OR/19/052 Appendix 3c - Array 3 Borehole description

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Kingdon, A, Fellgett, M W, and Spence, M J. 2019. UKGEOS Cheshire Energy Research Field Site - Science infrastructure. *British Geological Survey Internal Report*, OR/19/052. *Contributors:* Midgley, J, Elsome, J W, Dearden, R A, Chapman, C, Burke, S P, Hough, E, Luckett, R R, and Bianchi, M.

Table 12 Array 3 Summary borehole metadata and planned sampling.

Array 3: Deep Borehole	**Description**
Scientific Objective:	Drilling of Permo-Trias succession & fault, coring of Carboniferous succession and installed of seismic monitoring and geophysical equipment
No of Sites	1 (co-located with Array 4)
Expected Lithostratigraphy at TD	Carboniferous Millstone Grit Formation
Boreholes per site	1 x 1200 mbGL
Casing Installed	Conductor 0 -30 mBGL, Permanent steel Casing to 428 mbGL (to achieve complete zonal isolation for aquifers)
Expected end use	Long Term Seismic Monitoring
Samples available during drilling	Drill cutting collected sporadically
Cored Boreholes	Continuous coring for 428–1200 m, likely 85/102 mm core diameter (TBC)
Geophysical logs: Run 1	0–425 M: Neutron-Density-Spectral Gamma Ray, P&S wave, Resistivity (+ potentially Cross-dipole sonic)
Borehole Imaging Run 1	0–425 M: High-resolution resistivity borehole imaging + inclinometry
Geophysical logs: Run 2	425–1200 M: Neutron-Density-Spectral Gamma Ray, P&S wave, Resistivity (+ potentially Cross-diplole sonic) Casing Inspection Logs (Cement Bond Log/Ultrasonic Imager)
Borehole Imaging Run 2	425–1200 M: High-resolution resistivity borehole imaging + inclinometry
Drilling parameters	Drilling data parameters & Extended leak-off test
Geomicrobiology sampling	Standard geomicrobiology sampling protocol: 1 sample per 10 m of core in cored boreholes
Gas testing during drilling	MFDT/RFT Pressurised fluid & gas sampling
Fluid testing during drilling	MFDT/RFT Pressurised fluid & gas sampling
Fluid Testing Post Drilling	None possible with borehole completion
Pump Testing	None possible with borehole completion
Permanently installed equipment	Guralp seismometer, DAS fibre optic cable & resistivity tomography to base casing

Intended purpose of array 3

The purpose of the proposed deep well is to characterise geological sequence in the area of the Ince Marshes horst block and is designed to allow long-term seismic monitoring of these formations for

the life of the project from the Quaternary through to the Carboniferous Millstone Grit Group.

Within the CERFS, Array 3 gives the single opportunity to obtain information relating to the Carboniferous Millstone Grit, Coal Measures and lower part of the Warwickshire Group bedrock strata. These rocks represent potential barriers between exploration targets for PEDL licence holders in this and adjacent areas, although have been faulted over geological time; they have also been explored in the past for coal-bed methane. As such, characterisation of these rocks is considered important to a range of potential innovative geoenergy technologies that may form topics of research projects as part of the broader UK Geoenergy Observatory aims.

The array will generate a dataset of drilling data, wireline log data (including image logs) and core as well as gas and drilled cuttings data. In combination these will allow for detailed studies of rocks which are often poorly characterised as a foundation for future research. The data will be relevant to furthering understanding from this site, but also add value to existing datasets from the region, including other deep borehole core, downhole log data, and released 2D and (not-yet released) 3D seismic data.

The well will be drilled in proximity to Array 4 (Multiscale) and potentially can be co-opted to service multiscale experimentation. The Array 3 borehole will be drilled in advance of Array 4. Given that Array 4 is intended to operate as an experimental infrastructure, with the flow properties of the Dungeon Bank Fault system being a key research objective, ensuring that the infrastructure is appropriately located within these wells is a key consideration for Array 3. The Array 3 research objectives include:

- Characterising intact and faulted rock properties
- Identifying the location and orientation of the main Dungeon Banks Fault plane
- Quantifying the width of the fault damage zone and the types of deformation present
- Identifying whether any significant gas is present in the vicinity of this fault
- Assessing the likelihood of borehole collapse in the vicinity of the fault
- Determining the offset on the fault and the depth to the top of the Pennine Coal Measures Group

Components of array 3

The array will consist of a single vertical borehole that will penetrate the Quaternary superficial deposits, the Permo-Triassic and some Carboniferous formations reaching total depth, estimated at 1200 m (TD) in the upper part of the Carboniferous Millstone Grit. The Permo-Triassic succession will be open hole drilled and then logged using wireline geophysical logging tools. This section will then be fully cased through the lower bounding fault to achieve zonal aquifer isolation. Both electrical resistivity tomography and fibre optic cables will be permanently installed behind the casing. Following the completion of the drilling to TD, geophysical logging (including borehole imaging) and fluid/gas sampling of the total borehole section will be undertaken. On completion of these activities a single seismometer will be inserted at TD and the borehole backfilled with engineered cement.

The components parts of the array are:

- A borehole approximately 1200 m Total Depth (TD) in the Carboniferous Millstone Grit
- Fibre Optic cable installed on outside of the casing(s) for Distributed Temperature Sensing (DTS) and Distributed Acoustic Sensing (DAS)
- A single seismometer installed in the base of the borehole for the detection of seismic activity

Data acquisition in array 3

Key data acquisition phases in this borehole, includes core recovery, geophysical wireline logging and borehole imaging. Pressurised fluid/gas samples will be acquired using wireline formation testing tools such as the Repeat Formation Tester and the Module Dynamics Tester. Depending upon the specific contractor and equipment used (to be confirmed) samples of specific intervals will be recovered at in-situ pressure allowing accurate quantification of the subsurface fluids and gas composition.

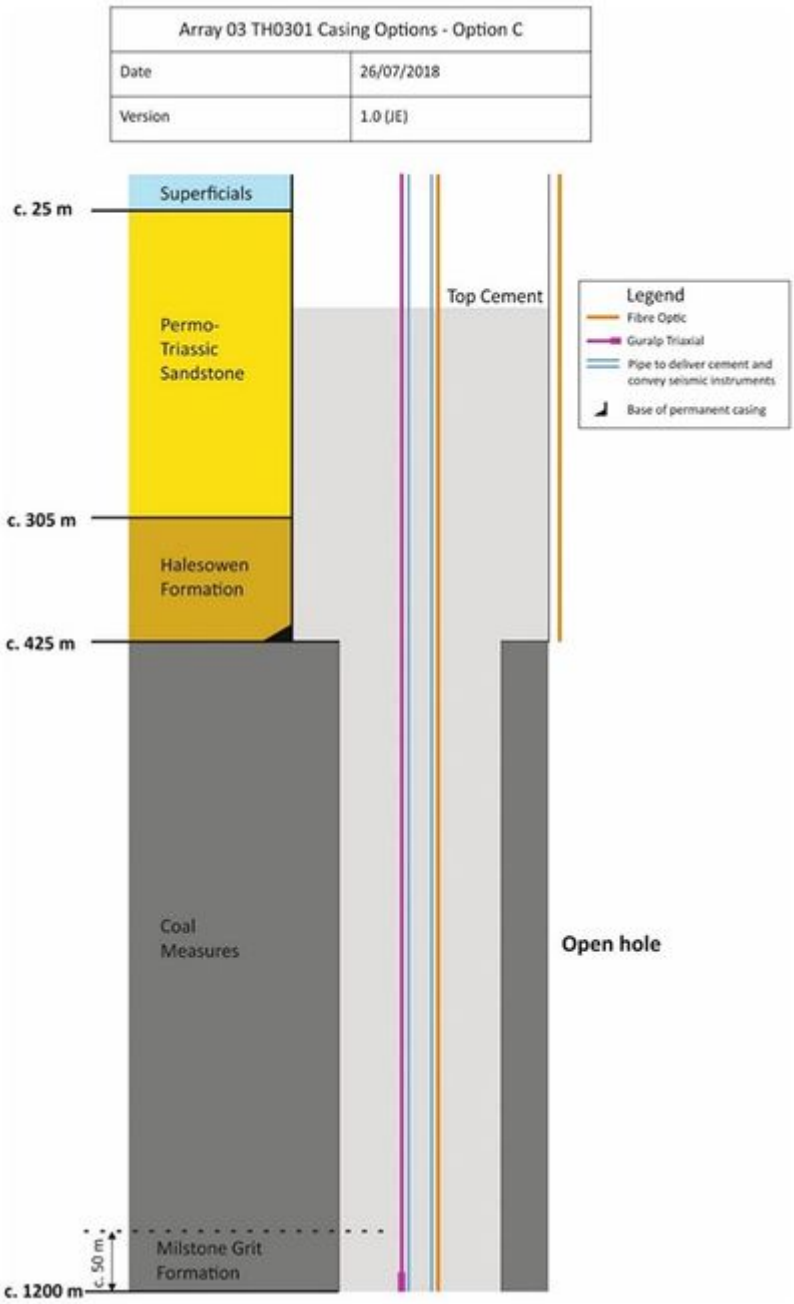

Figure 19 Array 3 Borehole construction/casing options and prognosis.

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