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Temperature control device for the electromagnetic measurement of clay materials in a coaxial waveguide setup

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Ground penetrating radar has been widely used for several decades to assess the properties of the Earth's subsurface, with large applications varying in the domain of civil engineering to astrophysics [1-3]. To benefit GPR data interpretation and to assess the limitations of this technique, the measurement of the dielectric properties of soils is extremely important, since it provides complementary information on moisture content, granulometry and temperature [4].

In this work, we present a temperature control device to measure the dielectric properties of dry and humid soil samples using a coaxial tapered waveguide [5,6]. The cell integrates a sample-holder, detachable and watertight, which is a great advantage when measuring powdery materials with controlled water content. The temperature of the sample holder is controlled (precision of 0.1°C) with a PID controller associated to a heating ring with an integrated temperature probe placed around the sample holder.

A sample of a clay and quartz based material (CTMNC, Limoges, France) was humidified with distilled water to reach 14.72% of Moisture Content (%MC) and a dielectric measurement of this sample was acquired at ambient temperature. The %MC is verified with a Moisture Analyzer. Then, the temperature was increased to 25°C, 30°C, 43°C, 70°C and 85°C, and a measurement was acquired after a delay of stabilization for each of the temperature points. The same procedure is repeated with the dry sample.

The dielectric measurements were performed from 10MHz to 6GHz. Results show relatively stable permittivity measurements throughout the analyzed frequency interval, only with a slight increase for the lowest frequencies, in the dry sample case, and a considerable increase for these frequencies, in the case of the 15% MC sample. This difference between dry and humid sample is expected, since water interacts with the salts present in the sample, which increases the imaginary part of permittivity, and consequently, the conductivity of the sample. This phenomenon is especially noticeable for lower frequencies. With increasing temperature, the permittivity of the sample tends to increase up until 1GHz, and then an inversion of this behavior occurs from 1 to 6 GHz.

With this type of complex moist sample, we were able to demonstrate the interest and straightforwardness of our variable temperature dielectric and magnetic measurement system. The electromagnetic measurements showed the expected behavior for this kind of soil sample, and it was possible to confirm the preservation of the sample's physical state throughout the temperature range.

Currently, the system can reach 85°C but future work will allow performing dielectric measurements up to 400°C on any type material.

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1. Meles, G. A., et al. IEEE Trans. on geoscience and remote sensing, 48(9), 3391-3407, 2010.
2. Brouet, Y., et al. Journal of Geophysical Research: Planets, 121(12), 2426-2443, 2016
3. Busch, S., et al., Geophysics, 77(6), H79-H91, 2012
4. Robert, A. Journal of Applied Geophysics, 40(1-3), 89-94, 1998
5. Georget, E. et al., Comptes Rendus Physique, 15(5), 448-457, 2014.
6. Neves, A. L., et al., Review of Scientific Instruments, 88(8), 084706, 2017