The Lower Jurassic of the Dansk Nordsø 0–1 boring, Central Trough

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The first Lower Jurassic series from the Danish part of the Central Trough is described. The biostratigraphic analyses based on the ostracod faunas refer the series to lower Upper Sinemurian, Lower Sinemurian, and Hettangian. Lithostratigraphically the series is compared with the Fjerritslev Formation in the Danish Subbasin.

Only a few lower Jurassic sequences from the central North Sea have been published (Rhys 1974, Michelsen 1976, Deegan & Scull 1977). The series from the Dansk Nordsø 0–1 boring is the first to be published of a few series known from the Danish part of the Central Trough. Since it is the only sequence released for publication, the present paper will primarily deal with the biostratigraphical identification of the Lower Jurassic sequence. The lithology and lithostratigraphy will only be treated briefly. When further borings are released a more thorough study of the lithostratigraphy, depositional environment, and basinal analysis will be described.

The Dansk Nordsø 0–1 boring is located in the southeastern margin of the Danish Central Trough which is a block faulted structural feature. The Jurassic series is relatively thin partly due to the occurrence of a Triassic structure (probably a Keuper salt structure) and partly due to Kimmerian movements (see fig. 2). To the northwest the Jurassic is more than 3000 m, near the Dansk Nordsø E-1 and H-1 borings. It seems mainly to be the Upper Jurassic Kimmeridge Clay which is thinner in the 0–1 boring. Furthermore, in this boring there is a large unconformity at the base of the Middle Jurassic.

The Dansk Nordsø 0–1 was drilled in the period 1972–10–09 to 1973–01–13, ca. 17 km southeast of the Dan Field, on the position 55°22′ 01.8″N and 05°19′ 19.4″E. The elevation of the kelly bushing was 92′ (28 m).

In the present paper the depths given in metres indicate the depth below sea level, and the depths in feet the depth below kelly bushing. Depth figures in feet are only used when referring to cuttings samples since this is the original labelling.

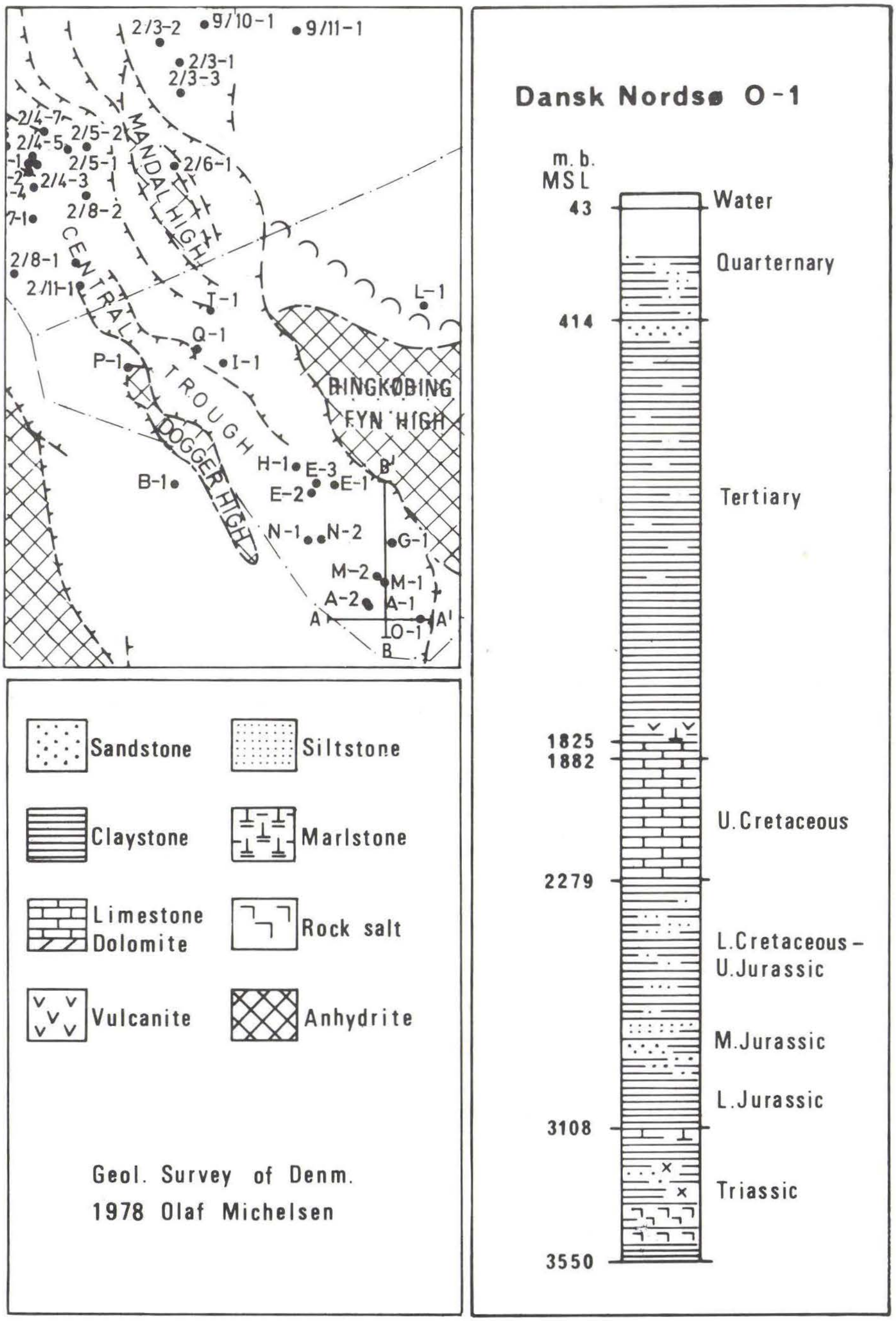
2/3-2
9/10-1
9/11-1
2/3-1
2/3-3
2/4-7
2/4-5
2/5-2
2/5-1
2/6-1
2/4-3
2/8-2
MANDAL HIGH
CENTRAL TROUGH
2/8-1
2/11-1
T-1
L-1
Q-1
I-1
P-1
RINGKØBING FYN HIGH
DOGGER HIGH
B-1
H-1
E-3
E-1
E-2
B'
N-1
N-2
G-1
M-2
M-1
A-2
A-1
A
A'
O-1
B
Sandstone
Siltstone
Claystone
Marlstone
Limestone Dolomite
Rock salt
Vulcanite
Anhydrite
Geol. Survey of Denm.
1978 Olaf Michelsen
Dansk Nordsø O-1
m. b. MSL
43
414
1825
1882
2279
3108
3550
Water
Quarternary
Tertiary
U.Cretaceous
L.Cretaceous - U.Jurassic
M.Jurassic
L.Jurassic
Triassic

Fig. 1.

Lithostratigraphy and lithology

For description of the sediments cuttings samples taken at 10 feet interval are used. The characterizing and subdivision of the series are based on this description and on interpretation of petrophysical measurements such as gamma ray, interval transit time, neutron porosity, density, and dipmeter logs as described by Priisholm & Michelsen 1978.

Stratigraphically situated below the Kimmeridgian and Oxfordian series, known from other borings such as Dansk Nordsø E-1 and G-1 (see Rasmussen 1978), is found the following succession:

2731–2843 m	Claystone, grey to brownish grey, and silt/sandstone, often yellowish grey, with intercalations of coal beds.
2843–2968 m	A variegated series of interbedded claystone and silt/sandstone.
2968–3107 m	Claystone, shaly, dark grey to greyish black, slightly calcareous, with pyrite and megafossils. In the lower part occurs brownish grey claystone. 3028–3107 m: With thin marlstone beds and slightly silty beds.
Below 3107 m	Claystone (at deeper levels reddish brown), limestone, marlstone, and deeper in the sequence anhydrite.

This succession is comparable with known series in the Danish Subbasin. The mainly arenaceous series with coal beds has been roughly determined to Middle Jurassic by preliminary palynological investigations (Finn Bertelsen, pers. comm.). No foraminifera or ostracods are known with certainty from this series. The underlying dark grey claystone series (2968–3107 m) is stated below to be of Lower Jurassic age. The series below 3107 m has been proved to be of Triassic age by studies of the palynology and the ostracod faunas (Finn Bertelsen and the present author).

The Lower Jurassic series, 2968–3107 m, is known from other borings not yet released for publication. It is a distinct formation which can easily be recognized from boring to boring. It is characterized by relatively uniform gamma ray and interval transit time curves (fig. 3). Taken together with neutron porosity and density curves it is demonstrated as an almost clean clay formation. The dipmeter measurements show the formation as uniformly bedded and with a higher structural dip than the formations above.

Mainly on the basis of the petrophysical measurements the formation can be subdivided into two members: Member A, 3028–3107 m, and member B, 2968–3028 m. Member A shows upwardly decreasing gamma ray and interval transit time values. Furthermore, it may be subdivided into two subunits, with a nervous interval transit time curve in the lower one and a uniform

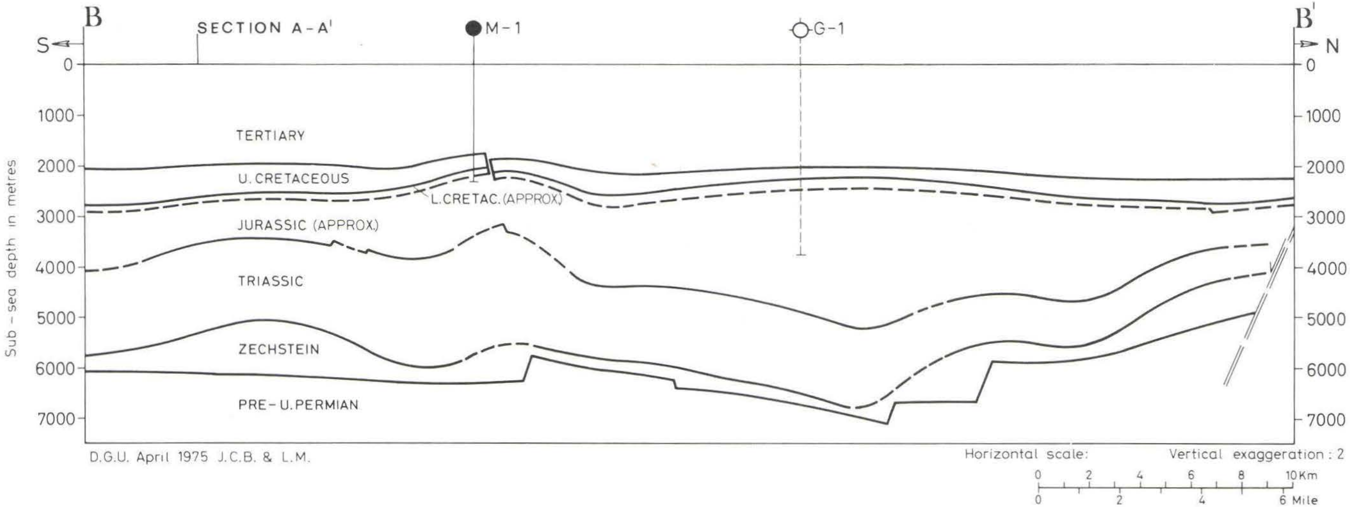

Fig. 2 a. For location of this section (B–B[1]) see the map fig. 1.

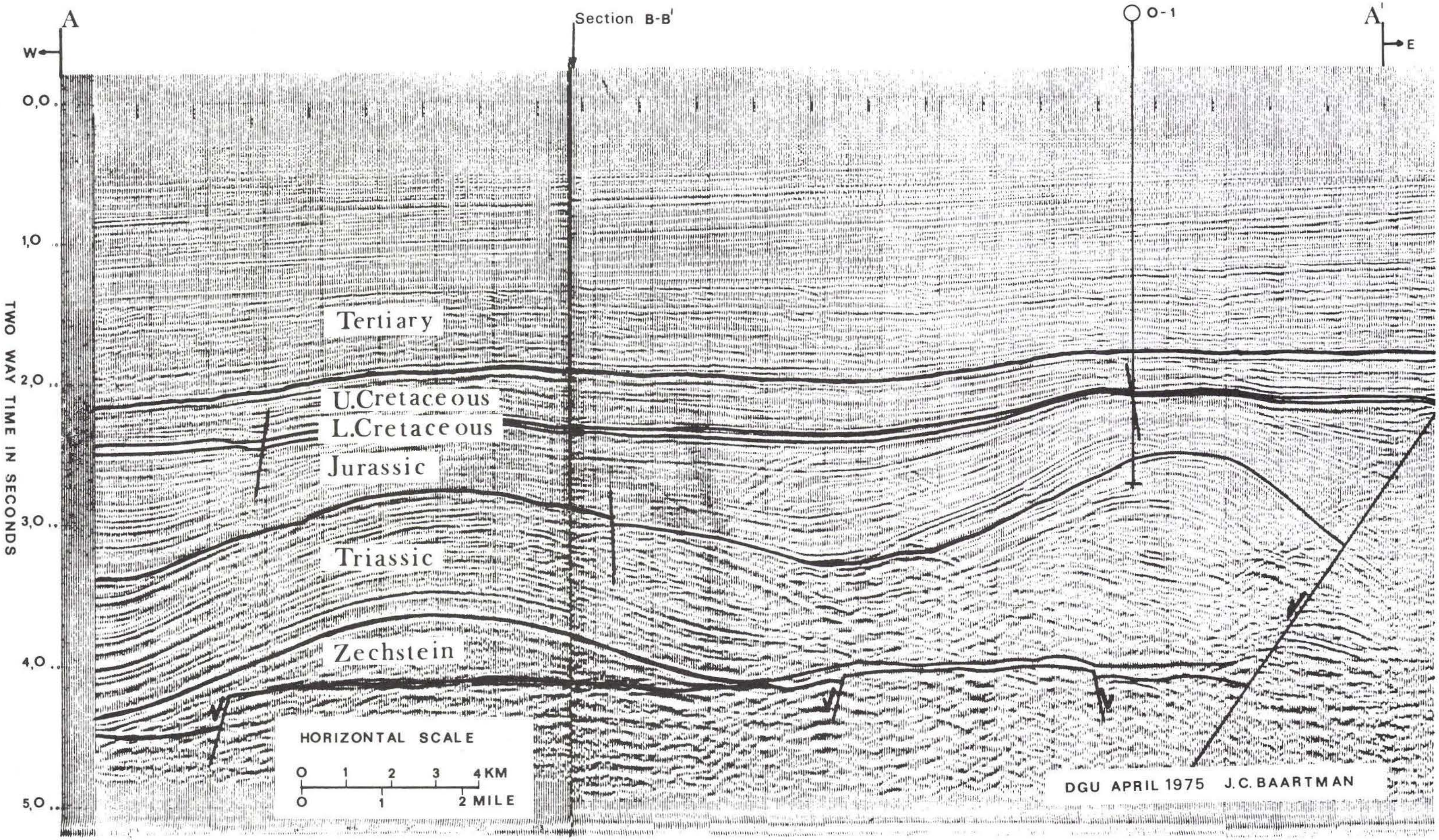

Fig. 2 b. For location of this section (A–A[1]) see the map fig. 1.

curve in the upper one. Lithologically, member A is distinguished by the scattered occurrence of marlstone and slightly silty beds. Member B is distinguished by very regular petrophysical measurements representing a uniform, clean claystone series.

The lower and upper boundaries of the formation are easily recognised by the interval transit time curve with the characters demonstrated in the section, fig. 3. In the cuttings samples the dark grey claystone differs distinctly from the overlying greenish and brownish claystone as well as from the underlying brownish grey, and often soft, claystone.

The formation has only been penetrated by a few borings, but from the seismic records it seems to be present in major parts of the Central Trough area.

A final status of the formation has not yet been evaluated as further studies in more borings are needed. The series present in the Dansk Nordsø 0–1 boring is comparable to the lower part of the Fjerritslev Formation, to the member F–Ia and lower part of F–Ib (Michelsen 1978). Member F–Ia is characterized by distinct silty beds and limestone beds demonstrated by pronounced deflections on the interval transit time curve, whereas member A include less clear interbedding of claystone, siltstone, and marlstone. Member B and member F–Ib both seem to have the same character. Studies of the ostracod faunas have shown the transitions between member A/B and member F–Ia/b to be of Lower Sinimurian age (placed uppermost in the *O. aspinata* Zone, see below).

Biostratigraphy

The biostratigraphy is based on analyses of the ostracod faunas. For synonyms of the ostracod species see Michelsen 1975. The specimens are picked out from the fraction 1.0–0.1 mm of most of the cuttings samples. Of the remaining cuttings samples the fraction 0.5–0.1 mm is used. The number of specimens picked out range between 30 and 160, – in the four uppermost samples less than 30 owing to cavings from the overlying, non-fossiliferous sequence. The methods for disintegration and washing of the samples are described in Michelsen 1975, p. 12.

The ostracod faunas found subdivide the sequence into two main assemblage zones, the upper one comprising the interval 9840′–9960′ (2971–3008 m) and the lower one 9960′–10287′ (3008–3107 m). The lower boundary (10287′) is determined by means of lithostratigraphical methods. The uppermost occurrence of Triassic ostracods (*Emphasia* spp.) is found in the sample 10390′–10400′ (3139–3142 m). Above this depth the number of Lower Jurassic ostracods increases to a maximum at 10240′ (3093 m). As this change in faunal density may be due either to the primary density or to cavings of fossiliferous sediments into an interval of non-fossiliferous sediments it was decided to use the mentioned lithostratigraphical boundary.

The biostratigraphical subdivision of the series can be referred to ostracod zones erected in the Danish Subbasin, to the *Ogmoconchella aspinata* Zone and the *Ogmoconchella danica* Zone (Michelsen 1975). Furthermore, indications are found of the presence of the *Cristacythere betzi – Cristacythere crassireticulata* Zone (see below).

The *O. danica* Zone comprises the interval 9840′–9960′ (2971–3008 m). The fauna is rather poor in species and specimens. The index species is only found in one sample, whereas *Kinkelinella (Klinglerella) triebeli* (Klingler & Neuweiler 1959) is the dominating species in the entire series. *K. (Klinglerella) bipartita* (Klingler & Neuweiler 1959) and *K. (K.) multicostata* (Klingler & Neuweiler 1959) are found in the upper part of the series, whereas *Acrocythere gassumensis* Michelsen 1975, *Pseudomacrocypris subtriangularis* Michelsen 1975, and *K. (Klinglerella) vulgaris* (Klingler & Neuweiler 1959) are found in the lower part. The succession of species refers the interval to the lower Upper Sinemurian, the ammonite zones: *obtusum* Zone and *turneri* Zone (Lias Beta la-b sensu Hoffmann 1960).

The occurrence of *Progonoidea reticulata* (Klingler & Neuweiler 1959) in the sample 9940′–9950′ (3002–3005 m) indicates the presence of the *P. reticulata* Subzone and refers the interval 3002–3008 m with certainty to the *turneri* Zone.

The *C. betzi – C. crassireticulata* Zone may be present in the series since three specimens of *Cristacythere betzi* (Klingler & Neuweiler 1959) are found in the middle of the underlying *O. aspinata* Zone. The occurrence of this species is considered to be due to cavings from the uppermost part of the *O. aspinata* Zone or from a thin series with the *C. betzi – C. crassireticulata* Zone above that zone.

The *O. aspinata* Zone comprises the interval 9960′–10287′ (3008–3107 m). The fauna is rich in species and specimens which is a characteristic feature of the zone, and it is characterized by the species *Ogmoconchella aspinata* (Drexler 1958), *O. telata* (Drexler 1958), *Ogmoconcha hagenowi* Drexler 1958, *Pseudohealdia nasuta* (Drexler 1958), *Pseudomacrocypris subtriangularis* Michelsen 1975, and *Kinkelinella (Klinglerella) medioreticulata* (Michelsen 1975). *O. aspinata* and *O. hagenowi* dominate throughout the zone. In the upper part of the zone the following species occur scattered: *Nanacythere (Goniocythere) elegans* (Drexler 1958), *N. (G.) paracostata* Michelsen 1975, and *N. (G.) circumcostata* Michelsen 1975.

The upper boundary of the zone is based on the occurrence of *O. hagenowi. O. aspinata* is not found in the sample interval 9960′–9980′, but the occurrence of *Isobythocypris* aff. *elongata* (Blake 1876) *sensu* Michelsen 1975 and *P. nasuta* is the basis for referring this interval to the zone.

The lower boundary is based on lithostratigraphical evidences (see above).

In the Danish Subbasin the *O. aspinata* Zone can be subdivided into two subzones referred to Lower Sinemurian and Hettangian respectively. The upper subzone differs from the lower by having a higher faunal diversity and density, and by a rather frequent occurrence of the subgenus *Nanacythere (Goniocythere)* Michelsen 1975. Such characters are less clear in series represented by cuttings samples. However, in the present series a corresponding subdivision seems to be present with a boundary at the depth 10100′ (3050 m). The maximum density and diversity is found in the sample interval 10050′–10100′, and the *N. (Goniocythere)* species decrease relatively in number below the depth 10100′. Furthermore, *O. hagenowi* decreases in number below 10150′. The latter species is not found in the lower half of the lower subzone (cf. Michelsen 1975, text-fig. 2 and p. 231). The species *O. aspinata* is here found as two morphospecies. The typical, subtriangular form is frequent below the depth 10050′. Above this depth dominates a more elongated and oval form which is not known from the Danish Subbasin. In South Germany corresponding morphotypes are known from Hettangian and Lower Sinemurian respectively (Drexler 1958).

Conclusions

For evaluation of the faunal affinities and communication the present faunas have been compared to faunas published by Dreyer 1965, Drexler 1958, Lord 1971, Donze 1966, 1967, 1968, and Viaud 1963. Furthermore a number of samples have been investigated from the localities Osterfeld and Sehnde (Germany), Rugby (England). Comparisons with faunas from the localities around the North Sea, including Danish onshore localities, have not shown any significant affinities with the faunas described above. However, the faunas from the Dansk Nordsø 0–1 boring show greater influence from the south than do the faunas from the Danish onshore area (see Michelsen 1975). By their inclusion of species such as *Ogmoconchella telata* and *Pseudohealdia nasuta* in pronounced numbers and the two morphotypes of *Ogmoconchella aspinata,* the faunas differ slightly from the Danish onshore fauna and show a higher affinity to the South German region.

The stratigraphical analyses indicate that marine sedimentation started early in the Lower Jurassic in the Central Trough area. The sediments and the rhythm of sedimentation can be correlated closely with that known from

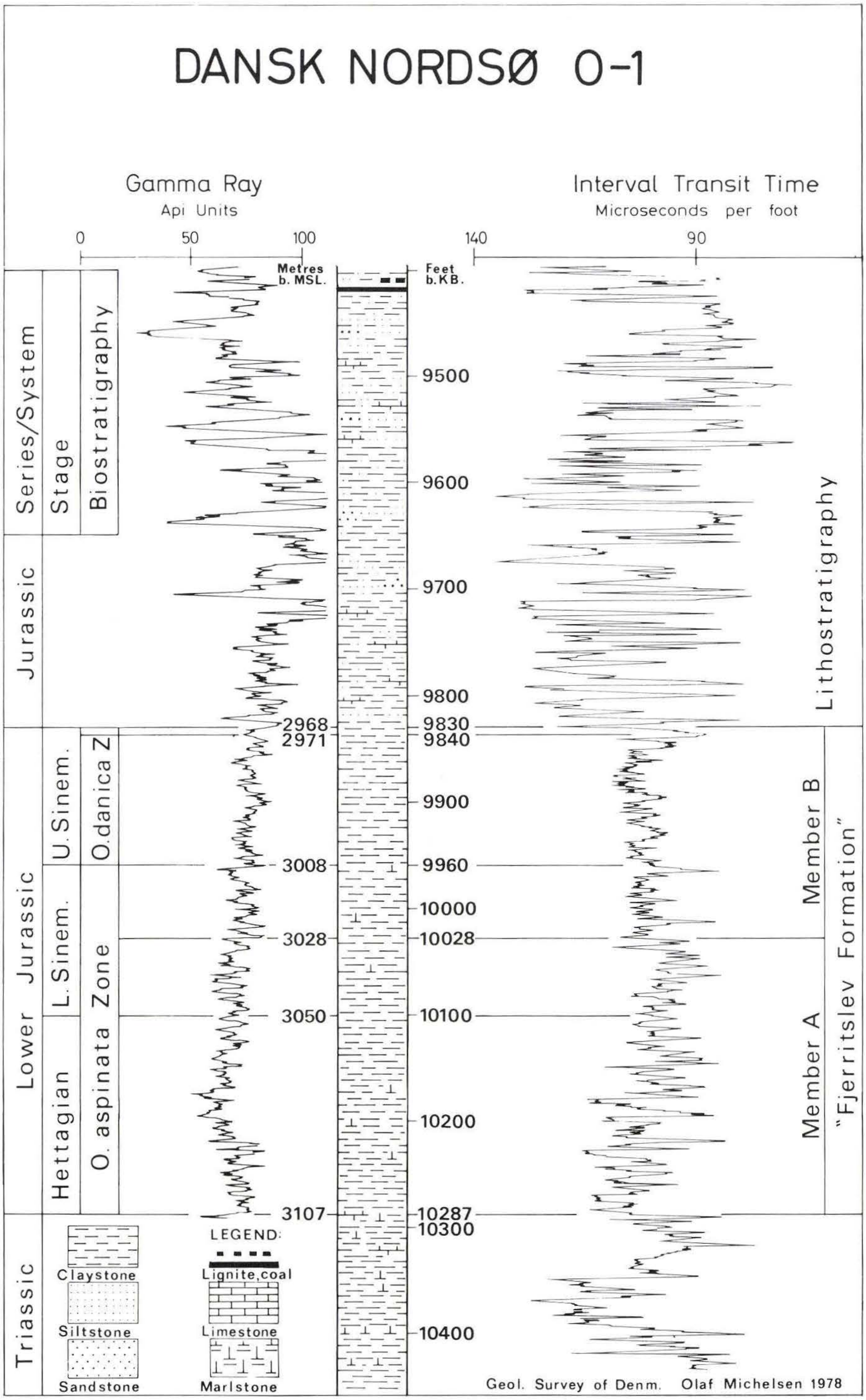
DANSK NORDSØ O-1
Gamma Ray
Api Units
0
50
100
Interval Transit Time
Microseconds per foot
140
90
Metres b. MSL.
Feet b.KB.
Series/System
Stage
Biostratigraphy
Jurassic
Lower Jurassic
U. Sinem.
L. Sinem.
Hettagian
O.danica Z
O. aspinata Zone
Triassic
9500
9600
9700
9800
2968
2971
9830
9840
9900
3008
9960
10000
3028
10028
3050
10100
10200
3107
10287
10300
10400
Lithostratigraphy
Member B
Member A
"Fjerritslev Formation"
LEGEND:
Claystone
Siltstone
Sandstone
Lignite,coal
Limestone
Marlstone
Geol. Survey of Denm. Olaf Michelsen 1978

Fig. 3.

the Norwegian-Danish Subbasin (cf. Michelsen 1978), from the area close to the Vestland Arch (cf. Deegan & Scull 1977, fig. 26), and from the East Shetland Basin (Younge *et al.* 1975, fig. 7). The sedimentation seems to have taken place under equal eustatic control in a large area and the Ringkøbing–Fyn High was not a source area during the Lower Jurassic (cf. Michelsen 1978). This interpretation is supported by the above-mentioned indication of a missing faunal barrier.

The unconformity between the Lower Jurassic (Upper Sinemurian) and the Middle Jurassic sequences can be correlated with corresponding unconformities elsewhere in the North Sea area, e.g. at the northern border of the Ringkøbing–Fyn High (see Michelsen 1978). It is thought to be due to regional uplift of the area at the end of Lower Jurassic and subsequent erosion of the upper part of the Lower Jurassic sequence. The change of structural dip from this series to the overlying Middle and Upper Jurassic series may be due to tilting of the blocks. After sedimentation of deltaic sediments in the Middle Jurassic a pronounced subsidence of the trough took place in the Upper Jurassic with deposition of very thick series of marine claystone.

Dansk sammendrag

Den nedre jurassiske lagserie er beskrevet fra boring Dansk Nordsø 0–1, der er beliggende i Central Trough (fig. 1).

Overlejrende øvre triassiske sedimenter findes marine lersten og skifre, der såvel ved sedimentkaraktererne som ved sedimentationsrytmen kan sammenlignes med den nedre jurassiske Fjerritslev Formation i det Norsk-danske Bassin. Lagserien inddeles uformelt i to members, A og B, der kan korreleres med de tilsvarende members F–Ia og F–Ib i nævnte bassin. Den overlejres af mellem jurassiske deltaiske sedimenter.

På grundlag af analyser af ostracodfaunaerne kan lagserien henføres til nedre del af nedre jura, øvre sinemurien og nedre sinemurien – hettangien (fig. 3).

Undersøgelser af såvel sedimenter som ostracodfaunaer tyder på at sedimentationen har fundet sted i eet stort sammenhængende aflejringsområde, inklusive det Norsk-danske Bassin. I slutningen af nedre jura perioden hævedes Ringkøbing–Fyn Højderyggen samtidig med at en generel hævning af Nordsø området fandt sted og en påfølgende erosion fjernede den øvre del af nedre jura lagserien. Målinger af laghældninger viser en tiltning af lagene ved overgangen mellem nedre og mellem jura.

References

Deegan, C. E. & Scull, B. J. 1977: A standard lithostratigraphic nomenclature for the Central and Northern North Sea. – Inst. geol. Sc., Report 77/25, 36 p.

Donze, P. 1966: Ostracodes de l'Hettangien entre Aubenas et Privas (Ardeche). – Trav. Lab. Geol. Univ. Lyon, N.S., 13, pp. 121–139.

Donze, P. 1967: Les ostracodes du sondage de Laneuveville-Devant-Nancy (Lotharingien de la région type). – Sciences Terre, XII, pp. 71–92.

Donze, P. 1968: Espèces nouvelles d'Ostracodes du Lias inférieur normand. – Bull. Soc. Linnéenne de Normandie, 10. Ser., 9, pp. 78–87.

Drexler, E. 1958: Foraminiferen und Ostracoden aus dem Lias α von Siebeldingen/Pfalz. – Geol. Jb., 75, pp. 475–554.

Dreyer, E. 1965: Mikrofossilien des Rät und Lias von SW-Brandenburg. – Jb. Geol., 1, pp. 491–531. Berlin 1965 (1967).

Lord, A. 1971: Revision of some lower Lias Ostracoda from Yorkshire. – Palaeontology, 14 (4), pp. 642–665.

Michelsen, O. 1975: Lower Jurassic biostratigraphy and ostracods of the Danish Embayment. – Danm. geol. Unders., II. række, 104, 287 p.

Michelsen, O. 1976: Kortfattet oversigt over de geologiske forhold i den danske del af Nordsøen. – Danm. geol. Unders., Årbog 1975, pp. 117–132.

Michelsen, O. 1978: Stratigraphy and distribution of Jurassic deposits in the Norwegian-Danish Basin. – Danm. geol. Unders., Ser. B, 2, 35 p.

Priisholm, S. & Michelsen, O. 1978: The use of porosity logs in lithology determination, lithostratigraphy and basin analyses. – Danm geol. Unders., Årbog 1977, pp. 89–100.

Rasmussen, L. B. 1978: Geological aspects of the Danish North Sea sector. With a report on the wells Dansk Nordsø E-1, E-2, F-1, G-1, H-1, I-1, J-1, and K-1. – Danm. geol. Unders., III. række, 44, 85 p.

Rhys, G. H. 1974: A proposed standard lithostratigraphic nomenclature for the southern North Sea and an outline structural nomenclature for the whole of the (UK) North Sea. – Inst. geol. Sc., Report 74/8, 14 p.

Viaud, J. 1963: Les Ostracodes des principaux bassins liasiques francais. – Unpubl. Thesis. Paris.

Younge, B., Myrland, R., Taylor, H. & Ruble, C. L. 1975: A preliminary report from the Jurassic stratigraphic nomenclature subcommittee in Norway. – NPF-Jurassic Northern North Sea Symposium, Stavanger 28–30 Sept. 1975, pp. 19/1–14.