2011 TEM at Warrior

June – September, 2011

Report to Citigold Corporation

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This report is divided into three sections:

SECTION I:
SUMMARY OF STRUCTURES

A Compilation of Interpreted Structures

These results are derived via geophysical modeling from all 2010-2011 ground TEM data as well as airborne and ground magnetic data.

This report is intended as a summary of all the work performed by Petros Eikon and the geophysical surveys performed under our supervision.

In this report, we do now show the details of the comparison of the simulated data to the actual data as shown in previous reports.

Summary of Structures

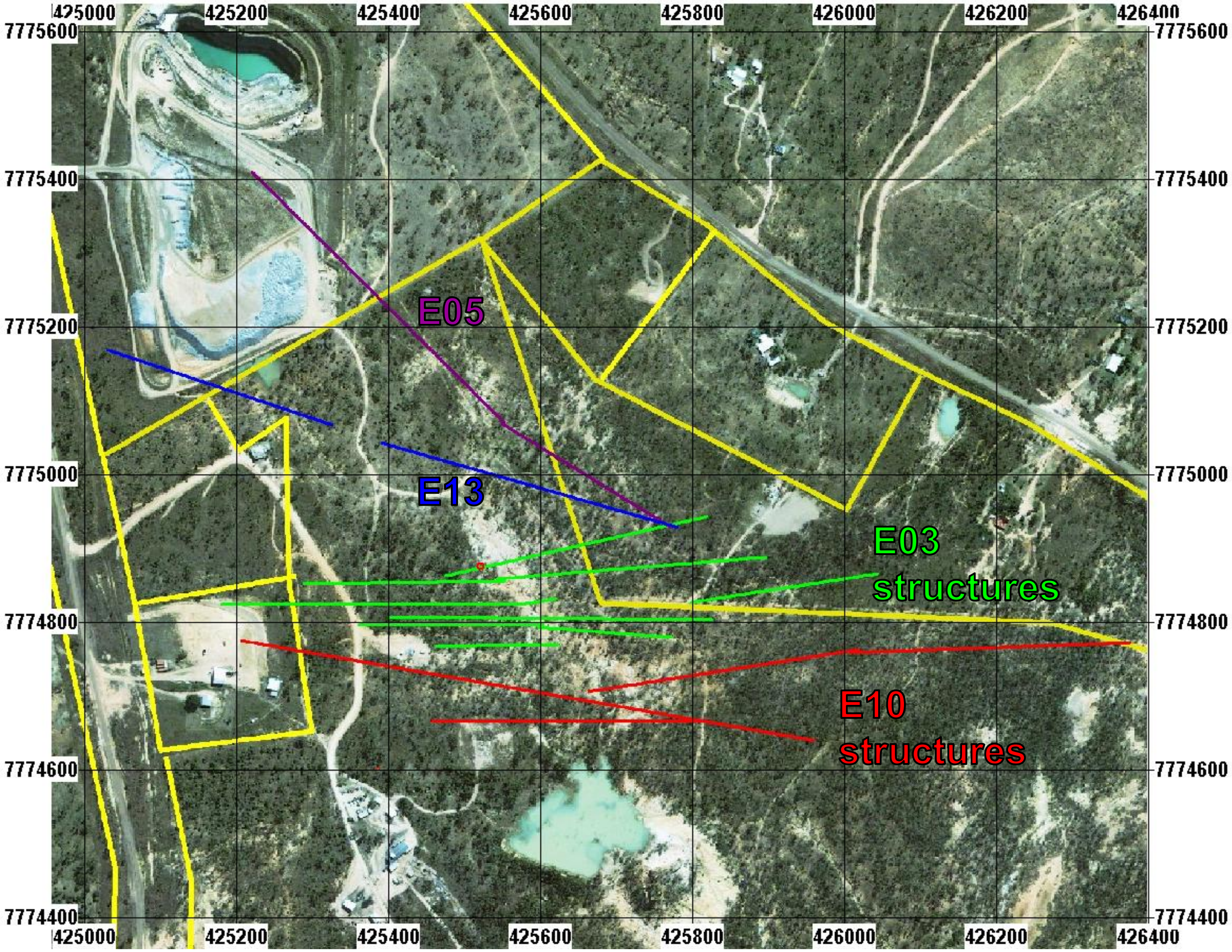


Fig. 1: *This is a summary of the structures we believe are near and south of the Warrior mine.*

Further details on this structures are provided on the following pages together with those datasets that have been used to identify each structure. Before the discussion of the individual structures, maps of the 2010 and 2011 TEM surveys are presented for reference.

Notes:

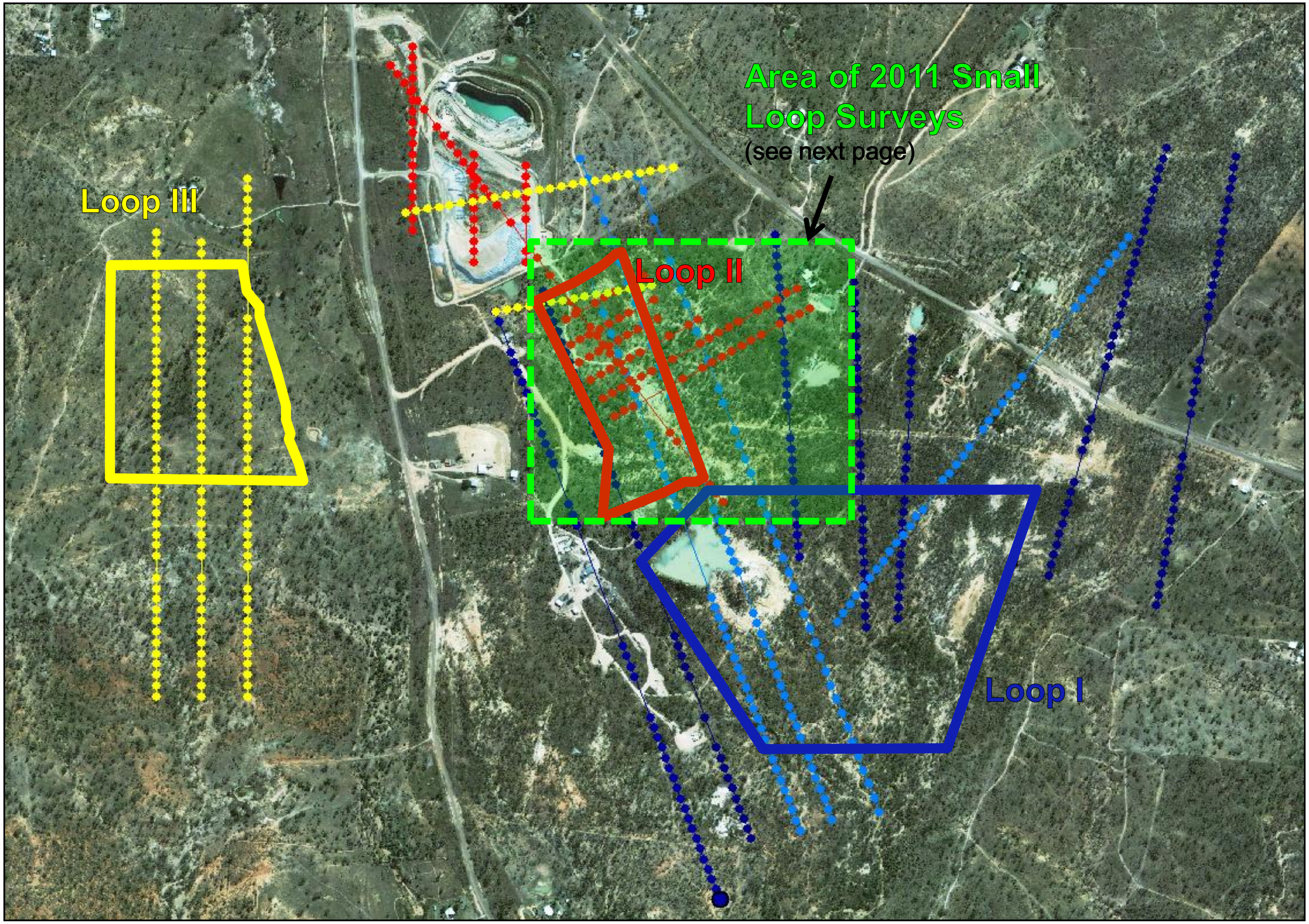
→ This map does not include structures east of 42600E, which are outside the area of the July/August 2011 small loops survey. These eastern structures are discussed on page 10.

→ While borehole TEM was collected as well in 2008, 2009, and 2010 and 2011, the data have not assisted us in understanding the subsurface. As such, these models are the result of study of the ground data only. For further details on issues with the borehole data, see Section III.

Registered map: nov2011_structures_model.jpg

Location of 2010 TEM Ground Surveys

All 2010 Surveys were performed by Outer Rim Exploration Services of Australia using CRONE Geophysics (Canada) equipment.



2011 TEM Survey Lines

- Loop I lines (Nov/Dec)
- Loop II lines (Nov/Dec)
- Loop III lines (Nov/Dec)
- Loop I lines (Oct)

Note: While preliminary modeling has been performed on the Loop III lines west of Bluff Road, these structures are not discussed in this report. No interest has been shown by the CitiGold exploration staff with regard to these structures. Thus, we have not yet finalized our results regarding the geophysical structures west of Bluff.

Fig. 2: Locations of Loop I, Loop II, and Loop III surveys from 2010.

Location of 2011 Small Loop Surveys

The purpose of these surveys to provide higher structural resolution. The surveys were designed based on the initial structural determinations made from the 2010 data and the ground and airborne magnetics data. By utilizing a smaller loop, the source field is focused on a smaller volume of the earth thus reflecting data back to the surface receivers capable of higher resolution interpretation.

Fig. 3: Location of 2011 small loop surveys. Two to four lines were surveyed with each of the eight loops. For further details on the July/Aug survey plan, see Section II. Loops are outlined in bold blue and numbered in red while the receiver stations are black dots.

E03 Structure

1) E03 – Consists of Several structures

A response to “E03” was observed in the October 2010 Loop I data, and the model was refined using the November/December 2010 Loop I data. In general, E03 is observed in the aeromagnetic and ground magnetic data but this data appears to indicate something more complicated than a single structure. However, multiple structures were not clearly identified until the series of small-loop surveys carried out over July/Aug 2011. These surveys were designed to provide more focused excitation of the structures, and spatial sampling of receiver data was considerably higher than in previous surveys. Evidently, the shear structures are much more complex than initially anticipated.

Below, the 2011 loops that were used to identify each sub-structure are listed.

E03 N – Loop 5, E03 C – several loops, E03 – Loops 1, 3, 4, E03 S – several loops

E03 SE – Loop 6, E03 X – Loop 4-6, E03 B – Loop 4

All the E03 sub-structures have similar dip angles!

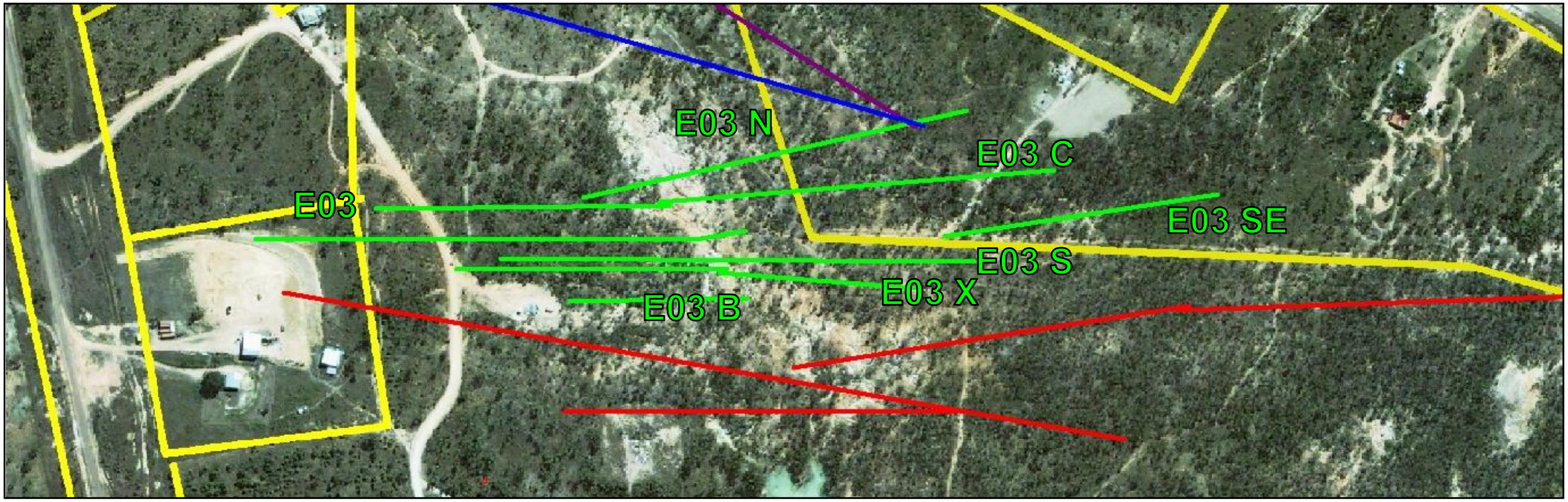


Fig. 4: Close-up of Fig. 1 with E03 sub-structures labelled and coloured green.

E10 Structure

2) E10 Structures

The existence of a structure south of Warrior was first noted in the October 2010 data. At this time, we named the structure E10 as it clearly had a steeper dip than Warrior (E03) at about 65^0 . This structure is south of Warrior and also dips to the north.

Through later surveys, we identified multiple structures south of Warrior and modified our models of these structures. The E10 structures also correlate with an anomalies in the vertical derivative of the airborne and ground magnetic data as with the E03 structures.

a) E10 W – Initially identified in the October 2010 Loop I data, but the strike length and angle could not be determined as there was insufficient data coverage. The model was refined using the November/December 2010 Loop I data, and modified slightly using the July/August 2011 data (several loops).

b) E10 SW – from July/August 2011 data, Loops 5 and 6.

c) E10 C – Identified in the November/December 2010 Loop I data. The position of the western half was modified using the July/August 2011 data (several loops).

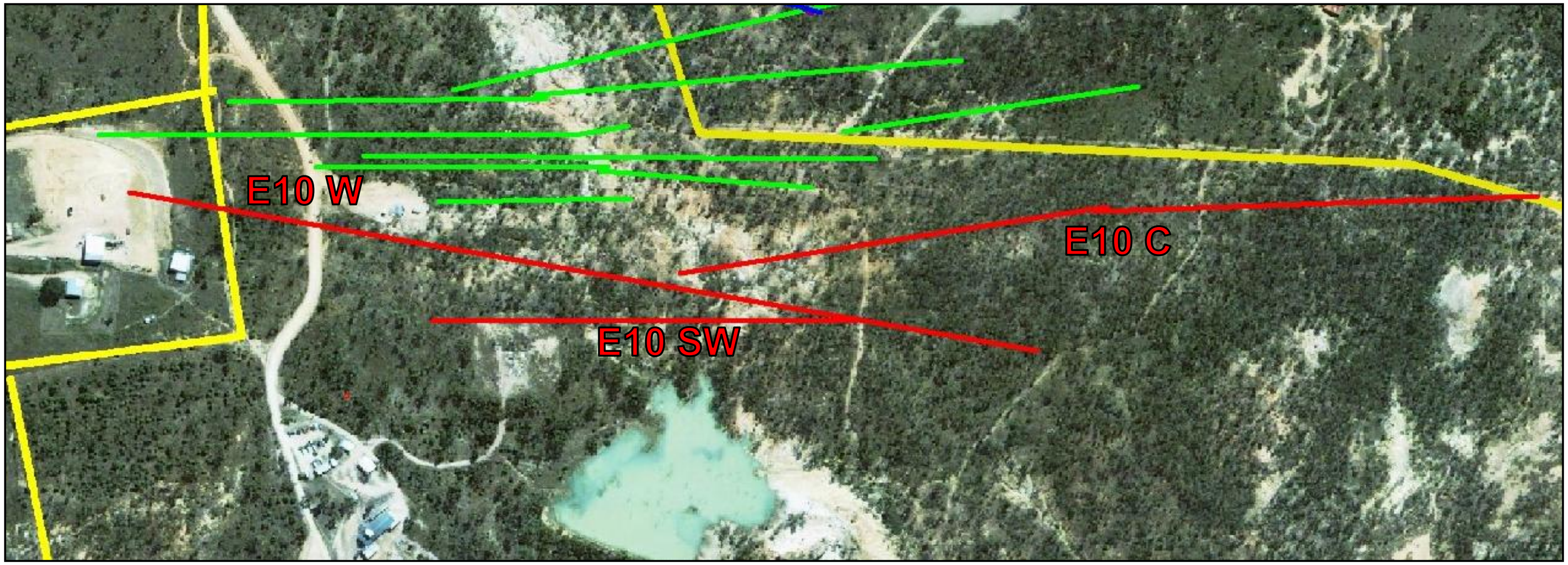


Fig. 5: Close-up of Fig. 1 with E10 structures labelled in red.

E05 and E13

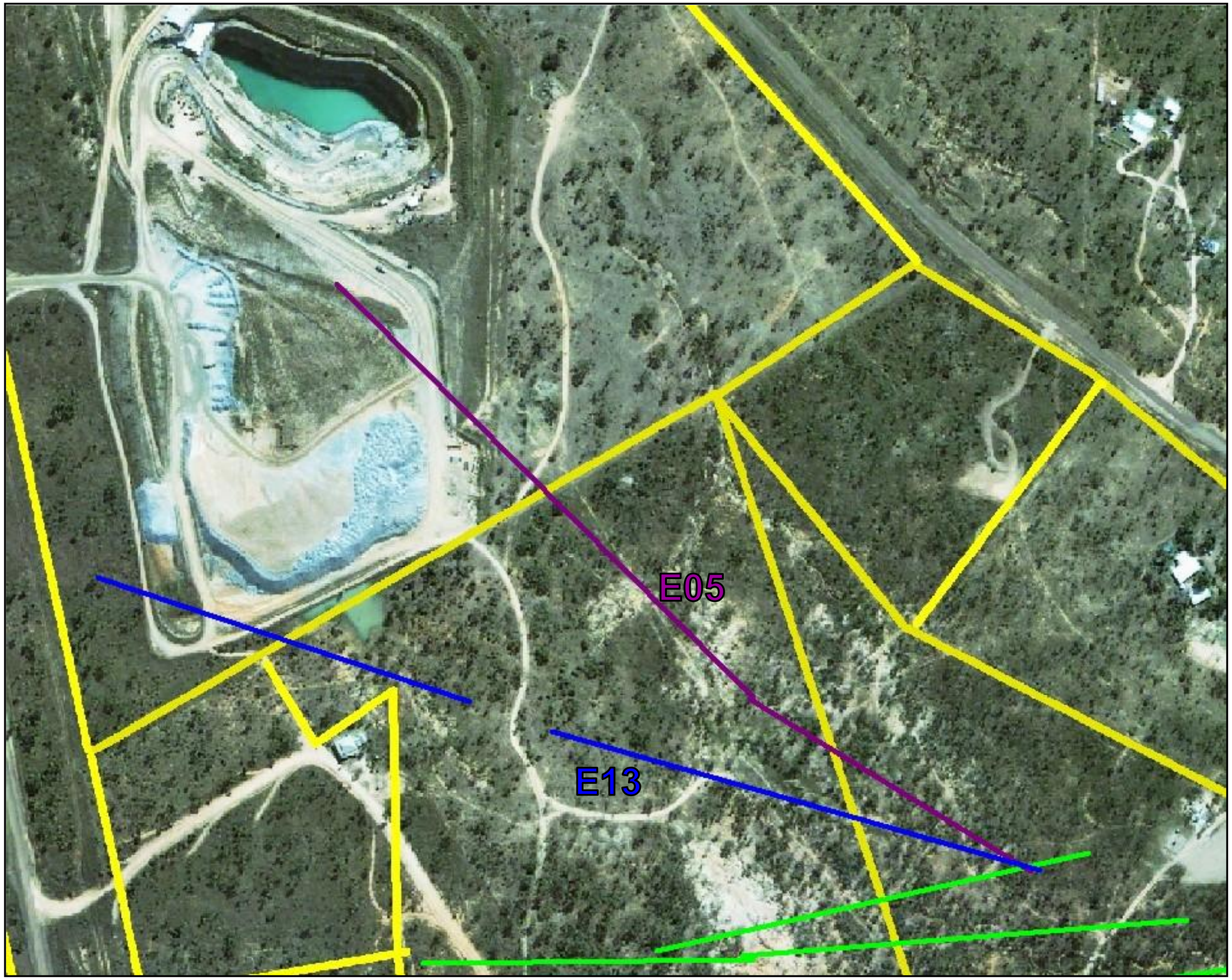


Fig. 7: Close-up of the north section of Fig. 1 with E05 and E13 labelled in purple and blue respectively.

These 2 structures are observed in the Loop 1 data (2010, pg 5) and also in some of the small loop data from 2011. However, the 2011 data only allowed us to study accurately the position of the tops of these structures. The locations of the loops and receiver locations meant that the data had limited sensitivity to other properties of the structures such as resistivity and dip angle.

E05 and E13 are also correlated with anomalies in the vertical derivative of the magnetic field.

3) ***E05*** (Sons of Freedom) – from Loop II (east part of E05) and Loop III (west part of E05), November/December 2010.

4) ***E13*** – from Loop II (east) and Loop III (west), November/December 2010. Continuity of this structure is unclear from present data.

Eastern Structures

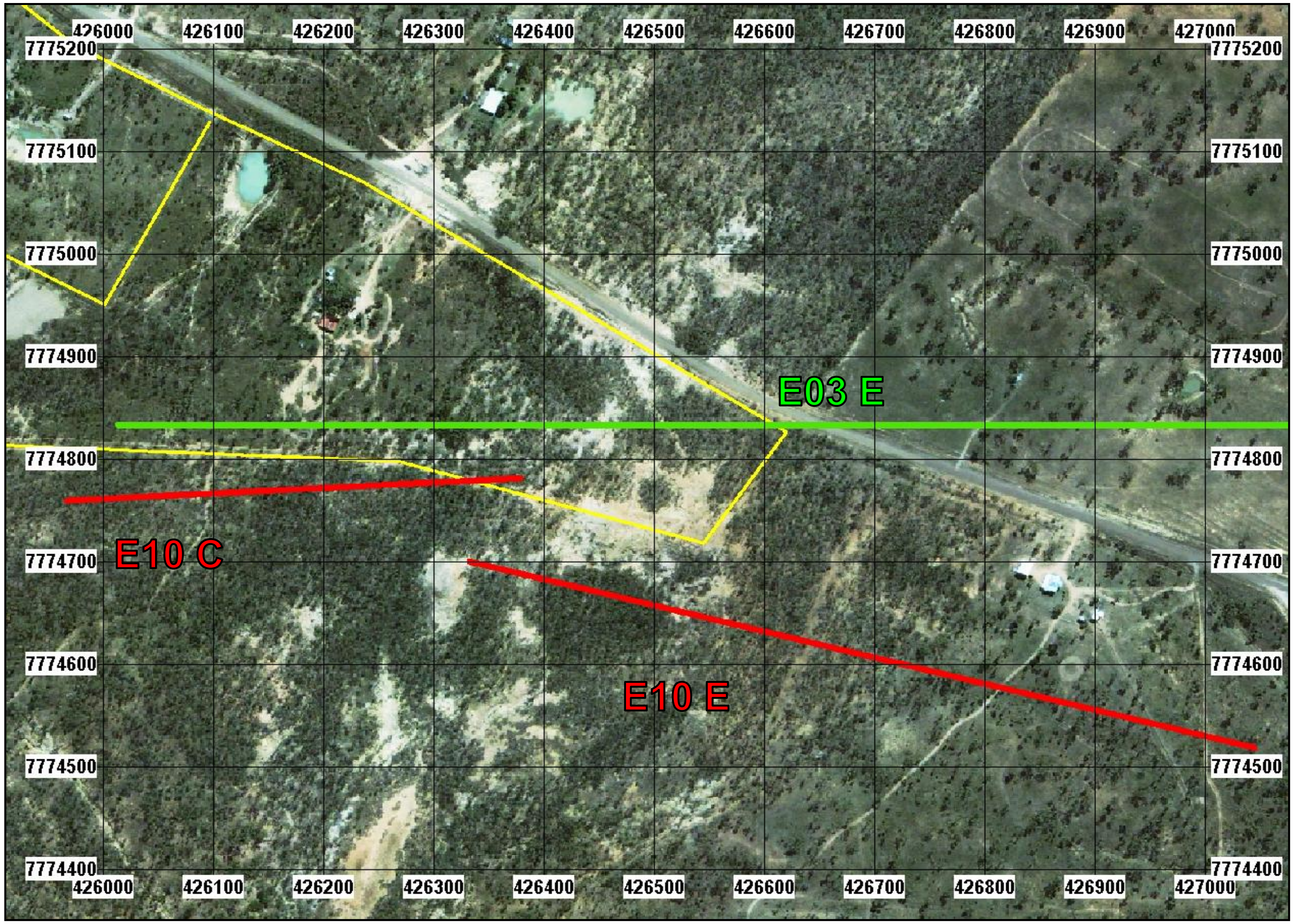


Fig. 8: East E03 and E10 structures, based on modeling of 2010 data.

East of 426000E

→ This area is outside the area of study for the July/August 2011 ground surveys. Results are based on 2010 data only. As these models are derived from data using Loop I (large loop) and line spacing was over 200 m in this area, the models are not as detailed as from the small loop 2011 data.

1) E03 (east extent) – from November/December 2010 Loop I data.

2) E10 E – from November/December 2010 Loop I data. Lines 6400E and 6650E only.

3) E10 C – see page 8. The relationship between E10 C and E10 E (i.e., whether they are connected) is unknown at present.

Registered map: nov2011_east_structures.jpg

SECTION II:
JULY/AUGUST 2011 (ORE) DATA

→Summary of survey plan and procedures

→Modeling results for six of eight loops

a) East Loops (5, 6, and 8)

b) West Loops (1, 3, and 4)

→ Combined model for E03 and E10

Introduction

From July 14 to August 2, 2011, Outer Rim Exploration (ORE) collected ground TEM data with Crone (Mississauga, Canada) equipment at the Warrior site. Data were collected with eight loops. Two to four lines of data were collected for each loop. In some cases, data were collected along the same line with multiple loops. Both vertical (Hz) and in-line horizontal (Hx) components were collected.

Purpose:
To obtain a more detailed understanding of both Warrior and nearby structures. Previous surface TEM surveys in 2010 were performed with larger loops. The smaller loops and tighter sampling of the July/August 2011 survey provide better resolution of the structures.

Note: For a summary of which stations were read with each loop, please see the following report: Summer 2011 Ground TEM at Warrior: Survey Summary. For the archive of the data, see summer2011_TEM_archive.

Survey Design July, 2011

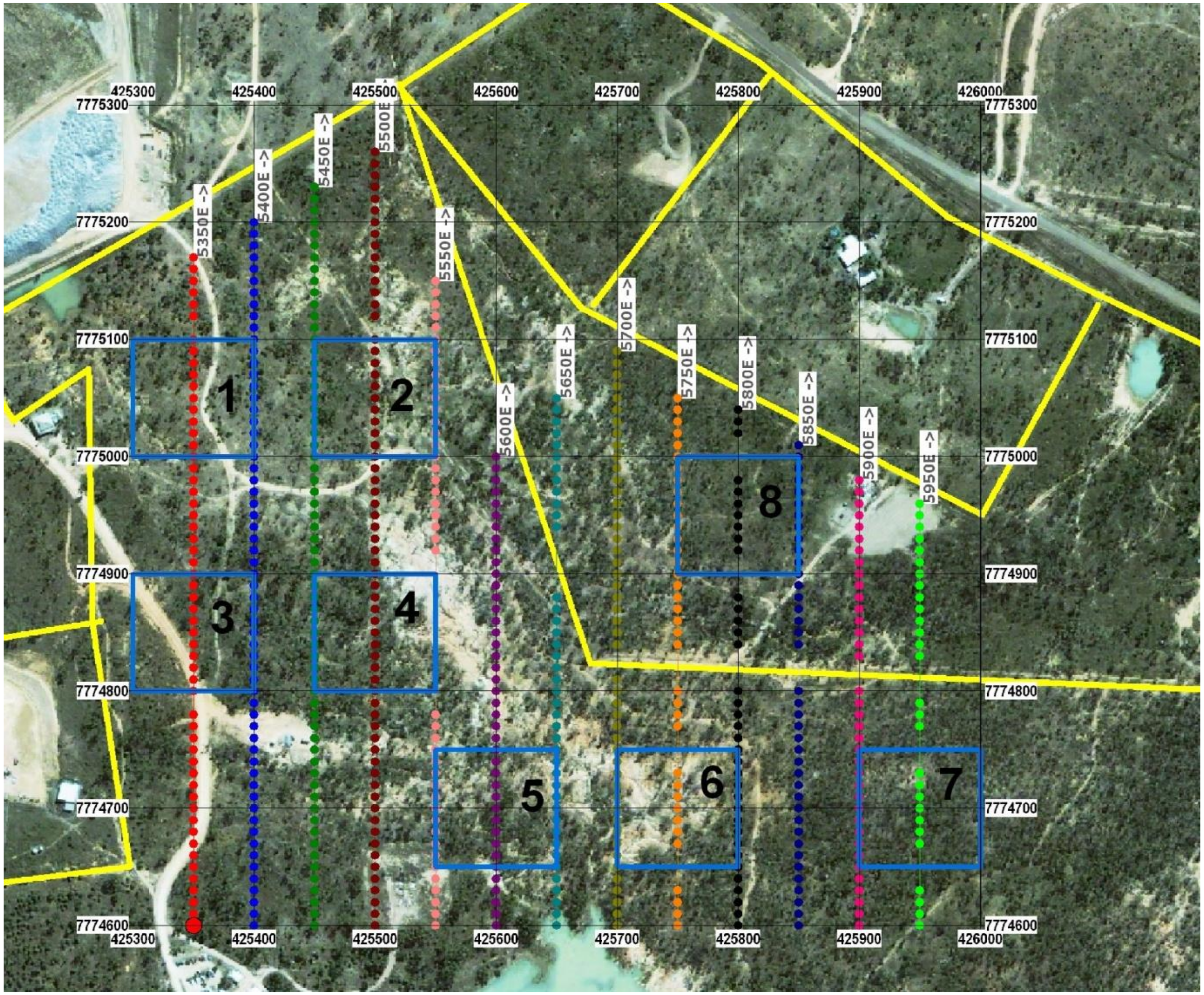


Figure 9: Planned loops and lines for Summer 2011 ground TEM survey.

Data was collected on two to four lines for each loop.

Some notes on survey procedures

1) Primary Pulse files

Primary pulse (PP) files were collected at the beginning and end of each day of surveying for Hz. These files contain 48 time channels between -0.1 and 0.1 ms near the end of the pulse. This data provides more precise definition of source allowing more accurate early time interpretation required for these types of structures.

Purpose: Based on previous experience, the timing of the channels are often shifted from their nominal positions. The PP files allow us to adjust the timing of the data. A typical shift for the data in this survey is 0.030-0.040 ms

Augmented primary pulse files (APP) files were also collected for Hz and Hx. These files contains 48 time channels over a 2 ms interval and sample the entire ramp.

Purpose: To examine the shape and length of the turn-off, as well as timing (in conjunction with the PP files) allowing more precise simulation of the geological models.

2) Current

Outside loop positions further than 40 m from the edge of the loop were collected with a current of 20A. In-loop data were collected with a lower current of 10A so that the data readings were not over the voltage threshold.

Data at 20 and 30 m from the loop were collected both at 20A and 10A for comparison. PP and APP files were collected with both currents for days on which the in-loop data were collected.

Note that: The 20A and 10A data have slightly different waveform characteristics.

Geophysical Modeling – Introduction

Definition: Geophysical Modeling: A hypothetical model is devised and then software is used to simulate the data as collected by the instrument. The simulated data from the model is then compared with the actual data and the model adjusted accordingly.

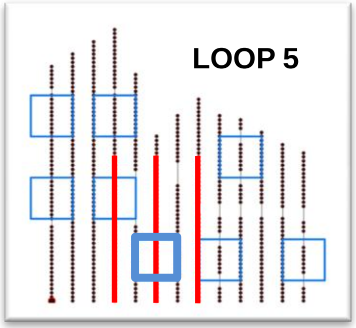
The models for the November/December 2010 data were used as a starting point and these were modified as required to fit the data.

Modeling has been performed on Loops 1, 3, 4, 5, 6, and 8; little work has been done on Loops 2 and 7. These modeling results are discussed in this report.

Modeling was initially performed on each loop separately. Then, Loops 1, 3, and 4 (west loops) were examined together to provide an integrated model suitable to all data on these loops. A similar process was performed for data from Loops 5, 6, and 8 (east loops).

Eastern Loops Results
2011 data

Loop 5



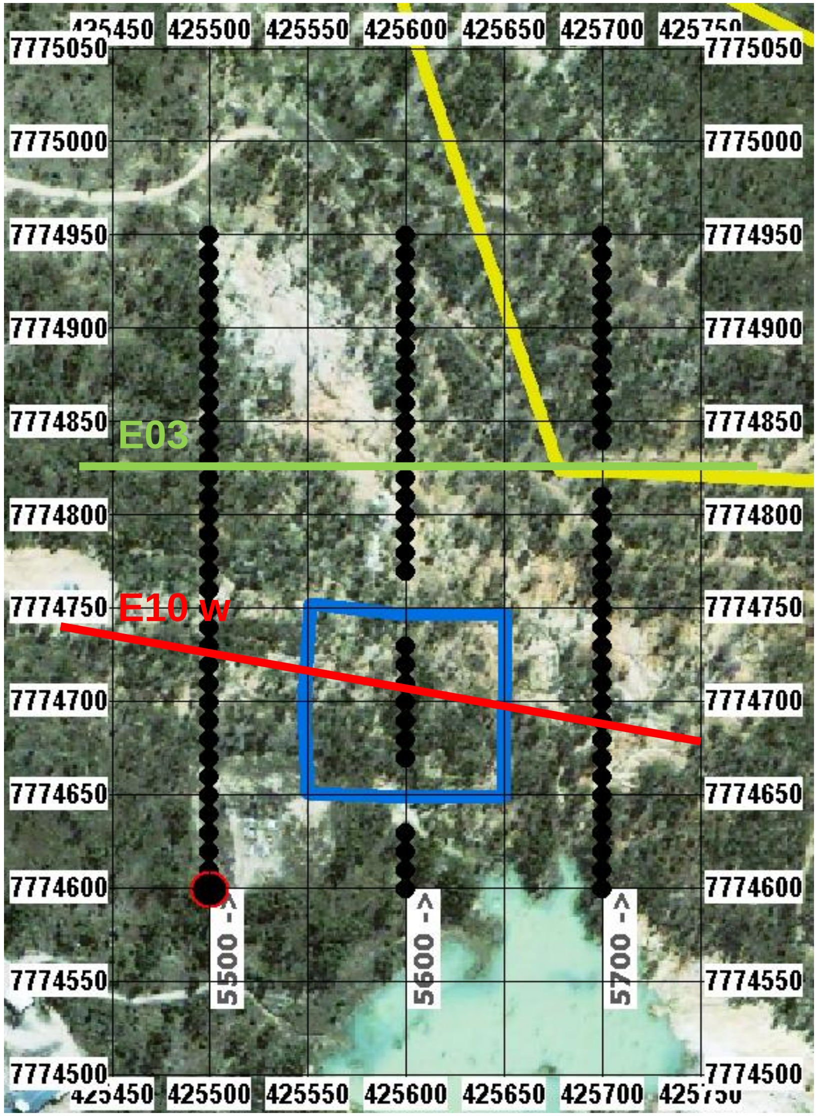
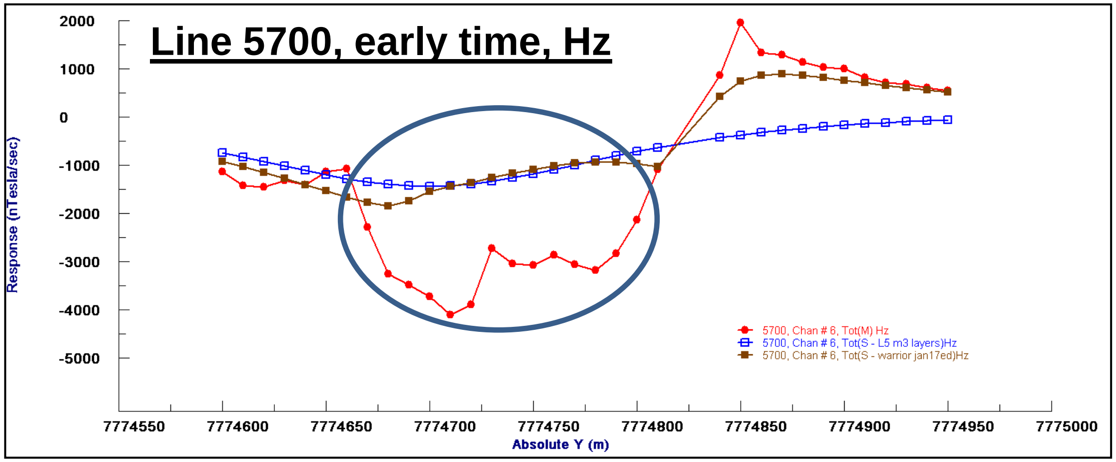


Figure 10: *The initial model from the 2010 ground TEM data in the vicinity of Loop 5. Tops of structures are marked.*

The model for the 2010 data (October, and November/December) was used as a starting point for the modeling of the 2011 small loop data.

Loop 5



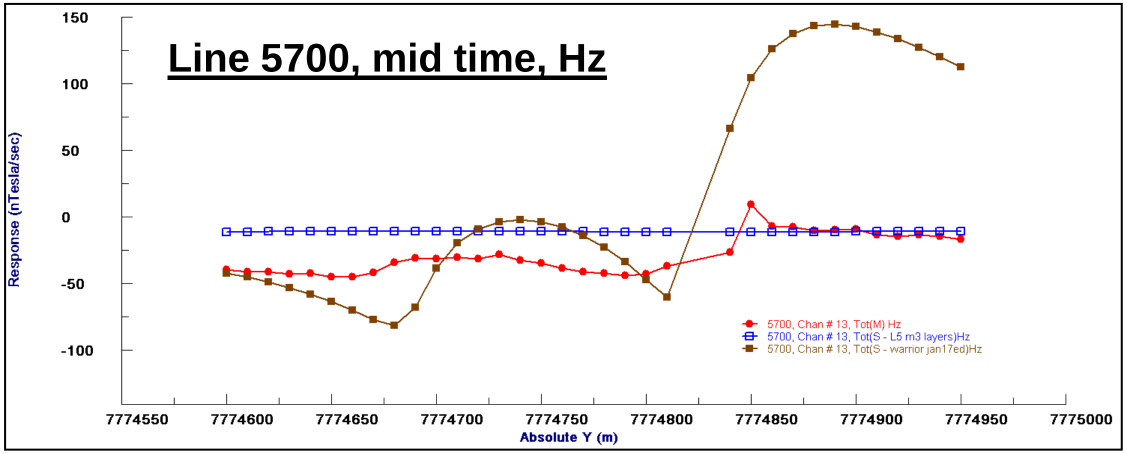


Figure 11: Profile response along Line 5700E (east line) for Loop 5, comparing the measured response with the simulated response of the background model and the 2010 plate model derived from the larger loop data. Early time (Ch. 6) and mid time (Ch. 13) for Hz are shown.

The 2010 model does explain some aspects of the measured response for Loop 5. This is presumably due to the reduced resolution capability of the 2010 surveys.
However:

1) The subsurface is clearly much more complex than the 2010 model. For example, this model does not explain the response between 7774700-7774800N at early times (circled).

2) The 2010 model has too large of a response as compared to the actual data beyond early times.

***The background model is a 2-layer model with a thin, conductive cover over a resistor (the granite).*

Measured Data (Hz)
Background Model
Dec. 2010 Model (E03 +E10)

Loop 5 New Results

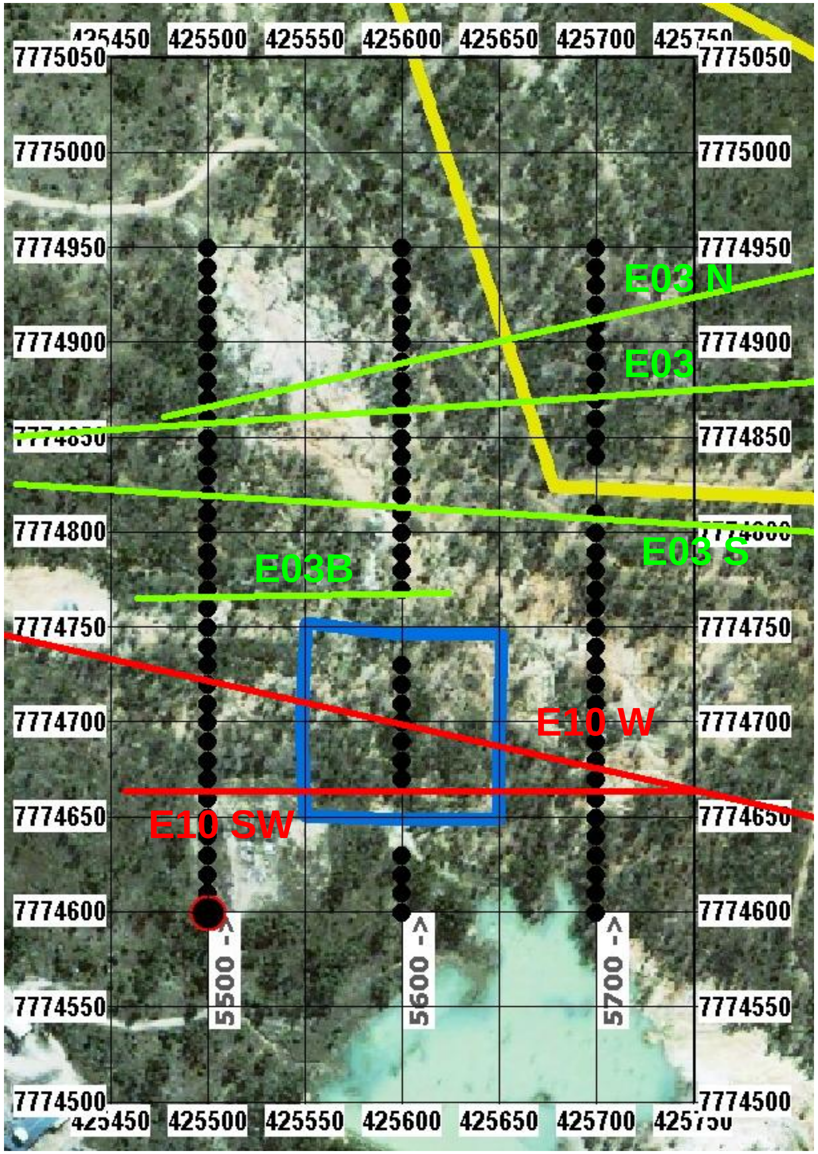


Figure 12: Model for Loop 5 data. Tops of structures are mapped.

E03_n:
Depth to top: 10 m
Dip extent: 150 m
Dip: 48^0 (north)
Conductance: 4.5S

E03:
Depth to top: 5 m
Dip extent: 200 m
Dip: 48^0 (north)
Conductance: 3S

E03_s:
Depth to top: 5 m
Dip extent: 200 m
Dip: 48^0 (north)
Conductance: 3.5S

E03B:
Depth to top: 5 m
Dip extent: 150 m
Dip: 48^0 (north)
Conductance: 3S

E10_w:
Depth to top: 5 m
Dip extent: 300 m
Dip: 65^0 (north)
Conductance: 3S

E10_sw:
Depth to top: 5 m
Dip extent: 150 m
Dip: 65^0 (north)
Conductance: 2S

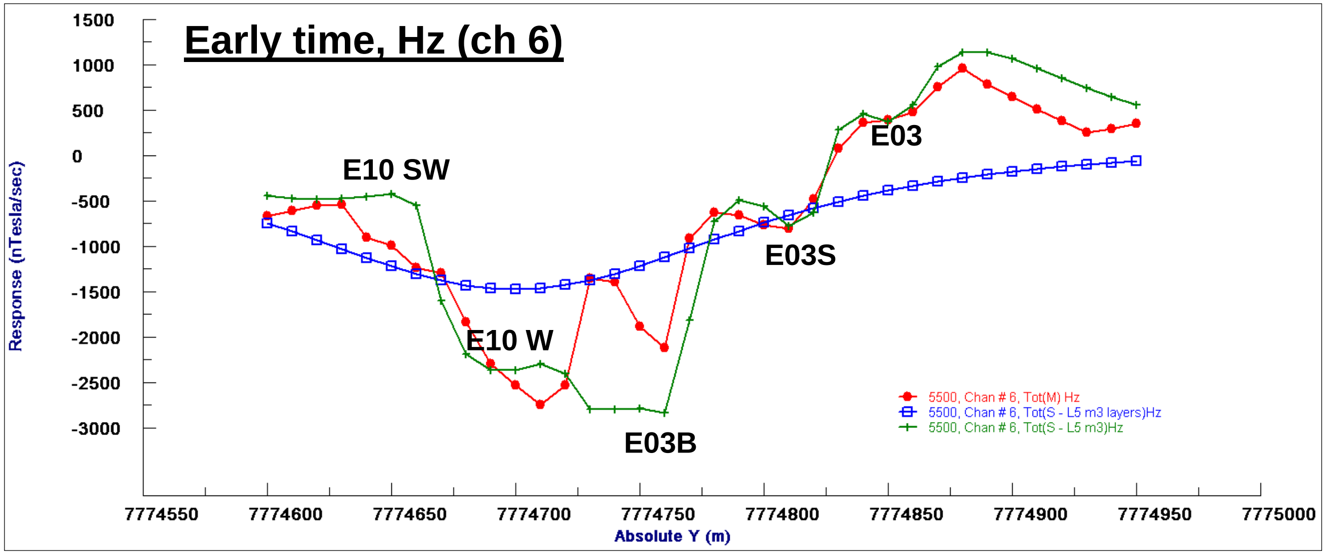
Through further modeling of the Loop 5 data, model L5_M3 was developed, which better fits the Hz and Hx response into late times. The tops of the structures in this model are shown on the map and their properties are listed.

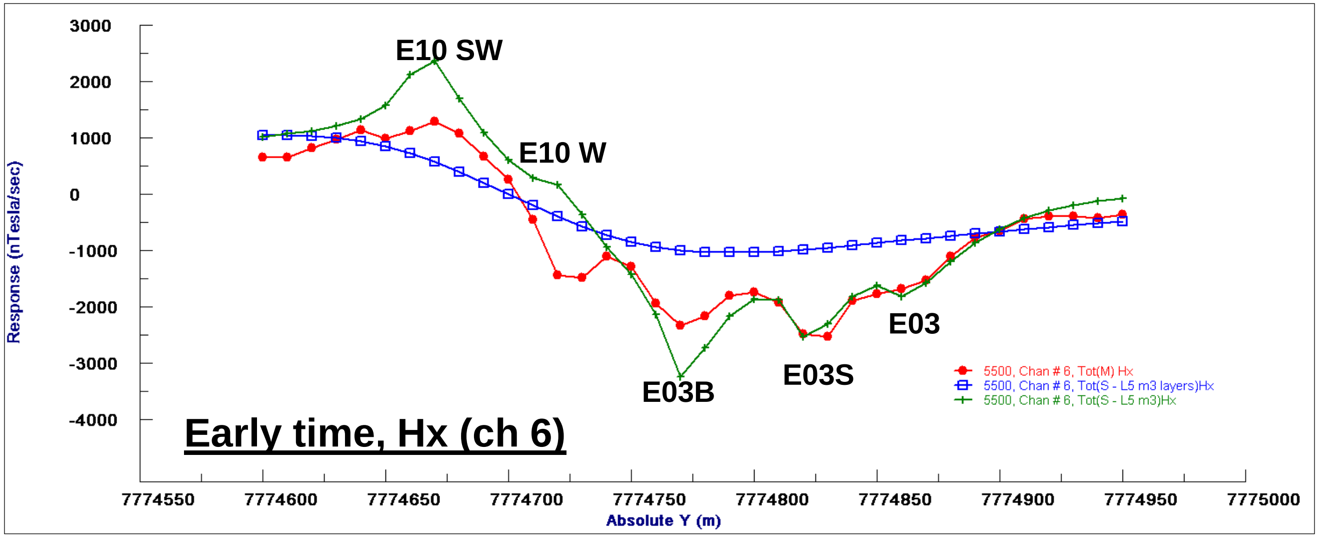
Four additional structures have been added to the model as determined from the new 2011 measured data, and the properties of the other two structures have been adjusted.

Structures to the north of 7774750 have been labelled as E03, and those to the south as E10 as previously explained.

Loop 5 2011

5500E (west line)





Measured Data (Hz)
Background Model
Loop 5 Model

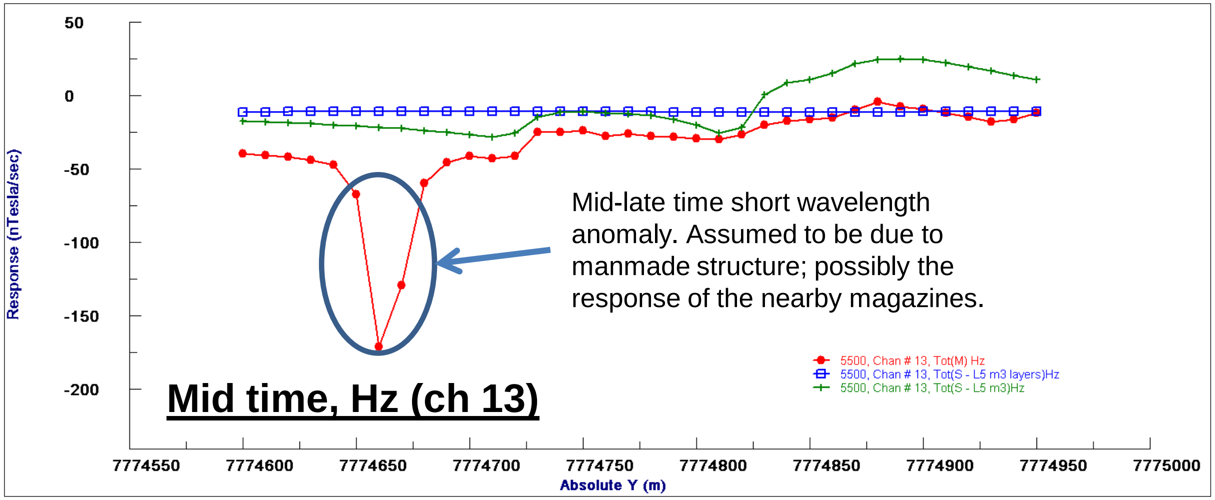
Fig. 12: *Comparison of the Loop 5 model response vs. the measured data on Line 5500E for Hz and Hx, early time.*

The responses caused by the different structures in the model are marked. Note that for Hx on 5500E, the response of E10 W in the model is the opposite of what is observed in the data. However, the response to this model of E10 W fits the center line data well (page 22). More modeling would need to be performed to determine if a more complex model could be developed that explains the data on both lines.

Loop 5 2011

5500E (west line)

- **Measured Data (Hz)**
- **Background Model**
- **Loop 5 Model**



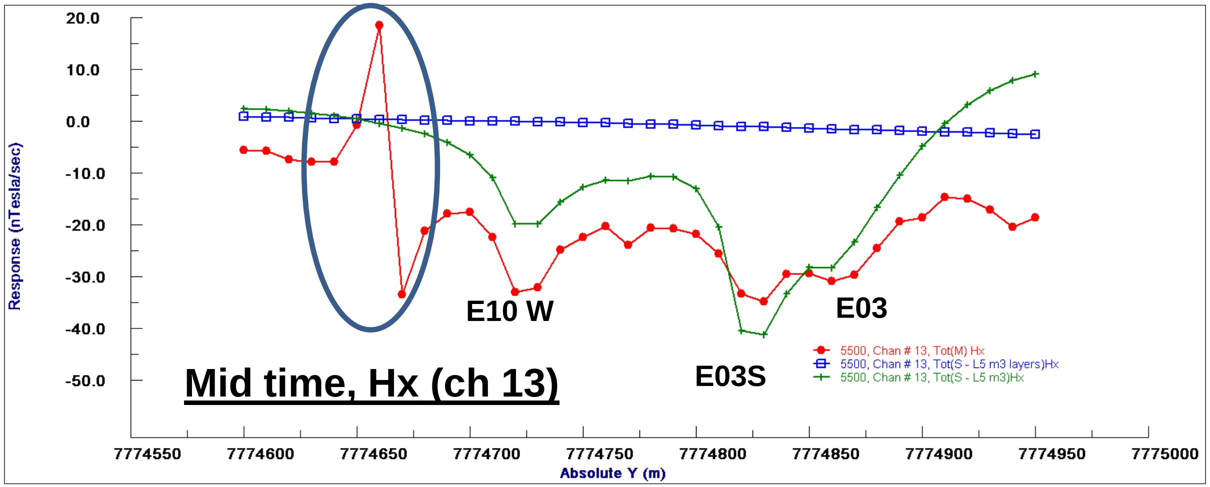
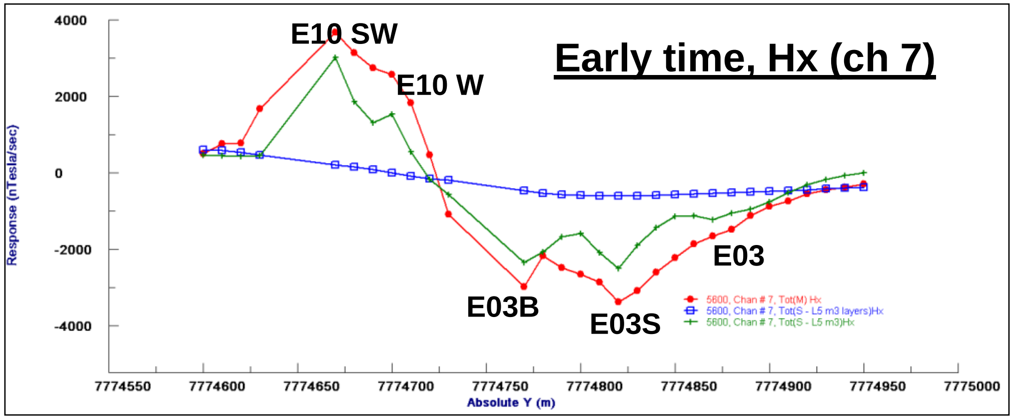
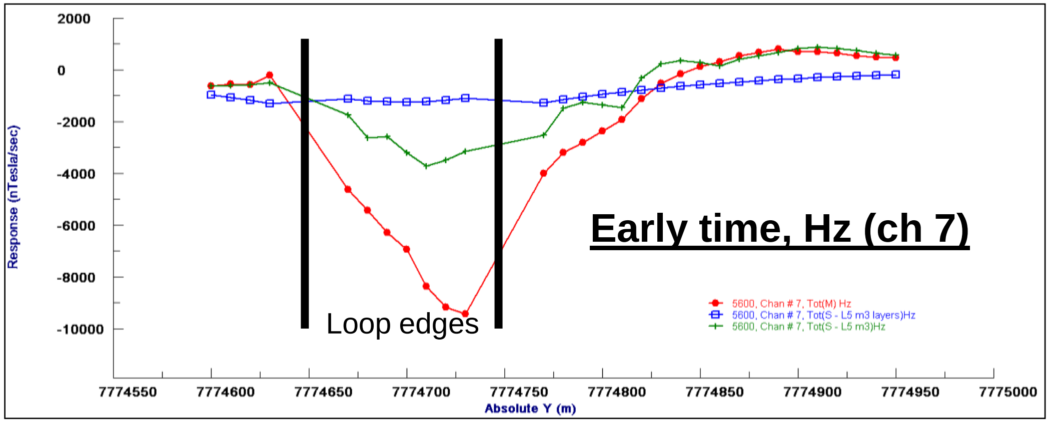


Fig. 13: *Comparison of the Loop 5 model response vs. the measured data on Line 5500E for Hz and Hx.*

Loop 5 2011

5600E (centre line)





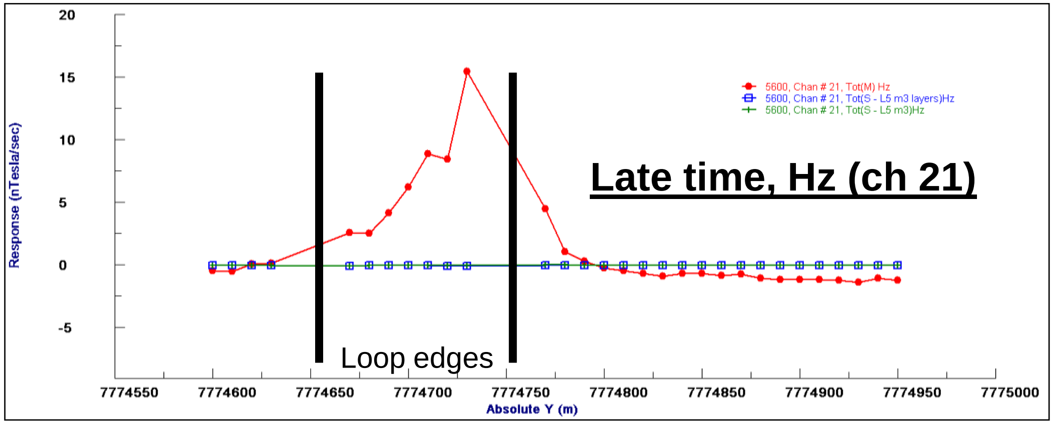
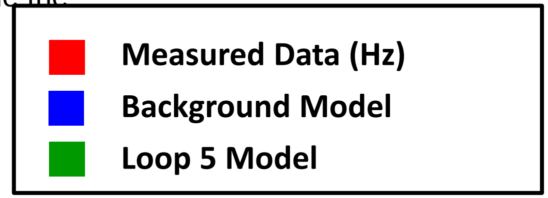


Fig. 14: *Comparison of the Loop 5 model response vs. the measured data on Line 5600E for Hz and Hx.*

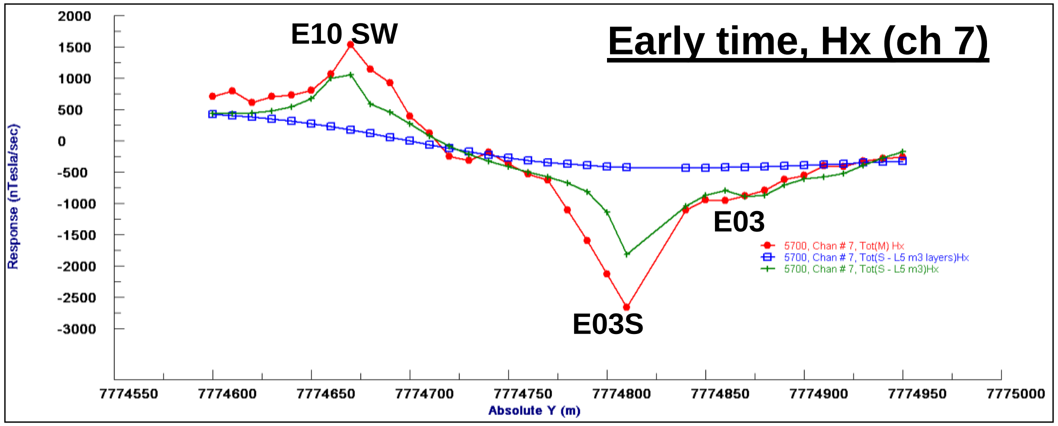
The measured data and model response well for Hx. Note that, in contrast to Line 5500E, the response of E10 W in the model is consistent with the measured data.

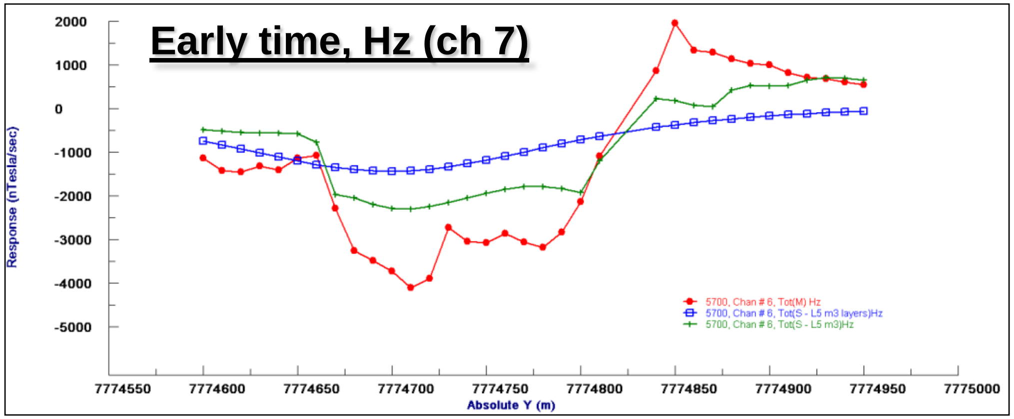
In the measured Hz data, there is an increased amplitude inside the loop. This is particularly noticeable at late times. It is thought that this is not geologic in nature, but is a response from the loop or a instrumentation failure as per our report concerning calibration studies performed by Khumsup later in 2011. Such a response inside the loop is observed in other loops as well.



Loop 5

5700E (east line)





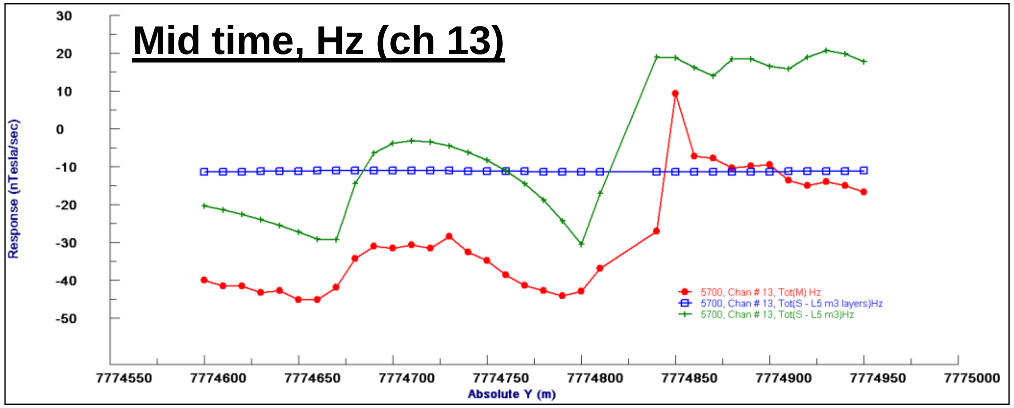
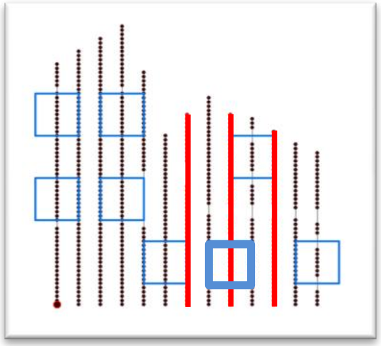


Fig. 15: *Comparison of the Loop 5 model response vs. the measured data on Line 5700E for Hx and Hz.*

Measured Data (Hz)
Background Model
Loop 5 Model

The general amplitude variation at Ch13 is considered to be instrumentation failure.

Loop 6 2011



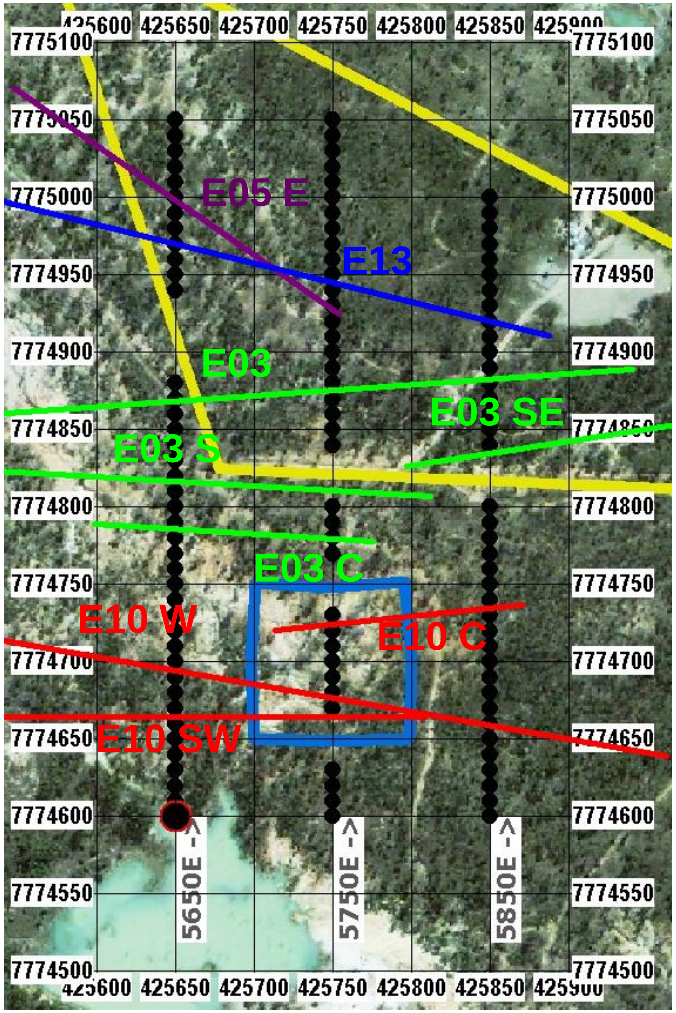


Fig. 16: Model of the Loop 6 data.
Tops of structures are shown.

E10_w:
Depth to top: 5 m
Dip extent: 200 m
Dip: 65^0 (north)
Conductance: 2S

E10_sw:
Depth to top: 5 m
Dip extent: 150 m
Dip: 65^0 (north)
Conductance: 2S

E10_c:
Depth to top: 10 m
Dip extent: 200 m
Dip: 48^0 (north)
Conductance: 3S

E05 E:
Depth to top: 2 m
Dip extent: 250 m
Dip: 25^0 (north)
Conductance: 4S

E13:
Depth to top: 5 m
Dip extent: 250 m
Dip: 25^0 (north)
Conductance: 4S

E03:
Depth to top: 5 m
Dip extent: 200 m
Dip: 48^0 (north)
Conductance: 3S

E03_se:
Depth to top: 5 m
Dip extent: 200 m
Dip: 48^0 (north)
Conductance: 4.5S

E03_s:
Depth to top: 5 m
Dip extent: 200 m
Dip: 48^0 (north)
Conductance: 3.5S

E03_C:
Depth to top: 5 m
Dip extent: 200 m
Dip: 48^0 (north)
Conductance: 3.5S

Model L6_m4, shown here, and which contains the 9 structures shown in Figure 16 was developed to fit the measured Loop 6 data.

*Note: The Loop 6 data have limited sensitivity to the dip and extent of E05 E and E13, which are located a couple hundred meters north from the loop. The data are mainly sensitive to the positions of these 2 structures..

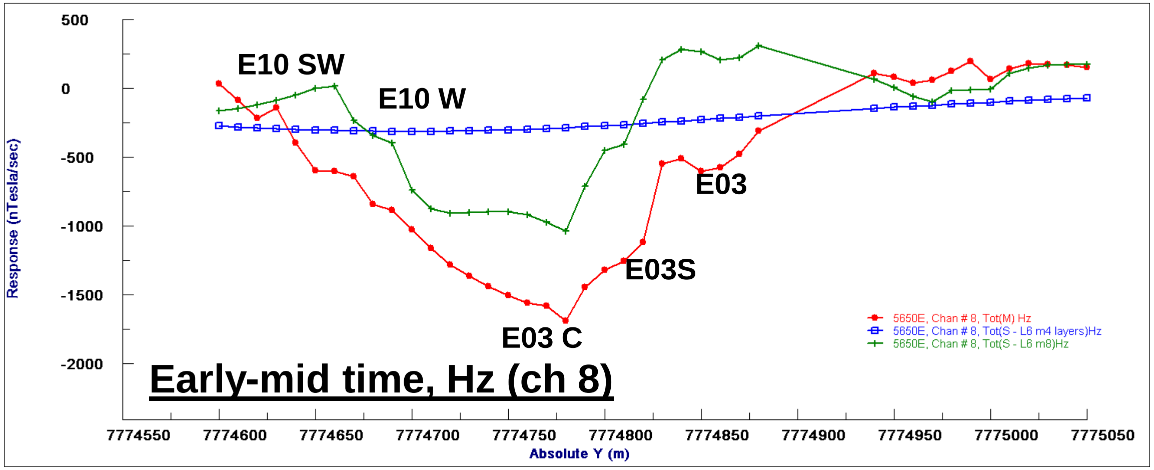
Loop 6 2011

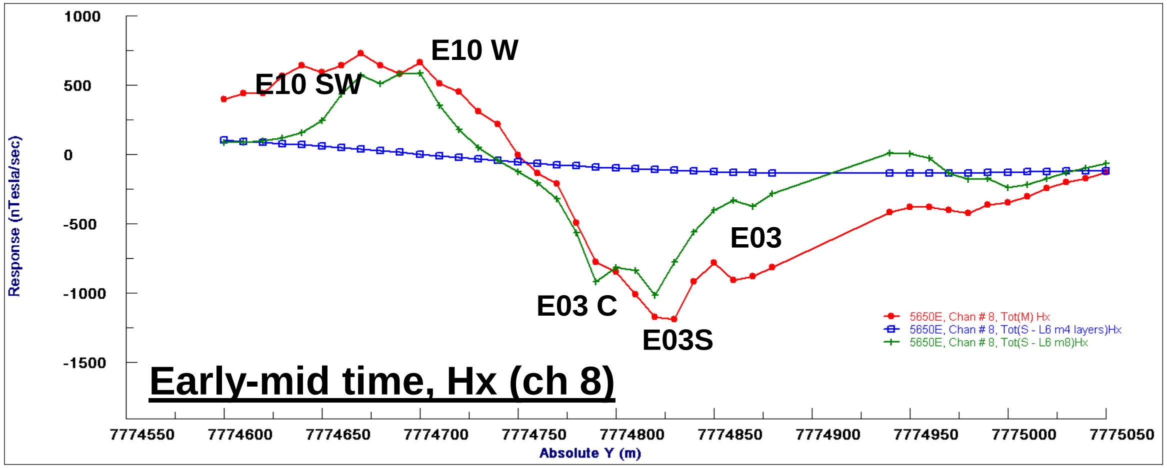
5650E (west line)

Fig. 17: *Comparison of the Loop 6 model (*Model L6_m4) *response vs. the measured data on Line 5650E for Hx and Hz.*

This model explains the main features of the Hx and Hz response; however, the response in Hz is too large in the mid-channels across most of the line. Further work would need to be done to better understand the response in this section of the survey.

But, also due to the instrumentation limitations as described in our report on the Khumsup data, another TEM system needs to be applied to the project to further understand the limitations of the Crone equipment.





Measured Data (Hz)
Background Model
Loop 6 Model

Loop 6 2011

5750E (centre line)

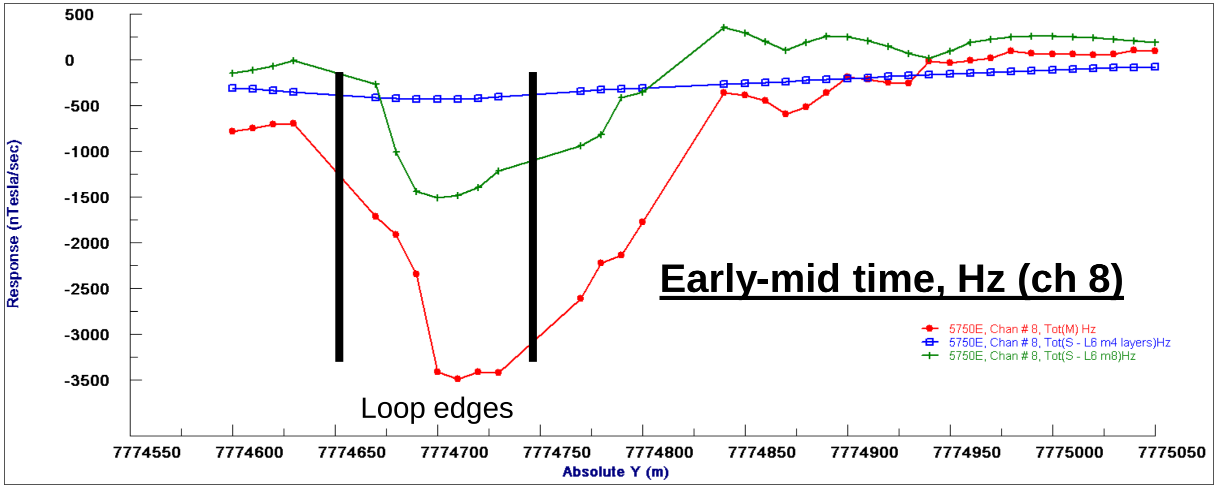
***Fig. 18:** Comparison of the Loop 6 model response vs. the measured data on Line 5750E for Hz.*

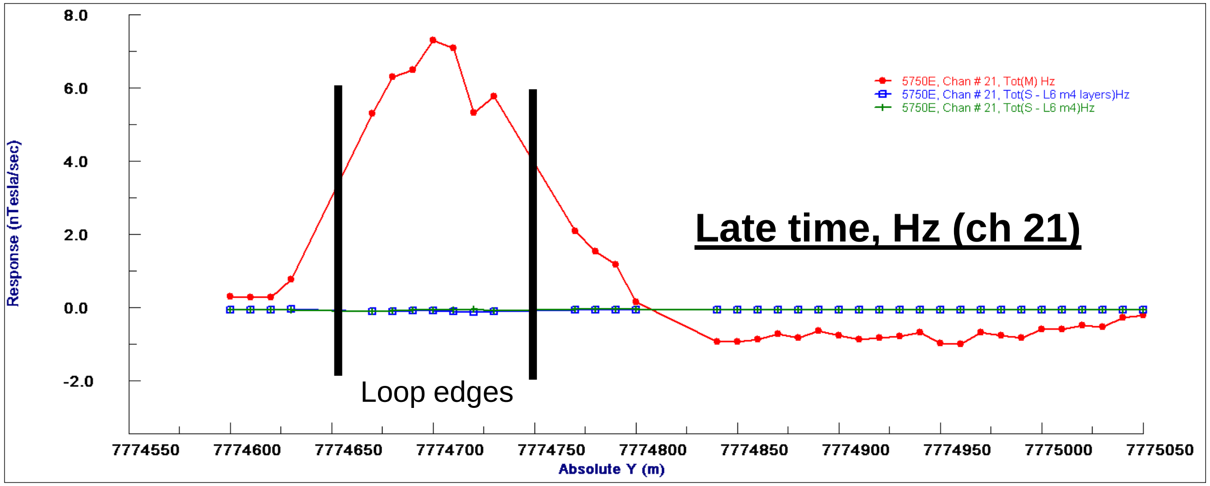
The model explains the main features of early-mid time response except that the measured response is larger inside the loop and just to the north. It is thought that this response may be due to the loop, and is not geologic or instrumentation limitations.

Similar to Loop 5, there is an increased amplitude in the response inside the loop, particularly at late time.

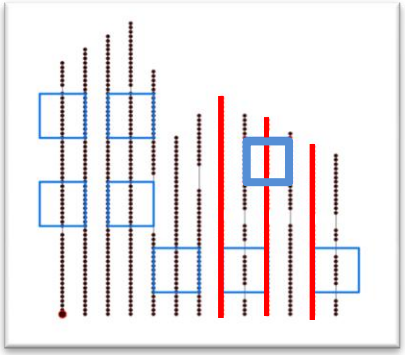
The late time response (lower figure) shows the measured data response much higher. In our opinion, this must be instrumentation failure as such a response in very unlikely from the geology.

Measured Data (Hz)
Background Model
Loop 6 Model





Loop 8 2011



E10_w:
Depth to top: 5 m
Dip extent: 400 m
Dip: 65^0 (north)
Conductance: 3S

E10_c:
Depth to top: 10 m
Dip extent: 300 m
Dip: 48^0 (north)
Conductance: 3S

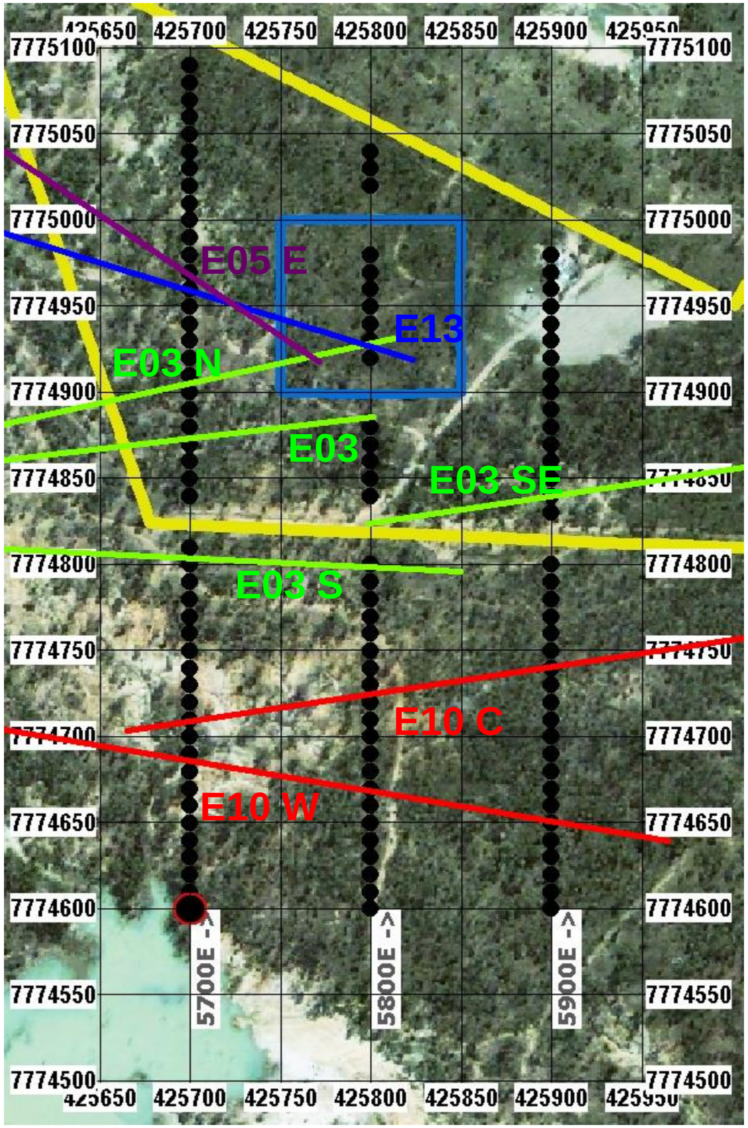


Fig. 19: Model of the Loop 8 data. Tops of structures are shown.

E05 E:
Depth to top: 6 m
Dip extent: 200 m
Dip: 25^0 (north)
Conductance: 4S

E13:
Depth to top: 13 m
Dip extent: 200 m
Dip: 40^0 (north)
Conductance: 4S

E03_n:
Depth to top: 10 m
Dip extent: 150 m
Dip: 48^0 (north)
Conductance: 4.5S

E03:
Depth to top: 5 m
Dip extent: 200 m
Dip: 48^0 (north)
Conductance: 3S

E03_se:
Depth to top: 5 m
Dip extent: 150 m
Dip: 48^0 (north)
Conductance: 4.5S

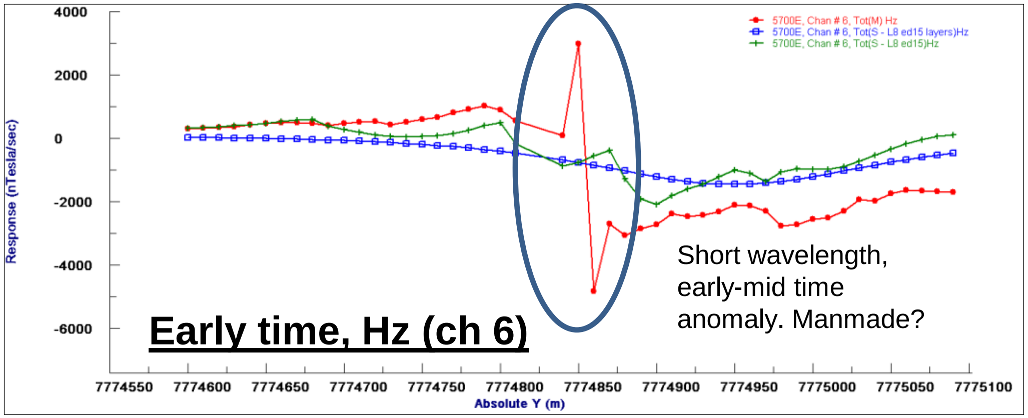
E03_s:
Depth to top: 5 m
Dip extent: 200 m
Dip: 48^0 (north)
Conductance: 3.5S

The combined model for the Loop 8 data is shown here. An additional structure, E03 SE, was added to the Loop 6 model under Lines 5800E and 5900E.

*Note: E05, E13, and E03 N appear to intersect inside the loop. This area needs to be studied in more detail.

Loop 8 2011

5700E (west line)



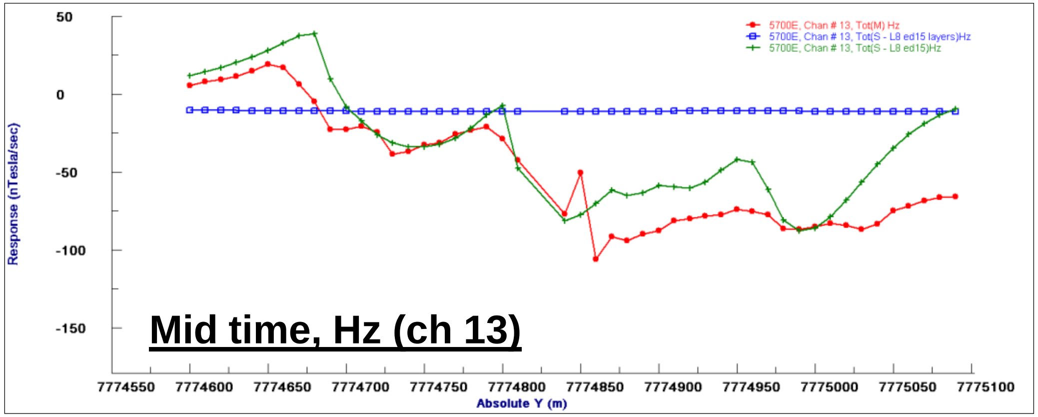
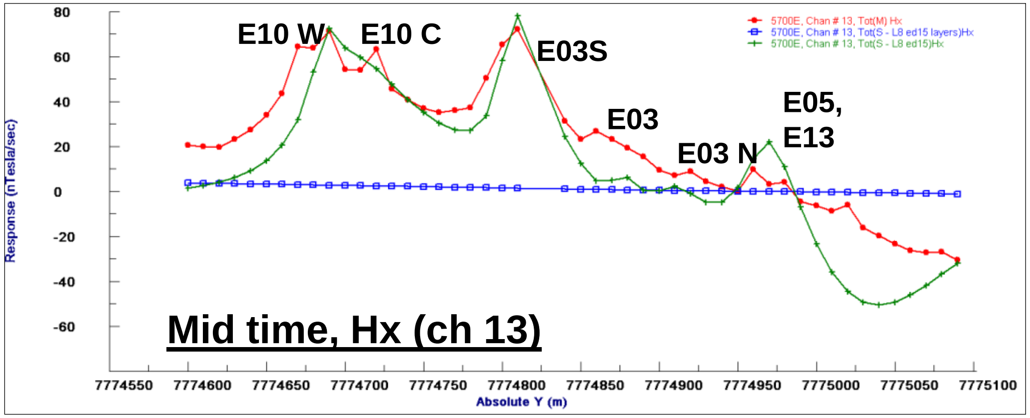


__Fig. 20:__ Comparison of the Loop 8 model response vs. the measured data on Line 5700E for Hz and Hx.

The model explains the main features of the early to mid time response aside from a short wavelength anomaly that is thought to be due to manmade structure. There is an east-west fence at 7774825N, but a similar effect is not observed on the other Loop 8 lines, which also cross the fence, so this is not thought to be due to the fence. Similarly, such large fence effects were never observed in the 2010 data.



Measured Data (Hz)
Background Model
Loop 8 Model

Loop 8 2011

5800E (centre line)

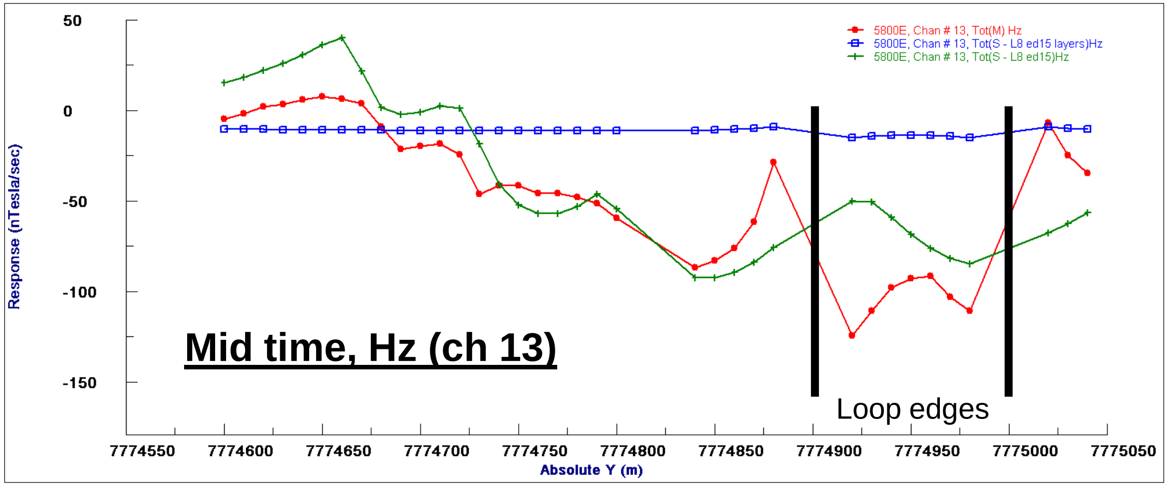
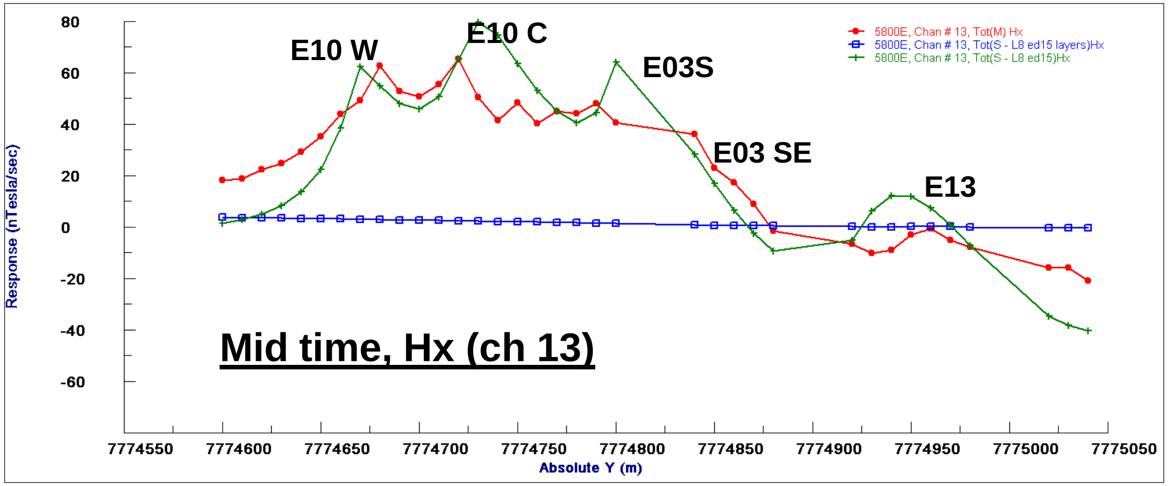


Fig. 21: *Comparison of the simulated response of the Loop 8 model vs. the measured data on Line 5800E for Hz and Hx.*

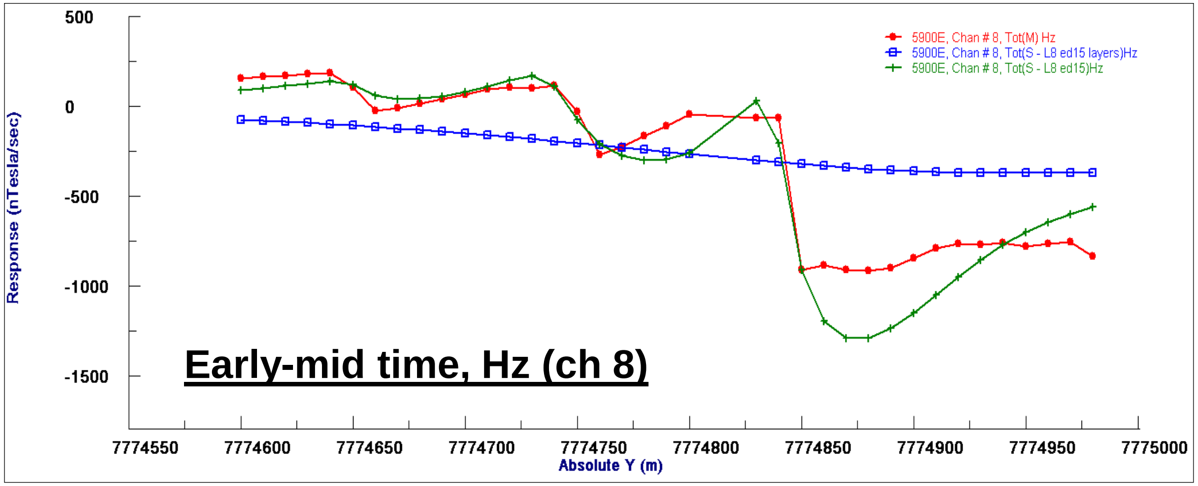
There appears to be a loop response in Hz, even at the mid time (e.g. Ch13). Note the symmetrical response across the wires as shown by the strong black lines.



- **Measured Data (Hz)**
- **Background Model**
- **Loop 8 Model**

Loop 8 2011

5900E (east line)



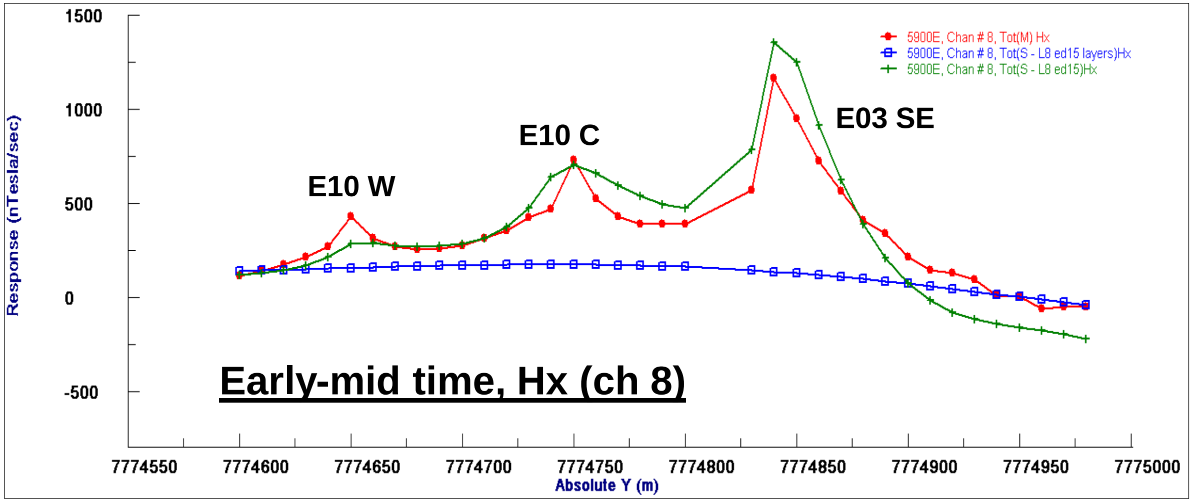


Fig. 22: *Comparison of the Loop 8 model response vs. the measured data on Line 5900E for Hz and Hx.*

The response on this line is less complicated than on other lines; i.e. there are fewer anomalies. The only E03 structure in the model that extends this far east is E03 SE.

Measured Data (Hz)
Background Model
Loop 8 Model

2011 Eastern Loops, Combined Model

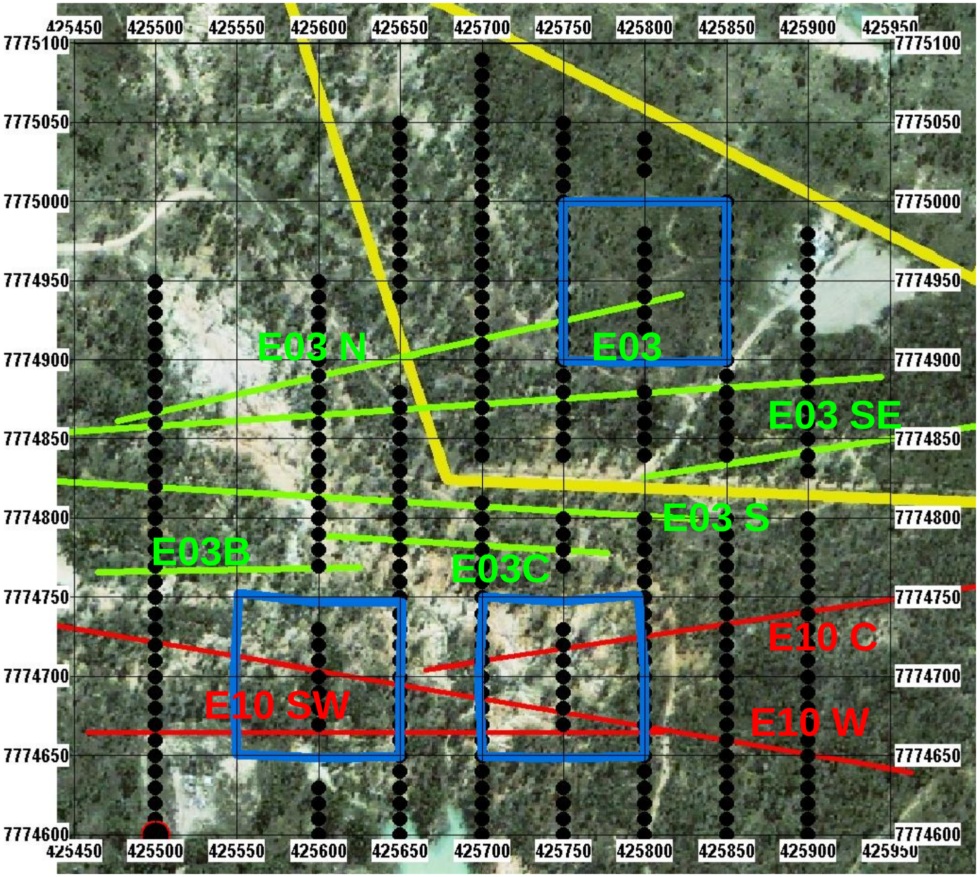


Fig. 23: Combined model of E03 and E10 as determined from the data of the East Loops (5, 6, and 8).

The various substructures of the E03 and E10 models for Loops 5, 6, and 8 as discussed in previous pages were combined to create a single model.

Structures from Loop 5: E03_N, E03B, E10_SW

Structures from Loop 6: E03_SE, E10_w, E03_C

Structures from Loop 8: E10_C

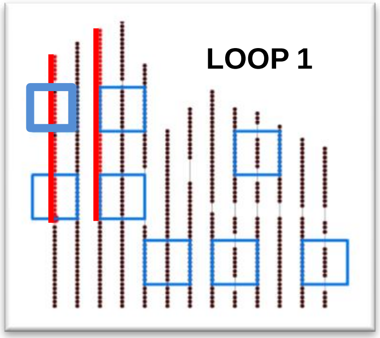
Modified structures from multiple loops: E03, E03_S

This is our best model of the subsurface between 425500-426000 based on all the TEM data to date. Tighter line and station sampling combined with the focused excitation provided by the smaller loops, allowed better resolution of the structures. It was found that the shallow geology is more complex than initially thought.

Model E03_S is the most similar model to that derived from the drill hole intersections provided by Citigold. However there are several other structures nearby such as E03C and E03B. It is possible that some of the structures join up at depth.

2011 West Loop Results

Loop 1



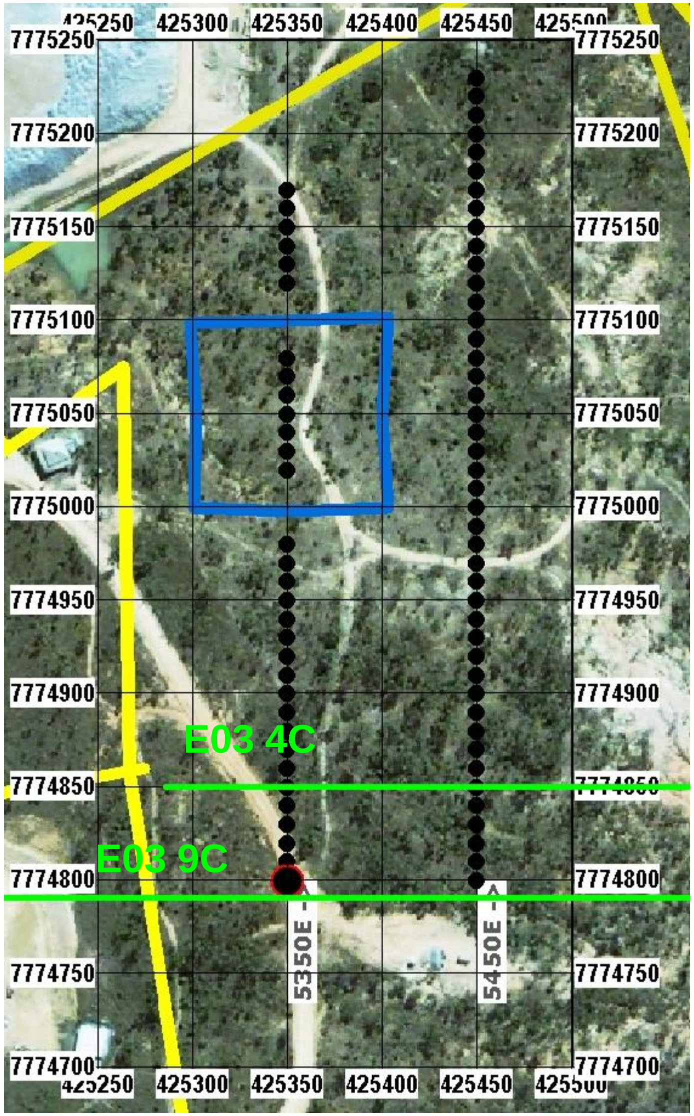


Fig. 24: Model derived from the Loop 1 data. Tops of structures are shown.

E03_4c:
Depth to top: 10 m
Dip extent: 200 m
Dip: 50^0 (north)
Conductance: 2S

E03_9c:
Depth to top: 10 m
Dip extent: 500 m
Dip: 43^0 (north)
Conductance: 1.7S

Loop 1 2011

5350E (west line)

Measured Data (Hz)
Background Model
Loop 1 Model

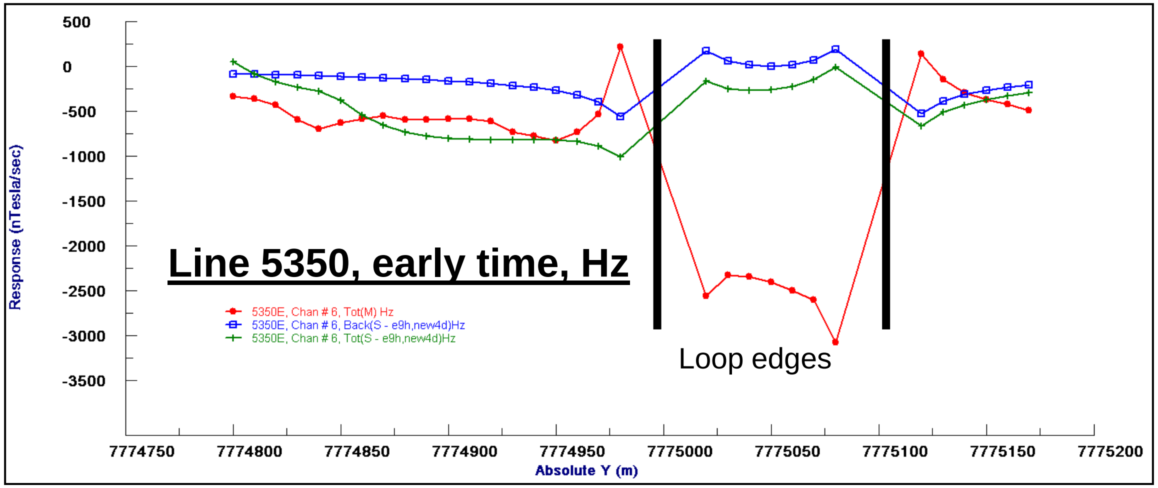


Fig. 25: *Comparison of the Loop 1 model response vs. the measured data on Line 5350E for Hz at Ch. 6.*

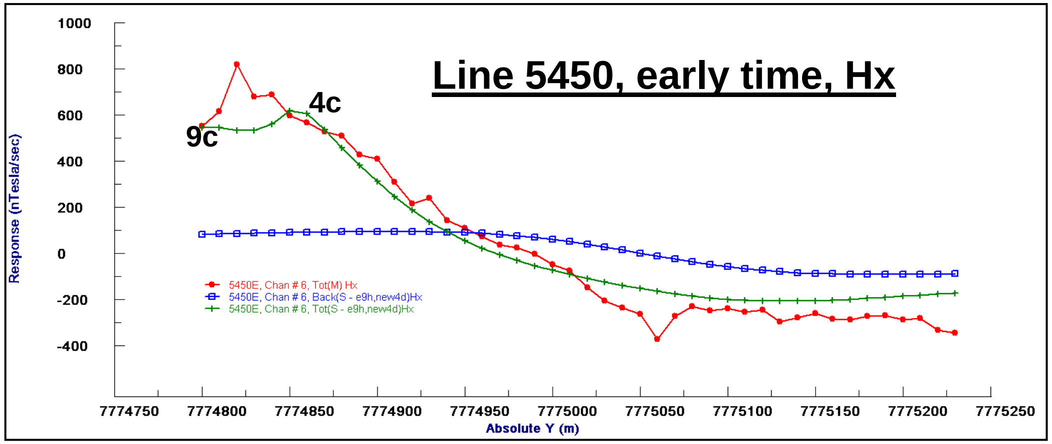
Line 5350E passes through the middle of the loop and there appears to be a significant loop response (high negative data values), larger than that observed in the simulations and sometimes of opposite polarity. This continues to mid-late times. This possibly due polarization characteristics of the weathered covering material or data timing problems. Modelling cannot characterize this response as shown as an IP effect.

Wire edges are again shown as bold lines in the figure.

Loop 1

5450E (east line)

Measured Data (Hz)
Background Model
Loop 1 Model



The model consisting of E03 4C and E03 9C as shown on page 33 explains the major features of the data.

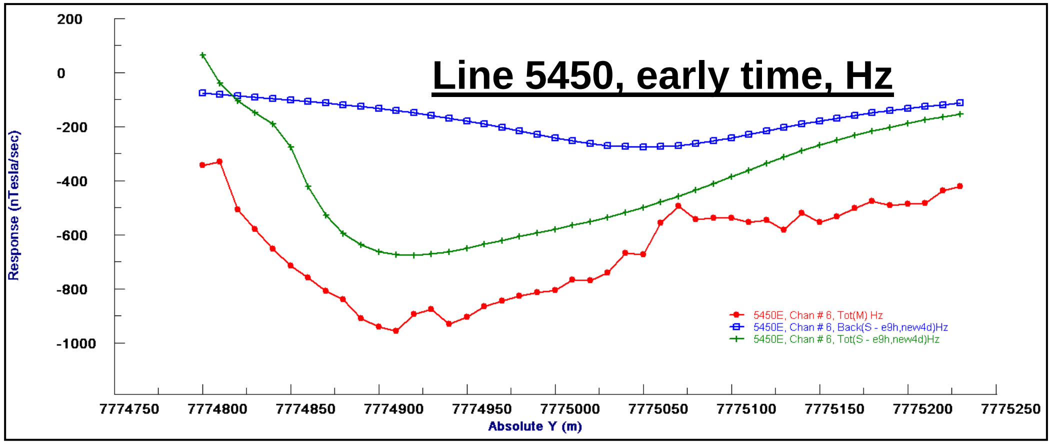
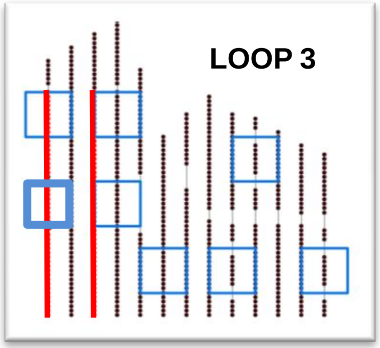
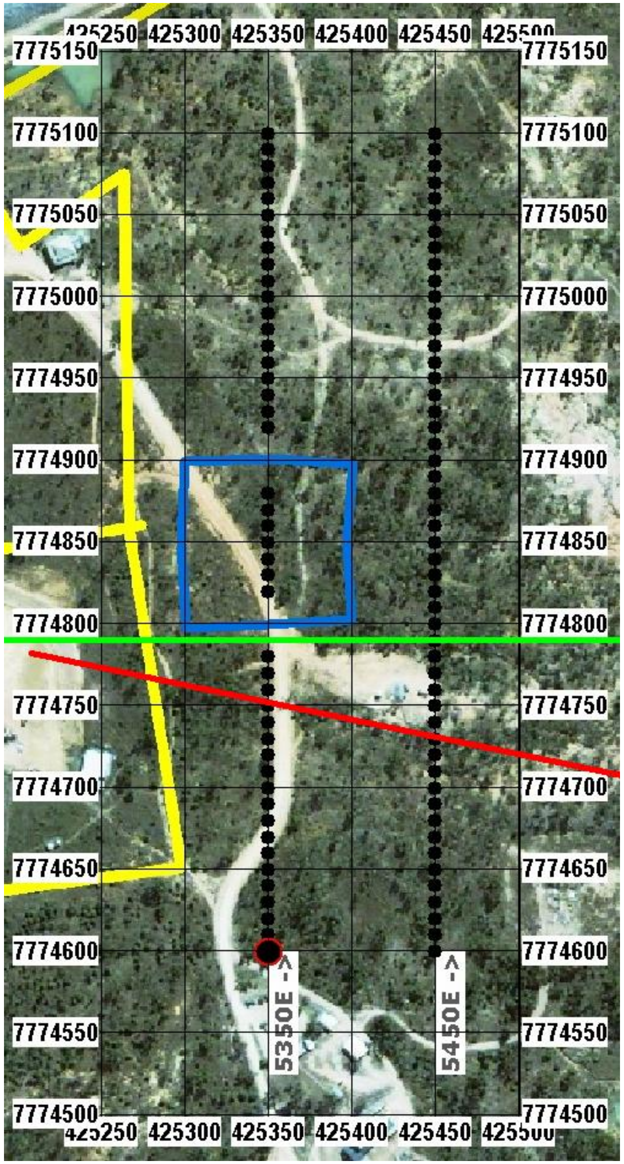


Fig. 26: *Comparison of the Loop 1 model response vs. the measured data on Line 5450E for Hz for both Hz and Hx.*

2011 Loop 3



E10:
Depth to top: 8 m
Dip extent: 500 m
Dip: 65^0 (north)
Conductance: 2.5S

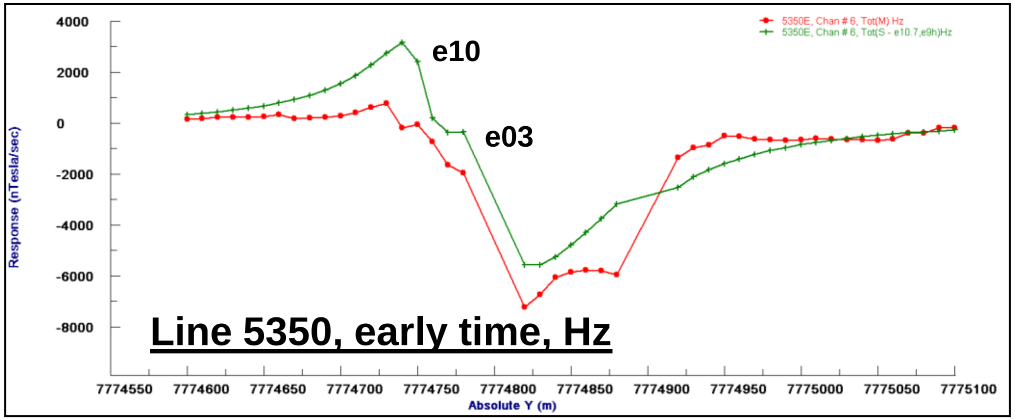


E03:
Depth to top: 10 m
Dip extent: 450 m
Dip: 43^0 (north)
Conductance: 1.7S

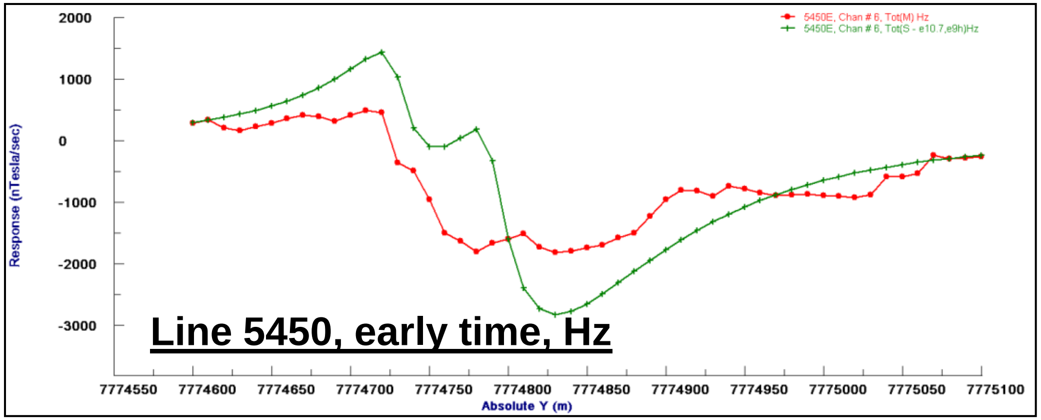
Fig. 27: The model obtained from the Loop 3 data. Tops of the 2 structures contained in the model are shown.

Loop 3

5350E (west line)



5450E (east line)



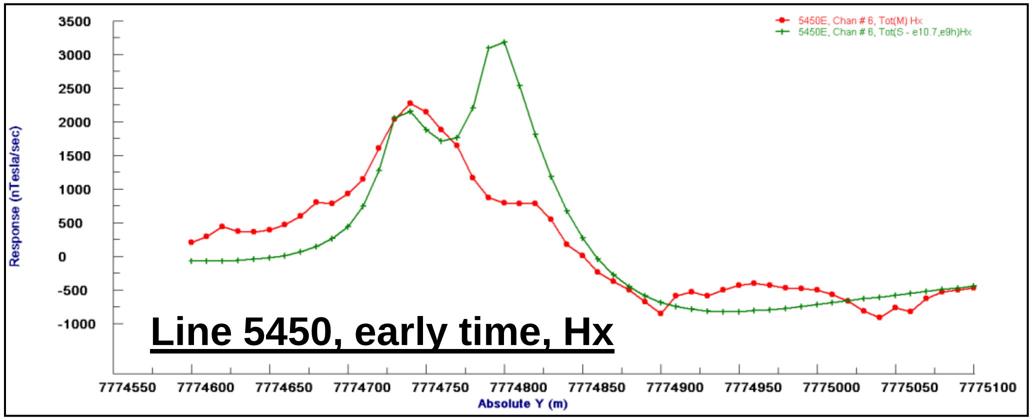
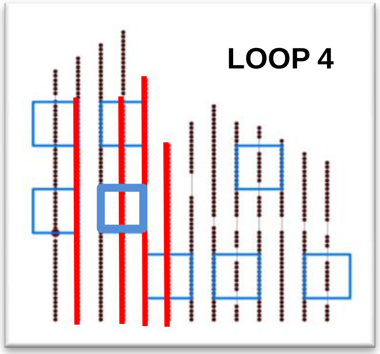


Fig. 28: *Comparison of the Loop 3 model (pg36) response vs. the measured data on Lines 5350E and 5450E for Hz and Hx.*

Measured Data (Hz)
Loop 3 Model

Petros Eikon

2011 Loop 4



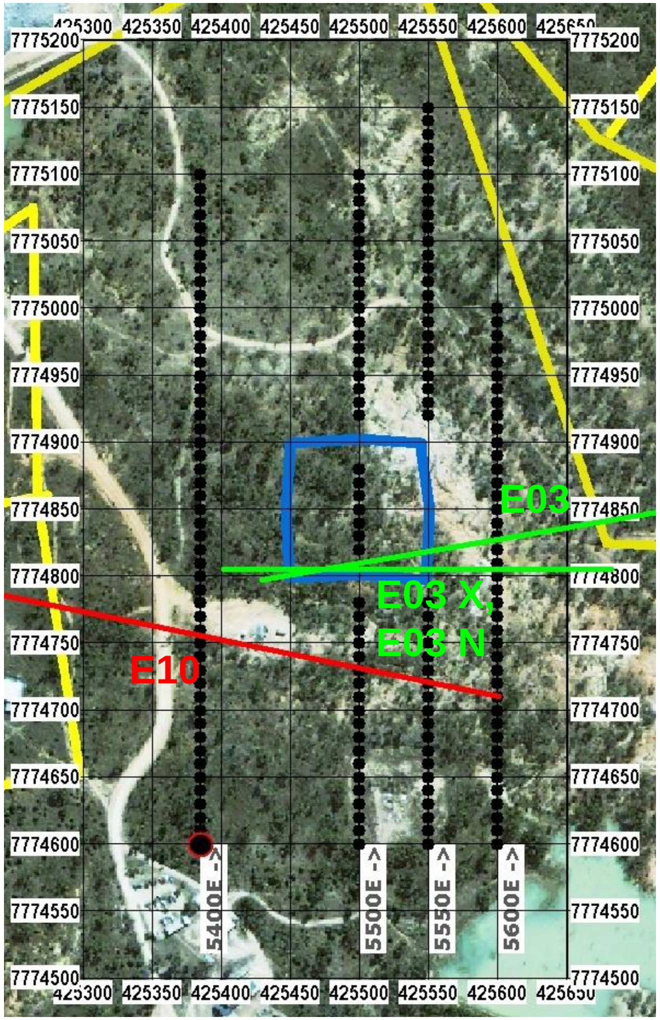


Fig. 29: The model derived from the Loop 4 data. This model consists of 4 structures. The tops of the structures are displayed in the figure.

E10:
Depth to top: 5 m
Dip extent: 500 m
Dip: 65^0 (north)
Conductance: 3S

E03:
Depth to top: 20 m
Dip extent: 200 m
Dip: 55^0 (north)
Conductance: 3.5S

E03 X:
Depth to top: 40 m
Dip extent: 100 m
Dip: 45^0 (north)
Conductance: 7S

E03 N:
Depth to top: 30 m
Dip extent: 100 m
Dip: 45^0 (north)
Conductance: 3S

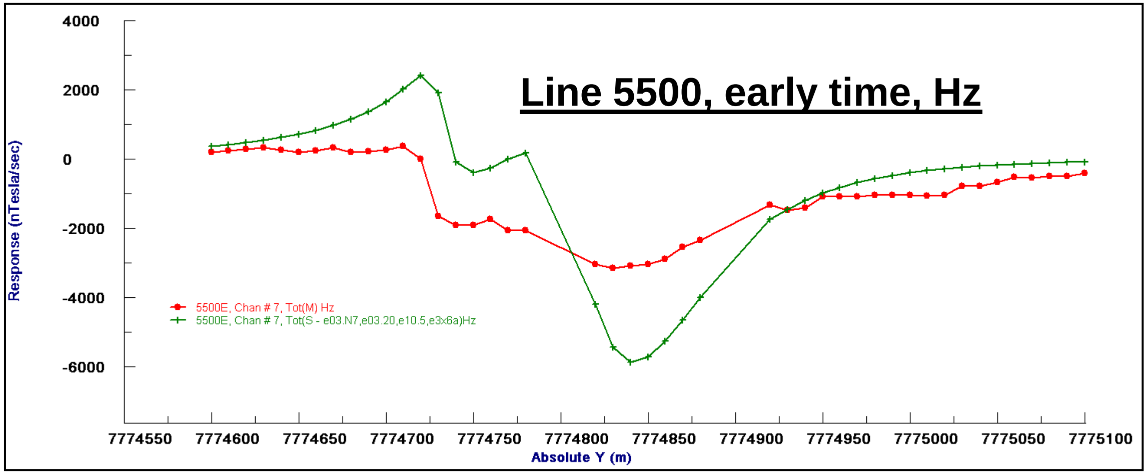
Note: the projection of the top of E03 X and E03 N overlay each other. However, E02 N is 10 m shallower than E03X.

2011 Loop 4

5500E (centre-west line)

Measured Data (Hz)

Loop 4 Model



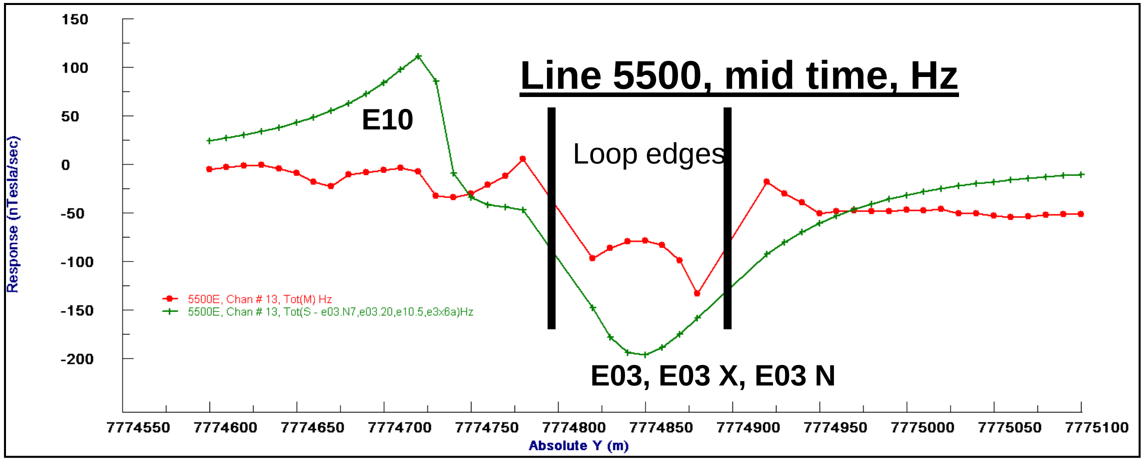


Fig. 30: *Comparison of the Loop 4 model response vs. the measured data on Line 5500E for Hz which goes through the centre of the loop. Early time (Ch. 7) and mid time (Ch. 13) are shown.*

On Line 5500E, a response near the middle of the loop can be observed. Such a response is observed also on the lines that do not pass through the loop at this northing as well. Thus, it is believed that the response in the centre of the loop on line 5500E is not simply the response of the loop, but that there is structure here as well. However, this issue points to later problems occurring in the calibration study carried out by Khumsup the following month.

Interestingly, the sharp response near the edge of the loop is most significant at mid-times, whereas we would normally expect it to be significant mainly at early times. This issue is not yet resolved.

Loop 4

5600E (east line)

Measured Data (Hz)
Loop 4 Model

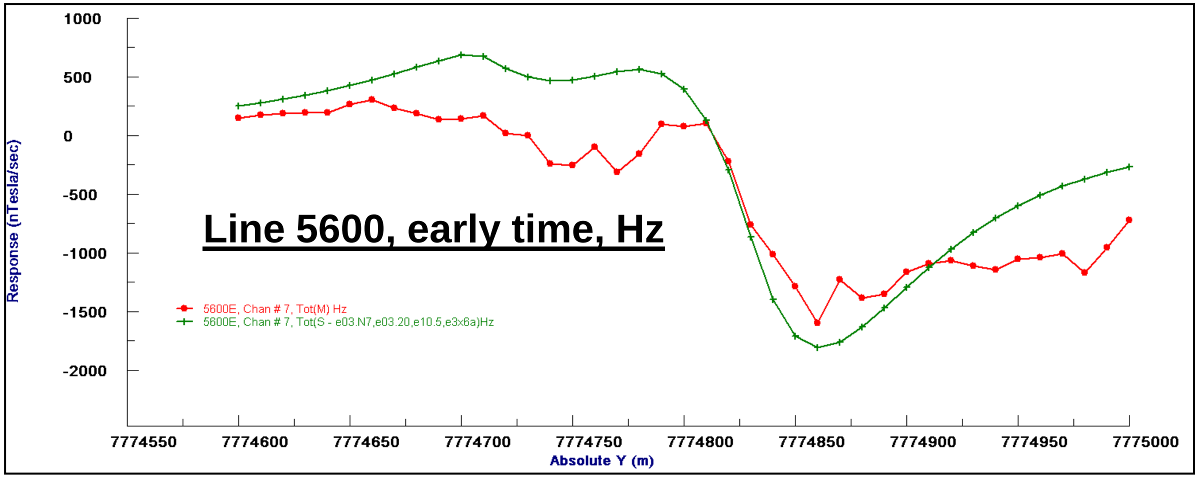
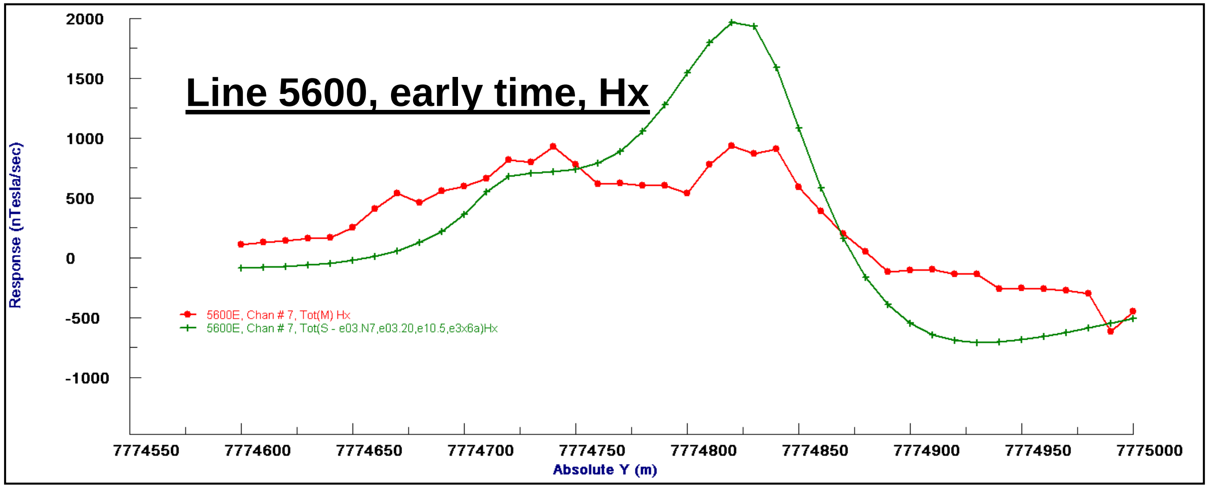


Fig. 31: *Comparison of the Loop 4 model response vs. the measured data on Line 5600E for Hz and Hx. The model explains the main aspects of the response. Line 5600E is immediately east of the loop.*



West Loops, Combined Model

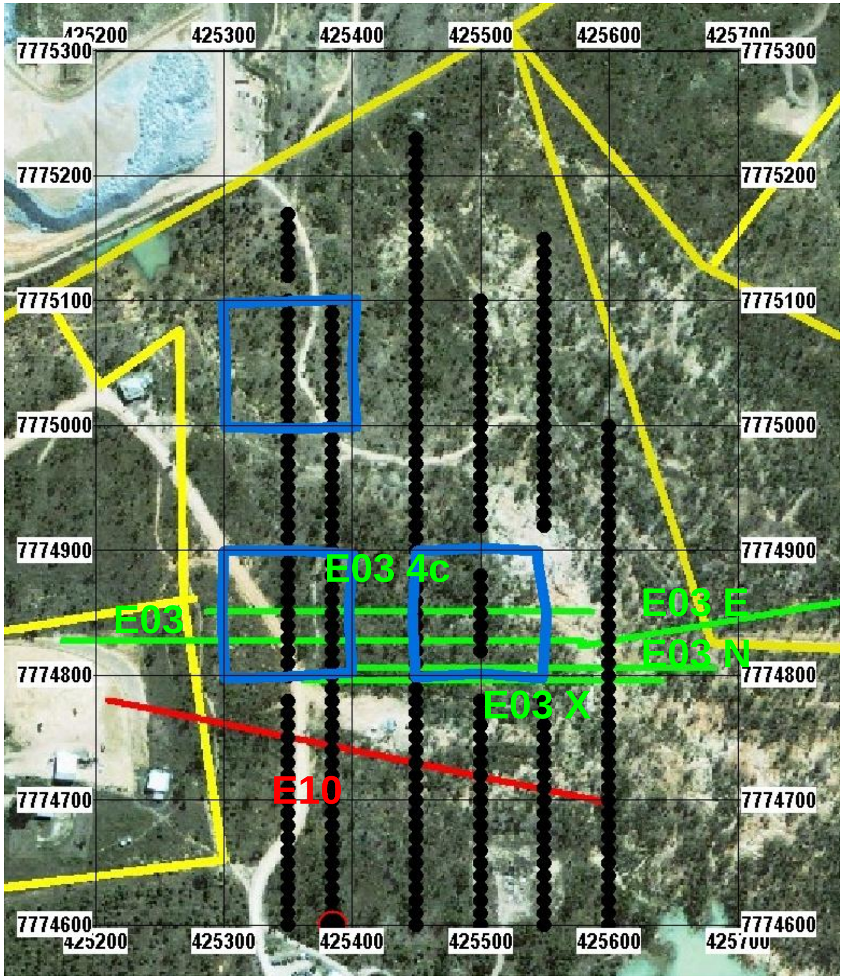


Fig. 32: Combined model of E03 and E10 for the West Loops (1, 3, and 4).

The various substructures of the E03 and E10 models obtained from Loops 1, 3, and 4 data were combined to create a single model.

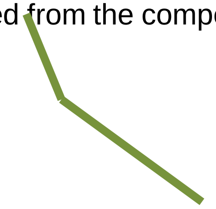
Structures from Loop 1: **E03_4c**

Structures from Loop 3**:** **E10**

Structures from Loop 4: **E03_E, E03_N, E03_X**

Modified structures from multiple loops: **E03**

*Note: At this stage in our modelling, E03 consists of two substructures approximating a bend in the structure. The shallow portion of E03 bends to a deeper portion with a shallower dip. The dip of the deeper portion is consistent with the dip of the surface obtained from the compendium of intersection data.



Combined model

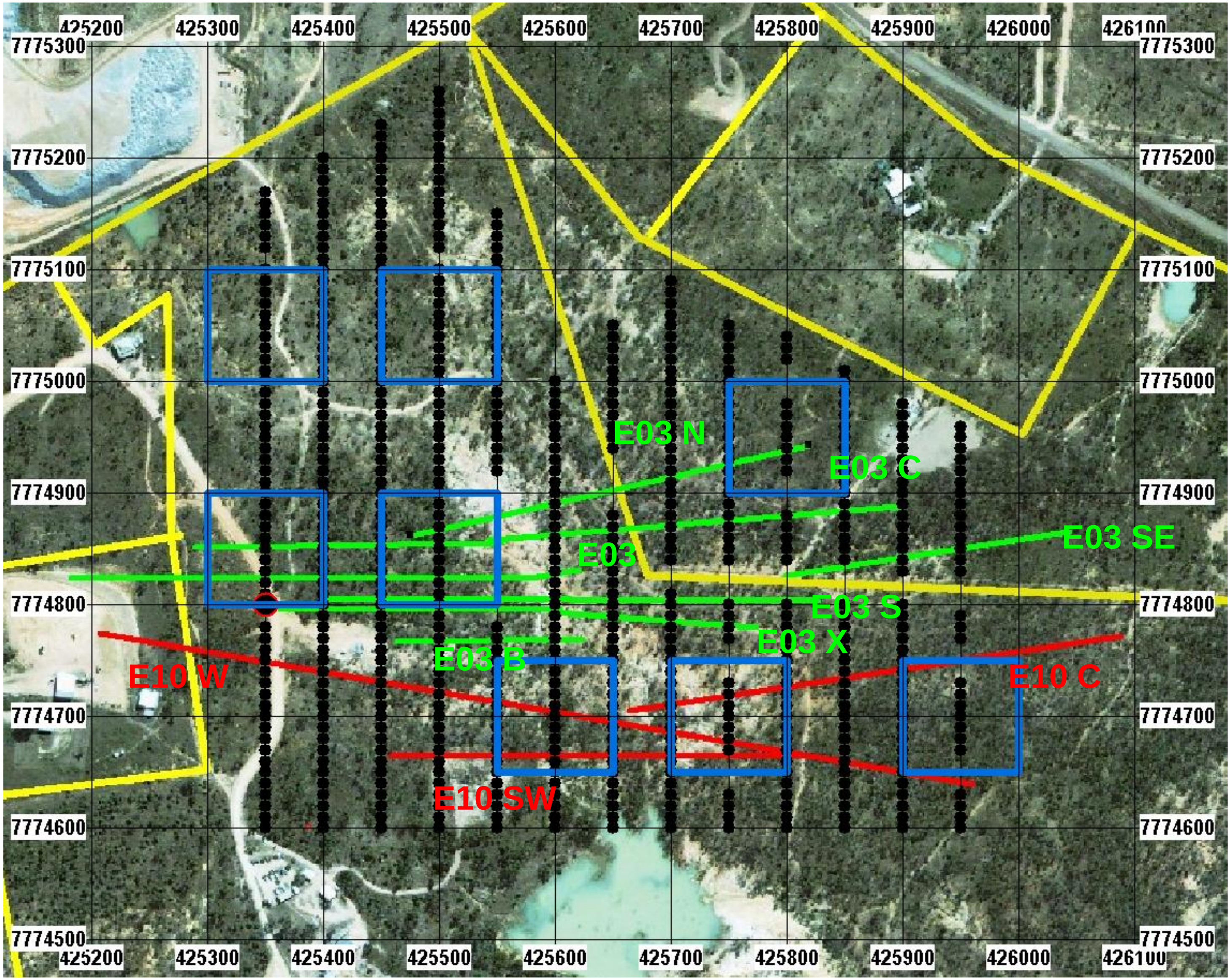


Fig. 33: *Combined model for the West Loops and East Loops of E03 and E10 structures. Locations of loops and lines are shown.*

Some structures that intersected or nearly intersected were thought to be a single structure, and these were combined as follows:

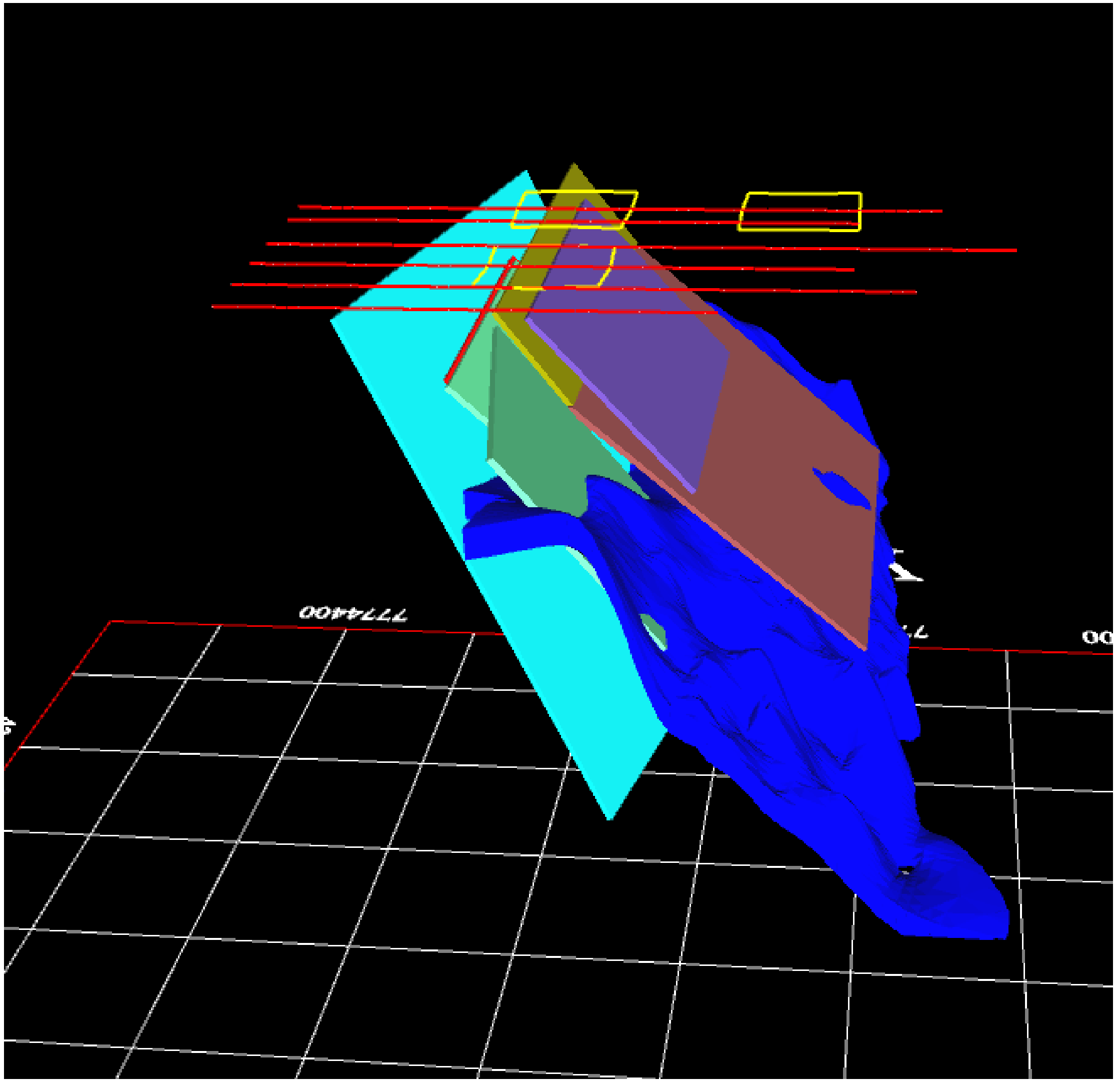
1) E03_4c from the west loops and E03 from the east loops are considered a single structure, E03C

2) E03 and E03E from the west loops are considered a single structure, E03.

3) E03N from the west loops and E03S from the east loops were merged into E03 S.

4) E03X from the west loops and E03C from the east loops were merged into a single structure, E03X.

Combined model



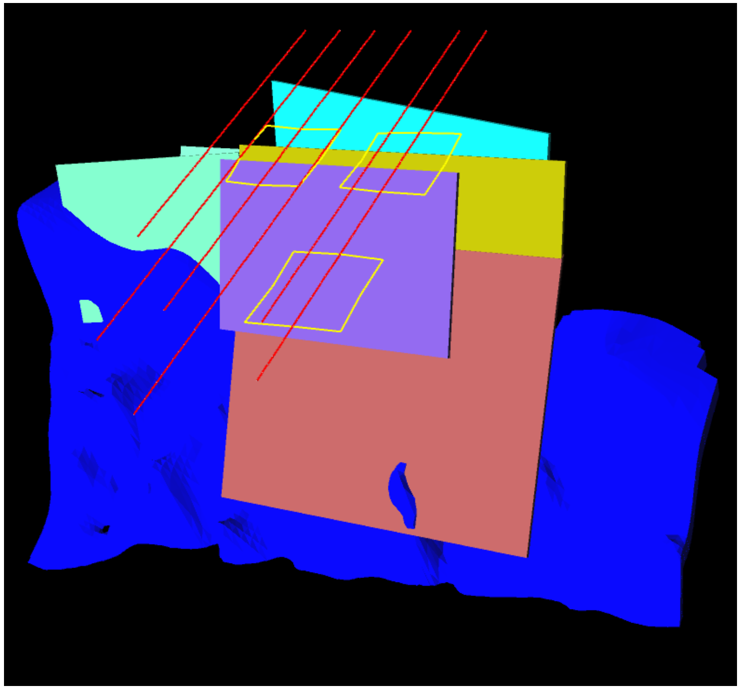
View from the East.

Fig. 33b: *Combined model for the West Loops and East Loops of E03 and E10 structures.*

Locations of 3 loops are shown in yellow and the survey lines in red.

The complex dark blue surface is a surface derived from all the information regarding drillhole intersections of E03

View from the North.



Comments on Depth Extent

In the current model for the East Loops, the E03 structures have dip extents of 150-200 m. Increasing the dip extent increases the late-time response so that it is inconsistent with the measured data. Note: E03 extends deeper for the western loops

→ However, Warrior is known to extend more than 200 m. It is thought that the deeper material could be disconnected from the shallow, there could be variability in the conductivity of the structure with depth, or that deeper, conductive material in the shear zone is disconnected from any conductance at depth.

→ Furthermore, the Loop I data collected in 2010 indicates a dip extent of about 400 m; if the dip extent of the model is decreased, its response does not fit the measured data at mid-times. This is consistent with models from the western loops.

→ The reason for this apparent discrepancy between the large-loop 2010 data and the east small-loop summer 2011 data is not known. Further modeling would need to be performed to understand the dip extent of E03, and whether a model can be found that could explain both datasets.

→ However, following study of the September 2011 data collected by Khumsup, we have concerns about the mid-late time decay of the Crone equipment, as the decays are not consistent between different coils. Thus, we are not sure how reliable these data are. Perhaps the discrepancy between the 2010 and 2011 models is due to issues with the equipment, and a single model cannot be found to explain both the small loop and large loop data.

Modeling – Work still to be Completed

1) Modeling of Loop 7 (furthest east), and integration of the Loop 7 model with the results for Loops 5, 6, and 8.

2) Modeling of Loop 2 data and integration of this model with the results for Loops 1, 3, and 4.

3) Further examination of depth extent, in conjunction with 2010 data.

SECTION III:
SEPTEMBER 2011 (KHUMSUP) DATA

Some of the contents following have been previously reported.

→Summary of data collected

→Summary of issues with Crone data

→ Comparison of response at surface with different coils (both ground and borehole coils)

→Comparison of ORE and Khumsup data for Loop 4

→Comments on Crone's response to data issues

Introduction

Borehole EM should permit better resolution of the structures at depth than surface surveys. This is because the receiver locations are closer to the structures at depth in a borehole and thus theoretically resolve the geometry of structures in more detail. As part of this better resolution, DHEM should allow a more extensive study of the dip and connectivity of structures. Borehole data had been collected with Crone TEM equipment in 2008, 2009, and 2010. However, all the results were inconclusive as of Spring, 2011.

Thus, a survey plan was developed with the purpose of determining why previous borehole data had been of limited use. Seven (7) boreholes were to be read with TEM. In this plan, one of the 2010 holes (3028) was to be repeated with the same loop as used in 2010 to examine repeatability of the data. Three of the seven planned holes were to be surveyed using more than one loop.

Before surveying began in the drill holes, calibration studies were performed on the ground to compare the responses at certain positions using both the surface and the borehole probes in order to better understand the borehole data in relation to the ground data. For the surface data, Crone utilizes a particular design for the coil antennae used for measuring both the vertical and horizontal fields. For the borehole system, there are two coil designs, one for measuring the axial component of the data and another to measure the other two orthogonal components (called here the XY components). Neither borehole coil design is similar to the surface coil design due to limitations on the housing of the probe.

Due to the results of the initial ground calibration, which indicated significant discrepancies in the results particularly in the decay of the data, further unplanned ground calibration work was performed, both in-loop and out-loop. Loop 4 from July 2011 and Loop I from 2010 were reoccupied and data were collected at some of the same stations as utilized by ORE in 2010 and 2011.

Unfortunately, 3028 was blocked as were some of the other planned holes. 749 was read from both Loop A and Loop I. No further borehole data was collected as a result of continuing concerns with the calibration tests and the quality of the 749 data. Communication transpired between Crone and Petros, followed by an in-depth meeting and then further discussions. However, from our perspective, several important issues remained unresolved.

Summary of Data Collected in September, 2011

1) **Loop A: (blue polygon)**

→ Surface coil data collected at 17 stations (red dots) along 5400E. Axial coil data and XY probe (both coils) data were also collected at numerous stations along this line both in-loop (axial and XY), and outside loop (axial and surface only). Many of these readings were repeated on different days.

→ Five stations on 5650E were read with the surface, axial, and X-coil outside the loop.

→ Borehole data was collected in CT749

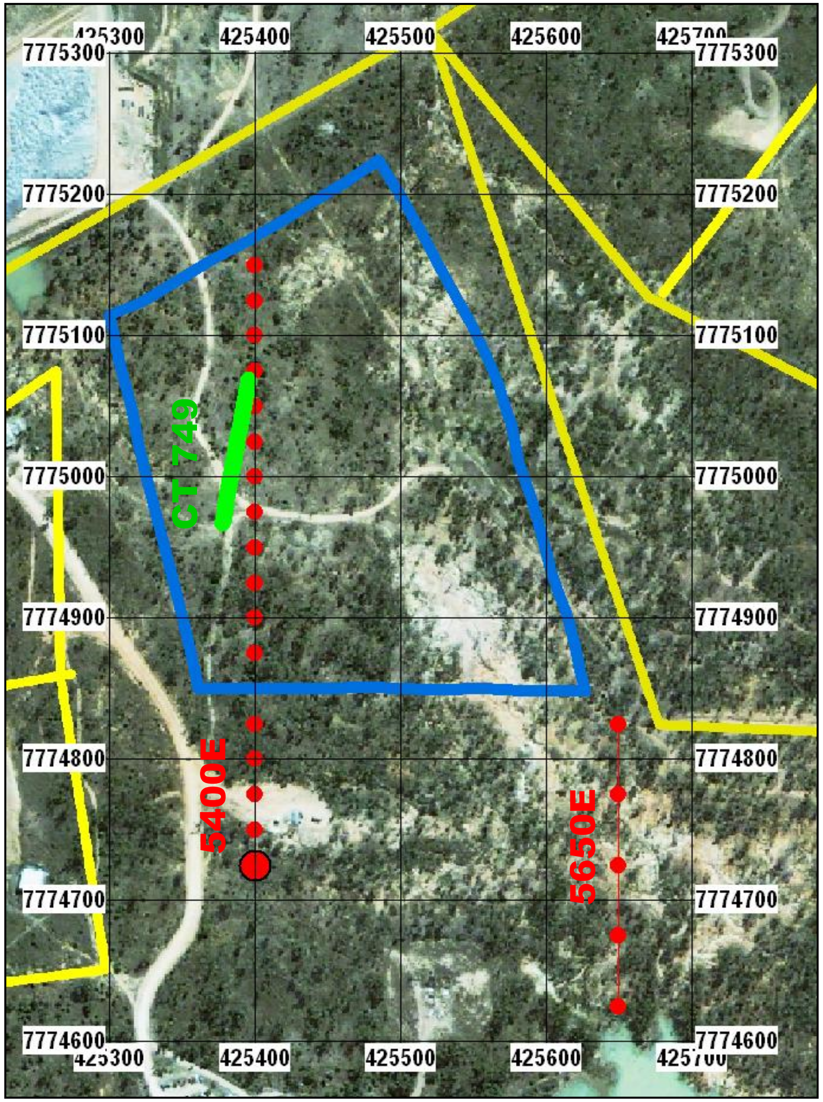


Fig. 34: Loop A and survey lines, September 2011.

Summary of Data Collected in September, 2011

2) Loop I (large loop from Fall 2010) :

→ Vertical surface coil data collected at several in-loop and outside loop stations (red dots) on Line 6050E (initially read in October 2010 by ORE).

→ Vertical axial coil data at eight stations and vertically orientated X-coil data at two stations on 6050E for comparison.

→ Borehole data was collected in CT749.

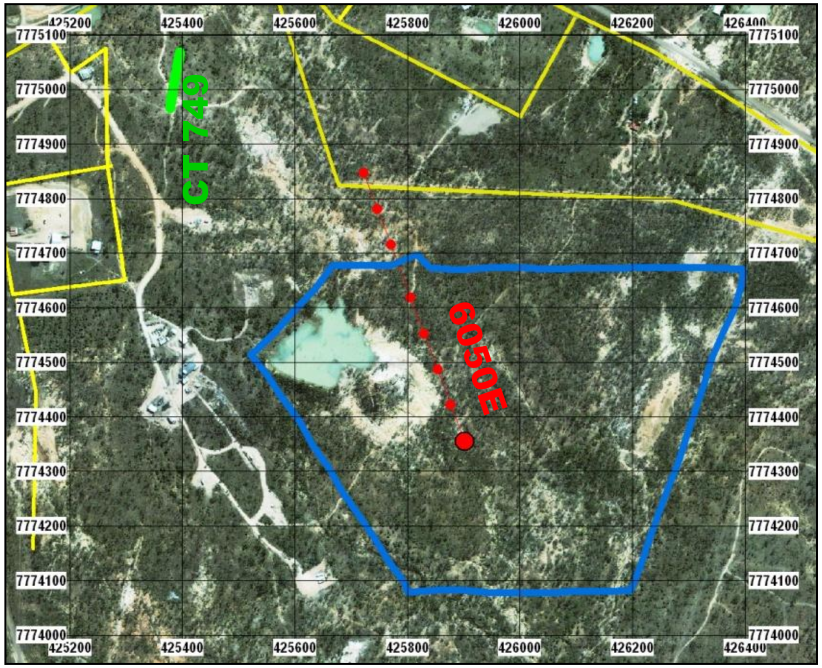


Fig. 35: Loop I and survey lines, September 2011.

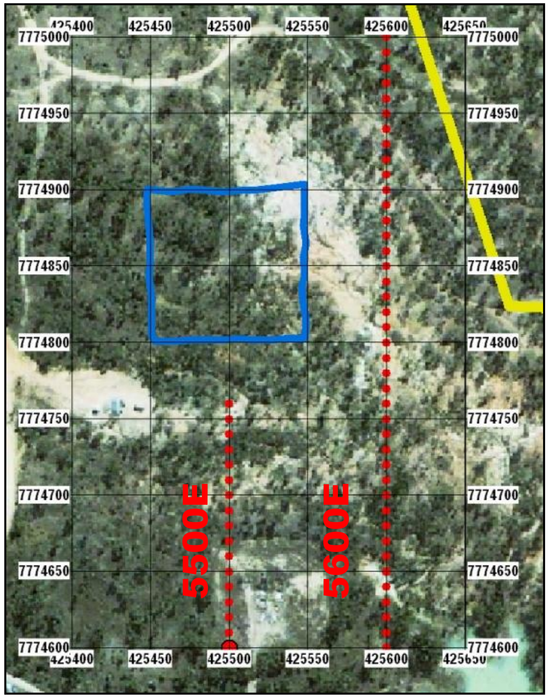


Fig. 36: Loop 4 and survey lines, September 2011.

3) Loop 4 (one of the July 2011 small loops)

→ Vertical component surface coil only: Lines 5500E and 5600E.

All these stations had been read early in the summer by ORE utilizing exactly the same loop position.

Summary of Data Collected (All Loops)

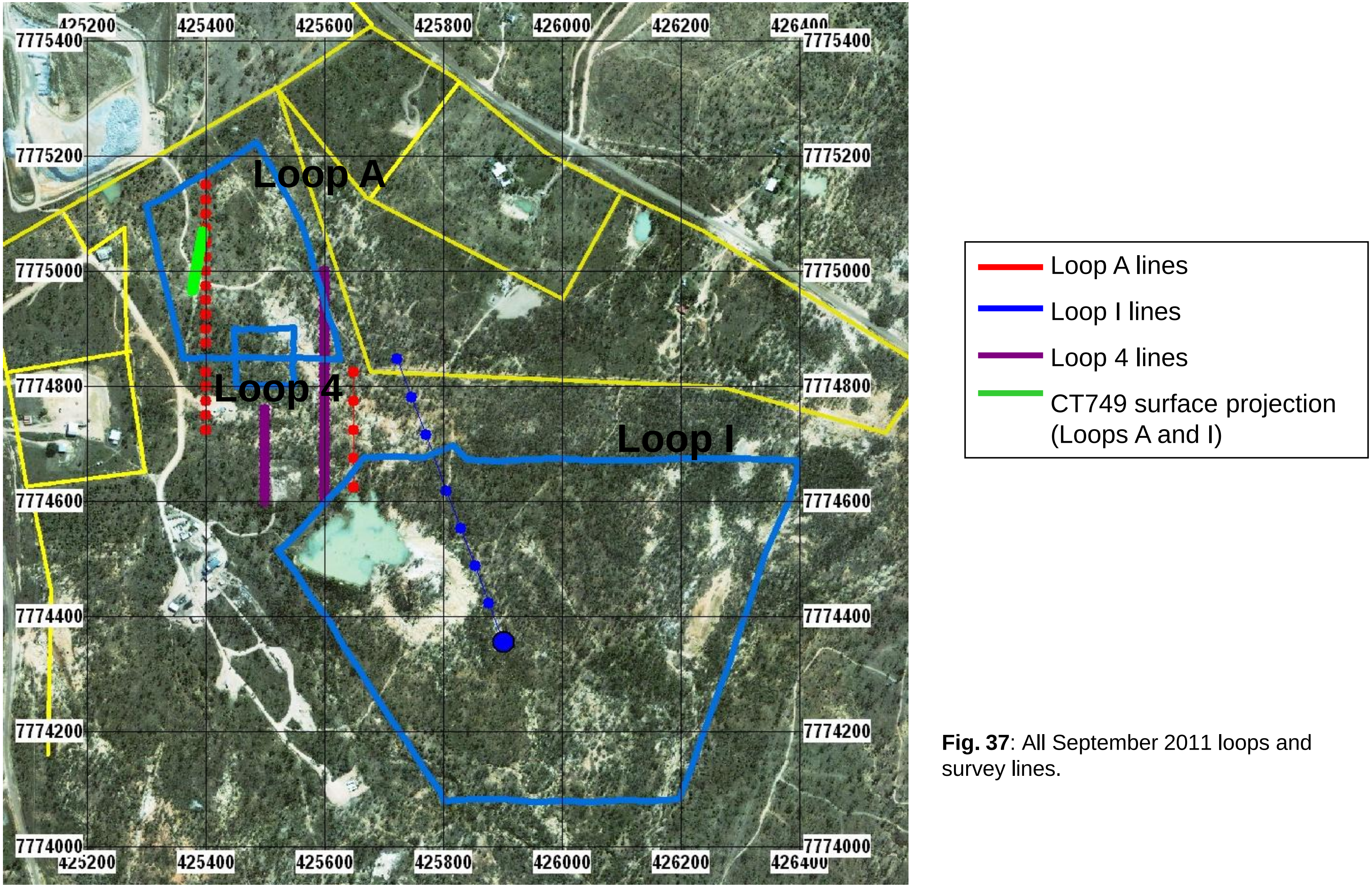


Fig. 37: All September 2011 loops and survey lines.

Summary of Issues with Crone Data

From document sent to Crone in late October

A number of these issues, questioning the reliability of the equipment, we had considered previously. Particularly, during the early months of 2011 when we were studying the extensive data collected in Nov/Dec 2011 in conjunction with earlier data. However, the survey work in September was performed to either prove the existence of the problems or the clarify the issues.

However, a number of other issues were not apparent to us until these calibration studies had been performed.

1) Differences in Decay Rates with Different Coils

Definition: **Decay Rate** *A pulse of current is injected into the loop. Following the termination of this current, currents that have been induced in the ground begin to **decay** in amplitude*.

Summary of Issue: The rate of decay is not consistent when comparing data between axial, surface, and XY BH coils all orientated to measure the vertical component. This effect is significant beyond 0.5 milliseconds (msec) beyond the end of the current pulse. The axial coil has the slowest decay and the surface coil has the fastest decay. X-coil and Y-coil data agree with each other which is expected as the coils are of the same design. These comparisons were performed for the vertical component measured at identical locations on the surface. Differences are much more pronounced inside the loop.

Data Available: 16 stations at which data was collected with axial, surface, and X coil both inside and outside the loop. 11 additional stations with data collected only with axial and surface coils. Two different loops were utilized.

Discussion: This issue is separate from the timing issues between the coils (#2). By late time, any difference in timing has a negligible effect. Nor is it related to the amplitude issues discussed in #3. An amplitude issue would result in a constant multiplicative shift in a log-log plot, but this is not what we observe. We see this problem at all the in-loop stations. Thus, it is not simply an issue of noise at a handful of stations. If it were a tilt issue as suggested by Crone (tilt from vertical in the Rx coil), and the vertically-oriented coil was sensing a horizontal response, we would expect the problem to be worse outside the loop, where the amplitude of Hx relative to Hz is larger. Hy is not very significant here, and so contamination with Hy also would not cause the elevated late-time response in the loop.

This issue is discussed further beginning on page 56.

2) Timing Issues of Data Time Channels

a) Discrepancy in timing between data collected by borehole and surface coils. On each of three days at a single location, APP and PP files were collected with all coils. For this data, the timing of the data for the surface and borehole coils disagree by 0.02 msec on average, even though the same transmitter was used without change to the transmitter settings. The timing of the response necessarily affects our interpretation of the data. Is this issue due to inherent differences in the timing of the channels for the different coils or in the acquisition of the data as performed by the operator?

Data available: At three stations, APP and PP data for three coils were collected on the same day at the same location within a very short time interval of less than 2 hours.

b) Length of Ramp. Although the ramp time in all the data files is stated in the data files as 1 ms (both Khumsup and ORE), examination of the data collected in the APP mode indicates that the ramp is shorter at about 0.92 msec (Khumsup) compared to 0.97 msec (ORE, July). However, surprisingly the amplitude of the response during the ramp is consistent with a 1 ms ramp except for the axial coil data! This aspect has never been explained by Crone engineers.

Data available: These results are consistent over about 30 days of surveying performed by Khumsup and ORE in 2011.

c) Location of the time channels with respect to the times given in the data file. Modeling of the PP and APP files using precise system responses indicates that for the Khumsup surface coil, the channels should be shifted 0.02 msec earlier in time than the channel times in the data file, and that the borehole coil data should be shifted about 0.04 msec earlier in time. (As noted above, there is an average 0.02 msec shift between the borehole and surface coils.) For the ORE data in July 2011 (only surface data was collected), the shift was 0.03-0.04 msec.

Data available: PP and APP data were collected on every day of surveying by both Khumsup an ORE (July 2011). On most days, two PP and PP files were collected.

3) Amplitude of Axial Coil Data

Summary of Issue: XY coils and surface coil data agree reasonably well in amplitude during the current pulse and in early time when measuring the vertical component on surface. However, the axial coil data is 23% larger on average. It varies from 22-25% larger over two loops over four days. When Crone processed the borehole data for Khumsup, they decreased the amplitude of the axial coil response by 10.0%, which was supposedly based on previous processing experience with Khumsup's probe.

Note that with a drop of 10%, the data collected with the axial coil both in-hole and at surface agree reasonably well with the theoretical freespace response using a ramp of 0.92 ms rather than 1 msec. This 10% decrease does not account for the entire discrepancy between the axial and other coils. With the other coils, the theoretical freespace response using a ramp of 1 ms better fits the data than with a ramp of 0.92 msec.

Data available: These observations were made at 19 stations for all three coils and an additional 11 stations for the axial and surface coils only. These readings were performed using two loops.

Discussion: Crone has said that this effect may be due to the operator entering the incorrect effective area. However, this would have to have been done consistently over several days of surveying, and indeed over several surveys according to their comments on the historical amplitude of this probe. This would more likely imply improper calibration of the axial coil. Note that the amplitude cannot be caused by tilt as suggested by Crone as this effect is not random and it is unlikely the level bubble is the cause of the problem. Also, the vertical component is a fair bit larger than the horizontal coils inside the loop.

It is curious that the correction to the amplitude applied by Crone was 10% as this is only about half the difference in amplitude between the axial data and the data from the other coils when the vertical component is collected on surface. However, with this adjustment in amplitude, it does match the freespace response for a ramp of 0.92 msec. Is this how Crone determined the amplitude correction? They have not explained this aspect.

4) Late-Time Anomaly in Loop 4 Data

Summary of Issue: Khumsup (Sept 2011) and ORE (July 2011) data do not agree for Loop4 (100 m x 100 m shown previously). Agreement is not significantly poor at early time but very significant from mid-time to late time which are times of most significant in determining the structure at depth. Note that there are no significant weather variations between September and July. Also in should be noted that comparison of data on a larger loop shows no such disagreement.

Data available: Vertical component on 28 stations on line 5600E, which is 50 m east of the loop. These were collected on a single day by each of the survey companies. Additional data are available on this line and on one line further west, but were not collected on the same day. Disagreements are similar on the other line.

Discussion: Khumsup's data exhibit a very slow mid-late time decay. This slow decay is unexpected given what we know of the geology and all the previous data collected at the site. The peak of this slow-decay anomaly is, interestingly, centered at the same northing as the center of the loop. We believe the Khumsup data is incorrect but it could be argued that it is due to operator error or cultural noise. We believe it is unlikely due to cultural noise as we have not observed these effects in previous surveying and know well the source and characteristics of cultural noise at the site. Khumsup's explanation of the present of a fence is inconsistent with the actual fence locations and the fact that ORE had no such problems.

This issue is discussed further beginning on page 66.

Coil Comparisons for Loop A

From: Crone_data_issues.pdf (Oct-Nov, 2011)

COMMENT to Crone Management (November, 2011):

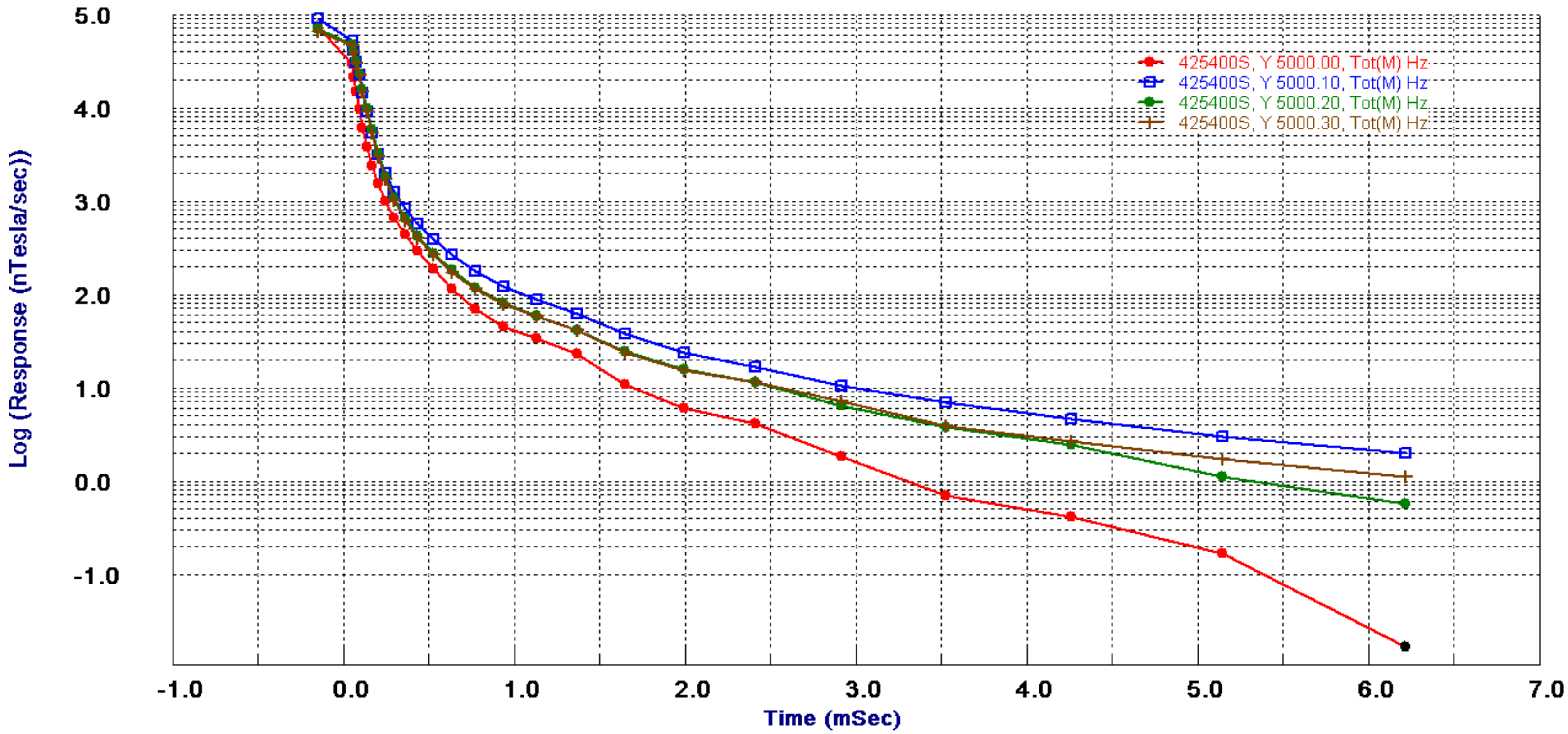
This is by no means a complete list of data issues. But, as far as we can determine, these results appear to indicate that none of the data collected by Khumsup can be used for the exploration purposes of the client. And indeed, without further calibration against other EM equipment, all of the borehole data collected by ORE in the last few years for this client may have to be negated. The surface data collected by ORE we believe is more accurate but still may not be of very high accuracy.

This is no small matter as it encompasses several hundred dollars in TEM survey costs to our client, CitiGold. plus thousands in interpretation costs. Plus, it effects millions of dollars of funds raised from investors and JV partners on the project.

I urge you to take this matter seriously and not as in your response of last week.

Again, these are just the beginnings of the issues that we have but they effect not only this client but other clients for whom we have been sub-contracted to perform modeling and interpretation.

Fig. 38: Comparison of measured data obtained with the surface coil and three borehole coils at (5000N) inside a loop of approximately 300 x 300m. The basefrequency is 25Hz basefrequency.



This figure summarizes the in-loop data using the different coils at exactly the same station on the same loop and the same day utilizing all 3 coils orientated to collect the vertical component. All used two 2048 repeat stacks. Data is generally very repeatable with 2048 stacks and between stacks.

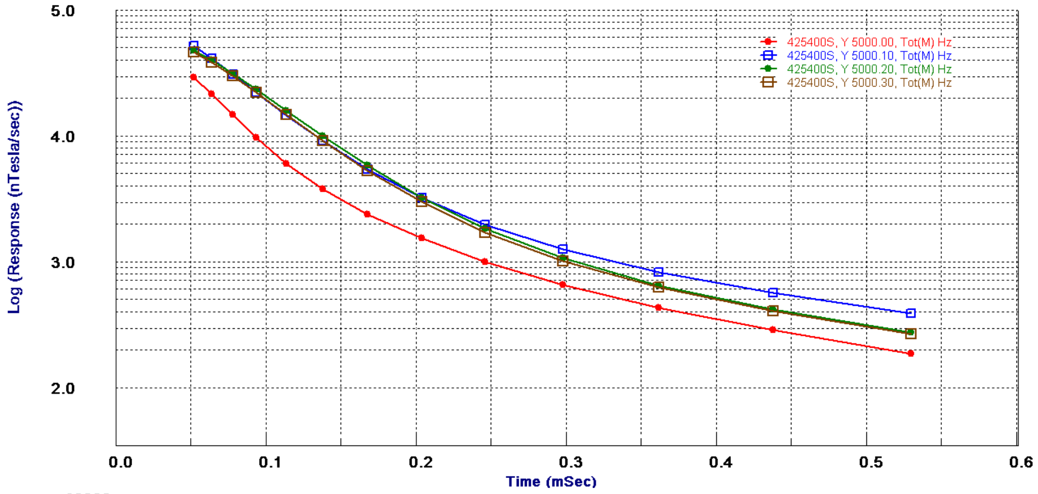
- Surface Coil
- Axial Coil
- X Coil
- Y Coil

One observes dramatically different responses between the coils beginning at 0.5msec on this figure which shows the entire decays. The XY coil responses indicate the general level of cultural noise after stacking.

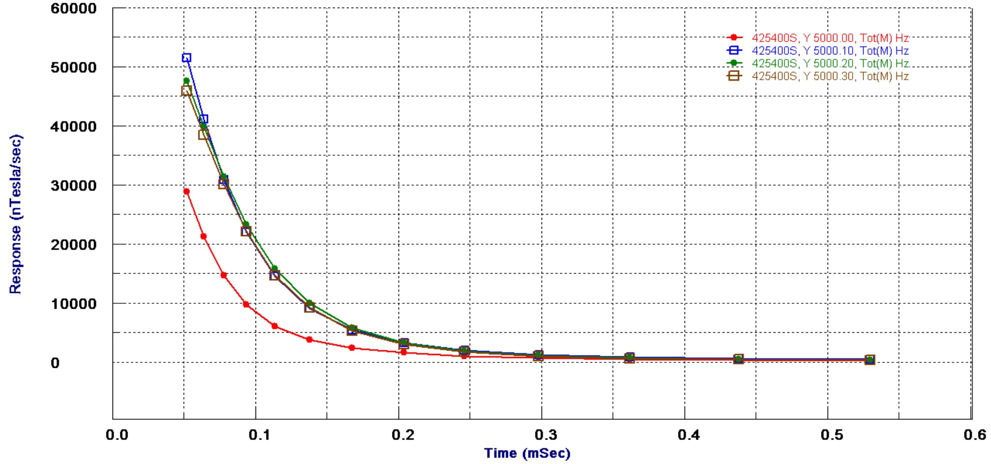
Note 1: While further figures indicate that there are timing variations between the different coils, these timing variations have a negligible effect on the data comparisons after 0.5msec

Note 2: These measurements were repeated for approximately 8 stations within the loop. The results are extremely similar at all stations. Thus, it implies not a random effect but rather an general instrument effect.

Fig. 39: Focus on early off-time data from the previous figure



Log amplitude



Linear amplitude

Surface Coil
Axial Coil
X Coil
Y Coil

A comparison of data between 0.0 and 0.6 ms (Channels 2-14) is shown.

Again for this figure, there have been no timing shifts for the different coils. The data compares adequately for the X,Y and axial coils until 0.25msec but then the axial coil begins to dramatically diverge from the XY data. Without a time shift on the surface coil, the surface coil would produce about 50% of the response of the other coils.

Shifting the timing of the channels:

The standard PP data which collects data at the very end of the ramp into the early offtime at first appeared useful to represent the waveform and the timing. However, we soon learned that the results could be ambiguous as the ground response was significantly affecting these PP files even though this environment is generally resistive granite with only a very thin weathered cover of less than 0.5S.

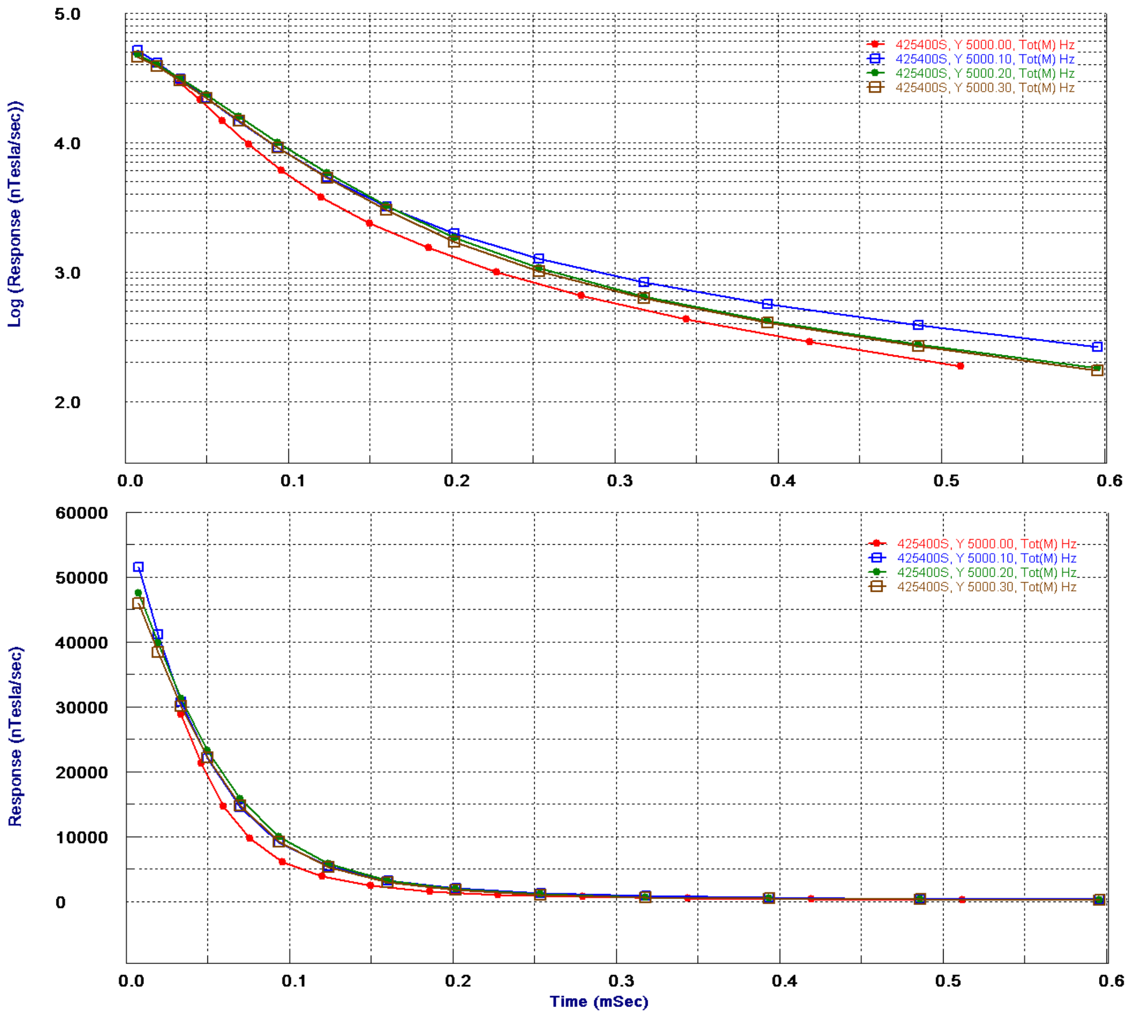
The ORE operator was sufficiently experienced to offer us varied PP files and we eventually came to collect PP files which sampled evenly from just before the beginning of turn-off out slightly in the off-time. These we term the APP data.

Both PP and APP files were collected using various coils, orientations, surface and downhole. Typically, at least 1 PP and APP data setup was repeated at the beginning and end of the day to examine instrument drift during the day.

As there is no explicit impulse response information for the different coils, we attempted to shift the data in time according to these (PP and APP) data files and adjust the instrument bandwidth to fit the data. The contractors apparently have little or no idea of the important technical specifications to accurately simulate the data. It should be noted that the client's objective is to image weak conductors within the resistive granite.

Generally, the weather was dry but warmed up somewhat during the day which could affect instrument drift.

Fig. 40: Early time data: Time shifted same data from the previous figures



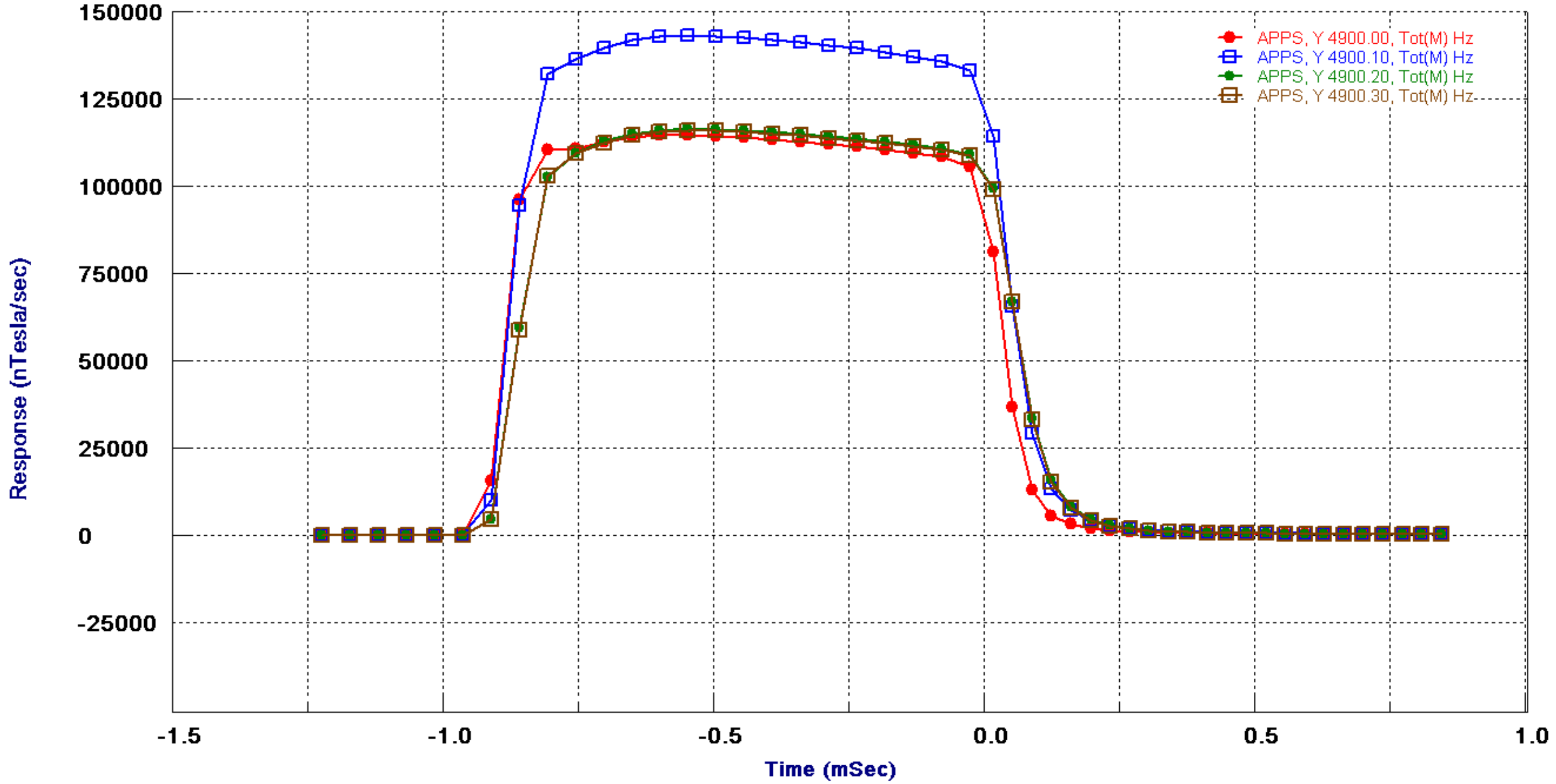
Surface Coil
Axial Coil
X Coil
Y Coil

The windows have been shifted earlier in time on the basis of the PP (primary pulse) and APP (augmented primary pulse) files. The surface data have been shifted 0.018 ms earlier and the borehole data (XYZ) have be shifted 0.044 ms earlier in time.

The time shift for the 3 borehole coils appeared to us to be very similar as determined from their PP and APP files and thus was taken here to be 0.44ms. The surface coil data was shifted early by 0.018msec. These shifts bring the very early time responses for all 4 coils to be somewhat comparable but certainly not as comparable as other such calibrations we have performed with other instruments. However most importantly, the surface coil response begins to divert dramatically from the others at only 0.05msec. This is one of the features that causes us to question the validity of the borehole data.

Augmented PP (APP) data.

Data collected on the same loop with the same settings inside loop at 100m from the previous data.



Surface Coil
Axial Coil
X Coil
Y Coil

Fig. 41: Comparison of APP (augmented primary pulse) files for the different coils at a single station (4900N) inside the loop. Here, the axial/surface) ratio is 1.25 in the middle of the ramp, which is a typical difference as we have observed in amplitude. This ratio was found to vary only slightly at all the stations performed with this loop but also at a number of other stations during the almost 2 weeks of surveying.

It should be noted that the arbitrary shift of the borehole data by 10% as done by Crone, is not validated by these surface calibration measurements.

Analyses of System Response as depicted by the APP data via the use of data Simulation.

Note: The system response is represented theoretically by linear ramp turn-off with a finite bandwidth from the fundamental to as estimated upper frequency as determined from iterative tests from large amounts of data. However, unlike for other instruments, we do not have impulse responses for the coils nor information of lowpass filters or the filtering effects of amplifiers. Apparently, Crone is not generally requested for this information from the clients of the data.

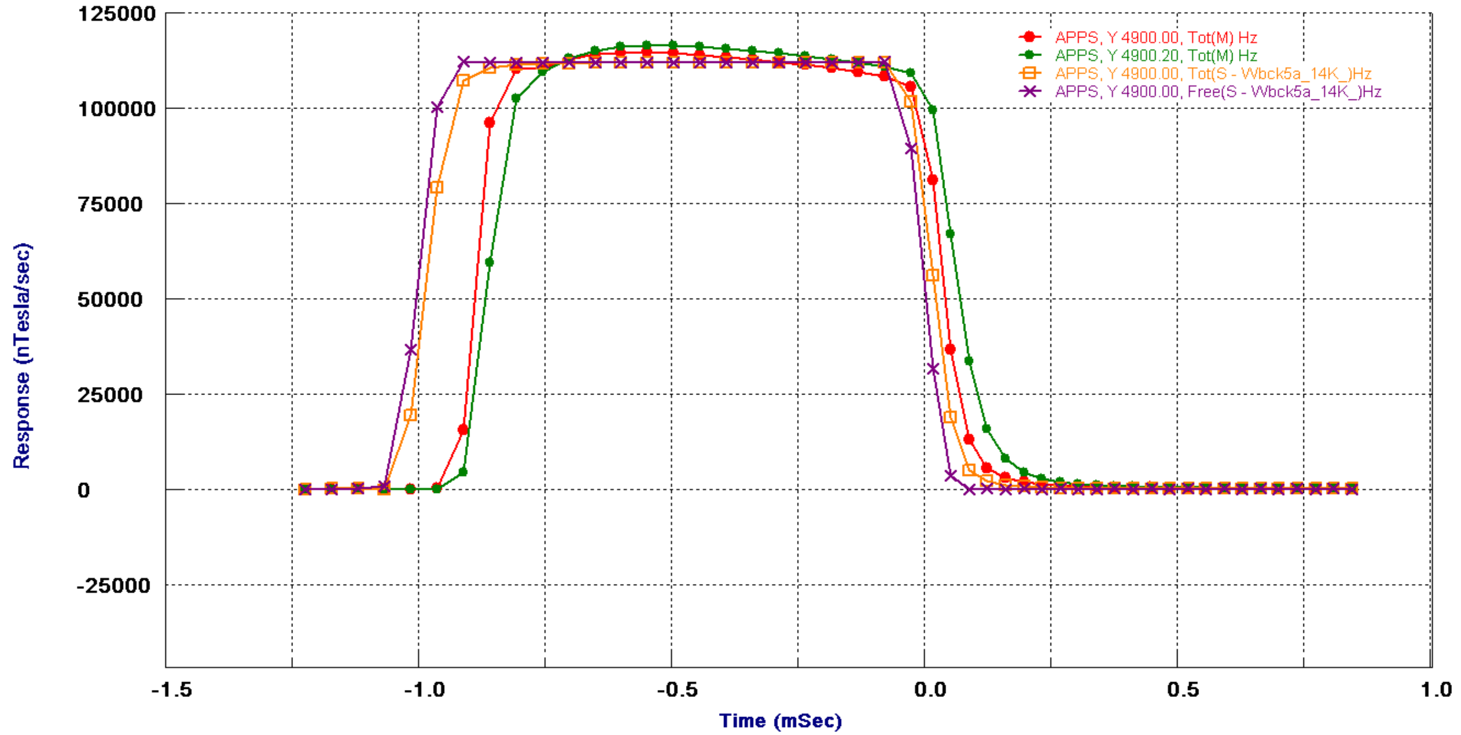


Fig. 42: APP files vs. simulated response with a 1 ms ramp. Initial time channels.

- Surface Coil
- X Coil
- Background simulation
- Freespace simulation

For the simulation, a 1 ms linear ramp was used as indicated by the operator and the data file although this clearly from the results as illustrated in this figures must be adjusted. While a 1ms ramp gives approximately the correct amplitude, the beginning of turn off is approximately 0.1msec later than anticipated. The turn-off is clearly parabolic rather than linear. No timing adjustments were made. The upper bandwidth for simulation was set to 14 kHz.

Analyses of System Response as depicted by the APP data via the use of Simulations.

- Surface Coil
- X Coil
- Background simulation
- Freespace simulation

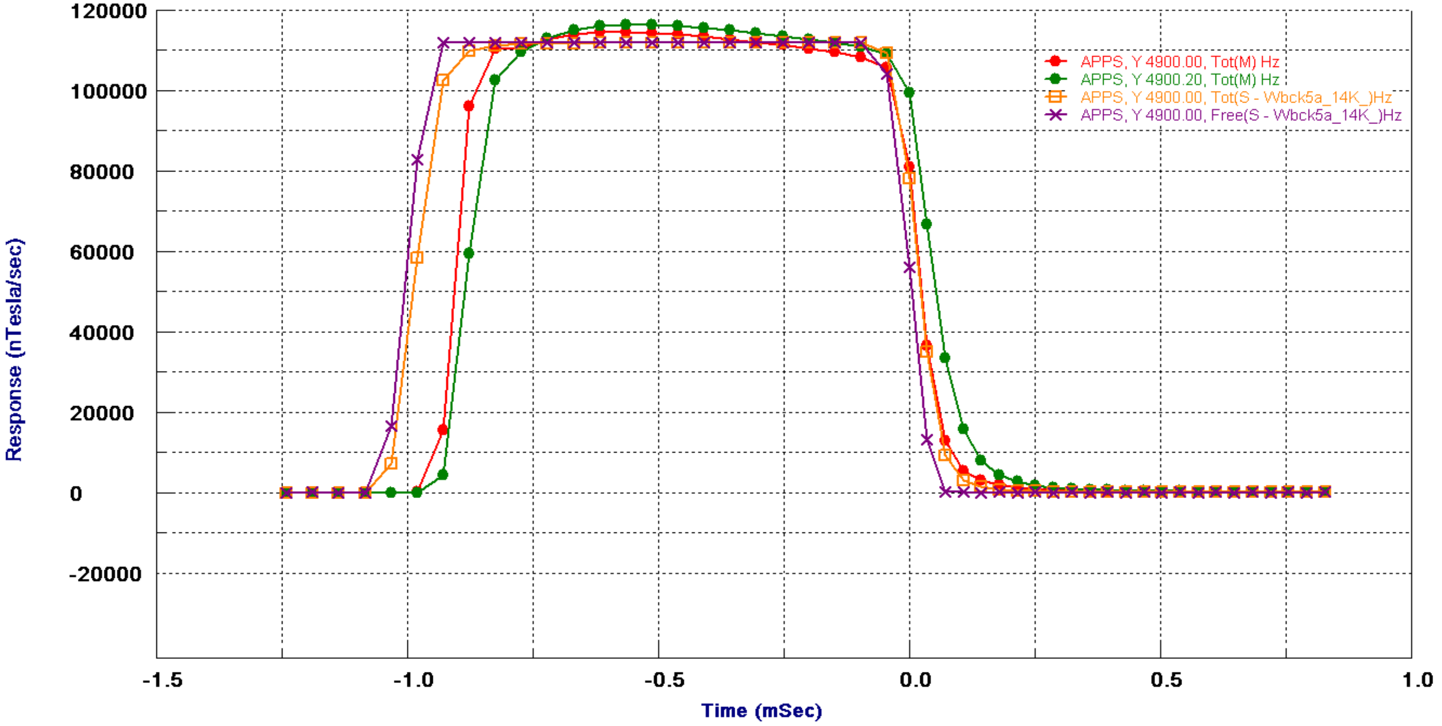


Fig. 43: APP files vs. Simulated response using a 1 ms ramp. Shifted time channels.

For the simulation, the time channels were shifted 0.018 ms earlier than indicated by the system specifications for both the surface and the downhole XY coil. The upper bandwidth was set at 14 KHz. The turnoff was set as 1msec to match the amplitude although not matching the beginning of turn-off. The Model – wbck5a_14K matches the surface data using data collected near the end of turn-off into the offtime. To match the XY coil response a shift of 0.046msec would have to be made.

Clearly, what is required is

a) A better description of the current waveform and in particular, the curvature in the turn-off. We understand that this curvature is difficult to see on an oscilloscope but as can be seen in the APP files, the curvature definitely there exists as seen during the pulse time as well as the early off-time.

b) An explanation as to why the amplitude during turn-off matches the displayed turn-off on the instrument but not the observed turnoff time which is evident from the beginning of turn-off in APP data to the end of turn-off.

c) An explanation, as to how the various coils have been calibrated, their effective areas and their impulse responses.

d) How indeed can the borehole data be used given the dramatically different characteristics of the data collected by the different coils?

e) Is the surface coil data correct as it differs dramatically from the data from the other coils?

Loop 4 Comparisons

From: Crone_surface_comparison.pdf

Survey Layout

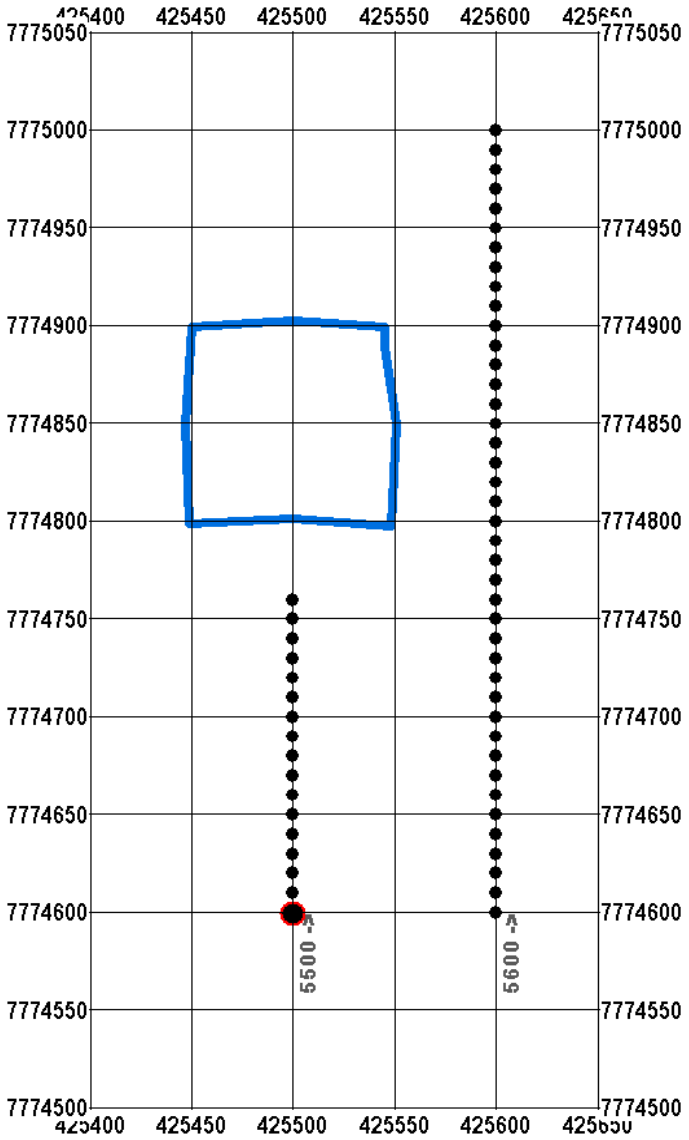


Fig. 44: Loop 4 survey, September 2011.

Data were collected for the same two lines using the same loop both by ORE and Khumsup. This report presents a comparison of the data as collected by the two operators.

Loop: 100 m x 100 m

Base frequency: 25 Hz

ORE data: July 2011, 2 x 2048 stacks, 20A

Khumsup data: September 2001, 1 x 4096 stacks, 17A

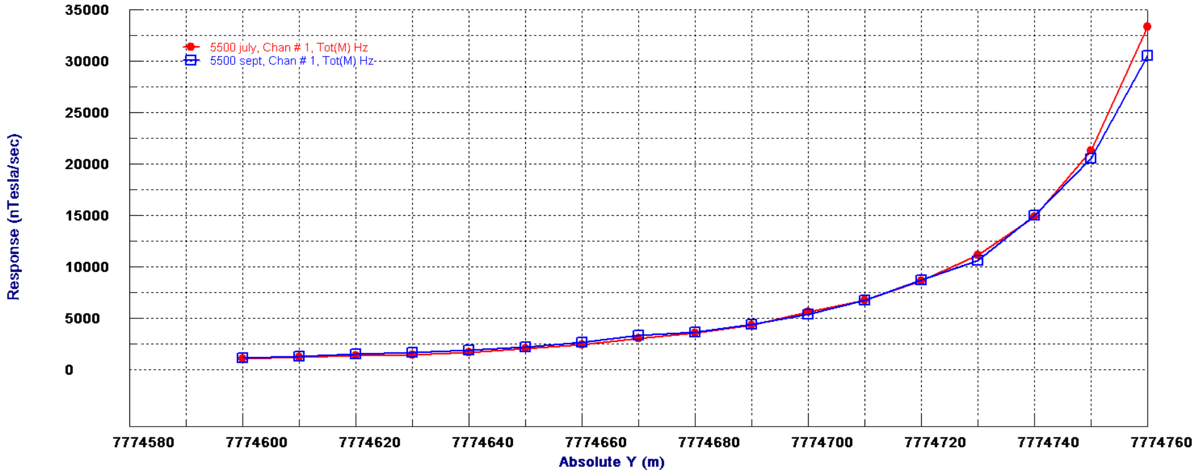
*Note: For comparison, the ORE data has been normalized to a current of 17A.

Data should be proportional to current so such a multiplicative factor should produce very comparable results.

Comparison of Channel 1 Hz (vertical) data

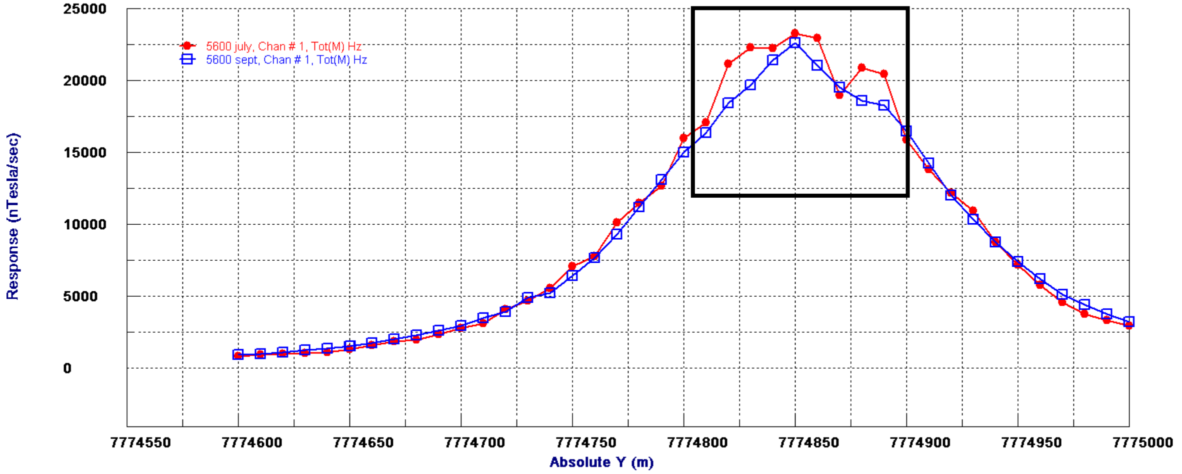
Line 5500E

Channel 1, Hz



Line 5600E

Channel 1, Hz



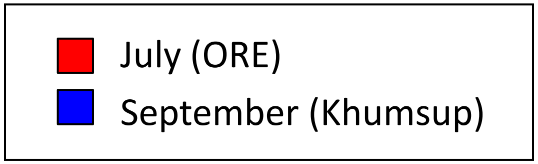


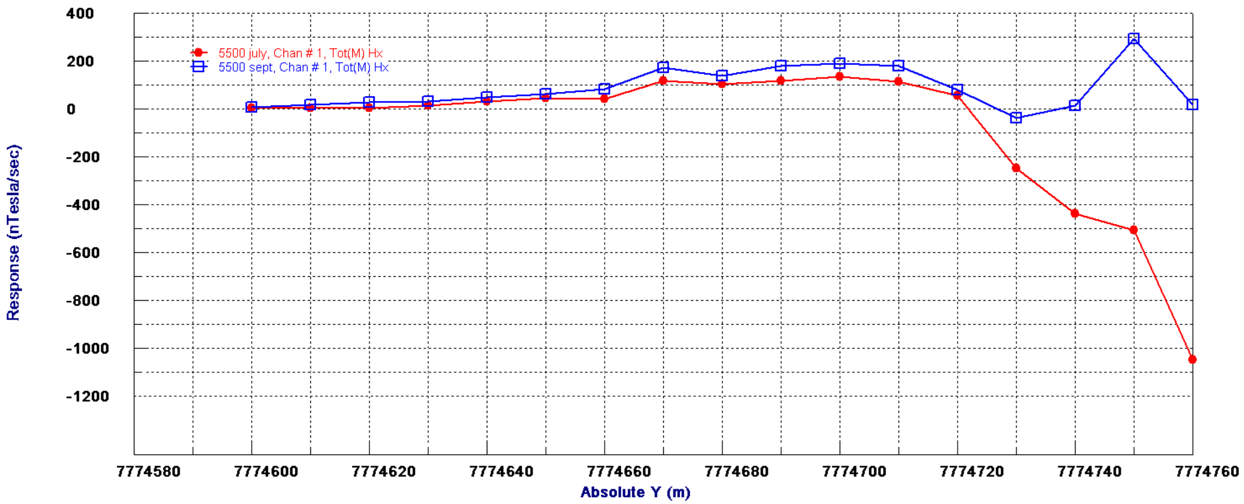
***Fig. 45**: Profile response at Channel 1 for Lines 5500E and 5600E, Hz: comparison between ORE and Khumsup data.*

Channel 1, Hz agrees reasonably well for the ORE and Khumsup data. There is a slight difference in the details of the response in the middle of Line 5600E. The reason for this is not known.

Channel 1 Comparison (Hx) Horizontal

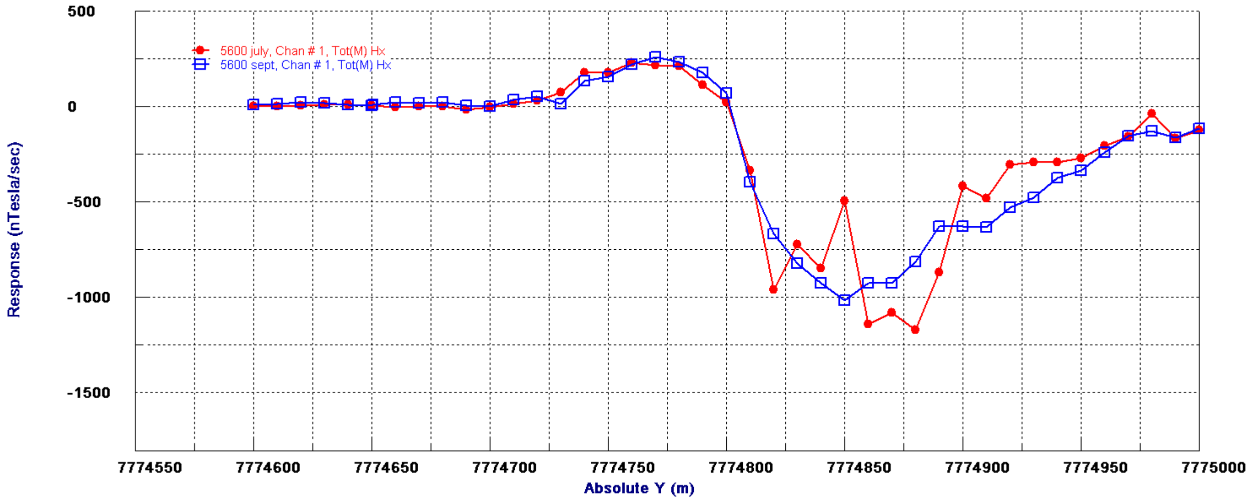
Line 5500E

Channel 1, Hz



Line 5600E

Channel 1, Hz



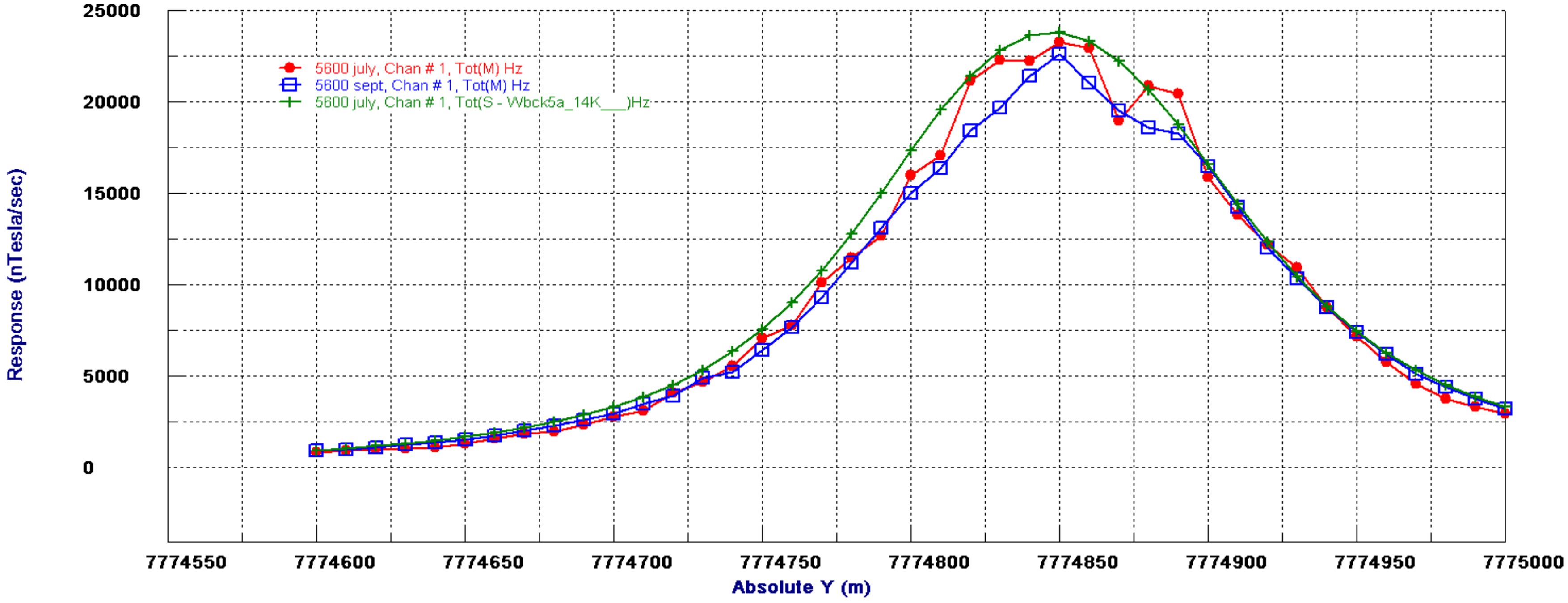
July (ORE)

September (Khumsup)

Fig. 46*: Profile response at Channel 1 for Lines 5500E and 5600E, Hx: comparison between ORE and Khumsup data.*

Channel 1, Hx does not agree as well as Hz. This may be in part due to levelling issues. However, the general profile response is similar. Leveling issues are either due to operator carelessness or the inaccuracy of the level bubble.

Channel 1 (On-Time) Simulation (Hz) Comparisons– Line 5600 E



July (ORE)

September (Khumsup)

Background Model Simulation

***Fig. 47**: Profile response at Channel 1 On-time for Line 5600E, Hz: comparison between measured data (both ORE and Khumsup) and background model simulation.*

The measured data agree with the general shape of the simulated response along the profile, although there are some differences, especially between 7774700 and 7774900, with the simulation generally larger than the measured data particularly for the September data. As noted previously, the two measured datasets differ somewhat near 7774800-7774900. However, they agree better between 7774700 and 7774900, but both are smaller than the simulation. Generally, the on-time response is simply the freespace response which implies a system response variation at these stations.

We are not sure of the reasons for the discrepancies. We simulated the response for the 3D targets we expect at this site, and these targets do not affect the on-time response. Thus, we believe that the differences between the measured data and simulation is not due to structure. We have not examined the effect of topography. This may possibly explain some of the discrepancy between the simulation and the data, although it would not explain the differences in the two measured datasets.

Overall, while there are minor differences between the two measured datasets at channel 1, and between these datasets and the simulation, the general responses agree, and do not give us any major cause for concern.

Channel 4 (Hz) – Line 5600 E

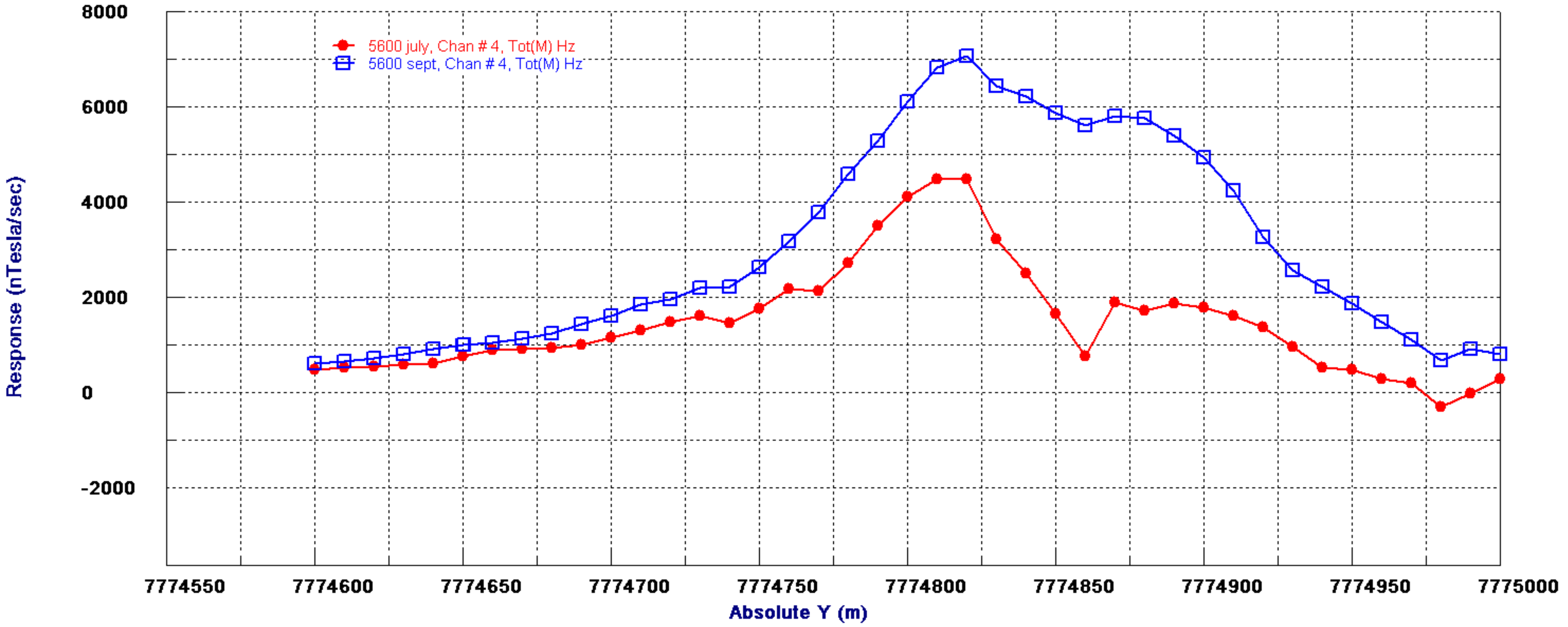


Figure 48: Line 5600E, *Channel 4 Early Offtime, Hz. Comparison of ORE and Khumsup data.*

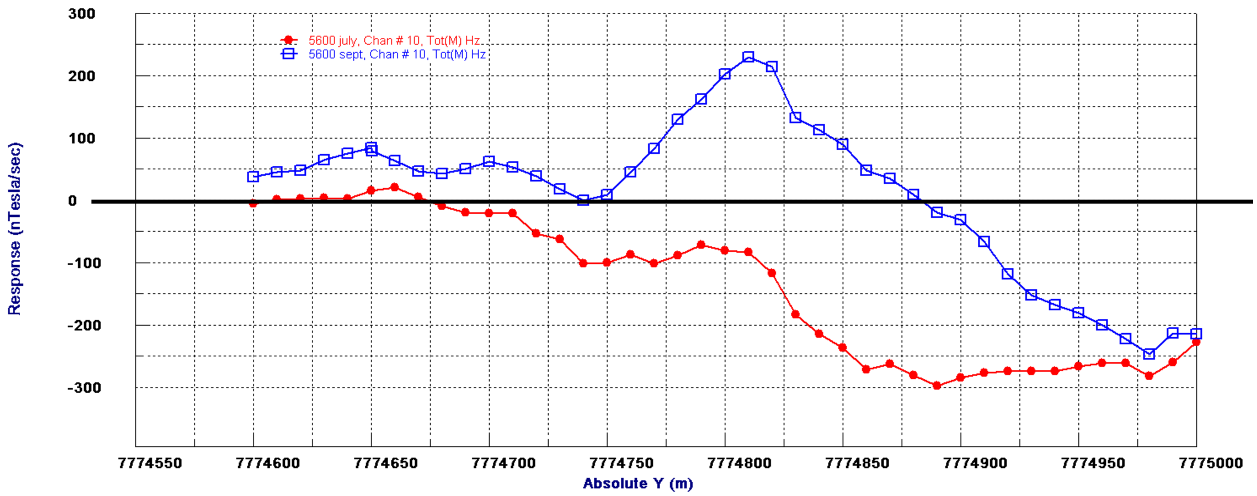
July (ORE)
September (Khumsup)

By Channel 4 during the early offtime, there are greater differences between the two measured datasets than at Channel 1, with the Khumsup data having a greater amplitude at all stations. This is particularly apparent in the middle of the line (*e.g. 7774800*).

Channel 10 Mid-Time– Line 5600 E

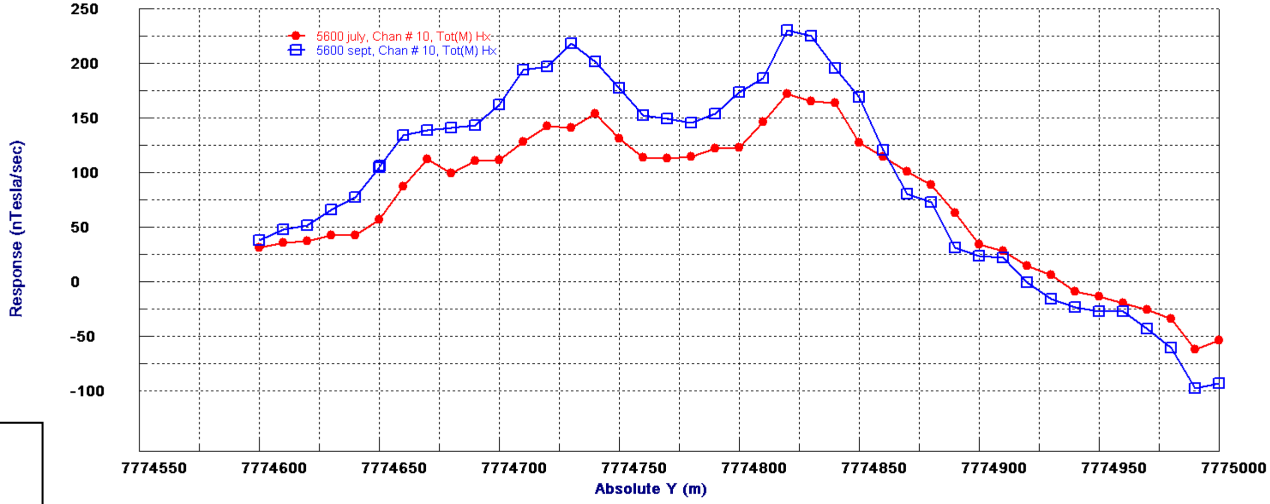
Line 5600E

Channel 10, Hz



Line 5600E

Channel 10, Hx



July (ORE)

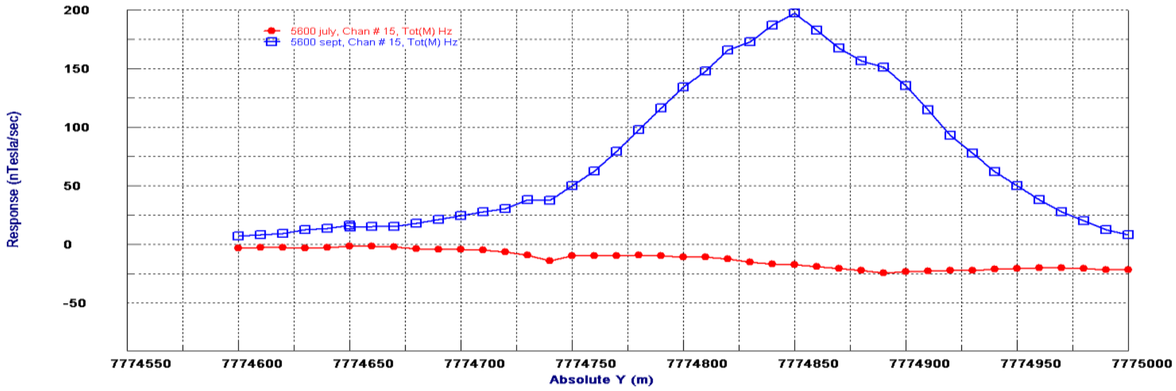
September (Khumsup)

Figure 49: *Comparison of ORE and Khumsup data on Line 5600E, Channel 10.*

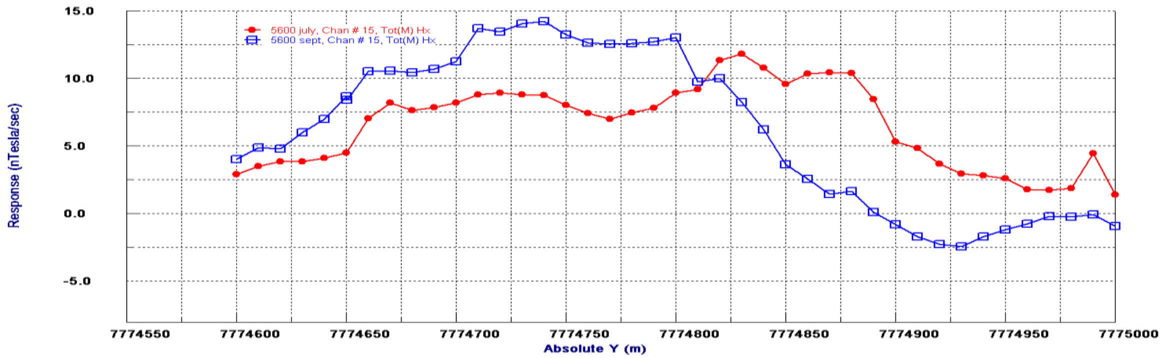
By Channel 10, the difference in the ORE and Khumsup measured Hz has increased. In the middle of the line, the Khumsup Hz data is positive while the ORE data is negative. Hx data, however, have better agreement.

Channel 15 Late Mid-Time – Line 5600 E

Line 5600E
Channel 15, Hz



Line 5600E
Channel 15, Hx



July (ORE)
September (Khumsup)

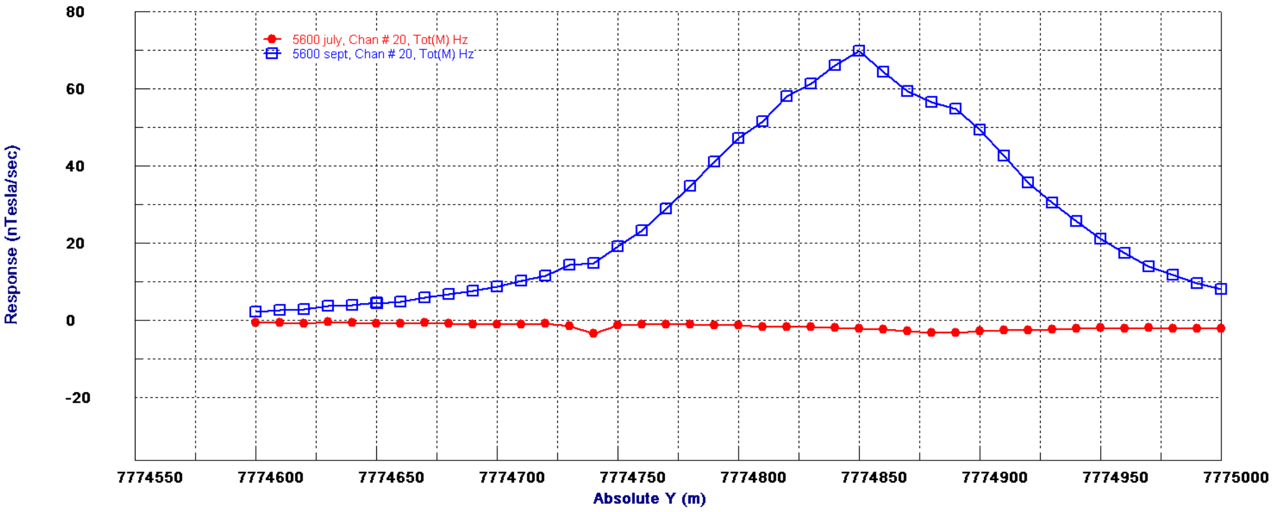
Figure 49: *Comparison of ORE and Khumsup data on Line 5600E at Channel 15.*

By Channel 15, the difference between the measured Hz is quite striking between the two datasets.. The Khumsup data shows a strong anomaly (200 nT/s) centered at 7774850 that is not observed in the ORE data. Note: The 100 m x 100 m loop is centered at (425500, 7774850). Thus, the peak of this anomaly corresponds to the center of the loop. It is thought that this apparent conductive response, observed in the Khumsup data but not in the ORE data, may be caused by a system dominated response.

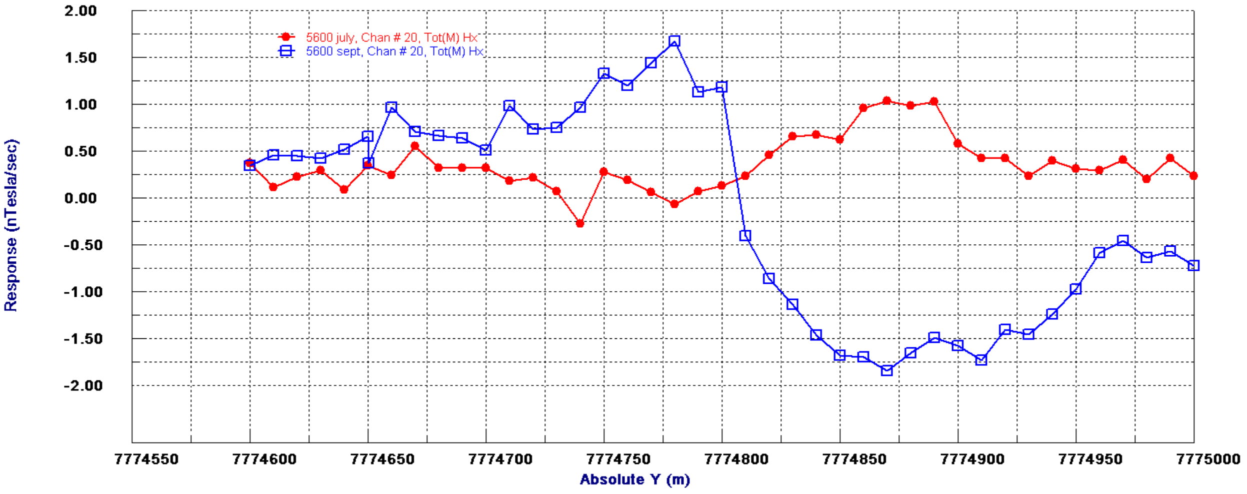
Hx surprisingly has better agreement than Hz, although the shape of the response is still different between the two surveys.

Channel 20 Late Time – Line 5600 E

Line 5600E
Channel 20, Hz



Line 5600E
Channel 20, Hx



July (ORE)
September (Khumsup)

Figure 50: *Comparison of ORE and Khumsup data on Line 5600E, Channel 20 during the late time.*

At Channel 20, the measured Hz for the ORE data is quite small, whereas the Khumsup data continues to show the apparent the anomaly observed at Channel 15 (Fig 49).

The Khumsup Hx data has an odd symmetry that is not observed in the July data from ORE. However, the response is quite small at only a few nT/s indicating a possible noise level for the instrument.

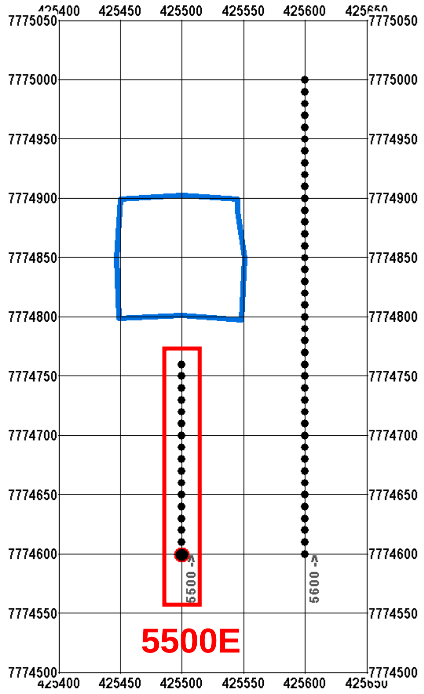
Line 5500 E (Hz component)

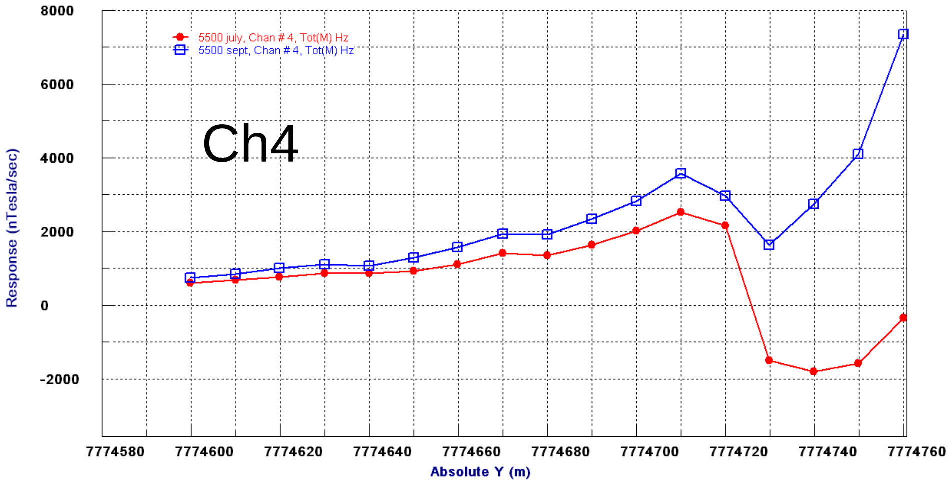
Figure 51: *Comparison of ORE and Khumsup data on Line 5500E Hz data is shown for three channels from early time (Ch4) to late mid-time (Ch15). 5500E is the centre line.*

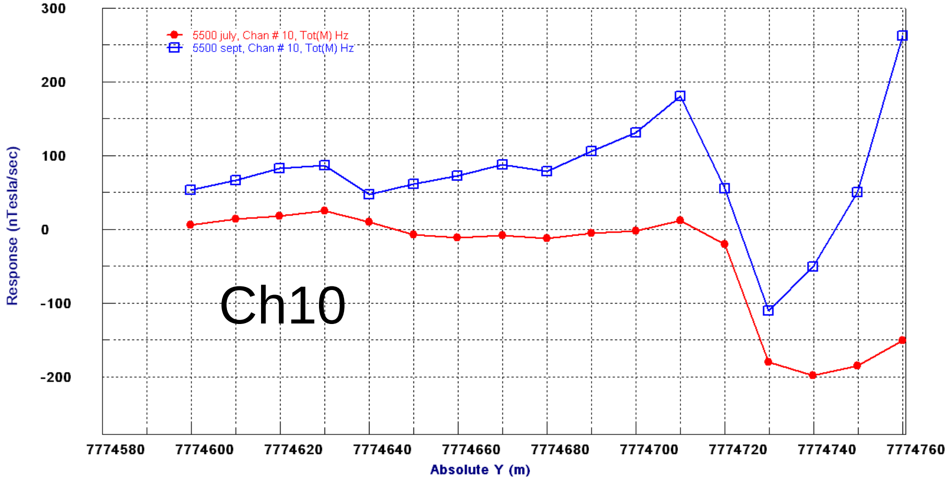
Similar to 5600E, a conductor is observed towards the center of the loop on 5500E. At the stations closest to the loop, this is observed from early times (see Ch4). By Channel 15, the Khumsup data along the profile differs dramatically from the ORE data.

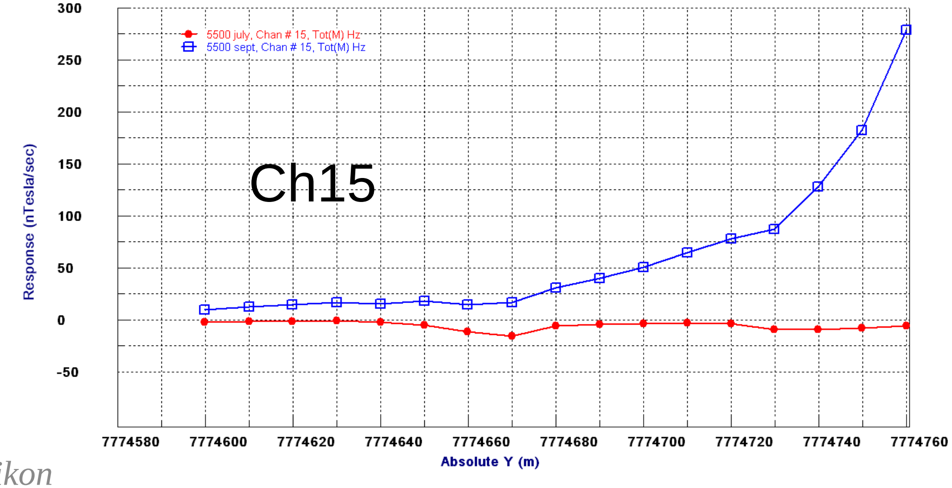
July (ORE)

September (Khumsup)









Decay at 7774650 (Hz) – Line 5600 E

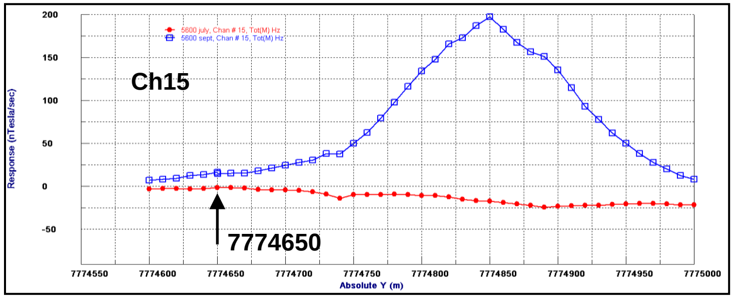


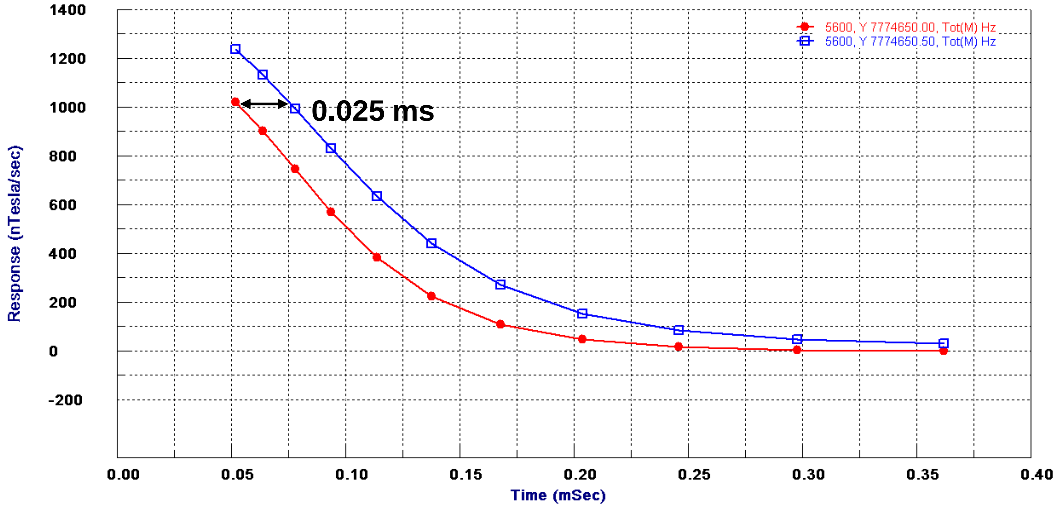
Figure 52: *Decays for the two measured datasets are at a point (7774650N) near the very south end of Line 5600E.*

The top plot is a comparison at early times. It appears there is a time shift on the order of 0.025 ms between the two datasets. A time shift of this degree is not a major concern for us as long as we have the primary pulse files to investigate the time shift.

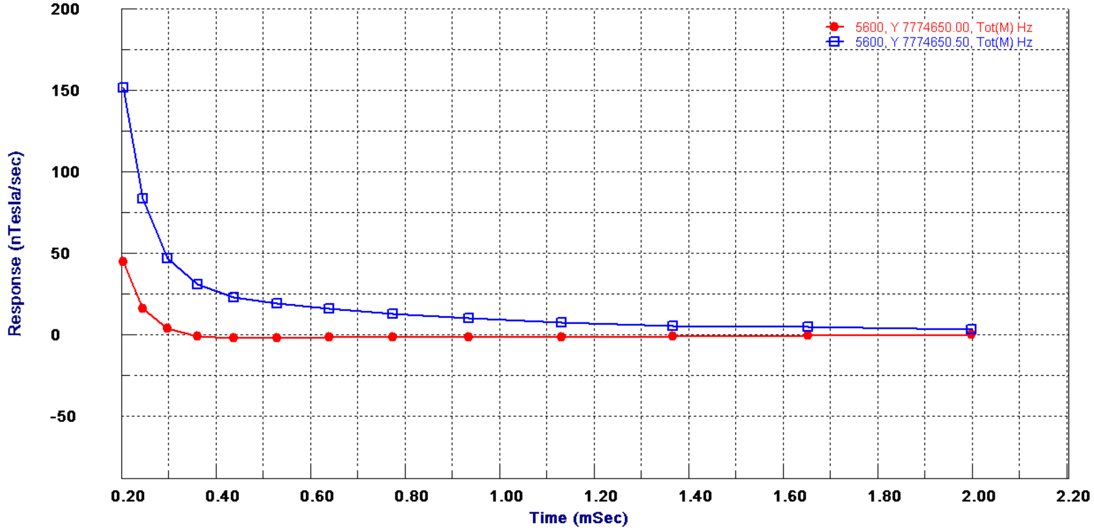
However, the plot of the mid-times is quite troubling. The ORE data asymptotes to zero very quickly, and by 0.40 ms, the response is quite small. However, the Khumsup decay is quite different. The mid-time decay is very slow comparatively. As shown in the profile plots, the Khumsup data has a mid-late time conductor centered at 7774850 that is not observed in the ORE data. Although 7774650 is 200 m from the center of this anomaly, the decay at this station is surprisingly still quite slow by about 0.40 msec.

July (ORE)

September (Khumsup)

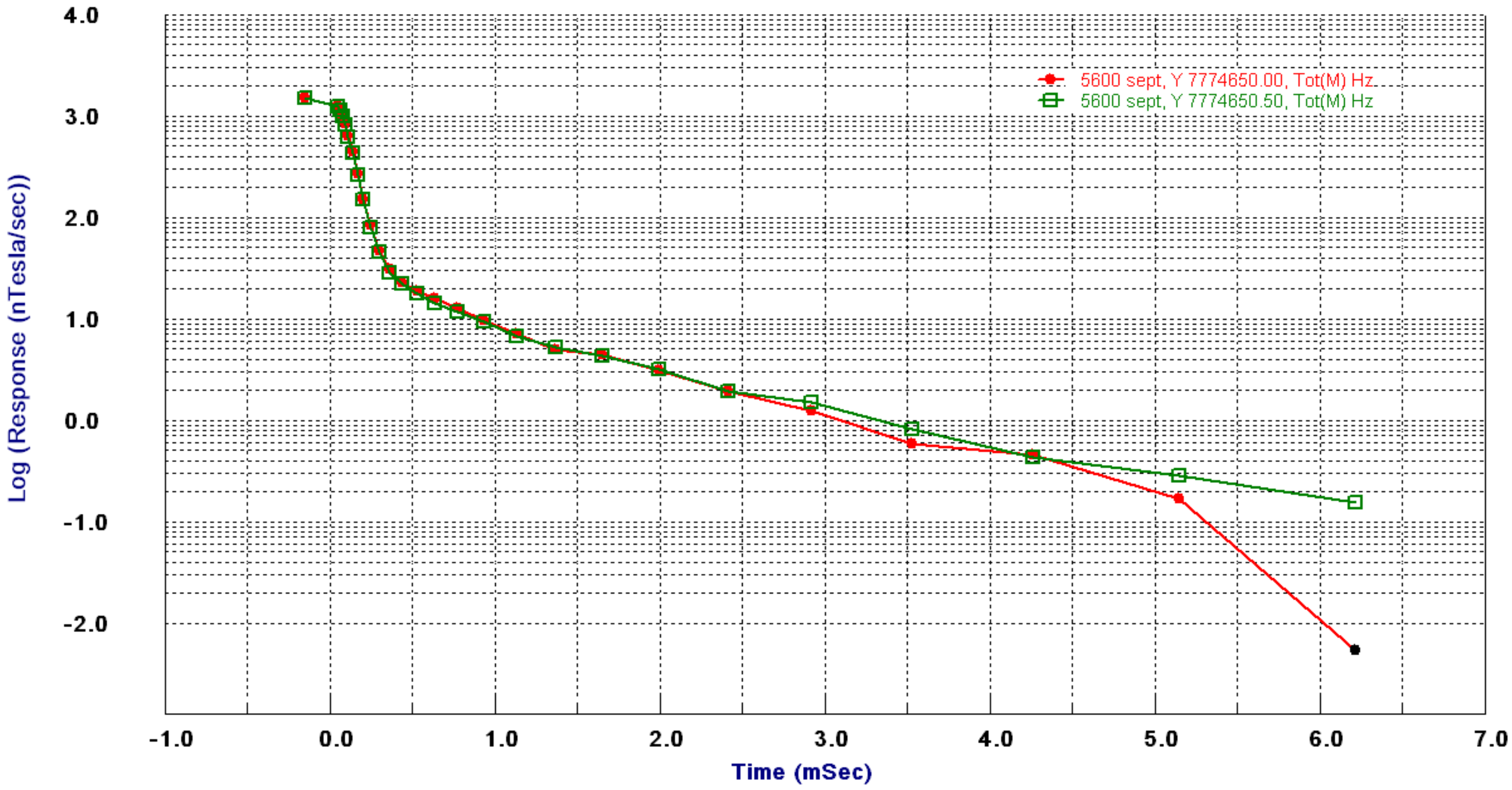


Line 5600E, 7774650; 0-0.4 ms (Ch 2-12) Hz



Line 5600E, 7774650; 0.2-2.2 ms (Ch 8-20) Hz

Decay at 7774650 – Line 5600 E



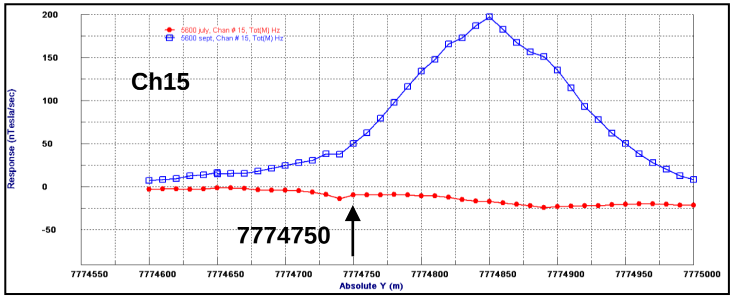
Khumsup, Sept 19

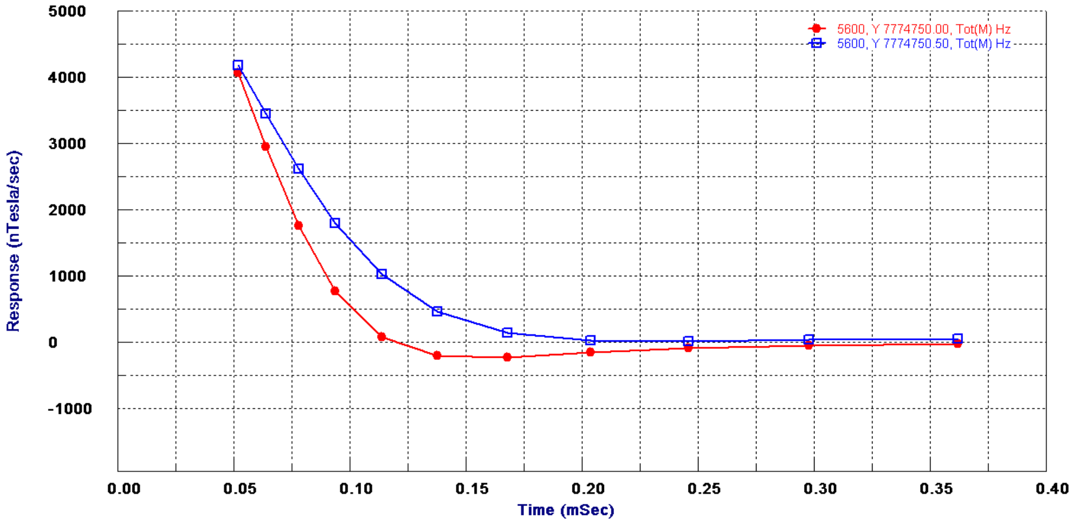
Khumsup, Sept 20

Figure 53: *Comparison Khumsup data (Hz) at 7774650N on Line 5600E on two different days.*

Note the sharp change in the nature of the decay around 0.4 msec. This is observed on both days. Thus, this unusual response compared to the ORE data as shown on the previous figure is repeatable in the Khumsup data.

Decay at 7774750 (Hz) – Line 5600 E



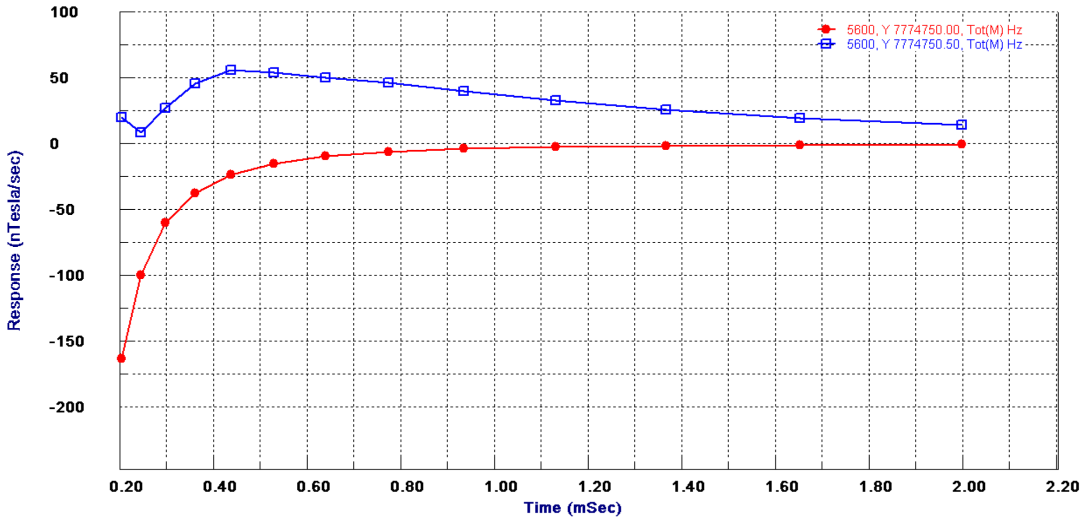


Line 5600E, 7774750; 0-0.4 ms (Ch 2-12) Hz

Figure 54: *Decays for the two measured datasets are shown at a point 100 m further north 7774750N) on Line 5600E.*

Even at early times (top plot), there are differences in the shape of the decay between the two surveys. The ORE data undershoots zero at Channel 7, but the Khumsup data does not.

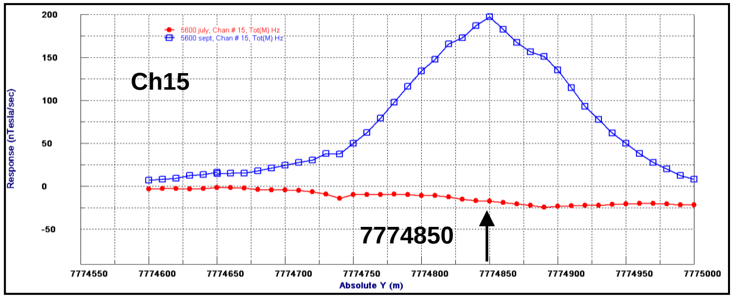
The plot of the mid times illustrates the very slow decay in the Khumsup data, which is not observed in the ORE Data.

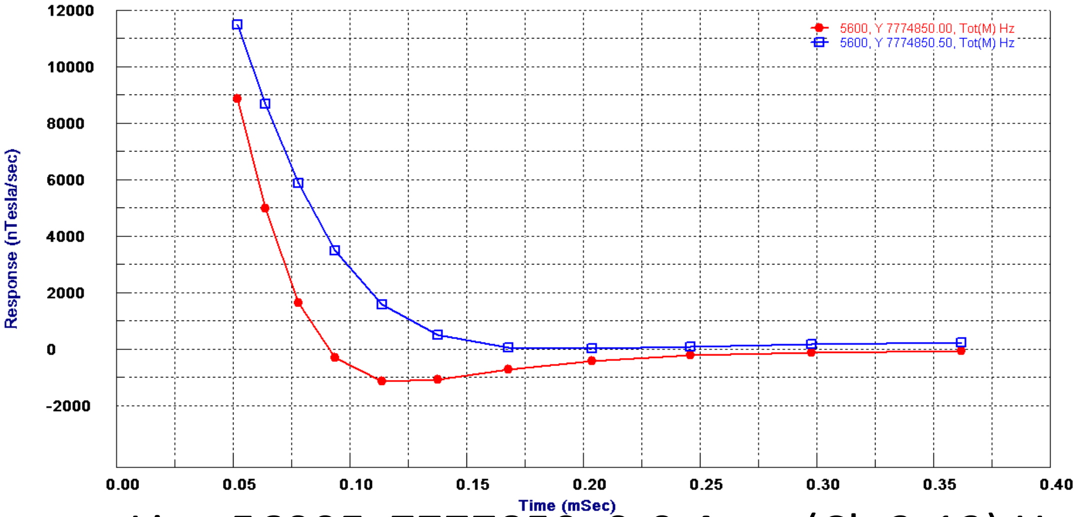


Line 5600E, 7774750; 0.2-2.2 ms (Ch 8-20) Hz

July (ORE)
September (Khumsup)

Decay Results at 7774850 (Hz) – Line 5600 E

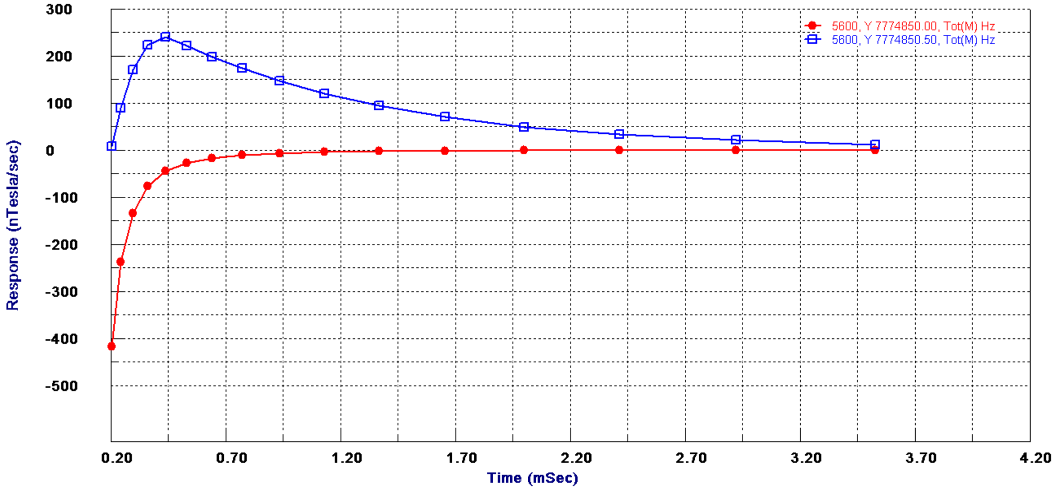




Line 5600E, 7777850; 0-0.4 ms (Ch 2-12) Hz

Figure 55: *Decay plots for the two measured datasets are shown at 774850N on Line 5600E.*

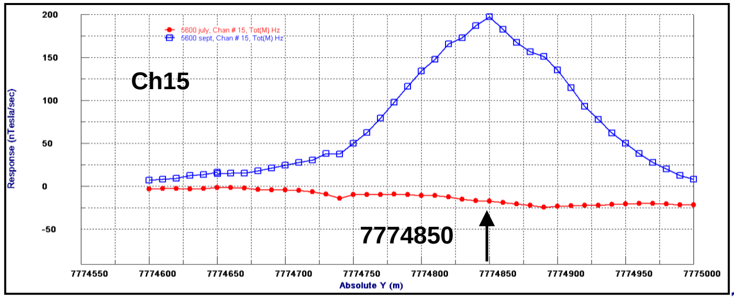
At 7774850, the difference in the decays is quite significant, even at early times. Note that the data have different signs at most channels, with the exception of the first few channels.

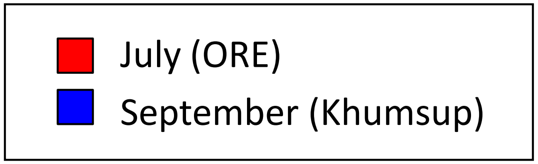


Line 5600E, 7777850; 0.2-4.2 ms (Ch 8-23) Hz

July (ORE)
September (Khumsup)

Decay Response at 7774850 (Hx horizontal) – Line 5600E





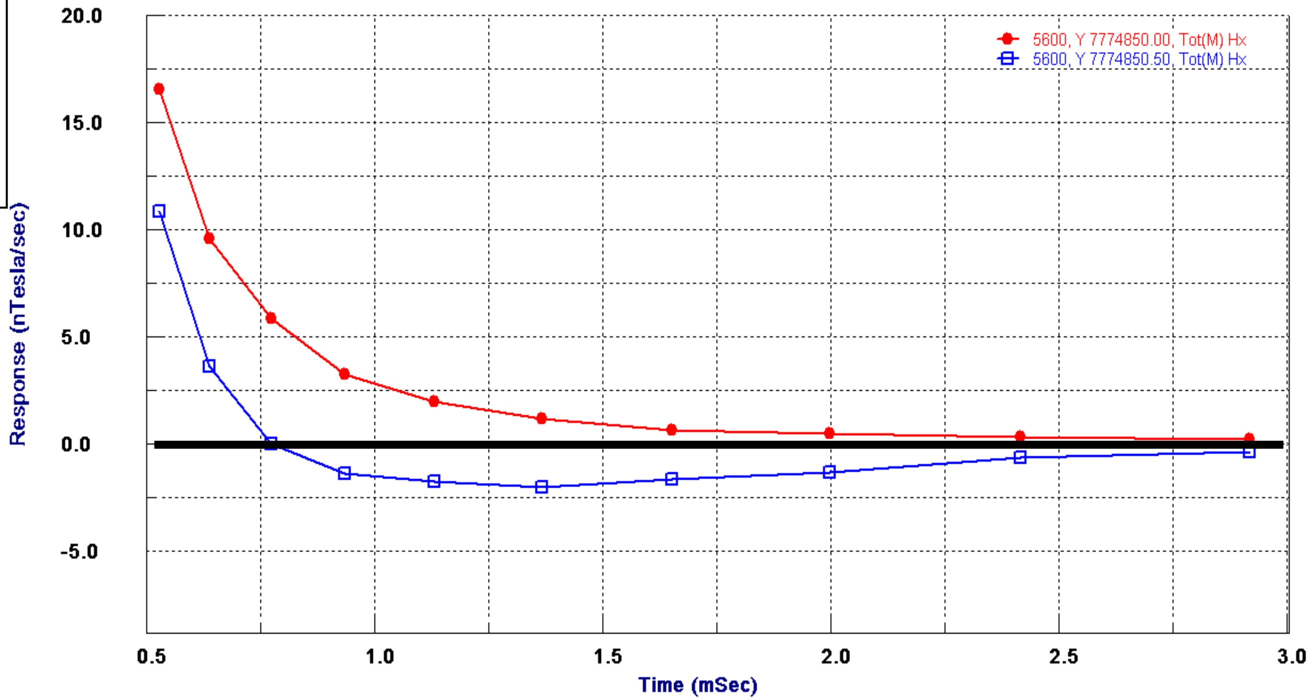
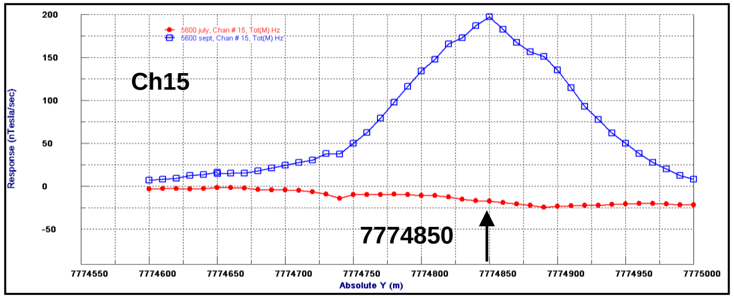
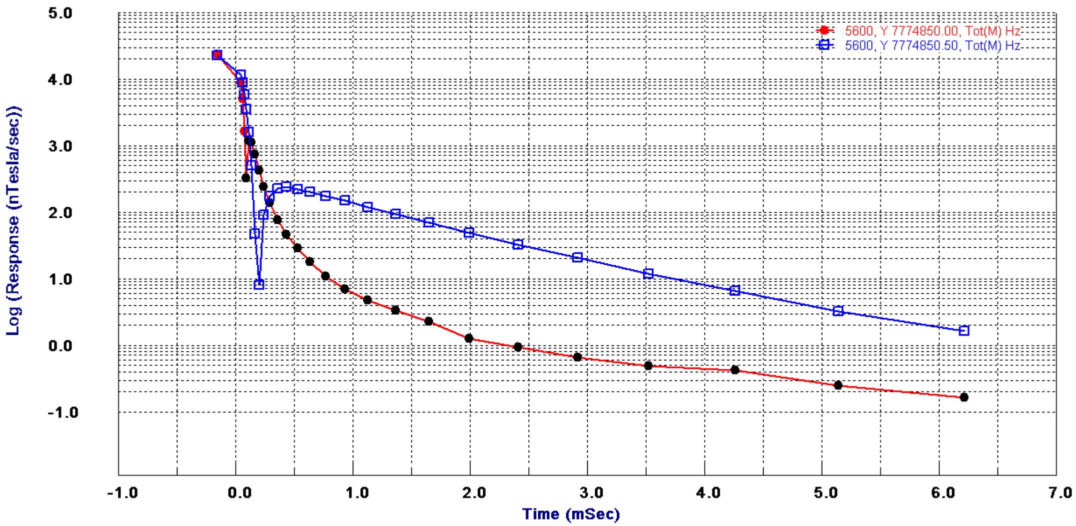


Figure 56: *Hx decay at 7774850N on 5600E from 0.5-3 ms (Ch. 8-23).*

The decays in the two datasets are different for Hx component (horizontal) as well. However, the difference is not as pronounced as that in Hz. Here, the mid-time channels at 7774850 are plotted for both surveys. The ORE data is positive at all of these time channels, whereas the Khumsup data is negative at the majority of them.

Hz Decay Response at 7774850 – Line 5600E



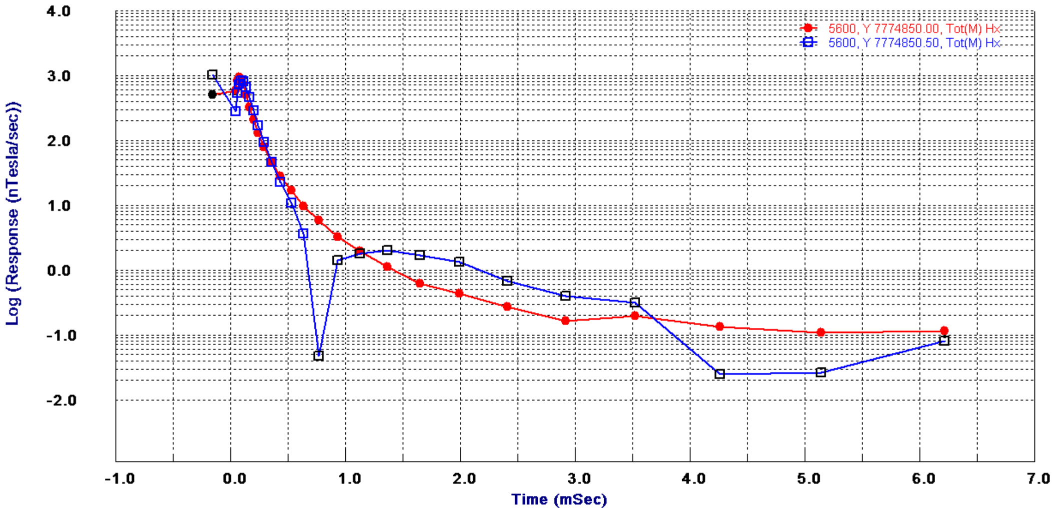


Line 5600E, 7777850, Hz

*Fig. 57: Decay plots at 7774850 in logarithmic amplitude. *Note that if the value was negative, the symbol is black.*

Although the decays were compared on previous pages, they are shown here with a log scale so that the difference across all time channels can be more readily observed.

The decays are completely different beyond early times, and the Khumsup data has an unexpectedly slow decay in Hz.

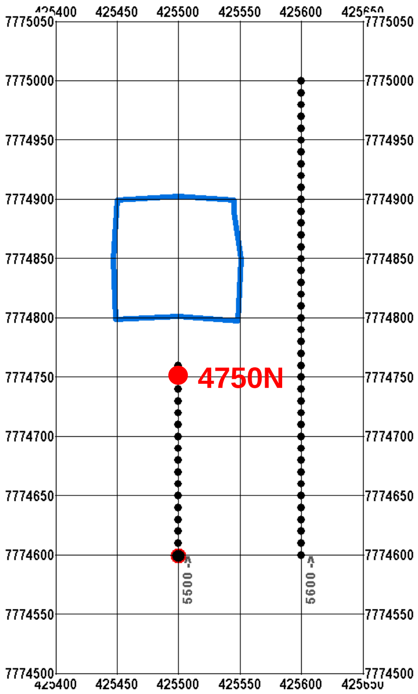


Line 5600E, 7777850, Hx

July (ORE)

September (Khumsup)

APP data (Hz) at Y=7774750 Line 5500E



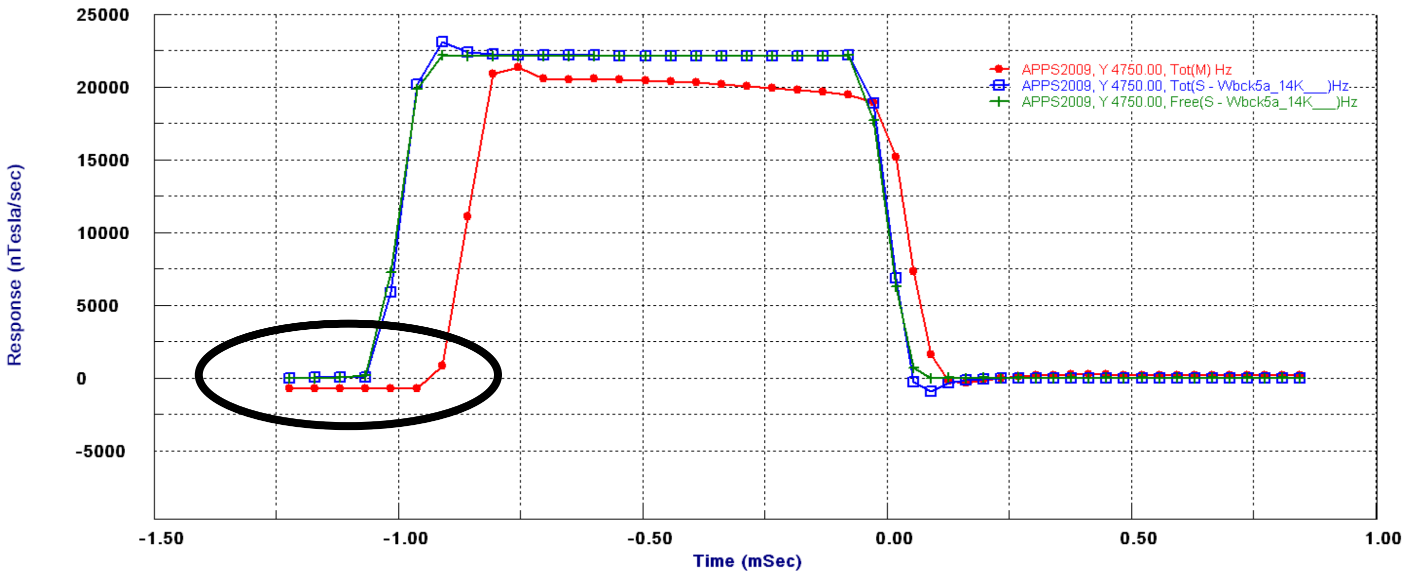


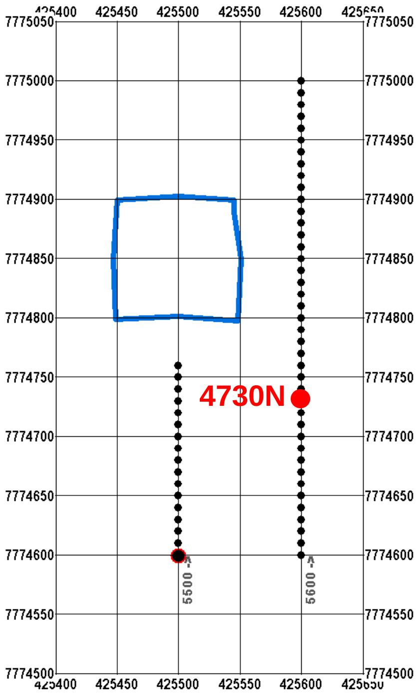
Fig. 58: APP data at Line 5500E, 7774750 North, Hz. Background and freespace simulations are also shown.

- September (Khumsup)
- Background simulation
- Freespace simulation

The simulation was performed with an upper bandwidth of 14 kHz. The nominal window times and ramp length (1 ms) were used. Note that the time channels must be moved earlier, and the length of the ramp must be shortened for the simulation to match the timing of the measured data. There is also a slight amplitude discrepancy between the measured and simulated data.

But the most troubling aspect of the APP data is observed just before the start of the turnoff ramp at approximately -.9msec. the measured response it is not near zero as would be expected. We do not know why this is the case and this issue is not observed with other data collected with this system on other loops. This was surprising, as we would have expected the current to be constant prior to turn-off and the response in the APP file to be zero as a result. This data implies a possible inconsistency with any of the collected data.

APP (Hz) – ORE vs. Khumsup



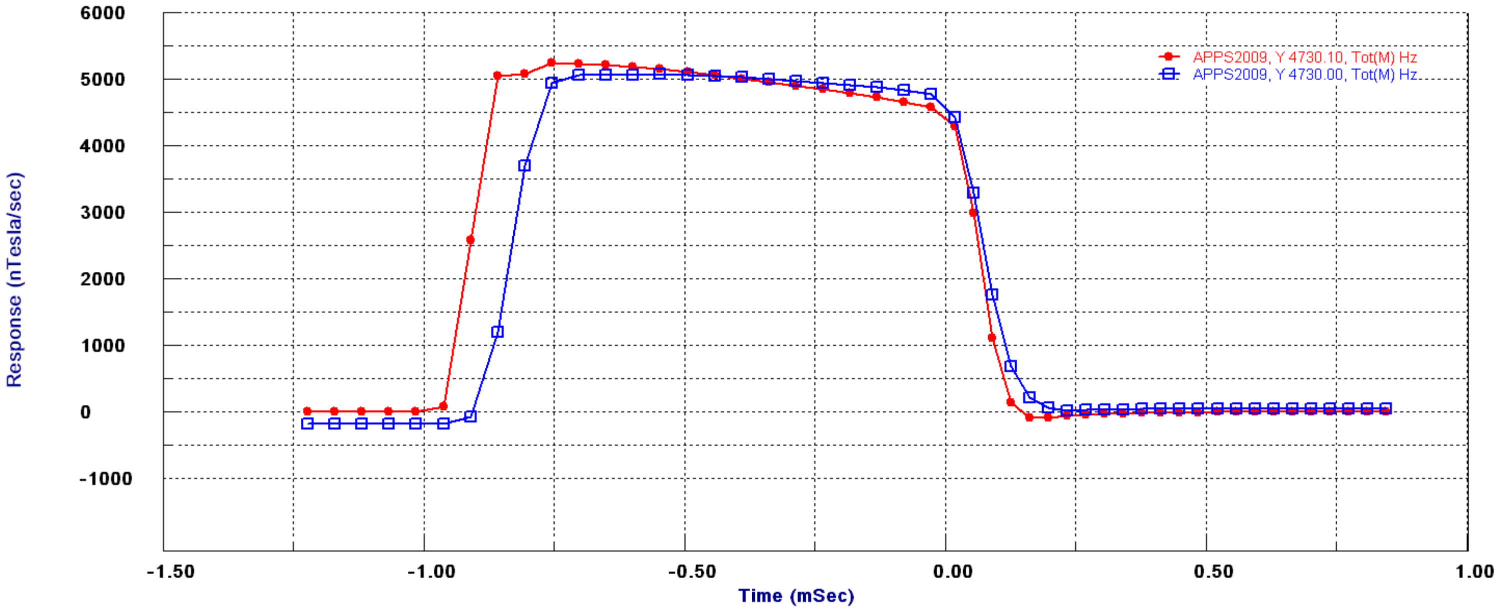


Fig. 59: Comparison of ORE and Khumsup APP files at Line 5600E, 7774730N, Hz

July (ORE)

September (Khumsup)

An APP data was also collected at a second location by Khumsup, at which ORE had previously collected an APP dataset with the same loop. A comparison is shown above. Note that the timing differs slightly and the ORE ramp is longer and much closer to 1 msec. The shape of the ramp is slightly different as well, with that from the Khumsup system being closer to a linear ramp. (This being the derivative of the current function, a perfectly linear ramp should have a constant response.)

As noted on the previous page, the Khumsup APP file did not have a zero response before the beginning of the ramp. In contrast, the ORE APP file does have essentially a zero response before the beginning of the ramp.

For this loop (Loop 4), the off-time decays are very different in the ORE and Khumsup data, particularly near the loop. Near the loop, this is observed throughout all time channels. Further from the loop, early time decays agree except for a time shift in the channels. The Khumsup data have unexpectedly slow decays at late time and the relationship between the anomaly and the loop suggests that this may be due to a loop response. This issue may be related to the size of the loop. With a larger loop (roughly 500 m x 500 m), ORE data from October 2010 and Khumsup (September 2011) data agree well. The reasons for the small loop discrepancies is unknown.

The Khumsup APP files for this loop do not show a zero response before the beginning of the ramp. This is in contrast to APP data for all other loops.

Comments on Crone's Response
Re: Data Issues

The following is a shortened version of document that Petros sent to Crone in mid-November after receiving their initial comments on the Khumsup data issues.

Summary of Crone's Response to Data Issues

1) Differences in Decay Rates at Mid-Late times with Different Coils

a) Axial vs. Surface Coils

Crone acknowledges that there are "slight" differences between the axial and surface coil decays inside the loop after accounting for timing differences. However, we do not consider these differences to be slight particularly for this geological application! The axial data have much slower decays at mid-late times; this data indicates a large, strong conductor at depth whereas the surface data do not. Also, our understanding of geology would not imply a strong conductor at depth.

It is stated that the reason for the supposed "slight" discrepancies inside the loop is not fully understood, but may be related to differences in how the sensors were read. One possibility suggested by Crone is that it may be due to the borehole cable being stretched out on the ground. If this is a possibility, then we are concerned as to how sensitive down hole readings are to the layout of the cable during normal collection of borehole data.

b) XY Probe vs. Axial Coil

According to Crone, the differences between the data collected by the XY coils and axial coil are due to the XY coils not being oriented vertically. The accelerometer data indicate that they were generally 25-30 degrees from the vertical. Such a variation from the vertical would not produce such a variation. Thus, this explanation is inconsistent with the data because:

1) This discrepancy between the axial and X coils is observed both for Loop 1 and Loop A. But for Loop 1, the horizontal component is insignificant in comparison to the vertical component even at late times and thus orientation must be a negligible effect.

2) Even for Loop A, for which the horizontal component is more significant, we calculate that a tilt of 45-55 degrees would be needed to obtain the response measured with the Z coil. This is very significant tilt in the sensor and is much greater than that of 25-30 degree tilt from the vertical indicated by the accelerometer data in the data files.

Crone Response to Data Issues

2) Timing Issues

a) Discrepancy in timing between borehole and surface coils

According to Crone, this effect is due to different timing methods being used: a synchronization cable was used for the borehole data and a crystal clock for the surface coil data. While the data collected using different timing methods should not be in disagreement, timing differences of this magnitude have also been observed in equipment made by another manufacturer for these two different modes.

b) Length of Ramp

We understand from a conversation with Crone that a variation in the ramp time from the nominal ramp is possible and the ramp should be consistent for a given piece of equipment. Indeed, this is what we observed: the ramp in the ORE data was consistently 0.97 ms, and the ramp in the Khumsup data was consistently 0.92 msec. But without the APP files that we specifically requested, we would have had no knowledge of the proper ramp time. Accurate knowledge of the ramp length is important because it affects the amplitude of the response.

c) Location of the time channels with respect to the times given in the data file

Our understanding is that the operator enters the delay into the data file. Apparently an incorrect delay was entered, in this case requiring us to shift the channels earlier by 20 μs for the surface coil data and 40 μs for the borehole data. These are significant differences in timing and we are concerned that the delays are not well-known or that the operators are not being given sufficient information to determine the appropriate delay.

Crone Response to Data Issues

3) Amplitude of Axial Coil Data
The discrepancy between the axial and surface amplitude in on-time is apparently due to the incorrect effective coil area being used to process the axial coil data. If the correct effective coil area is used the amplitude is decreased such that it is in agreement with the surface data.

However, the effective area of the XY coils was apparently incorrect in the data files as well. If the XY data were adjusted for the correct effective area, then its amplitude would be about 12% smaller than that of the surface coil data and the corrected axial coil data. Therefore, there is apparently an error in the amplitude of the XY probe data or in the effective area of these coils.

Thus, the information provided on the effective area of the coils solves the discrepancy between the axial and surface coil data amplitude, but indicates that there is a problem with the XY probe data.

4) Late-Time Anomaly in Loop 4 Data

Apparently in the Khumsup survey, access problems at the corner of the loop necessitated that wires be run to the transmitter and these were run across a fence. It is thought that this is the cause of the strong late-time response in the Khumsup data.

What is curious about this explanation is that it is inconsistent with our knowledge of the site, and that ORE had no such problems only two months earlier.

2011 Khumsup Data Results Summary

Through examination of the data collected with different coils on the surface for Loop A and Loop I, we discovered that there is a significant difference in decay between the different coils. The different decays result in different models, and we do not know which is correct. This is our primary concern with all the Crone data. We have raised this issue with Crone, but have not received a satisfactory and consistent answer.

We also found that the data were shifted from the nominal windows, based on our study of the primary pulse files, and that the borehole data were on average 0.02 ms later than the surface coil data. The timing can be adjusted using the primary pulse files, but we have not received any guidance from Crone on how to deal with these adjustments.

We have also attempted modeling of CT749 from both loops, but as with previous borehole data, the data have not added to our understanding of the subsurface.