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The Biased Heterodyne Method - Nonlinear Electrical Conduction in Sulphides

Induced Polarisation (IP) and Transient Electromagnetism (TEM) are among the most widely used Ground Electrical Geophysics methods in Australia, being specialised in detecting conductive and chargeable targets such as sulphide deposits. A key challenge of IP & TEM methods is that mineralogy of a chargeable target is not able to be determined; often a chargeable body is not a sulphide deposit but a graphite-rich formation of black shale or clays. As these shale deposits are undesirable targets, distinguishing by physical methods such as drilling is exhaustive on exploration resources.

White 1974 identifies the effect of disseminated sulphide crystals acting as a diode in the presence of two electrical signals of non-harmonic frequencies. The graphite-rich shales, which plague induced polarisation surveys, cannot be distinguished by current electrical methods. These shales produce a strictly linear response, which contrasts to the non-linear response of sulphide-rich rocks when the mixed signal is received and transformed into the frequency domain.

A laboratory-based reinvestigation into non-linear properties of sulphides has been undertaken with a view towards field application. Variable frequencies and signal strengths were used to validate the method, based initially on the processes in White 1974. The application of a DC bias to either signal increased the detectability of non-linear responses, allowing for a lower current density threshold for measurement.

The intermodulation products produced in this laboratory-based investigation as a response by sulphide mineralised deposits allows for distinction from non-mineralised shales and clays. The magnitude of the non-linear signal detected provides a basis for field testing of this previously unutilised electrical property, to greatly reduce the number of drill targets barren of mineralisation.

Initial field testing for this new method has also been undertaken to determine the potential for applying this electrical property to active sulphide exploration, and research is ongoing into the field applications of this new technique.

Key words: Non-linear conduction, heterodyne method, sulphide exploration, laboratory study, field trials.