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Characterisation and 3D modelling of a nuggety, vein-hosted gold ore body, Sunrise Dam, Western Australia

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ABSTRACT

In high-nugget gold ore bodies, samples taken from drill core for gold assay are typically too small to allow for the extreme spatial variability in grade and are a poor representation of the underlying distribution of mineralisation. The GQ North lode at the Sunrise Dam Gold Mine in Western Australia is a good example of an orebody which has a very strong nugget effect (coefficient of variation >20) and that has proved very problematic to model. Gold is hosted in vein stockworks and shear zones and although there is a clear spatial relationship between mineralisation and alteration, high vein density and well-developed foliations, the relationship is best defined statistically because the association between high gold grades and various combinations of these features is non-trivial. We present a method for automating the inclusion of geological data (proxies for gold mineralisation) into the prediction of mineralised rocks, using conditional probability. The method uses the gold assays and the logged geological data to calculate the probability that rocks with particular geological features will be mineralised. The ore body can then be modelled automatically using interpolation software with isosurfaces indicating the regions with highest probability of gold mineralisation. A good understanding of the geological features associated with mineralisation and consistent geological logging are important prerequisites for successful conditional probability modelling of drill hole data.

1. Introduction

Understanding the 3D geometry and distribution of metal within an orebody are important steps towards resource estimation and determining mining strategy. A 3D model of the orebody can be constructed using mining software packages which interpolate assay data. However, in areas of high-nugget gold, modelling the orebody using gold assay values is problematic. We use the term high-nugget to refer to a geological nugget effect rather than a sampling nugget effect (Dominy et al., 2003). High-nugget gold exhibits extreme variability over very short distances (cm scale); which causes assay results to be very erratic as the spatial continuity controlling the distribution of gold in a vein is very much shorter than the drill spacing used to sample the mineralisation. In an underground environment the problem is increased where limited drill access necessitates clustered sampling patterns. The high nugget effect means that it is not possible to reliably interpolate gold grades between drill holes at normal drill hole spacing and sample size. Typically, gold resources are underestimated in areas of high-nugget (Dominy and Johansen, 2004; Johansen, 2004) and this has historically been the case at Sunrise Dam Gold Mine (SDGM) in the exploration and resource development stages where sampling is less dense than in the grade control stage.

In high-nugget systems, the geological continuity is usually much more consistent than the grade continuity, on all scales (Dominy et al., 2003). Therefore, if a proxy for the mineralised zones can be found in the geological features (e.g. mineralogical or textural features) it should be possible to generate a more reliable and continuous 3D model of the orebody using mining software. Understanding which geological features are associated with mineralisation is a routine part of the study of orebodies and this information can be used to help define the boundaries of the orebody. For example, Haren and Williams (2000) used the presence of

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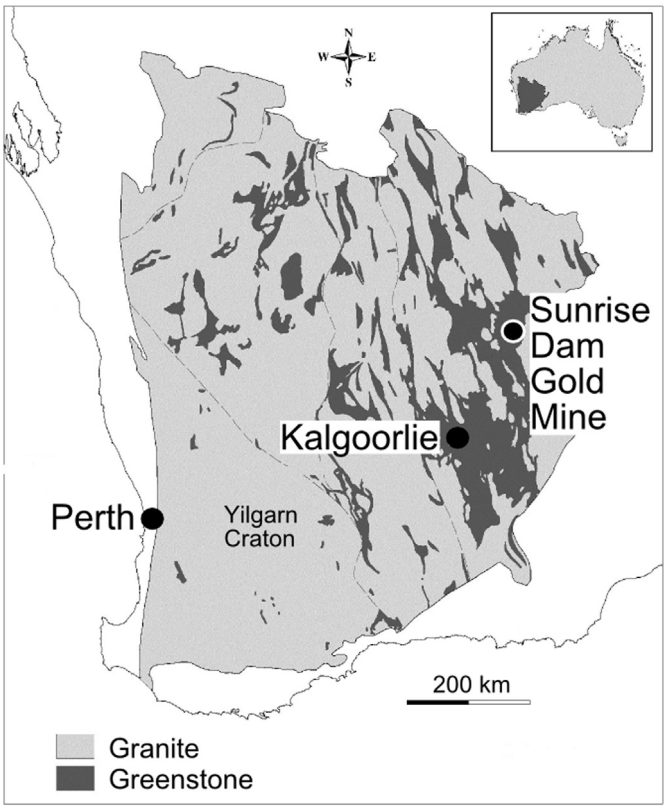

Fig. 1. Location of Sunrise Dam Gold Mine in Western Australia and regional geological setting.

shear zones and sedimentary banded iron formation (BIF) to define part of the Sunrise Dam ore body at an early stage of mining; subsequently Nugus et al. (2009) used macroscopic structural domains and alteration as proxies to map zones of high grade mineralisation at Sunrise Dam; and Haren et al. (2003) used alteration intensity to map the Wallaby orebody (an orebody in the same tectonic district as Sunrise Dam). However, where very large data bases of information exist we require an automated method for applying this knowledge to the construction of the 3D model.

In this paper we will use the GQ North (GQN) lode at SDGM to illustrate our method (using conditional probability) for combining several different types of geological feature into a single measure for predicting regions of high grade gold. The conditional probability value can be interpolated and isosurfaced using mining software to generate a 3D model of the zones which are most likely to contain high grade ore. In the first part of this paper we will document the geological features which are believed to be related to gold mineralisation in the GQN lode. The second part of the paper will describe the conditional probability modelling and present results.

2. Sunrise Dam Gold Mine and the GQ North Lode

SDGM is an excellent example of a high-nugget orebody hosted in a structurally complex Archaean greenstone belt. SDGM is located approximately 850 km ENE of Perth and 45 km SSE of the township of Laverton (Fig. 1). The deposit is currently owned by AngloGold Ashanti Australia and, as at 30 June, 2010, has produced in excess of 7.2 million ounces (Moz) of gold, with Resources of 23.3 million tonnes @ 2.9 g per tonne Au for 2.17 Moz gold (excluding significant surface stockpiles). The Sunrise Dam Operation consists

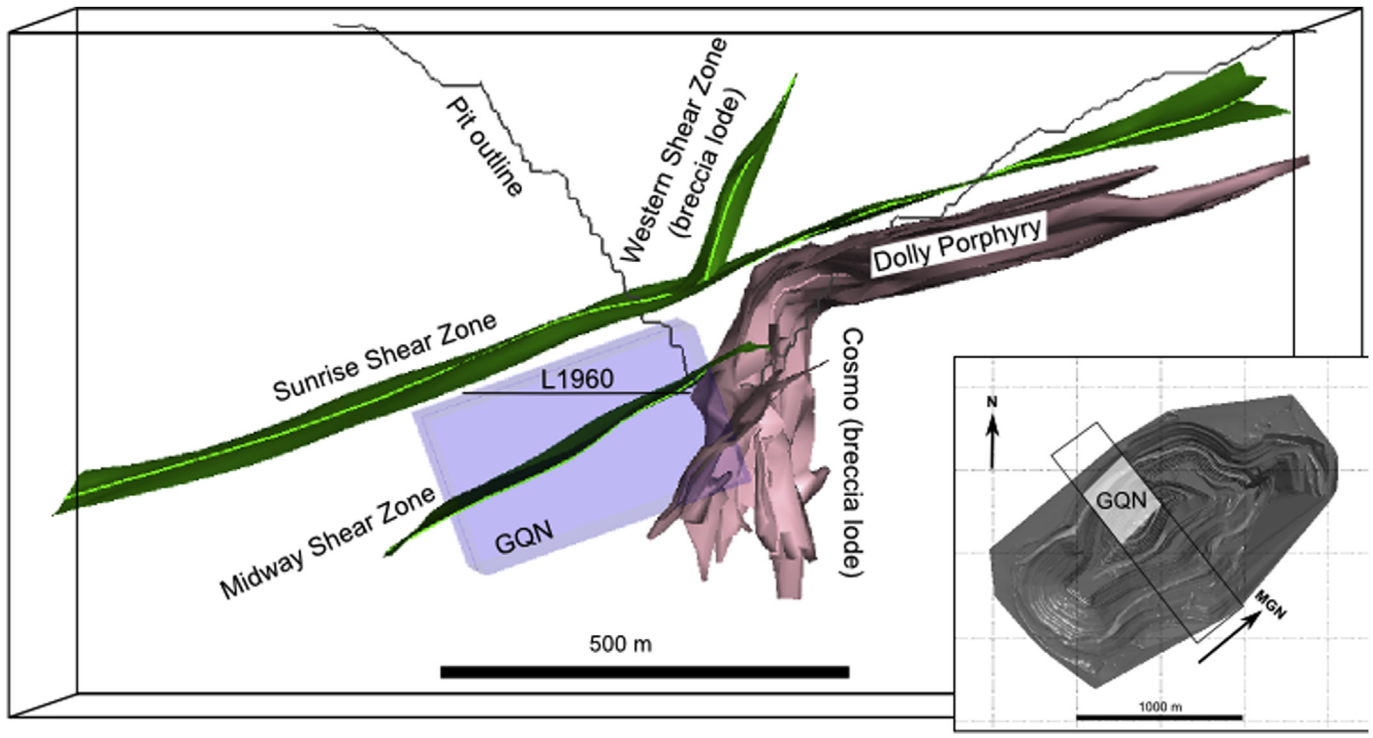

Fig. 2. 3D slice through the Sunrise Dam deposit showing major structural and lithological elements and location of the open pit, the GQN orebody and Level 1960. West-dipping (relative to mine grid) shear zones and steeply dipping breccia lodes host much of the gold mineralisation. Vertical scale = horizontal scale. Inset shows the orientation of the pit relative to true north and orientation of mine grid north (MGN), which is used in subsequent figures. Inset also shows the location of the 3D slice (black rectangle), which is viewed looking towards MGN.