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Geophysical surveys to inform heat-flow experiments in a fractured chalk aquifer, Berkshire, UK

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Urban geothermal solutions to heating and cooling have developed slowly in the UK, partly due to limited understanding of subsurface heat flow regimes and how stored heat might be sustainably governed within heterogeneous aquifers. Understanding heat flow through various aquifers is the goal of the *SmartRes* project, in which heat flow trials will be conducted in a number of sites. To provide context for heat flow experiments in a fractured chalk aquifer, geophysical surveys were acquired at Trumplett's Farm, a groundwater abstraction and monitoring site near Reading (Berkshire, UK). Here, groundwater flow is primarily within a fracture network, likely in an active zone within the upper 10 m of the saturated chalk.

Seismic surveys recorded energy generated with an impact source at surface geophones (24 cabled GEODE, and 20 nodal Smart-Solo, geophones) and hydrophone strings, deployed to 100 m depth in boreholes drilled at the site. Smart-Solo nodes were deployed in a ~10 x 5 m grid at the site, with cabled geophones occupying lines between adjacent boreholes, with geophone intervals of up to 2 m. Nodal geophones recorded passively throughout the 3-day deployment and will be analysed using ambient noise correlation to evaluate anisotropy. The remaining data has been used for preliminary analysis with MASW (Multichannel Analysis of Surface Waves), P-wave refraction velocities, and vertical seismic profiles (VSPs).

MASW analyses suggest shear wave velocity (Vs) ranges from 250-600 m/s in the uppermost 1.5 m, but estimates are challenging given poor dispersion imaging of the fundamental mode. Different source-receiver offsets were tested to eliminate mode superposition, but the best dispersion curves are observed for zero-offset shots. Data were processed in a commercially available software with relatively limited freedom to adjust inversion parameters, hence further analysis will use the MuLTI code to undertake a constrained Monte Carlo inversion approach. The deeper structure of the chalk was characterised in VSPs, indicating reflective P-wave horizons at 52 and 69 m depth, separating material with interval velocities of ~2100 m/s, ~2500 m/s and 3000 m/s. Observing these reflections required aggressive frequency-wavenumber filtering to suppress direct waves in the water column.

Electrical resistivity tomography (ERT) surveys were conducted using the BGS PRIME ERT system to optimise array configuration for long-term monitoring. The reconnaissance survey included in-hole, borehole-to-surface, and surface ERT at 1 m intervals, employing C1P1-C2P2 bipole-bipole and dipole-dipole arrays around the site. Preliminary ERT inversion revealed low resistivity zones within the top 1.5 – 2 m across the site and mapped a potential south-dipping high resistivity structure. A longer ERT survey spread is planned to better reveal hydrodynamic interactions at deeper depths.

This initial insight will be refined with a fibre-optic distributed acoustic sensing deployment at the Trumplett's site and an optimised repeat of the BGS PRIME ERT array. These will be synchronous with a thermal response test at the Trumplett's site monitored with distributed temperature sensing.

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