Remanence remembered – an exploration case history from western Tasmania

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SUMMARY

A magnetic anomaly apparently sourced within Neoproterozoic strata in western Tasmania has attracted exploration attention repeatedly since it was first identified in 1960. Two drill holes, three decades apart have been targeted at the source of the anomaly, ostensibly unsuccessfully. Re-examination of magnetic property data obtained from the first hole drilled, coupled with analysis of samples from the second, indicates that the material responsible for the magnetic feature has in fact been intersected, just not recognised as such.

Key words: magnetic, remanence, susceptibility, pyrrhotite

INTRODUCTION

The richly mineralised terrane of western Tasmania encompasses a range of mineralisation styles and examples. Several of these, such as the Renison Bell major Sn-Cu deposit and the Mt Lindsay Sn-W deposit, are associated with significant magnetic responses. In the case of Renison Bell, these arise from the primary mineralisation; cassiterite-bearing massive pyrrhotite (Roberts and Mudge 1997).

A composite magnetic anomaly of up to 600 nT amplitude, a few kilometres west of the Renison Bell major tin deposit, has therefore been targeted by exploration episodically since it was first identified by an airborne survey in 1960 and attributed to an ultramafic intrusive. It coincides with an area mapped by MRT as mudstone and lithic wacke of the Neoproterozoic Crimson Creek Formation, correlated with parts of the Renison Mine host sequence. The area also lies astride a subsurface Devonian granite ridge identified primarily from gravity data. This intrusion is understood to be a key component of metallogeny in the region, particularly at Renison Bell. Recent MRT 3D modelling (Bombardieri et al. 2021) places the granite intrusion dipping from 1800 m to 3200 m depth in the vicinity of the magnetic anomaly.

EXPLORATION - 1

After a program of geological mapping, rock and soil geochemistry, ground magnetics and a VLF survey, the anomaly was first targeted by drilling in 1984 based on a magnetic forward model (Kilpatrick 1985). The model posited several pyrrhotite-bearing volumes, which were to be intersected at approximately 160 and 400 metres down the hole.

598.6 metres of unaltered Crimson Creek Formation greywackes, tuffs and siltstones were intersected. Magnetic susceptibility readings showed only "isolated zones of moderate susceptibility that could not produce the anomaly". A follow-up ground EM (UTEM) survey was planned to define possible conductive zones associated with the magnetic anomaly in preparation for a second drillhole. Only moderate responses were observed, interpreted to indicate that no massive pyrrhotite body existed within 250 metres of the surface.

The possibility that remanent magnetic effects could produce the observed anomaly was recognised, though considered unlikely. Nevertheless petrological and magnetic remanence test work were commissioned. Downhole EM (SIROTEM) and a surface dipole-dipole IP survey were also conducted. The petrology on 40 samples demonstrated "quite abundant magnetite" below 411 metres down hole, and additionally 'disseminated to locally semi-massive pyrrhotite' from 75 metres, 'conspicuous pyrrhotite' at 193 metres and 'pervasive pyrrhotite' at 351 metres. Meanwhile the DHEM produced a response at 220 metres interpreted as an in-hole source, attributed to pyrrhotite from 219 to 222 metres. Magnetic remanence determined on 5 samples returned Koenigsberger ratios (Q values) as high as 15. Despite these indications, it was concluded that the source of the magnetic anomaly remained unexplained.

EXPLORATION - 2

This conclusion was taken up by a subsequent phase of exploration in the late 2000s-early 2010s. Unfortunately, these explorers apparently were unaware of the earlier work on magnetic properties of samples from the first hole, which not only showed very high Q values, but also that the originally logged magnetic susceptibility was substantially too low. In addition to apparent systematic under-reading by the magnetic susceptibility meter used in 1984, no geometric correction had been applied to the data obtained. This invalid data from the first hole apparently contributed to erroneous assumptions of regional geological unit magnetic properties used in forward modelling. The (incorrect) presumption that the material intersected by the 1984 hole was effectively non-magnetic led to proposal of an extremely magnetic body located just deeper than its trajectory, hypothesised as ultramafic rocks known to be associated with Ni-Cu mineralisation in the district. Subsequent 3D but apparently unconstrained inversion (for susceptibility only) produced a somewhat shallower result. This body, or a 'split difference' with the body identified in the previous model, was targeted by a second hole completed to 645 metres in 2011, at an angle slightly steeper than the first hole but collared in the same location. It too was held to leave the anomaly unexplained, despite (somewhat remarkably) no susceptibility or other magnetic property data being obtained or at least reported, and disseminated pyrrhotite noted through much of the hole. Recent examination by the author of a number of core samples from this hole using both susceptibility meters and a Qmeter (Schmidt 2015) indicated several significantly magnetic intervals, with susceptibilities exceeding 10 x 10^{-3} SI and Q ranging well above 10.

ANALYSIS

Several different magnetic forward models originally made in the course of the 1980s exploration phase include bodies overlapping with both eventual drillholes, which can account for the observed anomaly given 'sufficient' magnetic susceptibility. No such susceptibilities are observed, even after correction for the errors identified above. However, if it can be assumed first that the remanence measured is in the same or similar direction to the Earth's current field (not unlikely in Tasmania), second that the five samples examined are typical of the entire sequence, and finally that the material responsible projects towards the surface from where it is intersected in the drillholes, then the 'apparent susceptibilities' obtained approach or even exceed 'sufficient'. While there are indications from the IP data that the holes drilled may not have encountered the greatest concentration of disseminated pyrrhotite, it appears the total effective magnetisation of material sampled by the drilling can largely account for the magnetic anomaly.

CONCLUSION

Unless using interpretive approaches that are insensitive to remanence, basing magnetic source targeting solely on rock susceptibility data is likely to be misled, especially in the common situation when $Q \geq 1$. Considerable drilling costs could be saved by allocating a small fraction of those costs to more comprehensive magnetic property determination.

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