Generating a Resource Estimate by Magnetic Field Inversion – a Study of the Hawsons Magnetite Deposit, NSW

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Resource definitions have regulatory requirements of sampling from drilling. Drilling provides direct and precise measurement of ore grades and characteristics which determine the financial viability of the resource, but close drilling of a resource is very expensive. Magnetic field inversion is an indirect method of estimating ore grades and volumes. It is generally only assigned an exploration role to make the resource discovery and design the initial drilling program. However, in favourable circumstances a combination of limited infill drilling and bulk sampling by magnetic field inversion may provide a cost effective and superior means of defining the resource. We illustrate this with a study of the Hawsons magnetite deposit south of Broken Hill.

The Hawsons magnetite deposit is a folded, bedded Neoproterozoic (Braemar) iron formation that is well expressed in regional (100 metre line spaced) aeromagnetic data. An initial inversion of this magnetic anomaly provided a 3 dimensional model of the envelope of the resource which is in good agreement with initial drilling results. The task of defining the resource is primarily to integrate the tonnage of ore at a specified cut-off grade and to determine its value and the cost of extraction, processing and shipping. The deposit is not a single homogeneous unit, but rather a series of adjacent units of different grade and thickness. Enhanced magnetic field imagery reveals that there is limited structural disruption of the units but that there are lateral variations of magnetization within the structure which most probably express local variation in ore grade and/or thickness. The more substantial of these variations are addressed by details of the initial inversion model, but that model provides insufficient resolution of the ore bands. Also, and most importantly the model is a geophysical model of the distribution of apparent magnetic susceptibility, rather than a geological model of ore grade.

The spatial resolution of the shallow structure in the magnetic field inversion has been enhanced by inverting the vertical derivative of TMI, and further spatial resolution improvements are being achieved through measurement of the magnetic field at ground level. The transformation from apparent magnetic susceptibility to a virtual ore grade poses substantial problems. The high magnetic susceptibilities require that self-demagnetization effects be included in the modelling. There is no evidence that the magnetization direction is rotated by any remanent magnetization oblique to the present field direction, as confirmed by the close spatial fit of the model to the intersected magnetite. This is consistent with the generally coarse grained texture of the magnetite which is not suitable for retaining an ancient magnetization. Nevertheless the magnetite is still expected to carry a soft remanence acquired in the ambient field which will cause discrepancies between the apparent susceptibility derived from the inversion and susceptibility measurements. To resolve these discrepancies we are performing a series of palaeomagnetic and rock magnetic studies

which will establish proven relationships between ore grade and magnetization. We are also currently combining the initial inversion model with calibration details from the drilling so as to use the geophysical inversion to extrapolate the drilling results. This upgraded and transformed model will provide predictions of intersection results for the next round of drilling. We will first test the model against those new drillhole results and then update the model again using the new drillhole data as further constraints for the next inversion. In this iterative process we hope to prove with each testing of the model that we have combined the inversion model and drilling results to prove the resource with sparser infill drilling than would otherwise be required. With each drillhole we will also grow the database of rock property measurements which are key to translating between geophysical inversions and ore grade geological models. In order to further improve spatial resolution of the model we are also currently researching the design and future deployment of novel down-hole magnetic field sensors to augment the above-surface magnetic field measurements.