DANMARKS OG GRØNLANDS GEOLOGISKE UNDERSØGELSE RAPPORT 2008/80

Blokelv-1 core Well, GGU 511101, Jameson Land, central East Greenland: Completion Report

Morten Bjerager, Stefan Piasecki, Jørgen Bojesen-Koefoed & John Boserup

GEOLOGICAL SURVEY OF DENMARK AND GREENLAND
MINISTRY OF ENVIRONMENT AND ENERGY

G E U S

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MINISTRY OF CLIMATE END ENERGY

GEUS

1. General information

1.1 Borehole data

Country	Greenland / Denmark
Borehole number	GGU 511101
Borehole name	Blokelv
Area	Central East Greenland, Jameson Land
Operator	GEUS
Drilling operator	GEUS

Borehole Location	
Altitude:	181 m above mean sea level.
Coordinates WGS 84:	Latitude: 70°45.305´ N, Longitude: 23°40.430´ W
UTM Zone:	27W 0401666 N - 7852249 E

Drill rig	Diamant Board 747
Drilling contractor	Faxe Kalk A/S
Casing diameter	85 mm
Casing depth	20 m
Borehole diameter	76 mm
Core diameter	56 mm
Total depth	233.8 m
Core recovery	100% from 1.72–233.8 m
Status	Abandoned open hole, top of casing closed with a steel cap.

Logistic history:

Rig arrival East Greenland, Constable Pynt	August 4th 2008
Rig arrival at drill location Blokelv	August 5th 2008
Spud	August 7th 2008
Drilling completed	August 15th 2008
Drill rig back at Constable Pynt	August 16th 2008
Effective drilling	8 days
Total days on drill location	12 days

1.2 Borehole summary

Blokelv GGU 511101 was drilled in central Jameson Land in the summer of 2008 app. 35 km west of Constable Pynt. Blokelv is the first core hole in an onshore drilling program in East and North-East Greenland starting in 2008. The drilling program is part of collaboration between GEUS and sponsoring Oil Companies regarding Petroleum Geological Studies, Services and Data in East and North-East Greenland. Field work and the core hole drilling was financed by GEUS. Subsequent analytical analytical work is financed by sponsoring companies. A more detailed description together with all analytical results will be delivered to sponsoring companies not later than the end of 2009. The analytical programme is described in appendix C1 in the collaboration agreement.

The primary objectives were to drill the Upper Jurassic Katedralen Member of the Hareelv Formation in the central and deepest part of the Jameson Land Basin and to recover thickness and stratigraphic control of this combined mudstone source rock and sandstone reservoir rock succession.

The Blokelv borehole was spudded on August 7th 2008 and completed on August 15th 2008 at a total depth of 233.8 m. The core recovery was 100% from 1.72–233.8 m. The core diameter is 56 mm and cores are stored in 63 core boxes of 25 kg each, with a total weight of 1.5 ton.
The borehole was abandoned open hole with casing down to 20 m. The casing is cemented and closed at the top. Wires are installed in the hole with temperature sensors down to 184 m. A small cairn, ½ m high, was build of sandstone on top of the borehole.

Logging in the field included a complete conductivity log and a gamma log from 232–184 m. A spectral gamma log for the complete core was later measured in the core-lab at GEUS.

1.3 Figures

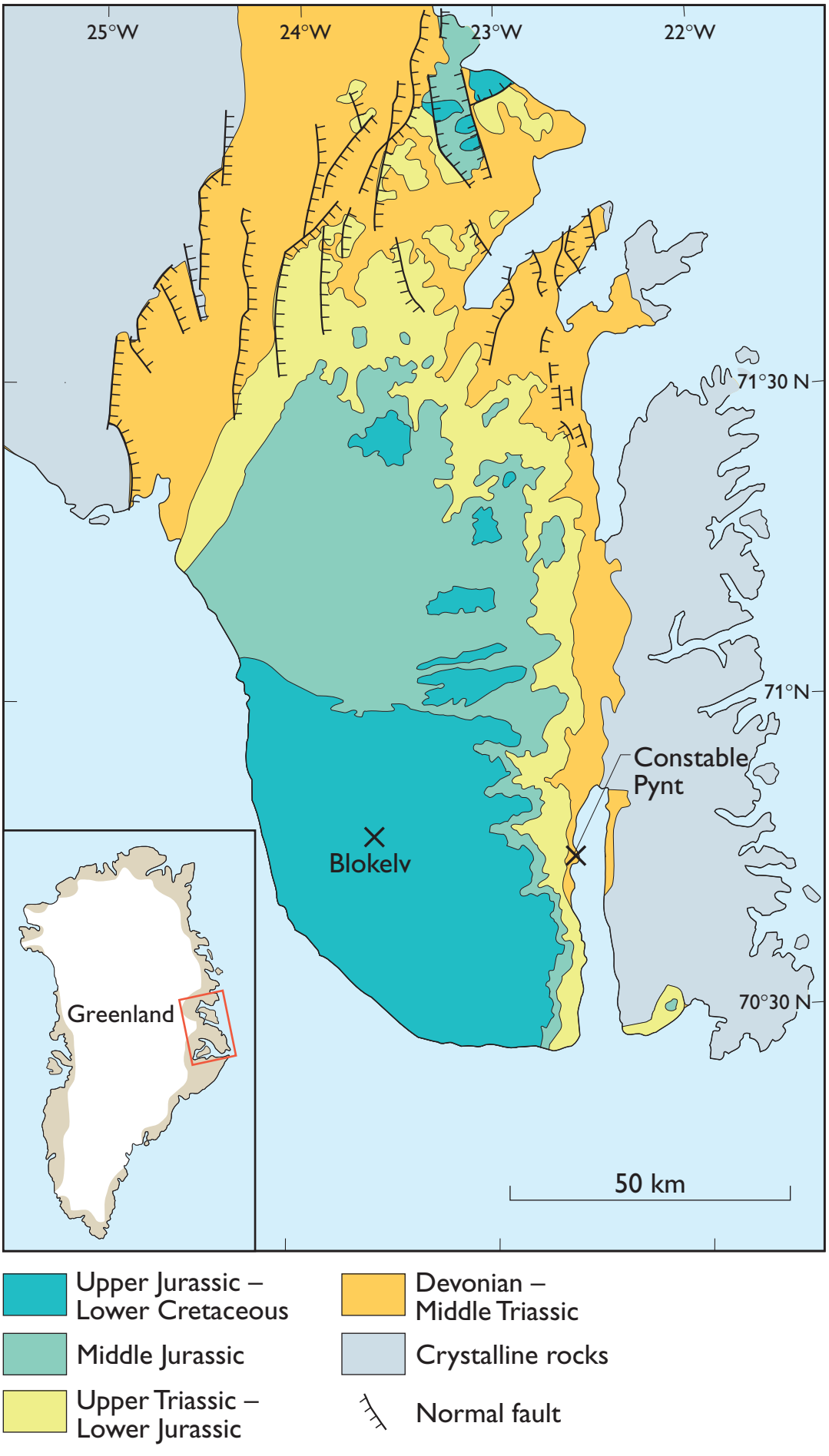
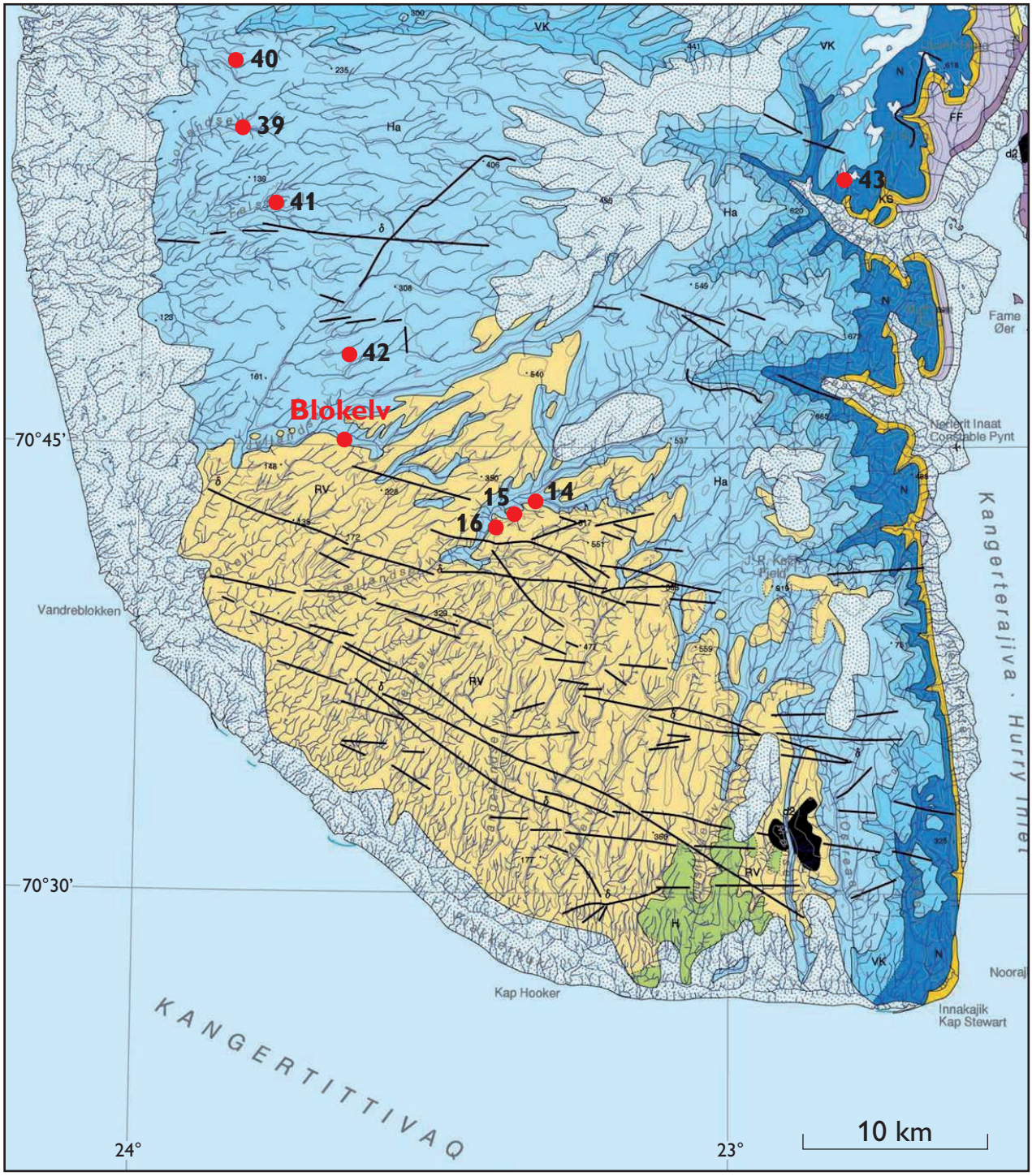

25°W
24°W
23°W
22°W
71°30 N
71°N
70°30 N
Constable Pynt
Blokelv
Greenland
50 km
Upper Jurassic – Lower Cretaceous
Middle Jurassic
Upper Triassic – Lower Jurassic
Devonian – Middle Triassic
Crystalline rocks
Normal fault

Fig. 1.1



Sjællandselv Member (Hareelv Formation), Raukelv Formation

Katedralen Member (Hareelv Formation)

Vardekløft Group

Neil Klinter Group

Boreholes

Fig. 1.2

2. Drilling operation:

The drilling camp personal:

Geologist Stefan Piasecki, GEUS
Geologist Morten Bjerager, GEUS
Senior technician John Boserup, GEUS
Catering (Laboratory technician) Annette Ryge, GEUS
Driller Peter Turner, Faxe Kalk A/S
Driller Andy Milton, Faxe Kalk A/S

Logistics were handled by POLOG
Helicopter from Grønlandsfly A/S was chartered for a full field season.

Two days of reconnaissance and location of drill site were conducted prior to drilling to make sure that the selected drill site was remote from exposed major sills and dikes.

Drilling was carried out by a Diamant Board 747 wire line rig, with a casing diameter of 85 mm). Core barrels are 3 m long and have a diameter of 76 mm. Core diameter is 56 mm.
The disassembled drill rig was shipped by boat from Denmark, and reloaded at Island to Constable Pynt in Greenland. From the ship at Constable Pynt it was unloaded by helicopter Eurocopter AS-350 with max sling load of 1.3–1.4 tons. From Constable Pynt the drill rig parts were launched by helicopter and flown to the Blokelv drill site. The drill rig was assembled directly from the helicopter sling (Figs 2.1, 2.2).

Mobilisation of the drill rig and camp took 3 days, with 6 tons transported in total 15 combined helicopter sling and cabin loads. Effective drilling took 8 days (Appendix A). Casing was drilled to 20 m. Demobilisation and down-hole logging took 2 days.

Drilling demanded a daily water consumption of 10 m^3, in total 80 m^3. Water was supplied from the nearest river at about 300 m lateral distance and 75 m vertical distance by a gasoline driven water pump through inflatable hoses into two 5000 l basins. In addition a 3000 l basin was used for saline water to circulate the borehole during nights thereby avoiding permafrost to freeze the drill string. Permafrost was present from a few decimetres below terrain surface and down to about 100 m.

2.1 Figures

Fig. 2.1 Assembling the drill rig.

Fig. 2.2

3. Geological and geophysical data

The Blokelv borehole is located in the central and deepest part of the Jameson Land Basin. The terrain plateaus in this area consist of sandstone of the Upper Jurassic Sjællandselv Member (Hareelv Formation) underlain by alternating black mudstone and grey – yellowish grey sandstones of the Katedralen Member (Hareelv Formation). The lower part of the Katedralen Member is generally poorly exposed in the region but pass into silty mudstone of the Fossilbjerget Formation.

3.1 Objectives

The target of the drilling was the Upper Jurassic, Katedralen Member of the Hareelv Formation. The purpose was to obtain thickness and stratigraphic control of this combined mudstone source rock and sandstone reservoir rock succession of the Katedralen Member in the central and deepest part of the Jameson Land Basin, i.e.:

- Improve the stratigraphic control of the upper and lower boundary of the Katedralen Member.
- Develop an improved depositional model of the Katedralen Member on basis of the core material.
- Acquire lithological data on the Katedralen Member in order to obtain quantitative data on the distribution of sandstone and mudstone intervals and individual bed thicknesses.
- Acquire fresh unweathered samples for modern analyses of source potential and reservoir quality within the Katedralen Mb.
- Provide a better correlation to previous boreholes from the area.

3.2 Results

The Blokelv core recovered fractured homogenous sandstones of the Sjællandselv Member (Hareelv Formation) from 0–10 m; very dark grey to black mudstones with grey homogenous gravity flow sandstones and heterolithic sandstone and mudstones of the Katedralen Member (Hareelv Formation) from 10 m–TD. The base of the Hareelv Formation was not reached. Mudstones comprise 57% and sandstones comprise 41% of the cored Katedralen Mb. Possible bentonite beds are present at 25.8 m, 79.9 m, 83.2 m and 216 m.

Intrusions represented by three sills (0.72 m, 1.07 m and 1.98 m thick) were recorded at 27, 55 and 102 meters, respectively.

Bitumen/oil stains occur on a fracture within the sill at 55.4 m and in a belemnite at 105.25 m. The mudstones in general release smell of oil and possibly some free bitumen. Sandstones are commonly brownish-grey stained towards the boundaries to the mudstones.

3.3 Coring

Conventional coring was performed from terrain surface to TD at 233.8 m. The core recovery was 100% from 1.72–233.8 m.

3.4 Sampling programme on drill site

A total of 79 whole round core samples for gas analyses were collected immediately from the bottom of each recovered core at every 3 m. Samples have lengths up to about 10 cm and they were stored in sealed metal cans.
Samples, collected for preliminary biostratigraphic age identification based on dinoflagellates, include three mudstone samples from the top part of the cored Katedralen Member at 10.10 m (511201), 15.0 m (511202) and 18.80 m (511203); and four mudstone samples from the lowermost part of the cored Katedralen Member at 201.90 m (511209), 216.6 m (511210), 224.68 m (511211) and 233.80 m (511212).

Samples of observed bitumen in the cores were collected at 55.4 m (511206) and at 105.47 m (Gas-can with belemnite and liquid bitumen). In addition gas and water samples were collected at 162.5 m (511207, 511208) where gas and oil film was observed in the drill water.
One surface sample (511204) of weathered shale (Sjællandselv Member) was collected at the drill site (0 m drilling / 181 m a.s.l.).

3.5 Logging

Logging of the Blokelv borehole was initiated after removal of the drill rig. A suite of well log applications was planned, including gamma spectral log, sonic log and conductivity log.

First successful run was completed with a “dummy” tool to ensure that the borehole was stable and clean.
Second successful run was a complete conductivity run. A positive spike at the bottom of the casing is clearly seen at 20 m. Another positive spike at 27 m shows a sill. Two combined negative-positive peaks at 55 and 105 m show the two sills (Fig. 3.5.1).
Third run was an incomplete gamma logging from 233.8–184 m. At 184 m the tool got stuck and was lost in the hole. Core material from this level show homogeneous sandstone with the so-called fish scale structures that probably imploded in the borehole. The recovered gamma log clearly differentiates sandstone and mudstone units (Fig. 3.5.1).
The field logging program was hereafter terminated but a spectral gamma logging of the entire core was performed in the core-lab of GEUS after return of the core to Copenhagen (Fig 3.5.2).

The temperature in the borehole was measured 25.5 and 40.5 hours after the drilling stopped, in the depths of approximately 10 m, 35 m, 85 m and 184 m. After 40.5 hours the temperature was stabilised and the estimated depth of the permafrost is at 100 m. Wire and sensors have been left in drilling whole for later measurements when temperature conditions are in totally equilibrium.

Table 3.5.1 Temperature in the Blokelv borehole

Depth/ m	Temperature after 25.5 hours	Temperature after 40.5 hours
0 m	12.8° C	8.5° C
10 m	12.5° C	0° C
35 m	12.0° C	-1.5° C
85 m	13.0° C	-1.0° C
184 m	12.7° C	2.2° C

3.6 Biostratigraphy of the cored succession

Surface outcrops around the drill site were intensively searched for ammonites without success. So mudstone samples for screening analyses of the content of dinoflagellates, were collected for fast preparation and screening analyses. Preliminary dinoflagellate biostratigraphy of three samples in the lower part of the Blokelv core indicates Late Oxfordian, Glosense Chronozone. Dinoflagellates in samples from the upper part of the Blokelv core indicate latest Kimmeridgian, Eudoxus–Autissiodorensis Chronozones. These ages are in accordance with the age of Katedralen Member, expected from analyses of outcrops.

3.7 Lithology

Two lithostratigraphic units were drilled in the Blokelv core:

Sjællandselv Member (Hareelv Formation) 0–10.08 m.
Upper Jurassic, Upper Kimmeridgian – Volgian

Sandstone, brownish grey – yellowish grey, medium-grained, homogeneous and faint wavy bedding intervals, water-escape structures and diagenetic staining common, quartz dominant, mica common, oblique fractures common.
Few, very dark grey mudstone intervals occur.

Katedralen Member (Hareelv Fm) 10.08 –233.8 m (Total Depth).
Upper Jurassic, Upper Oxfordian – Upper Kimmeridgian

Succession of mainly mudstone and sandstone units.
Mudstones comprise 57%, sandstones comprise 39% and mudstone conglomerates comprise about 2% of the Katedralen Mb.

Mudstone, very dark grey – black, laminated, organic rich, with varying abundance of thin silt and very fine-grained sand laminae and lenses, up to a few mm thick. Pyrite is common and pyritised ammonites, belemnites and coal/lignite clasts/branches 0.3–0.5 cm thick occur.

Mudstone conglomerate, black and grey, matrix–clast supported, matrix of fine-medium sand, elongated angular mudstone clasts, mm–cm in size, bedding parallel – randomly oriented clasts.

Mudstone shell-bed, 3 cm thick, very dark grey, with common thin bivalve shells (*Posidonia*?).

Sandstone, grey, fine- to medium-grained, homogeneous, commonly with abundant intraformational mud clasts, quartz dominant, mica common to abundant, and commonly dominant at top of sandstone units.

Sandstone–mudstone heterolith, grey and very dark grey, very fine- to medium-grained, quartz dominant, mica common, plane laminated, wavy laminated, ripple laminated, common graded beds, common slump structures.

Sandstone, fine- to medium-grained, dark grey, muddy, organic, homogeneous, quartz dominant, mica common.

Few, possible bentonite, laminae and beds have been recorded.

Three sills of fine-grained igneous rocks were recorded at 27 m, 55 m and 102 m. The thickness of these strata is 0.72 m, 1.07 m and 1.98 m, respectively.

3.8 Bitumen

Bitumen/oil stains were recovered from a fracture within igneous rocks at 55.4 m (Fig. 3.8.1), and in a porous belemnite at 105.25 m. Analysis of the bitumen from 55.4 m (GGU 511206) show a source of marine shale. The bitumen is lightly biodegraded and has a highly anoxic signature with abundant 28, 30-bisnorhopane. The overall signature is similar to the most prolific source rock interval present in the main North Sea source rock, the Kimmeridge Clay and equivalents (Preliminary data Figs. 3.8.2–4).

3.9 Figures

3.2.1 Lithological log of the Blokelv core.

3.2.2 Core photographs of boxes 29, 50, and 62 showing black organic rich mudstone, mudstone conglomerate, massive sandstone, laminated heterolithic mudstone-

sandstone, slumped heterolitic sandstone-mudstone and sandstone dikes in the Upper Jurassic Katedralen Member (Hareelv Formation).

3.5.1 Conductivity log and Gamma Ray log.

3.5.2 Scanned preliminary spectral gamma log together with lithology and measured gamma log (green lines). The scanned spectral gamma log is without depth corrections and will be further processed.

3.8.1 Photograph of bitumen at 55.4 m.

3.8.2-4 Biomarker analyses of bitumen at 55.4 m.

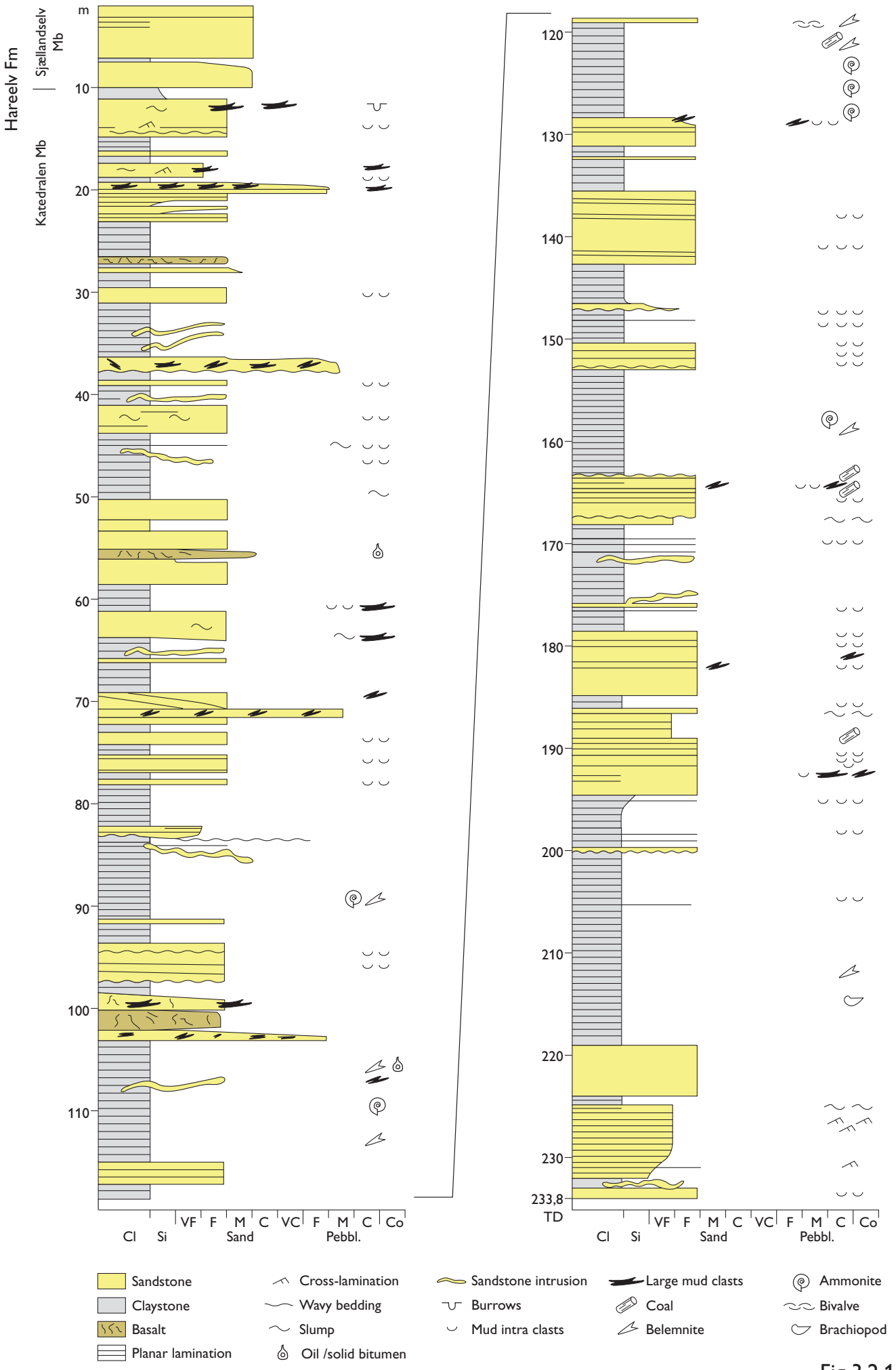

Hareelv Fm
Sjællandselv Mb
Katedralen Mb
m
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
233,8
TD
Cl
Si
VF
F
M
C
VC
F
M
C
Co
Sand
Pebbl.
Sandstone
Claystone
Basalt
Planar lamination
Cross-lamination
Wavy bedding
Slump
Oil /solid bitumen
Sandstone intrusion
Burrows
Mud intra clasts
Large mud clasts
Coal
Belemnite
Ammonite
Bivalve
Brachiopod

Fig 3.2.1

T 106.3 m Box 29

B 109.85 m

T 184.07 m Box 50

B 187.95 m

T 229.66 m Box 62

0.5 m

B 233.40 m

Fig. 3.2.2

Well Name: Blokelv
Location: Jameson Land
Reference: Ground surface

Borehole logging by GEUS, 16 August 2008

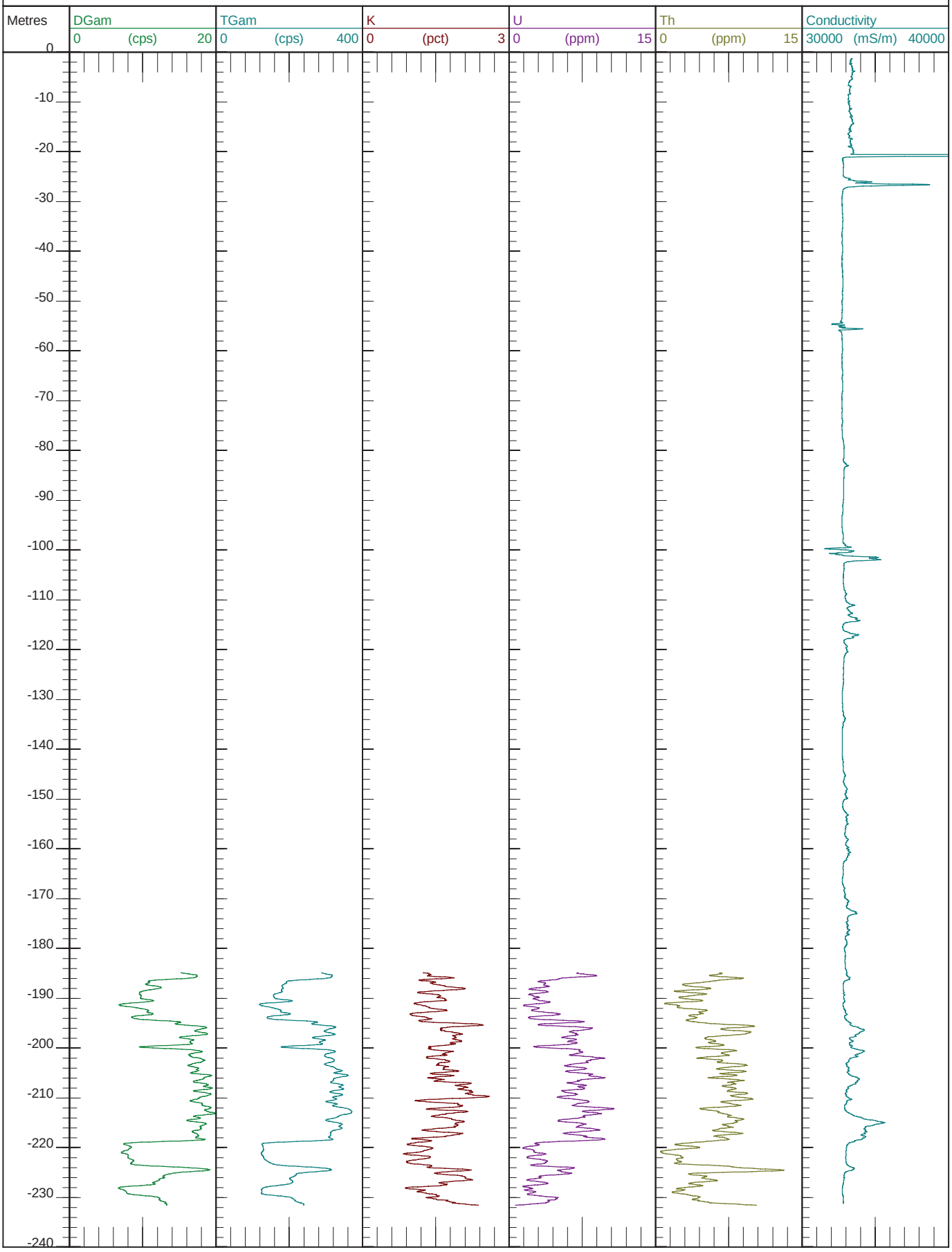
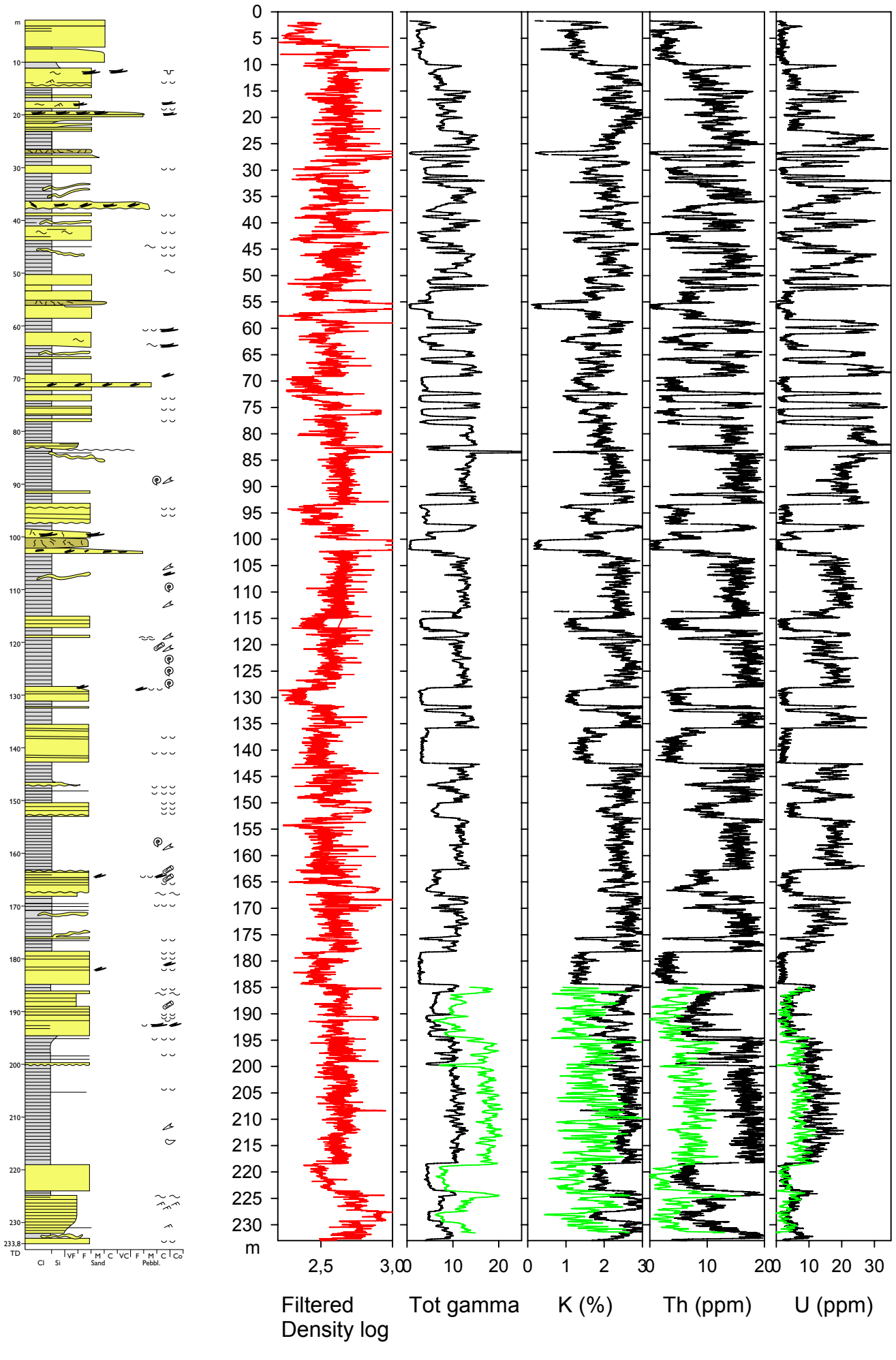


Fig 3.5.1


m
TD
Cl
Si
VF
F
M
C
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F
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0
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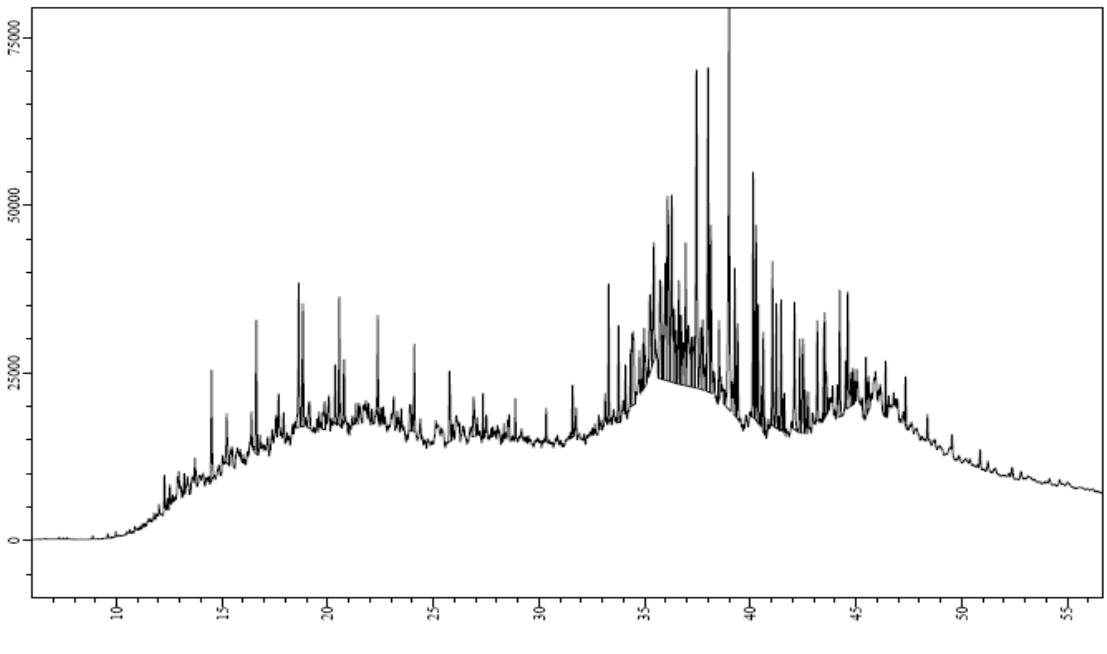
130
135
140
145
150
155
160
165
170
175
180
185
190
195
200
205
210
215
220
225
230
m
2,5
3,00
10
20
0
1
2
30
10
200
10
20
30
Filtered Density log
Tot gamma
K (%)
Th (ppm)
U (ppm)

Fig 3.5.2

Fig. 3.8.1

GC/FID



Triterpanes, GC/MS-SIM

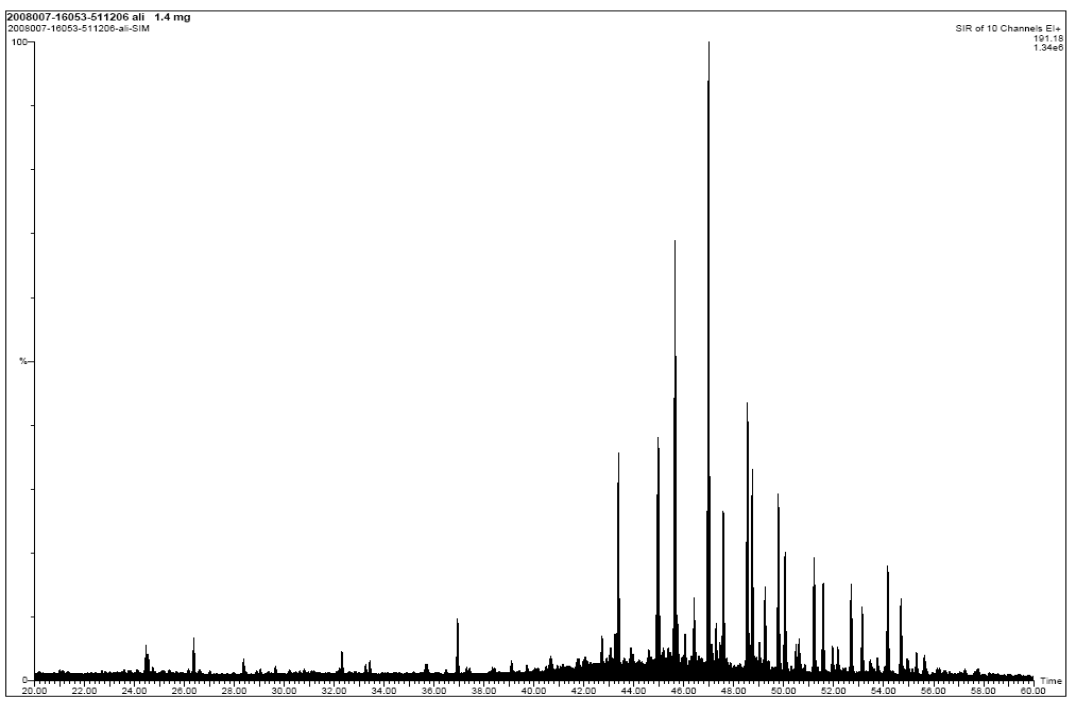
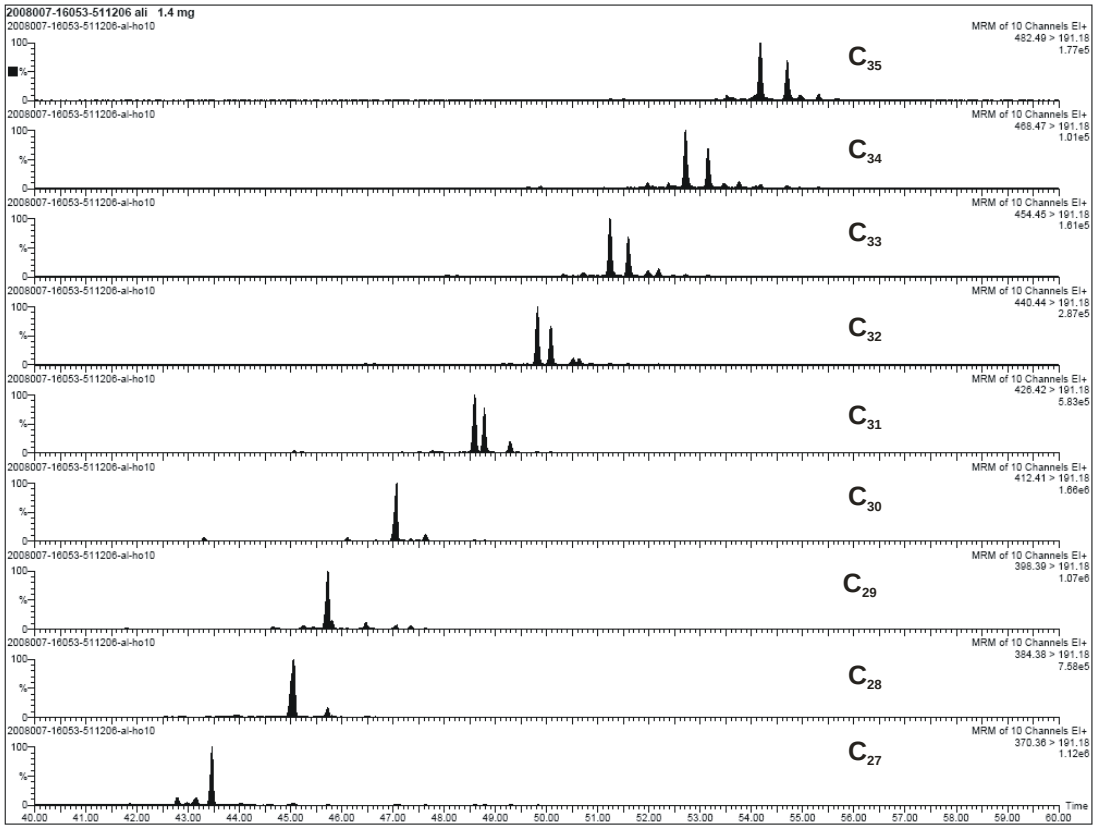


Fig. 3.8.2

Hopanes, parent-daughter GC/MSMS



Steranes, GC/MS-SIM

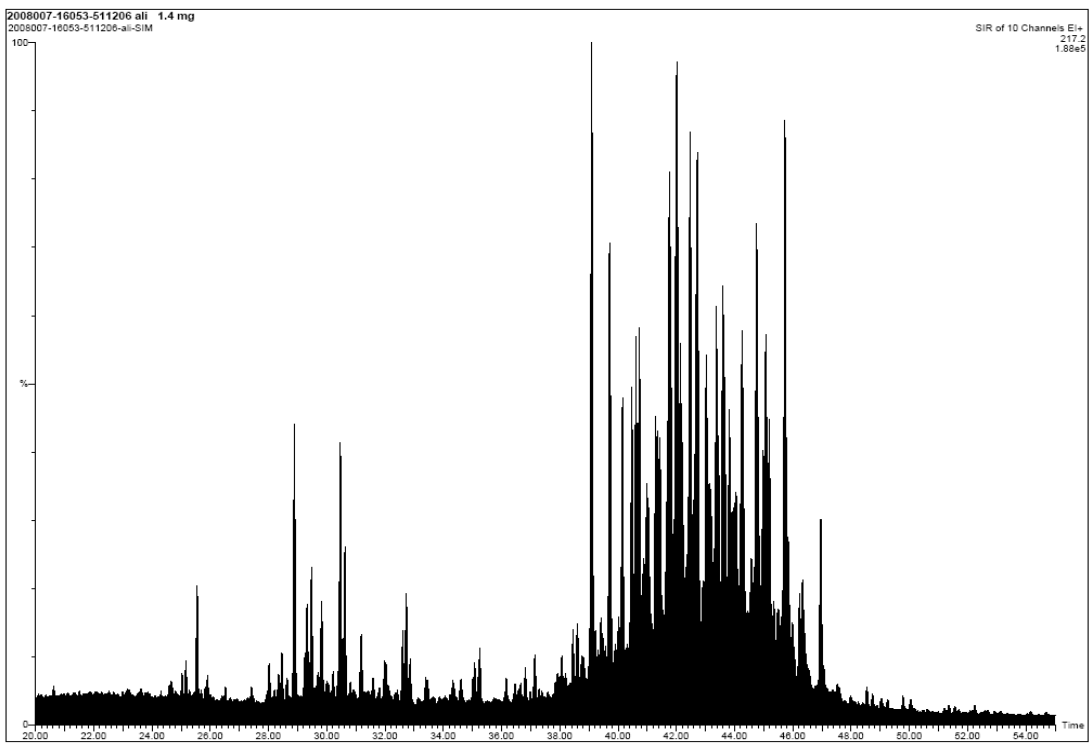


Fig. 3.8.3

Steranes, parent-daughter GC/MSMS

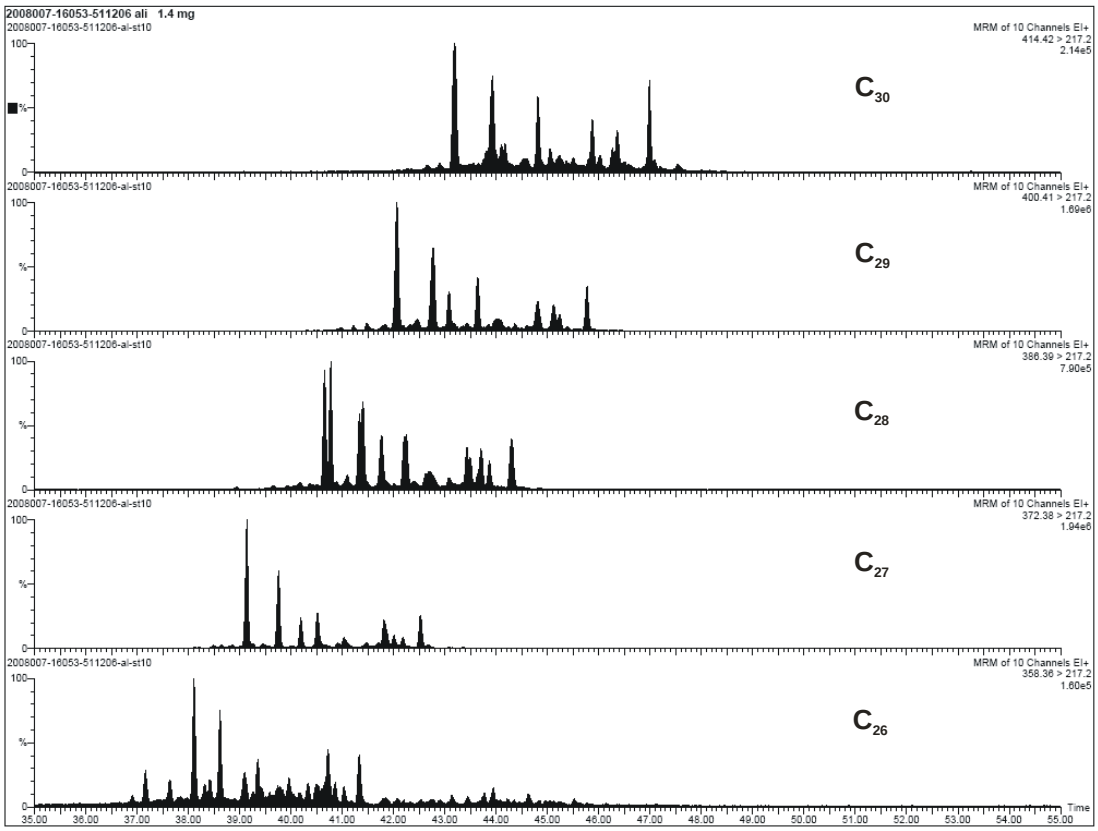


Fig. 3.8.4

1. APPENDIX

Appendix A: Daily drilling log/report

Appendix B: Blokelv GGU 511101 Core Box Depths.

Appendix A: Daily drilling report

Date	Cored	Remarks
1/8-2008		SP and MB arrival at Blokelv, drill site reconnaissance.
2/8-2008		Drill site reconnaissance, arrival of AR.
3/8-2008		Establishment of drill camp.
4/8-2008		Establishment of drill camp, arrival of JB, PT. Drill site selected.
5/8-2008		Sling of drill rig parts from Constable Pynt to Blokelv and drill rig assembling, 9 slings in total. Arrival of AM.
6/8-2008		Drill rig assembling, water supply establishment. 3 slings of drill rig parts + 1 local sling of water pump to river.
7/8-2008	21 m	Drilling of casing 0–20 m. Coring 1.72–20.9 m. Cementation of casing with concrete.
8/8-2008	12 m	Drilling 0–32.8 m incl. concrete with 100% core recovery.
9/8-2008	39 m	Drilling 32.8–71.8 m with 100% core recovery.
10/8-2008	21 m	Drilling 71.8–92.8 m with 100% core recovery.
11/8-2008	20 m	Drilling 92.8–122.8 m with 100% core recovery. Sling of core barrels and core boxes.
12/8-2008	30 m	Drilling 122.8–152.8 m with 100% core recovery.
13/8-2008	27 m	Drilling 152.8–179.8 m with 100% core recovery.
14/8-2008	27 m	Drilling 179.8–206.8 m with 100% core recovery.
15/8-2008	26 m	Drilling 206.8–TD 233.8 m. Dismantling drill rig. Petrophysical logging, Dummy and Conductivity. 9 combined sling and cabins loads.
16/8-2008		Dismantling drill rig. Sling of core boxes and drill rig parts. 9 combined cabin loads and slings. Petrophysical logging, gamma ray.
17/8-2008		Drill site abandoned. 2 Helicopter transports

Appendix B: Blokelv GGU 511101 Core Box Depths.

Box	Top Depth/m	Bottom Depth/m	Core length in box/m
Box 1	1.72	5.51	3.79
Box 2	5.51	9.33	3.82
Box 3	9.33	13.12	3.79
Box 4	13.12	16.81	3.69
Box 5	16.81	20.56	3.75
Box 6	20.56	24.23	3.67
Box 7	24.23	27.80	3.57
Box 8	27.80	31.66	3.86
Box 9	31.66	35.31	3.65
Box 10	35.31	38.98	3.67
Box 11	38.98	42.80	3.82
Box 12	42.80	46.53	3.73
Box 13	46.53	50.23	3.70
Box 14	50.23	53.85	3.62
Box 15	53.85	57.66	3.81
Box 16	57.66	61.22	3.56
Box 17	61.22	65.00	3.78
Box 18	65.00	68.77	3.77
Box 19	68.77	72.32	3.55
Box 20	72.32	76.25	3.93
Box 21	76.25	80.00	3.75
Box 22	80.00	83.80	3.80
Box 23	83.80	87.60	3.80
Box 24	87.60	91.35	3.75
Box 25	91.35	95.20	3.85
Box 26	95.20	98.80	3.60
Box 27	98.80	102.45	3.65
Box 28	102.45	106.13	3.68
Box 29	106.13	109.85	3.72
Box 30	109.85	113.70	3.85
Box 31	113.70	117.46	3.76
Box 32	117.46	121.12	3.66
Box 33	121.12	124.90	3.78
Box 34	124.90	128.56	3.66
Box 35	128.56	132.21	3.65
Box 36	132.21	135.90	3.69
Box 37	135.90	139.64	3.74
Box 38	139.64	143.35	3.71
Box 39	143.35	146.97	3.62
Box 40	146.97	150.79	3.82
Box 41	150.79	154.56	3.77
Box 42	154.56	158.26	3.70
Box 43	158.26	161.94	3.68
Box 44	161.94	165.66	3.72
Box 45	165.66	169.35	3.69
Box 46	169.35	173.04	3.69
Box 47	173.04	176.72	3.68
Box 48	176.72	180.33	3.61
Box 49	180.33	184.07	3.74
Box 50	184.07	187.95	3.88
Box 51	187.95	191.75	3.80
Box 52	191.75	195.40	3.65
Box 53	195.40	199.17	3.77
Box 54	199.17	202.90	3.73
Box 55	202.90	206.80	3.90
Box 56	206.80	210.62	3.82
Box 57	210.62	214.42	3.80
Box 58	214.42	218.25	3.83
Box 59	218.25	222.07	3.82
Box 60	222.07	225.84	3.77
Box 61	225.84	229.66	3.82
Box 62	229.66	233.40	3.74
Box 63	233.40	233.80	0.40