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# GGC01 Cored, seismic monitoring borehole – initial data release

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BRITISH GEOLOGICAL SURVEY

UK GEOENERGY OBSERVATORY PROGRAMME

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# GGC01 Cored, seismic monitoring borehole – initial data release

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Keyworth, Nottingham British Geological Survey 2019

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## Summary

This report gives a short overview of information related to the initial data release for GGC01. The cored, seismic monitoring borehole GGC01 (BGS SOBI number NS66SW BJ 3754) was drilled between 19 November and 12 December 2018 producing a core of 102 mm diameter. The borehole was wireline logged in December 2018 and a string of 5 seismometers were installed in February 2019.

Contributions to this report and the data acquired are as follows:

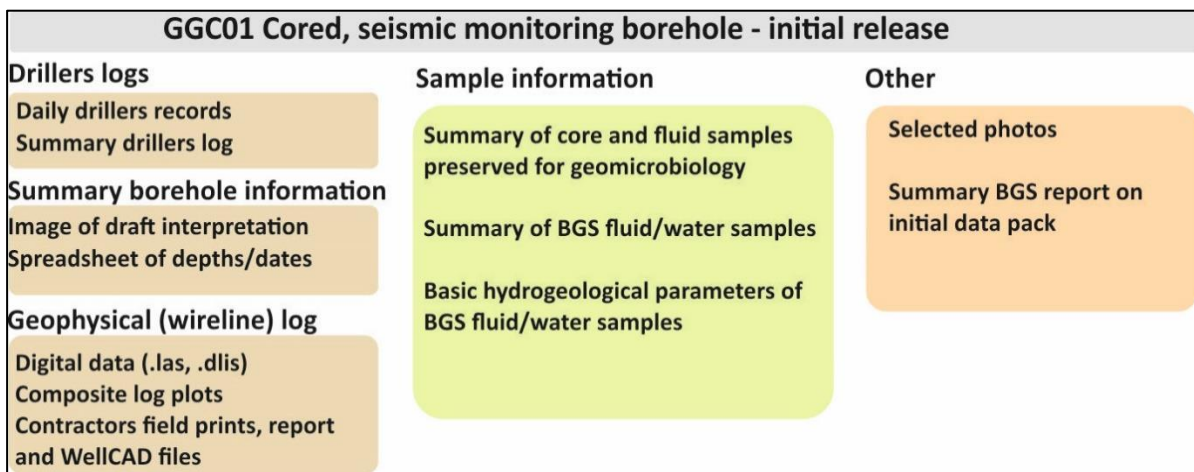
- Vanessa Starcher: Technical overview, wireline log data acquisition
- Kirsty Shorter: Fluid and geomicrobiology samples, tracer information, field measurements, photo metadata
- Hugh Barron: On-site core and data acquisition, initial geological interpretation
- Joel Burkin; Geomicrobiology samples, on site core management and initial geological interpretation
- Jack Elsome: Fluid and geomicrobiology samples
- Mark Fellgett: Wireline log data checking and documentation
- Andy Kingdon: Wireline log data checking and documentation
- Megan Barnett: Geomicrobiology samples
- Alison Monaghan: Coordinating initial data pack, initial geological interpretation

**IMPORTANT – Note that all borehole depths given in the initial data release are based on the drillers log dataset (excepting wireline data). Borehole depths will be subject to minor change once non-recovery intervals are assigned. Borehole and sample depths will be revised in the final borehole data pack so that core scans, wireline logs and borehole logs/samples are consistent.**

# 1 Introduction

This report gives a short overview of information related to the initial data release for GGC01. The cored, seismic monitoring borehole GGC01 (BGS SOBI number NS66SW BJ 3754, British National Grid reference 260915, 663109) was drilled between 19 November and 12 December 2018 producing a core of 102 mm diameter. The borehole was wireline logged in December 2018 and a string of 5 seismometers were installed in February 2019. A range of fluid, water and core samples were taken during the drilling process.

In due course a full report and dataset will be released for this borehole including core scan, core log etc. data matched to a consistent depth scale.



**Figure 1 Visual summary of data files within the initial data pack for the UK Geoenergy Observatories cored, seismic monitoring borehole GGC01**

## 2 Drillers logs

### 2.1 DAILY DRILLERS RECORDS

*File names: BAA4202-GGC01\_DL\_page8(2018-12-04).pdf and similar (17 files)*

The daily drillers records were compiled by BAM Ritchies, the drilling contractors, and provide a summary of the operations that take place on the rig during one day. The reports contain information about the amount of rock that was drilled and cored during the day as well as the driller's basic description of the lithology that was encountered – note that this is approximate, as it was through an opaque core liner. Information regarding hole diameter and casing diameter for each section drilled is also shown. The records are produced in the field and have not been reviewed. There are no records for the days where drilling did not take place.

All drilling was advanced using a rotary-cored method with water flush. This involves rotation of the core barrel as it goes down and the retrieval of a core of material when the barrel is pulled back to the surface.

## 2.2 SUMMARY DRILLERS LOG AND FINAL INFORMATION SHEET

*File names: GGC01 Final Log 070319.pdf and GCC01 Final info sheets 070319.pdf*

The summary drillers log is a compilation by the drilling contractor of the daily drilling records. Please note the caveats above – that this was an on-site record through an opaque liner (only the ends of the rock core being visible). The final information sheet summarises the information from the daily drillers records and includes information on the depth of the seismometers installed.

# 3 Summary BGS borehole information

## 3.1 SPREADSHEET OF DRILL DEPTHS/DATES/CORE RECOVERY

*File name: GGC01 Coring data\_V6.xlsx*

The same information as is presented on the summary drillers log is contained within a BGS spreadsheet summarising the core runs, basic recovery information and approximate lithology as recorded at the drill site. The depth intervals of the 1 m cores sub-sampled straight after drilling for geomicrobiology and geochemistry investigations are highlighted.

Note that as highlighted above depth correction of some core intervals will be needed in the poor recovery zones to align features visible in the geophysical (wireline) logs and core scans. Revised depth information will be included in the final borehole data pack.

## 3.2 IMAGE OF DRAFT BOREHOLE INTERPRETATION

*File name: BoreholePrognosis\_GGERFS10\_draft\_v9\_Preliminary\_v2.pdf*

This image compares the anticipated geology with the initial interpretation from the drillers/ BGS record. This interpretation will be greatly improved by subsequent core scanning, core logging and depth matching with the geophysical (wireline) log and should be treated as a preliminary guide only. The depths of the geomicrobiology core samples are shown.

The drilled superficial deposits succession and depth of the lithological rockhead surface was much as expected (these parts of the geological prognosis being well constrained by existing borehole data). The bedrock part of the succession is typical of the base of the Upper Coal Measures and Middle Coal Measures, possibly just penetrating into the Lower Coal Measures. The drilled succession likely includes a slightly thicker interval of the Upper Coal Measures succession than was anticipated, which is accounted for by the nearest control borehole being a few hundred metres away. Coal mining is not recorded by abandonment plans in the vicinity of GGC01, but mine workings were considered 'possible' based on the records to the east of the site. On drilling, no evidence of mining was encountered in the borehole and several thick intact coals were cored.

Initial comparison of the drillers/ BGS lithological records and the wireline logs indicates that there are additional coals present that were not observed during drilling operations (being inside the opaque core liner). These will be fully logged and recorded in the final borehole data pack.

## 4 Geophysical (wireline) logs

Geophysical logging is the process of measuring the properties of a formation using sensors attached to a winch cable (wireline) suspended in the borehole. Measurements are made continuously down the borehole by raising or lowering the sensor tools. The property measurements are then converted to a standard series of geophysical logs including: Density, P-Wave Transit Time, Neutron Porosity etc.

Description of geophysical logging technology is beyond the scope of this report, there are a number of textbooks which cover the acquisition and interpretation of wireline logs including: Serra (1983); Hearst et al. (2000) and Ellis and Singer (2007). Wireline logs have also been used extensively as part of the Integrated Ocean Drilling Program with a number of resources available online<sup>1</sup>.

### 4.1 LAS FORMAT FOR CONVENTIONAL LOG DATA

*File name: GGC01\_Composite\_Certified.las and 6 similar named files*

Conventional geophysical logs are provided in [LAS format<sup>2</sup>, version 2.0](#). This is a column separated ASCII format. Almost all specialist logging software is capable of loading and interpreting geophysical log data in LAS format. In addition to this LAS files can also be viewed in any software capable of manipulating an ASCII text file, including Notepad (Windows), VI (Unix) or spreadsheets (e.g. Microsoft Excel).

### 4.2 DATA PROVISION OF BOREHOLE IMAGING DATA IN DLIS FOMAT

*File name: GGC01\_Acoustic\_2.dlis*

Acoustic borehole image logging was acquired for borehole GGC01. When processed using specialist software this file provides an unwrapped interior borehole wall image. The image facilitates visualisation of the physical condition of the borehole's wall, such as presence of breakouts, open fractures etc. and also some details of geological features visible on the borehole wall, such as intersections of some beds with the borehole and some types of discontinuity which are not open.

Borehole imaging data is provided in the form of Digital Log Interchange Standard (DLIS) files. This binary format cannot be read with anything other than specialist borehole imaging software, which is required to interpret the data files. The file was acquired and processed by Robertson Geo Ltd using the WellCAD software and the associated DLIS file integrity has been checked by BGS scientists using Schlumberger Techlog borehole imaging software.

**Note:** The Robertson Geoscience AWS imaging tool DLIS format is not supported by all specialist borehole imaging software and so additional processing stages may be needed to

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<sup>1</sup> <http://mlp.ideo.columbia.edu/log-data-processing/>

<sup>2</sup> <http://www.cwls.org/las/>



load the data. DLIS files contain array-formatted data, which prevented their conversion into the LAS (Log ASCII Standard) format used to report the other logging parameters. The borehole image logging data can however be viewed in the field prints, 'GGC01\_acoustic updated.pdf'

### 4.3 LOG ACQUISITION METADATA

Three LAS files are supplied with a standard metadata package defining the well metadata and acquisition

**Table 1: Simplified well metadata header from LAS files**

PARAMETER	UNIT	VALUE	DESCRIPTION
STRT	M	0	First reference value
STOP	M	198.856	Last reference value
STEP	M	0.004	Step increment
NULL		-9999	Missing value
WELL		GGC01	Well name
FLD		Glasgow	Field
LOC		Project_ GGERFSNS66SW BJ 3754BGS ID_ 20650619	Location
PROV		N/A	Province
DATE		17-Dec-18	Date
COMPANY		BGS	Operator
Completion_date		14-Jan-19	DD-MMM-YYYY
CTRY		Scotland	COUNTRY
EGL	M	9.66	Ground Level Elevation
EKB	M	9.66	Datum Elevation
DREF		MSL	Permanent Datum
FL		Glasgow	Geographical area name
LCNM		Robertsons	Logging contractor
LMF		GL	Log Datum
LATI	deg	55.8411448	Latitude
LONG	deg	-4.2213957	Longitude
ORIGINALWELLNAME		GGC01	Well Name
OPER		BGS	British Geological Survey
SPDA		15-Nov-18	Spud Date
TD	M	199	Drillers Depth
UNKNOWN		GGC01	Full well title
WELL-ID		20650619	UNIQUE WELL IDENTIFIER (BGSID)

WELL-NAME		NS66SW/3754	Single Onshore Borehole Index
Water_depth	M	0	Water Depth
X	M	260915	Easting
Y	M	663109	Northing
TYPE_FLUID_IN_HOLE		Water	Drilling Fluid
TOP_LOGGED_INTERVAL		0.0m	Top Logged Depth
BTM_LOGGED_INTERVAL		198.86m	Bottom Logged Depth
RECORDED_BY		KO	Logging Engineer
WITNESSED_BY		IJ	Observer

#### 4.3.1.1 GGC01\_COMPOSITE\_CERTIFIED.LAS

This file contains the main geophysical logs that define the geological succession that would typically be included in an industry composite plot.

**Table 2: Contents of GGC01\_Composite\_Certified**

Parameter	Units	Description
DEPT	M	DEPTH
INC	DEG	Inc
CONDUCTIVITY	US/CM	Conductivity
TEMPERATURE	DEGC	Temperature
CAL_X	MM	Cal X
CAL_Y	MM	Cal Y
GAMMA	API	Gamma
AZ	DEG	Az
DENSITY	GM/CC	Density
BRD	CPS	BRD
HRD	CPS	HRD
PORS	LPU	Pors
NEAR	CPS	Near
FAR	CPS	Far
TX1-RX1	μS	TX1-RX1
TX1-RX2	μS	TX1-RX2
SLOWNESS	μS/FT	Slowness
RESISTIVITY	OHMM	Resistivity

#### 4.3.2 GGC01\_Flowmeter\_Certified.LAS

This file contains the flowmeter outputs that show the fluid ingress into the well bore

**Table 3 Contents of GGC01\_Flowmeter\_Certified.LAS**

Parameter	Units	Description
DEPT	M	DEPTH
RATE_D4	RPM	RATE d4
CABL_D4	M/MIN	CABL d4
RATEU4	RPM	RATEu4
CABLU4	M/MIN	CABLu4
RATEU6	RPM	RATEu6
CABLU6	M/MIN	CABLu6
RATED6	RPM	RATEd6
CABLD6	M/MIN	CABLd6
RATED8	RPM	RATEd8
CABLD8	M/MIN	CABLd8
RATEU8	RPM	RATEu8
CABLU8	M/MIN	CABLu8

#### 4.3.3 GGC01\_Full\_Waveform\_Sonic\_Certified.LAS

This is the full wave form sonic including the interval transit time between the multiple source receiver pairs that allow the detailed sonic profile to be constructed.

**Table 4: Contents of GGC01\_Full\_Waveform\_Sonic\_Certified.LAS**

Parameter	Units	Description
DEPTH	M	Depth
SVEL	$\mu\text{s}/\text{ft}$	5 Interval Transit Time
TA	$\mu\text{s}$	1 Transit Time TX1-RX1
TB	$\mu\text{s}$	2 Transit Time TX1-RX2
TC	$\mu\text{s}$	3 Transit Time TX2-RX1
TD	$\mu\text{s}$	4 Transit Time TX2-RX2

#### 4.4 SUMMARY COMPOSITE LOG IMAGE FILES

*File names: GGC01\_Comp\_Plot\_1\_200.pdf and GGC01\_Comp\_Plot\_1\_500.pdf*

Two composite log image files are included in the data pack at scales of 1:200 and 1:500.

## 5 Sample information

### 5.1 SUMMARY SPREADSHEET OF CORE AND FLUID SAMPLES PRESERVED FOR GEOMICROBIOLOGY

*File name: GGC01\_geomicrobiology\_externalversion\_V2.xlsx*

This Excel workbook details sub-samples collected from rock cores immediately after core recovery and preserved for geomicrobiology analysis, and which will be made available for the science community via a future sampling call. It contains two worksheets: one lists the core samples and the other describes fluid samples that were collected and preserved from around the core barrel.

Each 5cm long subsample of core collected for geomicrobiology analysis was split into four pieces, with the preservation of these pieces being as described in the 'type of sample' column:

- '-80' denotes the 2 quarters preserved at -80°C (for DNA/RNA studies etc.)
- 'culture' denotes the 1 quarter preserved at 4 °C (for culture studies; 4°C samples were flushed with nitrogen and sealed).
- 'counts' denotes the 1 quarter preserved at 4°C (from which a portion was been removed and preserved in glutaraldehyde fixative for tracer and cell counts).
- 'SSK' denotes the sample number. GMC=geomicrobiology core

In the second worksheet the fluid samples collected are described as follows:

- '1 ml fix' denotes core barrel fluid preserved in glutaraldehyde fixative and frozen at -80°C
- '30 ml drilling fluid' denotes the remainder of the core barrel fluid collected and preserved at -80°C
- '1g count' denotes crushed core material preserved in glutaraldehyde fixative

### 5.2 SUMMARY SPREADSHEET OF BGS FLUID/WATER SAMPLES AND BASIC HYDROGEOLOGICAL PARAMETERS OF BGS FLUID/WATER SAMPLES

*File name: GGC01\_fluidsamples\_fieldparameters\_externalversion\_V4.xlsx*

This spreadsheet records water, fluid and other samples that were taken by BGS over the course of drilling.

Two water samples were taken from the top of the borehole using a hand bailer upon completion of drilling. The first was taken on the 17/12/2018 after the casing had been removed up to the superficial deposits and the borehole had been flushed with clean water and left to settle overnight. The second sample was taken on 07/01/2019 after the borehole had been left open and uncased for two weeks. Samples of mains water (used for borehole flushing) were also taken for comparison. When taking these samples the following water quality parameters were monitored at least three times over an interval of not less than five- minutes: pH, redox (Eh), dissolved oxygen, temperature and conductivity. Alkalinity was also measured, using a Hach Digital Titrator, a minimum of three times.

Post sample collection the redox potential was corrected for temperature and the bicarbonate (HCO<sub>3</sub>) value of the water was calculated using the field alkalinity values.

The samples collected will be analysed for a suite of water chemistry parameters.

### 5.3 SUMMARY OF TRACER AND ADDITIVE INFORMATION

#### 5.3.1 Geomicrobiology tracer

A geomicrobiology tracer, AFN-09 RADGLO UV Blue, was added daily to the settling tanks containing the re-circulating water used to drill the borehole. The tracer was added to allow the extent of drilling fluid ingress into core material to be assessed. The volumes added, based on BGS records, are summarised in Table 5 below. Various sizes of settling tanks were used throughout the drilling for the re-circulating of drilling water and therefore different amounts of tracer was added to these tanks depending on which one was in use on that day. The original addition of tracer to the settling tanks was based on a ratio of tracer to drilling fluid was 1:40000 and this was attempted to be maintained throughout the drilling process. In order to account for potential losses of water throughout the drilling, additional tracer was added to the settling tanks daily. The tracer data sheet documents it as a mixture of the following chemicals: Ammonium hydroxide (<1% weight), iron (III) sulfate (<0.1% weight) and acrylonitrile (<0.1% weight). A 30 ml sample of the geomicrobiology tracer, AFN-09 RADGLO UV Blue, was taken during the drilling.

**Table 5 Volume of tracer added**

Date	Volume of re-circulating water (litres)	Volume of tracer added to water (ml)
27/11/2018	13,000*	325^
28/11/2018	13,000	60
29/11/2018	13,000	60
30/11/2018	13,000	60
03/12/2018	7,000** (new tanks)	175
04/12/2018	7,000	30
06/12/2018	13,000* (new tanks)	325
07/12/2018	13,000	60
10/12/2018	13,000	60
11/12/2018	13,000	60
12/12/2018	13,000	60

\*based on 6,000 litres in two settling tanks and 1,000 litres in borehole

\*\*based on 3,000 litres in two settling tanks and 1,000 litres in borehole

^Added at beginning of day after morning samples were taken

#### 5.3.2 Polymer drilling additive

To aid drilling, a drilling additive called Insta-pac supplied by CETCO Europe, was added by the drilling contractors to the re-circulating water in the settling tanks at various points throughout

the drilling. This additive contains Naphtha (petroleum), hydrotreated heavy [low boiling point hydrogen treated naphtha] (<3%). A 60 ml sample was taken by BGS.

## 5.4 OTHER DATASETS

### 5.4.1 Selected Photos

A selection of photos covering drilling and sampling at GGC01 has been added to the BGS photo database which can be accessed at <http://geoscenic.bgs.ac.uk/asset-bank/action/viewHome>. Search on 'UKGEOS Glasgow'.

## References

British Geological Survey holds most of the references listed below, and copies may be obtained via the library service subject to copyright legislation (contact [libuser@bgs.ac.uk](mailto:libuser@bgs.ac.uk) for details). The library catalogue is available at: <https://envirolib.apps.nerc.ac.uk/olibcgj>.

Ellis, D.V. and Singer, J.M. 2007. Well Logging for Earth Scientists. 2<sup>nd</sup> Edition. Springer. <https://doi.org/10.1007/978-1-4020-4602-5>

Hearst, J.R., Nelson, P.H., Paillet, F.L. 1999. Well logging for physical properties: a handbook for geophysicists, geologists and engineers. 2<sup>nd</sup> Edition. Wiley

Serra, O.E. 1983. Fundamentals of well-log interpretation. Elsevier