Kimberlite exploration under thick cover using the new powerful SPECTREM^{PLUS} AEM system

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Introduction

The challenge in modern kimberlite exploration (and indeed all minerals exploration) is locating economic kimberlite deposits under thick sedimentary cover. In places such as Botswana, South Africa, Angola and Australia, the sedimentary cover sequences can be over 400 m thick. This makes geological exploration and in particular geochemical sampling and mapping extremely difficult.

Geophysical exploration, particularly airborne electromagnetic (AEM), magnetic and gravity techniques, provide an alternative tools that can be deployed in such terrrains. These methods also have specific limitations in that some kimberlites are, for example known to be devoid of magnetic or gravity signature. For AEM, the challenge is that the sedimentary cover is not only thick but tends to be conductive. This limits the penetration and the detection of primary and secondary EM fields respectively. In order to overcome the latter challenge, SPECTREM AIR PTY LTD (henceforth called SPECTREM AIR), has upgraded its AEM system (SPECTREM^{2000}) to the latest generation SPECTREM^{PLUS}, where the dipole moment has effectively being doubled and the processing improved (Leggatt, 2015) to image geology and possible minerals deposits below thick conductive cover (Pare, 2012).

SPECTREM^{PLUS} AEM system

The SPECTREM^{PLUS} system (Figure 1**)** is the world most powerful AEM system on a fixed-wing platform. The system is mounted on a modified Basler DC3 twin-turbo prop engine aircraft, and collects EM, magnetic and radiometric data simulatenously. The main advantages of the SPECTREM^{PLUS} system are (1) increased power, which results in high-resolution mapping geology and conductive mineral deposits under thick conductive cover, (2) real-time (on board) processing, which means the data are virtually ready to be modelled as soon as the sortie completed (i.e,, fast turn around of data), (3) cost effective mapping of large areas, as the sytem can aquire over 500 line-kilometers of data per sortie. Table 1 shows more system specifications.

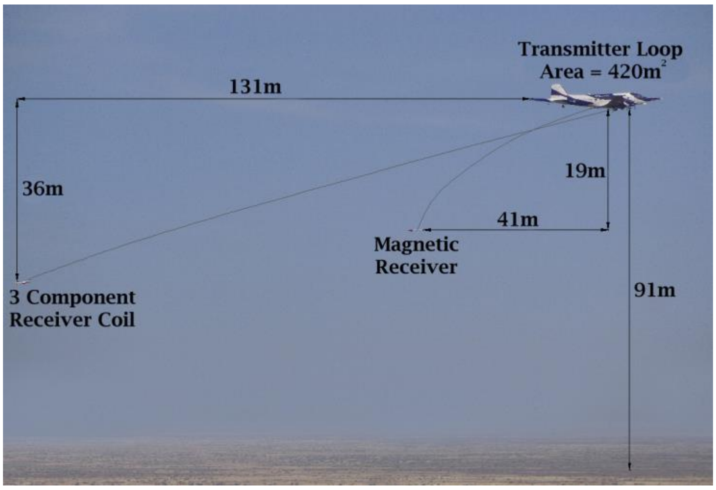
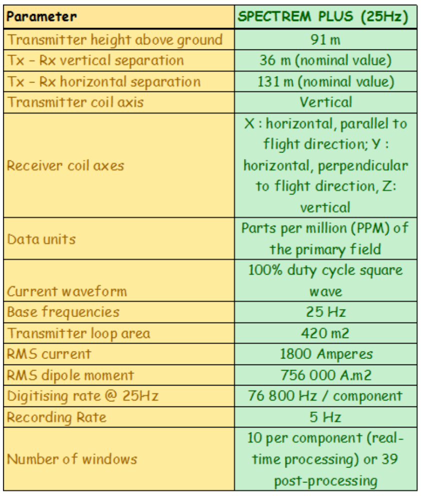


Figure 1: The SPECTREM^{PLUS} AEM system configuration specifications



Parameter	SPECTREM PLUS (25Hz)
Transmitter height above ground	91 m
Tx – Rx vertical separation	36 m (nominal value)
Tx – Rx horizontal separation	131 m (nominal value)
Transmitter coil axis	Vertical
Receiver coil axes	X : horizontal, parallel to flight direction; Y : horizontal, perpendicular to flight direction, Z: vertical
Data units	Parts per million (PPM) of the primary field
Current waveform	100% duty cycle square wave
Base frequencies	25 Hz
Transmitter loop area	420 m2
RMS current	1800 Amperes
RMS dipole moment	756 000 A.m2
Digitising rate @ 25Hz	76 800 Hz / component
Recording Rate	5 Hz
Number of windows	10 per component (real-time processing) or 39 post-processing

Table 1 SPECTREM system

The SPECTREM^{PLUS} system employs a 100% duty cycle transmitter that that transmitter an near square-waveform (Figure 2). A square transmitter waveform has more than double the low frequency spectral content compared to the “pulse” or ”rectangular ramp” type transmitter systems, which gives considerably better depth of penetration for good conductors in conductive environments.

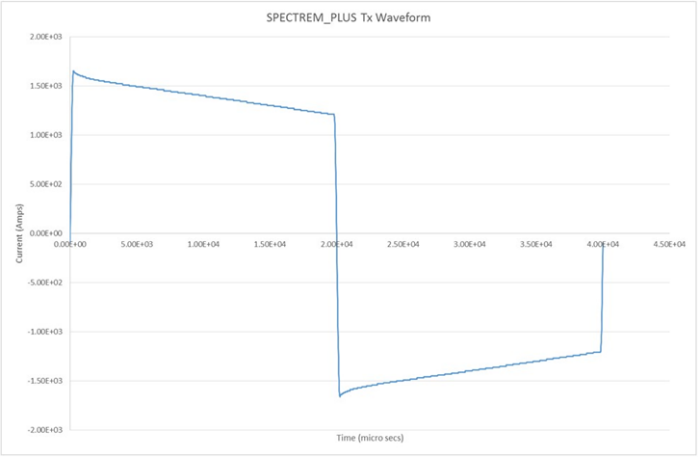


Figure 2: SPECTREM^{PLUS} transmitter waverform

Kimberlite modelling

In order to assess the efficiency of the new SPECTREM^{PLUS} a forward modelling exercise was conducted to investigate how the sytem would map kimberlite in a geology similar to that in Botswana. For a kimberlite that lies at the base of the Karoo, Figure 3 shows the resulting model. For display purposes, note only the latest EM channels (depicting deeper geology) are shown against the system noise levels derived from data measured at higher altitudes of 3 000 feet.

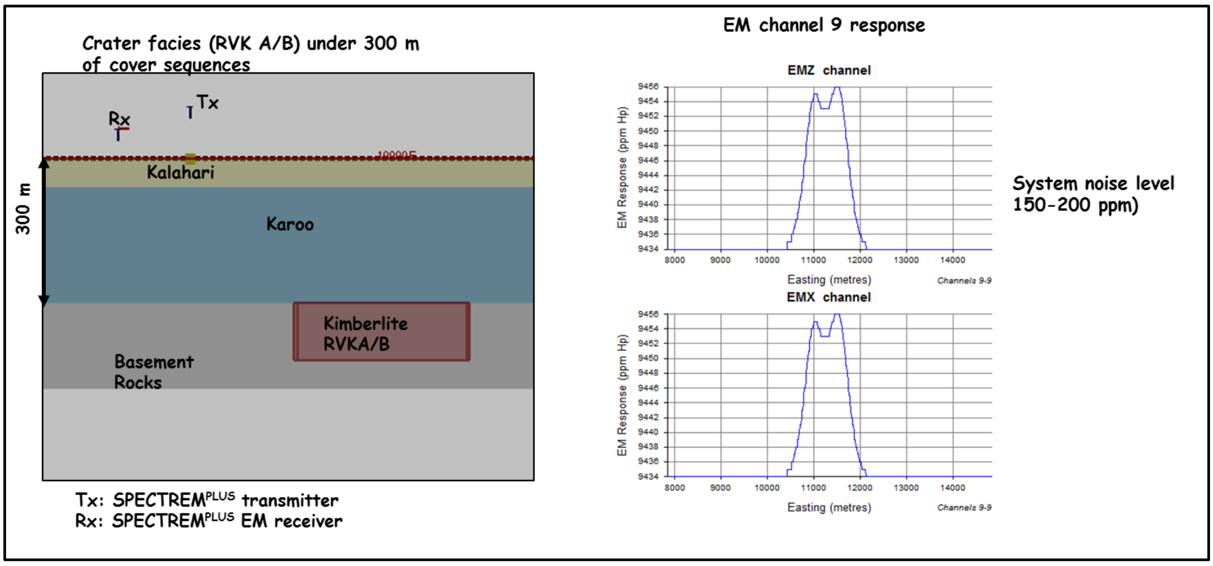


Figure 3 A model depicting a typical geological model where kimberlite RVK-A facies intrudes into the base of the Karoo and the resulting late time EM responses (channel 9). Note these channel 9 amplitudes are above the the system noise level

The model above illustrates the difference that having a higher system power makes in detecting kimberlites under cover.

This next example is based on a typical Orapa type kimberlite which does not have thick cover sediments sequences. It can be readily seen that the kimberlite is clear delineated at late channels, therefore the system will be able to map targets in this setting.

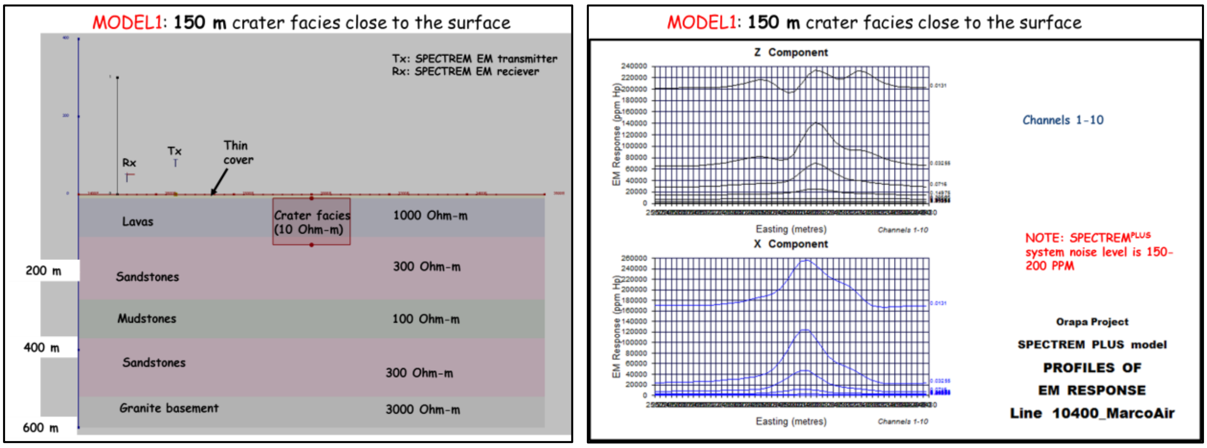


Figure 4 Typical Orapa-type kimberlite setting and the resulting SPECTREMPLUS EM responses, clearly showing that the target will be mapped

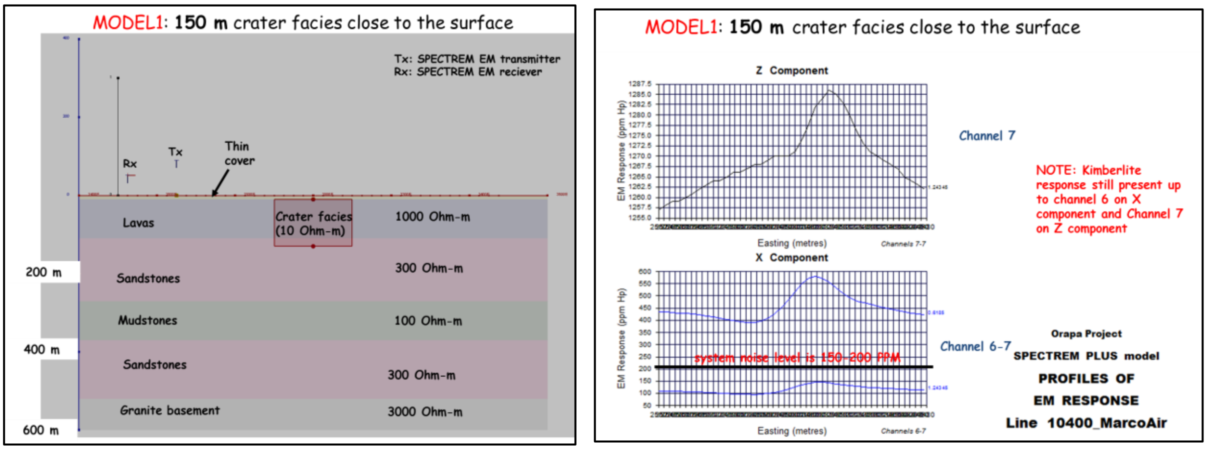


Figure 5 Typical Orapa-type kimberlite setting and the resulting SPECTREMPLUS EM responses, clearly showing that the target will be mapped at late channels

Discussion

The main results of the modellign is that the SPECTREM^{PLUS} system can be used to map kimberlite targets under Kalahari and Karoo cover at 300 m depth. The crater facies (RVK-A/B) has to be significantly more conductivie than the Karoo sediments, which in many cases is the case.
Given that some kimberlite can exhibit non-magnetic signature, the results above indicate that AEM can be used to map those kimberlites that otherwise could be missed with AEM.
The results will be presented where SPECTREM^{PLUS} system is flown over an area in Botswana for kimberlite mapping. The non-magnetic targets are mapped relatively well where airborne magnetic could not.

References

Leggatt, P (2015), Extending the range of conductivities recorded by the SPECTREM AEM system, Exploration Geophysics, 46, 136-139

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