Then and now: UTEM3 and UTEM5 comparison over the Hudbay Lalor deposit.

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Summary

UTEM test surveys were carried out over the Hudbay Lalor deposit using two generations of UTEM equipment: UTEM3 (then) and UTEM5 (now). The results of two UTEM test surveys are presented, compared and modeling results are shown. The UTEM surveys were carried out by Lamontagne Geophysics Ltd. with the support of Hudbay.

The initial UTEM3 surveying was carried out using the Hudbay test loop, Transmitter **Loop 5**, designed to test the deeper extent of the deposit. Further UTEM3 and all UTEM5 surveying was carried out using a modified version of the test loop – **Loop 5L** – designed to better couple with the overall Lalor deposit.

Pertinent details of the two UTEM surveys are as follows (map Figure 1):

- UTEM3: January 2011 – earlier in construction phase on Lalor site: no power line installed
  single-component surface coil, Hz (vertical) and Hx (inline horizontal) components collected
  data collected on survey lines: 176N, 182N, 196N and Line 63E, transmitter Loop 5 and Loop 5L
  10Channel UTEM data collected at 30/4/2Hz
  modeling results (MultiLoop 2) are shown

- UTEM5: April 2014 – late-stage of Lalor site construction, power line in place.
  3-component surface coil:HZ (vertical) HL/HT (inline/transverse horizontal) components collected
  data collected on survey lines: 176N, 182N and Line 63E using transmitter Loop 5L
  12Channel UTEM data collected at ~1.0/0.25Hz
  modeling results (MultiLoop X) are shown

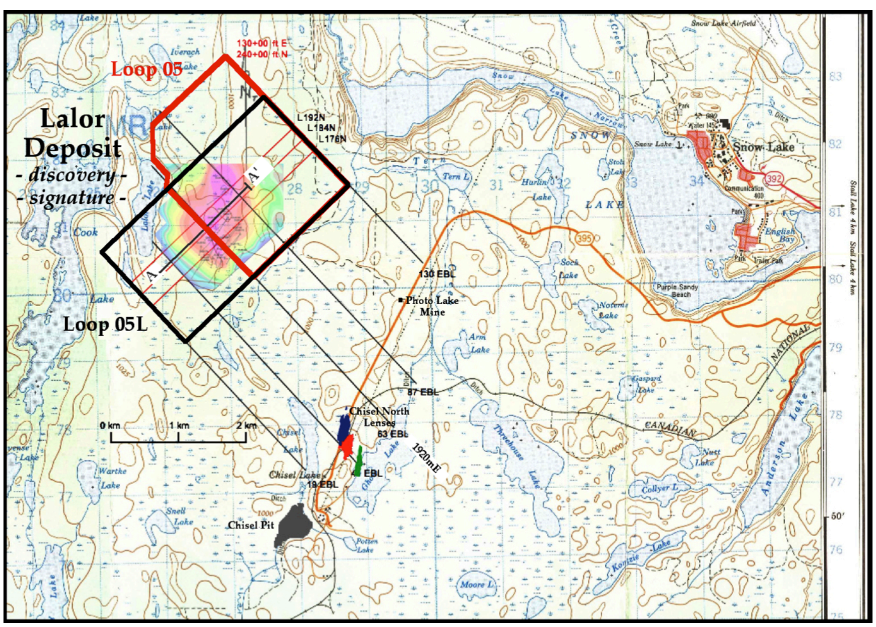

Figure 1: Location map

The UTEM SYSTEM - Now

UTEM uses a large, fixed transmitter loop as its source. Transmitter loops range in size from 300x300m to dimensions as large as 4km by 4km. Loops less than 800x800m are rarely used. In general smaller loops are used for surveys over very conductive ground and for some depth-sounding applications. The larger loops are typically used over resistive terrain

The UTEM instruments are synchronized together at the beginning of a survey day. The instruments have precision clocks and can operate remotely for a full survey day – even underground – without any timing reference. In surface surveys measurements are routinely taken to a distance 1.5 to 2 times the loop size. Survey distance can be extended beyond this - depending on the ambient noise level and stacking time allowed. Lines can be surveyed inside the loop, outside the loop or through the loop depending on the orientation of the intended targets. BHUTEM surveys – the borehole version of UTEM surveys – have been carried out to depths of 3000m.

System Waveform

The UTEM transmitter passes a low frequency current waveform of precisely regulated shape through the large loop antenna. The frequency is set to minimize the interaction of power line effects. Using automated frequency interleaving, the receiver can do simultaneous multi-transmitter 3-axis measurements with up to three transmitters.

The transmitted current has a pre-emphasized triangular waveform which is optimized for signal-to-noise and power efficiency. The base frequency of the waveform can be set to any value with great accuracy. The usual range is 0.25Hz to 32Hz. The UTEM sensors are very linear nulling coils that generate feedback signals proportional to the B field. The signal from the sensor consists of digital data sampled at 100kHz rate for each of three components. The signals are deconvolved in the receiver into square wave responses using a filter which exactly inverts the effect of the transmitter pre-emphasis filter. All channels after stacking should have amplitudes equal to the primary field in the direction of the particular sensor axis - in the absence of any conductor. The sampled channel data on every successive half-cycle should be equal in magnitude and of alternating polarity. The channel sampling methods of UTEM3 and UTEM5 are similar, but the UTEM 5 sampling method includes a number of enhancements.

UTEM3 10Ch Sampling

The UTEM3 receiver measures the time variation of the magnetic field in the direction of the receiver coil at 10 delay times (channels). UTEM channels are spaced in a binary, geometric progression across each half-cycle of the received waveform. Channel 10 is the earliest channel and it is $1/2^{10}$ of the half-cycle wide. Channel 1, the latest channel, is $1/2^{1}$ of the half-cycle wide Figure 2). The measurements obtained for each of 10 channels are accumulated over many half-cycles. Each final channel value, as stored, is the average of the measurements for that time channel. The number of half-cycles averaged generally ranges between 512 (256 full-cycles) to 32768 (16K) depending on the level of ambient noise and the signal strength.

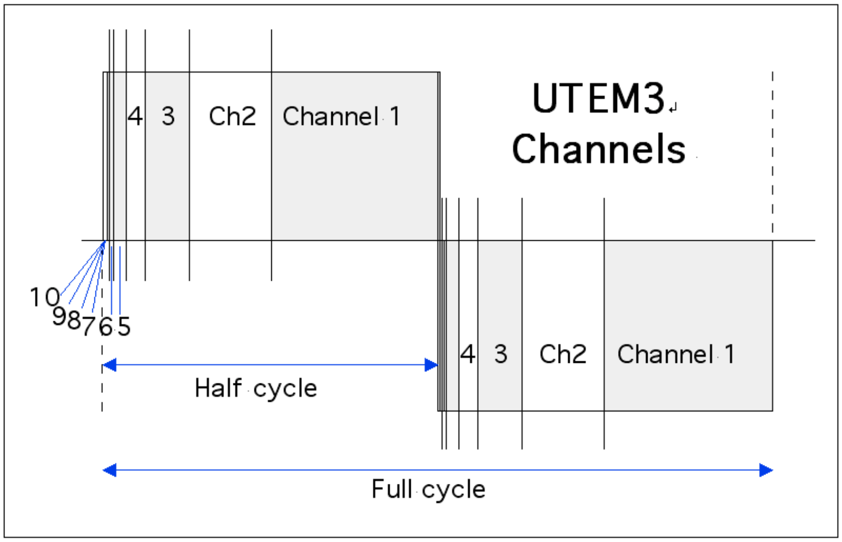

Figure 2: UTEM3 10Ch boxcar sampling

UTEM5 12Ch Sampling

The UTEM5 system collects 3-component EM data from up to 3 transmitter loops - three coupling angles - simultaneously - translating to improved target definition and greater sensitivity to all targets. UTEM5 surface equipment has a greater advantage at low frequency – below 4Hz. And the UTEM5 technical advantage is greatest in the search for targets that are deeper and more highly-conductive using large transmitter loops – the geometry of the applied field is simpler. UTEM5, however, was designed to be useful in numerous other applications.

UTEM5 12Ch sampling is detailed in Figure 3. Both boxcar (equivalent to UTEM3) and tapered sampling are shown. The use of UTEM4/5 Transmitters and UTEM5 Receivers allows for the implementation of:

• Ch0 - a narrow Ch later than Ch1 and making Ch0 normalization - normalization at a later point in time - possible.

• 3 timing channels - Ch13/14/15 for 12Ch UTEM5 - these improve the operator's ability to monitor Rx/Tx(s) synchronization and allows more precise phase correction/improved post-measurement deconvolution.

The ability to simultaneously collect higher-precision, 3-component data from multiple transmitters (multiple coupling angles) at low frequency is really what the UTEM5 system is designed for - to be efficient and precise. To date UTEM5 surveys using multiple transmitters operating at base frequencies as low as 0.25Hz have confirmed that both the sensitivity of the system and the rejection of non-survey frequencies (power line noise etc.) is far superior to previous UTEM systems.

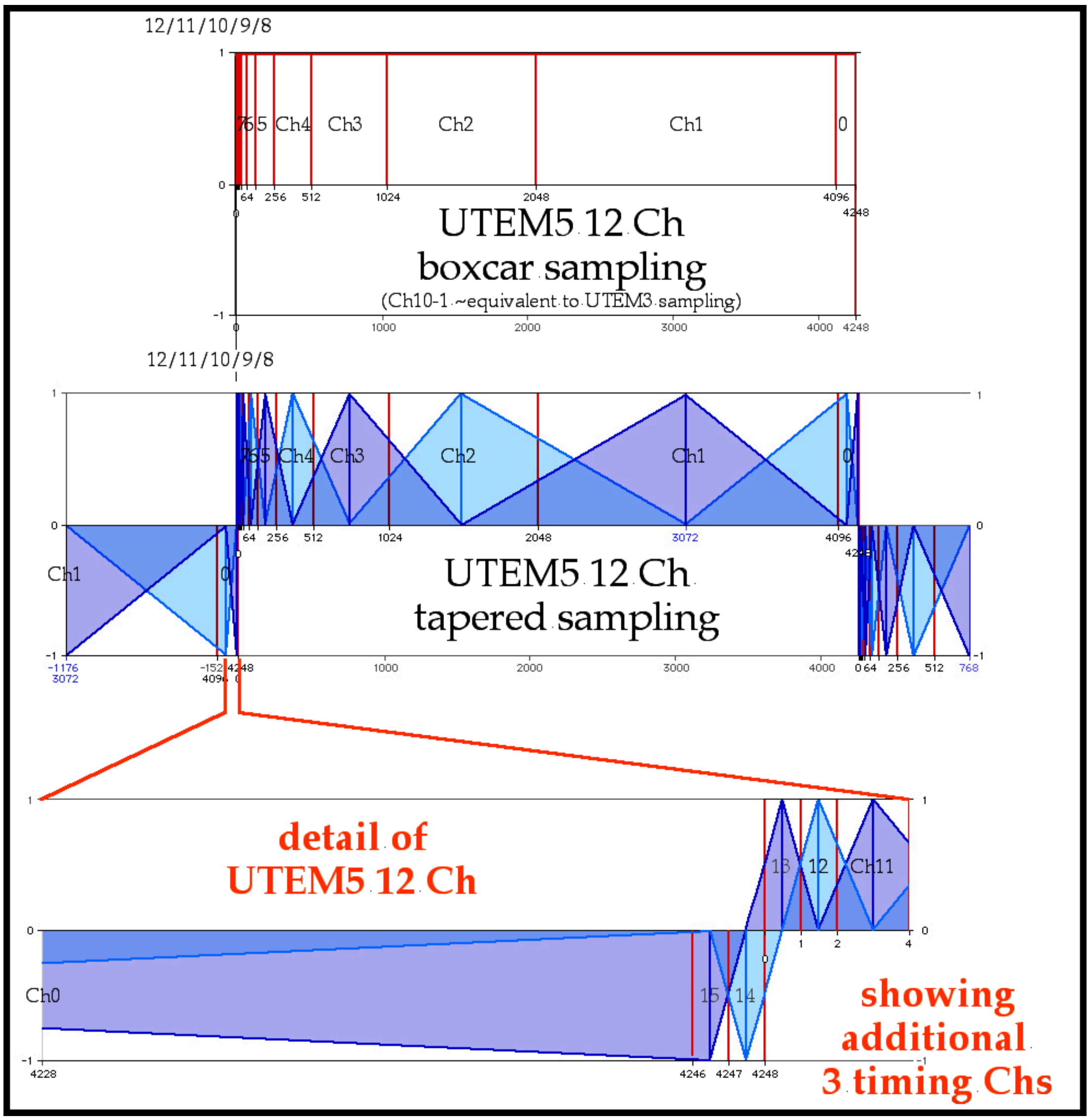

Figure 3: UTEM5 12Ch sampling

Lalor Deposit UTEM3 Profiles (Figure 4)

UTEM 3 survey data collected (February 2011) over the Lalor Deposit of HudBay Minerals Inc. The deposit is located in the Chisel Basin portion of the Flin Flon Greenstone Belt and is believed to be the largest VMS deposit found in this region to date. Mineralization occurs (2011) in six separate stacked lenses of zinc rich-polymetallic near-solid to solid sulphide mineralization ~570-1,170m below surface. Exploration continues to focus down-plunge. The discovery of Lalor by the HudBay team won the 2008 Bill Dennis Award for a Canadian discovery by the Prospectors and Developers Association of Canada (PDAC).

Profiles are shown for Loop 05 and Loop 05L reduced with UTM easting/northings but not topography.
The deposit is clearly detectable with UTEM 3.

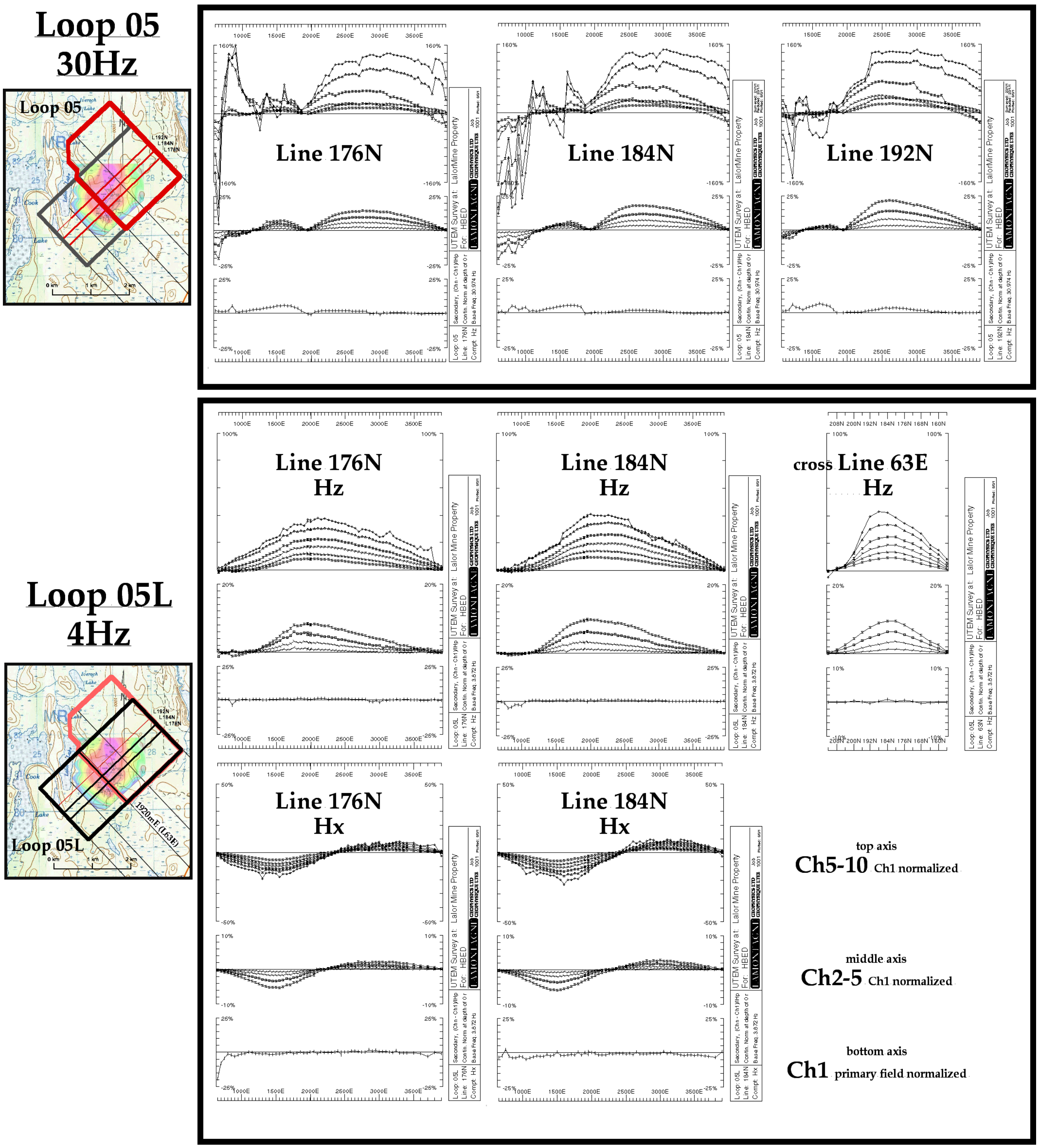

Figure 4: Lalor Deposit UTEM3 Profiles

UTEM3 MultiLoop 2 Modeling Results - Lalor Deposit

MultiLoop 2 modeling results for the 4Hz UTEM Loop 05L profiles - Lines 176N, 184N and cross-Line 63E - are shown below. The aim of the modeling is to show that the results are consistent with the known deposit.
Notes on the model:

- a single 300S plate modeling the Upper Chisel/Lower Chisel contact surface
- a broader, 50m deeper, 50S plate modeling the response of the footwall alteration/mineralization package
- Zinc-rich Base Metal Zones -10,11,20,30,31,40 - roughed in as 300S plates (from the 43-101 information) erring a bit on the large size - cut off is ~grade, not conductivity.

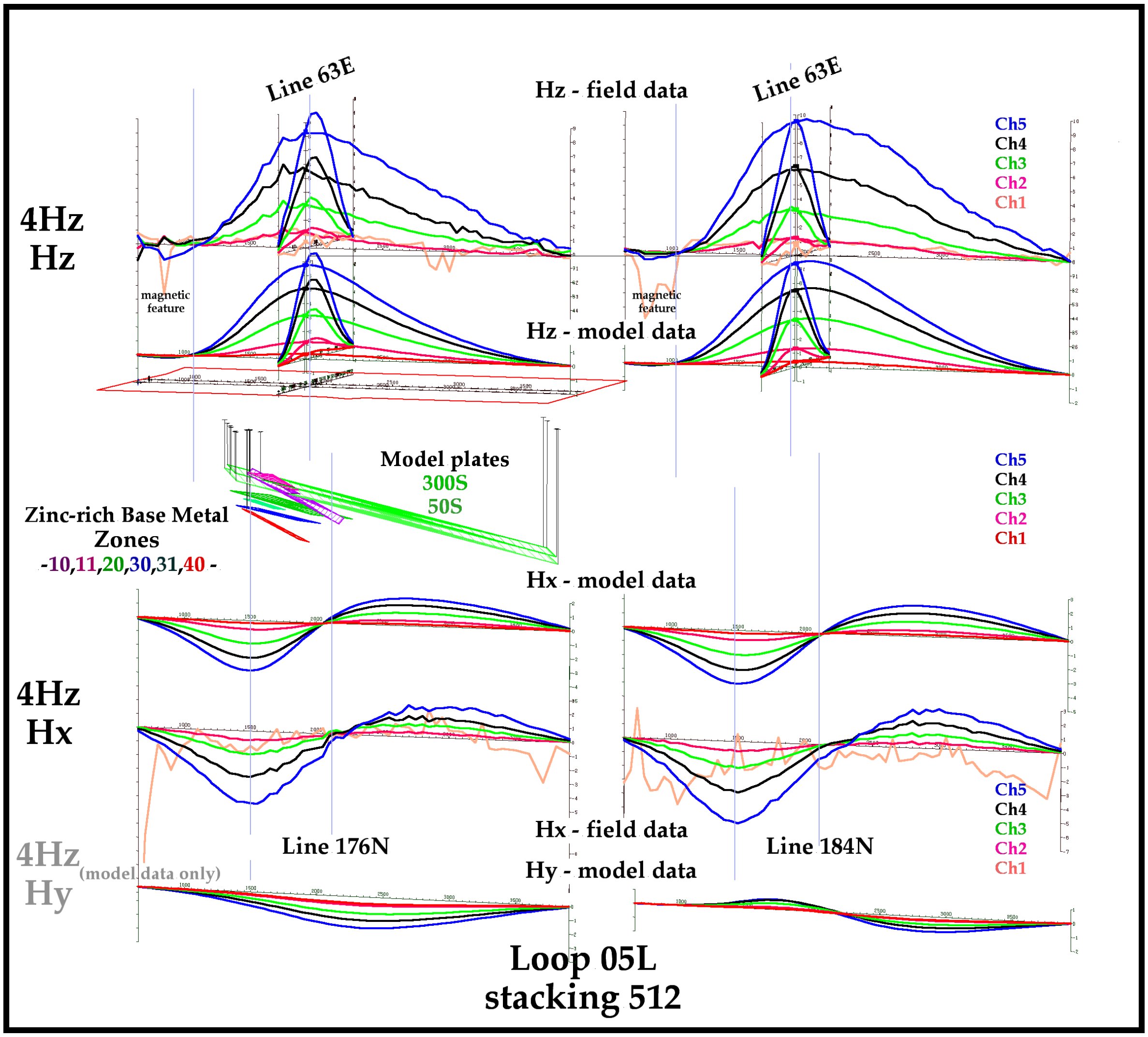

Figure 5: UTEM3 MultiLoop 2 Modeling Results - Lalor Deposit

Lalor Deposit UTEM5 Profiles (Figure 6)

UTEM 5 survey data collected (April 2014) over the Lalor Deposit of HudBay Minerals Inc. Profiles are shown for Loop 05L reduced with UTM easting/northings and DEM topography.

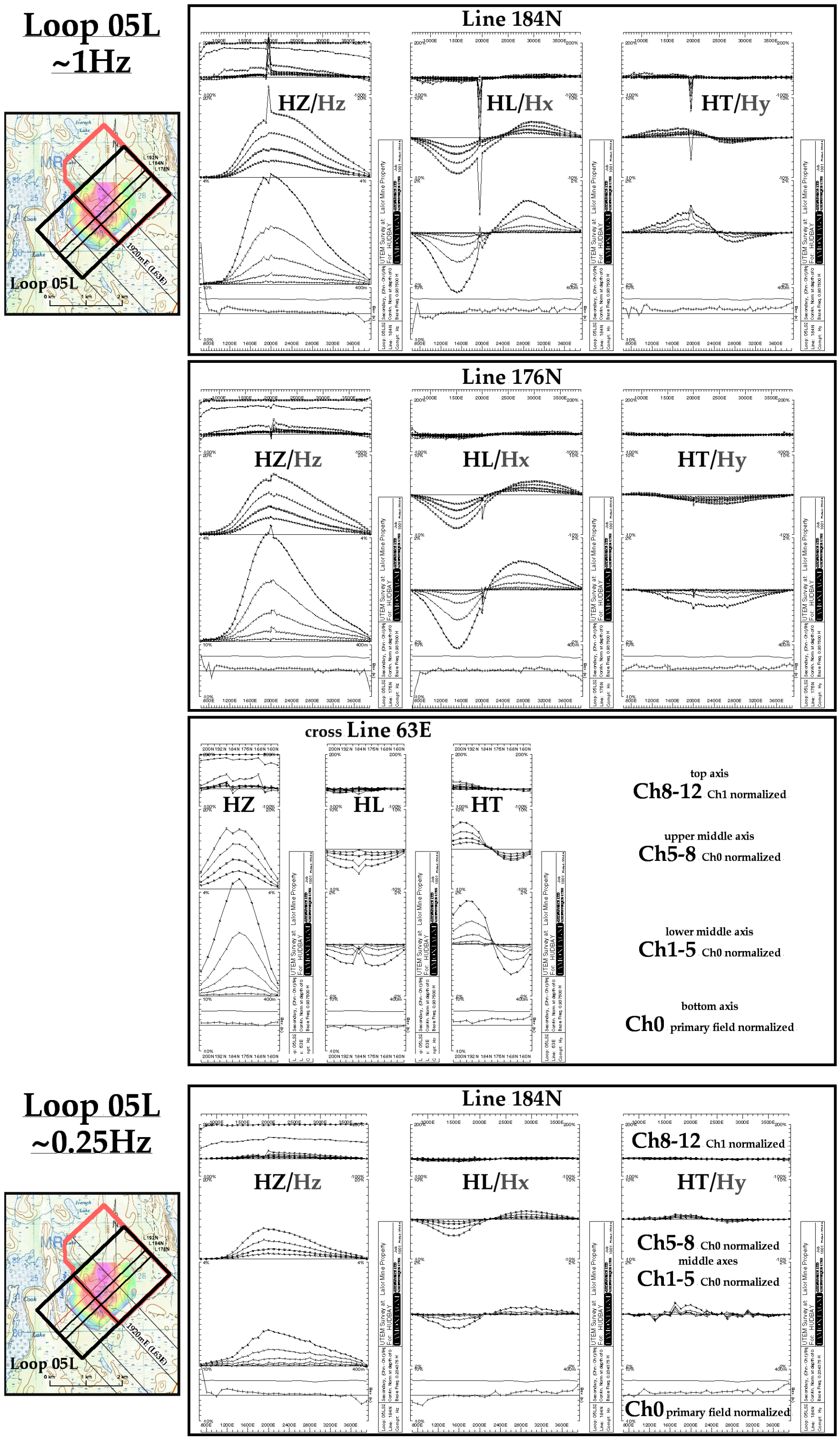

Figure 6: Lalor Deposit UTEM5 Profiles

MultiLoop X Modeling Results - Lalor Deposit

Initial MultiLoop X modeling results for the 0.25Hz UTEM Loop 05L profiles - Lines 176N, 184N and cross-Line 63E - are shown below. The aim of the modeling is to show that the results are consistent with the known deposit. The deposit is clearly detectable.

MultiLoop X - EM Modeling in Your Browser - is a cross-platform version of MultiLoop 3. The user interface runs in a browser as a client HTML5 application - taking advantage of powerful JavaScript libraries - whereas the computations are done in an application that can be either local or on a server. MlpX presents the user with a 3D-modeling scene in which it is easy to compose and modify models by using WebGL based tools. Modeled responses are presented as plots embedded in 3D. An svg plotting layer makes it possible to present and compare the results in the same format as regular 2D plots that can be saved in pdf or kept in svg format for large or detailed presentations.

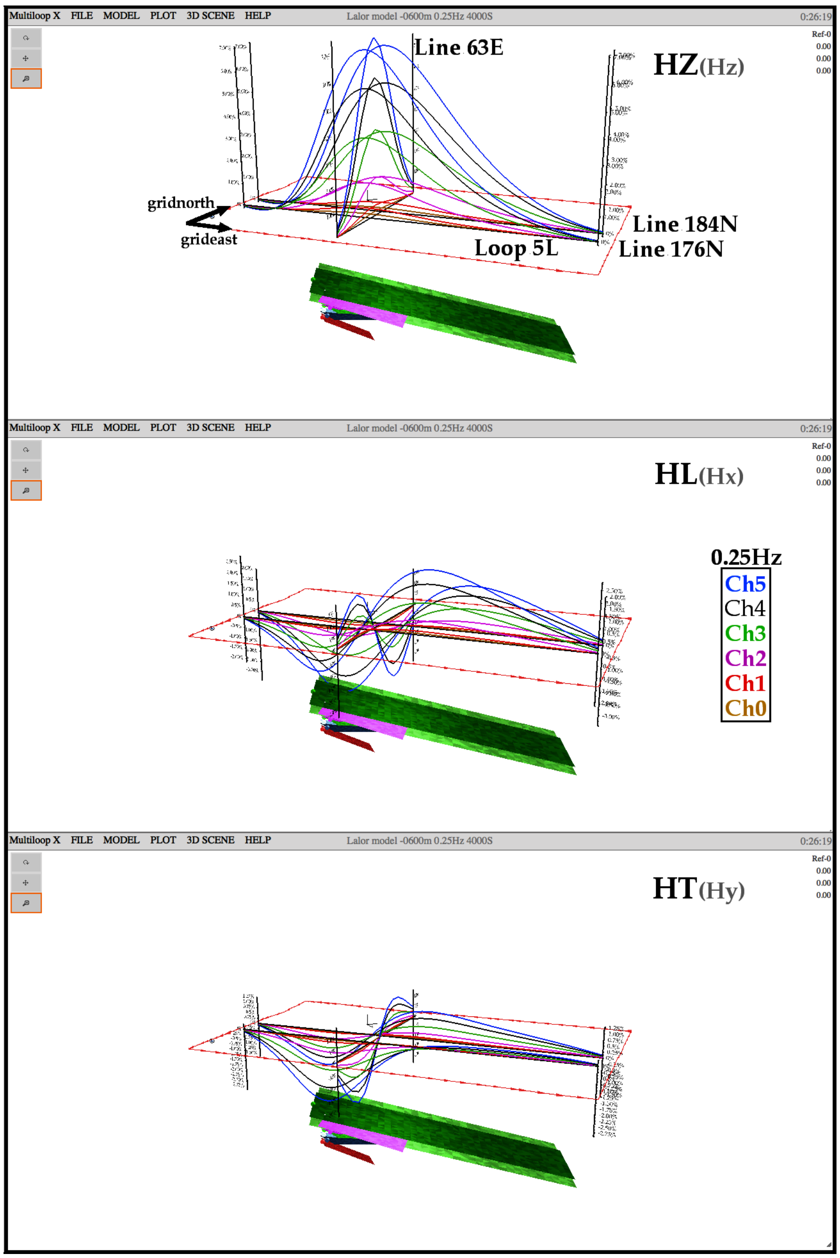

Figure 7: UTEM5 MultiLoop X Modeling Results - Lalor Deposit