READ ME JET_5065_1_Dataset: Downhole logging

Dataset citation: Wonik, T. (2023) Downhole logging data of the ICDP Scientific Drilling Project "Early Jurassic Earth System and Time Scale (JET)". GFZ Data Services, https://doi.org/10.5880/ICDP.5065.001

Summary: The data relates to the downhole logging operations of 5065_1_C (Prees-2C) that was drilled onshore in the Cheshire Basin, Shropshire, UK in 2020 as part of the ICDP funded JET Project with expedition number 5065. The dataset was funded through the Leibniz Institute for Applied Geophysics (LIAG), Hannover, Germany. This Data description is a copy of the description on the data set in the Appendix A of the JET_5065 Operational Report (JET Scientific Team et al., 2023), where additional information on the Downhole Logging can also be found. First results on the project are published in Hesselbo et al., 2023.

Files included:

- JET_5065_1_BL_CompositeLogs.zip
- JET_5065_1_BL_LoggingData.zip
- JET_5065_1_BL_DataDescription.pdf
- JET_5065_1_BL_LoggingTools_Robertson.xlsx

1.1 Downhole logging

Downhole geophysical data were acquired from 33 m to 240 m depth on November 16th/17th, 2020, and for the remainder of the hole after drilling was completed (December 28th/29th, 2020). The probes successfully from ~240 m to 33 m were: Spectral Gamma Ray (SGR), Density (DEN), Neutron Porosity (NP), Focused Electric Log (FEL), 4-Arm Caliper (CAL), Mud Temperature/Conductivity (TEMPSAL), Full Wave Sonic (SONIC), Acoustic Televiewer (BHTV).

Probes successfully run from the bottom of the hole up to 240 m were: Spectral Gamma Ray, Density, Neutron Porosity, Dual Focused Induction (IND/RES), 4-Arm Caliper, Mud Temperature/Conductivity, Full Wave Sonic, Acoustic Televiewer. Further details on the downhole logging is available within the JET Operational Report (JET Scientific Team, in revision).

1.2 Pre-processing of downhole geophysical logs

After the respective compilation of the raw data measured in the two campaigns, the data were merged into one overall composite file. To achieve this, the following processing steps were carried out:

Step 1:

The reference depth for all measurements of a campaign is based on the depth of the first gamma ray measurement. This means that in both campaigns the GR data of the SALTEMP probe were chosen as the respective master curve.

Since each probe, except for the SONIC and BHTV, was equipped with its own GR sensor, the depth difference between the respective measurements can be determined by comparing the GR data and the GR master curve. This results in the following depth shifts for the measurements of campaign 2, for example, by means of optical determination:

CAL = -2.6 m, SGR = 0 m, IND = -0.4 m, DEN = 0 m, and NP = -0.4 m.

The depth difference in the BHTV of -0.5 m was obtained by comparing the clearly imaged pipe shoe with the caliper data. The depth difference in the SONIC data (-0.3 m) was determined by comparison with prominent GR anomalies.

Step 2:

The influence of the steel piping on the data does not have to be considered, as almost all measurements of campaign 1 were stopped at the pipe shoe at 33 m. The few data measured above a depth of 33 m are not used further. Two exceptions are the measurement of the inclination of the borehole and the temperature and conductivity of the fluid, which are not influenced by the casing.

In campaign 2, data from some of the probes were registered to a depth of about 230 m, i.e. about 7 m into the cased area of the borehole (pipe shoe at 237 m). The data above 237 m could be neglected, as in campaign 1 measurement data were recorded down to a depth of 240 m in the "open hole" condition.

Step 3:

Although the respective cable tension was not recorded for any probe, it is easy to determine where each probe lifted off from the deepest point of the borehole (240 m or ~650 m). Data from greater depths are not included.

Step 4:

Data affected by the approach to the casing is not used in the composite file. The following serves as an example: due to the design of the FEL probe, the drill string disturbs resistivities up to several metres before the tool reaches the casing shoe.

Since the water level in the borehole was almost at the ground surface during both visits, the effect of a dry borehole did not have to be considered or corrected in the data. (e.g. SALTEMP, SGR).

Step 5:

Some remarks on the determination of VP, VS and VP/VS from SONIC data are necessary. The probe records the full sonic wave-train at all three receivers simultaneously. This can be displayed either as a variable density log (VDL) or as a waveform ("wiggle"). The waveform data were exported for use in Robertson Geo's GeoCAD® software package to calculate the compressional (P) and shear (S) velocities. This calculation was carried out by Robertson Geo. A check of the picked first arrival of the p- and s-waves was possible using the pdf and WellCAD® files provided and gave clear and very good results. This is also due to the uniformity of the layers drilled through and the calibre of the borehole, which was true to size except for a few depth intervals.

Step 6:

Robertson Geo recorded all measurements (except BHTV) at a sampling rate of 1 cm, regardless of the tool used. This very dense sampling rate does not do justice to the sensors that are built into the borehole probes. The SGR probe serves as an example for this statement: by means of an SGR probe, the gamma rays from the formation are counted in a detector system. The cylindrical detector used here has the following dimensions: diameter 3.8 cm and height 15 cm. It is therefore obvious that the vertical resolution of this probe is at least in the decimetre range. The data of all probes except the BHTV were recalculated with a sampling rate of 10 cm, also to achieve an initial smoothing for better readability of the measurement curves.

Despite this first form of data smoothing, some measurement curves are still too noisy. This applies in particular to the NP (porosity), SGR (K, U, Th) and SONIC curves (VP, VS and VP/VS), which were additionally smoothed with a moving average filter of length 5 points.

Step 7:

Splicing between the measurements of the two campaigns was carried out separately for each trace at a depth between 230 m and 240 m. Each best splice point is determined visually. The final resistivity curve is composed of the values of the curve R_Long (IND) in the lower borehole section and the resistivity data of the FEL tool in the upper interval. We assume that the results with the deep radius of investigation of the Dual Focused Induction probe reflect the resistivities of the undisturbed formation better than the results with the "medium" radius.

The results of three probes are not spliced, but listed as individual measurements in the composite file: TEMPSAL, CAL and BHTV. The mud present in the two borehole sections when logging took place differs in its composition: in the upper section the mud has an average conductivity of about 80,000 uS/cm, whereas in the lower depth interval the mud conductivity was clearly "sweeter" with about 17,000 uS/cm. The BHTV measurements were not spliced because they already generated very large files in the individual intervals due to the data density of the ultrasonic imaging of the borehole wall. Splicing would only complicate the handling and evaluation of the BHTV measurements in one very large file.

All Robertson Geo probes were fully tested and calibrated at the Robertson Geo Deganwy site a few weeks prior to their deployment. The available protocols of the calibration measurements show a very good reproducibility of the data.

In summary, the quality of the data can be described as good to very good, although no environmental corrections were carried out. Different measurements require different corrections to be made to the log measurements to fit the standard conditions for which the tool has been characterised. For example, resistivity and density measurements usually require correction for changes in borehole diameter. In this borehole, however, the diameter is nearly true to size except for the two sections 580-610 m and 630-640 m and thus borehole corrections are not necessary over long distances. However, some narrower negative anomalies in the density curve indicate that caliber breakouts were not corrected. To compensate for the effects of borehole diameter, the SONIC, IND and NP probe use an array of multiple sensors. The NP probe uses dual detectors and a ratio method to provide a porosity measurement that compensates for, but is not independent of, the borehole diameter.

REFERENCES

Hesselbo, S.P. and the JET Science Team et al. (2023) Initial results of coring at Prees, Cheshire Basin, UK (ICDP JET Project); towards an integrated stratigraphy, timescale, and Earth System understanding for the Early Jurassic. *Scientific Drilling*, 32, 1–25, https://doi.org/10.5194/sd-32-1-2023

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