Helitem^2 – System Updates for Broadband AEM Data

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SUMMARY

In the last 5 years, advances in receiver suspension and receiver construction have made airborne electromagnetic low-base frequency operation possible and greatly improved the ability to explore in conductive environments. We discuss the changes made to the Xcalibur Helitem^2, helicopter time domain EM, system to enable low base frequency operation - first at 15 / 12.5 Hz, and then at 7.5 / 6.25 Hz.

The transmitter has also been redesigned to now use a square input waveform at 50% duty cycle, with a rapid turn-off. At low base frequencies this results in a long, high powered transmitter pulse that still creates high frequency signal.

Various data examples will be shown to illustrate the practical advantages of the system updates. This includes an example from Nevada where various Helitem^2 system configurations were flown over a line of ground TDEM data at different heights, as well as a Nickel exploration project.

Key words: Time Domain Electromagnetics, Low base frequency, Coil motion, Mineral exploration

INTRODUCTION

Increasingly, mineral exploration is targeting deeper deposits in areas under cover and geophysical methods are being used as a first pass screening tool. There is value in an airborne EM system that is able to penetrate conductive cover and is sensitive to deeper deposits so that large areas can be explored quickly and with greater confidence. However, it would be foolish to ignore the response from near surface targets, or targets in resistive host rocks.

Additionally, system upgrades have also been targeted at specific commodities, such as Nickel Sulphides (NiS) and Lithium brines (Li). The extreme conductivity of massive NiS can cause the decay constant of a potential resource to be very large (Smiarowski and Macnae, 2013), necessitating low-base frequency or ground EM surveys. Exploration for saline groundwater that is enriched in dissolved lithium faces a similar challenge. Unlike airborne acquisition, ground EM surveys can be time-consuming, very costly, and suffer in difficult to access terrain.

GOALS FOR SYTEM UPGRADES

In general, the team responsible for the Helitem system has endeavoured to increase the system bandwidth. Initially, this resulted in the Helitem MultiPulse system, which employed a short (1 ms), low moment square pulse at the end of the standard half-sine offtime. The increase in high frequency power above 2 kHz can be seen in Figure 1. This overlapped with the lowering of the transmitter base frequency from 30 / 25 Hz to 15 / 12.5 Hz to be the first step in achieving generally broadband data from AEM systems.

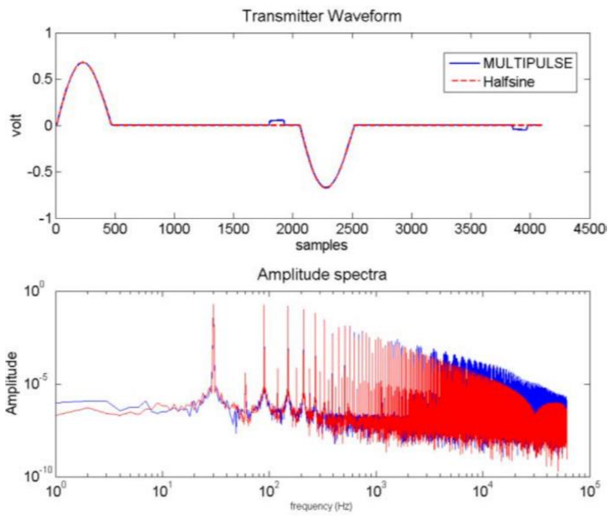

Figure 1. Current waveform for a halfsine-only pulse (red) and MultiPulse (top panel) and their calculated power spectra (bottom). At low frequencies, the power spectra are the same but at high frequencies (> 2 kHz) the MultiPulse waveform has significantly more power.(Smiarowski, et al, 2018)

More recent developments have used further refinements in the receiver suspension system to decrease the base frequencies even further to 7.5 / 6.25 Hz. This can be seen in Figure 2, where the receiver corner frequency has been moved from 25 Hz to 6 Hz, and general electronic noise has also been reduced.

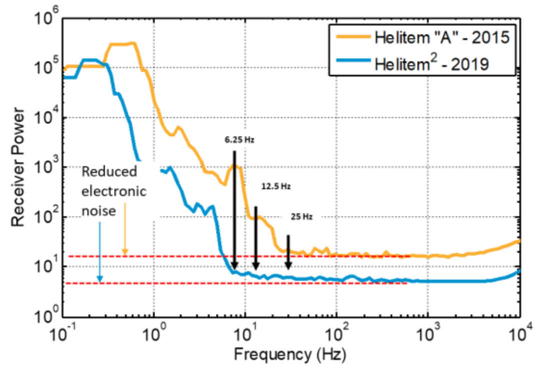

Figure 2. Receiver power spectra collected with the transmitter off for Helitem generations from 2015 (orange line) and 2019 (blue line).

In conjunction with this the transmitter waveform has been redesigned to now use a square input waveform at 50% duty cycle, with a rapid turn-off. At low base frequencies this results in a long, high powered transmitter pulse that still creates high frequency signal amplitude.

FORRESTANIA REPEAT LINE

The Forrestania EM test range is situated approximately ~350 km east of Perth. Two discrete bedrock conductors were defined during previous geophysical exploration – drilling intersected barren, disseminated to semi-massive pyrrhotite and pyrite bodies hosted in granite. We will concentrate on the western conductor (IR2) which is of limited areal size (<75 m x 75 m), shallow depth (<100 m), high conductance (>7000 S) and moderate dip (30-40 degrees). This conductor is well defined by surface and downhole EM and makes for an interesting airborne EM target (Gilgallon et al, 2019).

Figure 3 compares the EM response measured before and after the system changes and contrasts data collected over the Forrestania test site, 7 years apart. The system changes can be summarised as follows:

Helitem generation	2012	2019
Base frequency	25 Hz	12.5 Hz
Transmitter pulse	6 ms half sine	20 ms square
Offtime	14 ms	20 ms
Peak dipole moment	1500 kAm²	560 kAm²

The dramatic difference in noise level is clear at the left-side of each profile; this is made possible from changes to the receiver coil itself as well as its suspension system. The anomaly in the centre of the profile is due to sulphide mineralisation. The response at the right side of the profile is due to conductive overburden. A subtle difference between the profiles is the relative amplitude between the central anomaly and the overburden response. The central anomaly is relatively larger for the system using a longer energisation pulse (right-side image). A longer pulse maximises the response from the very conductive target. This is critical for detecting targets at depth or in conductive overburden.

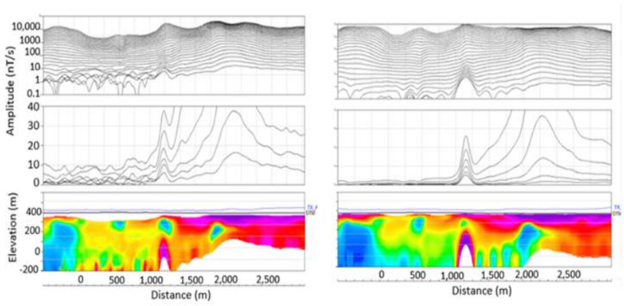

Figure 3. Log and linear-scale EM Z dB/dt response (top and middle, respectively) with a Conductivity-Depth Image shown in the bottom panel. Left column shows result from a 25 Hz survey flown in 2012 while right image shows a result from a 12.5 Hz survey flown in 2019

NEVADA TEST LINE

An acquisition program in Nevada required two different Helitem² system configurations to be flown over a test line for verification purposes. The test line also had ground TDEM soundings to be used as a calibration. The two system configurations tested can be summarised as follows:

Helitem transmitter	35 m loop	21 m loop
Base frequency	7.5 Hz	30 Hz
Transmitter pulse	33 ms square	5 ms square
Offtime	33 ms	12 ms
Peak dipole moment	560 kAm²	100 kAm²
Turn off ramp	450 µs	50 µs

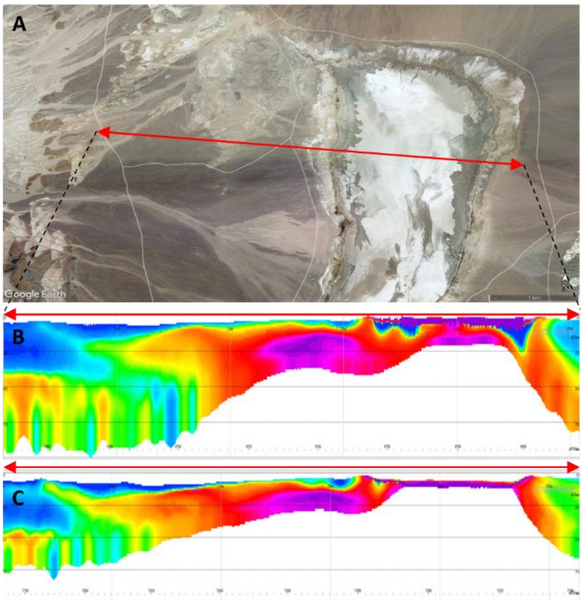

Figure 4. A) Satellite image of test line location in Nevada, USA. B) 35 m loop differential conductivity section. C) 21 m loop differential conductivity section. Both sections B and C use the same linear colour scale, and extend to 500 m depth (125 m scale divisions shown)

The test line contained features with a wide variety of conductivity and depth ranges and, in general, provided a good comparison of the imaging capability for the two systems. The system specifications were designed to focus on opposite ends of the depth / bandwidth spectrum. The 35 m configuration was imaging deep features and the 21 m configuration was imaging shallow features.

Comparing the Differential Conductivity images in Figure 4, the 35 m system was able to penetrate through some portions of a conductive playa in the eastern portion of the test line, while also detecting a subtle feature in the resistive western portion of the line. The lower moment 21 m system did not penetrate as deeply, especially in the conductive portions of the test line. However, due to its very rapid transmitter turn-off (50 µs) the near surface content of this data is greatly improved, as is the ability to map moderately conductive features in the western portion of the line.

NICKEL EXPLORATION

The Julimar Complex is located within an inferred 1200 x 100 km Ni-Cu-PGE province that follows the western margin of the Yilgarn Craton about 70 km north east of Perth. It is a mafic-ultramafic layered intrusive complex, the structure of which has been delineated with high-resolution regional airborne magnetics in an area of poor exposure. The Helitem^2 survey was designed to test for conductors within and proximal to the Julimar State Forest associated with magmatic Nickel Sulphides. The survey successfully imaged the known mineralization, and the outlined three new extensive EM anomalies within the Julimar State Forest – Hartog, Baudin and Jansz.

In September 2020 a 6.25 Hz Helitem^2 survey was flown in an attempt to understand the conductive response of the Gonneville discovery, and to identify similar mineralized zones. As can be seen in Figure 5, a large conductive zone extends directly north of Gonnville, termed the Hartog anomaly. The conductive Hartog anomaly is offset 500 m to 1,000 m west of the magnetic anomaly, and is coincident with Ni-Cu-Pd anomalism in soil sampling that is comparable to Gonneville. The amplitude of the EM response of the Hartog anomaly is almost double that of Gonneville, and once permission is obtained to access the state forest the anomaly will be drill tested.

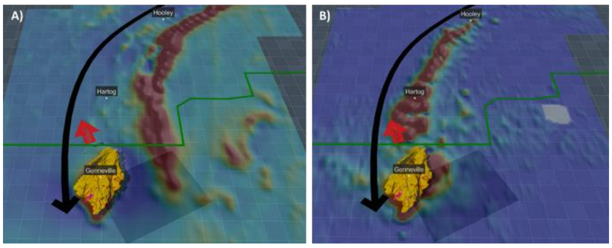

Figure 4: Perspective view looking north of, A) Gonneville mineralisation with magnetic data background, B) Gonneville mineralisation with EM data background.

CONCLUDING REMARKS

The redesigned Helitem system, now called Helitem^2, has allowed for an increase in the general bandwidth of the system. The ability to operate at low base frequencies is possible due to a complete receiver system redesign, including the receiver suspension system. Additionally, the ability to accurately control the waveform allows the transmitter turn off time to be chosen based on the near surface sensitivity required.

The advancement of airborne EM systems to collect data at ever lower base frequencies has been occurring for some time and will likely continue. This advancement fits with the exploration for deeper, under cover deposits, and to some extent for very conductive Nickel Sulphides.

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