DANMARKS OG GRØNLANDS GEOLOGISKE UNDERSØGELSE RAPPORT 2011/79

Completion report Billegrav-2 well (DGU 248.61) southern Bornholm

Part 2: Review of Skelbro-1 and Billegrav-1

Niels H. Schovsbo

GEOLOGICAL SURVEY OF DENMARK AND GREENLAND
MINISTRY OF CLIMATE AND ENERGY

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1. Introduction

The Skelbro-1 (246.749) and Billegrav-1 (247.560) wells were drilled in 1984 on Bornholm. The scientific wells were drilled by GEUS and represented the first cored sequence of the Lower Palaeozoic from Bornholm. The cores have been extensively studied, including sedimentology (Pedersen 1989), stratigraphy (Pedersen & Klitten 1990, Koren & Bjerreskov 1997), geochemistry (Buchardt et al. 1986), maturity (Buchardt & Lewan 1990) and fluid inclusions (Jensenius 1987).

The purpose of this report is to outline the work done so far on the Skelbro-1 and Billegrav-1 wells in a log-stratigraphical framework, which allows comparison with the new fully cored Billegrav-2 well drilled about 800 m south of the Billegrav-1 well (Figure 1). The review deals with lithology, stratigraphy, TOC content, maturity and the burial history of Bornholm. A detailed log-based correlation between the three wells facilitates a direct comparison of measured properties between the wells.

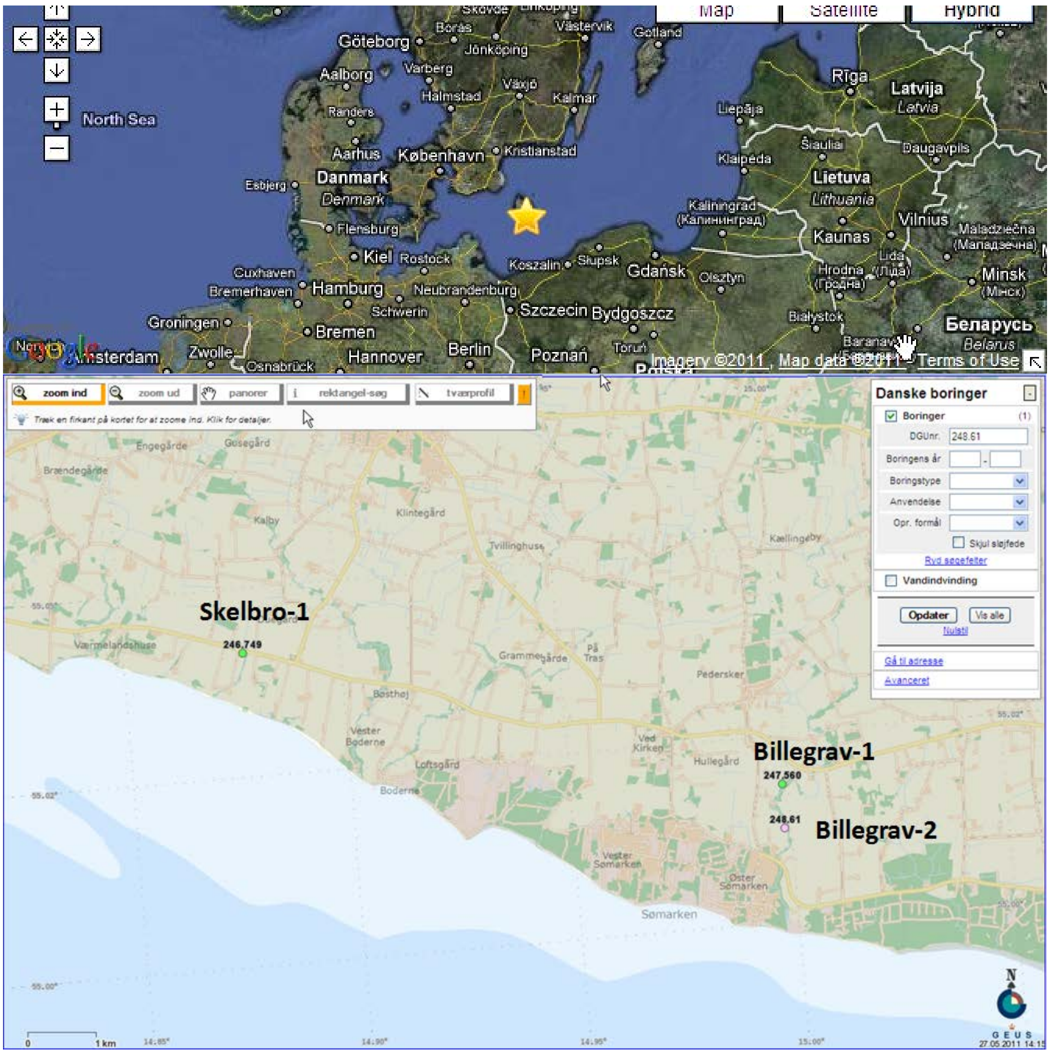

Figure 1. Map showing location of the Skelbro-1 (246.749), Billegrav-1 (247.560) and Billegrav-2 (248.61) wells on southern Bornholm, Denmark. The Skelbro-1 well was drilled approximately 8 Km west of the Billegrav wells.

2. Well data summary sheet Skelbro-1

DGU well number:	246.749
Common well Name:	Skelbro-1
Location:	Drilled in the abandoned Komstad Limestone quarry
UTM zone	33
Drill Position, UTM:	492250, 6099614
Terrain elevation, m:	35 DNN
TD:	43.2 m drillers depth below top of the Komstad Limestone in the quarry
Formation at TD:	Læså Fm, Norretorp Mbr
Drilling type:	Diamond coring
Core diameter:	2.5 cm
Core barrel length:	1.5 m
Recovery:	From below 0 m: 100%
Drilling fluids:	Fresh water with no additives
Casing:	None
Drilling company:	GEUS
Drilling date:	May 1984
Logging:	Technical University of Denmark (DTU). The GR log was the only log type obtained in the hole. The log trace was obtained in analogue form and no digital version of the log exists
Purpose:	Scientific
Location of cores (2011):	Institute of Geography and Geology, University of Copenhagen (Gunver K. Pedersen).
Summary:	The Skelbro-1 well cored the Komstad Limestone from 0 to 3.9 m (Fig. 2). The Alum Shale Formation is 33.4 m thick and includes the Middle Cambrian Andrarum and Exsulans limestone beds that both serve as important regional marker beds (Nielsen & Schovsbo 2006). The base of the Alum Shale was reached at 37.2 m and the well was terminated at 43.2 m in the Norretorp Member of the Læså Fm after penetrating the Rispebjerg Mbr (3.2 m thick).

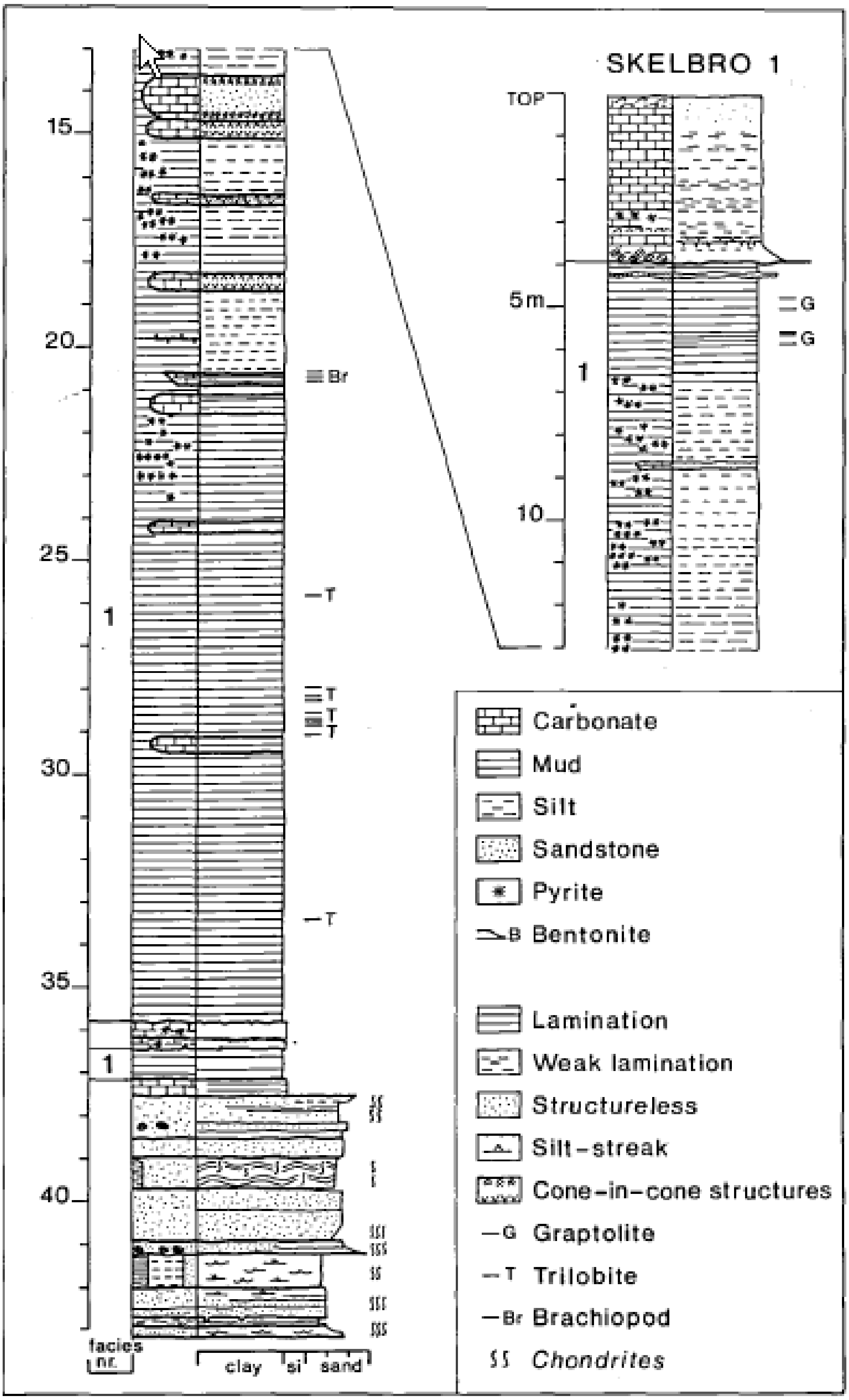

Figure 2. Sedimentological log of the Skelbro-1 well. The well cored 33.4 m of Alum Shale. From Pedersen (1989).

3. Well data summary sheet Billegrav-1

DGU well number:	247.560
Common well Name:	Billegrav-1
Location:	Drilled in the Øle Å valley
UTM zone	33
Drill Position, UTM:	499994, 6097068
Terrain elevation, m:	15 DNN
TD:	60.6 m drillers depth below terrain
Formation at TD:	Dicellograptus Shale, Upper Ordovician
Drilling type:	Diamond coring
Core diameter:	2.54 cm
Core barrel length:	1.5 m
Recovery:	From below 2 m: 100%
Drilling fluids:	Fresh water with no additives
Casing:	None
Drilling company:	GEUS
Drilling date:	May 1984
Logging:	Technical University of Denmark (DTU). The GR log was the only log type obtained in the hole. The log trace was obtained in analogue form and no digital version of the log exists.
Purpose:	Scientific
Location of cores (2011):	Institute of Geography and Geology, University of Copenhagen (Gunver K. Pedersen) of the Ordovician section and the Geological Museum, University of Copenhagen (Arne Thorshøj Nielsen) of the Silurian section.
Summary:	The Billegrav-1 well cored Silurian Rastrites Shale from 2 m below the ground level down to 29.2 m. The Rastrites Shale comprises light to dark grey mudstone except for a distinct grey mud to siltstone unit containing carbonate cemented sandy beds (Fig. 3). The Upper Ordovician includes the Lindegård Formation (previously referred as the Tretaspis Shale or Tommarp and Jerrestad mudstones), comprising grey mud- and siltstones, and the dark organic-rich Dicellograptus Shale (Fig. 3). The Dicellograptus Shale was not penetrated when the well was stopped at 60.6 m. The shale contains numerous bentonites in its lowermost part including a 1 m thick K-bentonite bed (Kinnekulle Bentonite) which represents the most significant volcanic eruption in the entire early Palaeozoic (Bergström et al. 1995).

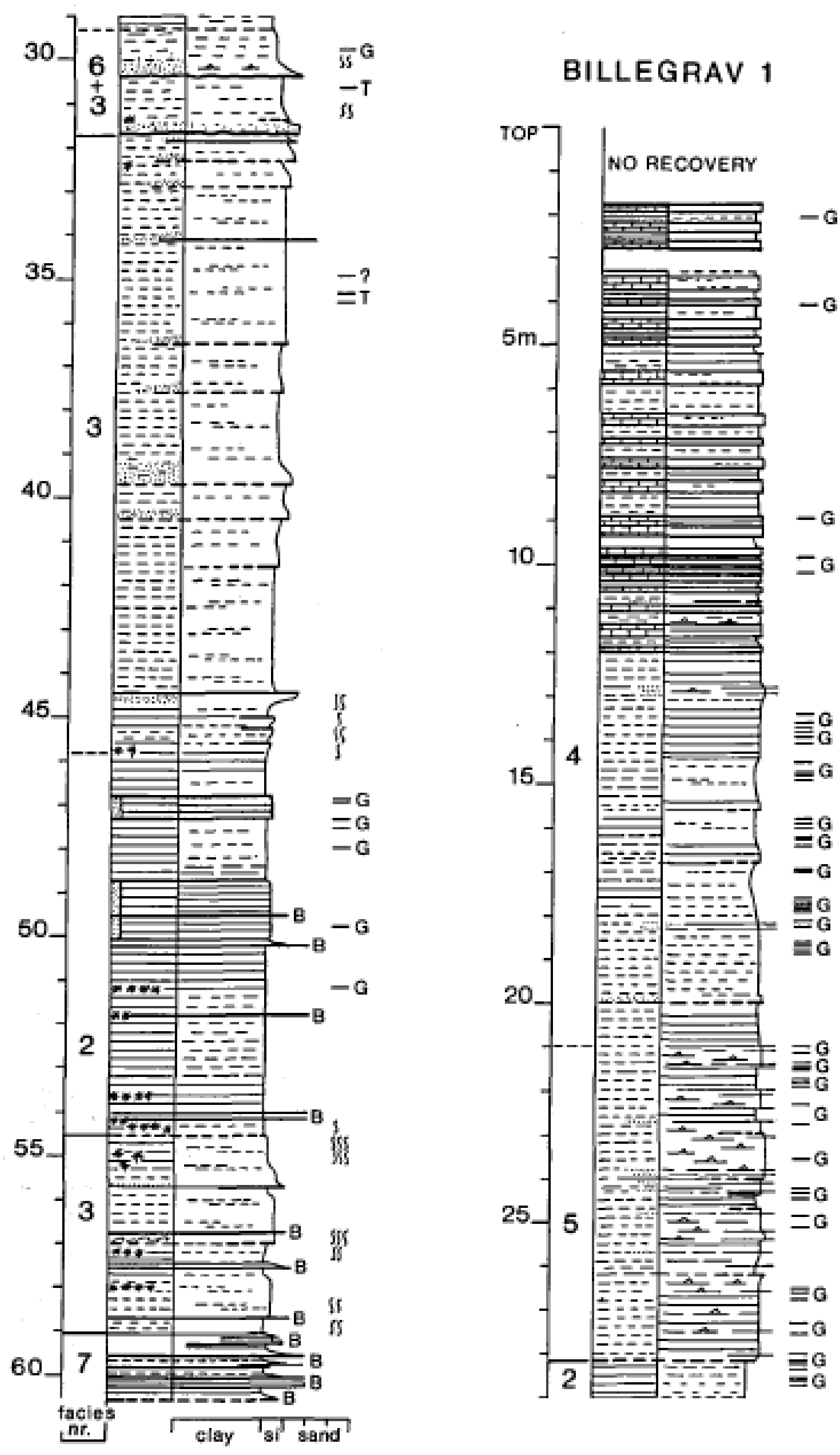

Figure 3. Sedimentological log of the Billegrav-1 well. For legend see Figure 2. From Pedersen (1989).

4. Stratigraphy

4.1. Litho- and biostratigraphical frame for the Lower Palaeozoic on Bornholm

The Middle Cambrian Alum Shale rests directly on the Lower Cambrian Læså Fm being separated by the pronounced regional unconformity termed the Hawke Bay event (Figure 4). The Hawke Bay event is a combined tectonic uplift of the plate margins and a sea level lowering that affected the sedimentation on a regional scale in Baltoscandia.

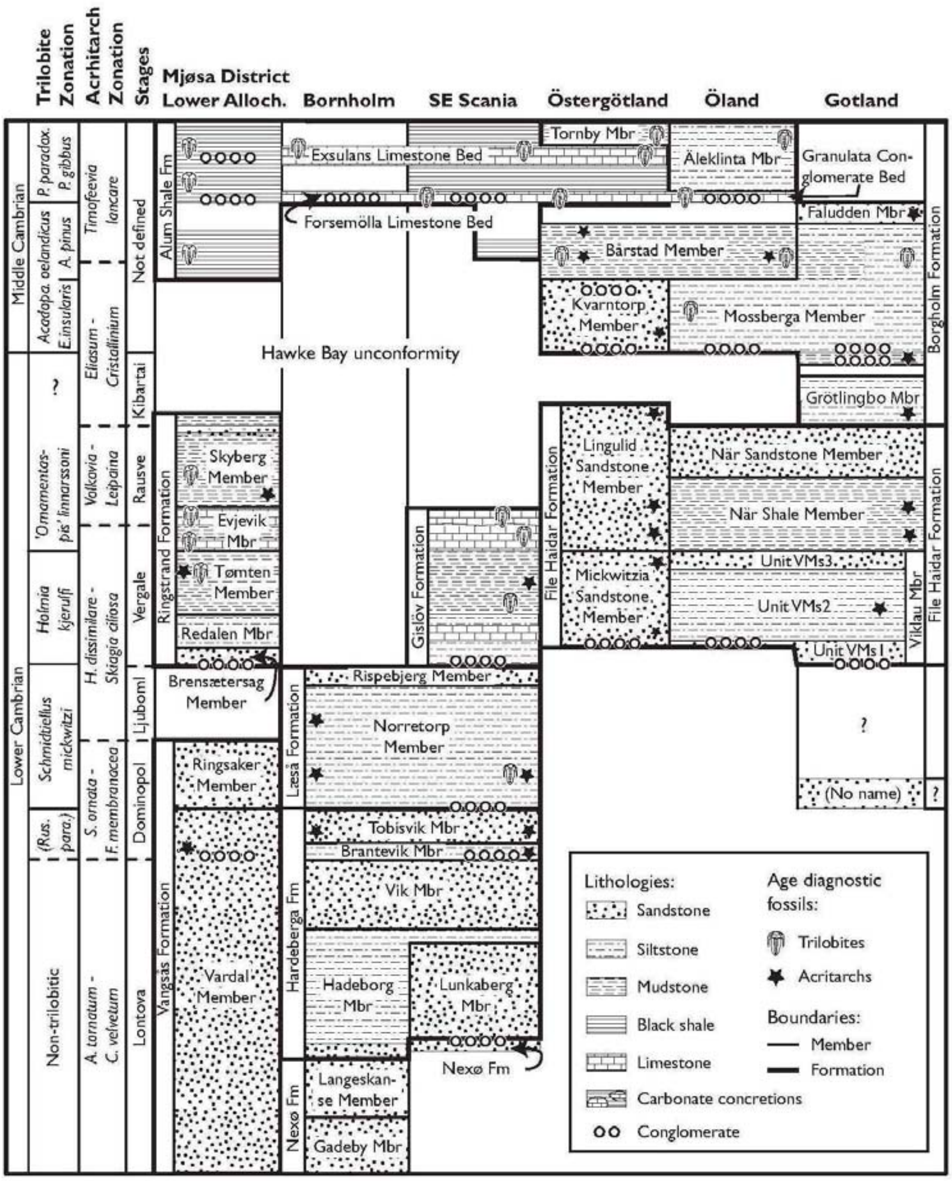

Figure 4. Lithostratigraphic scheme for the Lower and lower Middle Cambrian of southern Scandinavia. From Nielsen & Schovsbo (2006).

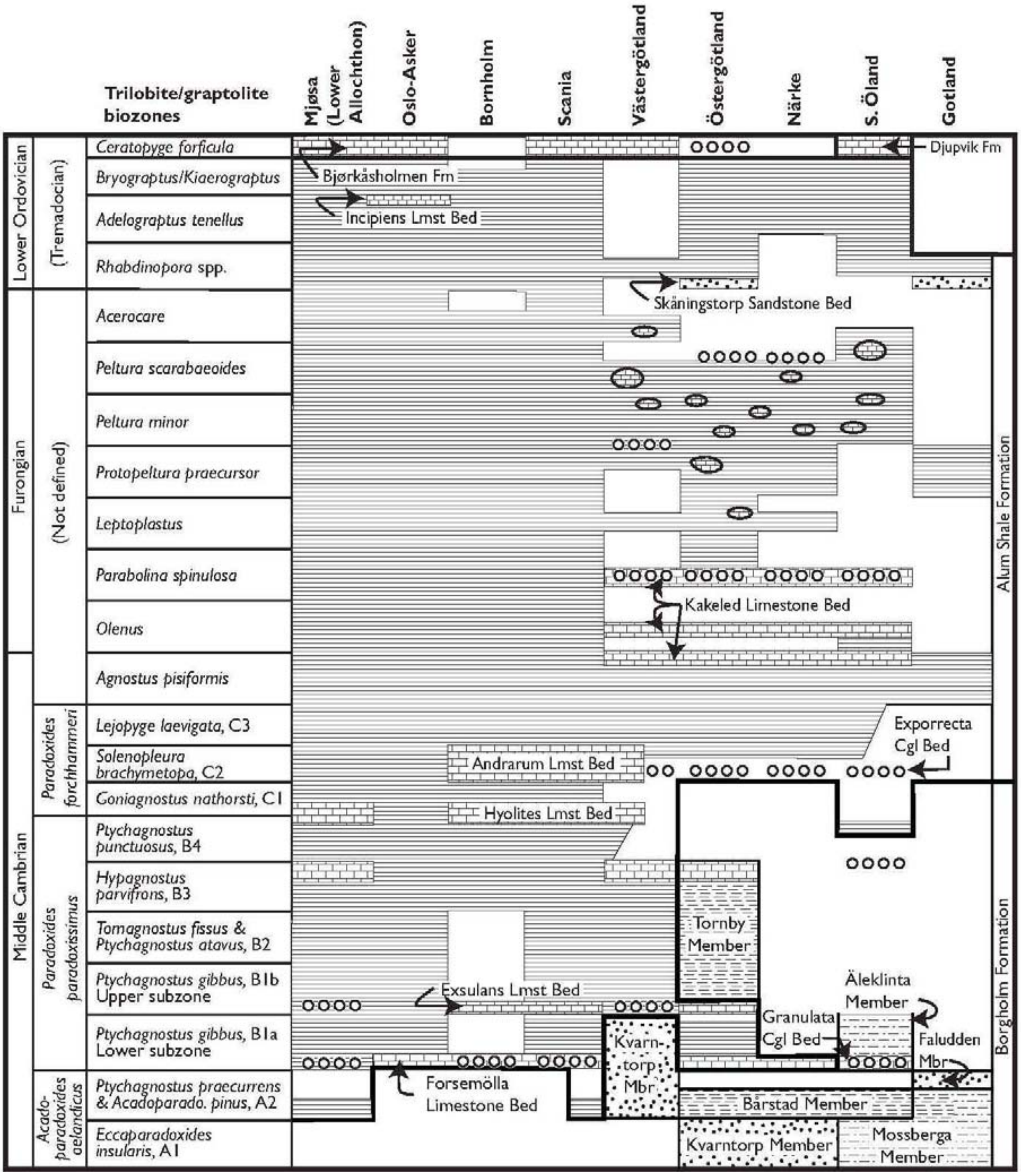

Figure 5. Lithostratigraphic scheme for the Middle Cambrian, Furongian and Lower Ordovician (Tremadocian) of southern Scandinavia. Avery sophisticated biostratigraphy has been established for the Middle Cambrian and Furongian based on agnostid and olenid trilobites. From Nielsen & Schovsbo (2006).

The lower part of the Alum Shale on Bornholm contains the thin Exsulans Limestone (c. 0.2 m thick) with a basal conglomerate equivalent to the Forsemölle Limestone Bed. The Exsulans Limestone is a primary bio-clastic limestone. Above the Exsulans follow a thin (up to 1.5 m thick) Alum Shale interval followed by the Andrarum Limestone, about 0.8 m thick (Figure 5). The Alum Shale sandwiched by these two beds represents the Middle Cambrian *P. paradoxissimus* Superzone.

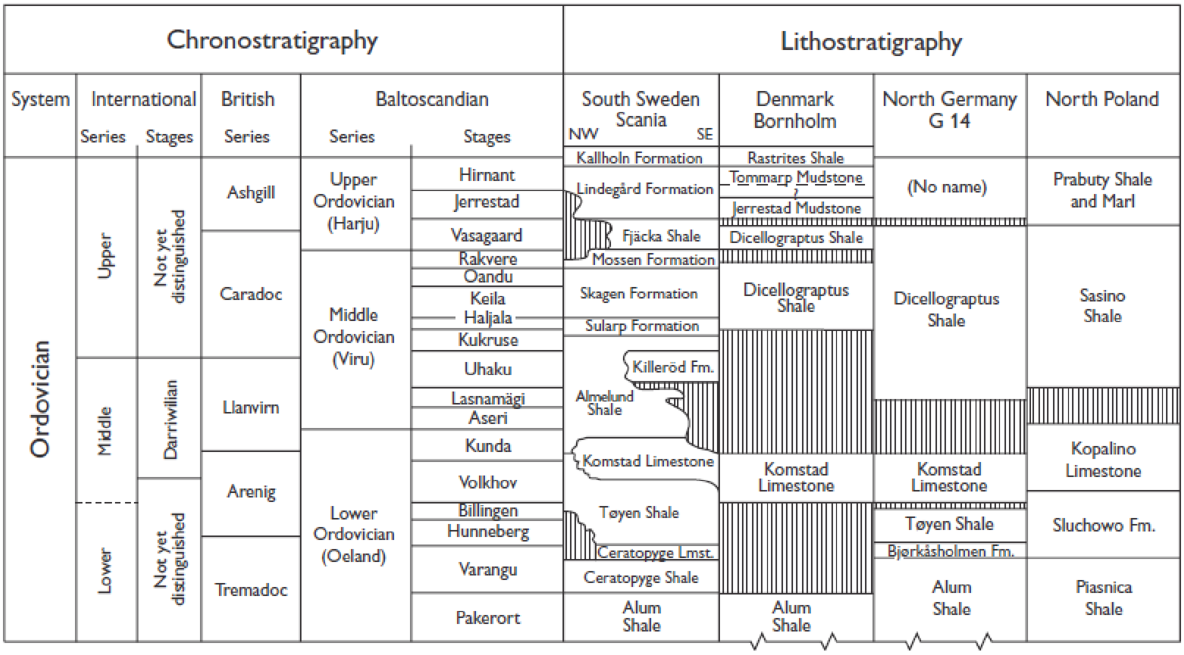

Figure 6. Stratigraphy of Scania, Bornholm, northern Germany (G14) and northern Poland with indications of main lithologies. From Stouge & Nielsen (2003).

The Alum Shale sequence above the Andrarum Limestone is overall fairly homogeneous and is composed of fine-grained mudstone with a low proportion of diagenetic carbonate beds. This type of Alum shale is also deposited in Scania and has been termed the ‘outer shelf’ type by Schovsbo (2002). Alum Shale with higher proportions of primary carbonates, conglomerates and diagenetic carbonate concretions is present in the south-central parts of Sweden and Öland (Figure 5) and is termed ‘inner shelf’ type (Schovsbo 2002).

The Alum Shale Fm is overlain directly by the Middle Ordovician (Arenig) Komstad Limestone on Bornholm (Figure 6). Compared to the stratigraphically more complete section in Scania the uppermost part of the Alum Shale (the Ceratopyge shale), the Bjørkåsholmen Fm and the Tøyen shale are missing on Bornholm. This unconformity likely reflects slight uplift/adjustment of the plate margins (Stouge & Nielsen 2003).

The Komstad Limestone is overlain directly by the Upper Ordovician Dicellograptus shale reflecting yet another gap in the succession corresponding to most of the Middle Ordovician and lowermost Upper Ordovician (Figure 6). Again this regional unconformity traceable from South Sweden to northern Poland may be related to both sea-level lowering and plate adjustment of the margins of Baltica (Stouge & Nielsen 2003).

In the uppermost parts of the Dicellograptus Shale on Bornholm unconformities of shorter duration, associated with conglomerates, reflect erosion related to sea-level fluctuations.

4.2. Logstratigraphical units in Skelbro-1 and Billegrav-1

Pedersen & Klitten (1990) discerned 6 units (A-F) and 16 subunits based on the GR log pattern in the Billegrav-1 and Skelbro-1 wells. They demonstrated its local consistency via detailed log based correlation of water wells on Southern Bornholm (Figure 7).

The logstratigraphical units are also readily identified in Billegrav-2 (Schovsbo et al. 2011, Figure 9) and they provide a very robust stratigraphical frame between the three wells. In Table 2 the pick depth of the log units in the three wells are listed.

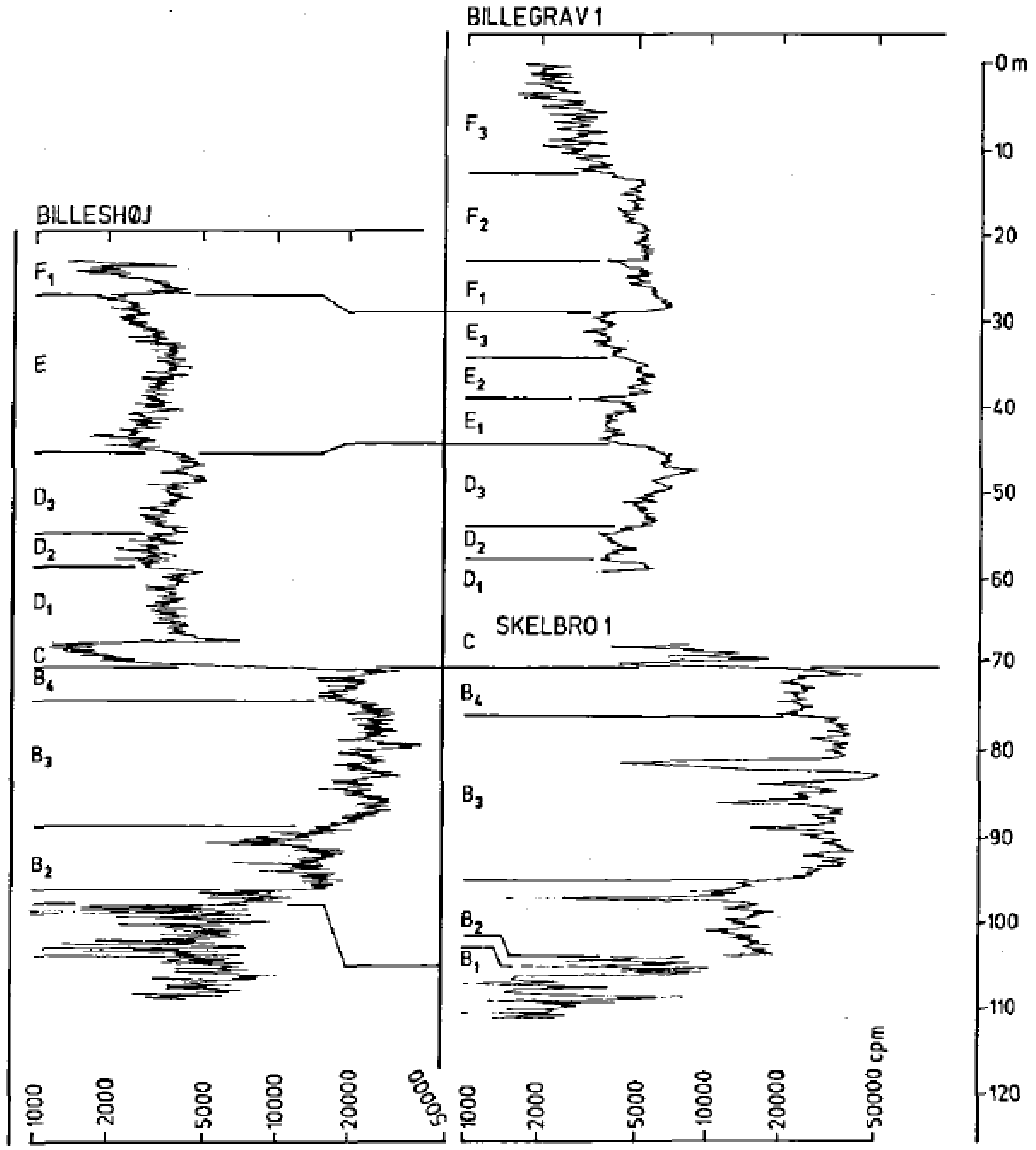

Figure 7. Example of correlation between the Billegrav-1 and Skelbro-1 wells and the uncored water well Billeshøj. The A-F refers to the log units. From Pedersen & Klitten (1990).

Below follows a brief description of the units, based on Pedersen (1989), Pedersen & Klitten (1990) and Nielsen & Schovsbo (2006). The biostratigraphy is inferred from Bjerreskov (1975), Koren & Bjerreskov (1997), Stouge & Nielsen (2003) and Nielsen & Schovsbo (2006).

Unit A: Rispebjerg Member and top of Norretorp Member, Læså Fm
Rispebjerg Member (3.7 m in Skelbro-1): Light grey medium to coarse grained quartz sandstone. The top part is impregnated with phosphorite.
The Norretorp Member is c. 100 m thick (Nielsen & Schovsbo 2006) and only the very top of the unit is penetrated by Skelbro-1 and Billegrav-2 wells. The upper part of the member is composed of fine silty sandstone partly heterolitic. The unit is extensively bioturbated.
TOC: No sample (0% TOC assumed).
Age: Early Cambrian. *Schmidtiellus mickwitzi* trilobite Zone.

Unit B: Alum Shale Formation (33 m in Skelbro-1)
The unit is characterized by gamma- readings much higher than all other units. The Alum Shale consists of black organic rich mudstone with beds and nodules of limestone. Barite and pyrite occur both as disseminated crystals and as nodules.

Unit B1: Exsulans Limestone and Lower Alum Shale (0.8 m in Skelbro-1)
The unit top is marked by low gamma values indicative of Andrarum Limestone. The B1 unit represent the Exsulans Limestone (0.2 m) and Alum Shale (0.6 m). The Exsulans Limestone is a primary bio-clastic carbonate bed.
TOC: 4% (one sample)
Age: Mid Cambrian (*P. paradoxissimus* to *P. forchhammeri* superzones).

Unit B2: Andrarum Limestone and Mid Cambrian to basal Furongian Alum Shale (9.4 m in Skelbro-1)
The log unit is bounded upwards by a sharp increase in gamma ray readings and the unit represents an interval in the Alum Shale characterised by intermediate gamma values. The unit contains in the Skelbro-1 well a diagenetic carbonate concretion (with low gamma readings) located about 3 m from the top of the unit. The concretion contains abundant olenid trilobites and represents the basal part of the Furongian. Concretions of similar age are also known from Scania (southern Sweden) and the concretion is informally termed the 'Olenus stinkstone'.
TOC: 5–8% (12 samples)
Age: Mid Cambrian (*P. forchhammeri*) to the lowermost Furongian (lower *Olenus* Zone).

Unit B3: Furongian Alum Shale (18 m in Skelbro-1)
An interval characterised by very high gamma values. Top of the interval is placed at the start of a stepwise decrease in GR values. The high fluctuation in GR values in some intervals in the unit reflects the presence of diagenetic carbonate nodules and beds. A very distinct spike in the gamma values occurs in the middle of the unit. A similar spike can be observed in numerous logged water wells on Bornholm and in logged wells in Scania. The high GR readings occur in a shale level that represents the Furongian *Peltura* Zones.
TOC: 8–14% (19 samples)
Age: Furongian (upper *Olenus* Zone – *Acerocare* Zone)

Unit B4: Ordovician Alum Shale (5 m in Skelbro-1)
An interval characterised by intermediate GR values. The interval is bound upwards by a very sharp drop in GR values reflecting the Komstad Limestone.
TOC: 4–9% (5 samples)
Age: Furongian (*Acerocare*) – Early Ordovician (Tremadocian)

Unit C: Early Mid Ordovician Komstad Limestone (0–3.9 m)
An interval characterised by very low GR readings reflecting the Komstad Limestone: The unit is a cold water carbonate that contains variable amounts of clay, phosphorite and glauconite.
TOC: 0% (no samples TOC assumed)
Age: Mid Ordovician (Dapingian)

Unit D: Dicellograptus Shale (> 7 m in Billegrav-1)
The unit is represented by grey to dark grey mudstone. It contains numerous bentonite beds in its lower part. The unit was not penetrated by Billegrav-1.

Unit D1: "Lower" Dicellograptus Shale (> 2 m in Billegrav-1)
The unit is characterized by high GR readings. The unit is composed by grey mudstone with abundant bentonite beds. The bentonites are easily recognized due to their high GR readings. The unit is bounded upwards by a local minimum in the GR values.
TOC: 0.5% (one sample)
Age: Late Ordovician (Caradoc), roughly corresponding to the *Dicellograptus foliaceus* Zone

Unit D2: "Middle" Dicellograptus Shale (5 m in the Billegrav-1 well)
The unit is characterized by high GR readings, and is composed of grey mudstone with few bentonite beds. The trace fossil *Chondrites* occurs frequently. The unit is bounded upward by a marked increase in GR values.
TOC: 0.1–1% (7 samples)
Age: Late Ordovician (Caradoc), roughly corresponding to the lower part of the *Dicranograptus clingani* Zone

Unit D3: "Upper Dicellograptus Shale" (9 m in the Billegrav-1 well)
The unit is characterized by high GR readings and is upward bound by an interval with very low GR values. The unit is composed by dark graptolitic mudstone with a few bentonite beds.
TOC: 0.1–5% (8 samples)
Age: Late Ordovician (Caradoc- Ashgill) roughly corresponding to the upper part of the *Dicranograptus clingani* Zone and the *Pleurograptus linearis* Zone.

Unit E: Lindegård Formation (25 m in the Billegrav-1 well)
The unit is characterized by moderate high GR readings, and is composed by green-grey mud and siltstones that usually are bioturbated. Sandstone beds and thin conglomeratic horizons occur.

E1: "Lower" Lindegård Fm (6 m in the Billegrav-1 well)
The unit is characterized by low GR reading. The top is marked by an interval of distinctive low GR values. The unit comprise grey mudstone intensely bioturbated in its top and base.
TOC: 0.1–0.4% (7 samples)
Age: Late Ordovician (Ashgill), *Tretaspis granulata* Zone

E2: ”Middle” Lindegård Fm (5 m in the Billegrav-1 well)
The unit is characterized by higher GR reading that the units above and below. The upper boundary is located at a low GR interval. The unit are composed of grey green siltstone.
TOC: 0.1–0.2% (5 samples)
Age: Late Ordovician (Ashgill), likely roughly corresponding to the *Staurocephalus clavifrons* Zone

E3: “Upper” Lindegård Fm (5 m in the Billegrav-1 well)
The unit is characterized by very low GR readings. It is composed by silty mudstone with occasional sandstones, partially conglomeratic. The sandstone beds are carbonate cemented with up to 25% carbonate.
TOC: 0.1–0.2% (4 samples)
Age: Late Ordovician (Hirnantian), likely roughly corresponding to the *Dalmanitina mucronata* Zone

Unit F: Rastrites Shale (> 27 m in the Billegrav-1 well)
The formation is characterized by low to medium high GR readings. The total thickness of the Rastrites Shale is estimated at 80 m in the Øle Å area (Bjerreskov 1975). Only the lower 29 m were penetrated by the Billegrav-1 well. The unit is composed by silty mudstones, occasionally with current generated sedimentary structures, and grey siltstone which contains calcite cemented sandy beds in some intervals. Dark grey to black intervals occur.

F1: Rastrites Shale (23–29.2 m)
The base of the unit is characterized by a very marked increase in GR reading. This base consists of approximately 1.5 m thick dark graptolitic mudstone with some silt beds. From here the GR values decreases and the top of the unit is placed at a local minimum in GR values.
TOC: 0.4–3% (7 samples)
Age: Late Ordovician (Hirnantian) to Early Silurian (Llandovery). *G. persculptus* to *A. ascensus graptolite* zones.

F2: Rastrites Shale (11 m in Billegrav-1)
The unit is characterized by intermediate high GR values. The top of the unit is defined at a plateau in GR values just below a low GR interval. The unit is characterized by grey siltstone with silty mudstone beds.
TOC: 0.5–1% (12 samples)
Age: Early Silurian (*M. acuminatus - vesiculosus* graptolite zones).

F3: Rastrites Shale (10 m in Billegrav-1)
The unit is characterized by low and variable GR values. The top of the unit is defined at a GR minimum just prior to a low GR interval. The unit consist of grey siltstone with abundant calcite cemented sandy beds. The interval has a cyclic appearance on the log that is caused by alternating cemented sandy beds (low GR values) with silty mudstone (high GR values).
TOC: 0.5–0.8% (10 samples)
Age: Early Silurian (*vesiculosus* graptolite Zone).

5. TOC and mineralogy in Skelbro-1 and Billegrav-1

5.1. TOC content in Skelbro-1 and Billegrav-1

The TOC content was measured with an equidistance of 1 metre between the samples in the Skelbro-1 and Billegrav-1 wells (see Buchardt et al. 1986). TOC measurements were carried out by combustion of acid treated carbonate-free samples in a LECO-type oven.

The data is included in Appendix A and the TOC content for each unit is summarised in Table 1.

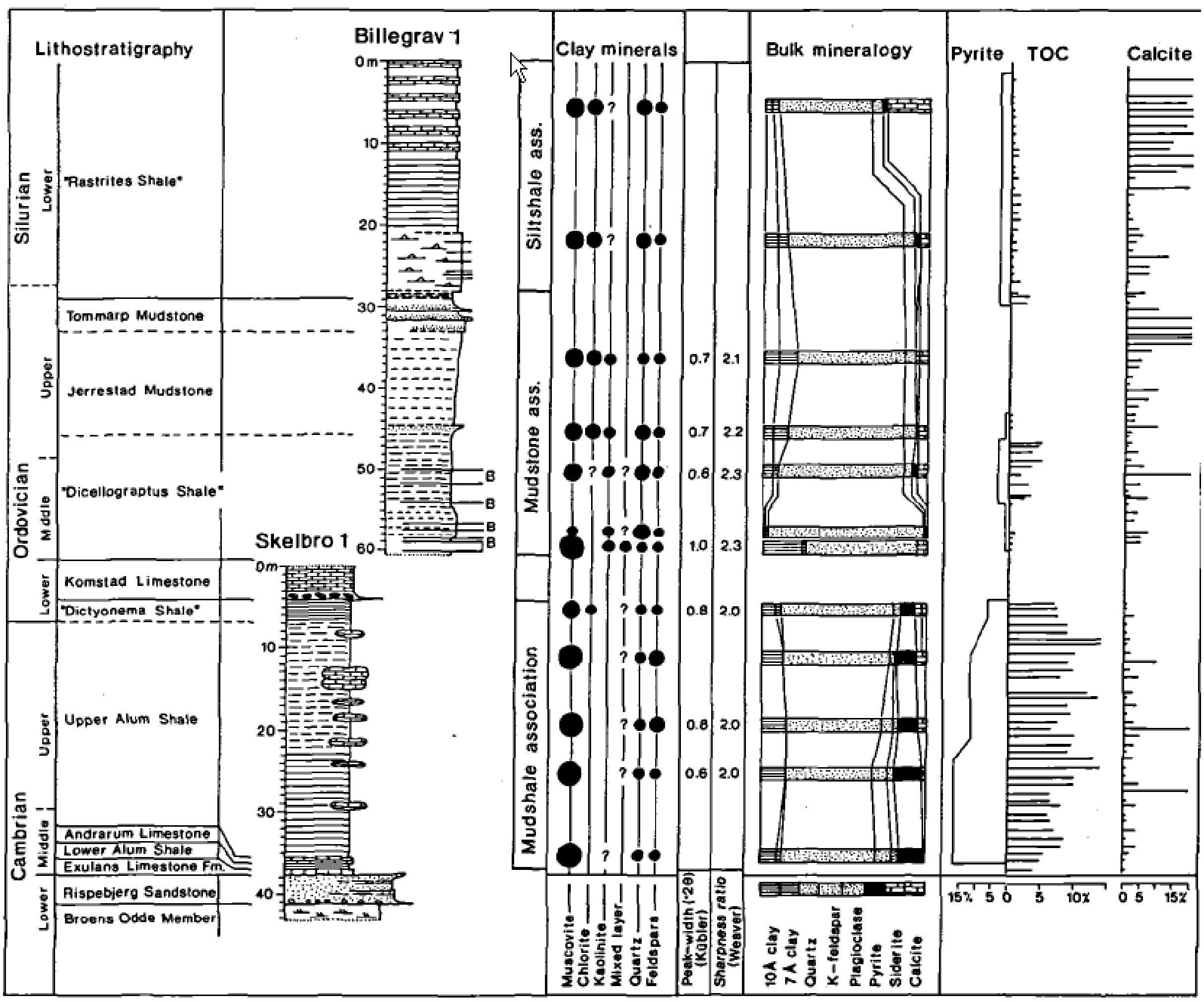

Figure 8. Mineralogy, TOC and carbonate content of Skelbro-1 and Billegrav-1 (Pedersen, 1989). The clay minerals were identified using XRD and the size of the black dots is proportional to the height of the peaks in the diffractograms. The bulk mineralogy was calculated from XRD-peak height in random oriented mounts. The TOC data is included in Appendix A and the TOC content for each log unit is summarised in Table 1.

Table 1. TOC contents and main lithology of units. Bold indicate TOC enriched units (>1% TOC).

Formation	Main Lithology	TOC %	Log unit	Thickness, m
Rastrites Shale	Grey siltstone with calcite cemented beds	0.5-0.8	F3	+12
Rastrites Shale	Grey siltstone	0.5-1	F2	11
Rastrites Shale	**Dark mudstone with silt streaks**	**0.4-3**	**F1**	**6.2**
Lindegård	Grey mudstone	0.1-0.2	E3	4.8
Lindegård	Grey-green mudstone	0.1-0.2	E2	5
Lindegård	Sandstone –siltstone	0.1-0.4	E1	6
Dicellograptus	**Black mudstone**	**0.1-5**	**D3**	**9**
Dicellograptus	Grey mudstone	0.1-1	D2	5
Dicellograptus	Grey mudstone with bentonite beds	0.5	D1	+2
Komstad	Limestone	0	C	3.9
Alum Shale	**Black mudstone**	**4-8**	**B4**	**4,9**
Alum Shale	**Black mudstone**	**8-14**	**B3**	**18.3**
Alum Shale	**Andrarum Limestone + Black mudstone**	**5-8**	**B2**	**9.3**
Alum Shale	**Exsulans Limestone + Black mudstone**	**4**	**B1**	**0.8**

The highest TOC concentrations are seen in the Alum Shale (Table 1) notably in the 18 m thick B3 unit. In this unit TOC ranges between 8-14%. The unit represent the Furongian (upper *Olenus* Zone to *Acerocare* Zone). A regional high TOC content in this part of the alum shale is well established (Buchardt et al. 1986, 1997), Schovsbo (2001, 2002).

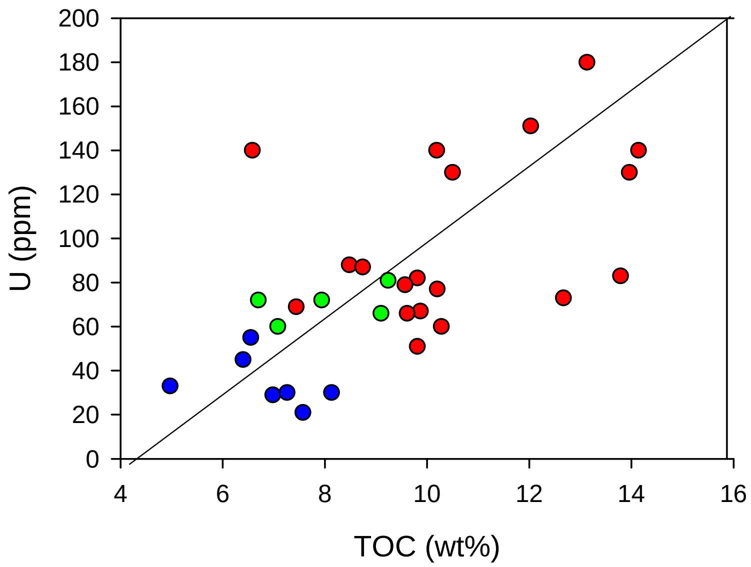

Figure 9. TOC content versus uranium concentrations in Alum Shale samples. Fill colour of circles indicate the log unit: blue, unit B2; red, unit B3; green, unit B4. The two parameters are positively correlated as indicate by the black line. Geochemical data is presented in Appendix A and B.

The organic carbon and uranium content are very closely associated in the Alum Shale (Figure 9). This suggests that organic richness might be calculated from the gamma ray log once proper calibrations have been calculated. Schovsbo (2002) showed that the U/TOC varied with stratigraphy. The ratio is about 6 in the Middle Cambrian and Lower Ordovician whereas the ratio increases in the Furongian part of the shale.

Apart for the Alum Shale, TOC enriched units occur in the 9 m thick upper Dicellograptus unit D3 and in the 5.5 m thick lower Rastrites unit F1. The c. 9 m thick Lower Silurian *M. convolutus* Zone, above the level penetrated by Billegrav-1, is also enriched in TOC (lower part of log unit F4 in Figure 11).

5.2. Mineralogy in Skelbro-1 and Billegrav-1

The clay mineralogy and bulk mineralogy were measured in 12 samples with a sample frequency of about one sample pr. 5 m of core. The clay mineralogy was identified by X-ray on oriented mounts on chemical pre-treated samples and the bulk mineralogy was calculated from the XRD-peak heights in random oriented mounts.

Pedersen (1989) indicated that the clay mineralogy and the bulk mineralogy varied systematically with stratigraphy (Figure 8). In the Alum Shale the dominant clay mineral is illite. Kaolinite and chlorite minerals do not occur in the Alum Shale. In the Ordovician and Silurian shales illite occurs together with kaolinite and chlorite (Figure 8).

<u>Unit B: Alum Shale bulk mineralogy</u>
The bulk mineralogy studies indicate that the Alum Shale contains about 50-65% quarts, 5-15% feldspar and 10-15% mica. The pyrite content is about 11% whereof most is finely disseminated. Macroscopic pyrite varies in amount and mode of occurrence from very thin (0.3-1 mm) streaks to nodules 0.5-1 cm in diameter. Barite crystals may also occur especially in the Upper Cambrian part of the succession.

Too few samples were analysed to enable a description of the bulk mineralogical variation within the log units. Judging from the 5 Alum Shale samples it appears that the B3 unit is slight more clay-rich relative to quarts in comparison with the other units. B4 appear most quarts rich. K- feldspar is only present in the B1-B2 units.

<u>Unit D: Dicellograptus bulk mineralogy</u>
Three Dicellograptus Shale samples were measured. They are all very quarts dominated and the lowermost sample in unit D1 almost consists exclusively of quarts. In the most TOC rich unit (D3) 70% quarts, 10% mica and 10% feldspar were measured.

<u>Unit E: Lindegård bulk mineralogy</u>
Only one sample were analysed for bulk mineralogy. It was fairly clay rich with >30% mica and 50% quarts. The upper unit (E3) had about 25% carbonate content (cement).

<u>Unit F: Rastrites Shale bulk mineralogy</u>
Two samples, one from F2 and one from F3, were measured for bulk mineralogy. The sample from the F2 unit had about 20% mica and about 60% quarts and low carbonate content. The F3 sample contained about 10% clay and 50% quarts. The carbonate value was 25% reflecting carbonate cement. High carbonate content was observed in all samples from this unit.

5.3. Major and trace elements Skelbro-1

Major and trace elements were measured in 13 bulk samples from the Skelbro-1. Measurements were determined on XRF apparatus at GEUS (major elements) and the Geological Institute, University of Copenhagen (trace elements). The analysis is presented in Appendix B and Excel tables are included on the enclosed CD.

The major element analysis of the Alum Shale indicates that the SiO_2/Al_2O_3 ratio is about 3.5 (Figure 10). Only one sample from unit B4 exhibits a very high SiO_2 content relative to Al_2O_3.

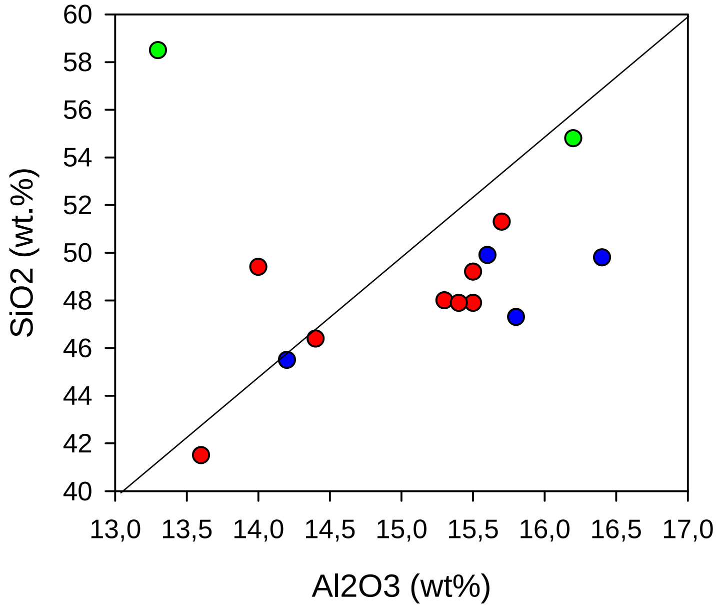

Figure 10. Al_2O_3 versus SiO_2 for Alum Shale samples in Skelbro-1. Fill colour of circles indicate the log unit: blue, unit B2; red, unit B3; green, unit B4. The two parameters are positively correlated as indicate by the black line. Geochemical data are presented in Appendix A and B.

6. Correlation to the Billegrav-2 well

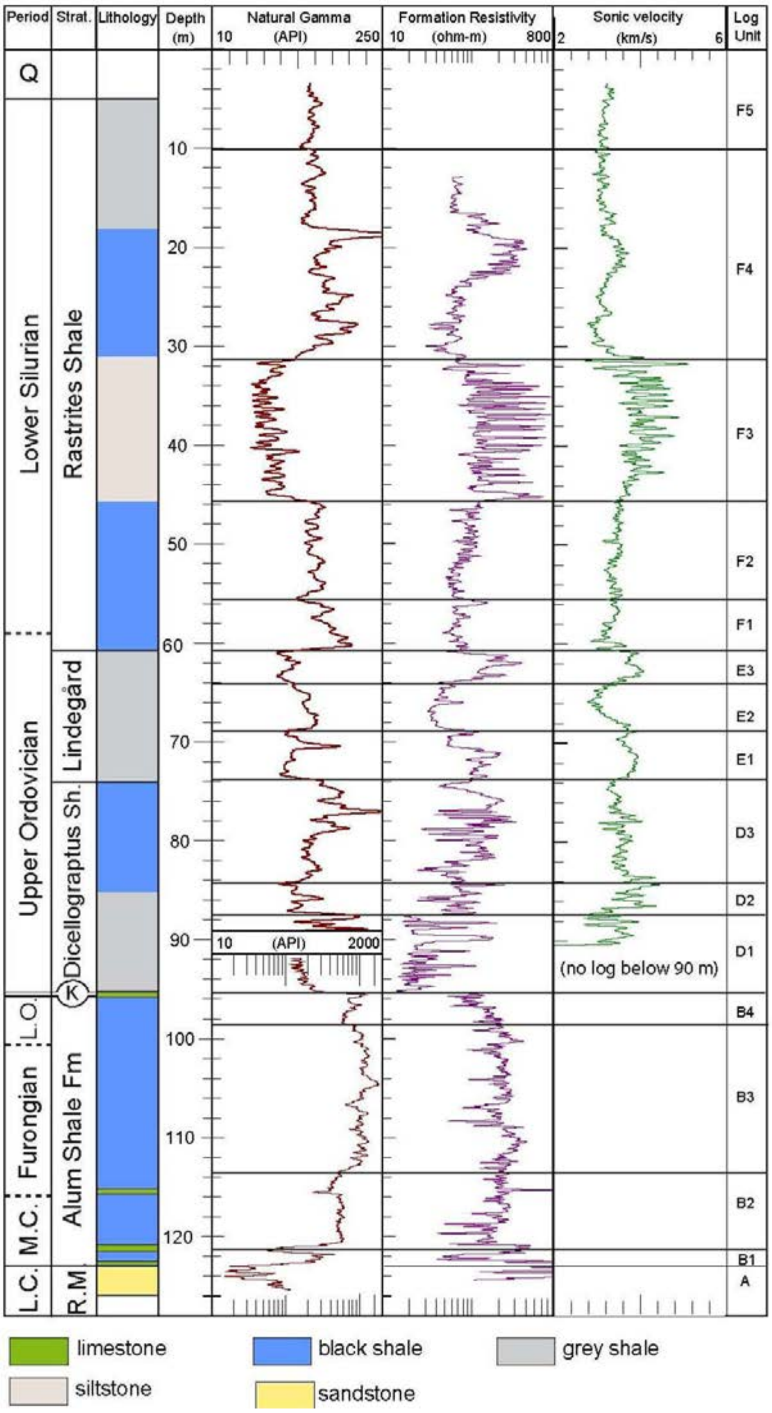

Figure 11. Lithologic and stratigraphic division of the Billegrav-2 well (from Schovsbo et al. 2011). Abbreviation: R.M.: Rispebjerg Mbr, K: Komstad Lmst, Q: Quaternary. Broken lines indicate uncertain chronostratigraphic boundaries. Log units are according to Pedersen & Klitten (1990).

The log stratigraphical units defined in Skelbro-1 and Billgrav-1 have all been identified in the Billegrav-2 well (Figure 11 and Table 2).

Table 2. Stratigraphic picks in Skelbro-1, Billegrav-1 and Billegrav-2.

Log unit	Lithostratigraphic Pick	Billegrav-1	Skelbro-1	Billegrav-2	Billegrav-2
		m, below surface	m, below surface	m, log depth below casing	core scan depth m, below surface
F5		not present		10.10	9.40
F4	Base Rastrites Unit F4	not present		31.50	31.30
F3	Base Rastrites Unit F3	12		45.70	45.20
F2		23		55.70	55.00
F1	Top Lindegård/Base Rastrites	29.2		61.10	60.80
E3		34		64.30	63.80
E2		39		69.10	68.80
E1	Top Dicellograptus/Base Lindegård	45		73.80	73.50
D3		54		84.50	84.20
D2		59		87.60	87.40
D1	Top Komstad/Base Dicellograptus	60.6 (TD)		95.30	94.90
C	Top Alum / Base Komstad		3.9	95.40	95.00
B4			8.8	98.50	98.10
B3			27	113.50	113.00
B2	Base Andrarum Lmst		36.4	121.30	120.70
B1	Top Læså Fm/ Base Alum Fm		37.2	123.00	122.40
A			43.2(TD)	126.30 (TD)	125.70

7. Maturity and burial history of Bornholm

Thermal maturity of the Alum Shale at Bornholm has been studied by Buchardt & Nielsen (1985), Buchardt et al. (1986, 1997, 1998), Buchardt & Lewan (1990) and Jensenius (1987). Thermal maturity parameters include stable isotopes, vitrinite reflectance, Rock Eval, atomic H/C and O/C ratios and fluid inclusions. Burial modelling of the Alum Shale in the Bornholm area has been published by Vejbæk et al. (1994) and a regional maturity map for the Alum Shale was presented by Buchardt et al. (1997, 1998).

7.1. Vitrinite Reflectance

The Alum Shale was deposited prior to the evolution of vascular land plants and thus the shale does not contain terrestrial derived vitrinite particles. Nevertheless the unit contains vitrinite like particles supposedly of marine origin. According to Buchardt & Lewan (1990) these particles behaves in a similar manner as true vitrinite. Consequently reflectance of vitrinite like particle has been widely used as a thermal marker in the shale. For detailed discussion of the origin and geochemical similarities between Alum Shale vitrinite and true vitrinite, see Buchardt & Lewan (1990).

Table 3. Summary of vitrinite reflectance data from the Skelbro-1 and Billegrav-1 wells.

Formation	Log Unit	Sample number	Depth. m	%Ro	STD %Ro	%Rmax	STD Rmax	%Rmin	STD Rmin	N
Alum Shale	B4	SKK 56	6.0			2.75	0.09	1.93	0.08	35
Alum Shale	B4	SKK 55	6.9	2.51	0.44					70
Alum Shale	B4	SKK 54	7.9	2.37						
Alum Shale	B3	SKK 52	9.7			2.66	0.12	1.98	0.06	27
Alum Shale	B3	SKK 48	13.6			2.91	0.08	1.96	0.08	22
Alum Shale	B3	SKK 45	16.9			2.94	0.1	2.09	0.08	29
Alum Shale	B3	SKK 44	17.9	2.14	0.42					70
Alum Shale	B3	SKK 41	20.2			2.88	0.08	2.15	0.09	21
Alum Shale	B3	SKK 38	23.2			2.92	0.09	1.99	0.09	33
Alum Shale	B3	SKK 35	26.2			2.89	0.14	2.09	0.11	22
Alum Shale	B2	SKK 34	27.1	2.31	0.41					70
Alum Shale	B2	SKK 31	30.1			2.77	0.15	2.04	0.09	21
Alum Shale	B2	SKK 25	35.7	2.36	0.27	2.84				52
Alum Shale	B1	SKK 24	38.2			2.88	0.13	1.71	0.15	38
Dicellograptus	E2	SKS 07	46.9	2.14	0.12					42
Rastrites	D2	SKS 27	28.5	2.50	0.38					45

Vitrinite reflectance measurements have been carried out on 14 samples from Skelbro-1 and 2 samples from Billegrav-1 (Table 3). All vitrinite reflectance analyses were measured at GEUS in the period 1980-1990. Measurements were conducted on polished slides of powdered whole rock (1-2 mm). Measurements were performed with non-polarized light at a wavelength of 546 nm through an immersion oil (n=1.52). The average of different vitrinite-like macerales in each slide is referred to as the mean reflectance and the abbreviation % Ro is used. In some cases measurements of oriented macerales was made. For these samples highest and lowest reflectance values was measured for the macerales and reported as Rmax and Rmin reflectance value. Rmax-Rmin measurements on samples were published by Buchardt et al. (1986). However it should be noted that in this publication Rmax values was reported erroneously as % Ro-values.

For the Alum Shale in Skelbro-1 the average is 2.34% Ro based on five measurements. For Billegrav-1 the two samples average to 2.32% Ro.

7.2. Rock Eval and atomic H/C ratio

Rock Eval data from the Skelbro-1 was published by Buchardt et al. (1986). The data was analyzed at GEUS on whole rock powder samples using a Delsi Rock Eval instrument. Results include extractable organic matter S1, pyrolysis yield S2 and temperature of maximal pyrolysis yields (Tmax). Calculated indices include the HI that represents the pyrolysis yield normalized to the TOC content.

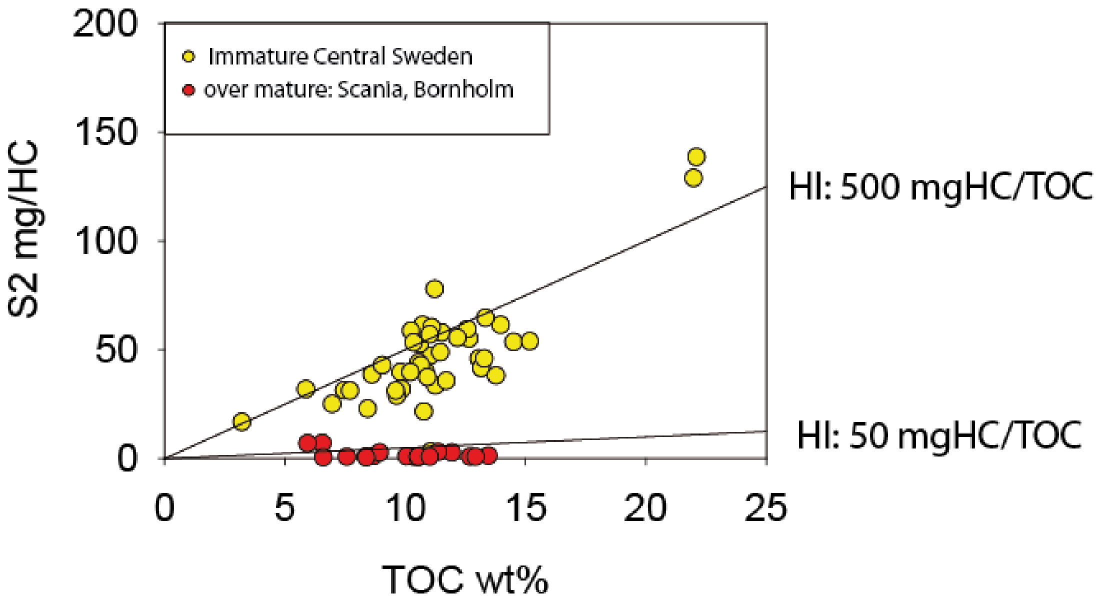

Figure 12. Comparison between Rock Eval S2 yields of immature (%Ro<0.5) and mature (%Ro>2) alum shale samples. Immature Alum Shale samples have pyrolysis yield between 400-600 mg HC/g TOC. At higher maturation the pyrolysis yield decreases to less than 50 mg HC/ g TOC. The S2 of the Bornholm samples are less than 10 mg HC/g TOC.

The pyrolysis yields of the S1, S2 and S3 are very low and thus the Rock Eval data from Skelbro-1 all indicates a very high thermal alteration (Table 4, Figure 12). Due to low yields no Tmax-value can be defined based on the S2 shape.

For comparison immature Alum Shale samples have S2 yield in the range of 30-80 mg HC /g and HI index values of about 400-500 mg HC/ g TOC (Figure 12).

No Rock Eval analysis was made for samples from Billegrav-1.

The atomic ratio was measured in 3 samples from Skelbro-1 (Table 4). The ratio ranges from 0.41 to 0.44, which is in agreement with the high maturation rank indicated by the vitrinite and Rock Eval data (Buchardt & Lewan 1990).

Table 4. Summary of Rock Eval and atomic H/C and O/C measurements from the Skelbro-1 well. The Tmax was not defined due to low S2 yields.

Formation	Log Unit	Sample number	atomic H/C	atomic O/C	TOC wt. %	S1. mg HC/g sample	S2. mg HC/g sample	S3. mg CO2/g sample	HI. mg HC/g TOC	OI. mg CO2/g TOC
Alum Shale	B4	SKK 56			7.6	0.05	0.31	0.21	4	3
Alum Shale	B4	SKK 55	0.44	0.04						
Alum Shale	B4	SKK 54			9.0					
Alum Shale	B3	SKK 52			11.1	0.03	0.24	0.05	2	0
Alum Shale	B3	SKK 48			10.6	0.03	0.41	0.02	4	0
Alum Shale	B3	SKK 45			13.0	0.05	0.30	0.00	2	0
Alum Shale	B3	SKK 44	0.42	0.04	9.6					
Alum Shale	B3	SKK 41			8.4	0.04	0.11	0.33	1	4
Alum Shale	B3	SKK 38			12.7	0.05	0.27	0.42	2	3
Alum Shale	B3	SKK 35			10.6	0.04	0.14	0.19	1	2
Alum Shale	B2	SKK 34	0.41	0.04	6.6					
Alum Shale	B2	SKK 31			6.6	0.04	0.01	0.19	0	3
Alum Shale	B2	SKK 25	0.46	0.06	5.0					

7.3. Fluid inclusions

Jensenius (1987) analyzed 3 samples from the Skelbro-1 well for fluid inclusions and one sample from Billegrav-1. The samples from Skelbro-1 were picked at 40.1 m (Rispebjerg Mbr), 3.3 m and 2.8 m (Komstad Limestone). A sample from 5.7 m in the Billegrav-1 (vein in Silurian shale) was analysed. Additional 4 outcrop samples were analyzed from Bornholm. Jensenius observed both aqueous and hydrocarbon inclusions in the samples.

Hydrocarbon and gaseous inclusions occurred in calcite veins cutting the Komstad Limestone. The inclusion fluoresced green-yellow during UV fluorescence microscopy. He found that that the hydrocarbons were slightly more enriched in higher hydrocarbon than wet gas.

Clathrate (gas hydrates) formation was observed in a few aqueous liquid-vapour inclusions in quartz veins from the Hardeberga sandstone. The analysis strongly indicated the presence of trace methane levels in the inclusions. Petrographic studies by Møller & Friis (1999) on analyses of outcrop samples of Hardeberga sandstone on Bornholm contained pyro-bitumen. Møller & Friis (1999) together with Jensenius assumed that the Alum Shale have sourced the hydrocarbons.

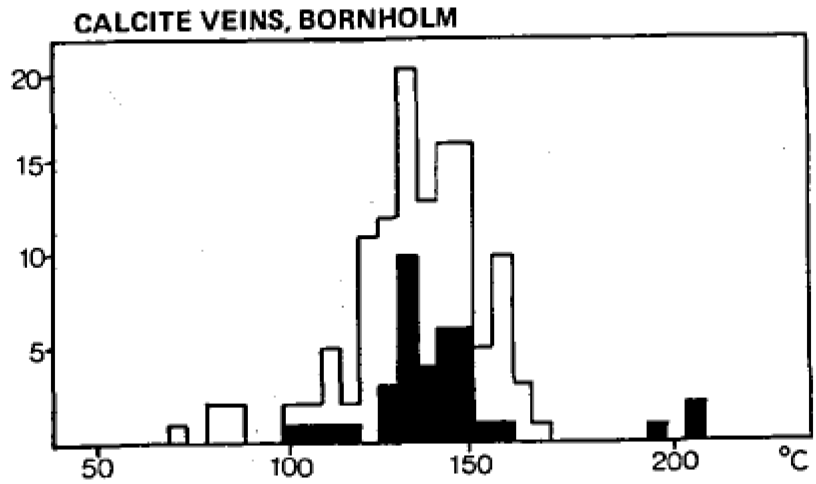

Figure 13. Homogenization temperatures for aqueous inclusions in calcite veins from Bornholm. All veins belong to the same 136 ^{o}C group of inclusions. From Jensenius (1987)

Studies of homogenization temperatures in the fluid inclusions indicate that the calcite veins at Bornholm were formed at 136 ^{o}C group (Figure 13). A few quartz veins belong to a 82 ^{o}C group. A general correlation suggests that salinity of inclusions decreases with increasing homogenization temperature, possible reflecting dilution of saline formation water with clay bound water released during smetite to illite transformation.

7.4. Burial History

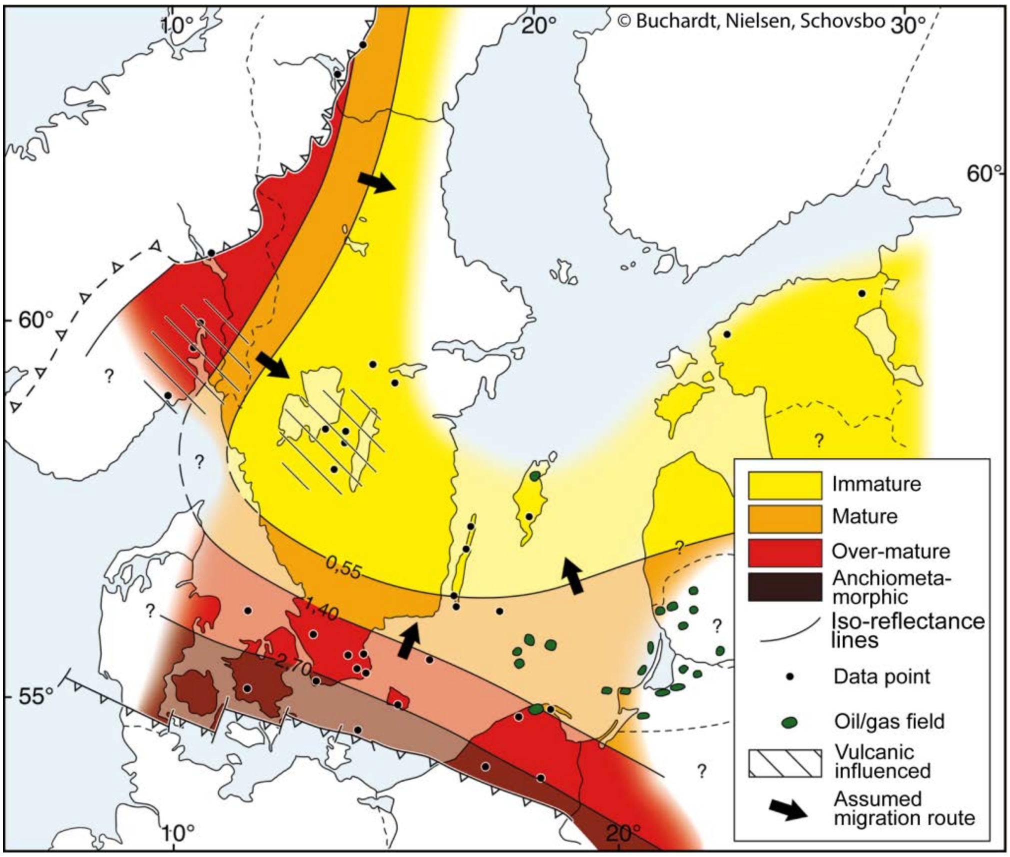

Figure 14. Maturity map of the Alum Shale formation based on vitrinite reflectance data. From Buchardt et al. (1997).

The burial history of the Bornholm area is very complex and involves several subsidence histories. It is generally assumed that the present day maturation pattern of the Lower Palaeozoic in the Bornholm area reflects the deep Caledonian burial and maturation. This part of the thermal maturation burial history in the Bornholm area has been discussed by Buchardt &Lewan (1990), Vejbæk et al. (1997) and Buchardt et al. (1997).

According to Buchardt et al. (1997) the Caledonian burial commenced in Late Silurian time where rapid subsidence led to deposition of at least 3 km of sediments. The increase in subsidence reflected the development of foreland basin in front on the German-Polish Caledonides. Based on oxygen isotope systematic of carbonate on Bornholm Buchardt & Nielsen (1985) concluded that Bornholm was heated to above 90^{o}C during this deep burial. They assume about 4 km of burial in the Bornholm-Scania area.

Vejbæk et al. (1994) conducted a series of burial and maturation modelling of the areas surrounding Bornholm. According to this model maturation to oil and gas stage was reached in Late Silurian time and with peak burial in the Early Devonian. About 3 km of Palaeozoic sediment was inferred from seismic mapping around Bornholm.

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9. Files included on CD

Attached to this report is a CD that contains the following:

1. In folder *Geochemical data* are Excel files with maturity, TOC and major & trace element analysis measured from Skelbro-1 and Billegrav-1. These data is also presented in Appendix A and B of the report
2. In folder *Literature* are pdf documents of the cited literature if the literature source is an open access source
3. In folder *table* are Excel files with the data presented in the report tables
4. A pdf version of this report *Completion report Billegrav-2 (DGU 248_61)_vol2*.pdf

Appendix A: Analysis of TOC in Skelbro-1 and Billegrav-1

TOC data Billegrav-1

Age	Stage	Zone	Formation	Log Unit	Sample	Depth	TOC
						m	wt.%
Silurian	Llandovery	vesiculosus	Rastrites	F3	SKS 54	1,98	0,68
Silurian	Llandovery	vesiculosus	Rastrites	F3	SKS 53	4,06	0,59
Silurian	Llandovery	vesiculosus	Rastrites	F3	SKS 52	4,8	0,62
Silurian	Llandovery	vesiculosus	Rastrites	F3	SKS 51	5,54	0,56
Silurian	Llandovery	vesiculosus	Rastrites	F3	SKS 50	6,28	0,71
Silurian	Llandovery	vesiculosus	Rastrites	F3	SKS 49	7,45	0,73
Silurian	Llandovery	vesiculosus	Rastrites	F3	SKS 48	8,45	0,71
Silurian	Llandovery	vesiculosus	Rastrites	F3	SKS 47	9,45	0,73
Silurian	Llandovery	vesiculosus	Rastrites	F3	SKS 46	10,23	0,79
Silurian	Llandovery	vesiculosus	Rastrites	F3	SKS 45	11,29	0,79
Silurian	Llandovery	vesiculosus	Rastrites	F2	SKS 44	12,65	0,54
Silurian	Llandovery	vesiculosus	Rastrites	F2	SKS 43	13,18	0,51
Silurian	Llandovery	vesiculosus	Rastrites	F2	SKS 42	14,04	1,17
Silurian	Llandovery	vesiculosus	Rastrites	F2	SKS 41	15,14	0,59
Silurian	Llandovery	vesiculosus	Rastrites	F2	SKS 40	16,05	1,52
Silurian	Llandovery	vesiculosus	Rastrites	F2	SKS 39	17,27	1,37
Silurian	Llandovery	vesiculosus	Rastrites	F2	SKS 38	18,16	0,92
Silurian	Llandovery	vesiculosus	Rastrites	F2	SKS 37	18,96	1,28
Silurian	Llandovery	acuminatus	Rastrites	F2	SKS 36	20,26	0,92
Silurian	Llandovery	acuminatus	Rastrites	F2	SKS 35	20,98	0,49
Silurian	Llandovery	acuminatus	Rastrites	F2	SKS 34	21,78	0,82
Silurian	Llandovery	ascensus	Rastrites	F2	SKS 33	22,88	1,11
Silurian	Llandovery	ascensus	Rastrites	F1	SKS 32	23,65	0,43
Silurian	Llandovery	ascensus	Rastrites	F1	SKS 31	24,9	0,66
Silurian	Llandovery	ascensus	Rastrites	F1	SKS 30	25,62	0,72
Silurian	Llandovery	ascensus	Rastrites	F1	SKS 29	26,63	1,37
Ordovician	Ashgill	persulptus	Rastrites	F1	SKS 28	28,03	1,11
Ordovician	Ashgill	persulptus	Rastrites	F1	SKS 27	28,48	2,83
Ordovician	Ashgill	persulptus	Rastrites	F1	SKS 26	29,2	2,67
Ordovician	Ashgill	extraordinarious	Lindegård Fm	E3	SKS 25	30,06	0,19
Ordovician	Ashgill	extraordinarious	Lindegård Fm	E3	SKS 24	31,15	0,19
Ordovician	Ashgill	extraordinarious	Lindegård Fm	E3	SKS 23	32,4	0,13
Ordovician	Ashgill	extraordinarious	Lindegård Fm	E3	SKS 22	33,2	0,23
Ordovician	Ashgill	extraordinarious	Lindegård Fm	E3	SKS 21	33,67	0,17
Ordovician	Ashgill	extraordinarious	Lindegård Fm	E2	SKS 20	34,37	0,22
Ordovician	Ashgill	extraordinarious	Lindegård Fm	E2	SKS 19	35,67	0,1

TOC data Billegrav-1 (continued)

Age	Stage	Zone	Formation	Log Unit	Sample	Depth	TOC
						m	wt.%
Ordovician	Ashgill	complanatus+ anceps	Lindegård Fm	E2	SKS 18	36,27	0,22
Ordovician	Ashgill	complanatus+ anceps	Lindegård Fm	E2	SKS 17	37,38	0,13
Ordovician	Ashgill	complanatus+ anceps	Lindegård Fm	E2	SKS 16	38,44	0,11
Ordovician	Ashgill	complanatus+ anceps	Lindegård Fm	E1	SKS 15	39,1	0,12
Ordovician	Ashgill	complanatus+ anceps	Lindegård Fm	E1	SKS 14	40,01	0,1
Ordovician	Ashgill	complanatus+ anceps	Lindegård Fm	E1	SKS 13	41,22	0,12
Ordovician	Ashgill	complanatus+ anceps	Lindegård Fm	E1	SKS 12	42,02	0,12
Ordovician	Ashgill	complanatus+ anceps	Lindegård Fm	E1	SKS 11	42,94	0,25
Ordovician	Ashgill	complanatus+ anceps	Lindegård Fm	E1	SKS 10	43,84	0,37
Ordovician	Ashgill	complanatus+ anceps	Lindegård Fm	E1	SKS 55	44,63	0,28
Ordovician	Ashgill	linearis	Dicellograptus	D3	SKS 9	45,17	0,15
Ordovician	Ashgill	linearis	Dicellograptus	D3	SKS 8	45,62	0,18
Ordovician	Caradoc	linearis	Dicellograptus	D3	SKS 56	46,32	4,97
Ordovician	Caradoc	linearis	Dicellograptus	D3	SKS 7	46,86	4,73
Ordovician	Caradoc	linearis	Dicellograptus	D3	SKS 6	47,66	3,25
Ordovician	Caradoc	linearis	Dicellograptus	D3	SKS 5	48,53	5,17
Ordovician	Caradoc	linearis	Dicellograptus	D3	SKO 25	49,58	3,19
Ordovician	Caradoc	linearis	Dicellograptus	D3	SKO 24	50,57	1,95
Ordovician	Caradoc	clingani	Dicellograptus	D3	SKO 23	51,48	3,12
Ordovician	Caradoc	clingani	Dicellograptus	D3	SKO 29	52,14	3,82
Ordovician	Caradoc	clingani	Dicellograptus	D3	SKO 22	52,95	3,49
Ordovician	Caradoc	clingani	Dicellograptus	D3	SKO 21	53,16	2,35
Ordovician	Caradoc	clingani	Dicellograptus	D2	SKO 20	54,1	0,76
Ordovician	Caradoc	foliaceus	Dicellograptus	D2	SKO 27	54,97	0,28
Ordovician	Caradoc	foliaceus	Dicellograptus	D2	SKO 19	55,92	0,13
Ordovician	Caradoc	foliaceus	Dicellograptus	D2	SKO 18	56,55	0,28
Ordovician	Caradoc	foliaceus	Dicellograptus	D2	SKO 17	57,45	0,98
Ordovician	Caradoc	foliaceus	Dicellograptus	D2	SKO 16	58,24	0,71
Ordovician	Caradoc	foliaceus	Dicellograptus	D2	SKO 15	58,96	0,52
Ordovician	Caradoc	foliaceus	Dicellograptus	D1	SKO 14	59,85	0,45

TOC data Skelbro-1

Age	Zone	Formation	Log Unit	Sample	Depth	TOC
					m	wt.%
Lower Ordovician	D2	Alum Shale	B4	SKO 13	4,42	6,7
Lower Ordovician	D1	Alum Shale	B4	SKO 12	5,00	7,94
Lower Ordovician	D1	Alum Shale	B4	SKK 56	5,96	7,08
Lower Ordovician	D1	Alum Shale	B4	SKK 55	6,94	9,24
Furongian (U Cambrian)	*Acerocare*	Alum Shale	B4	SKK 54	7,94	9,1
Furongian (U Cambrian)	*Peltura*	Alum Shale	B3	SKK 53	8,84	13,96
Furongian (U Cambrian)	*Peltura*	Alum Shale	B3	SKK 52	9,68	13,79
Furongian (U Cambrian)	*Peltura*	Alum Shale	B3	SKK 51	10,66	10,19
Furongian (U Cambrian)	*Peltura*	Alum Shale	B3	SKK 50	11,60	10,2
Furongian (U Cambrian)	*Peltura*	Alum Shale	B3	SKK 49	12,54	10,5
Furongian (U Cambrian)	*Peltura*	Alum Shale	B3	SKK 48	13,56	8,48
Furongian (U Cambrian)	*Peltura*	Alum Shale	B3	SKK 47	15,16	12,03
Furongian (U Cambrian)	*Peltura*	Alum Shale	B3	SKK 46	15,70	13,13
Furongian (U Cambrian)	*Leptoplastus*	Alum Shale	B3	SKK 45	16,92	9,87
Furongian (U Cambrian)	*Leptoplastus*	Alum Shale	B3	SKK 44	17,86	9,61
Furongian (U Cambrian)	*Parabolina spinulosa*	Alum Shale	B3	SKK 43	18,85	7,44
Furongian (U Cambrian)	*Parabolina spinulosa*	Alum Shale	B3	SKK 42	19,41	6,58
Furongian (U Cambrian)	*Parabolina spinulosa*	Alum Shale	B3	SKK 41	20,19	9,81
Furongian (U Cambrian)	*Parabolina spinulosa*	Alum Shale	B3	SKK 40	21,66	9,57
Furongian (U Cambrian)	*Olenus* (Upper)	Alum Shale	B3	SKK 39	22,36	8,74
Furongian (U Cambrian)	*Olenus* (Upper)	Alum Shale	B3	SKK 38	23,15	12,67
Furongian (U Cambrian)	*Olenus* (Upper)	Alum Shale	B3	SKK 37	24,40	14,14
Furongian (U Cambrian)	*Olenus* (Upper)	Alum Shale	B3	SKK 36	25,53	9,81
Furongian (U Cambrian)	*Olenus* (Upper)	Alum Shale	B3	SKK 35	26,24	10,28
Furongian (U Cambrian)	*Olenus* (Lower)	Alum Shale	B2	SKK 34	27,08	6,55
Furongian (U Cambrian)	*Olenus* (Lower)	Alum Shale	B2	SKK 33	28,32	6,45
Furongian (U Cambrian)	*Olenus* (Lower)	Alum Shale	B2	SKK 32	28,98	8,13
Furongian (U Cambrian)	*Olenus* (Lower)	Alum Shale	B2	SKK 31	30,09	6,4
Furongian (U Cambrian)	*Olenus* (Lower)	Alum Shale	B2	SKK 30	30,88	6,61
Middle Cambrian	*A pisiformis*	Alum Shale	B2	SKK 57	31,37	6,98
Middle Cambrian	*A pisiformis*	Alum Shale	B2	SKK 58	31,50	6,67
Middle Cambrian	*A pisiformis*	Alum Shale	B2	SKK 59	31,72	6,39
Middle Cambrian	*A pisiformis*	Alum Shale	B2	SKK 29	31,94	7,26
Middle Cambrian	*A pisiformis*	Alum Shale	B2	SKK 28	33,00	8,33
Middle Cambrian	*A pisiformis*	Alum Shale	B2	SKK 27	34,06	7,57
Middle Cambrian	*Lejopyge*	Alum Shale	B2	SKK 26	34,78	5,4
Middle Cambrian	*Lejopyge*	Alum Shale	B2	SKK 25	35,72	4,97
Middle Cambrian	*P. paradoxides*	Alum Shale	B1	SKK 24	36,70	3,92

Appendix B: Major and trace element data in Skelbro-1

Log Unit	sample	Depth	CO2	SiO2	Al2O3	CaO	MgO	Na2O	K2O	Fe2O3	P2O5	Mn2O3	TiO2	Sum
		m	wt.%	wt.%	wt.%	wt.%	wt.%	wt.%	wt.%	wt.%	wt.%	wt.%	wt.%	wt.%
B4	SKO 13	4,42	1,7	58,5	13,3	3	1,8	0	3,7	5,3	0,5	0,06	0,75	97,51
B4	SKK 55	6,94	0,5	54,8	16,2	0,9	1,7	0,1	4,8	5	0,1	0,04	0,89	96,87
B3	SKK 53	8,84	0,87	49,4	14	1,5	1,2	0,1	4,7	6,1	0,2	0,05	0,75	97,13
B3	SKK 51	10,66	0,5	51,3	15,7	1	1,2	0	5	6,1	0,2	0,04	0,84	96,67
B3	SKK 49	12,54	2,1	46,4	14,4	3,1	1	0	4,5	9,7	0,2	0,11	0,78	99,99
B3	SKK 46	15,70	0,1	48	15,3	0,4	1,1	0	5	8	0,2	0,02	0,81	98,36
B3	SKK 44	17,86	0,1	47,9	15,5	0,4	1,1	0	5	8,9	0,2	0,02	0,86	96,79
B3	SKK 42	19,41	0,9	47,9	15,4	1,5	1,1	0,1	4,8	8	0,2	0,05	0,84	93,77
B3	SKK 39	22,36	0,05	49,2	15,5	0,3	1,2	0	5,1	8,3	0,1	0,03	0,83	95,75
B3	SKK 37	24,40	0,3	41,5	13,6	0,8	1	0,1	4,4	13,5	0,2	0,03	0,78	101,05
B2	SKK 34	27,08	0,3	45,5	14,2	0,7	1,1	0,1	4,7	11,6	0,1	0,03	0,81	94,89
B2	SKK 31	30,09	0,27	49,9	15,6	0,6	1,5	0,2	4,9	10,6	0,1	0,04	0,9	98,71
B2	SKK 29	31,94	0,94	47,3	15,8	1,4	1,7	0,1	5	10,5	0,1	0,06	0,87	98,33
B2	SKK 25	35,72	0,1	49,8	16,4	0,3	1,7	0,2	5,5	11	0,1	0,03	0,91	98,41

Log Unit	sample	Depth	Ba	Cr	Nb	Rb	Sr	Th	U	Y	Zr
		m	ppm	ppm	Ppm	ppm	ppm	ppm	ppm	ppm	ppm
B4	SKO 13	4,42	450	200	30	190	40	14	72	20	130
B4	SKK 55	6,94	680	300	20	240	40	16	81	30	160
B3	SKK 53	8,84	840	200	20	220	50	10	130	50	130
B3	SKK 51	10,66	790	200	20	230	40	16	140	30	150
B3	SKK 49	12,54	1100	200	30	200	30	8	130	30	130
B3	SKK 46	15,70	770	200	20	240	30	12	180	40	160
B3	SKK 44	17,86	7440	200	20	240	80	14	66	30	150
B3	SKK 42	19,41	850	200	20	230	20	16	140	60	150
B3	SKK 39	22,36	880	200	40	250	20	14	87	40	160
B3	SKK 37	24,40	720	200	20	200	30	8	140	50	140
B2	SKK 34	27,08	820	200	30	240	30	10	55	30	150
B2	SKK 31	30,09	820	200	30	230	30	12	45	40	170
B2	SKK 29	31,94	840	100	20	250	50	10	30	10	170
B2	SKK 25	35,72	710	200	30	280	40	8	33	40	180