Controlled source electromagnetic monitoring of Inferno Crater Lake, Waimangu, New Zealand

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SUMMARY

An experiment to test the feasibility of using CSEM measurements to detect electrical conductivity changes beneath Inferno Crater Lake was conducted at the Waimangu geothermal field. Here, changes in the steam content of the 2-phase zone beneath Inferno Crater cause the level of the hot lake occupying the crater to rise and fall by ~7 m over 6 weeks. The change in lake level and temperature provide a known signal that we can compare directly with the CSEM response and provide a proxy for the sort of change we might expect to see prior to a phreatic- or hydrothermal-eruption. A key determinant of the success of this 6.5-month long monitoring experiment will be whether it is possible to distinguish effects associated with the lake level change from changes in the 2-phase hydrothermal system beneath the lake.

A least-squares time-domain approach was used for signal recovery. This approach provided hourly estimates of the amplitude and phase of the frequency-comb used for the transmitter signal and allowed near-real-time remote monitoring of the transmitter. The frequency of each comb component is precisely known with its phase controlled by a GPS clock. An identical approach was used to recover the receiver electric-field signal. In this way the electric-field response at the receivers can be normalized for small variations in the transmitter current due to diurnal temperature variations and rainfall. A time-domain approach facilitates noise-spike removal and allows the noise statistics of the transmitter-receiver system to be determined at the comb frequencies. Phase control was accurate enough to detect a ~100 ns/day phase drift caused by a problem with transmitter synchronization. Receiver magnitude and phase variation strongly correlate with lake level but have different frequency dependencies inconsistent with a purely galvanic (or static) effect caused by changes in lake level alone.

Keywords: Controlled source electromagnetics (CSEM), signal processing.