DANMARKS OG GRØNLANDS GEOLOGISKE UNDERSØGELSE RAPPORT 2018/3

Well completion report: Juraklø ft-2 fully cored borehole, Wollaston Forland, Northeast Greenland

Contribution to Petroleum Geological Studies Services and Data in East and Northeast Greenland

Gunver K. Pedersen & Jørgen A. Bojesen-Koefoed

GEOLOGICAL SURVEY OF DENMARK AND GREENLAND
MINISTRY OF ENVIRONMENT AND ENERGY

G E U S

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Confidential report

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DANISH MINISTRY OF ENERGY, UTILITIES AND CLIMATE

G E U S

1. General information

1.1 Borehole data

Country	Greenland / Denmark
Borehole number	GGU 517008
Borehole name	Jurakløft-2
Area	Northeast Greenland, Jurakløft, Wollaston Forland
Operator	GEUS
Drilling operator	GEUS

Borehole Location

Altitude:	229 m above mean sea level.
Coordinates WGS 84:	74º 39.258´N, 20º 16.007´W

Drill rig	Sandvik DE 130
Drilling contractor	GEUS
Casing diameter	64/57 mm,
Casing depth	Casing 64/57 mm to 19.2m
Borehole diameter	56 mm
Core diameter	42 mm
Total depth	72.5 m
Core recovery	91%
Status	Abandoned, open hole

Logistic history:

Transportation of rig and crew to drill site at Jurakløft	July 14th–16th 2017
Establishment of field camp and drilling rig	July 14th–17th 2017
Spud, Jurakløft-1	July 18th 2017
Spud, Jurakløft-2	July 21st 2017
Drilling completed	July 22nd 2017
Drill rig transported to Ravn Pynt, Store Koldewey	July 24nd – 28th 2017
Effective drilling	4 (2) days
Total days on drill location	10 days

1.2 Borehole summary

The Jurakløft-2, GGU 517008, fully cored borehole was drilled as a second attempt to test the succession of Middle Jurassic sandstones exposed in northern Wollaston Forland after the Jurakløft-1 borehole had to be suspended due to technical problems. The Jurakløft-1 and Jurakløft-2 were drilled at essentially the same location, the Jurakøft-2 borehole being situated approximately 2m from the Jurakløft-1. Both boreholes were drilled during the summer of 2017 at Jurakløft ("Jurassic Gorge"), northern Wollaston Forland (Figs 1, 2).

The boreholes were drilled by GEUS as part of the ongoing GEUS-industry collaboration "Petroleum Geological Studies, Services and Data in East and Northeast Greenland", however, with participation exclusively by companies holding an exploration license offshore Northeast Greenland. Hence, the borehole was drilled on behalf of a consortium including all groups holding licenses for exploration offshore Northeast Greenland, represented by the operating companies Chevron, ENI and Statoil.

The objective was to test the Middle Jurassic Sandstone succession exposed in northern Wollaston Forland, represented by the Payer Dal and Pelion formations (Surlyk 2003 and references therein), in order to obtain data on the petroleum reservoir properties of these units that are expected to be present in the offhore license areas as well.

The Jurakløft-2 borehole was spudded on July 21st 2017 and completed on July 22nd 2017 at a total depth of 72.5m, at which depth drilling had to be suspended since the nature of the formation precluded further drilling. The borehole was planned to reach a depth of more than 150m, which, however, proved impossible to reach. The total core recovery was slightly less than 91%.

The borehole was abandoned as an open hole.

Logging in the field included a total gamma log from terrain surface and down to 72.5 m.

Fig. 1. Overview map of Northeast Greenland. Red frame: detailed map, fig. 2.

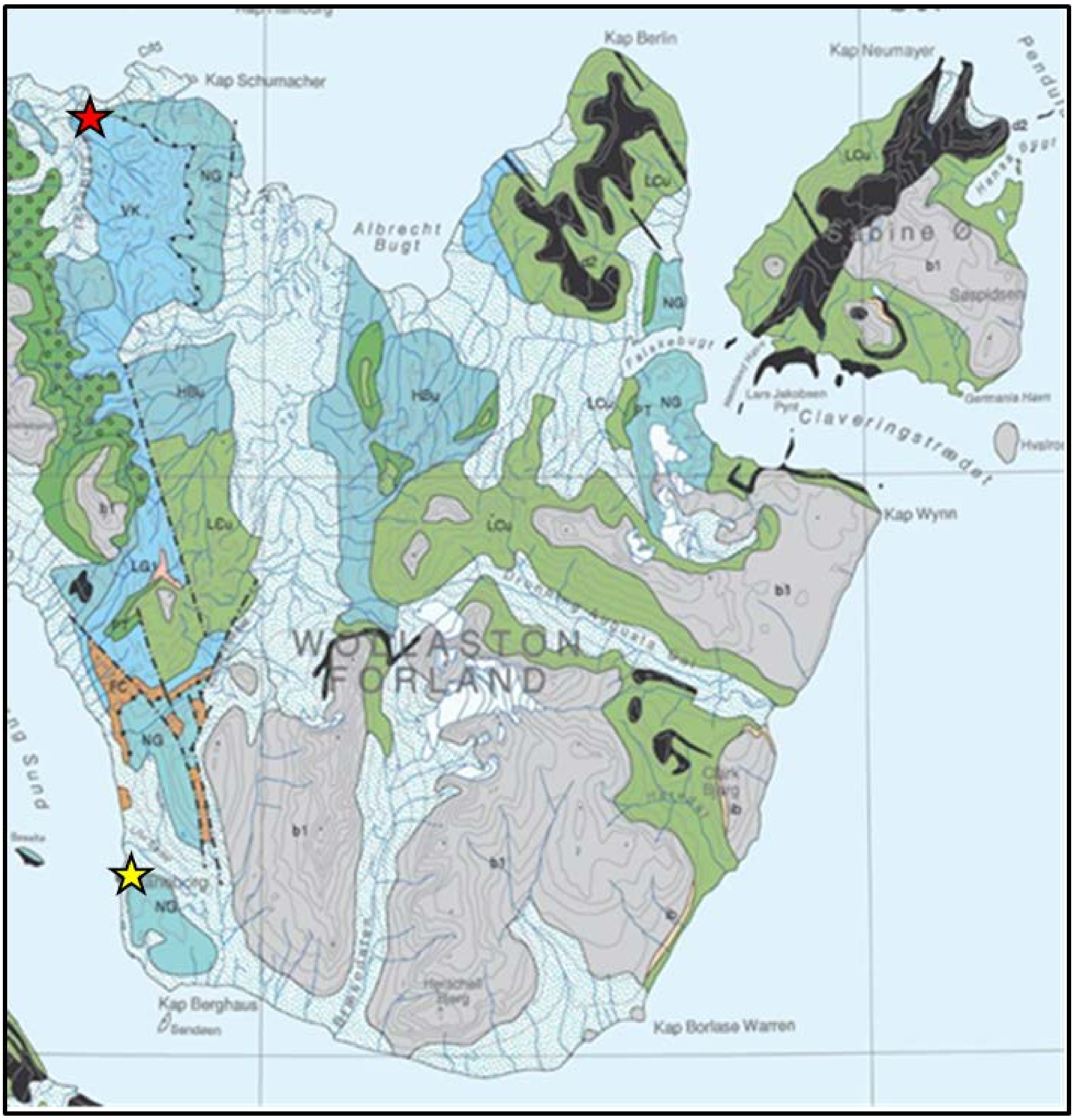

Fig. 2 Geological map of Wollaston Forland. Yellow star: Basecamp in Daneborg. Red star: Drill-site Jurakøft-1, 2 boreholes. Jurassic deposits (blue) are overlain by the Lower Cretaceous succession (green).

2. Drilling operations

Drilling team:

Senior technician John Boserup, GEUS

Driller Jan Varup

Driller Tonny Arndt

Driller’s assistant Kathrine Hedegaard

Driller’s assistant Kristine Balslev Jørgensen Fasting

Driller’s assistant Christopher Trinder Nielsen

Driller’s assistant Rune Hende

Well site geologist Gunver Krarup Pedersen

Logistics were handled by GEUS.

Helicopter from Air Greenland (Eurocopter AS-350B3) was chartered for a full field season.

Drilling was carried out by a Sandvik DE 130 wire line rig, with inner and outer casing diameter of 57 mm and 67 mm, respectively. The borehole diameter is 56 mm, whereas the core diameter is 42 mm. Core barrels are 1.5m and 3m long.

Most field equipment, helicopter fuel and the drill rig was transported late summer 2016 by ship to Daneborg at Wollaston Foreland, the headquarters of the Sirius dog sledge Patrol. Equipment was left in sealed containers, to be opened when operations were initiated during the summer of 2017. Daneborg served as basecamp for the field campaign, which included both shallow borehole drilling and traditional fieldwork.

Rig, equipment and personnel were mobilised from Daneborg by helicopter to the drill site at 82º 37.053´N, 21º 34.375´W. The drill site is situated 229 m above sea level (Figs 3, 4, 5).

Casing was drilled to 19.2m, drill core was recovered throughout the drilled section until TD at 72.5m, freshwater pumped from a nearby creek was used for drilling. The drill site is situated in a permafrost area and the formation was generally frozen throughout the penetrated section.

In the early morning of Thursday, July 20th, 2017, the Jurakløft-1 borehole had to be suspended at 68.2m due to sad combination of a damaged/lost bit, lost circulation resulting in a stuck drill stem and a damaged main bearing in the gearbox of the drill head. An attempt to provisionally repair the main bearing while waiting for a spare to arrive was successful, and the rig was in operation at again 1800. It turned out to be possible to recover the drill stem and change the bit. However, since the damaged bit remained in the hole, apparently intact, it proved impossible to pass and it was decided to abandon the hole shortly after midnight.

The core recovery was approximately 90%, and the core showed predominantly sandy and minor muddy lithologies varying from extremely indurated to perfectly loose and unconsolidated, and the drilling problems must be attributed to the geological conditions, the loose horizons causing lost circulation and supplying sand that tended to block the rotation of the drill stem.

An attempt was made to find an alternative drill site on a terrace lower in the succession, which would hopefully allow two partially overlapping cores to be drilled. However this proved impossible since the existing terraces were all slides.

It was then decided to make a second borehole next to the Jurakløft-1 borehole by manually moving the rig app. 2 metres, using levers and jacks.

Thus the Jurakløft-2 borehole was spudded on Friday, July 21st, 1400H local time and at midnight the first 15m of core had been recovered. However, due to the repeated alternations between hardened and unconsolidated units, additional casing had to be placed.

Drilling continued until the evening of Saturday, July 22nd, 1930H, at which time the drill stem instantaneously became stuck at 72.5m, probably in the same bed that caused problems in the Jurakløft-1 borehole. Core recovery was approximately 91%, the quality excellent and the succession showed predominantly sandy and minor muddy lithologies varying from extremely indurated to perfectly loose and unconsolidated, very similar to the neighbouring Jurakløft-1 borehole (Figs 6, 7).

Several attempts were made to re-establish circulation and resume drilling, however all unsuccessful, and shortly before midnight, it was decided to abandon the hole in order not to jeopardize further drilling-activities on Store Koldewey.

The rest of the night was spent logging the hole and saving as much of the drill stem as possible.

A total Gamma Ray log was collected in the hole (Fig 8)

The results from the drilling at Jurakløft are two parallel cores of excellent quality into the Payer Dal Formation. The underlying Pelion Formation was not reached. This result is somewhat dissatisfactory, given the planned depth of >150m, but the geological conditions on the site did not allow further drilling.

Fig. 3 Study area and drill site location viewed form the NW towards the SE (Photo by Peter Alsen)


Fig. 4. Drill site and drill camp viewed from the S towards the N. In the background, Kuhn Ø with exposures of basement covered by Jurassic sedimentary rocks (Photo by Signe U. Hede).

Fig. 5. Drill site and drillcamp viewed from the NE towards the SW, showing the formation exposed in the Juraklφft ("Jurassic Gorge") (Photo by Henrik Vosgerau).

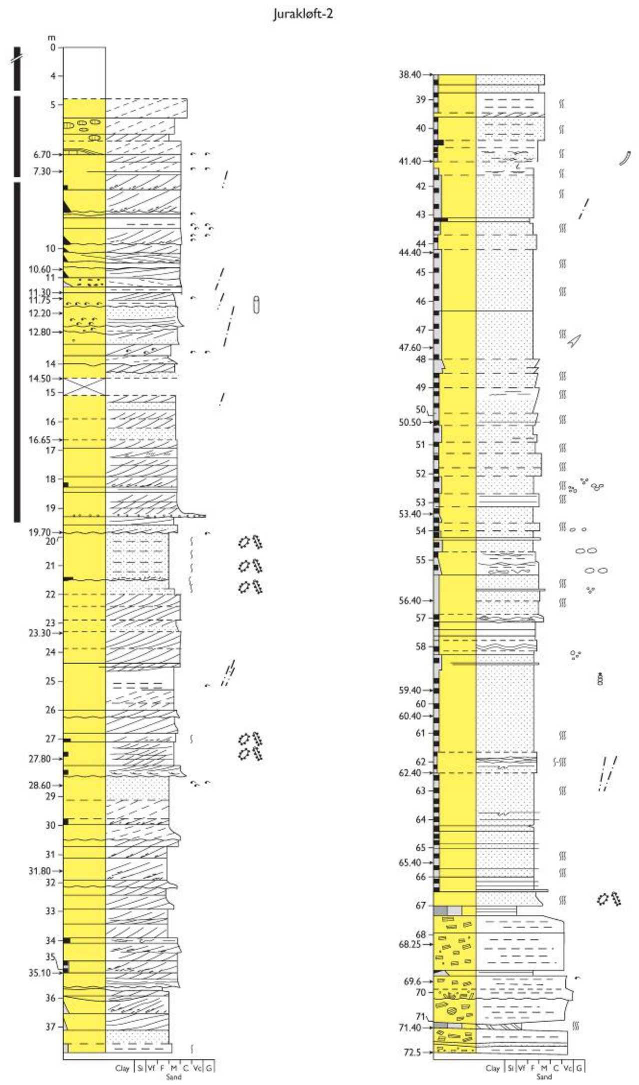

Fig. 6 Sedimentary log of the drilled succession. Minor adjustments may be added to the final version of the log. Legend, see fig 7.

Fig 7. Legend for sedimentary log

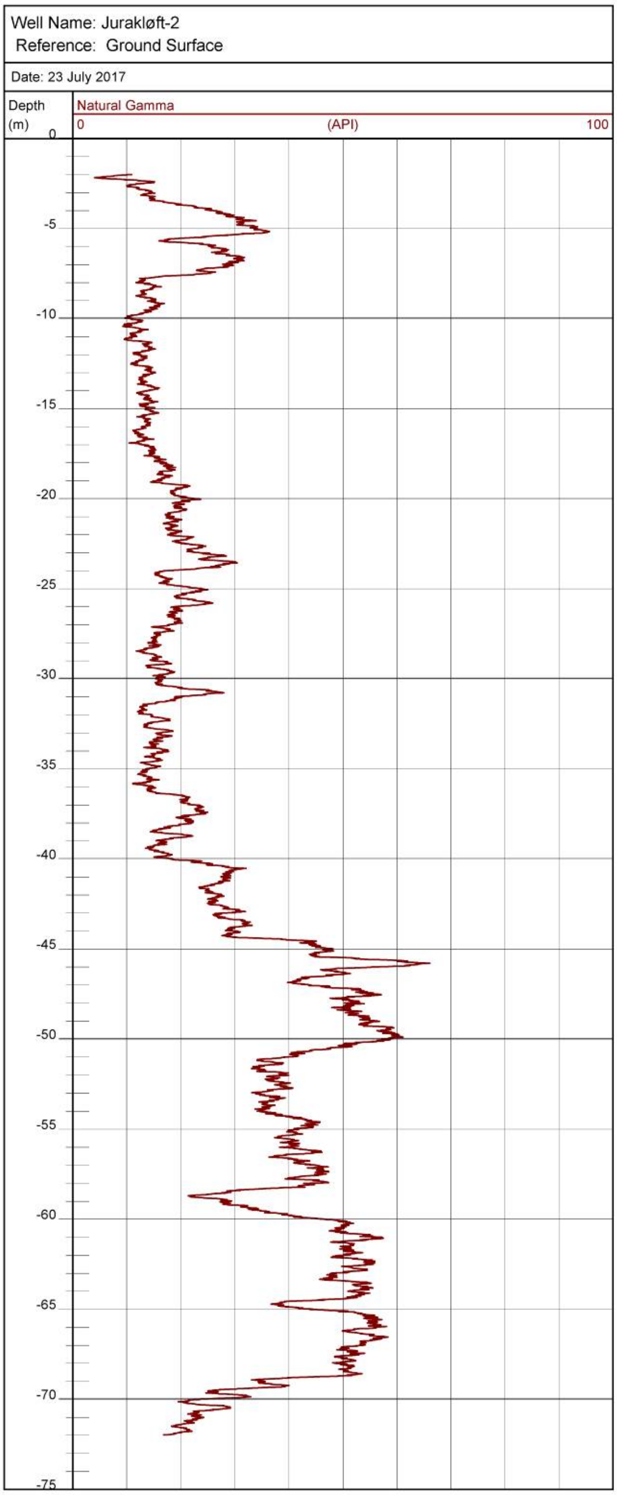

Fig. 8. Total Gamma Ray log of the Jurakløft-2 borehole

3. Geology

3.1 Description of lithology

The Jurakløft-2 core recovered 72.5 m thick succession:

Strata	Lithology	Depth (m)	Thickness (m)
Payer Dal Fm	Friable brown sandstone alternating with pale grey cemented sandstone	4.7–41.6 m	36.9 m
	Brownish-grey strongly bioturbated heterolithic very fine-grained sandstone	41.6–66.1 m	24.5 m
	Mudstone interbedded mud-clast conglomerates and fine-grained sandstone	66.1–72.5 m	6.4 m

The base of the Payer Dal Formation was not reached. Next pages include a short lithological description of the core starting from the top.

Sandstone of the Payer Dal Fm
4.7–41.6 m

This interval is dominated by well-sorted, medium-grained cross-bedded sandstone. The distinction between planar- and trough cross-bedding is rarely possible in slim cores. Set thicknesses range from 0.1–0.8 m, but are typically 0.2–0.5 m. Thin clasts of coal or mudstone occur locally at the toe of foresets. Bivalves are common and outcrops demonstrate that many are oysters. The core photos (Figs 9–14) clearly show the alternation between brown, friable sandstone and pale grey cemented sandstone. Trace fossils are generally scarce, but burrows such as *Ophiomorpha* isp. are common in certain intervals (Figs 6, 7). A number of joints are observed, some of them are open (Figs 9, 10), while others are cemented. The oysters, the trace fossils and the sedimentary facies suggest a marine depositional environment, in agreement with earlier studies (Alsgaard et al. 2003; Vosgerau et al. 2004).

Bioturbated heterolithic very fine-grained sandstone of the Payer Dal Fm
41.6–66.1 m

This interval is characterized by high-quality cores of heterolithic very fine-grained sandstone, which is strongly bioturbated. The bioturbated sandstone is interbedded with thin beds of slightly coarser sandstone (Fig. 6: 52–67 m). These beds show wave-ripple cross-lamination, small-scale hummocky cross-stratification, parallel lamination, and locally soft-sediment deformation structures. These sandstone beds are tentatively interpreted as storm sand deposits. The trace fossil assemblage is different from that of the overlying sandstone and includes *Teichichnus* isp. and other traces, which often are attributed to deposit feeding animals. The trace fossils awaits further examination. The heterolithic fine-grained sandstones were deposited in lower energy environments than the overlying sandstone.

Mudstone interbedded mud-clast conglomerates and fine-grained sandstone 66.1–72.5 m

The lower part of the core comprises three lithologies: mudstones, sandstones and conglomerates (Figs 18, 19). The mudstones form thin beds, 0.05–0.2 m, which consist of clayey, silty and sandy laminae with little bioturbation. The sandstones are typically 0.05–0.1 m thick, and have sharp bases and may show normal grading. Some beds are structureless and others show wave-ripple cross-lamination, low-angle cross-stratification or flaser bedding. Trace fossils are relatively scarce. The dominant lithology is the mudclast-conglomerates, which are 0.1–0.9 m thick and contain mud-clasts in a matrix medium- to coarse-grained sand. The mud-clasts are sub-angular and range in size from 2x1x0.2 cm to more than 5x3x2 cm, and imbrication is not seen. A few beds appear to be inversely graded with respect to the clasts rather than the matrix. The conglomerate and sandstone beds are tentatively interpreted as deposited from sediment gravity flows.

Figs 9 through 19 (this and following pages) show photos of cores. The photos were taken at the drill site, and core-depths are preliminary, related to markers used as datums for measurements, which may occasionally cause a small apparent overlap of cores. Slight revisions of depths will take place during later core description and laboratory handling of the cores.

Fig. 9. Core photo from drill site. Box 1: 0 - 11.30m

Fig. 10. Core photo from drill site. Box 2: 11.59 – 18.82m

Fig. 11. Core photo from drill site. Box 3: 18.61 – 25.27m

Fig. 12. Core photo from drill site. Box 4: 25.94 – 32.12m

Fig. 13. Core photo from drill site. Box 5: 32.12 – 38.77m

Fig. 14. Core photo from drill site. Box 6: 41.40 – 47.03m

Fig. 15. Core photo from drill site. Box 7: 45.74 – 52.33m

Fig. 16. Core photo from drill site. Box 8: 52.08 – 58.72m

Fig. 17. Core photo from drill site. Box 9: 52.67 – 65.08m

Fig. 18. Core photo from drill site. Box 10: 65.08 – 71.97m

Fig. 19. Core photo from drill site. Box 11: 72.27 – 72.50m

4. Further analyses

- Detailed sedimentological analysis and core description
- High resolution photography in both UV and white light
- Core scanning to produce a spectral GR-log
- Biostratigraphic dating
- Systematic porosity and permeability analysis
- Diagenesis analyses
- Digital photogrammetric mapping and correlation to the geology of the nearby area studied in outcrops

Data from such studies will be included in the final reporting.

5. References

Alsgaard, P.C., Felt, V.L., Vosgerau, H. & Surlyk, F. 2003 : The Jurassic of Kuhn Ø, North-East Greenland. Geological Survey of Denmark and Greenland Bulletin 1, 865–892.

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