Discovery of the Moran massive nickel sulphide deposit using down-hole transient electromagnetic surveying

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SUMMARY

The Moran nickel orebody was discovered in 2008 when underground drill-hole LSU-152 intersected a 12.3 m thick interval of mineralisation with an average grade of 6.0% Ni. The discovery drill-hole had been designed to test a strong conductor detected by transient electromagnetic surveys read in drill-holes that had passed above and below Moran.

Moran is located approximately 1.1 km south of the Long orebody. Both orebodies are interpreted to be hosted within the same komatiite lava channel. The exploration program was premised on the observation that fertile komatiite lava channels are often mineralised over significant distances. Diamond drill-holes were drilled from underground mine workings in order to test the target lava channel to the south of Long over 1.7 km of strike. Recognition of potential ore-hosting environments, integrated with conductor models developed from DHTEM data, were keys to success.
Key words: Moran, Kambalda, nickel, DHTEM

INTRODUCTION

The Kambalda nickel camp was discovered by Western Mining Corporation in 1966. The Moran discovery in September 2008 is the most recent significant addition to the mineral inventory of the camp, with a maiden indicated and inferred resource estimate of 456 000 tonnes grading 7.1% Ni for 32 400 tonnes contained nickel metal.

Moran lies within the Long-Victor Complex; an underground mining operation owned by Independence Group NL since 2002 through its wholly-owned subsidiary Lightning Nickel Pty Ltd. The operation was purchased from WMC Resources Ltd with a modest mining inventory of 746 345 tonnes grading 3.59% Ni for 26 800 tonnes contained nickel metal; a small remnant after production of over 200 000 tonnes of nickel since 1979. Lightning Nickel has produced 59 597 tonnes of nickel metal between October 2002 and December 2009, and has an estimated mineral resource containing 93 900 tonnes of nickel metal (June 2009). This large increase in mineral inventory and produced metal is the result of successful in-mine exploration programs, which led to the discovery of the McLeay orebody in 2005 and Moran in 2008. Lightning Nickel continues to invest heavily in exploration, in order to expand existing resources and discover new orebodies.

The principal exploration methods employed at Long-Victor are underground diamond drilling and down-hole transient electromagnetic (DHTEM) surveying. Geological interpretation of drill-hole geochemistry, petrology and structure leads to identification of potential ore-hosting environments within the basal komatiite flow. DHTEM surveys are used to directly detect highly conductive massive sulphide mineralisation in the vicinity of each drill-hole, and to define the geometry of both intersected and off-hole conductors. This highly successful multidisciplinary approach is supported by a management team prepared to invest millions of dollars in development of exploration declines to provide platforms for drilling.

GEOLOGY OF KAMBALDA-STYLE NICKEL OREBODIES

The Moran orebody is located in the Long Victor Complex, on the eastern flank of Kambalda Dome in the South Central portion of the Achaean Norseman-Wiluna Greenstone belt in Western Australia. The Kambalda Dome is a double-plunging antiform with a core of granodiorite flanked by tholeiitic basalt which is overlain by komatiite and intercalated sediments. The region hosts a number of historically and currently mined nickel orebodies. Nickel deposits in the camp are hosted by the basal ultramafic Silver Lake Member of the Kambalda Formation, at the contact with the underlying Lunnon Basalt.

The nickel sulphide deposits of the Kambalda field occur within linear embayments in the footwall basalt, with marked differences in the ultramafic sequences developed within the ore environment compared to those in barren flanking positions (Ross and Hopkins, 1975; Gresham and Loftus-Hills, 1981). The barren flanking ultramafic sequence contains sulphidic interflow sediments, and grades from thicker orthocumulate peridotite basal flows to thinner, less magnesian olivine-pyroxene spinifex textured rocks. The ultramafic sequences within the ore-hosting embayment structures lack interflow sediments and are composed of olivine mesocumulate to adcumulate rocks throughout.

Lesher (1983) showed that the basal contact embayments were originally conformable volcanic features, where the komatiitic lava flowed in channels. Formation of more olivine-enriched cumulate rocks within the embayment occurred as a result of continuous addition of olivine crystallizing from the moving lava and removal of the olivine-depleted melt.

Three modes of nickel ore occurrence are recognized at Kambalda: contact, hanging wall and offset ore. Contact ore (typically massive to matrix textured sulphide) is localised in footwall embayment structures, and occurs within the basal ultramafic unit at the contact with the underlying basalt. Hanging wall ore occurs as disseminated or blebby sulphide within the second or third ultramafic lava flow above the basal unit, and is generally found stratigraphically above positions where contact ores are well developed (Marston et al, 1981). Offset ore occurs within shears in the ultramafic or basalt, and has been structurally remobilised from its primary depositional location. The field relationships between sulphide ore and the host komatiite, and between the different ore types, are consistent with the sulphides forming an immiscible liquid that settled at the base of the lava channel (Naldrett, 1973).

MORAN EXPLORATION HISTORY

Western Mining Corporation completed numerous surface diamond drill holes after the discovery of the Kambalda field in 1966 to systematically test the ultramafic basal contact for nickel mineralisation. Hole KD6067B intersected 0.76m of massive nickel sulphide mineralisation grading 8.2% Ni at the ultramafic basal contact with the Lunnon Basalt approximately 770 m from the southern limit of the Long nickel orebody. The komatiite lava channel hosting the Long orebody was assumed to continue to the north and south of the mine, consistent with other channels in the Kambalda region. The mineralisation intersected by hole KD6067B provided confirmation that a fertile lava channel existed close to an orebody containing >200 000 tonnes of nickel metal.

In June 2003, Independence Group drilled a wedge hole (KD6067BW7) from a depth of 560m in KD6067B, which intersected 3.24m of matrix and stringer sulphide mineralisation and 0.36m massive sulphide, with the entire interval grading 3.3% Ni. This intersection was located 24m south southwest of the original WMC intersection in the parent hole KD6067B. In October 2004, the company commenced an extension of the 16/8 decline to the south at the Long mine, in order to provide a platform for drilling the lava channel in the vicinity of these intersections, as surface drilling had proven expensive and prone to failure. The 16/8 decline development continued in several stages until December 2006, with fans of diamond drill holes collared in stockpiles along the length of the decline. This program resulted in several sub-economic intersections of mineralisation close to the original KD6067B target, including a cluster of occurrences near the decline face. However, the results provided insufficient encouragement to extend the decline development, which had cost over $10 million.

A review of the historical drilling data in February 2007 identified an intersection of disseminated nickel sulphides well above the ultramafic basal contact and located 980m in plan projection to the south of the 16/8 decline face, apparently close to the southern projection of the Long lava channel. Hole KD6068 had intersected 12.28m of blebby sulphide mineralisation grading 1% Ni from 787.72m down-hole, but remained in ultramafic rock at the end of hole (875 m), failing to test the prospective contact. The spatial association of hanging wall disseminated sulphide mineralisation with basal contact ore had been long recognized in the Kambalda field (Marston et al, 1981). This KD6068 nickel sulphide occurrence provided justification for a program of wildcat holes designed to test the Long lava channel several hundred metres to the south of the 16/8 exploration decline. Hole LSU-103 was collared in the 500S development of the McLeay orebody, and intersected high tenor (8% Ni estimated by portable XRF) nickel sulphide stringers between basalt pillows in a 0.6m interval grading 1.88% Ni. A down-hole TEM survey of hole LSU-103 defined an anomaly consistent with a small, high conductance plate-like body lying close to the drill hole. This conductor is now interpreted to represent a part of the Moran mineralisation.

The next phase of drilling (October, 2007) was designed to test the prospective contact mid-way between LSU-103 and the 16/8 decline face. Hole LSU-140 intersected 8.9m of disseminated and blebby nickel sulphide grading 0.6% Ni (Figure 1). The hole had intersected a sheared basalt-ultramafic contact, and then passed through an intact and mineralised ultramafic-basalt contact further down-hole. This structural feature is commonly encountered at the edge of a basal contact embayment hosting a komatiite lava channel. The follow-up drill hole (LSU-141) failed to intersect the basal contact, remaining within footwall basalt to the end of hole due to a 12° deviation. Nevertheless, down-hole TEM surveys in both LSU-140 and LSU-141 defined anomalies consistent with a strong conductor located on the interpreted basal contact between the holes and close to the disseminated sulphide intersection in LSU-140 (Figure 2).

The “discovery” anomaly in LSU-141 was identified from a single reading taken during the initial survey of the hole at 100m station spacing. Operators attempt to finish logging holes prior to blasting time at the end of the shift, and there is usually insufficient time to log an entire 600m long hole with closely spaced stations. A trade-off exists between production and data quality. A hole may be logged over more than one shift, but this introduces a risk that it will collapse before the survey is completed. In this case, the operator was able to re-enter the drill hole, and the single-station reconnaissance anomaly was confirmed by down-hole TEM surveying at 5m station spacing.

A strong conductor about 90 m wide down-dip and over 200 m long was interpreted from the DHTEM data collected in holes LSU-128, LSU-140 and LSU-144 (all drilled down-dip and above Moran), LSU-141 (drilled down-dip and below Moran) and LSU-143 (drilled along strike and above Moran).

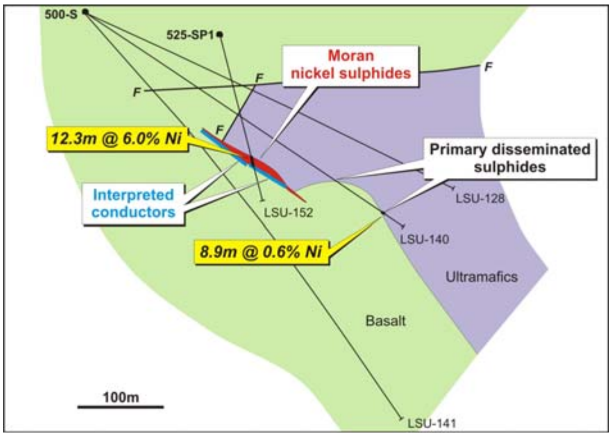

Figure 1. Geological cross-section of the Moran deposit, showing exploration drill-holes and interpreted conductors derived from DHTEM surveys.

The low angles of target-drill hole intersection attainable using collars located in the McLeay and Victor South mine workings made effective testing of the interpreted conductor difficult. Consequently, the Directors of Independence Group authorized development of a 180m long drill drive from the end of the Victor South decline to provide a suitable platform for testing the conductor. The drill drive was completed in August 2008 and hole LSU-152 was drilled from the face, intersecting 12.3m of disseminated, matrix and massive sulphides grading 6.0% Ni. Subsequent drilling resulted in a 2009 maiden resource estimate of 456 000 tonnes grading 7.1% Ni for 32 400 tonnes contained nickel metal.

DHTEM DATA ACQUISITION AND INTERPRETATION

We collected all DHTEM data after completion of the 16/8 exploration decline using an underground transmitter loop constructed by passing wire through underground workings and inside a drill-hole collared in the Victor decline and intersecting the face of the 16/8 decline. The loop has a circumference of 2.77 km and lies roughly in the plane of the moderately (60°) dipping prospective contact. This loop provided excellent electromagnetic coupling with massive sulphide targets conformable to this surface, and poor coupling with the conductive lake sediments and weathered rock. Positioning the loop close to the target zone also results in a stronger induced target response than could be achieved using a loop laid on the ground surface. This proved particularly important during the early phase, prior to the LSU-103 wildcat hole, in which drilling targeted small conductors near the face of the 16/8 decline. Initial surveying of these holes using a loop located on the surface failed to detect the anomalies subsequently defined using the underground loop.

We recorded DHTEM data using the SMARTem receiver (Wellington et al, 1997; Duncan et al 1998) and Atlantis three-component fluxgate magnetometer probe manufactured by Electromagnetic Imaging Technologies Pty Ltd. The transmitter system consisted of a switch developed by Curtin University which was triggered by a SMARTem controller and powered by a bank of up to ten 12 V car batteries. A later version of this transmitter used a pair of DC power supplies connected to the 415 V three-phase mine power supply, which enabled us to transmit a bipolar 50% duty cycle waveform with a peak current of 50 ampere through the 16/8 loop. The resistance of this loop is 8 ohms.

The DHTEM data were interpreted by fitting model responses to the observed late-time data using the program Maxwell, which implements the same current ribbon approximation as the original Multiloop software (Lamontagne et al, 1988).

CONCLUSIONS

The exploration program leading to the discovery of Moran was motivated by the conviction that the komatiite lava channel hosting the Long orebody was mineralised to the south of the mine. Geological evidence for the existence of this new orebody was inconclusive until the discovery hole LSU-152 was drilled. The sub-economic intersections of basalt-hosted stringer sulphides in LSU-103 and komatiite-hosted disseminated sulphides in LSU-140 provided encouragement that a potential ore environment existed. However, DHTEM data provided the direct evidence that potentially economic massive sulphide mineralisation was present near these exploration holes. The complementary lines of evidence from geological and geophysical interpretations supported the decision to invest significant capital in order to test the target.

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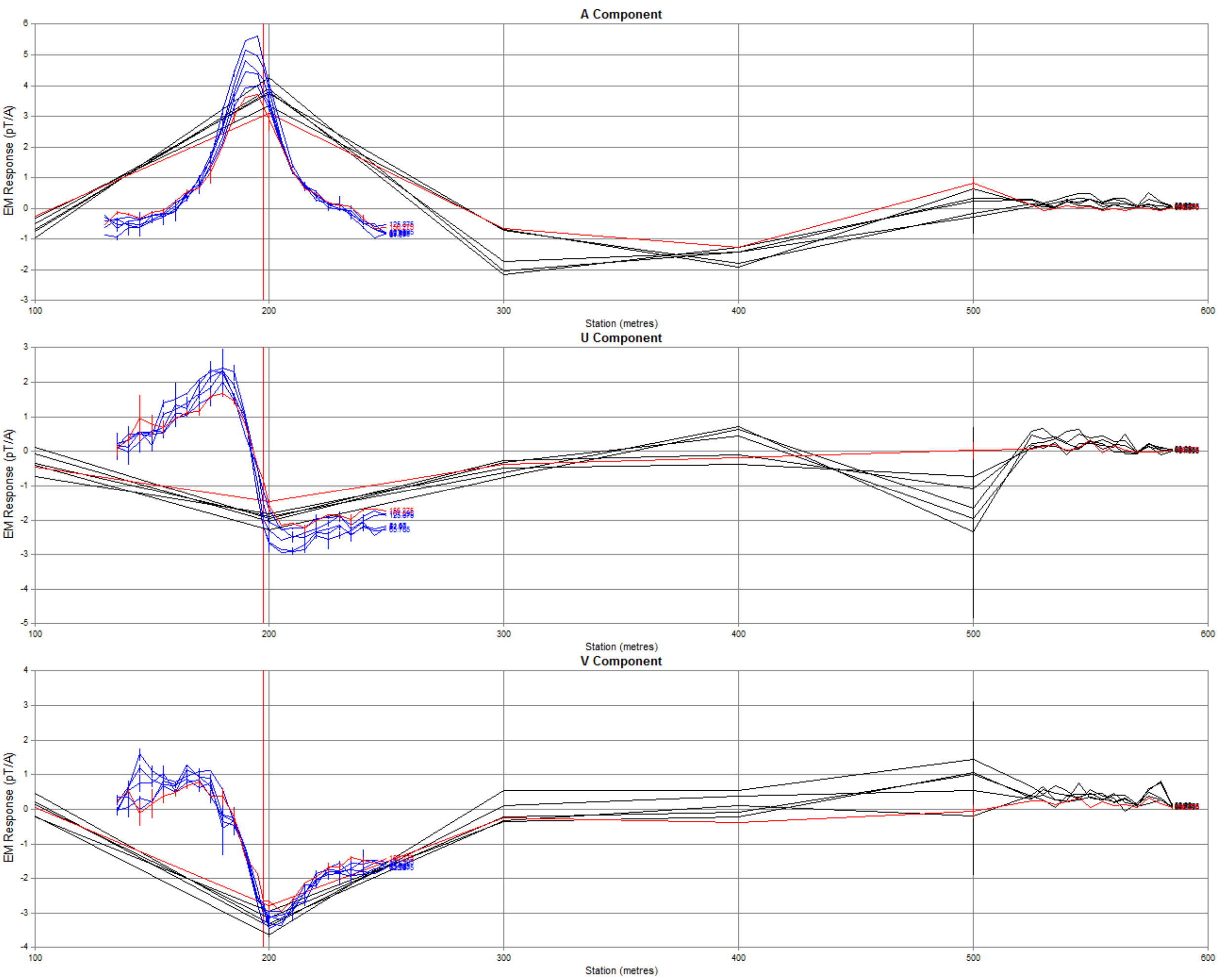

Figure 2. Profiles of DHTEM response measured in drill-hole LSU-141 at late delay times (52.99 to 156.275 ms). The black profiles covering the interval from 100m to end-of-hole correspond to the initial survey. The blue profiles correspond to a later survey read to follow up the single-point anomaly at 200m in the initial survey.