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Development of recovery domains: Examples from the Prominent Hill IOCG deposit, Australia

Julie Hunt [a,*], Ron Berry [a], Dee Bradshaw [b], Brett Triffett [c], Steve Walters [b,d]

[a] CODES ARC Centre of Excellence in Ore Deposits, University of Tasmania, Private Bag 79, Hobart, Tasmania 7001, Australia
[b] JKMRC (Julius Kruttschnitt Mineral Research Centre), University of Queensland, Indooroopilly, Queensland 4068, Australia
[c] OZ Minerals, Melbourne, Victoria 3000, Australia
[d] CRC ORE (Optimising Resource Extraction), University of Queensland, St. Lucia, Queensland 4067, Australia

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ABSTRACT

New methods and concepts for recovery domaining with outputs that are suitable for geometallurgical modelling are being investigated. In the work reported here, mineralogical and textural information obtained for drill core samples by a combination of techniques has been investigated to develop models for predicting recovery. The simplest and cheapest method involves assay data only and gives predicted results with ~±4% RMS error. Since this model involves only assay data it could be used to predict Cu recovery values for the remainder of the deposit. The predicted Cu recovery values can be used to rank samples and divide the deposit into recovery domains that are suitable for integration into the planning process for mining, mineral processing and scheduling.

1. Introduction

Prominent Hill is an iron oxide–copper–gold deposit in South Australia owned and mined by OZ minerals. Ore is obtained from open pit and underground mines and is treated via a grinding and flotation processing plant with a 10 Mt pa capacity (OZ Minerals, 2012). The first saleable concentrate was produced in February 2009 and a total (measured, indicated and inferred) resource of 186 Mt of 1.1 %Cu and 0.7 g/t Au were reported in June 2013 (OZ Minerals, 2013).

The deposit is made up of copper- and gold-bearing hematite-rich breccias (Belperio et al., 2007). Copper and gold principally occur in chalcocite + gold (±bornite ± covellite ± diginite) and chalcopyrite + gold (±bornite ± uraninite ± fluorite ± pyrite) style mineralisation within a hematite-dominant matrix (Belperio et al., 2007). Iron oxide-white mica-silica alteration is pervasive within and marginal to the main breccias and is surrounded by a wider zone of less intense alteration.

An investigation of methods for predictive recovery of copper suitable for geometallurgical modelling was carried out on samples from Prominent Hill (Hunt et al., 2011a). The primary aims were to improve prediction of recovery and classify recovery domains by assessing the variability of different ore types through the use of parameters that can be routinely and cost effectively measured on ore material. Chemical and mineralogical information was obtained along with the results of batch flotation in order to develop a range of models for recovery of copper. Testing identified the simplest most effective recovery model which was then used to calculate predicted recovery values for samples in the site data base. This allowed the samples to be ranked and, based on the ranking, the deposit could be divided into potential recovery domains. The modelling and domaining should be viewed as an iterative process and can be modified as new areas of the mine are developed or additional ore types identified.

2. Sample selection and characterisation

2.1. Sample selection

A sample set with highly constrained characteristics that covered a wide compositional range especially in Cu grade, sulphide speciation and gangue association was required to support the construction of a recovery model. A review of site ore type definition and multivariate (i.e. principle component) analyses of an assay data base provided by site, led to the development of a copper sulphide speciation diagram and a gangue discriminant diagram that could be used to aid sample selection (Fig. 1; Walters and Hunt, 2011). The gangue discriminant diagram is based on analysis of a set of site data from 313 drill holes and includes a full suite of

* Corresponding author. Tel.: +61 362262782.
E-mail address: Julie.hunt@utas.edu.au (J. Hunt).

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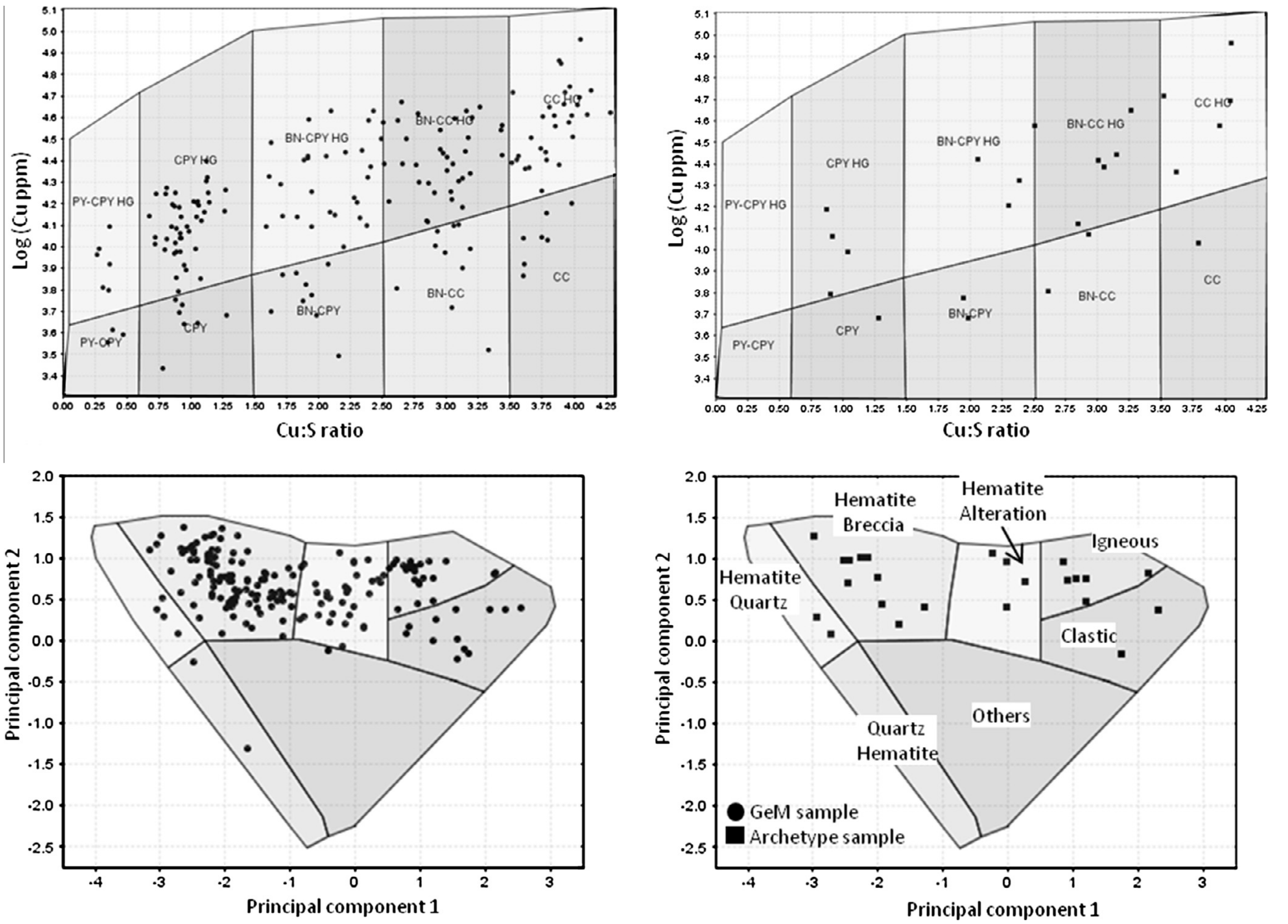

Fig. 1. Cu speciation (top) and gangue discriminant (bottom) diagrams developed for Prominent Hill samples. Left diagrams show all 169 GeM samples (labels as in right diagram); right diagrams show archetype samples. BN = bornite, CC = chalcocite, CPY = chalcopyrite, HG = high grade, PY = pyrite.

multi-element geochemistry. Chemical analyses that were selected as model parameters for the principal component analysis were Fe, Al, Si, K, Mg and Ca. The principal component analysis was carried out on ~23,000 assay samples from 53 drill holes that were considered potential geometallurgical samples for the study reported on here. Each sample selected for this study consists of a contiguous 10 m zone of ¼ drill core which was entirely from one compositional domain as defined by both the ore type classification and the domains in the principal component space shown in Fig. 1. Samples were chosen to cover the range of dominant ore types recognised (NB: as this was a geometallurgical study one of the main aims was to search for variable response from different ore types). The samples from this study are plotted in the field of the first two principal components (Fig. 1) showing the range in sample compositions tested.

The gangue classification scheme was compared with the sulphide speciation classes to check for sulphide associations. This indicated, for example, that bornite–chalcocite assemblages can occur in a range of gangue lithologies including quartz-white mica dominant to hematite-siderite dominant. The different gangue mineralogies associated with the sulphides would be expected to have an influence on grinding and liberation behaviour and flotation recovery. Samples with a chalcopyrite dominant sulphide association also come from a wide range of gangue associations.

Final selection of samples took place after discussions with site to ensure adequate coverage of open pit and underground areas of the mine and availability of drill core. One hundred and sixty-nine (169) samples were selected for mineralogy and textural analysis. A subset of these ($n = 24$) was identified as 'archetypes' representing distinctive signatures in terms of the Cu and gangue classification schemes (Fig. 1) that would be expected to result in different recovery response. Batch flotation testing to determine Cu recovery was carried out on the 'archetype' samples.

2.2. Sample characterisation

As one of the main aims of this study was to predict recovery from parameters that can routinely be measured on ore material, data was collected on all samples in several ways to test for cost effective options. High quality XRF assay data was collected for comparison with mine site assay data (mine site data was analysed via inductively coupled plasma optical emission spectrometry/inductively coupled plasma mass spectrometry – with detection limits of 100 ppm for Si, Al, Fe & P, 50 ppm for Mg, Ca, K & Ti, 1 ppm for Ba – and modified aqua regia multi element inductively coupled plasma mass spectrometry – with detection limits of 10 ppm for Cu and 50 ppm for S) to check for any problems that may be present in the mine site assay data base in terms of analytical methods used. In addition, four primary sources of mineralogical information were obtained: SEM-based point counting (i.e. MLA-XMOD), automated optical microscopy (AOM; Berry, 2008, 2011), quantitative XRD (QXRD – e.g. Rietveld, 1969) and mineralogy calculated from assay (e.g. Berry et al., 2011).