

Magnetotelluric Survey Report for KUTh Exploration Pty Ltd

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Summary

During the period 4/9/2008 to 16/10/2008 broadband data was collected at 96 of the proposed 100 sites along two profiles for KUTh Exploration Pty Ltd. The survey had been delayed because of personal and instrument issues and I very much appreciate the patience of KUTh on both matters. I had hoped that the survey could be performed in approximately 4 weeks but underestimated the conditions (especially on the southern profile) and also a remote station was required for the northern profile so the survey totaled 6 weeks. Unfortunately, ground-truthing was not performed before the survey commenced so accessing and production at sites was an unknown and sometime quite difficult. Under the conditions, I was generally satisfied with the way the survey preceded. The data quality was quite variable but in general "OK". Cultural noise was a significant problem along both profiles. The logistics were well handled by Tim Watson and Bronwyn Kimber and their help was much appreciated.

Acquisition

The Phoenix made MTU-5A data recorders and MTC-50 induction coils were used to record MT data for this survey. Three component of the magnetic field (H_x , H_y and H_z) and 2 components of the electric field were recorded at all sites except for a few sites where the H_z component was omitted because of difficult digging conditions. Times series data was recorded for a minimum of 16 hours at each site in an effort to resolve apparent resistivity and phase to a period of 100 seconds.

At the commencement of the survey all of the induction coils were calibrated to calculate the response of each coil to a known signal over a range of frequencies. The calibration files were then used for processing. Parallel tests were also performed to ensure all induction coils were measuring the same signal.

Southern Profile

The acquisition of broad-band magnetotelluric (MT) data commenced on the 4/9/2008 on the southern profile centered on Lake Leake with a team of 3 people including myself. Data was collected at 54 of the proposed 57 sites between Campbell Town and Swansea. Three of the sites were not occupied as site 1 was positioned within the township of Campbell town and sites 56 and 57 are located very close to the coast. It was felt that these three sites would not provide usable results. Initial production was 2-3 sites per day which was lower than the initial estimated. This was mainly due to the difficult digging conditions in the area and also difficulties accessing certain sites. The decision was made to employ another field assistant, resulting in increased production to 3-4 sites per day for the remainder of the southern profile. Data acquisition for the southern profile was completed on 27/9/2008.

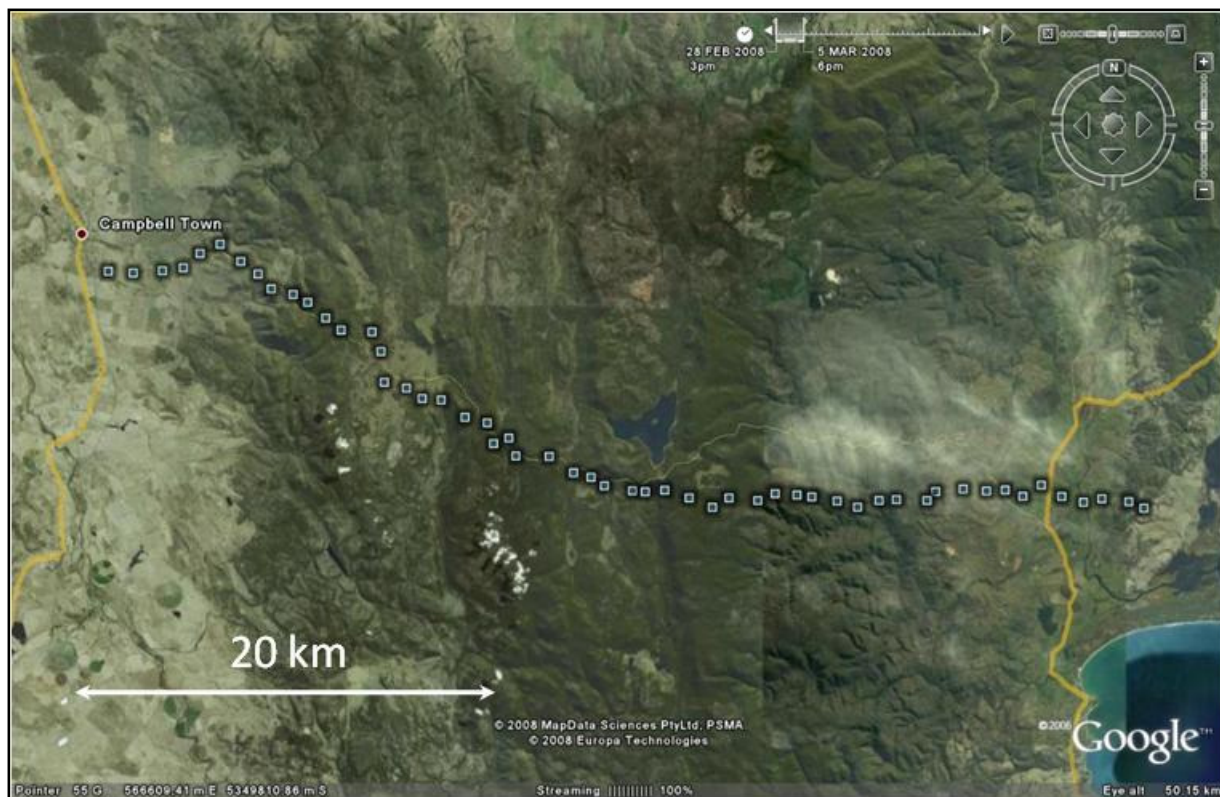


Figure 1: Site locations for the Southern Profile.

Northern Profile

Data acquisition for the northern profile commenced on the 28/9/2008. After 3 days of surveying it became apparent that cultural noise was a significant problem and it was decided that a distant remote station should be used in an effort to improve data quality. On the 1/10/2008 a station was installed at Oatlands close to the proposed drill hole. This site was chosen because of its “quiet” location and its proximity to the drill hole and would provide subsurface information. MT data was recorded continuously here until the end of the survey. Because one to the MT systems was used as a distant remote, production on the northern profile was limited to 3 sites per day. The extra field assist was released from this part of the survey. Acquisition along the northern profile was completed on the 16/10/2008 with a total of 44 sites (figure 2). Sites 12, 13 and 14 were not occupied as were located in the Tamar River or residential areas. Data was recorded at 2 extra sites in an effort to investigate a noise source between sites 32 and 37 (see text below).



Figure 2: Site locations for the Northern Profile.

Processing and Data Quality

The function of data processing is to take the raw time series and produce MT impedance responses, as a function of frequency, from which interpretations and inversions can be performed. This is achieved by extraction of frequencies from the time series using Fourier transforms. In a homogeneous or horizontally-layered Earth, and in the absence of noise, the procedure for calculating the apparent resistivity is simply to square the ratio of a set of orthogonal E and H pairs at a certain frequency and then multiply by the appropriate constant. The time series data is processed by the Phoenix SSMT software to produce apparent resistivity and phase values (which are calculated from the impedance response). The apparent resistivity and phase values are stored in EDI files. The EDI format is the industry standard format for processed magnetotelluric data as defined by the SEG. The Phoenix processing software is based on the robust processing jackknife approach of Jones and Jodicke (1984). In most cases the remote reference processing technique of Gamble et al, 1979, was also employed to reduce biasing on spectral impedance estimates.

Southern Profile

The data quality along the profile was quite variable. Poor data quality is due to two reasons; 1) low signal and 2) the presence of electrical noise. Generally, in the field a qualitative assessment is made of the data by inspecting the continuity of the time series data. Smooth continuous time series generally indicates high quality data (e.g. figure 3). Spikes and edges within data usually degrade the quality and are usually from a cultural or atmospheric source (e.g. figure 4). The signal that is utilized in MT at periods greater than 1 second come from solar radiation and is roughly coincident with the number of sunspots (the greater the number of sunspots the better the signal). The number of sunspots generally varies through an 11 year cycle and at present we are in the minimum of the cycle so the signal has been quite low. Low signal is particularly problematic in the period range 5-50 seconds.

Atmospheric noise was coincident with rain periods and resulted in spiking in the time series (see figure 4). The spikes are thought to be due to cloud-to-cloud lightning although thunder was rarely heard. Cultural noise occurred at some sites due to electric fences. The pulses from the electric fence (figure 5) could be seen in the electrical field measurements and generally affect the data in the frequencies greater than 1 Hz.

One of the concerns before the survey commenced was the possible effects the Base Link DC power cable may have on the MT data. During the acquisition on the southern profile, two days were taken to acquire data at two sites on the northern profile to determine whether or not noise from the Base Link was going to be a significant problem. Data were recorded on the northern profile at sites 19 and 42. High amplitude square wave and edges that are typical DC noise were not seen in these data and from this test it was assumed that the rest of profile would not be affected. That being said, there were still problems with electric fence noise and atmospheric noise so the data quality was quite low.

Northern Profile

Approximately half of the sites on the northern profile were contaminated by electric fence noise causing poor data in the 1-10 Hz range. A request was put in to the property owners to turn the fences off overnight and in most cases the property owner would agree to this request. In some cases this would help but most of the time noise from neighboring properties could also be detected so there would be a number of different sources.

Between sites 32 and 37 another unknown noise source has contaminated the electric field data but not the magnetic field. The noise introduces random square waves and edges (e.g. figure 7) which are very destructive to the longer period data (> 10 seconds, e.g. figure 6). This noise is what one would have expected from the Baseline though I do not believe the Baseline to be the source of the noise. If the Baseline was going to be an issue in this survey its effect would have been seen at most if not all of the site. In this case, the noise is restricted to sites 32-37. One possible source of the noise is cathodic protection on a pipeline running through this area but this theory has not been further investigated. The processed data from these sites are of very poor quality due to the combined effects of the unknown noise source and the electric fence noise. Although the underlying trends of the apparent resistivity and phase curves can be seen, extreme caution should be taken when interpreting these data. Two extra sites were recorded (NTL044 and NTL045) to investigate the extents of this noise further. Although both of the sites still contained noise, site 44 (located 2-3km north of the main profile) was of significantly higher quality than 45 (2-3km south of the main profile) which may indicate that the noise is less to the north.

Because MT measures such small quantities of the Earth's naturally varying electromagnetic field, there was always going to be a risk of contamination from cultural noise along this northern profile. Only 20km to the north is Tasmania's most industrialized area.

Deliverables

Time Series is recorded at 3 sample rates, 15, 150 and 2400 Hz and written to 3 separate files (*.TS3, *.TS4 and *.TS5) as well as a table file (*.TBL) containing recording parameters. These 4 files for each site will be delivered to KUTh. I would expect that the consultant interpreting these data would have the capabilities to read these data. I can organize for the time series data to be converted to ascii format if required.

Prior to the commencement of the survey all of the magnetic sensors were calibrated. The calibration files will also be delivered.

The time series data is processed to produce apparent resistivity and phase curves and is written to one *.EDI file for each site and will be delivered to KUTh. The data have been processed using the Phoenix proprietary processing software. Most of the sites from the northern profile used the Oatlands remote site for remote reference processing. Every effort was made to improve the quality of the processed data through cross power editing and the exclusion of contaminated data.

Two text files will be included to provide actual locations for each of the sites that were surveyed. This information is also contained within the EDI files.

References

Gamble, T.D., Goubau, W.M., and Clark, J., 1979, Magnetotellurics with a Remote Reference: *Geophysics*, **44**: 53.

Jones, A.G. and Jödicke, H., 1984. Magnetotelluric transfer function estimation improvement by a coherence-based rejection technique. *54th Society of Exploration Geophysics Annual General Meeting*. Atlanta, Georgia, U.S.A., December 2-6. Abstract volume pages 51-55.

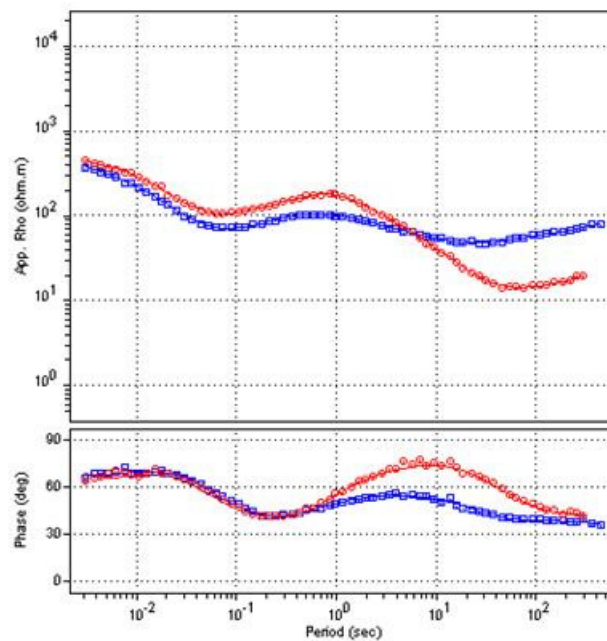
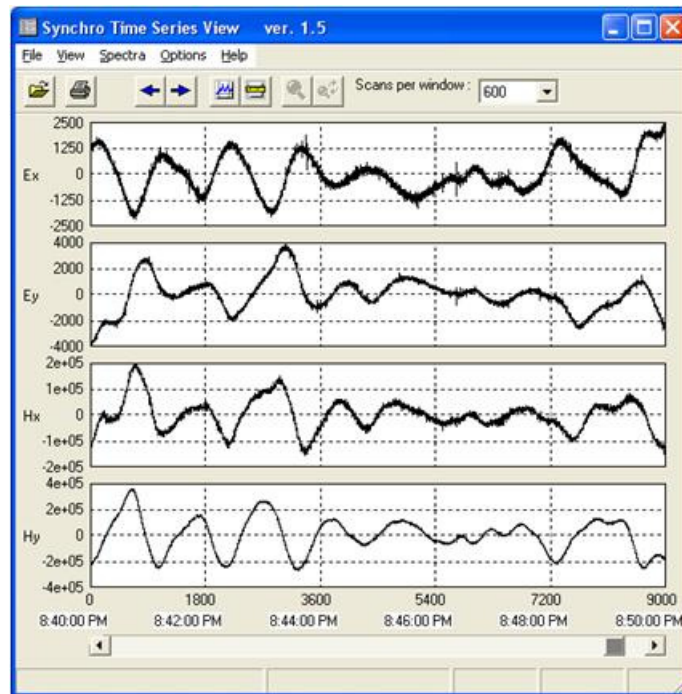


Figure 3: Example of high quality time series data (top) and processed data (bottom).

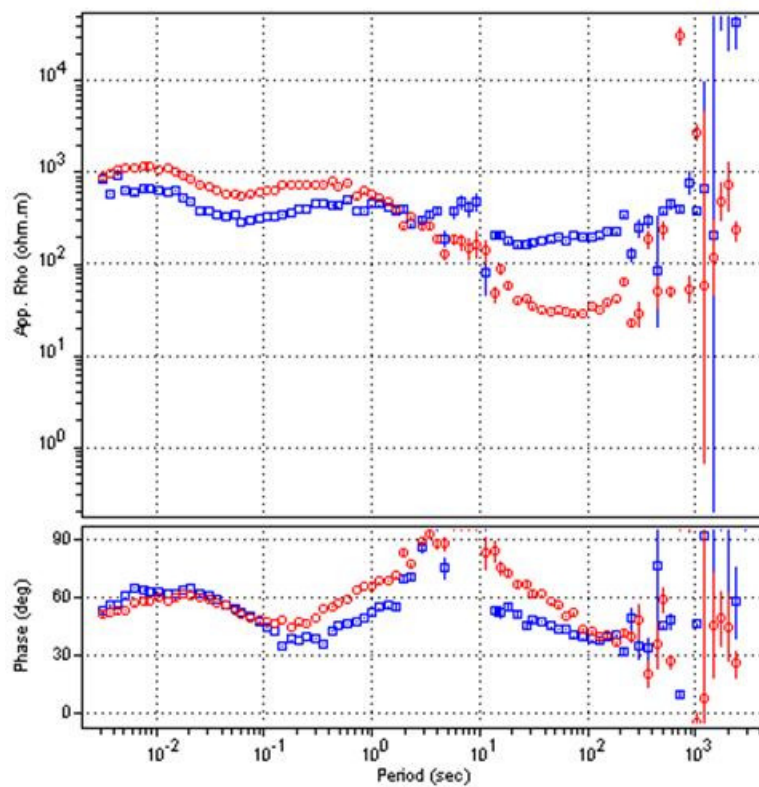
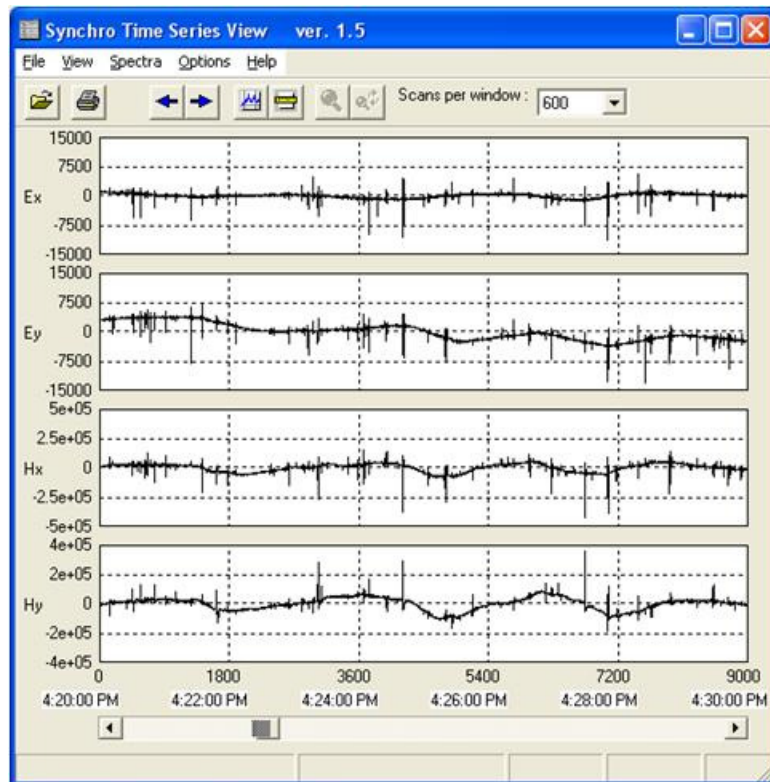


Figure 4: Example of time series data (top) and processed data (bottom) contaminated with atmospheric noise.

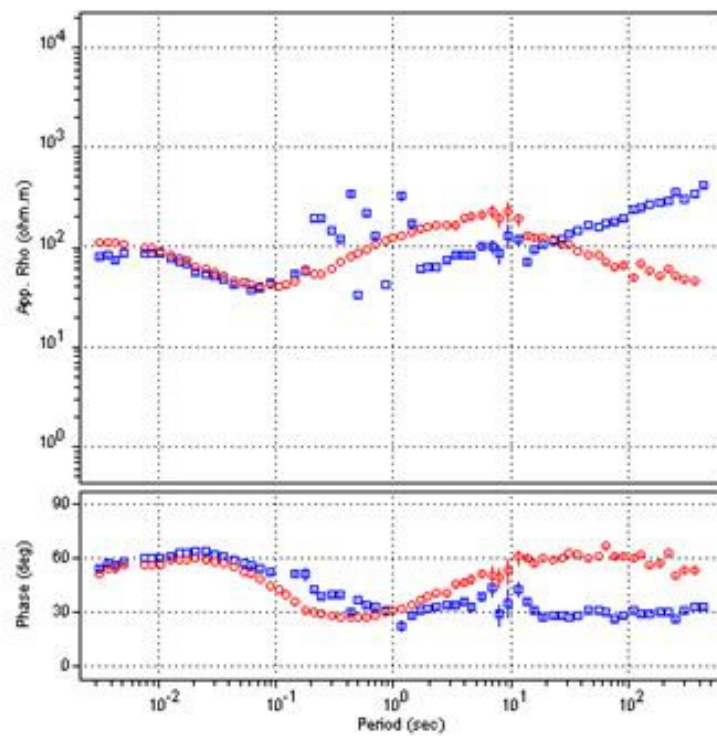
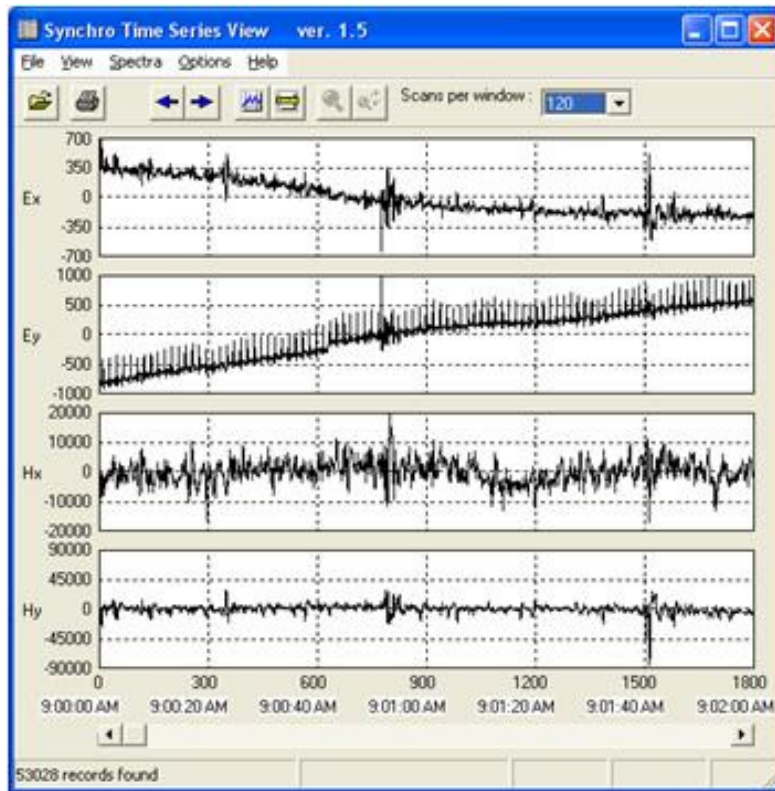


Figure 5: Example of time series data (top) and processed data (bottom) contaminated with electric fence noise.

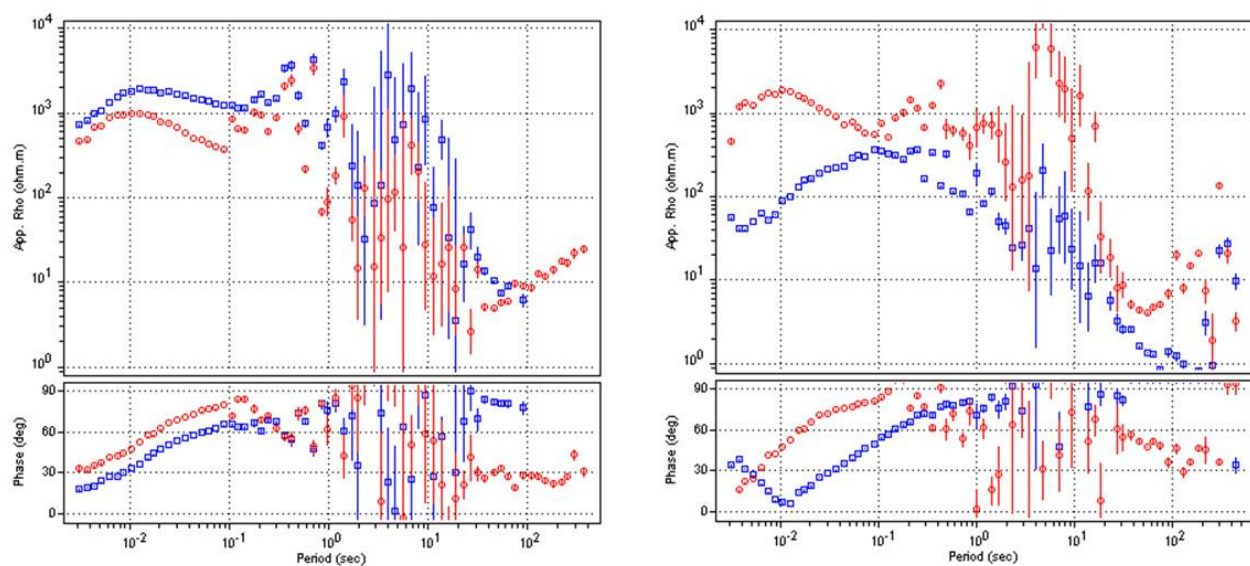
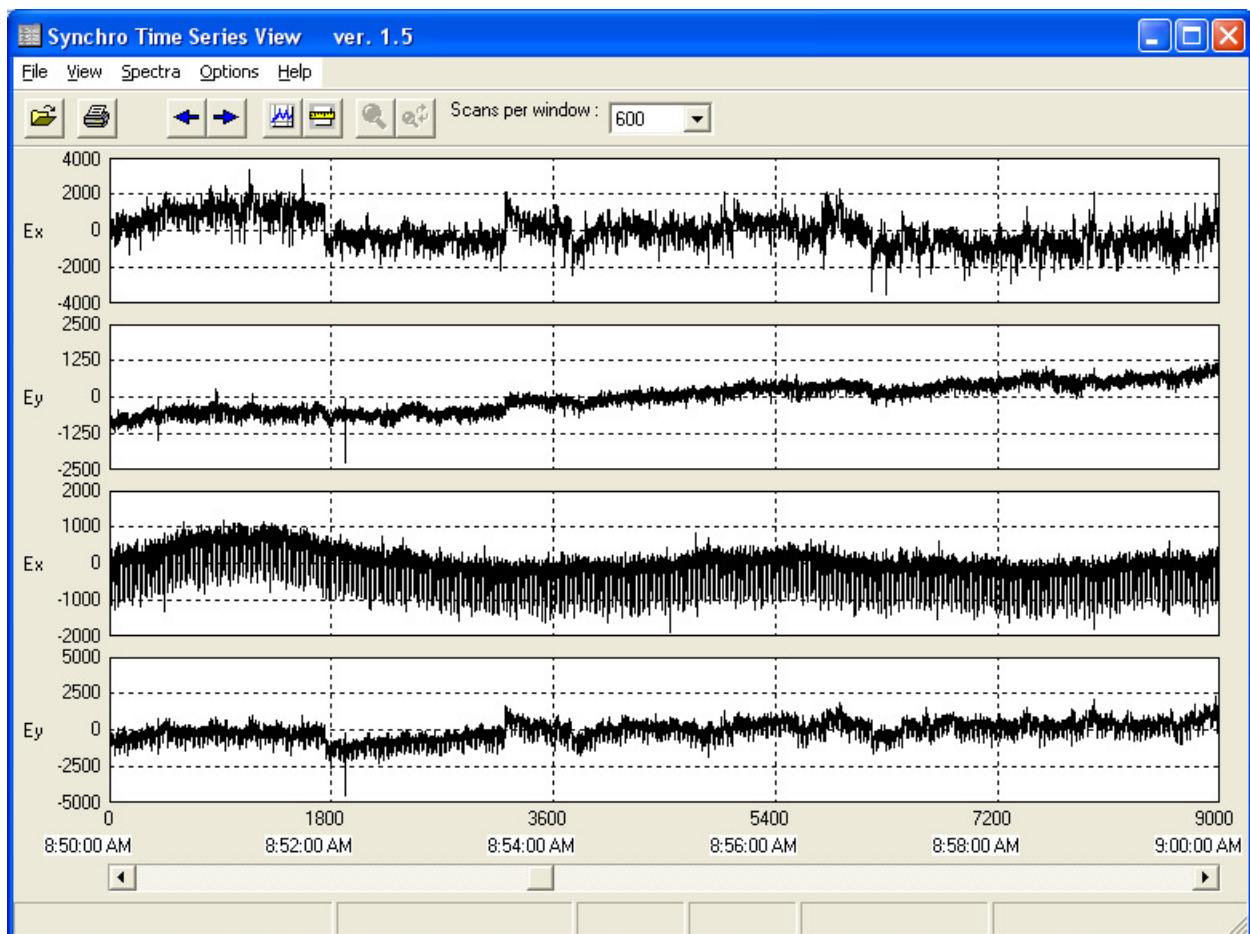


Figure 6: Example of E field time series data (top) and processed data (bottom) contaminated with the unknown noise at sites 35 and 36.

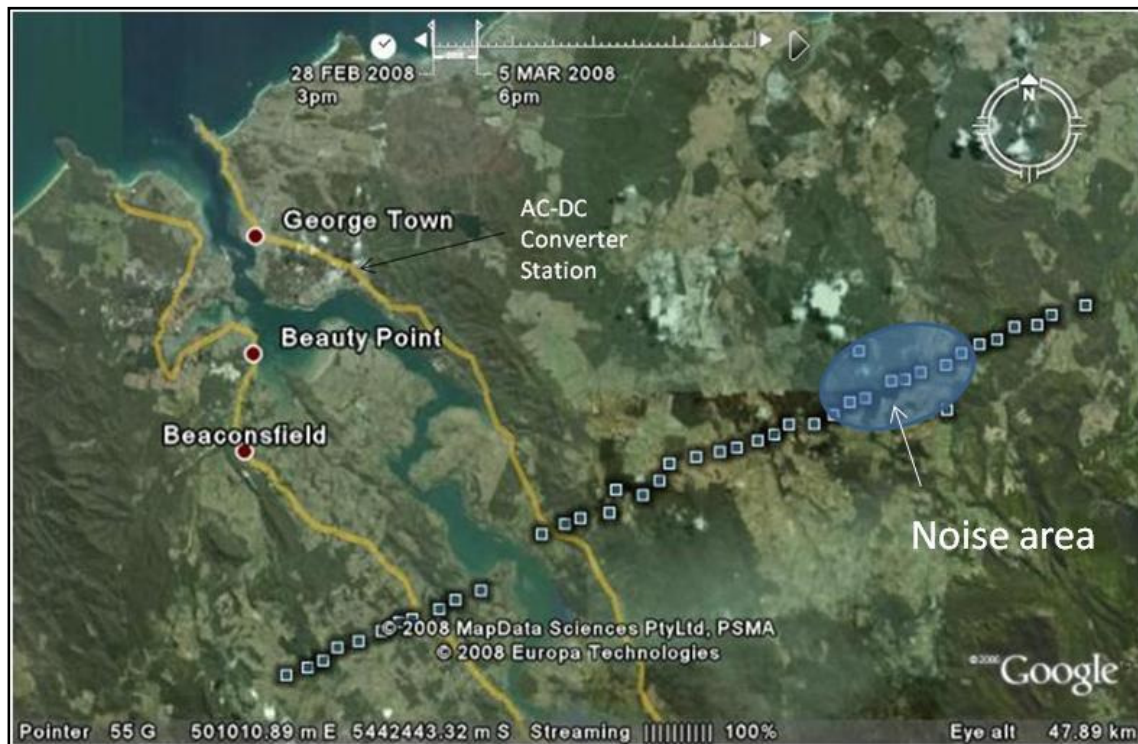


Figure 7: Map showing the location of the unknown noise.

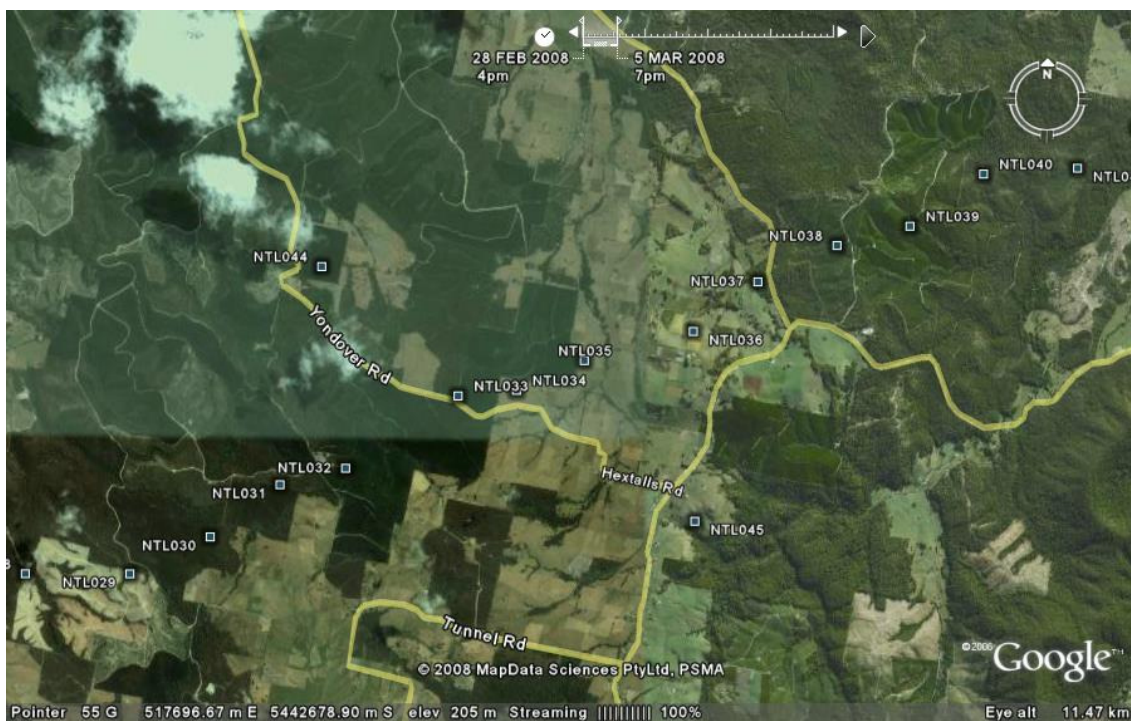


Figure 8: Map showing the locations of the extra sites NTL44 and NTL045