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The stability and temperature sensitivity of long-term measurements of the electric potential

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Summary

We carried out long-term measurements of the electric potential in the laboratory and in the field and assessed the stability and temperature sensitivity of the recordings. To do so we designed and built modular porous-pot electrodes, which facilitates repair, using an over-saturated metal-salt electrolyte stabilized in a clay and ceramic or wood porous plugs.

In the laboratory, using multiple different pairs of electrodes, we found that the electric potential measurements appeared to stabilize over the course of several days (for example, variations of ~0.2 mV), and in the following time they showed a smooth and slight drift of 0.05–0.5 mV/month. The noise, defined as the standard deviation of the electric potential measured at a select period, was found to be very small (0.2–0.4 µV at a periods of 1–120 s).

The temperature sensitivity of the electric potential recordings was assessed by measuring in a temperature-controlled climate chamber and varying the temperature from −3°C to 35°C. This experiment determined a temperature sensitivity of about −30 µV/°C. This is considered very low compared to some commercially available electrodes (which can be up to 1 mv/°C).

In the field, a robust design for long-term telluric recordings including a redundant parallel dipole so that consecutive stable time windows are more likely to be recorded was implemented in the Sauerland region of Germany (more than three months). Field testing is complicated by the fact that the system is no longer in isolation. However, the stability of the electric potential measured in the laboratory was a reasonable predictor of the stability of electric potential measured in the field. Nevertheless, instabilities in the form of spikes in the potential, steps, and spontaneous jumps (on the order of 1 mV) of unknown origin were observed.

The field measurements included a temperature-logging device. The temperature was monitored at two locations: a) the bottom-hole temperature at a depth of 80 cm below the surface, where the electrode was planted, and b) the top-hole temperature at a depth of 5 cm below the surface. The recorded temperatures in the electrode hole can be compared to the air temperature (as recorded in the nearby village). The results clearly show that planting the electrode deeper avoids the daily variations of temperature, which, in this case, were appreciable (up to 7°C), and which can affect the electric potential recordings. The bottom-hole temperature variation follows the long-term seasonal trend (e.g., 1–2°C/10 days), but is insensitive to short-term variations. Furthermore, installing electrodes at such depths can insulate them and avoid problems associated with the temperature going below the freezing point.

Keywords: electrical resistivity; electrode; long-period measurement; temperature; noise