Woodlawn revitalised by DHEM

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SUMMARY

This paper presents the critical and thought-provoking role DHEM has played in revitalizing the Woodlawn mine. Woodlawn, a well-known volcanic massive sulphide deposit in New South Wales, had been dormant since mine closure in 1998. Attempts to reopen the mine were stymied by a lack of lower-cost mineral resources which in turn was a function of budgetary constraints of the then-owners and the perception that new reserves would only be found at +700m depth. DHEM surveys had been little used since the 1990's due to a widespread view that the mineralization was poorly suited to EM. Despite this preconception, a deep exploration hole was approved for DHEM in 2012 and, importantly, that the entire length of hole would be surveyed 'just in case'. The result was a large off-hole conductor recorded in the upper portion of the survey, in an area considered sterilised by previous drilling. The resultant high grade and relatively shallow (300m below surface), discovery of the ~1Mt 'Kate Lens', as well as several subsequent discoveries, many using DHEM, means that Woodlawn is now on track to reopen in 2018/19. This case study illustrates the importance of the 'never assume' approach to exploration, as well as the value that DHEM can add to exploration projects.

Key words: DHEM, Woodlawn, VHMS, VMS

INTRODUCTION

The Woodlawn high grade zinc–copper-lead–silver–(gold) deposit, 210 km southwest of Sydney and 50 km east-northeast of Canberra, is the largest volcanic massive sulphide (VMS) type deposit hosted by the late Silurian to Early Devonian basins of the Lachlan Orogen of eastern Australia (Downes *et al.,* 2017). The deposit was discovered in 1970 by Jododex Australia Proprietary Limited through regional geochemical sampling programs and subsequent IP surveying (Whitely, 1981). The discovery hole (W2) intersected a 24m zone of high grade banded massive sulphides.

The Woodlawn mine opened in 1977 and produced a total of 13.8 million tonnes of ore assaying 1.6% Cu, 3.6% Pb, 9.1% Zn, 74 g/t Ag and 0.50 g/t Au prior to its closure 1998. Shortly after open-pit mining concluded, the mine was sold to Denehurst in 1987 who mined underground until 1998 when they were placed into administration relating to other business assets, leaving approximately 2 years reserves and other remnant mineralisation. After mine closure, the Canadian owned Tri Origin Australia NL acquired the rights to the Woodlawn tenements and listed on the ASX in 2004 before changing its name to TriAusMin Ltd in 2010. The new owners recommenced exploration in 2001 and soon deemed the remnant resource, though significant, as uneconomical to mine, in large part because of the lack of low-risk ore: The existing ore was in small pockets spread throughout the (now flooded) mine on the margins of the known lenses (named lens A through J in order of their discovery) as well as in the surface tailings. Furthermore, the density of historical drilling around the mine generated a perception that the only potential for expanding the resource was to search down-plunge from the major ore lenses, an area which required deep (700m+) and therefore expensive drilling.

In 2012, TriAusMin commenced a deep exploration program searching for extensions to the major ore lenses at depth. This paper presents the use of DHEM in that program, which radically changed Woodlawn's economic viability, as well as Heron Resources' widespread use of DHEM to further expand the resource after they acquired the project in 2014.

It is important to recognise that Woodlawn is generally quite low conductivity mineralisation. Most of the ore lenses average a conductance of 30-50S and rarely exceed 200S (internal report to TriAusMin; Hine, 2012). Experience shows that this is a function of a) mineralogy and b) grade. To date, only G2 and D1 lens are definitely 'non conductors' because they are sphalerite-rich with very little pyrite, chalcopyrite, galena or other sulphide. The remaining 11 or so polymetallic lenses are conductive enough to be detected with DHEM, with the better conductors associated with higher chalcopyrite content.

Test work comparing coil receivers with B field receivers has demonstrated (unsurprisingly) that the coil receivers are more sensitive to these relatively weak conductors. The ideal system is therefore a high power transmitter with a reasonably fast turn off ramp and a good quality, 3 component, coil probe.

Ore deposit geology

Woodlawn comprises a series of stacked lenses in a Silurian to Devonian volcanic pile of felsic extrusives and associated volcaniclastics. The pile has been rotated and faulted such that the package of ore lenses plunges west-northwest at 70º, dips moderately

(45-70º) southwest, and 'youngs' towards the west. To date, 12 individual lenses have been delineated. These are named alphabetically 'A lens' through to 'L lens'.

Two major ore-types are recognised. These are a "copper-rich" assemblage and a "complex" or "polymetallic" assemblage (see McKay & Hazeldene 1987; Glen et al. 1995). The "polymetallic" assemblage includes fine- to medium grained, banded to massive sulphides with a pyrite–sphalerite–galena–chalcopyrite assemblage. The copper-rich assemblage occurs as copper-rich massive sulphide zones and as stockwork vein-type mineralisation and is dominated by pyrite–chalcopyrite, lesser sphalerite, galena, and pyrrhotite. Beneath the copper-rich massive sulphides are zones of chalcopyrite-rich stockwork mineralisation that are interpreted to be fossil feeder zones. Sphalerite-rich stringer/feeder zones are also present in the recently discovered, shallow G2 lens position to the south of the main G lens.

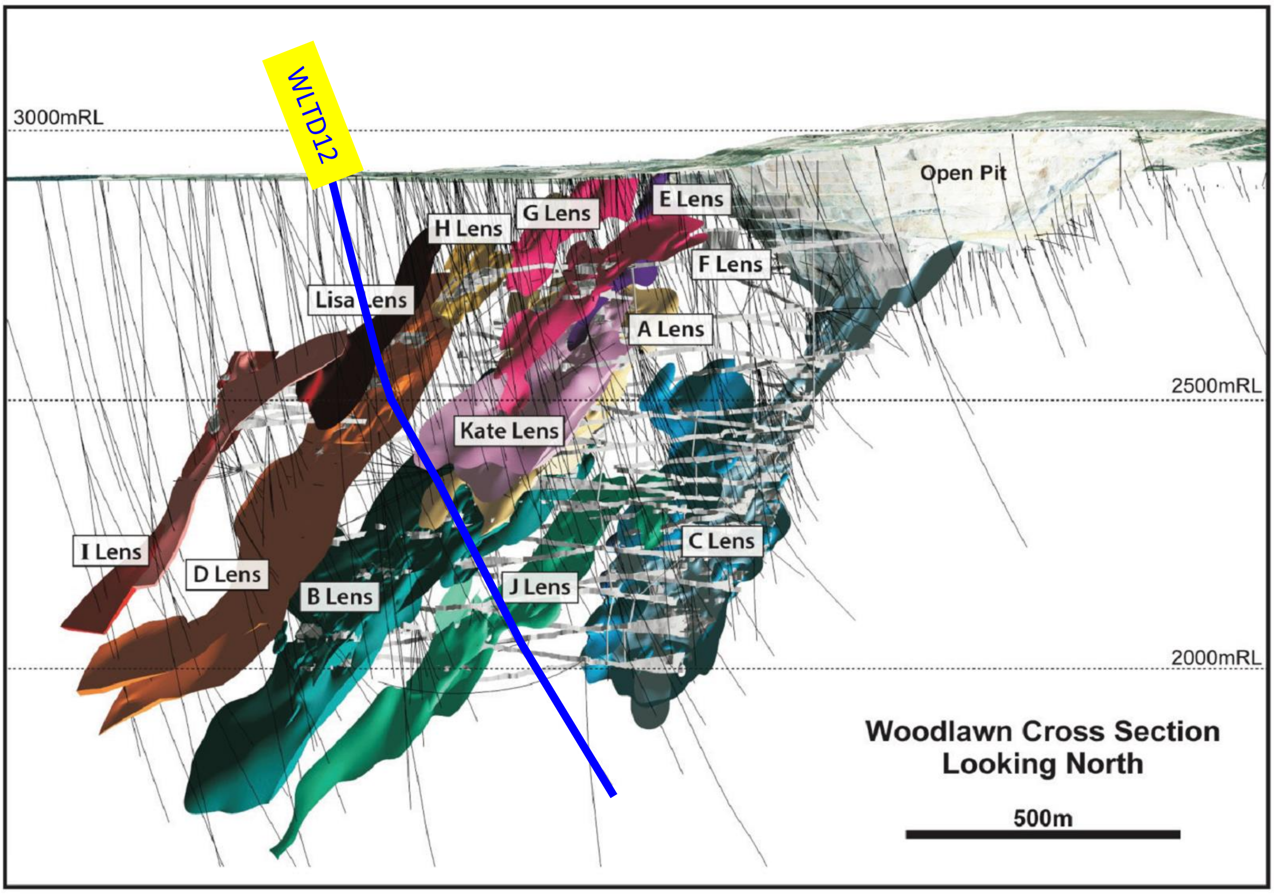

Figure 1: Cross section looking north east showing the Woodlawn ore lenses and the 'discovery' drillhole, WLTD12.

"Kate Lens" Discovery

In 2012, TriAusMin contacted Mitre Geophysics to discuss whether it would be worthwhile conducting a DHEM survey at Woodlawn on their newly completed drill hole, WLTD12. This 970m long hole was drilled targeting the down dip extension of C lens, one of the largest and historically highest-grade lenses in the Woodlawn mine. DHEM, which had only had limited use at Woodlawn, was suggested when WLTD12 failed to intersect significant mineralisation. The aim of this survey was to see whether 'C lens proper' was near the hole and, if so, delineate the distance and direction so that the next drill hole could be more successful.

The initial brief was to only survey the bottom C lens portion of the hole because as a 'live hole' the drill rig standby costs were considerable and the area above this appeared to be well tested by drilling. However, TriAusMin was persuaded that it was worth getting the shallower data 'just in case'. Furthermore, only 2 days were available to get a crew mobilised to site before the hole was closed off. Fortunately, Outer Rim Exploration Services were in the area and

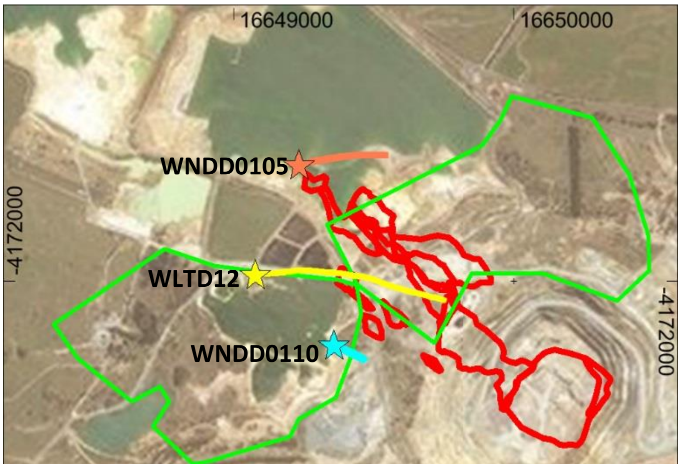

Figure 2: Location of two transmitter loops used to survey WLTD012 with main ore lenses outlined in red. Also shown are the locations of the subsequently surveyed holes, though their transmitter loops are omitted.

available within the set time frame. WLTD012 was soon surveyed using a Crone PEM system using a 50msec time base (i.e., a 5Hz repetition frequency) with a 0.5msec controlled ramp and 34A transmitter current. As can be seen in Figure 2, the loop locations were largely dictated by the tailings dams and open cut.

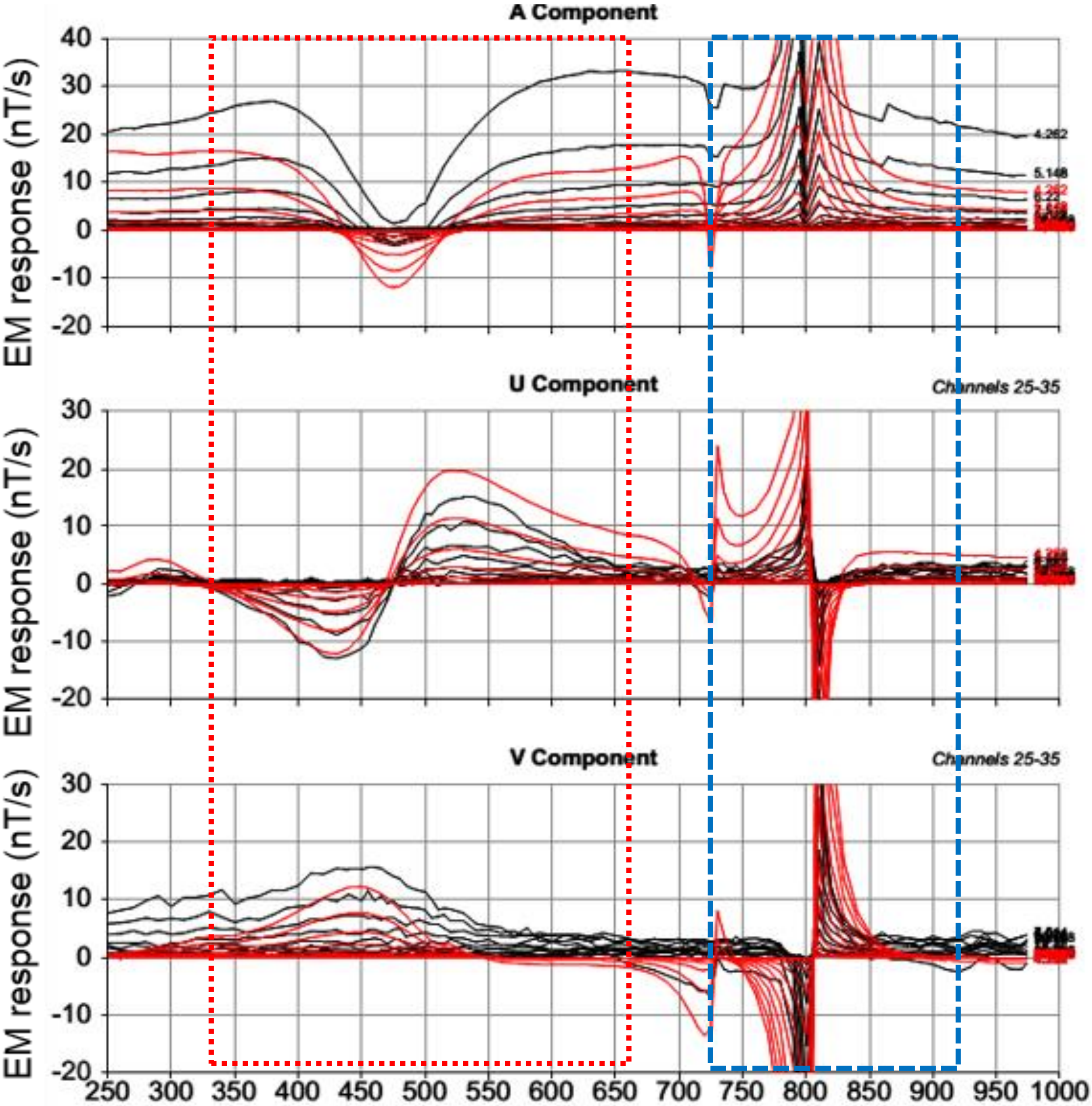

Figure 3: Recorded data (black) and model response (red). The response centred at 475m and outlined in stippled red is due to an unexpected, large, off-hole conductor which, when drilled out, was eventually named 'Kate Lens'. This interval was originally thought not to be worth surveying because the area was considered to be well tested with drilling. The response outlined in stippled blue is from the margins of the J lens mineralisations.

The WLTD12 DHEM survey profile is shown in Figure 3. Several small responses are outlined and are interpreted to be due to the stringer zones around I lens, J lens and C lens but there is no evidence of significant massive sulphides in the C lens position (between 850 and 970m downhole). However, a strong off-hole response was recorded in the upper section of the hole which was entirely unexpected. The response extends from 320m to 620m and peaks at 475m.

The responses were modelled using thin rectangular plates in an infinitely resistive host in the 'Maxwell' software suite. A reasonably good fit to the response centred at 475m was achieved with a large (125m strike length x 125m depth extent) moderate conductance (125-175S) plate, above and mostly south of the drill hole trace, about 50m away from the hole, and dipping steeply towards the west-southwest. Figure 4 shows the off-hole conductive plate with respect to the mine lenses in long- and cross-section and, in Figure 5, with the existing drilling (red plate). The conductor fits neatly into an effectively undrilled space. Follow up drilling has now defined a resource of ~0.98Mt at 6.2% Zn, 2.3% Cu, 2.0% Pb, 1.0g/t Au and 55g/t Ag. TriAusMin named this new lens 'Kate Lens' in recognition of the lead author's role in its discovery.

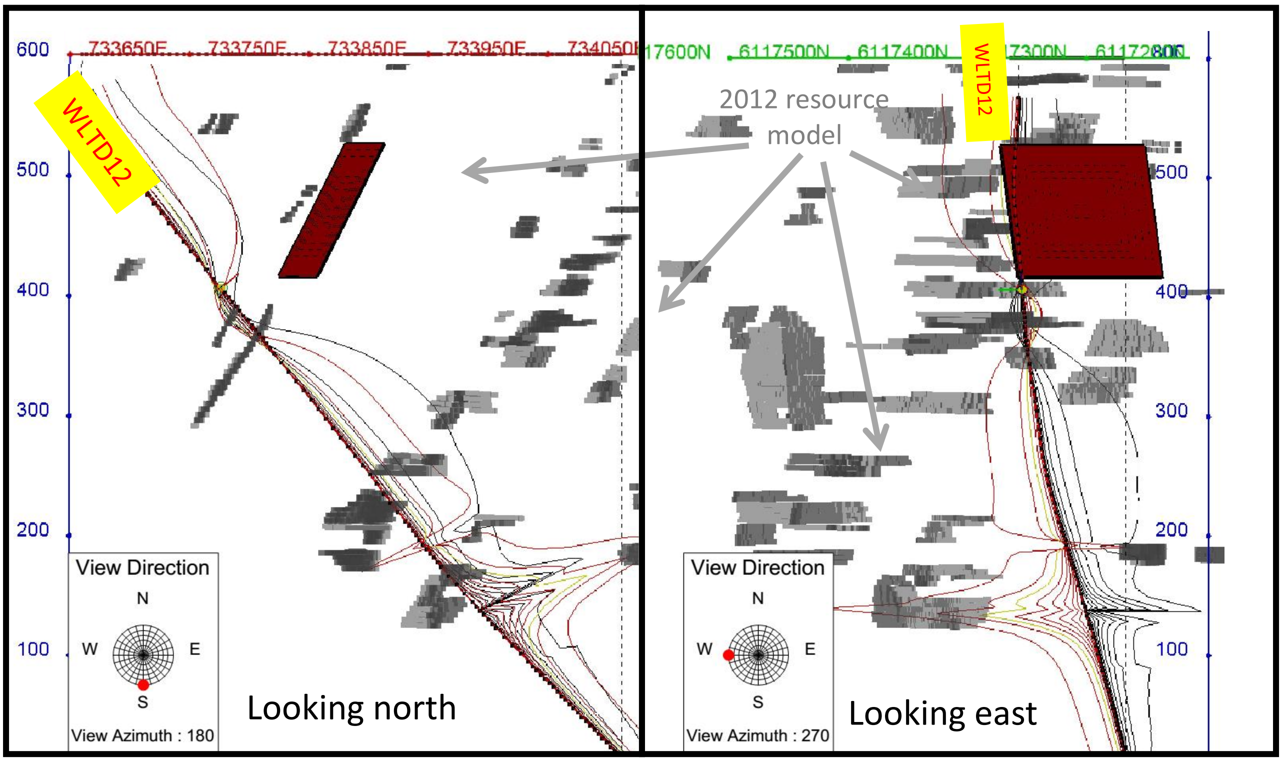

Figure 4: Hole WLTD12 with the 2012 mine resource (grey polygons) compressed on to the sections.

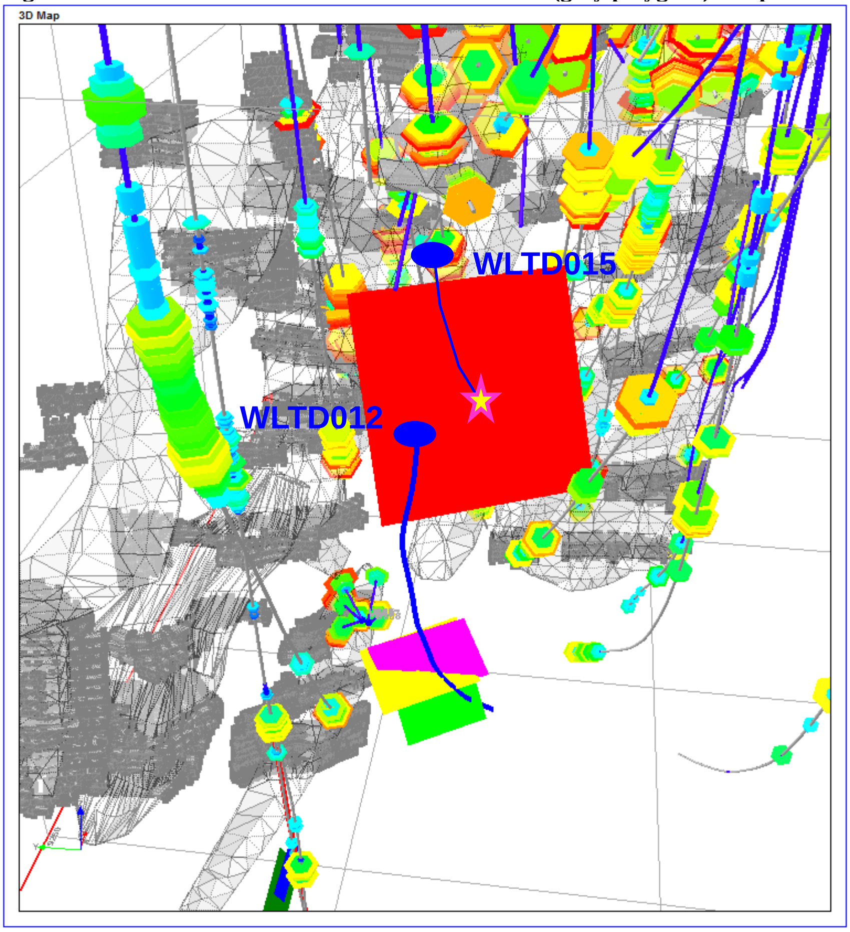

Figure 5: View looking down the axis of WLTD12 showing the surprise off-hole conductor (red plate) with respect to existing drilling and the resource model in 2012 (grey polygons). The conductor fitted neatly into a small area which had not been drilled. Hole WLTD15 was targeted on the centre of the red plate and intersected 32m @1.8% Cu, 1,2% Pb, 4.6% Zn, including 9m @ 4% Pb, 16% Zn, 0.8g/t Au, 52g/t Ag.

B lens Extension

Heron Resources Ltd took over the Woodlawn project in 2014, following a company merger with TriAusMin soon after the discovery of Kate Lens with the aim of re-opening the mine. Heron recognised that DHEM could be a valuable tool to help expand the resource further, and so proceeded to drill ambitious 'step out' holes and to systematically survey these with DHEM. This approach allowed Heron to explore more quickly and more effectively because fewer holes were needed to explore a given area and the holes could be targeted more confidently using the EM results.

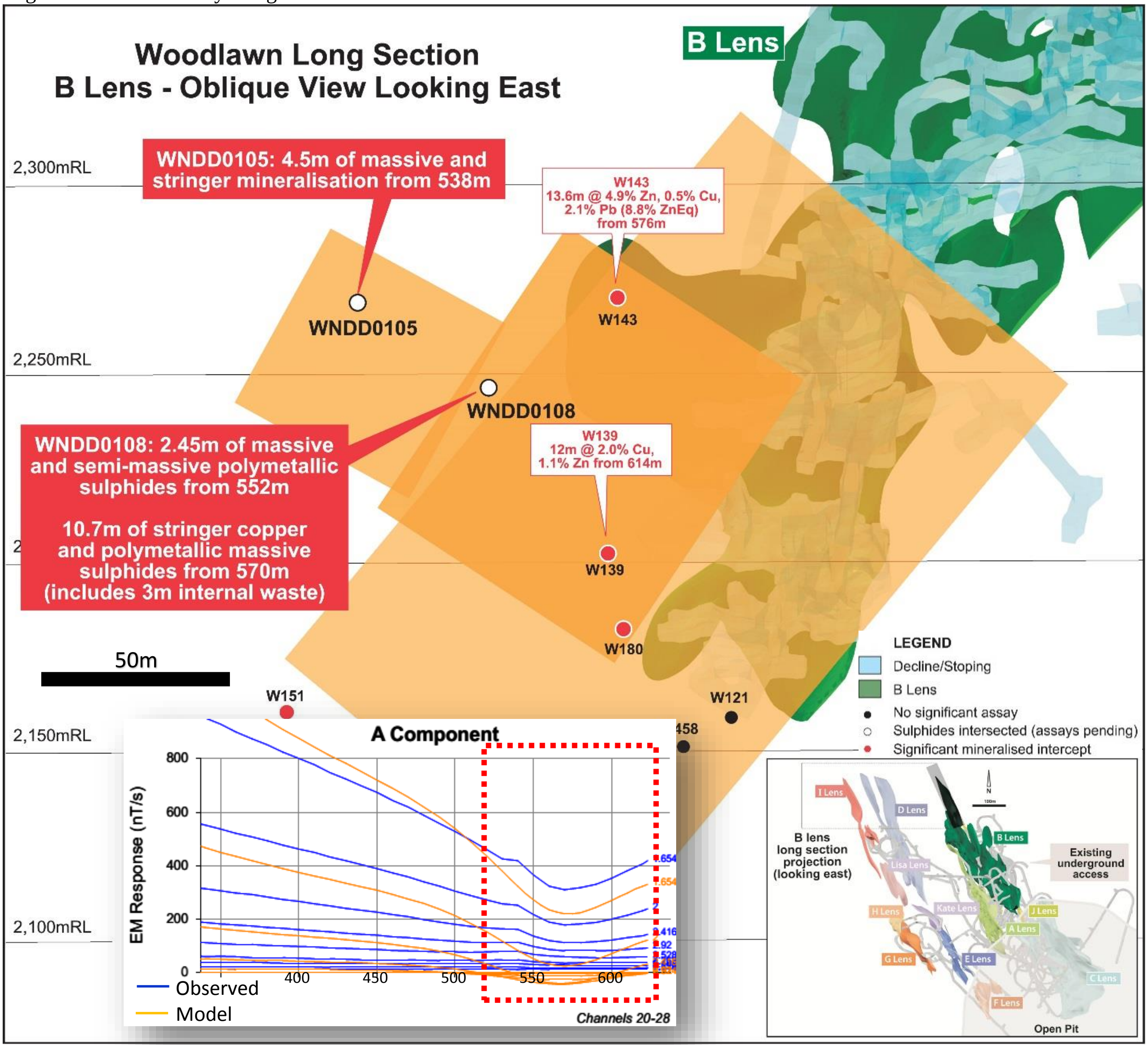

Figure 6: Oblique long-section (looking approximately east) for the northern end of the B Lens position, showing location of WNDD0105, DHEM plates and earlier drilling. The model of the small intersection response (centred at 545m on the inset) measured approximately 70m x 70m with a conductance of 25S. The model of the larger off-hole response (centred at 570m on the inset), measured 250x150m with a conductance of 50S. The modelling indicated that the bulk of the conductors were south of the hole and, importantly, that the intersections in W139, W143, W151, W180 and WNDD0108 were almost certainly due to a previously unrecognised, large down-plunge extension to B lens. {INSET} Profile showing off-hole response in WNDD0105.

A good example of the success of this approach was the B lens drilling (Figure 6). Though several historical holes had recorded promising intersections on the northern side of B lens at depth, none of these had been surveyed with DHEM. The area is structurally complex and deep (expensive) to drill so it was difficult to determine whether these widely spaced intersections were related to anything interesting. To better understand this area, Heron drilled hole WNDD0105, targeted an ambitious 100m north of the known ore envelope. The express purpose of this hole was to use DHEM to illuminate B lens. WNDD0105 intersected only a relatively narrow zone of polymetallic sulphides from 538m depth (4.5m @ 2.3% Zn, 0.8% Cu, 0.5% Pb, 0.2g/t Au, 13.1g/t Ag)), but, importantly, the DHEM showed 3 large conductors mostly south of the hole at ~550m depth: These conductors strongly indicated that a) the mineralisation intersected by WNDD0105 was in fact the northern fringe of the B lens ore body (extending the mineralised area over 100m north from the current ore model) and b) the disparate, historical intersections in W143, W151 , W139, and W180 were in fact very likely to all be from a significant down plunge extension to B lens. This information was critical in helping to decide if and where to target more exploration holes in this area.

Confirmation drilling by WNDD0108 on these conductors intersected 2.4m of massive polymetallic sulphides from 552m and 10.7m of massive polymetallic and Cu stringer sulphides from 570m. These good quality intersections combined with the DHEM plates means there is excellent potential to add a further 1.1Mt of high grade polymetallic mineralisation to the existing 6.6Mt underground resource

G2 lens drilling

G2 lens is a shallow extension to the mined-out G1 lens (as shown on Figure 6). G2 lens is generally less suitable to DHEM because the mineralisation is primarily stringer sphalerite. Despite this, Heron surveyed drill holes WNDD0109 and WNDD0110 'just in case'. These holes targeted deeper extensions of G2 lens (intersection points are shown on Figure 6).

WNDD0109 intersected 5m of weak G2 lens Zn stringer sulphides from 130m, but showed no significant EM response to this mineralisation and no other significant responses. WNDD0110 intersected 6.1m of G2 lens Zn stringer sulphides at 140m and showed a very weak EM response which proved to be very difficult to accurately model. However, WNDD0110 also intersected a surprise 7.0m of high grade massive polymetallic sulphides from 109m, and this mineralisation showed a clear response in the EM. The early time data showed a small intersection response from the broader mineralised zone which migrated to an off-hole response from a small source north of the hole at later times. The modelling indicated that the source could only be quite small (<50x50m). Follow up drilling has since confirmed that the new ore zone (now called G2-hanging wall) is a small but very high grade zone of polymetallic sulphides. However, since G2-hanging wall is on the route of the planned new decline, it represents important early stage feed stock for the processing plant and therefore plays an important factor in the economics of reopening the mine.

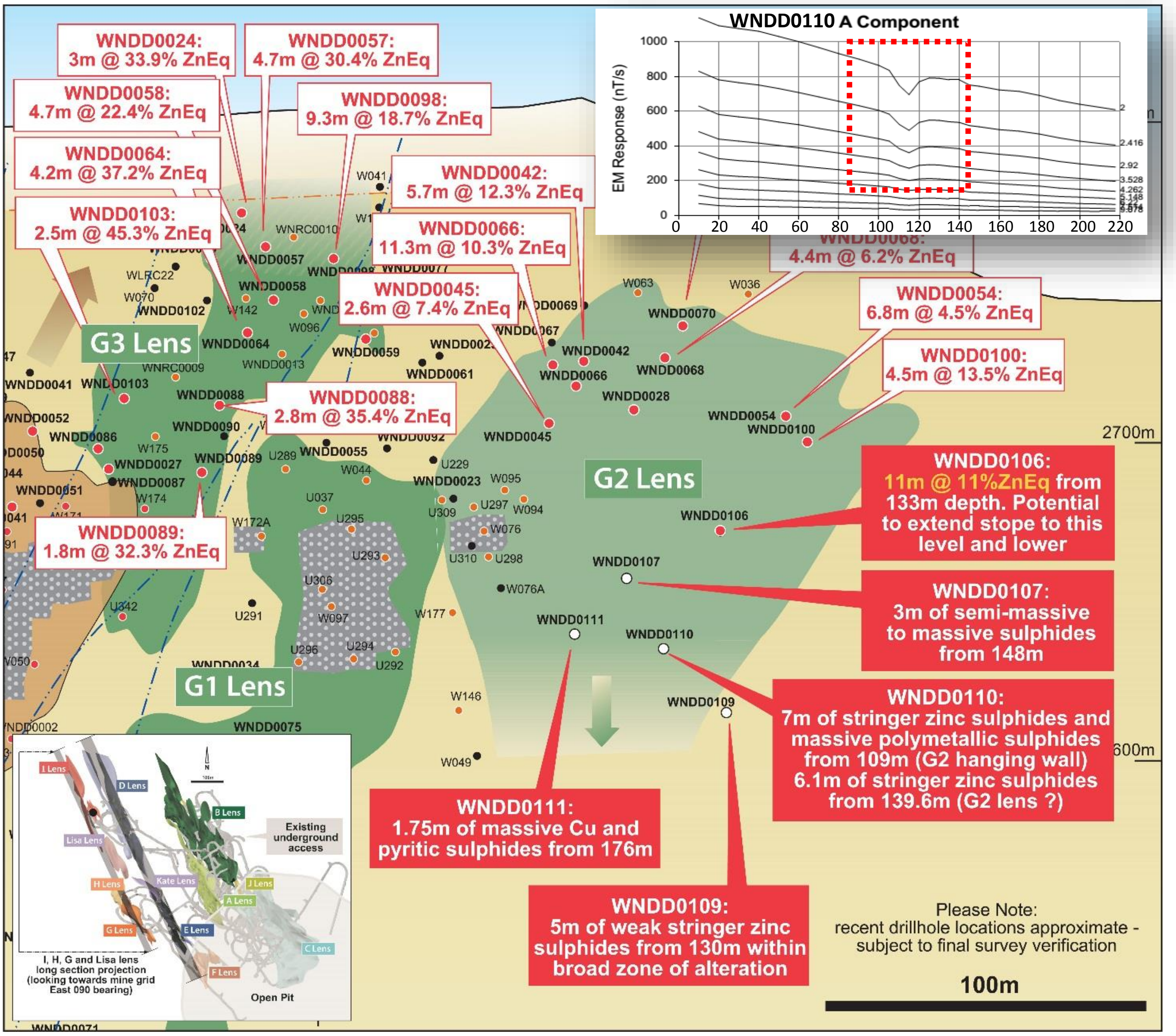

Figure 6: Oblique long-section (looking approximately east) for the G2 lens position. Holes WNDD0110 and WNDD0109 are highlighted. {Inset} There is a clear late time off-hole (early time intersection response) visible in the EM data from WNDD0110 at 109m downhole. This is from the polymetallic sulphides in G2-hanging wall. The narrow width of the response indicates a very small response – later proven correct in the resource drill out.

Thus, while the EM on G2 lens has not been able to map the Zn stringer sulphides accurately enough to be useful, it was still able to help the resource drill out by estimating the size of the high grade polymetallic zone in WNDD0110. Unfortunately, the fact that high grade pods such as G2-hanging wall are so small means that they a) can only be detected if very close to the drill hole and b) are only poorly resolved because EM surveys and EM models are usually under-sampled for such narrow anomalies (generally much less than 20m width).

Discussion

The above illustrates that DHEM is an important tool in the near mine environment at Woodlawn. The most straightforward application is to discover new ore and avoid 'near misses' by effectively expanding the search radius of the drill hole by up to 150m. Interestingly, 'Kate lens' was in fact a near miss for several older holes: WLTD10 was surveyed from 550m to 936m downhole and would have detected Kate lens if the upper portion of the hole had not been ignored.

DHEM also has application for early stage resource delineation, because while the data can not of course define thickness of an ore zone, can reliable estimate lateral extents (depth extent and strike length). The initial model of Kate lens suggested the ore zone could be up to 1Mt. The final JORC resource after 2 years drilling is 0.98Mt. At the other end of the scale, the DHEM results from the G2-hanging wall strongly suggested only a very limited size conductor (<<50mx50m with unknown thickness). Subsequent drilling confirmed that the ore zone is relatively small and within these limits.

Conclusions

DHEM surveys at Woodlawn mine led to the eventual discovery of Kate lens and the B lens extension, as well as contributing to the resource drill out of G2-hanging wall lens and multiple other parts of the mine. In total these lenses represent an additional 2.2 Mt of underground resource, significantly improving the economic viability of the mine.

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