X-ray Computed Tomography – Determination of Rapid Scanning Parameters for Geometallurgical Analysis of Iron Ore

L C Bam[1,2], J A Miller[3], M Becker[4], F C De Beer[5] and I Basson[6,7]

ABSTRACT

Geometallurgy brings together geologists, mine planners and process engineers to extract meaningful mineralogical and textural information from an orebody, with a view to predicting its metallurgical response. Preferably, automated analytical techniques, which provide mineralogical and textural information, should process a large number of samples quickly, relatively inexpensively and reliably. Microfocus X-ray computed tomography (µXCT) is capable of producing 3D volumetric information on texture and mineralogy that satisfies some of these criteria. µXCT has been used extensively to study the porosity and internal pore structure of iron ore pellets as part of downstream processing. It has not been widely applied to earlier mineralogical and textural analysis of unprocessed ore, due to the limited ability of X-rays to penetrate high-density samples. In this contribution, we propose scanning methods to overcome this limitation, thereby facilitating a broader application of µXCT to iron ore resource management.

INTRODUCTION

In the past, iron ore mines have typically exploited high-grade ores, which are characterised as having on the order of 60–67 wt per cent Fe (Beukes, Gutzmer and Mukhopadhyay, 2002). Because of this high grade, the ore usually requires minimal upfront processing before it is sent for further processing and smelting. Typical contaminants of ore, which cause downstream complications and penalties, thereby requiring further processing, include Al_2O_3 > 5 wt per cent, SiO_2 > 10 wt per cent (Rao *et al*, 2009; Nayak, 2014), clay minerals, Mn, P and base metals (Vatandoost *et al*, 2013). In contrast, new discoveries of iron ore and expansion of existing iron ore mines focus increasingly on higher tonnage (Aasly and Ellefmo, 2014) but poorer-quality ores, which are typically <60 wt per cent Fe, although in some cases extending to <40 per cent wt per cent Fe (Das *et al*, 2007). In these instances, bulk quality criteria need to be met and mineralogical and textural variability of ore needs to be characterised to enable full exploitation of the deposit. These parameters are determined by geometallurgical models, which require geologists, mine planners and process engineers to extract meaningful mineralogical and textural information (Lund, 2013) in order to represent the full variability of the orebody and to predict its metallurgical response (Newcombe, 2011). Such models tend to be ore deposit-dependent or specific (Newcombe, 2011; Lund, 2013; Williams, 2013).

The complex and often variable mineralogical characteristics of low-grade ore make it difficult to accurately predict its true processing behaviour. This is due to textural variability (eg hard, microcrystalline, massive, laminated, conglomeratic) as well as gangue minerals and elements (eg Al_2O_3, SiO_2, Mn, clays, base metals). Hapugoda *et al* (2011) emphasise mineral characterisation to better understand the relationship between minerals of interest and gangue minerals and the way this determines grind size for liberation and beneficiation process performance. Ores with similar Fe grades may show variable processing behaviour and product quality, due to differences in gangue texture and mineralogy (Vatandoost *et al*, 2013; Sinha *et al*, 2015). As such, it is critical that information concerning these often subtle mineralogical and textual changes is incorporated into the geometallurgical block model, which represents the 3D spatial variability of these parameters.

Characterisation of ore texture and mineralogy relies on a suite of analytical techniques to provide robust, reliable and

1. PhD candidate, Department of Earth Sciences, Stellenbosch University, Matieland 7601, South Africa.
2. Scientist, Radiography/Tomography Section, NECSA, Radiation Science Department, Pretoria 0001, South Africa. Email: lunga.bam@necsa.co.za
3. Senior Lecturer, Department of Earth Sciences, Stellenbosch University, Matieland 7601, South Africa. Email: jmiller@sun.ac.za
4. Senior Research Officer, Centre for Minerals Research, Department of Chemical Engineering, University of Cape Town, Rondebosch 7701, South Africa. Email: megan.becker@uct.ac.za
5. Chief Scientist, Radiography/Tomography Section, NECSA, Radiation Science Department, Pretoria 0001, South Africa. Email: frikkie.debeer@necsa.co.za
6. Extraordinary Senior Lecturer, Department of Earth Sciences, Stellenbosch University, Matieland 7601, South Africa.
7. Director, Tect Geological Consulting, Tokai, South Africa, Email: ianbasson@tect.co.za