

A Case History of the Discovery of the Chisel North Zinc/Copper Deposit – Snow Lake, MB. *Alan K. Vowles* - Hudson Bay Exploration and Development Company Limited. (Hudbay), Flin Flon, Manitoba*

Summary

Beginning in 1979, Hudbay embarked on a deep drilling program in an effort to find additional ore lenses down dip/down plunge from the original Chisel Lake Zinc Mine. In the years 1979, 81, 84 & 87 a total of 14 holes were drilled to explore what is generally referred to as the Chisel Structural Basin. Because the zinc, or sphalerite, is associated with highly conductive massive sulfides, it was thought that borehole EM would be an effective deep exploration tool. In 1983 a program was planned for the survey of all of the deep drill holes, using the Crone Pulse EM system. The holes were systematically surveyed from multiple transmitter loops as well as from loops common to several drill holes, for ease of interpretation. The Primary field strength was recorded as well as the Secondary field decay, to aid in the interpretation. In June 1987, two new holes were surveyed and the results compared to two, nearby holes, surveyed in 1984. Based on the interpretation of the primary field deflection, hole C-87-8 was drilled and intersected 61.7 feet (18.8m) of ore. In April 1988, hole C-88-4W1 was surveyed. The secondary field response indicated a distant offhole anomaly. This target was tested in January 1990 with the drilling of C-90-2, which intersected 13.1 (4m) feet of ore in a separate zone. Additionally, recent advances in Crone borehole technology have been responsible for expanding and better defining the limits of the Chisel North Deposit. This involved the use of the new 150 millisecond time base transmitter developed by Crone Geophysics. The estimated geological resource of the Chisel North deposit is approximately 3 million tons of 0.019 oz/t Au, 1.23 oz/t Ag, 0.23% Cu, 12.18% Zn and 0.81% Pb. Development of a 2.5 Km. ramp, to access the deposit, began in August, 1998.

Introduction

The original Chisel Lake Mine was discovered in 1956 by drilling a ground E.M. anomaly as a follow up to airborne geophysics. It is located 6 kilometres south-west of the town of Snow Lake, Manitoba. The mine produced approximately 7.87 million tons of ore, grading 10.6% Zn and 0.54% Cu. and ceased production in 1994. The Chisel and Chisel North ore bodies are proximal, volcanogenic massive sulphide (VMS) deposits in the eastern part of the Flin Flon volcanic belt. The sulfide mineralization occurs as semi-massive to massive Sphalerite-Pyrite. The deposits are stratigraphically underlain by a broad, hydrothermal, alteration zone hosting sericite and chlorite rich lenses containing Zn, Fe, Pb, Cu, As, Au and Ag. (Galley, Bailes, and Kitzler, 1993).

The exploration strategy involved drilling fences of holes at approximately 400-600 foot step-outs, down-dip/down-plunge of the main ore lenses.

Fig.1 is a Plan View of the Green, Red and Purple zones which, together, comprise the new Chisel North orebody. Structurally the ore lenses are substantially flat lying, dipping in a north-easterly direction at -17° and plunging almost due north. A total of nine holes are shown, eight of which were drilled prior to the discovery of Chisel North, with none of the holes intersecting any of the ore lenses. The pierce points of the Red and Purple Zone stratigraphy, shown on the plan, clearly indicate how all of the holes straddled both lenses. Noting the location of C87-5, it is apparent that the drilling had already overshot the Chisel North Orebody and was proceeding to the northeast out into the Chisel basin. It was at this stage of the drilling program that the decision was made by G.H. Kitzler and A.T. Baumgartner to suspend drilling additional step-out holes and to test a borehole geophysical anomaly which lay between holes C84-18 and C87-4w1. Hole C87-8 that drilled this target intersected 61.7 feet (18.8 metres) of ore.

Instrumentation and survey method

The survey equipment used was the Crone, Borehole Pulse EM system. This is a Time Domain system which transmits an electromagnetic field from a loop laid out on surface. The transmit loops used on this project were normally 1000 feet (305 m) square. There were three vintages of equipment used over the period from which data was gathered for this compilation. In 1987-88 the transmitted pulse had a peak current of 16 A, at 110 V and a base frequency of 22.96 Hz. Eight channels of data were gathered with a datalogger linked to an analog receiver. The surveys in 1993 were run at a peak current of 16 A at 110 V and a base frequency of 15 Hz. Twenty channels of data were gathered with a digital receiver. In 1998 a 4.8 kW transmitter was used with a peak current of 20 A at 192 V and a base frequency of 1.67 Hz. 42 channels of data were recorded. In all configurations the current waveform is rectangular. The mid points of the channels that were recorded are listed in table form in the Crone Operators Manual. Details on equipment and system configuration have been described in instrument specifications and information sheets by Crone Geophysics & Exploration. (Ravenhurst).

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As described earlier, the geological structure was substantially flat lying at a dip of 17 degrees. As such all the loops were hanging wall loops and all holes were drilled from hanging wall to footwall. Therefore, in keeping with normal sign convention, the conductive lenses were always normally coupled. i.e. The recorded Primary field and secondary field direction was from footwall to hanging wall. (Figure 8).

Data Presentation

Presentation of the borehole data is produced using a suite of software developed in-house at HudBay by G.R. Frazer. The data sets are compressed to eight channels or time windows with each being profiled on a separate datum. The advantage of separate datums is channel differentiation. All profiles show the amplitudes in nanotesla/sec, plotted at a linear scale. The hole depths are shown down the left side of the figure, and plotted in feet rather than metres because the grid system and holes co-ordinates used the English system in 1987. Each channel number and corresponding datum is shown across the top of the profile. Offhole anomalies are shaded in green and inhole anomalies and Primary field anomalies shaded in red.

Interpretation - General

The convention adopted for the polarity of the field is +ve up hole for the Z or axial component; +ve upward, perpendicular to the azimuth of the hole for the X component and +ve left or -90 degrees to the azimuth of the hole for the Y component. The primary purpose of reading the X-Y components is to determine direction to offhole conductors and direction to the centre of the most conductive area in the case of an inhole anomaly. For clarification of terminology the terms 'inhole', 'offhole' and 'inhole/offhole' should be described. Offhole anomaly refers to a conductor that was not intersected by the borehole. Inhole anomaly refers to a conductor that was intersected at the most conductive area of the body. An Inhole/Offhole anomaly (which sounds ambiguous and often leads to confusion) is described as a conductor that was intersected but a more conductive portion of the conductor lies away from the hole or offhole. Let us use an example in which a large regional sheet of 10% conductive material contains, within it, a local portion of 80% conductive material. In the example a hole is drilled through the 10% conductive material. Because we are measuring the decay of the secondary field and the current collapses into the more conductive part of the body during the decay; then one might say that early in the decay the current is travelling around the outer edge of the body and therefore around the probe. This would, therefore show an inhole anomaly early in time or on the early channels. As the field decays inward to the more conductive area, the current collapses past the probe and is no longer flowing around it. This will now show an offhole anomaly later in time on the higher channels. This is important to understand when examining the benefit to using a long time base system as will be shown in this case study.

Prior to 3-Dimensional borehole, with the development of the X-Y component probe, it was necessary to lay out multiple loops to determine direction to the target. This was done by comparing secondary field amplitude from each loop. This method was successfully used in targeting the discovery hole in the Purple Zone in 1990. Another common method is to survey multiple holes from a common loop and compare the amplitudes from hole to hole.

Interpretation

Discovery of Chisel North (Red Zone) – July, 1987

Figures 3, 4, 5 & 6 show Z component profiles of four holes, all of which were surveyed from a common loop # 23, shown on the plan view in Figure 2. The pierce points of the Red Zone horizon for the four holes, C84-15, C84-18, C87-4W1 and C87-4 are shown on Figures 1 & 2. In all four holes a distinct inhole anomaly occurs, coincident with a mineralized alteration zone, carrying zinc and copper values, which was later discovered to host the Green Zone. However, only holes C84-18 and C87-4W1 produced anomalies coincident with the Red Zone horizon. These anomalies were inhole anomalies in the secondary field. And, in the case of the primary field, the responses can be described as depletion anomalies, caused by inductive reflection of the field around a highly conductive body (Lamontagne, 1994). In adopting this view, it would mean that the primary field must be deflected around the body and in so doing would be flowing across the coils of the Z probe, producing a zero or low +ve or -ve response rather than up through the coil giving a high +ve response. This, then would mean that the primary field would produce a significant response from the X or Y coil. In numerous examples, this can be shown to be true and clearly supports this interpretation. Unfortunately, in 1987, we did not yet have the X-Y probe.

In the conclusion of a report written July 2, 1987, on the interpretation of the above four holes, it was stated that a target still remained untested between holes C84-18 and C87-4W1 at the 1750 foot level (533 metres from surface). See Figure 1. The target

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was described as extremely conductive material that was responsible for altering the Primary field. Hole C87-8 was proposed to test this anomaly (Figure. 2) .The hole succeeded in hitting its target at the predicted depth, intersecting 61.7 feet (18.8 m) of .154 oz. Au, 4.22 oz. Ag, .17% Cu, 5.6% Zn, and 1.7% Pb.

Discovery of the Chisel North Purple Zone – February, 1990

Figure 7 shows a Z component profile of hole C88-4W1. At a hole depth of 1740 ft.(530.4 m), an offhole anomaly occurs. A calculation of the half width from the profile indicates the near edge of the conductive target to lie approximately 330 feet (100 m) from the hole. The hole was surveyed from four transmit loop locations. Transmit loop # 19 which was laid to northwest of the hole, produced the highest amplitude response, indicating that to be the most likely direction to the target. The PEM profile also indicates an inhole spike at 1880 feet, coincident with a mineralized intersection. It was thought that if the sulfides intersected lay within the same stratigraphic horizon as the conductor causing the offhole anomaly then this conductor must lie updip as shown in Figure 8.

In January of 1990, when the ice on Ghost Lake was thick enough to support a diamond drill, hole C90-2 was drilled to test the offhole anomaly. It was collared 350 feet, grid northwest of the collar of C88-4W1. At a hole depth of 1610 feet, C90-2 intersected 13.7 ft. of 14.9% zinc and 0.36% copper.

Delineation of added tonnage to the Red Zone – Oct., 1998

In 1993 additional holes were drilled to define the limits of the Red Zone. Hole C93-4 intersected mineralization but failed to hit ore grade material within massive sulfides. When the hole was originally surveyed in 1993 using a time base of 16.66 milliseconds, the survey produced a 7 channel inhole response with an offhole spike on channel 8, coincident with the intersected mineralization. From this information there was still insufficient data to target the most highly conductive area. **Note:** On Figure 9 the mid point of the latest channel is 10.57 milliseconds.

In 1998, C90-2 was re-surveyed using the 150 millisecond, 4.8 kW transmitter. **Note:** On Figure 10 the mid point of the latest channel is 113.85 milliseconds. By measuring much further into the decay of the secondary field , enough time has elapsed to permit the current to collapse past the probe to the edge of the massive sulfide conductor, which lay away from the hole, producing an offhole anomaly on the later channels. It was now possible to determine the distance to the near edge of the massive sulfides by doing a half width calculation from the profile. This new information extended the limit of the Red Zone an additional 70 feet from the previous estimated limit.

Figures 11 & 12 show PEM profiles of the X-Y data indicating direction to the massive sulfide portion of the Red Zone horizon. By employing the 150 ms time base and basing the interpretation on the later channels, the results indicate the centre of conductivity to lie grid southeast of the hole. This location is confirmed by existing holes in the ore body. Software developed in-house by G.R. Frazer was used to calculate the precise direction to the target.

Conclusions

Without the use of Borehole EM, the Chisel North Mine may not have been discovered. Although not yet confirmed by drilling, the use of the Crone, long time base system may have expanded the limits of the Chisel North Red Zone. By measuring later into the decay of the secondary field, one can accurately target the more conductive regions of extensive mineralized horizons.

Acknowledgements

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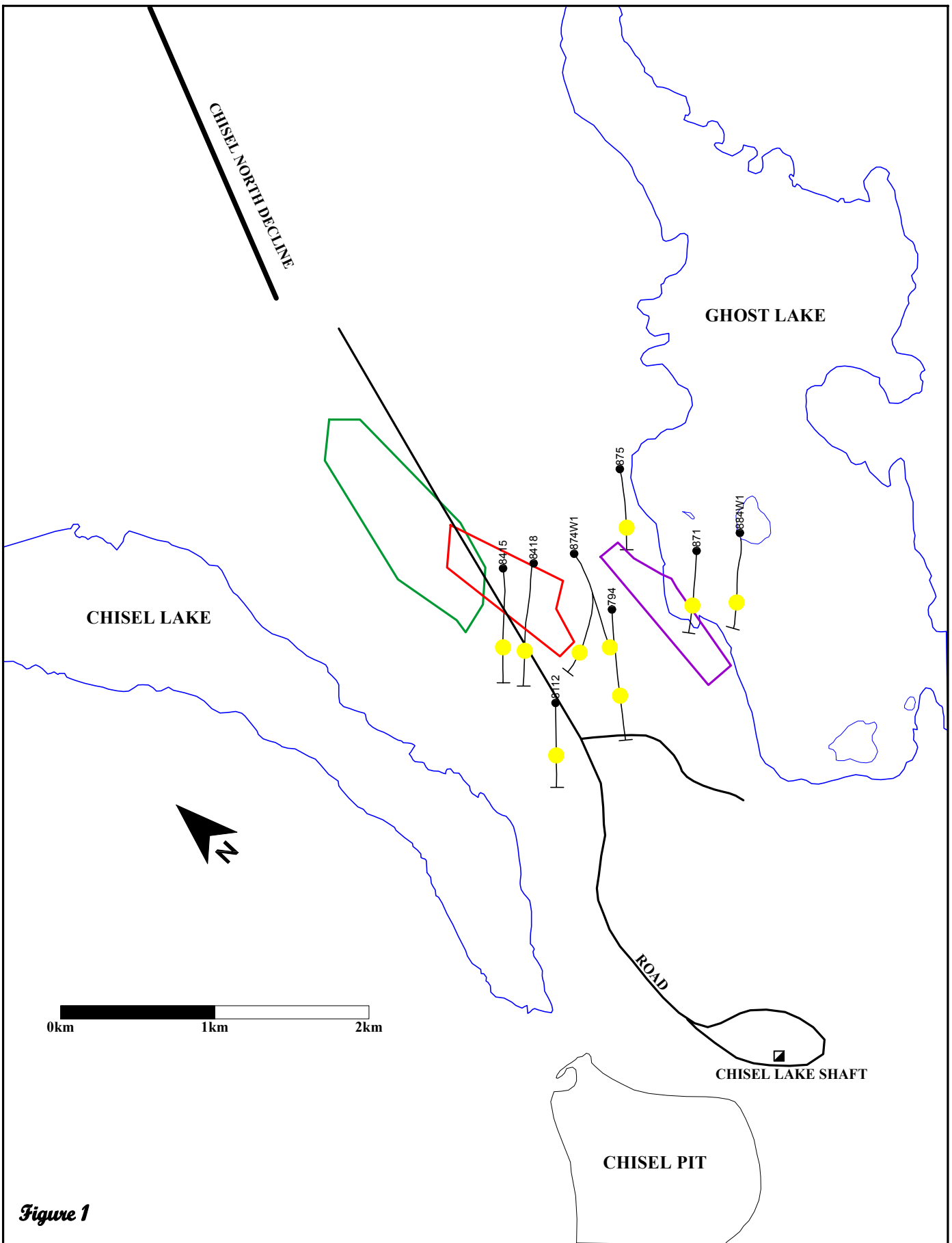


Figure 1

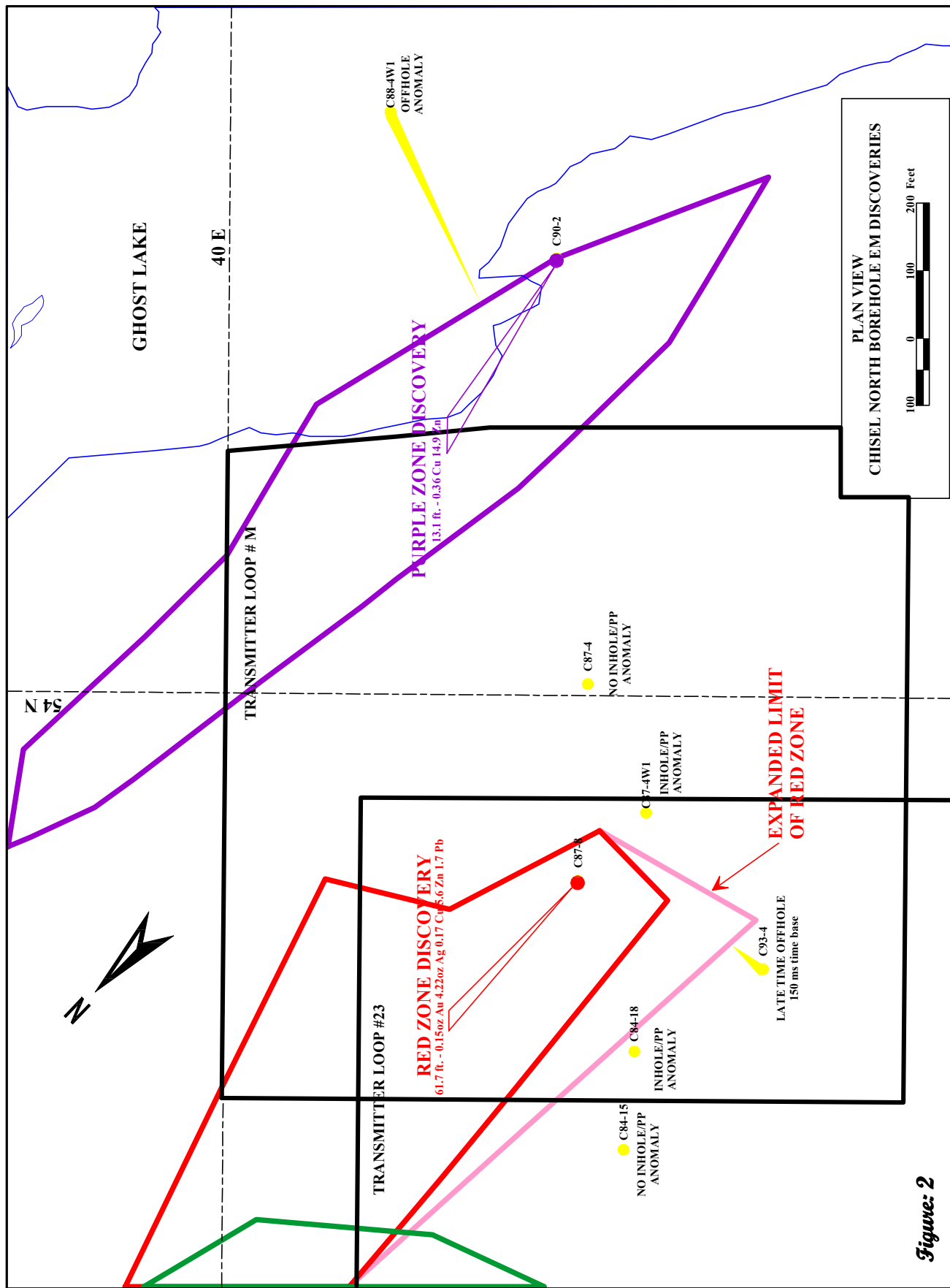


Figure: 2

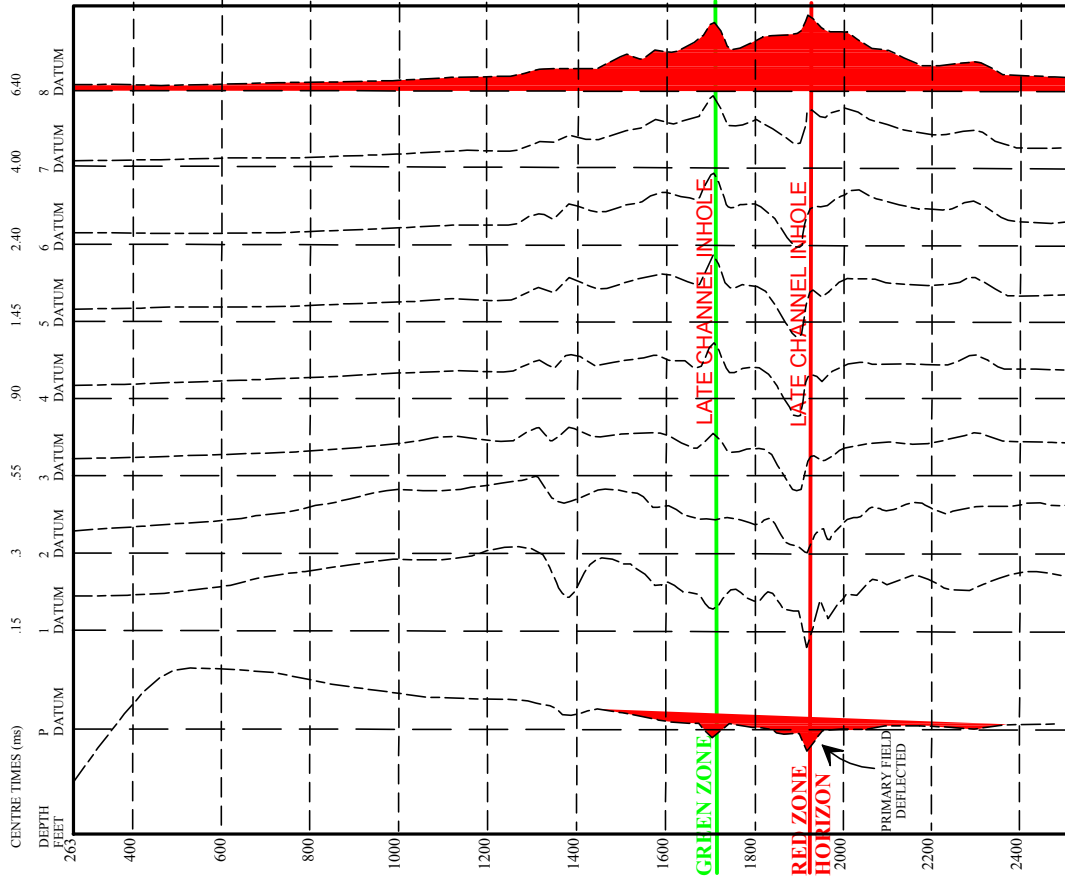


Figure 3: Hole C84-18. Borehole PEM response profiles. Channel number and respective datum is identified at the top of each profile. Hole depths are labelled in feet on the left. Inhole anomalies at 1710 feet and 1930 feet are shown red for the Primary field and for channel 8 of the secondary field.

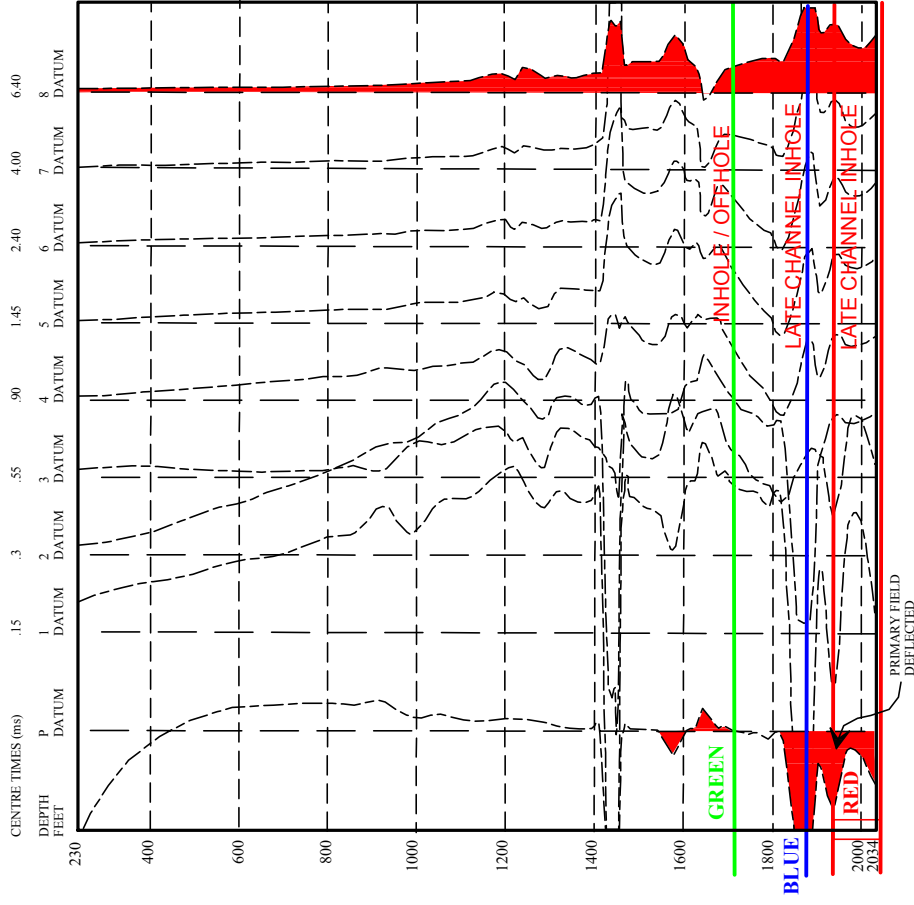


Figure 4: Hole C87-4W1. Borehole PEM response profiles. Inhole / offhole anomaly and primary field anomaly is shown at 1640 feet coincident with the Green Zone horizon. Inhole and primary field anomaly is shown at 1940 feet coincident with the Red Zone horizon.

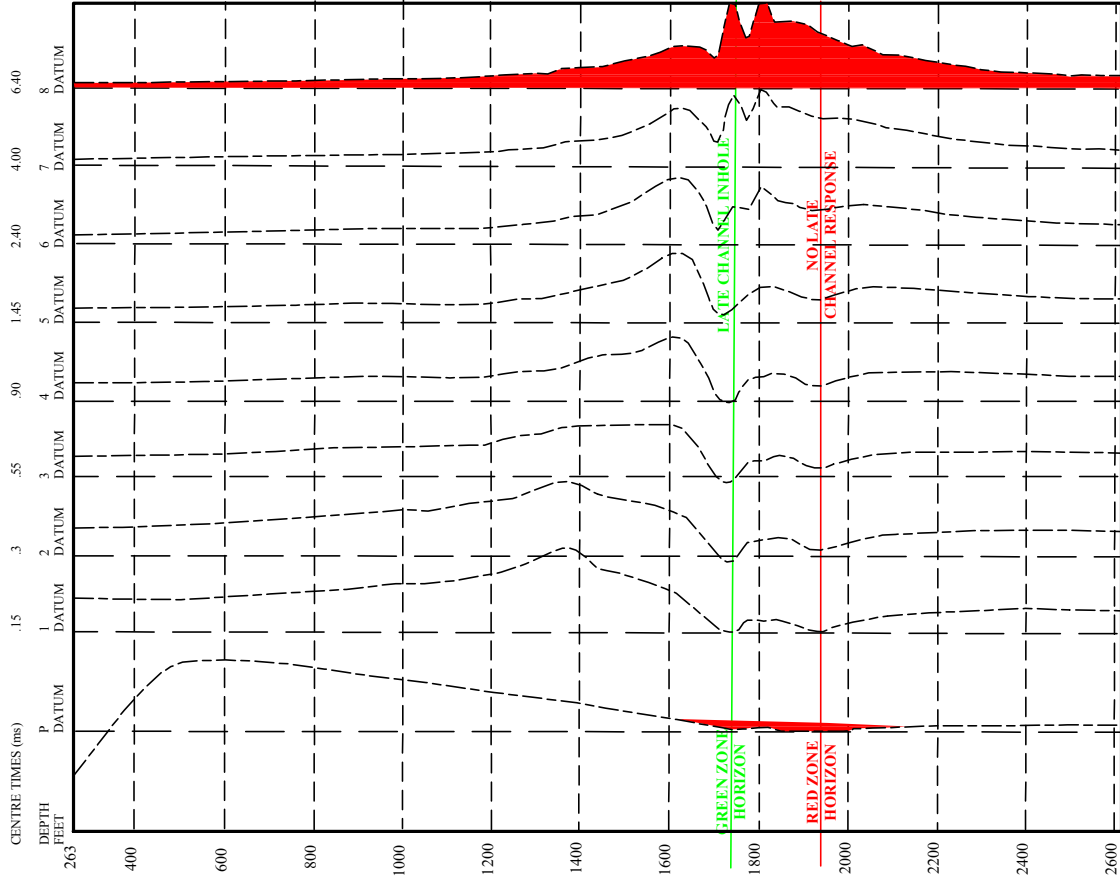


Figure 5: Hole C84-15. Borehole PEM response profiles. Inhole and Primary Field anomalies are shown at 1740, coincident with the Green. But no anomalies occur within the plane of the Red Zone.

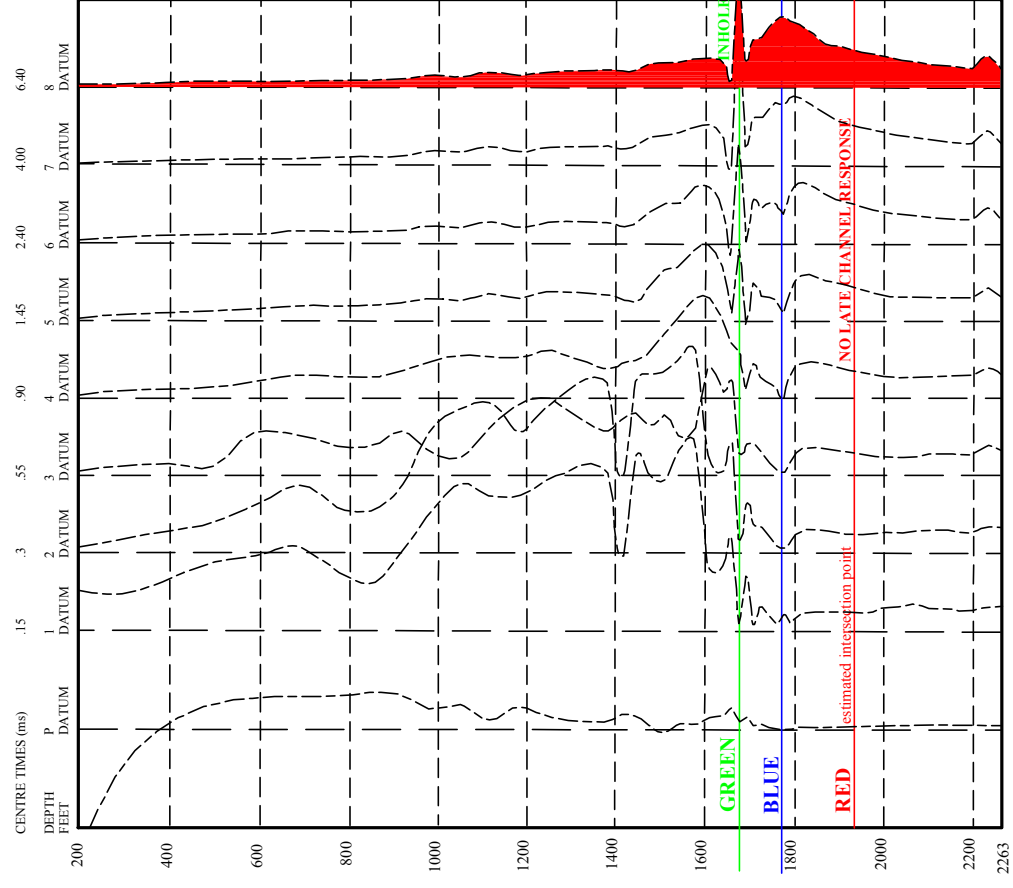


Figure 6: Hole C87-4. Borehole PEM response profiles. Inhole anomalies are shown at 1670 and 1770, respectively, with the Green and Blue Zones coincident. But no anomalies occur within the plane of the Red Zone.

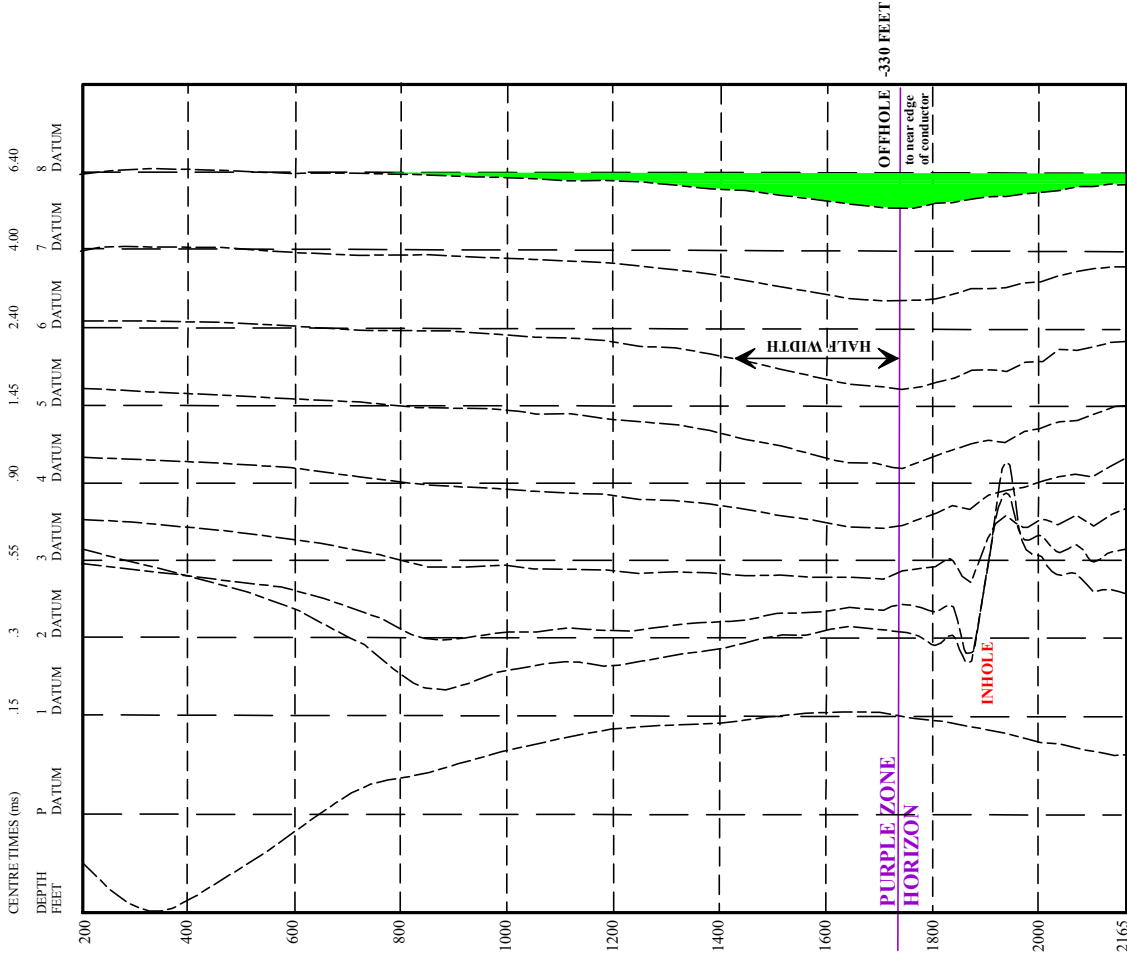


Figure 7: Hole C88-4W1. Borehole PEM response profiles. An Offhole anomaly is shown in green at 1740 feet. The distance to the conductor (Purple Zone) is calculated to be 330ft. (100 m). An Inhole spike occurs at 1880 ft., coincident with the down dip projection of the Purple Zone.

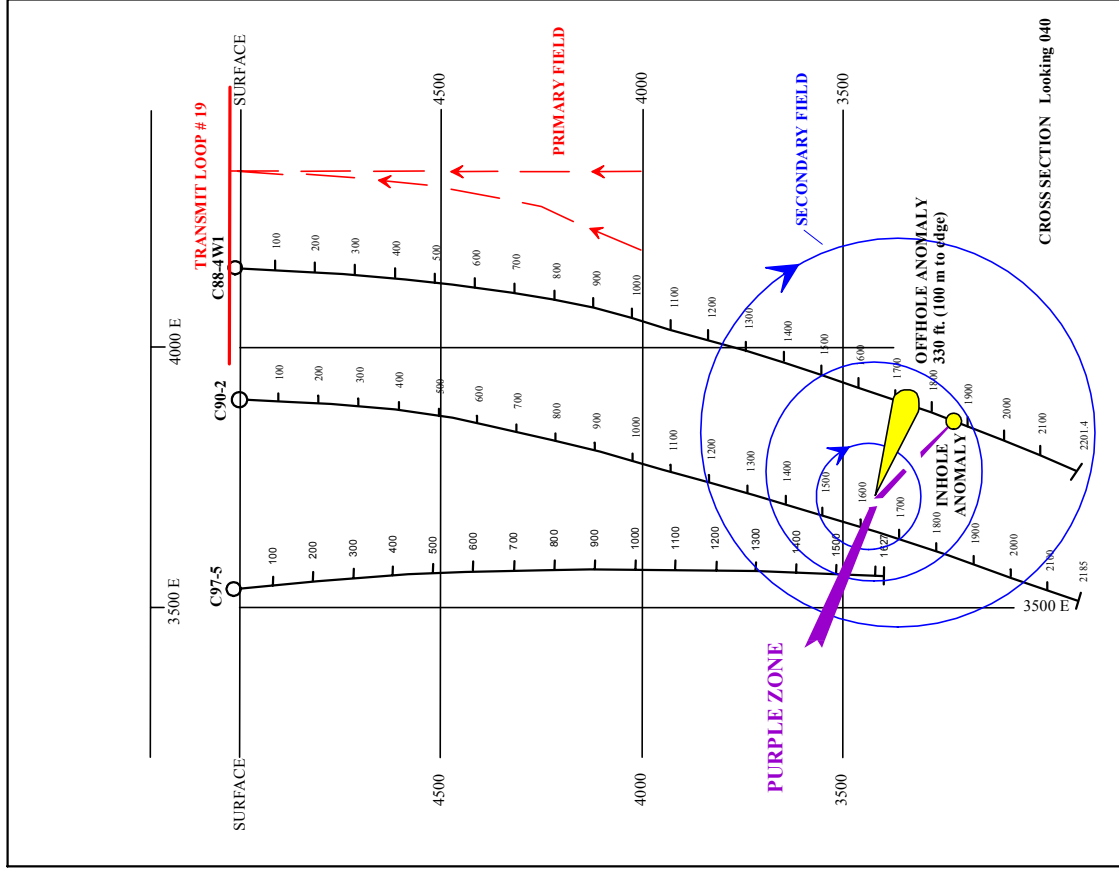


Figure 8: Section showing holes C97-5, C90-2 and C88-4W1. The location of the Purple Zone is shown 330 feet up dip of the Offhole response in C88-4W1 which is highlighted in yellow at 1740 feet. The Primary and Secondary field directions are indicated from the transmit loop and the Purple Zone.

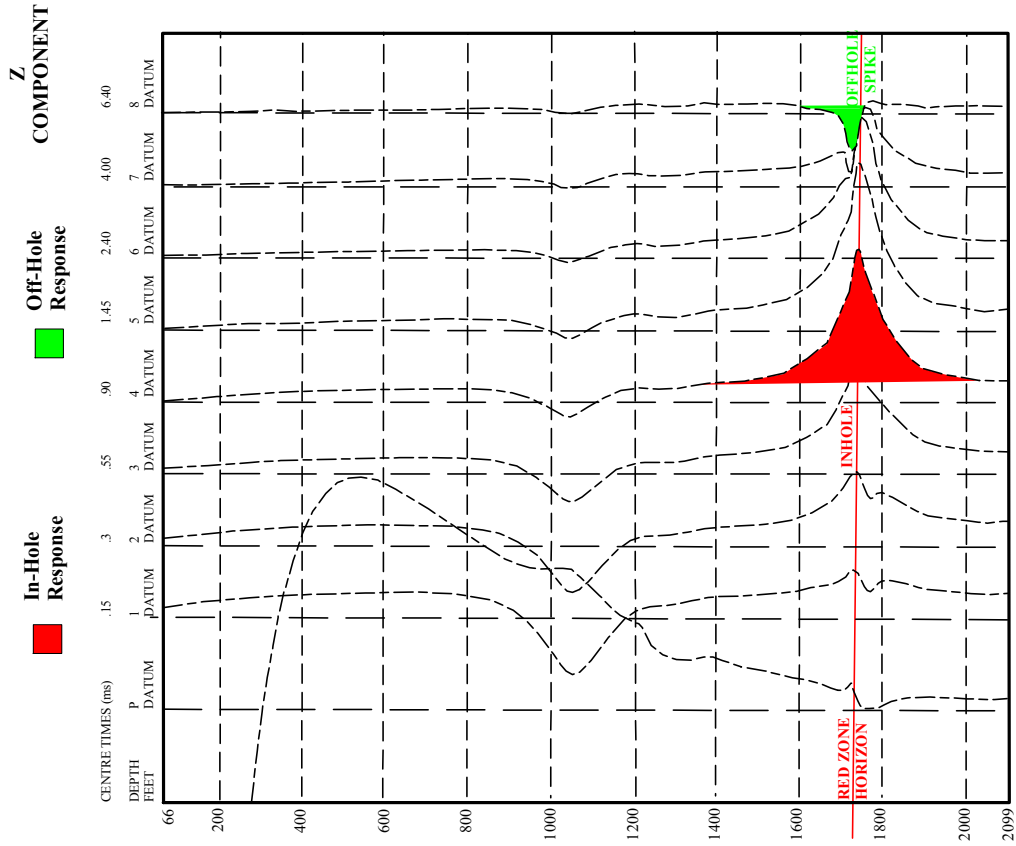


Figure 9: Hole C93-4. Borehole PEM response profiles. Z components above each channel datum represent the centre of each time window or channel during the off time of the transmitter. An Inhole anomaly is shown in red with an Offhole spike, shown in green, coincident with the Red Zone horizon at 1740 ft.

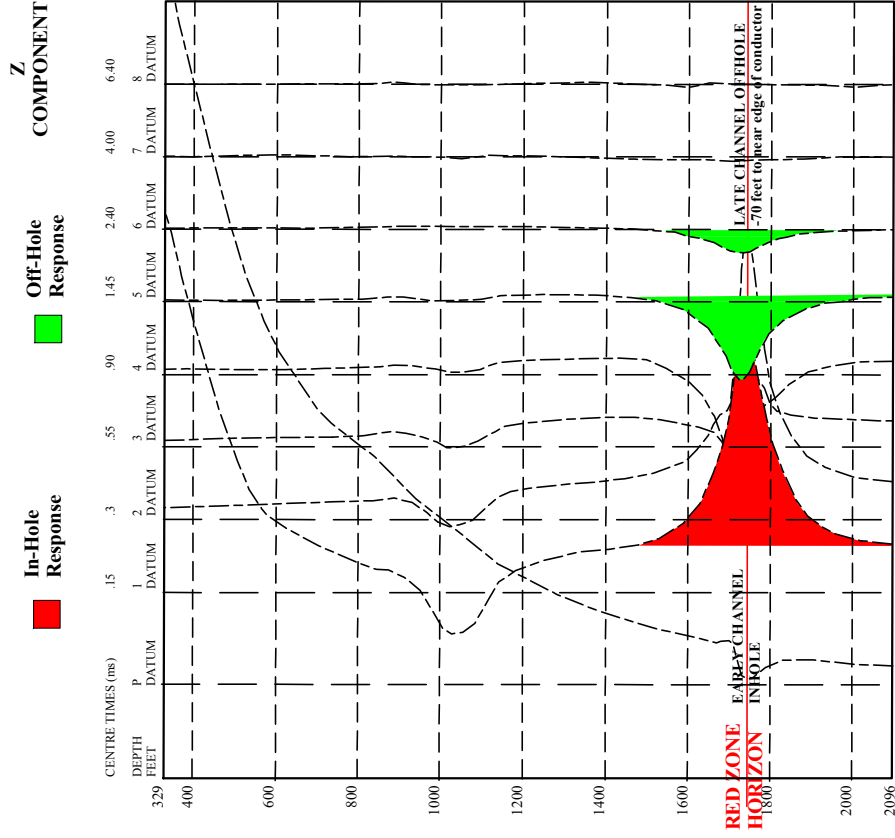


Figure 10: Hole C93-4. Borehole PEM response profiles. Z component, with 150 ms time base. An Inhole anomaly is shown in red, coincident with an Offhole anomaly, shown in green on the later time windows, coincident with the Red Zone horizon at 1740 ft.

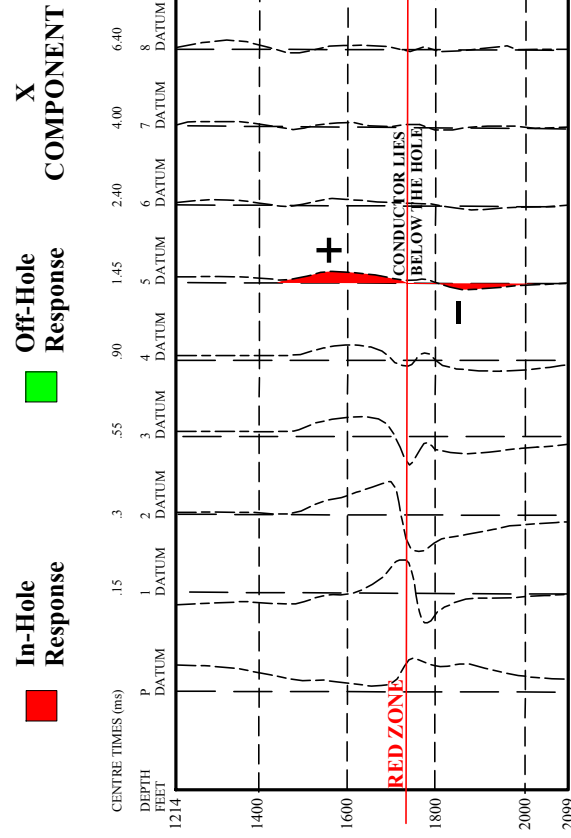


Figure 11: Hole C93-4. Borehole PEM response profiles. X component, with 150 ms time base. A positive to negative cross over indicates the conductor centre lies below the hole or in the negative X direction.

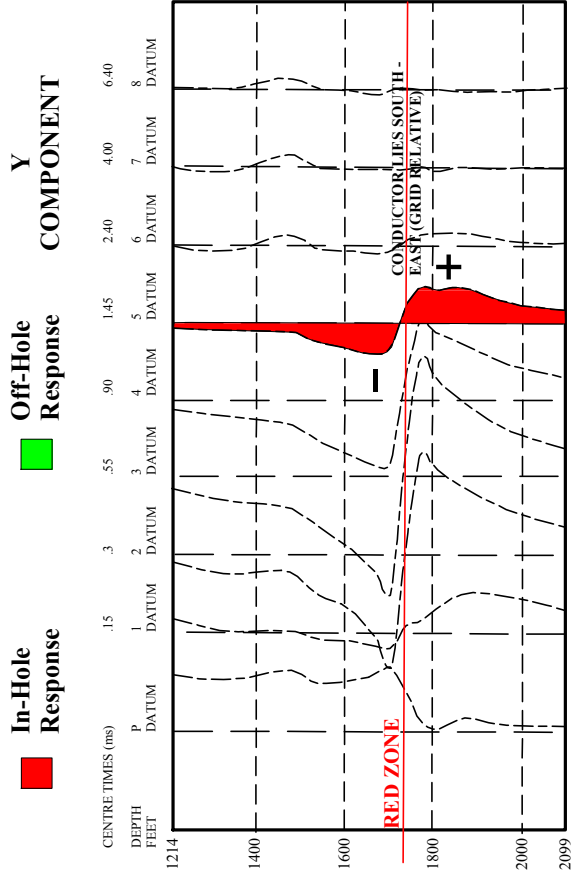


Figure 12: Hole C93-4. Borehole PEM response profiles. Y component, with 150 ms time base. A negative to positive cross over indicates the conductor centre lies to the left of the hole or in the positive Y direction.