

# Preliminary report on the Jurassic lithostratigraphic nomenclature in the Danish North Sea area

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A lithostratigraphical subdivision of the Jurassic sequence in the Norwegian-Danish Basin is proposed. The outlined stratigraphy is the preliminary result of the work within the Danish subcommittee for Jurassic lithostratigraphy in the North Sea. The Fjerritslev Formation and the Haldager Formation are used in accordance with the original description, but it is proposed that the former is subdivided into three members. It is proposed that the Børglum Formation and the Frederikshavn Formation are treated as members and included in a new formation.

A short review is given of the Jurassic sedimentary sequence in the Central Trough.

In August 1975 the Geological Survey of Denmark was asked by the Norwegian Petroleum Directorate to co-operate in a committee for the creation of a lithostratigraphic nomenclature in the northern part of the North Sea. Co-operation was established between England and Norway. The purpose was to establish a uniform lithostratigraphic nomenclature of the sedimentary sequences found during the last years' exploratory work in the North Sea.

A lithostratigraphic nomenclature for the southern part of the North Sea was published by Rhys (1974).

The work is carried out at national level. As in Norway, four subcommittees were set up in Denmark: a Tertiary, Cretaceous, Jurassic, and pre-Jurassic subcommittee. The Danish subcommittee on Jurassic lithostratigraphic nomenclature has the following members: Inger Bang, Finn Bertelsen, Arne Buch, and Olaf Michelsen (chairman).

The present article may be regarded as a preliminary report on the Jurassic sequence in the Norwegian-Danish Basin. For the Norwegian offshore, corresponding reports were published by Younge *et al.* (1975) and Myrland (1976). In the present article the main features of the subdivision

will be outlined on the basis of the analyses given by Larsen (1966) and Michelsen (1975), corrected for data derived from the recent onshore and offshore borings.

In this article the Jurassic sequence is represented by the Dansk Nordsø J-1 boring situated centrally in the Norwegian-Danish Basin (figs. 1 and 2). This section is used preliminarily as a reference section. Type sections for the previously published formations are to be found in Larsen (1966).

A detailed description of the lithostratigraphic units and a definition of the new ones will be included in a paper in preparation. A corresponding paper on other parts of the Danish North Sea area, the Central Trough, is also being prepared.

## The Norwegian-Danish Basin

The following subdivision of the Jurassic sequence is proposed:

### Group C

#### Formation X

Frederikshavn Member

Børglum Member

#### Haldager Formation

### Group B

#### Fjerritslev Formation

Member III

Member II

Member I

#### Gassum Formation

#### Vinding Formation

The Vinding Formation is Triassic and the Gassum formation is predominantly Triassic (Larsen 1966, Michelsen 1975) and will be described by the subcommittee for pre-Jurassic lithostratigraphic nomenclature.

The Jurassic sequence was interpreted by Larsen (1964) as comprising two sedimentary cycles: the sandy Rhaetic and the clayey Liassic deposits as the 1st cycle; the sandy Dogger and the clayey Malm as the 2nd cycle. The two groups mentioned above correspond to the two cycles.

### *Fjerritslev Formation*

(Larsen 1966)

*Derivation of the name:* From the name of the type section.

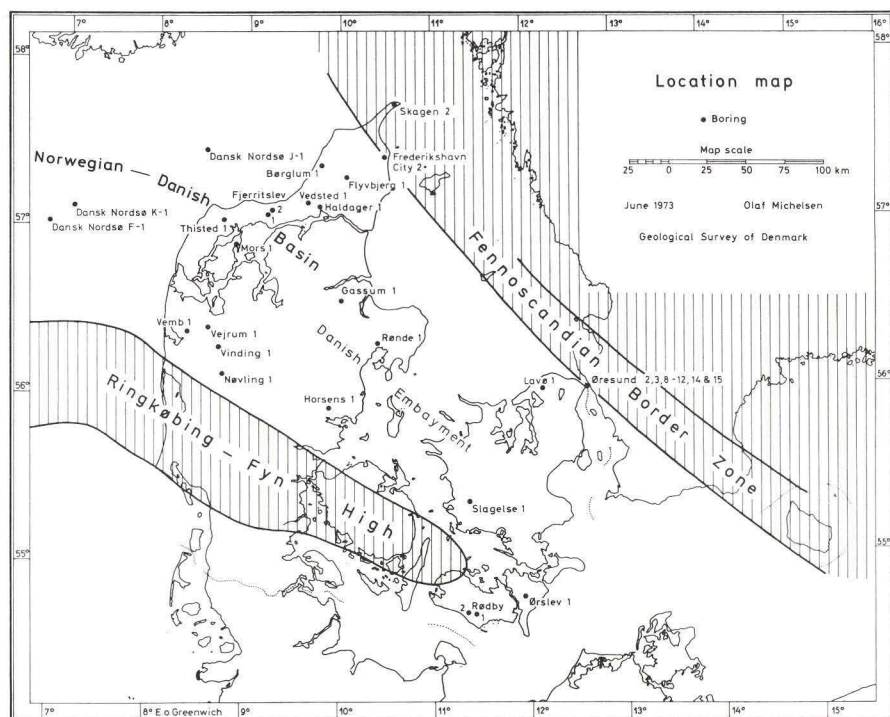


Fig. 1

*Type section:* The Fjerritslev No. 2 boring, 1315–2295 m below M.S.L.

*Lithology:* Marine claystone or shale, with varying silt content, dark grey to black (rarely brownish or greenish), slightly calcareous. Few intercalations of siltstone or fine-grained sandstone. Clay-ironstone concretions are common.

*Remarks:* In the type section the upper boundary of the formation is placed between a claystone series and the overlying sandstone series (the Haldager Formation). A corresponding transition zone is seen in the Dansk Nordsø J-1 boring (fig. 2). The boundary is defined on the Spontaneous Potential and the Resistivity logs. A complementary definition may be based on the Gamma Ray and the Interval Transit Time logs in the Dansk Nordsø J-1 boring.

The lower boundary is not defined by petrophysical measurements in the type section. It is therefore proposed that this boundary (the boundary between the Gassum Formation and the Fjerritslev Formation) be defined

in the Dansk Nordsø J-1 boring on the basis of the Gamma Ray and the Interval Transit Time logs. The lower boundary in the Vedsted No. 1, Flyvbjerg No. 1, and Børglum No. 1 borings is not correlatable as originally described (see Michelsen 1975, pp. 48, 50, and 53, pl. 42). A probable intercalation between the Gassum Formation and the Fjerritslev Formation make a re-investigation and a re-description necessary.

*Occurrence:* Originally the formation was described as occurring in the entire Danish Embayment. However, its occurrence in the southeastern part has been stated as questionable (Michelsen 1975, p. 78). As only few borings have been drilled to the south, only the northwestern part of the basin will be dealt with here.

The formation occurs throughout this part of the basin, but it is developed in two different ways. To the northeast it can be subdivided into three parts with a middle more silty series, and an overlying and an underlying series with frequent occurrence of silt/sandstone intercalations uppermost and lowermost in the formation. To the southwest the formation is uniformly developed throughout, as seen in the Dansk Nordsø F-1, Dansk Nordsø K-1, and Nøvling No. 1 borings (cf. Michelsen 1975, figs. 13, 14, 18).

The maximum thickness found in borings, 980 m, was recorded in the type section.

*Geological age:* Lower Jurassic (Michelsen 1975).

*Subdivision:* Subdivision into three subunits is proposed: members I, II, and III.

#### *Member I*

(New member)

*Lithology:* Shale and claystone, dark grey, non-calcareous to slightly calcareous. Subordinate beds of siltstone, light grey, strongly calcareous.

*Remarks:* This member can be distinguished as a shale series with thin beds of siltstone in the lower part. The upper and lower boundaries can be defined on the Gamma Ray and the Interval Transit Time logs (cf. fig. 2).

In the middle of the member there is a distinct sand/siltstone bed (fig. 2) which may prove to be important for correlation.



*Occurrence:* This member probably occurs in all sections northeast of the Dansk Nordsø J-1 and Mors No. 1 borings. A typical appearance is seen in the Dansk Nordsø J-1, Fjerritslev No. 2, and Vedsted No. 1 borings.

The thickness in the Fjerritslev No. 2 boring is 450 m.

*Geological age:* Hettangian and Sinemurian (Michelsen 1975).

### *Member II*

(New member)

*Lithology:* Claystone, silty, dark grey, grey, brownish grey, slightly calcareous, with pyrite. Subordinate layers of siltstone, coarse-grained, light grey, calcareous.

*Remarks:* This member is clearly recognized by means of the Gamma Ray and the Interval Transit Time logs as a more silty part of the Fjerritslev Formation (fig. 2).

*Occurrence:* On the basis of correlations, it may be found in the borings containing Member I. A typical development of the member is seen in the Dansk Nordsø J-1, Fjerritslev No. 2, Mors No. 1, Børghlum No. 1, and Vedsted No. 1 borings.

The thickness in the Fjerritslev No. 2 boring is 180 m.

*Geological age:* Lower Pliensbachian and lower Upper Pliensbachian (Michelsen 1975). It is assumed to be contemporaneous with the Swedish Kattlösa Formation.

### *Member III*

(New member)

*Lithology:* Claystone (shaly). grey or greenish grey, non-calcareous; and claystone, silty, grey to dark grey, slightly calcareous; with beds of light sandstone in the upper part.

*Remarks:* This member is characterized by shaly claystone, often greenish. Subordinate occurrence of sandstone beds uppermost and lowermost seems typical (cf. fig. 2).

Definition of the boundaries of the member may be based on the Gamma Ray and the Interval Transit Time logs in the Dansk Nordsø J-1 boring.

*Occurrence:* The member may be distinguished in all sections containing Members I and II. Characteristic log features are found in the Dansk Nordsø J-1, Fjerritslev No. 2, Flyvbjerg No. 1, Børglum No. 1, and Vedsted No. 1 borings.

The thickness in the Fjerritslev No. 2 boring is 350 m.

*Geological age:* Upper Upper Pliensbachian and Toarcian-Aalenian (Michelsen 1975).

### *Haldager Formation*

(Larsen 1966)

*Derivation of the name:* After the name of the type section.

*Type section:* The Haldager No. 1 boring. 1076–1401 m below M.S.L.

*Lithology:* A deltaic deposit of sand and sandstone, fine- to coarse-grained, subordinate occurrence of gravel, whitish to light grey, with subordinate beds of clay (light grey to dark grey, silty, and with mica), with coal. Marine claystone may occur uppermost and lowermost.

*Remarks:* This formation is distinguished by means of the petrophysical measurements. However, the lower boundary in the type section is not developed in a typical way inasmuch as the underlying Fjerritslev Formation may be reduced and is not correlatable with the Fjerritslev No. 2 section.

*Occurrence:* The formation is found throughout the basin. The maximum thickness, 325 m, is recorded in the type section, and the minimum thickness in the central part of the basin.

*Geological age:* Mainly Middle Jurassic.

*Subdivision:* Is not yet subdivided.

*Formation X*

(New formation)

*Lithology:* Marine deposits of claystone and shale, (dark) greenish grey, often silty, with clay-ironstone concretions. Marginally in the basin the upper part of the formation consists of siltstone or fine-grained sandstone, greenish grey or whitish, with glauconite and mica.

*Remarks:* Larsen (1966) established two Upper Jurassic formations which below are described as members: the Børglum Formation and the Frederikshavn Formation. As the two units were described mainly from marginal parts of the basin they were clearly separated and easily recognizable by means of petrophysical measurements.

Regarding the new borings more centrally in the basin it is obvious that such a subdivision is difficult to work with. The Børglum Member *s.str.* may be recognized by means of the Gamma Ray and the Interval Transit Time logs, whereas the upper part of the Upper Jurassic series corresponding to the Frederikshavn Member is difficult to classify (cf. fig. 2). The latter part is a more or less silty claystone series which cannot be a true part of the Børglum Member. Furthermore, final conclusions cannot yet be given on the overlying claystone series which is questionably determined to Upper Jurassic (fig. 2). Another problem is that in certain sections, the Haldager No. 1 and Børglum No. 1 borings, the Frederikshavn Member consists of two parts: a lower arenaceous and an upper argillaceous subunit. More studies on the upper part of the Jurassic series are necessary for establishing a new lithostratigraphy.

It seems reasonable to lower the rank of the two formations to members and to include them in a new formation.

Definition and description of this formation can probably be based on the Dansk Nordsø J-1 section, including the Gamma Ray and the Interval Transit Time logs. Correlation with older borings such as Børglum No. 1 and Haldager No. 1 can be made by the Gamma Ray and the Resistivity logs.

Definition and correlation of the upper boundary present some problems. Centrally in the basin (see fig. 2) the petrophysical measurements show a gentle development from the clayey Børglum Member through the more silty "Frederikshavn Member" to the overlying clayey sequence. Preliminarily it is proposed that the upper boundary of Formation X be placed at the top of the silty unit.

The lower boundary is easily determined by the top of the Haldager Formation.

*Occurrence:* The formation seems to occur throughout the basin (see also Christensen 1974, fig. 5).

The maximum thickness, 253 m, is recorded in the Børglum No. 1 boring.

*Geological age:* Upper Jurassic (Sorgenfrei & Buch 1964, Christensen 1974).

*Børglum Member*  
(Larsen 1966)

*Derivation of the name:* From the name of the type section.

*Type section:* The Børglum No. 1 boring. 911–990 m below M.S.L.

*Lithology:* Marine claystone or shale, dark grey to light greenish grey. In places there are brownish red and greenish grey horizons. With clay-ironstone concretions.

*Remarks:* Marginally in the basin, where this series is overlain by the Frederikshavn Member, it is distinctly recognizable by means of petrophysical measurements, as it is situated between two arenaceous sequences.

For the central part of the basin a preliminary demarcation is shown in fig. 2. The upper boundary is placed at a slight increase in the silt content.

The lower boundary coincides with lower boundary of the formation.

*Occurrence:* The member is found in the entire basin (see Larsen 1966 and Christensen 1974, fig. 5), but not in the Horsens No. 1 boring (Christensen 1971).

*Geological age:* Oxfordian in the type section (Sorgenfrei & Buch 1964). Elsewhere Oxfordian to Portlandian (Christensen 1974).

*Frederikshavn Member*  
(Larsen 1966)

*Derivation of the name:* From the name of the type section.



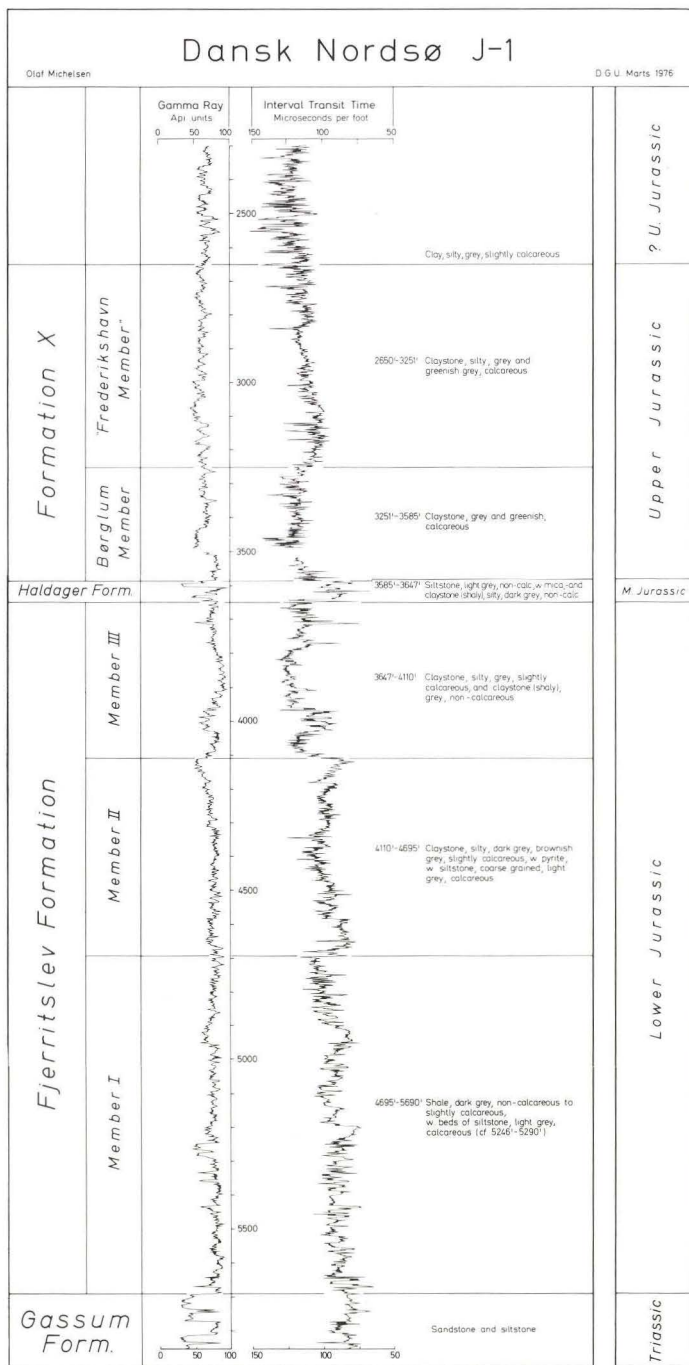


Fig. 2.

*Type section:* The Frederikshavn City No. 1 boring, 569–627 m below M.S.L.

*Lithology:* Marine sandstone, fine-grained, in places with cross-bedding; and siltstone, greenish grey or whitish, with glauconite and mica, in places with thin beds of limestone, and subordinate beds of claystone. The deposit contains marine fossils.

*Remarks:* The member is easily recognizable as defined by Larsen (1966). However, in certain borings, Haldager No. 1 and Børglum No. 1, the petrophysical measurements show a subdivision so that the upper part of the member includes an argillaceous subunit. Further interpretation is necessary for a final conclusion.

Another problem is an identification and definition of the upper silty part of the formation centrally in the basin (see fig. 2). The silty part is preliminarily regarded as contemporaneous with the marginal deposit in the present member.

*Occurrence:* The Frederikshavn Member *s.str.* occurs along the north-eastern border of the basin, reaching to the Vedsted No. 1, Haldager No. 1, Gassum No. 1, and Rønde No. 1 borings to the southwest.

*Geological age:* Kimmeridgian to Portlandian in the Børglum and Haldager borings (Sorgenfrei & Buch 1964, see also Christensen 1974).

## Central Trough

The thickness of the Jurassic sequence in the Central Trough is found to be very large. As details of only a few of the borings in the Jurassic sediments have been released for publication, only a short outline of the series will be given below. More detailed descriptions and drawings of the lithology are given in Rasmussen (1974 and 1976) and Michelsen (1976). A formal subdivision has not yet been worked out.

Overlying non-marine Triassic sediments are found Lower Jurassic marine shales representing the lowermost stages. These are overlain by Middle Jurassic sandstone and siltstone with coal beds. These two sedimentary sequences can easily be recognized by means of petrophysical measurements and may be regarded as units at formational level.

The Upper Jurassic sequence, which exceeds 1000 m in thickness, is a shale/claystone series. It may be subdivided into two or more units at

formational level. Especially characteristic is a thick, upper claystone series with numerous thin "limestone layers" (recognized by means of petrophysical measurements). This latter series is found to be of Kimmeridgian age. As can be seen from the Dansk Nordsø E-1 and G-1 borings this series shows very characteristic features on the Gamma Ray and Interval Transit Time logs.

## Dansk sammendrag

På grundlag af igangværende arbejde med den lithostratigrafiske nomenklatur indenfor den nordlige del af Nordsøen gives der i nærværende artikel en kortfattet og foreløbig oversigt over jura-aflejringerne i det Norsk-Danske Basin og i Central Trough. Den foreslåede inddeling af lagserien i førstnævnte område er baseret på beskrivelser publiceret af Larsen (1966) og på kendskabet til de nyere boringer.

Inddelingen i de to grupper, Group B og Group C, er i overensstemmelse med den cykliske udvikling indenfor aflejringerne (se Larsen 1966).

Den nedre jurassiske Fjerritslev Formation foreslås opdelt i tre underenheder: Member I, Member II og Member III.

Den mellem jurassiske Haldager Formation behandles i overensstemmelse med Larsen (1966).

De øvre jurassiske aflejringer foreslås indordnet under én ny formation. De to eksisterende formationer, Børglum Formationen og Fredrikshavn Formationen, underordnes denne nye formation som members.

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