands industry.

1. Introduction

The practise of geometallurgy has gained significant popularity over the past five years and major advances in materials characterisation together with increased computer modelling capabilities have contributed to increased research output in this multidisciplinary subject area (Dunham et al., 2011). Geometallurgy offers appreciable benefits across the entire mineral industry value chain, particularly at the operational level, where it can be effectively positioned to help optimise mineral resource utilisation.

Numerous case studies have been published the last few years describing the geometallurgy of various commodities including base metals (Triffett et al., 2008; Alruiz et al., 2009), platinum group metals (Becker et al., 2009) and diamonds (Hoal et al., 2009). To date, however, the mineral sands industry has lagged in embracing geometallurgy, possibly because the high costs associated with geometallurgical testing, as well as the difficulties in incorporating the complex data into existing geological models have been key disincentives. The continued long-term outlook of challenging market conditions in the context of a changing global economy, plus a rapid depletion in the world reserves of titanium minerals and zircon should prompt the mineral sands industry to re-consider the implementation of geometallurgical techniques.

As a pro-active measure, Namakwa Sands, a South African heavy minerals operation, has implemented a systematic geometallurgical strategy that has fundamental tenets in ore characterisation and process mineralogy. This paper focuses on the advanced ore characterisation part, and is aimed to define the various ore types of the Namakwa Sands deposit in terms of bulk geochemistry and mineralogy, including the mineral characteristics that could possibly affect the recovery of the valuable heavy mineral fraction. A novel geometallurgical template model was developed to study and quantify the penalties these mineral characteristics could potentially impose on the recovery of the valuable mineral fraction. As a result, for the first time, the mineral recovery potential for all discrete ore types that constitute the Namakwa Sands deposit has been estimated. In addition to enhanced ore classification, this geometallurgical template model also allows for mineral resource scoring and ranking, which are critically important to improve mineral resource management processes.

2. Background

Namakwa Sands, currently operated by Tronox Limited, is a heavy minerals mining and beneficiation business located on the west coast of South Africa (Fig. 1). The Namakwa Sands deposit was discovered in 1986, production commenced in 1994, and today Namakwa Sands remains a significant producer of titania slag, pig iron and premium ceramics grade zircon and rutile concentrate to several export markets. Mechanised opencast dry mining per-

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Fig. 1. The locality of the Namakwa Sands deposit, which borders the coastal settlement of Brand-se-Baai.

mits a production capacity of 21 Mt run-of-mine ore annually and mineral processing capacity has the ability to deliver 450 kt ilmenite, 120 kt and 25 kt of zircon and rutile concentrate, respectively. The ilmenite is sent to the company titanium smelter at Saldanha Bay, yielding at least 150 kt of titanium slag and 90 kt of pig iron per year.

The commercial beneficiation of saleable heavy mineral products requires the physical separation of individual particles, which is accomplished by exploiting the differences in four key mineral characteristics: density, size, magnetic susceptibility and electrical conductivity (Dawson, 1997). The Namakwa Sands flow sheet is in principal similar to those of other mineral sands operations, with processing stages that include feed preparation, gravity concentration, screening, magnetic and electrostatic separation. Two primary concentrator plants (PCP), called PCP East and PCP West, prepare the run-of-mine ore for subsequent wet gravity concentration by removing slimes (−45 μm) and oversize (+1 mm) material. PCP West houses a semi-autogenous (SAG) mill, the only installation in the mineral sands industry to liberate locked ore. The PCP heavy mineral concentrates are dispatched for wet magnetic separation at the secondary concentration plant (SCP), which produces an attritioned ilmenite-rich magnetic concentrate and a zircon/rutile-rich non-magnetic concentrate. These two concentrates are subjected to dry magnetic and electrostatic separation at the mineral separation plant (MSP), yielding the final ilmenite, rutile and zircon products. The MSP houses a hot acid leaching kiln to remove surface contaminants from the zircon/rutile-rich non-magnetic concentrate, prior to the final separation stages.

3. Methodology

The Namakwa Sands geometallurgical study was designed to integrate with the current mineral resource management processes and follows two routes, namely process mineralogy and ore characterisation (Fig. 2). A key objective of the process mineralogy survey was to establish quantitative relationships between ore characteristics and mineral recoveries. These ore characteristics manifest either as bulk characteristics for e.g. oversize contents (+1 mm particle size), slimes contents (−45 μm particle size), mineral grade and heavy mineral composition, or as particle characteristics such as size, shape, density, surface exposure, mineral liberation and particle chemistry. A geological sample set was analysed based on these characteristics and the geological block model was augmented with this information. The process mineralogy and ore characterisation data were used to construct several geometal-