The application of Airborne Electromagnetic Methods in the search for buried Kimberlites and Diamondiferous Gravels.

Leggatt, P.B.[1] and Klinkert, P.S.[1]

1. Geophysical Services Department, Anglo American Corporation of South Africa Limited, P. O. Box 61587, Marshalltown, 2107, South Africa

In the past 29 years, airborne electromagnetic methods have been used in a number of environments around the world in the search for diamonds. This paper describes the various methods that have been used with special emphasis on the use of the SPECTREM AEM system in this search.

Prior to 1984, all AEM systems were analog systems. Interpretation of the data was largely a manual process done on analog records and was therefore rudimentary and time consuming. With the development of fully digital systems such as SPECTREM, the nature of interpretation has changed completely. AEM anomaly maps showing the location of all conductors and their conductivity thickness products, dips, depths and magnetic associations amongst other things can now be generated within a day or two after flying an area. In the search for diamonds, other sophisticated methods such as Conductivity - Depth Imaging (CDI) can be applied equally rapidly. This technique was originally adopted for airborne use with the SPECTREM system and is now being used by most of the other AEM contractors.

There are essentially two AEM approaches which are used in the search for diamonds. The first one is used to detect kimberlite directly by measuring the thickness and conductivity of the material overlying the fresh kimberlite itself. It is usually the increased depth of weathering and considerably higher conductivity of the weathered kimberlite compared to the host rock, that enable it to be detected rather than any other electrical property of the fresh unweathered kimberlite itself.

The second approach is to detect buried river or marine channels in which diamonds were deposited. Again these are detected by measuring the thickness and conductivity of the relatively unconsolidated sediments overlying the bedrock channels.

The following examples show how AEM methods are applied to solving these problems. The first two examples show the traditional use of airborne electromagnetics to detect kimberlites in the North West Territories, Canada. These are GEOTEM responses over the Willy-Nilly and Point Lake kimberlite bodies. In these cases, no sophisticated processing such as Conductivity-Depth Imaging was necessary since the kimberlites are very easily detected using the AEM anomaly profiles and the apparent conductivity map. Note that the bodies also give coincident negative magnetic anomalies.

The next example is along the west coast of southern Africa and here the search problem was to detect the thickness of relatively unconsolidated shallow marine sediments overlying bedrock. The data was processed to Conductivity-depth images from which the sediment depth was contoured in order to detect channels in the bedrock where alluvial diamonds could be found.

The next example in southern Africa consisted of a few widely spaced test lines flown over thin sand and Karoo sediment cover underlain by Ventersdorp lavas which occasionally had conductive

black shale units in them. This area was flown with both the SPECTREM and DIGHEM AEM systems so that a comparison could be made between them. The search problem here was firstly to map the thickness and conductivity of the thin Karoo cover present here, and secondly to detect possible kimberlites at the base of the Karoo sediments which would probably show up as increased values of thickness and conductivity at these localities.

The fifth example is also from southern Africa and shows the direct detection of a hitherto unknown kimberlite situated under thin Kalahari sand cover. The data from this survey was flown with the DIGHEM system.

The sixth case study, also from southern Africa, was flown with the SPECTREM system. It shows how Karoo sediments can be differentiated from Stormberg lavas under thin Kalahari sand cover using conductivity-depth images. Obviously this information would be useful in the direct detection of kimberlites under the sand cover.

In conclusion, AEM methods have been successfully employed in the search for diamonds around the world. Because the technique is more expensive than other airborne methods such as magnetics, it usually used where favourable areas have already been outlined by these and other methods and where the geological environment is such that airborne electromagnetics provides the best chance of success.

References:

Macnae, J. C., 1979, Kimberlites and Exploration Geophysics: Geophysics, 44, 1395-1416.
Macnae, J.C., 1995, Applications of Geophysics for the Detection and Exploration of Kimberlites and Lamproites: Journal of Geochemical Exploration, 53, 213-243.